Bringing embodied carbon upfront

Coordinated action for the building and construction sector to tackle embodied carbon

ADVANCING NET ZERO

WORLD GREEN BUILDING COUNCIL

RAMBOLL

C40 CITIES

World Green Building Council

The World Green Building Council (WorldGBC) is a global network leading the transformation of the built environment, to make it healthier and more sustainable. Collectively, with our Green Building Councils (GBCs) in around 70 countries, we accelerate action to deliver on the ambition of the Paris Agreement, by eliminating the buildings and construction sector´s emissions by 2050.

We are committed to green buildings for everyone, everywhere to build a better future.

Our approach to this report

The research for this report has been conducted in three phases. In the first phase, a detailed literature review and expert interviews were carried out. These were followed in the second phase by a series of stakeholder workshops that applied visioning and backcasting methods to identify possible pathways to achieving net zero embodied carbon. Finally, in the third phase, the drafting of the report has been reviewed and consulted on by hundreds of experts and stakeholders from across the value chain in order to refine and strengthen our proposals.

Contact information

Web www.worldgbc.org
Twitter @worldgbc
Email office@worldgbc.org

London, United Kingdom office
c/o UK Green Building Council
The Building Centre
26 Store Street
London
WC1E 7BT
United Kingdom

Toronto, Canada office
Attention: World Green Building Council
401 Richmond Street West, Suite 236
Toronto, Ontario
M5V 3A8
Canada

Acknowledgements

Report team

World Green Building Council
Author: Matthew Adams, Project Coordinator, Advancing Net Zero
Author: Victoria Burrows, Director, Advancing Net Zero
Author: Stephen Richardson, Head of Projects, Europe Regional Network
James Drinkwater, Director, Europe Regional Network
Cristina Gamboa, CEO

Ramboll
Christine Collin
Xavier Le Den
Lars Ostenfeld Riemann
Samy Porteron
Andreas Qvist Secher

Report funders

European Climate Foundation (ECF)
Children's Investment Fund Foundation (CIFF)

Report contributors

We Mean Business (WMB)
WorldGBC European Regional Network

Technical partner

Ramboll

Delivery partner

C40 Cities

Advancing Net Zero Green Building Council (GBC) Steering Committee

Alliance HQE-GBC (France)
GBCA (Australia)
GBC Brasil
Canada GBC
China Acandemy of Building Research (CABR)
Croatia GBC
DGNB (Germany)
Dutch GBC
Emirates GBC
GBC España
GBC Finland
Guatemala GBC
Hong Kong GBC
Indian GBC
GBC Indonesia
Irish GBC
GBC Italia
New Zealand GBC
Norwegian GBC
Singapore GBC
GBC South Africa
Sweden GBC
UKGBC
USGBC

Other contributors to the report

We would also like to acknowledge the contributions made by the people and organisations who provided expert interviews, participated in our workshops and provided feedback during consultation and report drafting.

A full list of contributors can be found at our website: www.worldgbc.org/embodied-carbon

Glossary

A variety of different terms and definitions are used in connection with greenhouse gas emissions from different stages of the lifecycle of products, buildings and infrastructure. Each term may include different interpretations and meanings across different sectors of the market and across countries and regions. This glossary defines what is meant by certain key terms used within this report. In the following definitions we make reference to the lifecycle stages or modules defined in the widely-adopted European standard EN 15978 shown in figure 1.

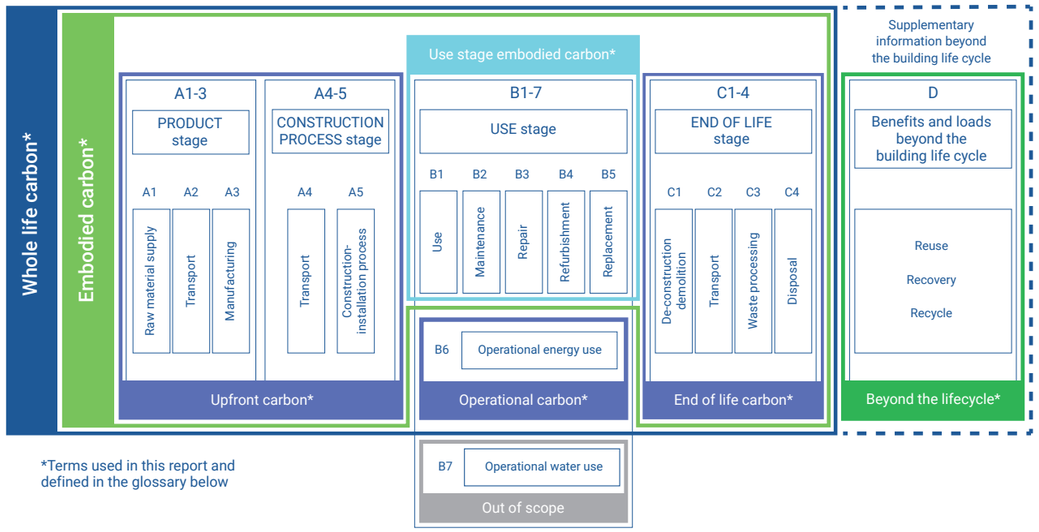


Figure 1: Terminology used in this report cross-referenced to terms and lifecycle stages defined in EN 15978

Carbon emissions Used in this report to refer to all emissions of greenhouse gases. Their global warming potential (GWP) is quantified in units of carbon dioxide equivalence. A kilogram of carbon dioxide therefore has a GWP of 1 $kgCO_2e$.

- **Beyond the lifecycle** Carbon emissions or emissions savings incurred due to reuse or recycling of materials or emissions avoided due to using waste as a fuel source for another process (module D). Consideration of module D is key for maximising resource efficient uses of materials at the end of life. Under forthcoming updates to European standards, it will be mandatory for product EPDs to report module D alongside other lifecycle stages in most cases, and will also be required for building assessments. This is to ensure our definition aligns with current international standards for lifecycle assessment. However we recognise that consideration of these emissions and emissions savings is important for maximising resource efficient uses of materials at the end of life and their inclusion in standards is a subject of ongoing debate and review by standards bodies. These benefits could be considered as part of an approach to offsetting, provided double-counting is avoided.
- **Embodied carbon** Carbon emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure. Embodied carbon therefore includes: material extraction (module A1), transport to

manufacturer (A2), manufacturing (A3), transport to site (A4), construction (A5), use phase (B1, eg concrete carbonation but excluding operational carbon), maintenance (B2), repair (B3), replacement (B4), refurbishment (B5), deconstruction (C1), transport to end of life facilities (C2), processing (C3), disposal (C4). Benefits beyond the system boundary (D) should also be reported separately to modules A-C.

In the report we refer to the embodied carbon of both buildings and infrastructure as well as the embodied carbon of individual materials.

- **End of life carbon** The carbon emissions associated with deconstruction/demolition (C1), transport from site (C2), waste processing (C3) and disposal (C4) phases of a building or infrastructure's lifecycle which occur after its use.
- **Operational carbon** The emissions associated with energy used (B6) to operate the building or in the operation of infrastructure.
- **Upfront carbon** The emissions caused in the materials production and construction phases (A1-5) of the lifecycle before the building or infrastructure begins to be used. In contrast to other categories of emissions listed here, these emissions have already been released into the atmosphere before the building is occupied or the infrastructure begins operation.
- **Use stage embodied carbon** Emissions associated with materials and processes needed to maintain the building or infrastructure during use such as for refurbishments. These are additional to operational carbon emitted due to heating, cooling and power etc.
- **Whole life carbon** Emissions from all lifecycle phases, encompassing both embodied and operational carbon together (ie modules A1 to C4, with module D reported separately).

Carbon footprint Used occasionally in the report to denote the carbon emissions caused directly and indirectly by a person, organisation or event.

Heavy industries Carbon intensive industries which manufacture materials and products. These include aluminium, cement and concrete, glass, gypsum, chemicals (eg in plastics), steel, ceramics, mineral fibres, clay, lime and asphalt.

Lifecycle assessment (LCA) LCA is a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy, and the associated environmental impacts directly attributable to a building, infrastructure, product or material throughout its lifecycle (ISO 14040: 2006).

Material passport Holds data attributes relating to the characteristics of a material or product. They are valuable for end of life planning to evaluate the potential for reuse, recovery and recycling. In some cases they may be combined at building level as a bank that encompasses all materials/products contained within the building.

Performance-based approaches Where the consideration and selection of embodied carbon reduction measures are guided by LCA-based calculations of the outcomes.

Prescriptive approaches Where the selection of embodied carbon reduction measures is based on a set of standard approaches that are defined using best practice principles of low carbon design and material selection, without conducting bespoke embodied carbon calculations.

Executive summary

Background and context – the climate emergency

We are now in a climate emergency. The landmark 2018 special report from the UN Intergovernmental Panel on Climate Change (IPCC 2018 report), *Global Warming of 1.5ºC*, presented a stark picture of the dramatically different world we will inhabit if global average temperatures rise by 2ºC compared to a 1.5ºC scenario. The catastrophic breakdown of climate associated with the difference between these two scenarios is likely to result in entire eco-systems being destroyed. And the negative economic impact globally of additional heating and cooling demand is expected to increase fourfold by the end of the century. The consequences will be long lasting and, in some cases, irreversible. This emergency calls for urgent action now to radically transform current unsustainable models of consumption.

The built environment sector has a vital role to play in responding to the climate emergency. With buildings currently responsible for 39% of global carbon emissions, decarbonising the sector is one of the most cost effective ways to mitigate the worst effects of climate breakdown.

In 2018, in line with the ambitions of the Paris Agreement and to accelerate the built environment sector towards a 1.5ºC pathway, World Green Building Council (WorldGBC) launched the Net Zero Carbon Buildings Commitment. Our aim was to inspire and promote advanced climate leadership focused on achieving net zero **operational carbon** at individual building level and at mass scale from businesses and government. Yet operational carbon emissions are only part of the story.

Bringing embodied carbon 'upfront'

As the world's population approaches 10 billion, the global building stock is expected to double in size. Without drastic changes to the way our sector operates, this growth will consume vast amounts of natural resources, contributing to an expected doubling of the total global consumption of raw materials by around the middle of the century, significantly increasing the sector's emissions and climate impact.

Carbon emissions are released not only during operational life but also during the manufacturing, transportation, construction and end of life phases of all built assets – buildings and infrastructure. These emissions, commonly referred to as **embodied carbon**, have largely been overlooked historically but contribute around 11% of all global carbon emissions. Carbon emissions released before the building or infrastructure begins to be used, sometimes called **upfront carbon**, will be responsible for half of the entire carbon footprint of new construction between now and 2050, threatening to consume a large part of our remaining carbon budget.

As operational carbon is reduced, embodied carbon will continue to grow in importance as a proportion of total emissions. While we must continue to focus on addressing operational carbon we must now rapidly increase efforts to tackle embodied carbon emissions at a global scale, too.

Our vision – going further and faster to decarbonise across the whole lifecycle

The urgent need to go further and faster requires a new response and a new vision for our sector. This vision sees a highly connected value chain radically reducing both embodied and operational carbon, improving wider lifecycle environmental impacts, and contributing as effectively as possible to the UN Sustainable Development Goals. To achieve our vision, we must take urgent action to tackle upfront carbon while designing with whole life carbon in mind. We have set timeframes for our vision in response to global climate goals and demonstrating the level of ambition needed.

Our vision:

By 2030, all new buildings, infrastructure and renovations will have at least 40% less **embodied carbon** with significant **upfront carbon** reduction, and all new buildings must be net zero **operational carbon**.

By 2050, new buildings, infrastructure and renovations will have net zero **embodied carbon**, and all buildings, including existing buildings, must be net zero **operational carbon**.

Our goals – the purpose of this report

To support and promote our vision this report issues an urgent call to action designed to bring the whole building and construction value chain together. We aim to:

- **Spark a global conversation around the value and importance of reaching net zero embodied carbon;** adopt a common language, definition, principles, milestones and feasible actions that can be used by all parts of the value chain.
- **Communicate the urgency of, and set deadlines for, goals and milestones to achieve net zero embodied carbon globally;** support the development of regional, national and sectoral roadmaps.
- **Stimulate market demand and facilitate radical whole value chain collaboration;** highlight current, realistic leadership actions that can rapidly reduce embodied carbon and demonstrate how full decarbonisation can be achieved by working together.
- **Advocate for policy and regulation on net zero embodied carbon;** demonstrate support for action from industry and highlight leading regulation and policy globally to demonstrate feasibility.

Achieving our vision – collaboration, market demand, and what it means for you

To date, very few buildings or infrastructure assets can claim to be fully net zero embodied carbon and in line with our vision. Our sector is highly dispersed and relies on a wide range of materials with long and complex supply chains. Many of the most widely used construction materials are from carbon-intensive heavy industries.

Many leading organisations within these industries and indeed in the wider sector have taken bold action on embodied carbon already. Our research into the state of the market has shown that many of the actions that will help lead the transition can, and indeed must, be taken now.

Achieving net zero embodied carbon for the entire sector will require far greater collaboration along the whole value chain to support efforts to decarbonise industry and to develop and deploy more low embodied carbon alternatives. Such collaboration allows businesses and organisations to identify and have confidence in the environmental, social and financial benefits of taking a leadership position in the transition to a decarbonised built environment.

This is a radical transition – driving it will require much greater demand from the market as well as rapid scaling of solutions by the supply chain. Large amounts of additional renewable energy are needed, and some of the solutions we will rely on are currently only at demonstration stage, including carbon capture for utilisation and storage. By stimulating market demand we will accelerate investment in actions that will lead to increased competitiveness, improved access to solutions and a wider range of strategies for achieving net zero embodied carbon.

Demand-side actors within the value chain, including investors, developers and designers, must work together with those on the supply side – the contractors and materials manufacturers. They will need strong policy and regulatory support and access to finance.

Current global leadership – a catalyst for market transformation

Although embodied carbon may be a new challenge for many in the sector, leading businesses, researchers and organisations around the world have been working on this topic for over a decade. It is thanks to their leadership and innovation that tools and data for calculating embodied carbon are becoming increasingly available and accessible.

More and more low embodied carbon products and solutions are entering the market, and flagship projects are having significant impacts using technology available today. Green Building Councils (GBCs) around the world, from Asia Pacific to Europe and North America, are already driving change in their markets by incorporating criteria for embodied carbon into their sustainability certifications. And leading city, state and national governments are implementing policy and regulation initiatives for meeting ambitious embodied carbon reduction targets.

Net zero embodied carbon – definition and principles

As a way of bringing greater clarity to our aims and objectives, WorldGBC has worked with our member GBCs and other valued partners to define net zero embodied carbon.

Net zero **embodied carbon** should be pursued as part of a whole lifecycle approach to carbon reduction that includes net zero **operational carbon**.

Our definition of net zero embodied carbon in practice:

A net zero **embodied carbon** building (new or renovated) or infrastructure asset is highly resource efficient with **upfront carbon** minimised to the greatest extent possible and all remaining **embodied carbon** reduced or, as a last resort, offset in order to achieve net zero across the lifecycle.

This new definition makes clear that net zero embodied carbon should be pursued as part of a strategy to decarbonise the whole lifecycle. It also recognises the urgency of addressing upfront emissions, which are being released into the atmosphere now, as we continue to extract and manufacture materials and products for construction. The definition builds on internationally accepted standards for lifecycle assessment of buildings and infrastructure and the terms in bold are further defined in the glossary section on page 5 of the report.

The following foundational principles can be followed by both demand-side and supply-side organisations in line with our vision, goals and definitions.

1. **Prevent** – avoid embodied carbon from the outset by considering alternative strategies to deliver the desired function
2. **Reduce and optimise** – evaluate each design choice in terms of the upfront carbon reductions and as part of a whole lifecycle approach
3. **Plan for the future** – take steps to avoid future embodied carbon during and at end of life
4. **Offset** – as a last resort, offset residual embodied carbon emissions within the project or organisational boundary where possible or if necessary through verified offset schemes

Converting barriers into opportunities – key steps towards net zero embodied carbon

We believe our vision of a completely decarbonised sector, including net zero embodied carbon, can be achieved through concerted and coordinated action. For such a radical transition to happen, business, government and civil society must all assume leadership roles, with each contributing to the following enabling actions:

- **Collaboration** across the whole value chain, including both public and private sectors, so as to create a common vision and establish regional, national and sectoral roadmaps
- **Communication** raising awareness about the importance of embodied carbon and sharing best practice strategies and leadership examples of progress towards achieving our vision
- **Education** addressing foundational gaps in skills, data and benchmarks globally through knowledge sharing, training and transparency for both prescriptive and performance-based pathways
- **Innovation** creating space for new business models, new technologies and circular patterns to evolve and thrive in response to financial and policy incentives
- **Acceleration** fostering and leveraging proven industry-wide demand drivers and market forces including voluntary, financial and policy measures
- **Regulation** mandating reductions in embodied carbon that are aligned with 1.5ºC compliant decarbonisation pathways

Taking action now – how you can respond to the climate emergency

This report sets out ambitious high-level pathways for business, government and civil society to follow in order to reduce embodied emissions associated with our sector. A summary of goals and target dates for key actors in the value chain is given in Figure 2. A vital first step – one that some leading countries and sectors have already taken – is to develop detailed roadmaps for complete decarbonisation of both embodied and operational carbon by 2050. We are committed to supporting our network of nearly 70 GBCs and their 37,000 members around the world in achieving this over the coming years.

We call on you, and all actors across the whole value chain, to help transform our sector from a major cause into a major solution to the climate emergency, securing a safe future for this generation and generations to come.

Join us and act now!

Figure 2: Summary of all stakeholder specific goals

Non-government organisations, networks and researchers

2020
- All GBCs and relevant NGOs/networks convene all sectors to co-create national roadmaps to net zero

2025
- Implement standardised embodied carbon calculation methods, design tools and guidance
- Contribute to establishment of databases and help set benchmarks
- All GBCs/NGOs certification schemes include embodied carbon requirements

Policymakers

Governments

2020
- All levels of government start to develop a strategy to achieve net zero embodied carbon

2025
- All governments implement embodied carbon targets for new public buildings, large public renovations and infrastructure

2030
- All governments have implemented policies that set progressive embodied carbon reduction targets and specify when net zero embodied carbon will become mandatory in line with national roadmaps

Cities

2020
- Cities start the process of developing a strategy to achieve net zero embodied carbon

2025
- Cities adopt a set of embodied carbon reduction targets with a clear trajectory towards net zero standards

2030
- Cities have implemented policies that set progressive embodied carbon reduction targets and specify when net zero embodied carbon will become mandatory

Investors

2020
- All investors commit to relevant industry roadmaps targeting embodied carbon

2025
- Investors only finance new projects incl. buildings, large renovations, infrastructure and manufacturing plants that are compliant with carbon reduction targets

2035
- Investors only finance new projects incl. buildings, large renovations, infrastructure and manufacturing plants that are net zero embodied carbon

Developers

2020
- All developers commit to relevant industry roadmaps and require disclosure of supply chain data for structural elements

2025
- All developers set embodied carbon reduction targets and require mandatory disclosure of supply chain data and track construction site emissions

2030
- All construction sites are highly resource and energy efficient and, along with site-related transport processes, are powered by renewable energy

2035
- Developers only build projects that have net zero embodied carbon

Designers

2020
- All designers commit to relevant industry roadmaps and have integrated low embodied carbon design at conceptual design stage

2025
- All design companies publicly share lifecycle assessment data
- Design companies propose best practice embodied carbon reduction targets and implement circularity principles

2035
- Design companies propose requirements for all projects to be 100% net zero embodied carbon

Material manufacturers

2020
- All manufacturers and suppliers commit to relevant industry roadmaps and have developed carbon reduction targets and with timelines set to achieve net zero embodied carbon by 2050

2025
- All manufacturers have declared the embodied carbon of the top 40% of their standard product portfolio by carbon footprint via EPDs

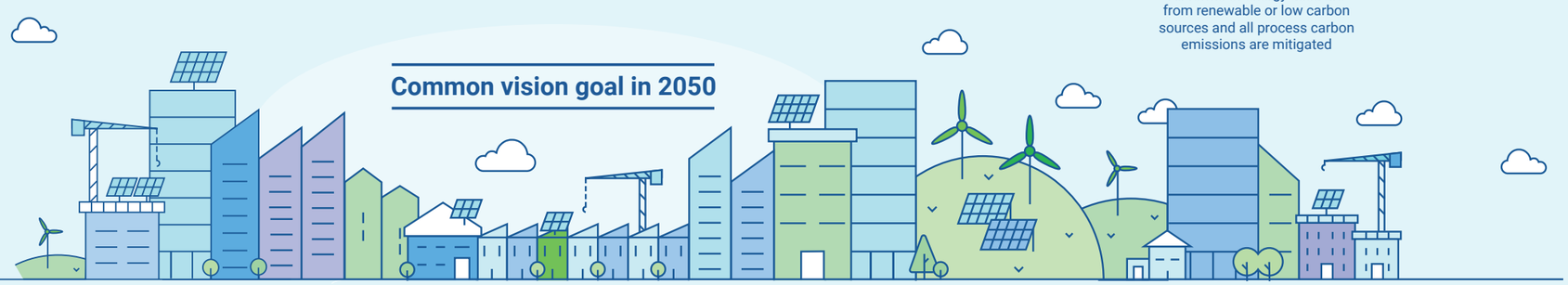
2030
- All manufacturers have declared their entire standard product portfolios via EPDs

2040
- All electricity is from renewable or low carbon sources (manufacturing and transport)

2045
- All forms of energy used are from renewable or low carbon sources and all process carbon emissions are mitigated

2050

Roadmaps
Tools
Data
Certification
Target setting/ benchmarks
EPD EPD
Policy
$$$ Finance
Disclosure
Renewable energy
Build/ develop
Design
Leadership action

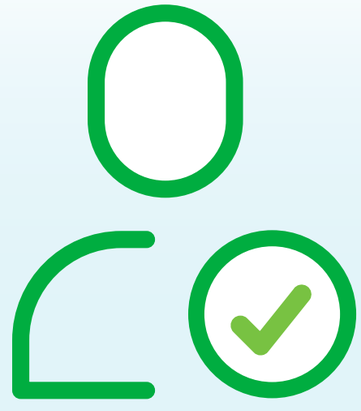


Common vision goal in 2050

Endorsements

The following organisations endorse the vision and ambition of this report, recognising the need for coordinated action across the whole value chain to achieve this. Their endorsement is a call to others to join them and work together to fully decarbonise buildings and infrastructure by 2050.

- Aalto University, Department of Architecture
- ABN AMRO Bank
- AECOM
- AESG
- Atelier Ten
- Australian Sustainable Built Environment Council
- Avison Young
- B+H Architects
- Barratt Developments PLC
- Bennetts Associates
- Building Research Establishment (BRE)
- C40 Cities Climate Leadership Group
- Canary Wharf Group
- Carbon Leadership Forum
- CEN/TC350, Sustainability of Construction Works
- City Developments Limited
- City of Sydney
- City of Vancouver
- Climate Agency, City of Oslo
- Climate Bonds Initiative
- Cundall
- Dalmia Cement (Bharat) Limited
- Danish Building Research Institute, Aalborg University
- EDGE ENVIRONMENT
- EllisDon
- Energy Transitions Commission
- Energy Research Institute @ Nanyang Technological University
- European Bank for Reconstruction and Development
- Frasers Property Australia
- GECA: Sustainability & Environmental Certification Program
- Global GreenTag International Pty Ltd
- Global Infrastructure Basel Foundation
- Google
- Grosvenor
- HeidelbergCement
- Infrastructure Sustainability Council of Australia
- Integral Group
- Interface
- International Living Future Institute
- JLL
- LafargeHolcim
- Landsec
- Lemay
- Majid Al Futtaim Holding
- Mantle
- Microsoft
- Ministry of the Environment, Finland
- Morgan Sindall Group
- Morrison Hershfield
- Multiplex Global
- New York City Mayor's Office of Sustainability
- One Click LCA / Bionova Ltd
- Pan-United Concrete Pty Ltd
- Ramboll
- RDT Pacific
- RICS
- Royal BAM Group
- Royal Institute of British Architects
- Ruukki Construction Oy
- Saint-Gobain
- Schneider Electric
- Signify
- Skanska Group
- Skidmore, Owings & Merrill LLP
- Stanhope PLC
- Stora Enso
- Surbana Jurong Consultants Pte Ltd
- The Climate Group
- thinkstep ANZ
- Urban Green Council
- Volvo Construction Equipment
- We Mean Business
- Willmott Dixon
- World Business Council for Sustainable Development
- WSP



Our vision

Driving the shift towards whole value chain collaboration

To deliver the ambitions of the Paris Agreement and keep global average temperature rise well below 2ºC, all sectors of the economy must decarbonise[1]. Currently, buildings account for 39% of energy-related global CO_2 emissions[2], demonstrating the importance of the building and construction sector in fulfilling these ambitions. Of this sector contribution, 28% comes from operational carbon with 11%[3] arising from the energy used to produce building and construction materials, usually referred to as embodied carbon.

The IPCC 2018 report paints a stark picture of how the difference between 1.5°C and 2°C of global warming greatly increases the risks of catastrophic climate breakdown. The difference between these two scenarios is likely to result in entire eco-systems being destroyed. And the negative economic impact globally of additional heating and cooling demand is expected to increase fourfold by the end of the century. The consequences will be long lasting and, in some cases, irreversible. The report calls for 'rapid and far-reaching'[4] economic transitions to limit global warming to 1.5°C

We must radically increase the pace and scope of decarbonisation efforts, collaborating across the whole construction value chain to achieve the scale of change needed. That is why we have created a vision for our sector to become fully decarbonised and to contribute as effectively as possible to the UN Sustainable Development Goals.

While our vision is ambitious, we are already taking significant steps towards achieving it by addressing net zero operational carbon. In May 2017, WorldGBC launched the call to action report *From Thousands to Billions*, outlining the action that business, government and NGOs must take to accelerate the market towards net zero carbon buildings. The report called for all buildings to operate at net zero carbon by 2050, and all new buildings from 2030.

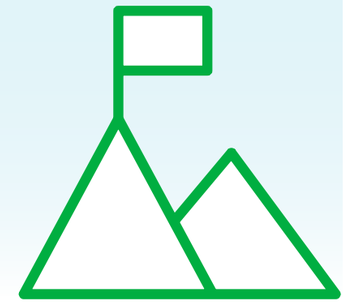
Our vision:

By 2030, all new buildings, infrastructure and renovations will have at least 40% less **embodied carbon** with significant **upfront carbon** reduction, and all new buildings must be net zero **operational carbon**.

By 2050, new buildings, infrastructure and renovations will have net zero **embodied carbon**, and all buildings, including existing buildings, must be net zero **operational carbon**.

In order to facilitate this shift, GBCs and WorldGBC have been developing tools and resources, including certification schemes and the Net Zero Carbon Buildings Commitment. The Commitment formalises initial calls to action in order to promote and inspire advanced climate leadership in decarbonising the operational emissions of the built environment at individual building and mass scale from businesses and government. It sets a level of ambition intended to create mass demand, stimulating the market to deliver net zero operational carbon solutions at scale.

We will continue to address the 28% of emissions attributed to operational carbon, together with our GBC network, and, as shown in our *Advancing Net Zero Status Report 2019*, we have been able to shift the market significantly towards net zero operational carbon. In the light of the IPCC report's urgency, and the need for full decarbonisation of the sector, we now believe the time is right to move to a whole life approach. This will address the remaining 11%[5] of emissions from building embodied carbon and rapidly transform the industry so that both net zero embodied carbon and net zero operational carbon become globally achievable. Embodied carbon has typically been overlooked in the past, but as operational carbon emissions are reduced, embodied carbon will continue to grow in importance as a proportion of total emissions.



Time value of carbon and the importance of upfront emissions

Our vision for 2050 is for the whole lifecycle of all buildings and infrastructure to be net zero carbon (ie net zero whole life carbon). This means net zero during operation and for all embodied carbon emitted during the whole lifecycle. The scale of this task is considerable, and we are already at a critical point in time.

The IPCC report highlights the urgent need to achieve radical emissions reductions in the next decade to avoid catastrophic climate breakdown. With operational carbon still the major portion of our sector's impact, we must not accept low operational performance levels now, that will need costly upgrades in the future – indeed, we should scale up decarbonisation efforts for operational carbon (eg via energy efficiency technologies, grid decarbonisation). While embodied carbon currently accounts for 11% of emissions globally, as operational carbon is reduced and development accelerates in parts of the world including China and Africa; it is estimated that more than half of total carbon emissions from all global new construction between 2020 and 2050 will be due to upfront emissions[6] from new building construction and, to a lesser degree, from building renovations in Europe in particular.

Our goals

To achieve our vision of catalysing market action, we have set out four key goals:

- **Spark a global conversation around the value and importance of reaching net zero embodied carbon;** adopt a common language, definition, principles, milestones and feasible actions that can be used by all parts of the value chain.
- **Communicate the urgency of, and set deadlines for, goals and milestones for achieving net zero embodied carbon globally;** support the development of regional, national and sectoral roadmaps.
- **Stimulate market demand and facilitate radical whole value chain collaboration;** highlight current, realistic leadership actions that can rapidly reduce embodied carbon, and demonstrate how full decarbonisation can be achieved by working together.
- **Advocate for policy and regulation on net zero embodied carbon;** demonstrate support for action from industry and highlight leading regulation and policy globally to demonstrate feasibility.

[1] Climate Change 2013: The Physical Science Basis – Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

[2] Data from Global Status Report 2018, Global Alliance for Buildings and Construction & International Energy Agency.

[3] These figures may be higher as they do not include transport to site and chemical conversion process emissions released during the manufacture of a number of key construction materials.

[4] IPCC, 2018: Strengthening and Implementing the Global Response. In Global Warming of 1.5°C.

[5] Data from Global Status Report 2018, Global Alliance for Buildings and Construction & International Energy Agency

[6] Architecture 2030, Total Carbon Emissions of Global New Construction every year from 2020 - 2050

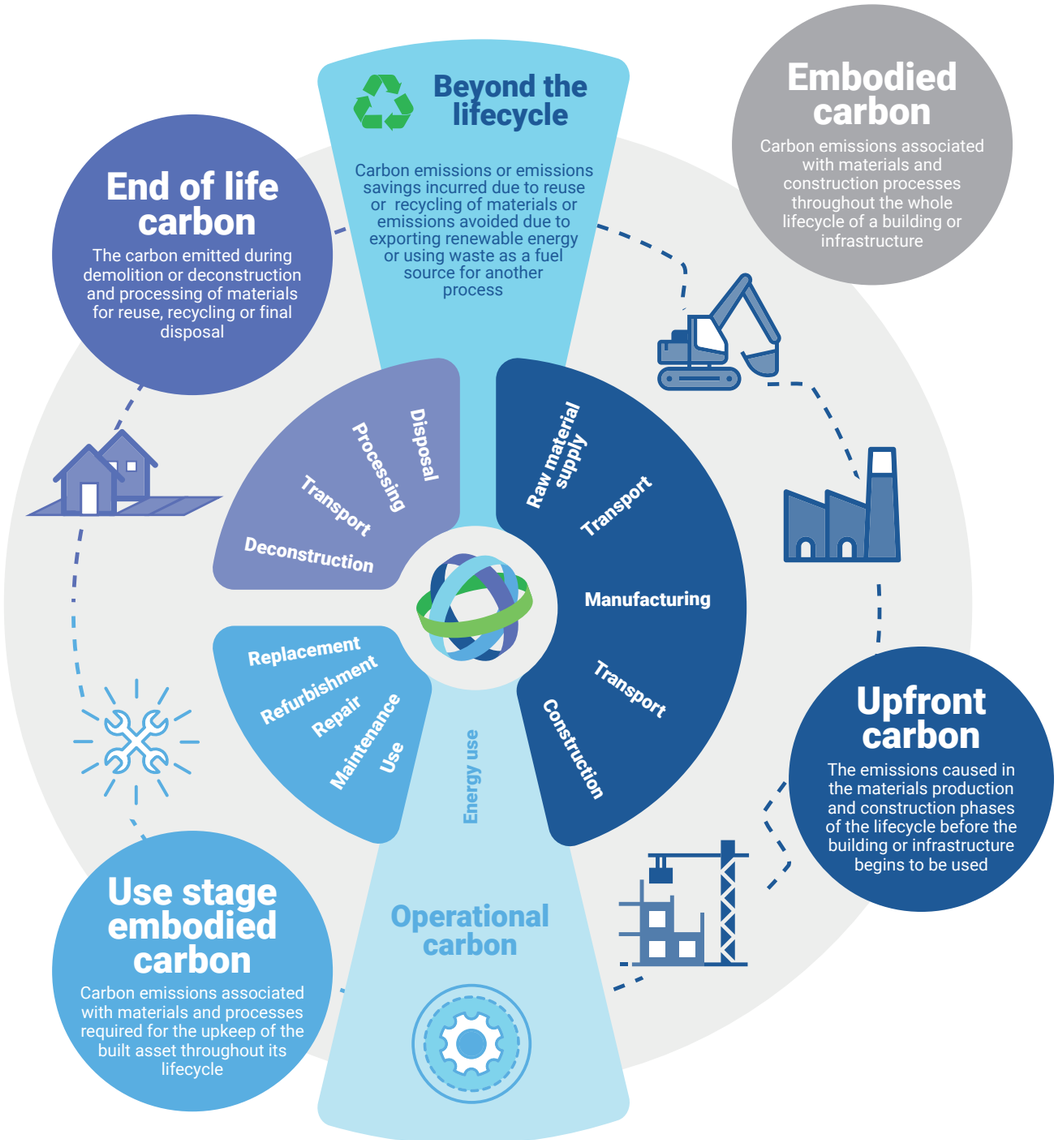


Figure 3: Project lifecycle showing both the scope of the definition and need for whole life consideration.

It is therefore imperative that we rapidly increase actions that achieve early emissions savings in the building lifecycle because these are using up our carbon budget ***now***. This is sometimes referred to as the time value of carbon[7] – it provides a stark and compelling reason to address embodied carbon in addition to operational carbon and to prioritise upfront emissions from materials and construction urgently. Once a building or infrastructure enters operation, nothing more can be done about its upfront emissions.

While minimising upfront carbon is vitally important, we must not risk creating adverse or negative outcomes for both operational carbon and whole life carbon. We therefore need to be conscious of the impacts that our upfront carbon decisions will have on whole life carbon. This is especially true for material selection where each material represents impacts and reduction opportunities throughout the whole lifecycle, and we must design with these in mind. A low embodied carbon building that performs poorly in operation creates adverse financial, environmental and social implications. To achieve our vision, we cannot address one without the other and so must take urgent action to tackle upfront carbon while designing with whole life carbon in mind.

By taking a holistic approach, we must maintain a concerted focus on transformational pathways for both net zero embodied carbon and net zero operational carbon. An explicit focus on embodied carbon is essential to accelerate and scale up rapid action needed through targeted policy tools, instruments and methodologies. Only then can we achieve the large scale design and manufacturing transformations needed over the next three decades.

There are many inspiring examples of existing leadership in this area from across the sector. Organisations right across the value chain are taking important steps towards net zero embodied carbon by drastically reducing upfront emissions and implementing whole life carbon thinking. In this report we build on these examples, setting out ambitious yet achievable actions to highlight the value and importance of achieving net zero embodied carbon. By communicating the urgent need and associated deadlines for these actions we hope to accelerate the development of regional, national and sectoral roadmaps for use by the public, private and non-profit sectors. Our aim is to foster the right conditions for deep collaboration across the value chain and to promote integrated strategies for embodied and operational decarbonisation.

Opportunities for reducing embodied carbon

Embodied carbon emissions are affected by many factors. These range from the type and volume of structure installed, the materials used and their associated carbon intensity of manufacturing processes to the modes and distances by which materials are transported and the processes by which these materials are constructed, maintained and finally removed and treated at the end of life.

Some materials also absorb or sequester carbon at different lifecycle stages, which can offset emissions from other lifecycle stages. Opportunities for reducing or eliminating embodied carbon are equally varied and will differ between types of projects as well as by region. In general, the greatest savings can usually be realised at the earliest stages of a project. As a project progresses, it becomes more challenging and more costly to make design changes in order to reduce embodied carbon (see figure 4).

[7] Carbon Leadership Forum (2017): Time value of carbon.

Carbon reduction potential

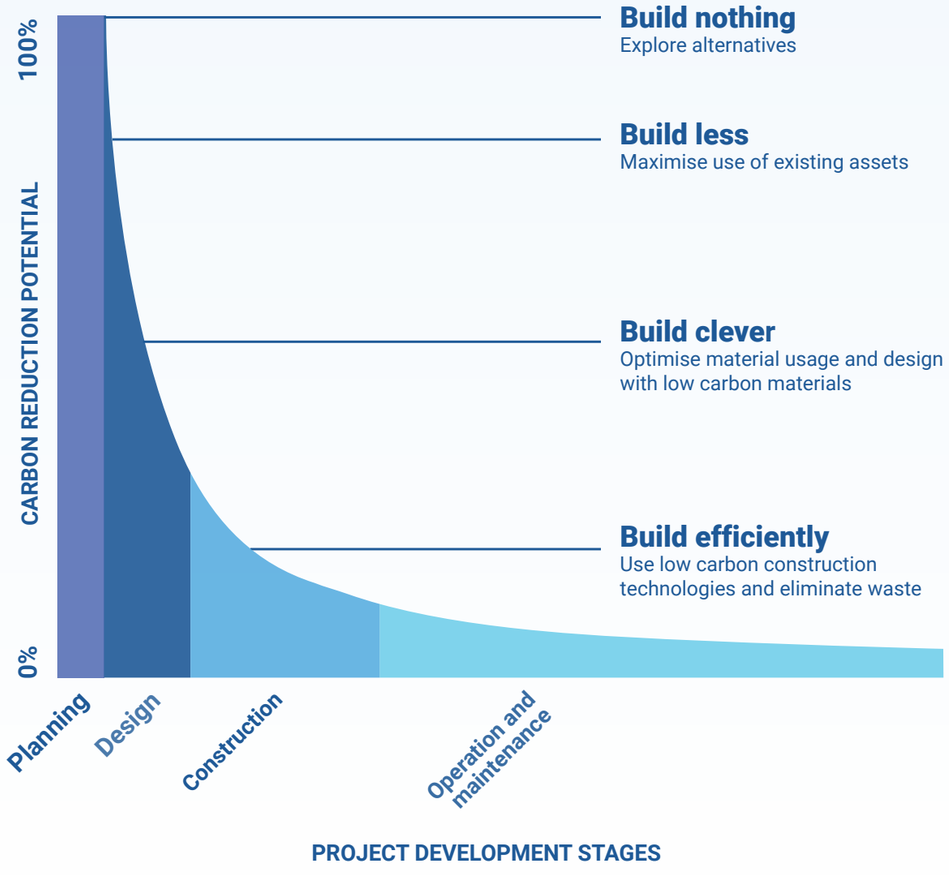


Figure 4: Opportunities to reduce embodied carbon from stage of design process.
Source: HM Treasury: Infrastructure Carbon Review, 2013

Our definition

To bring clarity to our goals and to help galvanise the whole value chain in support of them, WorldGBC is adopting the following definition for net zero embodied carbon.

Net zero **embodied carbon** should be pursued as part of a whole lifecycle approach to carbon reduction that includes net zero **operational carbon**.

Our definition of net zero embodied carbon in practice:

A net zero **embodied carbon** building (new or renovated) or infrastructure asset is highly resource efficient with **upfront carbon** minimised to the greatest extent possible and all remaining **embodied carbon** reduced or, as a last resort, offset in order to achieve net zero across the lifecycle.

Our principles

The best way to reduce embodied carbon is through prevention. As figure 4 shows, by building nothing we altogether eliminate the potential for embodied carbon emissions. Taking the ideas of figure 4 a step further, we have defined four key principles that support our goals. These principles can be applied by all stakeholders, regardless of their position in the value chain, the nature of their project or product, and the region they operate in.

1. Prevent

Consider embodied carbon emissions and reduction strategies from the outset, whether for a whole project or for a single product. Question the need to use materials at all, considering alternative strategies for delivering the desired function, such as increasing utilisation of existing assets through renovation or reuse.

2. Reduce and optimise

Use low carbon design guidance and calculation tools and benchmarks to evaluate each design choice in terms of upfront emission reductions and as part of a whole life approach.

- Apply design approaches that minimise the quantity of new material required to deliver the desired function
- Prioritise materials which are low or zero carbon, responsibly sourced, and which have low lifecycle impact in other areas, including the health of the occupant, as determined through a product specific environmental product declaration where available
- Choose low or zero carbon construction techniques having maximum efficiency and minimum waste on site

3. Plan for the future

Consider future use scenarios and end of life, maximising the potential for maintenance, repair and renovation, and ensure flexibility for future adaptation. Design for disassembly and deconstruction to facilitate future reuse, selecting materials which can be recycled and which can be extracted and separated easily for processing.

4. Offset

As a last resort, offset residual embodied carbon emissions either within the project or organisational boundary[8] or through verified offset schemes[9].

[8] For hard to abate sectors, consult sector decarbonisation roadmaps for appropriate carbon mitigation technologies and processes.
[9] Approved offset schemes to be determined by local GBC or relevant industry body.

State of the market

Understanding embodied carbon today

Rising demand for construction materials and the case for action

By 2060, the total global floor area of buildings will double, with more than 50% of this anticipated within the next 20 years[10]. The growth in new buildings will be particularly rapid in Asia and Africa. Europe faces a different challenge – that of an ageing existing building stock and the expectation that up to 80% of buildings in use in 2050 already exist today. Currently about 35% of buildings in the EU are 50 years old or older, and 97% of the building stock is not efficient enough to comply with future carbon reduction targets[11]. These buildings will require deep, energy efficient renovation, contributing to increased embodied carbon even as operational emissions are reduced.

Population growth and rapid urbanisation across the world will necessitate significant amounts of new infrastructure. Capital investments in infrastructure across the sector are forecast to grow by 40-70% between 2020 and 2040[12]. In certain types of infrastructure projects, such as water supply and drainage or provision of low carbon power generation and distribution, embodied carbon emissions can account for a much higher share of the whole lifecycle emissions than in buildings. This means there is an even more compelling case for action.

Key sources of embodied carbon – construction elements and materials

Increased awareness of embodied carbon, and research into the carbon emissions of different materials and projects over recent years, have revealed which parts of buildings and infrastructure are typically responsible for the majority of embodied carbon emissions. Although this will vary depending on the type of construction, some general trends can be identified – these can help to prioritise embodied carbon reduction efforts.

Building elements

Building elements such as foundations, frames and other forms of superstructure often represent the biggest contribution to embodied carbon[13], not least because of the large volumes of material they use. But, additionally, these elements often contain carbon intensive load bearing structural materials such as steel, concrete and masonry. Facades may also contribute significantly if they utilise large amounts of aluminium and glass, both of which have carbon intensive production processes.

These different structural elements often last different lengths of time (see figure 5) – some require frequent replacement while others have the potential to outlast the asset and be reused.

[10] International Energy Agency, Global Status Report 2017.
[11] http://bpie.eu/wp-content/uploads/2017/12/State-of-the-building-stock-briefing_Dic6.pdf
[12] Oxford economics (2017) Global Infrastructure Outlook.
[13] UK Green Building Council (2017) Embodied Carbon: Developing a Client Brief.

Across other types of infrastructure there may be a greater diversity of elements with differing lifetimes, but similar patterns exist. Load-bearing elements that rely on carbon intensive materials such as concrete, steel and asphalt will often contribute the majority of emissions.

A focus on building elements as a principal source of embodied carbon presents an opportunity to ensure that structures achieve the maximum possible useful life. Embodied carbon reduction efforts are therefore increasingly weighing the merits of retrofitting against those of demolition and new construction.

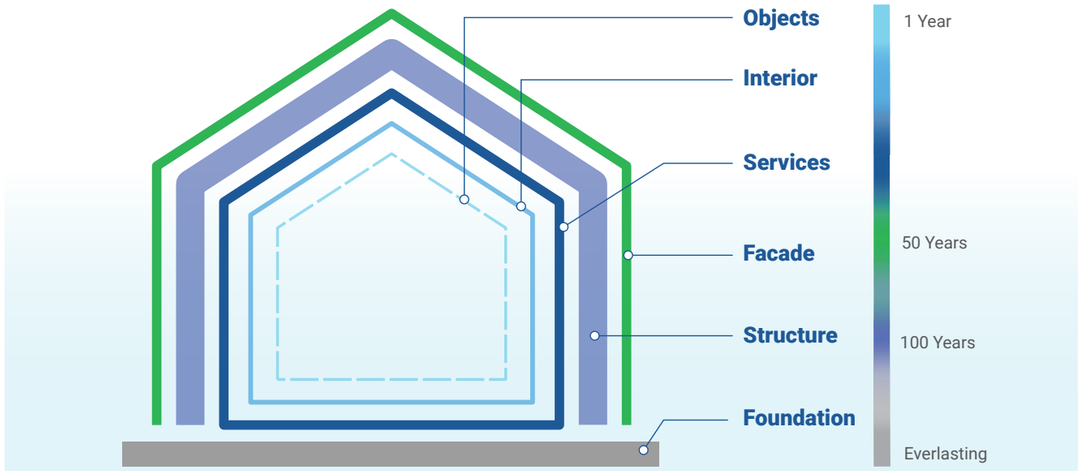


Figure 5: Elements of a building and their typical lifetime, before replacement is needed[14].

United Nations headquarters – assessing the carbon saving value of retrofitting versus demolition and new construction (USA)

Description

In 2007 the United Nations initiated a multi year renovation of its New York City headquarters, the Capital Master Plan (CMP)[15]. Fundamental to the project approach was the decision to renovate the existing campus as opposed to demolishing the complex and building anew. This study advocates for a better understanding and accounting of the true cost of demolition and makes a strong case for retrofits and renovations.

Key characteristics

- The comparative study considered both embodied and operational carbon.
- The study noted that if the campus were demolished and reconstructed, it would take 35-70 years before the operational efficiencies gained by the new construction would offset the initial outlays of embodied carbon.
- Sustainable design performance targets were defined across a wide range of areas, including operational energy use and associated carbon emission reductions, water efficiency, use of environmentally preferable materials, and measures to improve indoor environmental quality.

[14] Adapted from Brand, S., 1994, How Buildings Learn: What Happens After They’re Built
[15] Urban Green Council

Building materials

The upfront emissions from materials and products used to construct buildings and infrastructure, and those installed later during maintenance and renovation, usually represent a significantly greater source of embodied carbon than all other stages in the lifecycle.

Globally, cement and steel are two of the most important sources of material-related emissions in construction. Cement manufacture is responsible for around 7% of global carbon emissions[16], with steel also contributing 7-9% of the global total[17], of which around half can be attributed to buildings and construction.

Both cement and steel require very high temperatures during production, making them energy intensive and, in both cases, the chemical reactions that take place during manufacture also release carbon dioxide directly. For this reason, emissions from these sectors have been considered 'hard to abate'[18].

Other common construction materials that require high temperatures during manufacture include aluminium and glass.

Globally, much of the energy for industrial heat is still supplied by fossil fuels such as oil and gas, though waste and biofuels are increasingly used in some industries and in some parts of the world. Recent research shows that it is feasible to decarbonise these sectors[19].

Global cement consumption is projected to increase by 12-23% by 2050[20], while global steel production is forecast to grow by 30% over the same period, with recycled secondary steel growing faster than the primary production[21]. It is important to recognise the crucial role that these materials have played and will continue to play in human society even as we point to the need for radical decarbonisation.

ResponsibleSteel standard development (Global)

Description

ResponsibleSteel, in partnership with both steel producers and users, is developing a standard to identify and reward companies that are committed to creating a 'responsible' steel value chain. This will cover everything from the sourcing of raw materials through to the sale of their final products.

Key characteristics[22]

- ResponsibleSteel operating companies are committed to 12 principles for the responsible sourcing and production of steel, including corporate leadership, climate change and greenhouse gas (GHG) emissions mitigation, and water stewardship.
- Principle 8: Climate Change and Greenhouse Gas Emissions requires operating companies to commit to reducing GHG emissions in line with the global goals of the Paris Agreement and to take necessary actions to achieve this. The specific criteria of this principle include:
  - corporate commitment to achieve the goals of the Paris Agreement
  - corporate climate-related financial disclosure
  - site-level GHG emissions measurement and intensity calculation
  - site-level GHG emissions reporting and disclosure covering:
    - site-level GHG reduction targets and planning
    - GHG emissions performance

[16] International Energy Agency (2018) Technology Roadmap: Low-Carbon Transition in the Cement Industry.
[17] Stockholm Environment Institute (2018): Low-emission steel production – decarbonising heavy industry.
[18] Material Economics (2019) Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry.
[19] Energy Transitions Commission (2018) Mission Possible - Reaching Net-Zero Carbon Emissions from Harder-to-Abate Sectors by Mid-Century

Concrete Sustainability Council (Global)

Description

The Concrete Sustainability Council (CSC) is committed to implementing a global responsible sourcing certification system for concrete and its supply chain.

CSC certified concrete[23], cement and aggregate producers are committed to a broad range of responsible sourcing principles, including:

- Respect for human rights
- Respect for the needs of employees and local communities
- Minimising environmental footprint in relation to the production of concrete, cement and aggregates

Key characteristics

- CSC certified members are implementing, among other things, dedicated measures to minimise:
  - land use
  - CO_2 and other emissions
  - energy and water consumption
- Members are also working to increase the use of secondary materials and fuels, and to promote biodiversity
- CSC certification promotes the responsible use of energy and the reduction of greenhouse gas (GHG) emissions. Specific evaluation criteria for plants undergoing certification include:
  - implementing an energy and climate policy
  - monitoring and public reporting of GHG emissions
  - setting a publicly available CO_2 reduction target
  - identifying and applying energy reduction measures
  - creating energy saving awareness
  - Promoting the use of secondary materials to reduce CO_2 emissions and move towards a more circular economy
  - conducting third party audits of target setting and achievement

[20] https://www.iea.org/newsroom/news/2018/april/cement-technology-roadmap-plots-path-to-cutting-co2-emissions-24-by-2050.html
[21] Energy Transitions Commission (2018): Reaching zero carbon emissions from steel – consultation paper.
[22] ResponsibleSteel (2019) ResponsibleSteel Draft Standard Version 3.0
[23] Concrete Sustainability Council (2019) Technical Manual 2.0.

Many other materials such as gypsum, glass, aluminium and plastics also contribute to total embodied carbon. These materials perform important functions in the same way concrete and steel do. While there may be lower carbon alternatives, these are not always available at scale, and achieving net zero embodied carbon will require significant decarbonisation efforts within all these sectors. Encouragingly, for these and other heavy industries, significant emissions reduction opportunities already exist, both in their production and in how they are specified and used. In some parts of the world, sectoral decarbonisation roadmaps have already been established[24].

In developed markets, manufacturers have typically already invested in maximising plant efficiencies and in many cases have started to switch to alternative energy sources such as biofuels, energy-from-waste or other renewable sources. Further significant emissions reductions will require more fundamental changes, such as switching raw material feedstocks, investing in new production methods, or applying carbon capture technologies[25].

In the global south where many countries are newly industrialised or still becoming industrialised, manufacturing plants may use older, less efficient technology and production techniques. It is critical that manufacturers operating in these regions have the technology and the finance available to 'leapfrog' directly to low and zero carbon manufacturing approaches with their next investment cycles.

Dealing with sequestration, carbonation and recycling

Some materials absorb carbon from the atmosphere during certain stages of their lifecycle. Timber products and other biomaterials like bamboo and hemp present possibilities for capturing and storing carbon sequestered during growth – known as biogenic carbon. Managed harvesting of mature timber for use in construction – making space for new growth – has the potential to make a significant contribution to decarbonisation efforts[26]. Deforestation is still a major source of global carbon emissions and forests must be replanted and responsibly managed to ensure sequestered carbon is effectively offsetting other sources of embodied carbon. Using timber from certified sustainable sources, where best practice forest management is applied, is key to preventing this.

Treatment of timber at end of life can have a significant effect on its embodied carbon, particularly if it is sent to landfill. Sending timber

to landfill is banned or restricted in many countries and methane capture technologies at landfill sites can also mitigate the effects. However, timber reuse or recycling should be always be promoted as this extends the time period over which biogenic carbon is stored.

Concrete also absorbs atmospheric carbon when it is exposed to air. This process offsets some of the upfront carbon emitted during manufacture. The amount offset will depend on its application and treatment at end of life, when the exposed surface can be significantly increased by crushing.

Metals like steel are recycled, often without any loss in physical qualities. Recycling and re-use contribute to the reduction of embodied carbon. These benefits can be credited upfront as recycled content or at the end of life in terms of future recyclability. Alternatively, in a full lifecycle approach, the net balance of recycled content and end of life credits can be calculated (thus avoiding double counting). These effects are captured in module D, which will be mandatory to declare under forthcoming updates to EN 15978 and 15804.

There are differing industry views on the best way to deal with each of these aspects when calculating embodied carbon. These issues are complex and it is vital that we find ways to move beyond these challenges and focus on the radical collaboration needed to realise net zero embodied carbon.

[24] eg SNIC (2019) Brazilian Cement Technology Roadmap 2050, Norwegian GBC (2016) Property Sector's Roadmap to 2050, International Energy Agency (2018) Technology Roadmap: Low-Carbon Transition in the Cement Industry.

[25] Material Economics (2019) Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry.

[26] UK Government Committee on Climate Change (2016) UK climate action following the Paris Agreement.

Lendlease mass timber design and construction (Australia)

Description

Lendlease is a leading international investment and infrastructure group headquartered in Sydney, Australia, with operations in Europe, Asia, Australia and the Americas.

Lendlease's in-house design and construction capabilities have evolved from the company's forward looking work in the Australian market leading to iconic Green Star rated projects including Forte Living, International House Sydney, and 25 King Street.

Key characteristics

- Lendlease believes that using engineered timber in projects can provide:
  - safer solutions for workers
  - sustainable solutions for community developments
  - improved quality for clients
- 25 King Street is the tallest engineered timber office building in Australia – a 10-storey engineered timber project that was able to reduce on site construction time waste through off-site material processing and pre-fabrication.
- International House Sydney was the first modern commercial engineered timber building of its size and type in Australia.

Assessment methods, low carbon design tools and data

Industry's understanding of the importance of embodied carbon has been enabled by our ability to quantify emissions across the whole lifecycle using lifecycle assessment (LCA). Data and results from these assessments are vital for guiding our efforts to decarbonise buildings and infrastructure.

Lifecycle assessment

LCA allows us to calculate a wide range of environmental impacts of a material, a product or a whole construction project. Its use allows more informed decisions to be taken not only in terms of reducing carbon emissions, but also in relation to other aspects of the project's performance such as material, water and energy needs across the whole lifecycle.

LCA has become a globally accepted method for evaluating and communicating these environmental impacts. International standards[27] have been developed which aim to ensure consistency and comparability of outcomes. Guidance on the use of LCA for the construction sector[28] has been developed by organisations including the German Sustainable Building Council (DGNB) and the Royal Institute of Chartered Surveyors (RICS) in the UK[29]. LCA relies on robust raw data and tools, expertise to interpret the results, and transparency in data sources and methodology to ensure the outputs support decision making that minimises negative environmental impacts.

Product lifecycle assessment and environmental product declarations

The results of LCA for a product or material are increasingly communicated in the form of environmental product declarations (EPDs). There are international standards that underpin EPDs – these include the use of standard product category rules that aim to ensure all EPDs for a given material are based on the same calculation methods, though comparability between materials is still subject to some disparities. EPDs are used by specifiers to compare the performance of different materials, or by manufacturers to certify the carbon and environmental impact of their products. They are an important data source for conducting LCAs of buildings and infrastructure.

The creation of EPDs for construction products and their use in design is voluntary in most regions and countries. However, the emphasis on environmental impacts from building and infrastructure materials is a growing trend, and some countries and regions have seen exponential growth in recent years in the number of new EPDs released. Some European

[27] EN15978, ISO14040.

[28] DGNB (2018) Life Cycle Assessment: A guide to using the LCA.

[29] RICS (2017) Professional Statement: Whole life carbon assessment for the built environment

countries, such as France, the Netherlands and Finland are moving towards legislative adoption of LCA requirements for the construction industry[30], which will be a catalyst for wider market penetration of EPDs.

International standards such as ISO14044 and EN15804 set high levels of transparency, quality and credibility for EPDs. These aspects are key to the reliability and comparability of EPDs. A number of national and regional online databases, such as ECO Platform, have been set up, and these also serve to facilitate agreement of common methodologies and implementation protocols for the generation of construction product EPDs between participating members. Within the manufacturing sector, organisations are also placing importance on EPDs for their products. This has encouraged the development of tools that aim to make the process of producing EPDs simpler and easier.

Global Cement and Concrete Association Environmental Product Declaration Tool (Global)

Description

The Environmental Product Declaration (EPD) Tool is owned and operated by the Global Cement and Concrete Association (GCCA). It was originally developed by World Business Council for Sustainable Development (WBCSD) through the Cement Sustainability Initiative.

The tool facilitates the production of EPDs for cement, clinker, lime and concrete via a user-friendly platform developed by Quantis.

Key characteristics

- The GCCA EPD tool is for all manufacturers and is pre-verified by International EPD System[31], reducing costs of preparing and verifying EPDs.
- Product Category Rules (PCR) are integrated into the GCCA EPD tool, ensuring compliance with relevant regional PCR.
- Manufacturers, designers, developers and investors can be confident of consistent and comparable EPDs when they are generated from the same tool.

Project lifecycle assessment tools and software

When applied at the project level (eg for a building or infrastructure asset rather than for materials or products) there is a trade-off between the accuracy of LCA and the opportunity to reduce emissions. The greatest potential for emissions reductions arises during early design phases, when the project data for conducting a detailed LCA may not be available. Moreover, the cost of traditional LCA software and data subscriptions coupled with the expertise needed can be prohibitive for small and medium-sized enterprises (SMEs).

Despite this, LCA is becoming more accessible to designers thanks to a range of simplified tools that are now available, including some that are freely available and some specifically developed to allow early design-stage assessments. For projects that use building information modelling (BIM), new BIM-integrated tools can even allow live assessment of the effect of design changes on the embodied carbon results. BIM can also be used to create so-called digital twins of built assets that provide a repository of data including material specifications and LCA data. This can improve the ability of owners and occupants to ensure embodied and operational carbon can be minimised during use, maintenance, renovation and at the end of life.

The availability and use of such tools varies by region, country and project. Although some are web based or free to access, care should be taken when using tools from other regions as the underlying LCA datasets associated with a particular tool may not be representative, due to differences in the way materials and products are sourced and made.

Examples of common LCA based tools for construction include: the French tool ELODIE; eToolLCD and The Footprint Calculator from Australia; One Click LCA from Finnish company Bionova: and Tally, a US developed plug-in for the design software Revit.

The Embodied Carbon Calculator for Construction (EC3), a tool for calculating upfront carbon emissions, has recently been developed by a consortium including Skanska and Interface in the United States. These embodied carbon tools should be used alongside operational energy calculations to ensure whole life carbon is being minimised.

[30] https://www.oneclicklca.com/simple-epd-guide/

[31] https://www.environdec.com/Creating-EPDs/Steps-to-create-an-EPD/Perform-LCA-study/pre-verified-epd-tools/

Design guidance and prescriptive embodied emissions reduction tools

Embodied carbon reductions can also be achieved using prescriptive design guidance and material specifications, without the use of LCA tools. Such tools provide information on the typical attributes of a range of construction materials (eg recycled content, biogenic materials, renewable energy supply, low/zero carbon manufacturing processes, transportation, existing building reuse and repurpose). Designers can use these tools to develop specifications for low carbon and carbon-positive materials, and policymakers and regulators can also use them as a guide. Implementing prescriptive pathways for embodied emissions reductions can be an important route to achieving immediate carbon reductions, for demonstrating best practices to manufacturers, and for accelerating the transition to net zero embodied carbon in regions where performance-based approaches are not yet feasible or possible at scale.

Architecture 2030 Carbon Smart Materials Palette (Global)

Description

Developed by Architecture 2030, with support from members of the Embodied Carbon Network (ECN), the Carbon Smart Materials Palette provides attribute-based design and material specification guidelines for impactful, global embodied carbon reductions in the built environment.

Key characteristics

- Identifies key attributes that contribute to a material's embodied carbon impact and offers guidelines and options for emissions reductions.
- Designed to support and complement lifecycle assessments (LCAs) and environmental product declarations (EPDs), while providing guidelines for low/no carbon material selections and specifications.
- Includes guidelines for high impact and naturally low carbon (carbon smart) materials, and whole buildings embodied carbon reductions.

Bionova One Click LCA (Global)

Description

One Click LCA is a web-based LCA, LCC and circularity metrics tool developed by Bionova Ltd, Finland. It supports easy, fast and impactful environmental analyses from the earliest project phases.

Key characteristics

- Imports design data from a range of sources including market leading BIM & energy software and includes specific tools for concept phase carbon optimisation as well as for later phases.
- Delivers LCAs according to international standards such as EN 15978 and dozens of voluntary certification schemes from GBCs around the world.
- Integrates a generic database of environmental impacts for construction materials as well as dozens of external databases from Asia Pacific, Europe, Middle East and North Africa, and North and South America.

Voluntary green building certification schemes

Green building certification schemes, also known as rating tools, are used to assess and recognise buildings that meet certain sustainability requirements or standards. They can provide targets for LCA conducted during design, including limits on the amount of embodied carbon per unit of floor area or as a percentage reduction against a baseline. These schemes promote performance beyond local regulatory compliance and so serve as a useful indicator of market maturity and adoption of embodied carbon approaches. A recent report by Bionova identified 105 sustainability certifications and regulations that include direct measures for embodied carbon, with national systems in 26 countries[32].

LCA of buildings and infrastructure has been a part of some green building certification schemes for over a decade, notably in Germany and the USA, and has been a key driver in promoting and supporting development of LCA methodology and tools. Some schemes reward improvements against a benchmark or from a reference design. Under some schemes, such as DGNB, the scheme run by the German Sustainable Building Council, and Green Star, run by the Green Building Council of Australia, credits can be gained by conducting LCA to identify alternative solutions during early project development, since its use in these strategic planning stages is still low.

Green Building Councils' certifications targeting embodied carbon

Description

GBCs in several countries have been developing green building certifications that include requirements or voluntary approaches to conducting LCA in order to calculate embodied carbon emissions. Despite some challenges, these efforts show positive trends in adoption of the methodology.

Key characteristics

- Some certifications are progressively moving towards addressing operational and embodied carbon emissions equally by capping the number or percentage of points that can be gained from operational energy efficiency and introducing requirements for LCA of building materials.
- Several certification programmes grant points to projects that conduct an LCA to help facilitate the uptake of the method. LCA methods range from full to simplified scope where only certain building elements are included (eg building structures and envelopes). USA's LEED and Germany's DGNB go further and reward points for percentage improvements against a benchmark. Australia's Green Star will be setting a target for upfront carbon in 2020.
- Several certification schemes, including Norway GBC's BREEAM-NOR, DGNB, LEED and Green Star, have contributed to industry interest and uptake of EPDs. Norway, Australia and USA do so by giving additional points to projects which demonstrate that a percentage of the products or materials used in the building or fit-out have an environmental product declaration (EPD) that is publicly available. In Norway and Germany, a project also achieves additional points by choosing low carbon building products and by making carbon calculations including embodied energy, showing material reductions.
- Overall, certifications have been shown to increase the value of buildings and reduce vacancy.

[32] Bionova: The Embodied Carbon Review, 2018.

Current leadership on embodied carbon

The emergence of embodied carbon as a key consideration in sectoral decarbonisation strategies has been, and is being, facilitated by market leaders across the globe. These actors are increasing awareness of the associated challenges, identifying solutions such as carbon measurement tools, databases and benchmarks, and developing new business models that embrace lifecycle approaches and the circular economy.

NGOs and cross-sectoral networks

Think tanks and collaborative forums from Europe and the Americas, such as the Energy Transition Commission and the Carbon Leadership Forum, have been leading the way in bringing low carbon solutions into mainstream decision making.

In some sectors, industry networks have developed decarbonisation roadmaps at various scales (global, regional, national) – these set out a vision, goals and milestones alongside agreed solutions and initiatives for advancing incrementally towards sectoral decarbonisation in alignment with global climate goals. Examples include the Swedish construction and engineering sector, the Norwegian property sector, the European cement and concrete industry (CEMBUREAU)[33], and the Carbon Positive Roadmap developed by the Green Building Council of Australia.

GBCs, too, have spearheaded efforts to address embodied carbon. For example, WorldGBC's Europe Regional Network worked successfully with the European Commission to develop Level(s), a new common approach to evaluating the sustainability of buildings that promotes the use of LCA. Several of WorldGBC's European regional partners are supporting efforts to pilot the new tool.

European Commission's Level(s) initiative (Europe)

Description

In 2017 the European Commission released the first version of its Level(s) framework[34]. Level(s) aims to create a common language for sustainability in buildings in Europe and to mainstream lifecycle approaches. Level(s) is a key tool of the EU's Circular Economy Package, and WorldGBC is working with GBCs and partners to develop a roadmap that will outline the actions needed to turn this from a voluntary to a regulatory framework.

For example, GBC Finland, Stora Enso, a partner of WorldGBC's Europe Regional Network, and WorldGBC, in cooperation with the European Commission, hosted a workshop in Helsinki to explore how Level(s) might be implemented in Finland.

Key characteristics

- Level(s) includes a step-by-step approach to conducting LCA in line with European policy objectives and existing national approaches.
- At its core, the framework aims to provide an easy starting point for introducing sustainability and lifecycle thinking into projects, focusing on a manageable number of concepts and indicators.
- The framework addresses assessment of buildings' greenhouse gas emissions and circularity performance across two of its six 'macro-objectives':
  - Macro-objective 1: Greenhouse gas emissions along a building's lifecycle
  - Macro-objective 2: Resource-efficient and circular material lifecycles
- Level(s) is being piloted in a range of projects around Europe. For example, Stora Enso helped the project team of the 14 storey Lighthouse Joensuu, Finland's tallest timber building project, use Level(s) to promote a lifecycle approach. Level(s) was essential in demonstrating the performance of massive wood structures over their lifecycle in terms of reduced embodied carbon and resources. Stora Enso used automated Level(s) indicator calculations from material and EPD information to demonstrate that, in total, the wood products used to construct the building store over 1,600 tonnes of CO_2.

[33] Fossil Free Sweden (2018) Roadmap for Fossil-Free Competitiveness Construction and Engineering Sector; Norwegian GBC (2016) Property Sector's Roadmap Towards 2050; The European Cement Association (2013) The role of CEMENT in the 2050 LOW CARBON ECONOMY.

[34] Level(s) – A common EU framework of core sustainability indicators for office and residential buildings

Governments, states and cities

Bold policy initiatives incorporating embodied carbon have been set at a national level in France, the Netherlands, Sweden and Finland, and in the State of California, as well as in cities like Vancouver and Oslo. These initiatives are already driving private sector action by providing progressive and predictable policy frameworks that set ambitious but feasible requirements for industry. Nevertheless, greater ambition is needed to drive change. For example, voluntary policies must become mandatory and must be enforced.

Approaches differ depending on the level of control and responsibility and typically national governments have greater powers than cities and regions. Some policy approaches focus on public buildings, while others involve introducing voluntary measures for the whole sector. By setting reporting requirements that allow benchmarks and targets to be formulated it is possible, ultimately, to move to enforcing more stringent building requirements. This approach to policy implementation allows businesses to prepare for upcoming legislation, encourages developing skills ahead of enforcement and creates regulatory and investment certainty, which in turn helps to create a market for low carbon products and approaches. Nevertheless, greater ambition is needed to drive change.

E+C- voluntary labelling scheme (France)

Description

France's National Low Carbon Strategy (2015) aims to achieve nationwide roll-out of positive energy buildings and to reduce GHG emissions from the building sector by 50% in 2030 relative to 2015 and by 87% in 2050. For buildings, France launched the E+C- voluntary labelling scheme, which adopts a collective and shared approach to ensuring that buildings of the future will be energy-positive and low-carbon throughout their entire lifecycle.

The first stage in this approach is to carry out a trial phase, commissioning firms to construct buildings with higher performance ratings than those stipulated in current legislation, and then gathering feedback from the experience.

The scheme represents an expansion of focus from solely energy to all environmental impacts and from solely the use phase to all lifecycle phases.

Key characteristics

- Environmental performance of buildings is determined by an LCA of the building. Objectives are to:
  1. reduce GHG emissions and other negative environmental impacts
  2. encourage systematic assessment of buildings' environmental footprint
  3. promote the use of bio and waste-based materials
  4. provide a density bonus to high performers meeting the carbon performance requirement by granting additional gross floor area rights[35].
- The second goal is supported by Ademe's Energy-Carbon Building Objective[36], a financing support instrument for building competencies in the area of LCA, refining a national LCA methodology, and collecting data on projects.
- LCA results from E+C- pilot projects will inform performance based requirement levels to be included in the new environmental regulation of 2020.

State of California Buy Clean Act (USA)

Description

The Buy Clean California Act was developed to address climate change through the power of procurement. It targets the embodied carbon of construction materials used in infrastructure projects such as roads, bridges, and public buildings. The Buy Clean California Act is the first in the nation to be signed into law.

Key characteristics

- Eligible construction materials are structural steel, rebar, flat glass and mineral wool board insulation.
- Environmental product declarations will be used to identify the GWP to produce the material.
- Beginning 1 July 2021, contracts will require eligible construction materials to have a GWP equal to or lower than a level established by state standards.

City of Vancouver Zero Emissions Building Plan (Canada)

Description

In 2016, the City of Vancouver published its Zero Emissions Building Plan, establishing specific targets and actions for achieving zero emissions in all new buildings by 2030.

In April 2019, the City of Vancouver approved the Climate Emergency Response report which amplifies and builds on past progress to reduce carbon pollution, to improve energy efficiency, and to help transition to renewable energy.

Key characteristics

- Zero Emissions Building Plan sets out four strategies for its zero emissions new buildings target for 2030:
  - Limits – establish GHG and thermal energy limits
  - Leadership – city-led building projects to lead from the front where viable
  - Catalyse – develop tools to spur leading private builders and developers
  - Capacity building – build industry capacity through information sharing tools, sharing of knowledge, and development of skills
- Set a target of reducing embodied emissions by 40% by 2030, as part of the city council's declaration of a climate emergency. The council believes the ambitious target will encourage innovation in construction materials, design and engineering while helping to position local industries as leaders in low carbon construction.
- The City of Vancouver's green building policy for rezoning requires projects to conduct a Whole Building Lifecycle Assessment (WBLCA) and to disclose the LCA results as part of their rezoning submission.

[35] Decarbonising construction in France: the E+C- scheme.
[36] Programme Objectif bâtiment énergie-carbone.

Businesses and industry

There are many examples from right across the building and construction value chain of companies that have taken a leadership role on tackling embodied carbon. They range from investors and developers who have incorporated embodied carbon assessment and reduction targets into their project briefs to contractors investing in fossil free construction sites and materials manufacturers making strategic investments in EPDs and data disclosure as well as in research and development to find new carbon free production processes and carbon capture techniques. Further support is needed to enable business to fully transition to net zero embodied carbon in construction. But leaders in the field have demonstrated that by taking action and collaborating across the sector they can help drive change beyond their own organisations.

Skanska Group's sustainability direction and involvement in Sweden's construction and civil engineering sector roadmap (Europe and USA)

Description

Skanska is a global development and construction group active in Europe, the Nordics, and the United States. Skanska's purpose is to build for a better society, with commitments to safety, ethics, green principles, and community Investment as well as diversity and inclusion.

In 2017, Skanska committed to reducing its carbon footprint significantly and reports its greenhouse gas emissions across all business units[37].

As a contractor and developer, Skanska is acting to mobilise engagement across the whole value chain through its operations.

Key characteristics

- In 2018 Skanska engaged with policymakers in developing a sector approach to embodied carbon. Under Skanska's leadership, Fossil Free Sweden published a Roadmap for Fossil-Free Competitiveness for the Construction and Civil Engineering Sector. The roadmap was co-signed by multiple Swedish organisations committed to reducing greenhouse gas emissions to net zero by 2045.
- In partnership with the Carbon Leadership Forum, Interface and C-Change Labs, Skanska led the development of the Embodied Carbon in Construction Calculator (EC3), an open source tool for calculating material volumes and their associated embodied carbon while allowing for the inclusion of a carbon price (internal, or based on an existing carbon tax).
- Skanska has also been actively including embodied carbon in its project proposals to clients and informing them of possible alternative project designs entailing variable carbon emissions, with success.

[37] Skanska – Sustainability.

Barriers and opportunities

Key areas where solutions are needed

For many in our sector, tackling embodied carbon may seem like a new challenge. Yet there are leading organisations that have been working on this topic for a decade or more. Understanding why progress has been slow will help us identify actions that best remove barriers and promote opportunities, thus accelerating market demand.

Given the number of sectors involved and the market differences between regions, a complete analysis of all barriers to take-up is beyond the scope of this report. But our research and consultation shows that some of the main reasons for limited engagement with the issue revolve around the following key areas.

Awareness and demand

Embodied carbon and the tools and methods needed to calculate it are relatively complex and new to many and the methods for addressing it are generally not well understood. By contrast, operational carbon and energy efficiency are more well established concepts with clear drivers and incentives for addressing them. Moreover, the false perception that embodied carbon is relatively insignificant compared to operational emissions over the lifecycle persists.

All this results in a lack of market demand for low embodied carbon materials and construction methods and affects the perceived value of conducting LCA, meaning it may not be pursued at all due to cost and resourcing implications.

Stimulating demand will require a major shift in awareness across all parts of the value chain combined with concerted action to create market, fiscal policy and regulatory demand drivers and incentives.

Skills and capacities

Low demand contributes to low investment in skills and capacity building across the value chain. Without the necessary knowledge and tools there is very limited scope to implement carbon reduction strategies successfully, whether for a material or an entire project.

Building capacity at the pace we need to reach our goals will require new approaches to knowledge transfer. Our whole sector must become far more open and transparent, sharing solutions and best practice collaboratively through networks such as WorldGBC's Green Building Councils.

Policy and regulation

Most existing policy measures that address embodied carbon emissions in the built environment do so indirectly from the supply side. They include energy efficiency standards for industry, taxes on energy consumption and landfill waste, and carbon trading schemes such as the Emissions Trading Scheme (ETS) in Europe. But further supply-side supportive policy measures are still needed for manufacturers to drive the necessary investment in technologies and processes. This includes innovativon funding and incentives for reuse and recyclability.

By contrast, demand-side levers for decarbonising the built environment, such as building codes, focus primarily on operational energy and carbon. Barriers to wider inclusion of embodied carbon in demand-side policy include lack of awareness and demand but also aspects of the political framework such as policy cycles and changing political priorities.

Some leading regulatory bodies have introduced embodied carbon into building codes and material specifications with varying levels of ambition or have supported voluntary incentive systems for further improvement. There are opportunities to learn from these examples and it will be very important to evaluate outcomes thoroughly in order to select the most effective policy measures. This could also inform the development of model policy toolkits that support accelerated action so that less advanced regions can replicate the success of policies and criteria from developed markets.

Technical considerations

On the demand side, a lack of high quality, robust data from LCAs and EPDs in some regions makes it difficult to set benchmarks and targets. This may be compounded by a lack of affordable technical solutions to help plan and implement embodied carbon reduction strategies.

On the supply side, the full range of technological solutions needed to achieve net zero embodied carbon globally is not yet available at scale. Technologies like carbon capture, utilisation and storage, or hydrogen-based production of iron for steel making, have been demonstrated but are not yet commercialised. Decarbonising industry will also require significant additional amounts of renewable energy capacity.

Finance and the challenges of making the business case

The business case for reducing embodied carbon is often poorly understood, making the resourcing needed to conduct LCA and implement reduction measures difficult to justify. Financial incentives and products such as green loans, grants and subsidies are almost exclusively targeted at reducing operational carbon through energy efficiency improvements and renewables.

For manufacturers, the cost of investing in new, low carbon technology and processes is likely to be a major barrier. Estimates suggest the necessary capital investments for heavy industry such as steel and cement could be up to 60% higher than current levels[38]. And those looking to innovate with circular business models may also face barriers in accessing finance because they may be assessed as 'higher risk' by lenders and investors using traditional risk criteria[39].

A further barrier that particularly affects the global south is the lack of financial institutions that specifically support climate change mitigation efforts[40].

To meet sectoral decarbonisation goals, the financing sector will need to play a key role by developing financial products and services targeted at low embodied carbon projects from the buildings and infrastructure sector, or by supporting decarbonisation processes within industry. Supporting finance will be needed from the public sector via policies such as carbon pricing and financing instruments like loans and guarantees.

Carbon pricing[41] and carbon markets can allow low carbon products and services to compete with their conventional equivalents, provided they are well designed. In 2014 the Climate Policy Info Hub noted that 'globally, 39 national and 23 sub-national jurisdictions have implemented, or are scheduled to implement, carbon pricing'. To be most effective, these mechanisms must be inclusive and flexible enough to account for ongoing technological advancements, particularly in respect of heavy industries.

Further research into the social cost of embodied carbon could strengthen the business case and help inform practice and trade-offs between lifecycle stages over time.

[38] Material Economics (2019) Industrial Transformation 2050: Pathways to Net-Zero Emissions from EU Heavy Industry.
[39] European Commission (2019) Accelerating the transition to the circular economy: Improving access to finance for circular economy projects.
[40] Energy Transitions Commission (2018) Mission Possible: Reaching Net-zero Carbon Emissions From Harder-to-abate Sectors By Mid-century.
[41] Carbon Pricing Leadership Coalition & International Finance Corporation (2019) Greening Construction: The Role of Carbon Pricing

Theory of change

How change in our sector will happen

Led by business, government and civil society action, the process of enabling bold change within our sector will be supported and shaped by addressing prominent market barriers through our theory of change (see Figure 6), which fully enables:

- **Collaboration** – enabling collaboration across the whole value chain, including both public and private sectors, so as to create a common vision and establish regional, national or sectoral roadmaps
- **Communication** – raising awareness about the importance of tackling embodied carbon and sharing best practice strategies and leadership examples of progress towards achieving our vision
- **Education** – addressing foundational gaps in skills, data and benchmarks globally through knowledge sharing, training and transparency for both prescriptive and performance-based pathways
- **Innovation** – creating an innovative space for new business models, new technologies and circular patterns to evolve and thrive in response to financial and policy incentives
- **Acceleration** – fostering and leveraging proven industry-wide demand drivers and market forces including voluntary, financial, policy and regulatory measures
- **Regulation** – mandating reductions in embodied carbon that are aligned with 1.5ºC compliant decarbonisation pathways and creating fiscal and policy incentives that drive innovation.

These actions are interrelated – together they represent an iterative process that must begin immediately. By placing emphasis on a collaborative and supportive relationship between supply- and demand-side actors, each action will create benefits across the entire value chain, forming positive feedback loops that stimulate market demand and uptake of net zero embodied carbon.

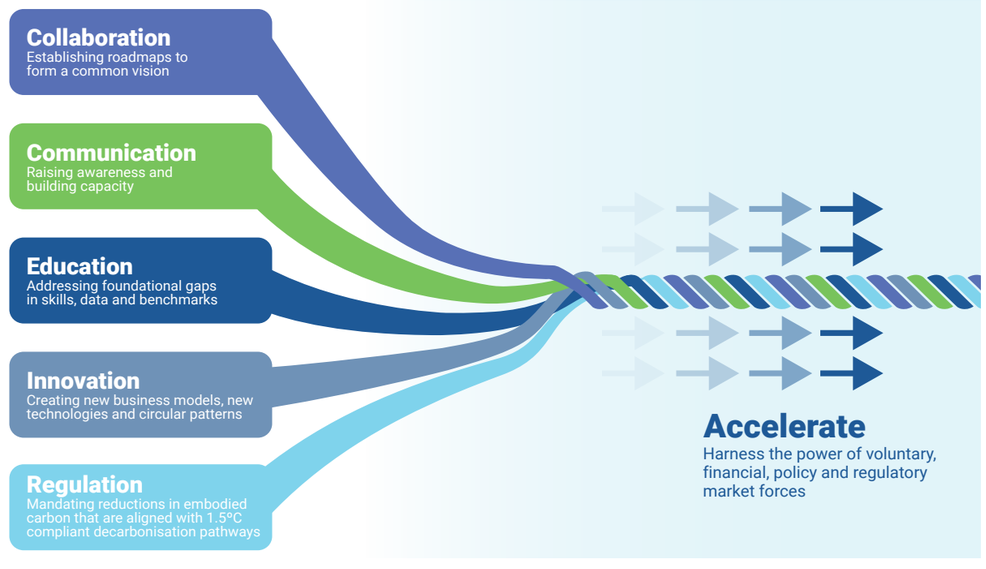


Figure 6: Making change happen in our sector

Enabling change – the key drivers

Increasing awareness and demand – Establishing roadmaps must be a priority to raise awareness and to inspire collaboration across sectors and with government. Roadmaps can create a common vision with converging pathways. Over the medium to long term they can help remove technical barriers by supporting standardisation through the integration of tools and metrics.

Honing skills and building capacity – Educate through knowledge sharing, best practice guidance, transparency and training focused on the importance of tackling upfront carbon during this critical decade. Enhance early stage building and infrastructure decision making among designers, architects, developers, construction companies and other relevant actors in the value chain.

Scaling for global uptake – Utilise both prescriptive and performance-based pathways to ensure impact can be scaled across different regions of the world with varying political, social and economic environments. Market leaders working successfully with performance-based approaches should help to develop prescriptive pathways focused on tangible and feasible actions – these are likely to meet with greater initial traction in markets currently struggling to address net zero operational carbon. In the long term, our ambition should be to build the capacity in all regions for performance-based approaches.

Data, benchmarks and toolkits – Leverage increasing market maturity to facilitate the development of common tools, databases and more standardised approaches including benchmarks, prescriptive design guidance and model policy toolkits in order to generate more publicly available data and to support performance-based assessments of materials, buildings and infrastructure.

New ways of doing business – Innovate in order to deploy new business models, practices and policies that will redefine the value of products in terms of their optimised longevity, incentivising low and zero carbon solutions as well as improving benchmarking and best practice ambition.

Tying economic growth to embodied carbon – Clear benchmarks, high quality data and high market demand will encourage and enable providers of financial products and incentives to convert to rewarding practices that address both operational and embodied carbon. Financial services providers will also need to support the adoption of circular business models[42] to reduce embodied carbon during the lifecycle of buildings and infrastructure.

Building momentum through collaboration – Accelerating meaningful collaboration between private and public sectors is crucial to building and maintaining momentum for change – such collaboration is needed urgently. Public sector action helps create a level playing field for low and zero carbon materials and technologies. Progressive and predictable policy frameworks, meanwhile, provide the long term confidence needed for business to invest in action towards net zero embodied carbon. Public procurement can set a leading example, raising awareness and understanding of low embodied carbon solutions. Equally, strong private sector action can give policy makers the confidence to issue clear signals that incentivise market maturity.

[42] https://ec.europa.eu/growth/industry/sustainability/circular-economy_en

Calls to action

Stakeholder specific pathways for tackling embodied carbon

Reaching net zero embodied carbon by 2050 requires immediate action, with far deeper cross-sector collaboration. We have identified key groups throughout the value chain that must act now in order to catalyse this radical transition as part of a whole life approach to decarbonisation – an approach that focuses on upfront carbon and whole life thinking.

Our calls to action address government, business and civil society, recognising that within these broad stakeholder categories different groups have control over different levers for change and that some actions must reach scale to enable others. A list summarising the goals for all sector specific actors appears in figure 2 of the executive summary on page 12.

This first section calls for actions that should begin immediately and that all stakeholders must take responsibility for, both individually and collectively as organisations and as a sector.

Act Now!

Immediately, all stakeholders must:

COLLABORATE to create action roadmaps Work with other public and private sector organisations to set clear strategies at national or sectoral level; develop timelines and targets against current baselines; establish disclosure processes; identify and address skills needed and plan for the possible impact on existing jobs; consider the greatest embodied carbon reduction opportunities and risks.

COMMUNICATE ambitions, successes and research In order to build momentum and show evidence of the possible, all actors should share information on their strategies and experiences of working towards net zero embodied carbon to share knowledge, skills and solutions. In particular, communicating technical concepts in accessible language to facilitate wider societal engagement from other sectors (ie finance).

ADVOCATE for embodied carbon reduction policies at regional, national and international level Convince governments and legislators that there is both urgent need and market demand for embodied carbon to be addressed in relevant policies.

EDUCATE all relevant members of the value chain Raise awareness of embodied carbon and lifecycle thinking, and how to implement these calls to action. Transfer internal knowledge and skills along the rest of the value chain.

The Embodied Carbon Network (Global)

Description

The Embodied Carbon Network (ECN) is a collective of individuals from industry and academia but also from wider society hosted by the Carbon Leadership Forum. It is open to all interested individuals committed to engaging with others working toward similar goals of a carbon neutral built environment

The network provides a mechanism for individuals to connect and promote awareness of embodied carbon in the built environment across nine different focus groups. Focus groups collaborate to create educational webinars and identify opportunities for collective action.

Key characteristics

- A community of individuals committed to designing embodied and operational carbon out of our new and renovated buildings to achieve a carbon neutral built environment by 2050.
- The ECN has over 500 different members from over 100 different cities hosted on a digital based community platform that facilitates and encourages communication across members and focus groups.
- An in-person ECN Vancouver chapter has formed and other regional chapters are in development.
- Has four core goals:
  - Foster ongoing communication between individuals focused on embodied carbon reduction
  - Drive alignment between similar research and work efforts
  - Facilitate resource sharing and collaboration
  - Support increased efficiency of the building sector in moving toward emissions reduction goals

NGOs, networks and researchers – together they are catalysts for the radical whole value chain collaboration needed to drive market transformation towards net zero embodied carbon.

Civil society – NGOs, networks and researchers

The role of NGOs, networks and researchers is central to the transition towards net zero embodied carbon. These organisations often work together to drive market transformation and play a key role in communicating the importance and feasibility of taking action to government and wider industry. The building and construction sector is currently fragmented in its approach to embodied carbon – it needs NGOs and networks to foster radical whole value chain collaboration to drive collective action.

The research and academic communities have a crucial role to play in accelerating this collective action by developing new technologies, tools and methodologies, and by making improvements to existing ones where needed.

Green Building Councils (GBCs) are at the forefront when it comes to driving down embodied carbon emissions from buildings and in some cases infrastructure. As well as playing a key role in educating industry on the need for embodied carbon reductions (described elsewhere in this section), GBCs are best placed to gauge the readiness of markets in which they operate to make the transition to net zero embodied carbon and to use this insight as a basis for setting out nationally specific action roadmaps for getting there. Market leaders must work alongside GBCs to effect transformation across the whole of their market.

From 2020

Start to convene all sectors to co-create national roadmaps for action and set out specific and time-bound actions for achieving net zero embodied carbon that all key actors can commit to.

Indicator

Number of national GBCs taking active part in convening industry and government to address embodied carbon emissions from buildings and infrastructure in their region.

Number of organisations subsequently endorsing and committing to national action roadmaps.

Key actions

GBCs/NGOs Convene all stakeholders and create roadmaps of concrete actions and timelines that ensure coherence across actors and sectors so that defined targets can be met, establishing ongoing collaboration platforms on net zero embodied carbon in the process.

GBCs/NGOs Work with those who commit to actions/timelines/targets within roadmaps to identify the support needed to enable this.

GBCs/NGOs Build internal capacity to support the transition to net zero embodied carbon in buildings and infrastructure.

GBCs/NGOs Where possible, major building certification schemes introduce requirements for EPDs for all major building components (eg building structure and envelope)

By 2025

Implement standardised embodied carbon emission calculation methods, design tools and guidance.

Indicator

Number of markets that have at least one tool for reducing embodied carbon that complies with relevant standards available in each market.

Key actions

ALL Implement and promote wide uptake of standardised embodied carbon calculation tools, and low carbon design guidance, to support industry and government adoption of lifecycle approaches that include carbon-based decision making at the design phase.

RESEARCHERS Contribute to the development of standardised methodologies at global and regional level to further refine embodied carbon benchmarks and to scale reduction efforts.

ALL Contribute to the development of government and industry strategies and commitments in all geographical regions focused on achieving net zero embodied carbon in buildings and infrastructure by 2050.

ALL Contribute to the development and implementation of embodied carbon calculation and low carbon design standards in green public procurement.

By 2025

Contribute to the establishment of databases for embodied carbon in all geographical regions at product and building level, and publish new data regularly. Report embodied carbon emission data from databases annually to help set embodied carbon benchmarks for each region.

Indicator

Geographical regions for which databases are available, benchmarks are set, and data is annually reported on.

Key actions

ALL Contribute to the collection and public release of high quality embodied carbon measurement data for building materials, buildings and infrastructure projects.

GBCs/NGOs Take the lead in setting up and managing national level public databases for embodied carbon data at both product and building level.

By 2025

All certification schemes for green buildings and infrastructure projects include requirements for embodied carbon measurements and performance.

Indicator

Number of certification schemes for green buildings and infrastructure projects that include requirements for embodied carbon measurements and performance.

Key actions

GBCs/NGOs Integrate embodied carbon disclosure requirements with rating tool criteria.

GBCs/NGOs Commit to a timeline for aligning rating awards or levels with net zero embodied carbon standards.

GBCs/NGOs Set incremental best practice benchmarks for embodied carbon.

GBCs: All green building certification schemes covering new buildings and large renovations set a date to include net zero embodied carbon requirement in line with national roadmaps.

The Carbon Leadership Forum (USA)

Description

The Carbon Leadership Forum (CLF) is an industry supported collaboration hosted at the University of Washington. Supporters include product manufacturers, building owners, general contractors, architects, engineers and policymakers. Members of the CLF work together to understand and reduce embodied carbon: leading by testing methods, developing standards, sharing results and motivating each other to improve.

Key characteristics

- Leading the data methodology and administering the development of the Embodied Carbon in Construction Calculator (EC3), an EPD database and building planner conceived of by Skanska, and C-Change Labs. EC3 is still in development, but early versions already allow calculation of material volumes and their associated embodied carbon. This open source project will be released publicly in autumn 2019.
- Offers resources including the Embodied Carbon Resources Database, listing tools, resources and initiatives on embodied carbon, an LCA Practice Guide, and several publications.
- Conducts foundational lifecycle assessment research and disseminates to professional audiences.
- Hosts the Embodied Carbon Network.
- Researchers from the CLF are contributing their knowledge and research to the development of public policy, such as the Buy Clean Washington Study[43] and the Low Carbon Concrete Code Project.

International Energy Agency Energy in Buildings and Communities Programme Annex 72 (Global)

Description

The International Energy Agency (IEA) Energy in Buildings and Communities programme (EBC) project, Annex 72, aims to foster the harmonisation of LCA methodology guidelines, the use of environmental information at early design stage, and the development of national databases. Annex 72 will provide case studies answering research issues, and develop empirical benchmarks.

Key characteristics

- Annex 72 will promote best practice associated with the environmental lifecycle assessment of buildings through deliverables[44] including:
  - A report on harmonised guidelines for the environmental lifecycle assessment of buildings
  - A report on establishing environmental benchmarks for buildings, including case study examples
  - A report on how to establish national/regional LCA databases targeting the construction sector, including recommendations for data exchange

[43] Simonen, K., Dilegge, T., Huang, M., and Ditto, J. (2018). Buy Clean Washinton Study.

[44] IEA EBC Annex 72 Newsletter no. 1

Governments – lead from the front, upholding ambitious embodied carbon reduction targets and enabling the market to act.

All levels of governments including city, state, regional and national must lead by example, implementing ambitious embodied carbon reduction targets as part of a whole life carbon approach in building and infrastructure projects. While having varying degrees of power and applicable actions, all governments have a vital role to play in stimulating and enabling market actors. Early and carefully designed policy and fiscal measures by governments are needed to remove market barriers, allow industry to prepare and ensure low and zero carbon products and projects can compete successfully in the market.

National, state and regional governments

National, state and regional governments are uniquely positioned to spark action from industry towards net zero embodied carbon as they have greatest powers to set standards and targets, implement legislation on materials and planning policies, invest in research and development, and to deploy financial and fiscal measures that can shift the market. In particular, national governments may have the widest reach to facilitate value chain collaboration, stimulate market demand and integrate new holistic approaches such as circular principles in buildings and infrastructure.

From 2020

All governments start to develop a strategy to achieve net zero embodied carbon, including:

- Targets and timelines for low carbon public procurement
- Timelines for introducing mandatory LCA of buildings and infrastructure
- Disclosure of environmental data for products and materials in accepted forms (eg EPDs)
- Where appropriate, commitments to support research and development into net zero embodied carbon solutions

Indicator

Number (and scope) of government roadmaps and policy paths created and made operational.

Key actions

Engage with all stakeholders to define a clear strategy and policy path for government. A strategy should include the following elements: baseline at jurisdiction level; timeline of climate objectives with building and infrastructure sector targets including, where possible, adherence to carbon budgets; embodied carbon disclosure requirements for large public projects; policy incentives and legislation to require and support embodied carbon reductions via best practice means; and consideration of the greatest embodied carbon reduction opportunities and risks for the state, region or country related to available resources (energy supply and materials).

Collaborate to create joint commitments, share knowledge and experiences with other governments at the same level (eg via intergovernmental networks, organisations and partnerships) and with other stakeholders.

Support industrial research and development Projects in early stages of technological development tend to need grant support due to lack of income. By contrast, pilot projects aiming at testing close-to-market technologies, or scaling-up/replicating market-ready technologies may be supported with financial instruments.

By 2025

All governments implement embodied carbon targets (using appropriate benchmarks) for new public buildings, large public renovations and infrastructure with a clear trajectory towards net zero standards.

Indicator

Percentage of buildings above a certain floor area or new infrastructure above a certain cost which comply with embodied carbon emission limits.

Key actions

Disclose lifecycle carbon measurements for public buildings and infrastructure and contribute to the collection of high quality data for benchmarking and target setting purposes.

Procure buildings and infrastructure projects which comply with embodied carbon emission targets, based on established methodologies such as carbon budgets, material screening and LCAs – simplified or full.

By 2030

All governments have implemented policies that set progressive reduction targets for the embodied carbon of all new buildings, large renovations and infrastructure and that specify when net zero embodied carbon will become mandatory in line with national roadmaps.

Indicator

Number of national and city regulations that set limits on the embodied carbon of new projects.

Key actions

ALL GOVERNMENTS: enforce embodied carbon disclosure requirements for buildings over a certain size, or infrastructure above a certain cost, as part of the construction permitting process and building codes. For private sector construction, implementation can be progressive (eg Finland's national roadmap) – first voluntary, and then as part of regulation which makes embodied carbon disclosure compulsory.

Implement carbon pricing and cooperate with other countries and regions in order to ensure full carbon price pass-through. Effective carbon pricing can play a role both in decarbonising primary material production and increasing the recycling and reuse of materials. This should be done without putting economies of the global south at a disadvantage.

Cities

Globally, cities have a critical role to play in leading and enabling the transition towards net zero embodied carbon buildings and infrastructure while also responding to the challenge of rapid global urbanisation. Depending on powers available to them, cities may be able to use planning and spatial strategies to influence the way assets are constructed to tackle embodied carbon emissions. Cities can be leading examples of policy action, boosting industry confidence by setting stringent criteria in their planning authorisations and integrating whole life approaches to buildings and infrastructure through zoning, municipal procurement, incentivisation schemes, industry dialogues and local policies and targets.

From 2020

Cities start the process of developing a strategy to achieve net zero embodied carbon to be adopted by 2024, which includes as a minimum:

- **Embodied carbon reduction targets**
- **Mandatory LCA of buildings[45]**
- **Targets and timelines for low carbon public procurement**

Indicator

Number (and scope) of city strategies and policy paths created

Key actions

Collaborate to create joint commitments, share knowledge and experiences with other cities, governmental levels and other stakeholders.

Disclose lifecycle carbon measurements for all public buildings and infrastructure and contribute to the collection of high quality data for benchmarking and target setting purposes.

Define a clear strategy and policy path, by engaging with all locally relevant stakeholders that seeks to create equity for broad implementation, accessibility and affordability of low carbon solutions towards net zero embodied carbon

By 2025

Cities adopt a set of targets with a clear trajectory towards net zero standards (using appropriate benchmarks) for new public buildings and large public renovation.

Indicator

Number (and scope) of embodied carbon targets set

Key actions

Enforce embodied carbon disclosure requirements for all new municipal buildings and, where possible, for other buildings over a certain size or infrastructure above a certain cost as part of the construction permitting process and building codes.

Procure buildings and infrastructure projects which comply with embodied carbon emission budgets, based on established methodologies such as carbon budgets, material screening and LCAs – simplified or full.

By 2030

Cities have implemented policies that set progressive embodied carbon reduction targets and specify when net zero embodied carbon will become mandatory for all new buildings, renovations and retrofits, and where possible all infrastructure.

Indicator

Percentage of relevant projects that comply with mandatory embodied carbon targets

Key actions

Embed requirements and strategies for embodied carbon emission reductions in new or existing policies such as climate mitigation policy, urban planning rules, building permits and rezoning. Such policies should aim to maximise use of existing assets through promoting building renovation, deconstruction and reuse and recycling over demolition and disposal. Incentives should also be considered such as permit prioritisation schemes and/or density bonuses attached to embodied carbon reduction requirements.

Facilitate circular buildings and infrastructure approaches, through new designs allowing for greater reuse of materials from existing assets that reach the end of life, for instance by contributing to databases mapping the materials which can be extracted from public and other assets at end of life (eg using material passports and treating buildings as material banks).

[45] where possible within the city's power and authority

The Netherlands' building decree (Bouwbesluit) (Netherlands)

Description

In 1992, the Netherlands implemented the first Bouwbesluit[46], a decree affecting a wide range of issues related to construction, including environmental impacts, health and safety. In 2018, this legislation was the first in the world to impose limits on embodied carbon emissions from buildings.

Key characteristics[47]

- All new residential and office buildings must account for embodied carbon emissions and 10 other impact categories (including health impacts) using an LCA based on the national methodology since 2013.
- The LCA calculation is reduced to a single metric, pricing all impact categories of the LCA. The final figure is thus expressed in euro/m^2. For carbon, a price of €50 per tonne is applied.
- Since January 2018, the mandatory environmental impact cap for offices and residential buildings has been set at 1 euro/m^2/year.

City of Oslo 2030 strategy (Norway)

Description

The City of Oslo works towards reducing its greenhouse gas emissions in a dialogue with construction contractors with the goal of defining a zero emissions standard for tender specifications for public projects, thereby fostering increased supply of technologies and services from market actors.

Key characteristics

- By 2030, Oslo intends to reduce carbon emissions by 95% from the 1990 baseline and become completely fossil fuel free[48].
- This includes zero emission construction sites, which are one focus of the city's 'Climate and Energy Strategy for Oslo'. Sites currently use biodiesel, or electric machinery, and are almost fossil fuel free already.
- A first step will be to implement standardised procurement criteria across different city agencies in charge of construction.
- A quantitative embodied carbon target will be defined after sufficient data has been collected.

[46] Rijksoverheid, https://rijksoverheid.bouwbesluit.com
[47] Embodied Carbon Review – Bionova.
[48] Climate and Energy Strategy for Oslo.

Finnish Ministry of Environment's Low Carbon Construction Roadmap (Finland)

Description

The Ministry of Environment in Finland announced the creation of a low carbon road map for the construction industry.

Key characteristics

- The roadmap was published in June 2017 and details how to reduce the carbon footprint of building materials and the construction industry in general, with the goal of regulating buildings' emissions via legislation by mid 2020s.
- Alongside the roadmap, the Ministry of Environment is writing a set of guidelines for public construction projects to pave the way for the low carbon procedures in the industry.
- The Ministry of Environment launched a public consultation in late 2018, regarding the approach to be taken in whole life carbon footprinting, that will be mandatory for new buildings under construction regulations by 2025.

Investors – scale up investments in support of net zero embodied carbon and trigger market demand.

Business – investors in manufacturing and property

The decarbonisation of the manufacturing industry and new resource-efficient and circular business models needed to achieve net zero embodied carbon for our sector will require significant capital investments. Manufacturers will only undertake significant investment if there are clear demand signals coming from designers, clients and real estate investors. The financial sector will need to be engaged on both the supply and demand sides to enable complete decarbonisation. Through their work, investors play a key role in advocating for stronger public policy and more ambitious action from the private sector.

In recent years there has been significant growth in demand for sustainable investments, with market leaders driven partly by the desire to divest from assets that they expect will devalue in the low carbon transition. We must capitalise on this by calling for divestment from those businesses and corporations that do not commit, and by incorporating embodied carbon metrics into sustainable investment criteria, to ensure finance flows where it is needed. Many pilot projects have demonstrated that targeting lower embodied carbon can also lead to capital cost savings due to a reduction in materials used.

While having limited influence in the early stage of a buildings lifecycle, **asset owners, occupiers and managers** play an important role as small-scale investors during use and end of life stages. Often, they decide when to renovate or how to maintain the asset to ensure longevity. A list of actions that should be taken by these actors appears on page 52.

From 2020

All investors commit to relevant industry roadmaps, targeting embodied carbon, when available.

Indicator

Number of investors committed to sectoral decarbonisation roadmaps.

Key actions

Collaborate with other public and private organisations to create joint commitments, share knowledge and experience, and define clear strategies for investors and developers.

Require embodied carbon assessments or LCA to be undertaken on all new investments.

Disclose portfolio and/or asset-level embodied carbon emissions.

By 2025

Investors only finance new projects (buildings, large renovations, infrastructure and manufacturing plants) that are compliant with carbon reduction targets set out in sectoral decarbonisation roadmaps.

Indicator

Percentage of new financed buildings and infrastructure projects with publicly disclosed embodied carbon emissions that align with a relevant sector decarbonisation roadmap.

Key actions

Require all investments to meet decarbonisation targets set against appropriate benchmarks.

Provide sustainable financial products targeting different parts of the value chain (eg building owners and tenants, contractors, and manufacturers) that incentivise low or zero carbon products and projects and circular business models.

By 2035

Investors only finance new projects (buildings, large renovations, infrastructure and manufacturing plants) that are net zero embodied carbon.

Indicator

Percentage of new projects that are net zero embodied carbon.

Calls to action – asset owners and occupiers

In many cases, the original asset investor is not the same individual or entity that takes key decisions throughout the lifecycle such as when to renovate or how to maintain the asset to ensure long life. These later decisions may be taken by new owners, tenants or facilities managers, often many years after initial construction.

Such decisions can have important impacts on use stage and end of life carbon emissions as well as emissions beyond the lifecycle. To minimise these emissions it is important that relevant organisations and individuals are equipped to act in the following ways:

- By applying our principles for reducing embodied carbon as part of a whole life approach, ensuring maximum utilisation of existing assets.
- By pursuing circularity – ie extending the life of the building or infrastructure asset and its components through regular maintenance, and reducing end of life emissions through reuse and recycling.
- Through prescriptive design guidance that allows them to specify low and zero carbon products for all maintenance, renovations and upgrades.

ABN AMRO (Netherlands)

Description

ABN AMRO has a number of ambitious targets for the carbon emissions associated with its loan portfolio including an ambition to finance only properties with an A-rated energy performance certificate. In relation to embodied carbon, the bank has also invested in innovations in the circular economy, including commissioning one of its own buildings, known as Circl, according to circular principles.

Key characteristics

- ABN AMRO's Circl building was designed to have the smallest possible environmental footprint. The insulation material in the ceiling is made from 16,000 pairs of used jeans, the window frames come from old office buildings and the furniture is reclaimed. Other materials – including the wooden frame and aluminium of the facade panel – can be fully reused in the future.
- The bank has financed initiatives to promote reuse of materials including the Urban Mining Collective and the online platform 'Madaster', which provides a database of materials that are available for reuse.

Developers – influence and accelerate supply chain action by embracing the new business opportunity of net zero embodied carbon.

Business – developers & contractors

Ambitious real estate and infrastructure developers are crucial to our carbon reduction goals – they often stand in between and interact with stakeholders right across the value chain. Developers have the knowledge and ability to influence the demand for embodied carbon emission reductions as part of a whole life approach. Digitalisation, new technologies and growing circular material markets will support developers, and subsequently their appointed contractors and designers operating under time and budgetary constraints, in delivering net zero embodied carbon buildings and infrastructure[49]. The net zero embodied carbon transition presents opportunities for new business models that maximise building and product use, and therefore extend their financial value.

From 2020

All developers commit to relevant industry roadmaps when available and require disclosure of supply chain LCA data for structural elements.

Indicator

Percentage of projects that require 100% disclosure of structural elements.

Key actions

Collaborate with other public and private organisations to create joint commitments and shared knowledge and experience, and define clear strategies for the supply chain.

Set prescriptive and performance-based procurement requirements for materials using available public procurement guidelines, specifications, or databases.

Create new contractual obligations that require transparency in the disclosure of embodied carbon data from the supply chain (such as EPDs).

By 2025

All developers set embodied carbon reduction targets and benchmarks for all new construction and large renovation projects and require mandatory disclosure of supply chain data and track construction site emissions.

Indicator

Percentage of projects that achieve best practice embodied carbon reduction targets

Key actions

Use a whole lifecycle approach in building and infrastructure development and construction.

Require low carbon or carbon positive materials and promote circular principles that meet defined performance requirements.

Monitor and disclose material and energy related carbon emissions for all new construction and for large renovation projects.

Develop new business and collaboration models such as building or product leasing services or alliances between client and key suppliers.

Use financial incentives, contractual obligations or carbon commitments to set performance-based requirements for best practice embodied carbon targets or benchmarks.

[49] Hobbs, G., Adams, K. (2017). Reuse of building products and materials – barriers and opportunities. International HISER Conference on Advances in Recycling and Management of Construction and Demolition Waste 21-23 June 2017, Delft University of Technology, Delft, The Netherlands.

By 2030

All construction sites are highly resource and energy efficient and, along with site-related transport processes, are powered by renewable energy.

Indicator

Percentage of construction sites with 100% of demand met from renewable energy sources

By 2035

Developers only build projects that have net zero embodied carbon.

Indicator

Percentage of projects that achieve net zero embodied carbon.

Key actions

Convert all plant and equipment to operate on carbon neutral biofuels or renewable electricity.

Adopt best available technologies and processes to replace those with higher carbon emissions.

Increase the energy efficiency of construction processes.

Minimise the impact of construction processes on the natural environment.

Calls to action – contractors

Contractors can play an important role as influencers in realising and even raising the ambition of requirements set out by the developer and the design team, even though they have limited direct control over decision making or opportunity to affect the embodied carbon reduction strategies for a project.

They are a central hub of knowledge for their subcontractors and downstream suppliers and provide a source of quality control for the developer regarding progress against requirements. Drawing on real life experience of delivering embodied carbon requirements across multiple projects, contractors can be a valuable source of education both upstream and downstream and help to deliver construction site related actions such as:

- Minimising the impact of construction processes on the natural environment.
- Explaining trade specific procurement requirements for low carbon or carbon positive materials to subcontractors.
- Acting as a gatekeeper for disclosure of embodied carbon data for materials used on site (through EPDs etc).
- Promoting circular principles through demolition and construction waste work flows where possible.
- Sourcing plant and equipment that operates on carbon-neutral biofuels or renewable electricity.

Masdar City building procurement policies (United Arab Emirates)

Description

The vision for the Masdar City development is to 'create a commercially viable sustainable city providing the highest quality of life with the smallest environmental footprint'. To achieve this vision, Masdar has established measurable goals in the areas of carbon footprint, energy usage, water usage, waste generation, social impact and economic viability.

Masdar City is an example of innovative city planning and development. Its location in a desert environment gives rise to particular challenges that will provide invaluable guidance to future development projects in the region.

Key characteristics

- 'Sustainability Action Plan' core principles include sourcing 'regional, high-recycled content / low carbon materials' to encourage the use of construction materials that are locally available, reclaimed, renewable, recycled and have the smallest environmental impact.
- Aim is to reduce embodied carbon of building materials by 30% and achieve a target of 550kgCO_2/ m^2 for building construction embodied carbon.
- Procurement policy aims to ensure that embodied carbon targets are met by developers and contractors, with a benchmark for embodied carbon from cradle to site.
- In order to ensure compliance with the requirements, Masdar teams (including procurement and delivery teams) work closely with contractors, through Life Cycle Costing (LCC) and by providing supply chain information regarding the Masdar requirements.

Norwegian real estate sector roadmap towards 2050 (Norway)

Description

In response to the prime minister's call for sectoral decarbonisation roadmaps, Norway Green Building Council (NGBC) together with Norweigan Property Federation prepared the property sector's roadmap towards 2050. 40% of the Norwegian real estate sector (by floor area) is owned or managed by members of NGBC. The roadmap was launched in 2016 and the majority of NGBC's real estate sector members have now committed to implement 10 immediate measures, including a commitment to always prioritise low carbon materials and to request fossil free building sites.

Key characteristics

- The roadmap sets a vision for the industry to have reduced its carbon emissions by 40% in 2030 and to be carbon neutral by 2050. It also calls for closed material loops and zero emissions of hazardous substances by 2050.
- The 10 immediate actions set out in the roadmap address both operational and embodied carbon, and include commitments to:
  - avoid building products with hazardous substances
  - reward innovative solutions
  - require flexible plans and ask for a plan for disassembly
  - request and prioritise building products with low greenhouse gas emissions (documented by EPD)
  - request fossil fuel free construction sites

Designers – challenge convention and unleash tomorrow's designs that incorporate whole life carbon thinking and greatly reduce embodied carbon from the outset.

Business – designers

Designers of buildings and infrastructure are well placed to challenge conventional approaches and unleash forward-looking designs that will lead to net zero embodied carbon by 2050. They have high potential for reducing upfront emissions of a building or infrastructure project by undertaking whole life carbon thinking at an early design stage, and evaluating emissions reduction strategies based not only on potential savings but also on how quickly those savings can be achieved. Furthermore, designers have a large impact at project level where they can facilitate awareness, improve skills and capacity, and propose cost effective and innovative technical solutions targeting net zero embodied carbon when their clients share the same vision. Designers, working with developers and contractors, are able to influence their supply chain by requesting EPDs and product/material data, specifying materials with low embodied carbon attributes, and setting organisational targets. Designers are also well placed to lead on developing whole life carbon thinking and promoting circular material use.

From 2020

All designers commit to relevant industry roadmaps when available and have integrated low embodied carbon material selection and lifecycle assessment at conceptual design stage for all new construction and large renovation projects.

Indicator

Percentage of projects where embodied carbon assessment has been completed at conceptual design stage.

Key actions

Commit to decarbonisation pathways that include net zero building and infrastructure by 2050.

Use the best available tools (prescriptive design guidance and specifications, or LCA and performance-based approaches where available) to adopt a whole life approach to carbon reduction in building and infrastructure design, applying our principles in order to identify cost effective low and, ultimately, net zero carbon designs while prioritising early emissions savings. Present clients with design proposals for reducing the embodied carbon in a project at concept stages and design review.

Integrate whole life carbon thinking into design processes through existing digital and prescriptive solutions.

Commit to raising awareness and increasing capacity for clients and contractors on embodied carbon.

By 2025

All design companies publicly share lifecycle assessment data for all new construction and large renovation projects where possible.

Indicator

Percentage of projects that have publicly shared their embodied carbon material specifications and lifecycle assessment data.

Key actions

Contribute to the collection of high quality embodied carbon data of building materials, buildings and infrastructure projects.

Disclose third party verified embodied carbon data for all new buildings and infrastructure projects with client's consent. Store in a public database.

Disclose supply chain specific data for building materials and products via EPDs or other third party reviewed data methods.

By 2025

Design companies propose best practice embodied carbon reduction targets and implement circular principles across lifecycle stages of the project.

Indicator

Percentage of projects that have embodied carbon requirements.

Percentage of projects with a digital twin containing material passports.

Percentage of projects that achieve best practice embodied carbon reduction targets.

Key actions

Propose embodied carbon targets for all new construction and large renovation projects.

Require low carbon or carbon positive materials and promote circular principles.

Develop, adopt and use digital twins for all new construction and large renovation projects – ie a digital model of the building that can be updated over the lifecycle – containing material passports (data on the material specification and its environmental impacts, such as an EPD).

Develop digital logbooks of building and infrastructure projects that facilitate access to structured information about building design, renovation, maintenance and performance service levels.

By 2035

Design companies propose requirements for all projects to be 100% net zero embodied carbon.

Indicator

Percentage of projects that achieve net zero embodied carbon.

Bayswater level crossing removal project (Australia)

Description

The Victorian Government's Level Crossing Removal Project (LXRP) is eliminating 75 level crossings across metropolitan Melbourne by 2025, in addition to upgrading or constructing more than 27 train stations, laying many kilometres of new track and making associated rail improvements.

In 2017, LXRP removed a dangerous and congested level crossing in the Melbourne suburb of Bayswater and built a brand new train station. As part of the project, the team incorporated a range of sustainability initiatives into the station design and construction programme, significantly reducing the project's overall carbon footprint.

Key characteristics

- The project has reduced carbon emissions by 30% during construction and a projected 43% over the operational life of the new train station, based on a 50-year life cycle, compared to a business-as-usual approach.
- One way the project reduced carbon emissions was to change the rail track alignment, as this requires less electricity to power the trains.
- The project reduced embodied energy in several ways, including using recycled waste products in the concrete mix and designing the new station in a way that required fewer materials. For example, by raising the alignment of the station platform, fewer piles were needed and therefore less concrete.
- The project achieved an Infrastructure Sustainability Council of Australia rating of 86, exceeding the government's mandated sustainability target of 65. The project also received a 4-Star Green Star rating[50].

Ramboll's GreenBIM tool (Global)

Description

Ramboll is an engineering and consulting company active in the building and infrastructure sector globally. It is currently developing a GreenBIM methodology supported by a tool that will increase sustainability in the design of buildings. The aim of GreenBIM is to integrate carbon calculations within the modelling of buildings and to allow the continuous assessment of building sustainability using multiple criteria across all phases of the building process.

Key characteristics

- GreenBIM will provide a structured methodology for evaluating sustainability criteria on a continuous basis throughout a project.
- It will facilitate interdisciplinary collaboration, thereby ensuring that solutions can be fully optimised and clients' sustainability ambitions are realised.
- In addition, GreenBIM will provide clients with a documented and certified level of sustainability while also helping to achieve cost savings.
- The tool will allow a smooth interaction with existing tools used by discipline specialists throughout Ramboll and across nationalities, including daylight simulation, energy and structural calculations.

[50] Bayswater Level Crossing Removal Project Sustainability Report.

Manufacturers – the engines of the embodied carbon transition, leading industry in delivering products that support the vision and goals of net zero embodied carbon.

Business – manufacturers

Materials are the main contributors of embodied carbon emissions from buildings and infrastructure, particularly the upfront carbon that is being emitted now. Arguably it is materials manufacturers that will be most profoundly affected by mass uptake of net zero embodied carbon in buildings and infrastructure. Winning their support and creating the right conditions for them to take radical action is crucial. Through disclosure of the embodied carbon emissions in their products, manufacturers also have an important enabling role to play in respect of other actors in the value chain who rely on this data.

Many solutions for substantially reducing carbon emissions in building materials are already known and need to be rapidly scaled. Yet manufacturers will not be able to achieve the levels of decarbonisation required to achieve net zero embodied carbon for the whole sector acting on their own. They will require finance, supportive policy frameworks, and adequate demand for their low carbon products, meaning coordination of the actions listed here with those of other stakeholders is an urgent priority.

From 2020

All manufacturers and suppliers start to develop company level carbon reduction targets, with timelines set to achieve net zero embodied carbon by 2050, and are reporting against these.

Indicator

Number of companies with published carbon targets and progress reporting.

By 2025

All manufacturers have product specific EPDs covering the top 40% (in terms of embodied carbon impact) of their standard product portfolio

Indicator

Percentage of manufacturers' standard products subject to EPDs.

By 2030

All manufacturers have declared the environmental impact of their entire product portfolios via product specific EPDs

Indicator

Percentage of manufacturers' standard products subject to EPDs.

Key actions

Commit to decarbonisation pathways that include net zero building and infrastructure by 2050.

Collaborate with other public and private organisations to create joint commitments and shared knowledge and experience, and define clear strategies and timelines for the supply chain.

Fully implement all currently available carbon reduction strategies immediately, including: maximising process energy efficiency; switching to low carbon and renewable energy sources; minimising use of virgin materials through design optimisation; use of recycled materials and the avoidance of production waste; exploring and implementing circularity principles such as maximising design life, product-to-service switching and product take-back schemes; and design for deconstruction and reuse. Explore carbon capture with storage or utilisation where relevant.

Announce all planned major investments in technology for delivering low and zero carbon products.

Key actions

Develop representative product specific EPDs to allow designers and buyers to make informed choices.

Publish EPDs via online platforms in relevant markets, ensuring alignment with agreed product category rules and transparency about assumptions and data quality.

Use EPDs and LCA data internally to identify carbon reduction opportunities that meet agreed sectoral decarbonisation timelines.

By 2035

All electricity for manufacturing and transport processes is from renewable or low carbon sources.

Indicator

Percentage of electricity input originating from renewable or low carbon energy sources.

Key actions

Use electricity produced from renewable sources where possible, or use biomass and waste materials for highly energy demanding processes that cannot be achieved with renewably sourced electricity (eg for certain heat processes).

Pilot and demonstrate novel low and zero carbon technologies, processes and products, collaborating with researchers and the entire supply chain. Depending on the sector, technologies may include carbon capture and storage (CCS), electrolysis, hydrogen ironmaking technology, 3D printing, and new materials using bio-based inputs.

By 2045

All forms of energy used in manufacture and transportation are renewable or low carbon and and strategies to mitigate all process carbon emissions are enacted.

Indicator

Percentage of total energy input originating from renewable or low carbon energy sources.

Key actions

Use electricity and/or fuels produced from renewable or low carbon sources for all energy consumed in production and transportation.

Scale and deploy low and zero carbon technologies, processes and products including measures to fully address process carbon emissions such as through carbon capture with storage and utilisation.

HeidelbergCement Group: Carbon reduction strategy aligned to Paris Agreement (Global)

Description

The fourth largest cement company globally with operations in 60 countries.

Heidelberg is the first company in the sector to set a carbon reduction strategy that is certified to be in line with the Paris Agreement.

Key characteristics

- HeidelbergCement has announced its vision to produce carbon-neutral concrete by 2050, a global first for the sector.
- Based on its Sustainability Commitments 2030, the overall target is a reduction of 30% of the carbon footprint in 2030 compared to 1990.
- HeidelbergCement's carbon reduction strategy for 2030 has been reviewed and certified by the Science Based Targets Initiative as being compliant with sectoral decarbonisation pathways needed to achieve the goals of the Paris Agreement.

ArcelorMittal carbon neutrality commitment (Global)

Description

ArcelorMittal has committed to achieving carbon neutrality in Europe by 2050 in line with the objectives of the Paris Agreement and the science-based trajectory for the steel sector.

Key characteristics

- Primary steel production from iron ore currently relies on high temperature carbon monoxide from fossil fuels.
- To reduce emissions within the timeframe needed, ArcelorMittal is exploring opportunities for combining different innovative technologies that:
  - use more clean power
  - involve circular sources of carbon
  - prioritise carbon capture, utilisation and storage
- ArcelorMittal is investing €250m in order to research and demonstrate these technologies.
- The company has also set out clear policy recommendations, at both global and European level, that it believes will create the market conditions needed to support its transition.

Dalmia Cement (Bharat) Limited to become carbon negative cement group by 2040 (Global)

Description

Dalmia Cement is one of India's leading cement manufacturers. The company currently has the smallest carbon footprint in the global cement sector and, in 2018, was ranked number 1 by CDP on business readiness for a low carbon transition in the global cement sector.

Dalmia Cement was the first company globally to sign up to both RE100 and EP100 commitments. The company was the first from heavy industry sector to announce a commitment to become a carbon negative cement group by 2040[51] during the Global Climate Action Summit (GCAS) and at COP-24 in 2018.

The company is a five times water positive cement group. It has further increased the ambition to become 10 times water positive by 2030.

Key characteristics

- Produces one of the lowest carbon intensive cements in the world[52], with a group average intensity of 526kg/t compared to the global average of 643kg/t[53].
- Developed a carbon negative roadmap 2040 which includes the following levers:
  - switch to 100% biofuels (agri-waste, bamboo, other biomass waste, compressed biogas) and alternative fuels (industrial wastes) by 2035
  - 100% fossil free electricity use by 2030 through deployment of solar/renewable energy and green energy generation from the heat from exit gases
  - reducing clinker factor in incremental stages and optimising clinker heat consumption
  - switching to solar drying for relevant raw materials
  - developing a new range of low-carbon cements
  - Carbon capture and utilisation (CCU) for process related emissions and carbon sequestration to reach negative carbon footprint by 2040
- Committed to procuring 100% renewable electricity and double energy productivity by 2030 through RE100 and EP100 respectively.

[51] Envisioning a carbon negative footprint: A Dalmia Bharat perspective.
[52] Greenbiz: 6 leading companies raising climate ambition.
[53] GNR (Getting the Numbers Right), 2017, https://gccassociation.org/gnr/

Join us

WorldGBC's Advancing Net Zero project was launched in 2016 to ensure that we and our member GBCs work towards a global net zero carbon building stock, to help win the battle against climate change by keeping global temperature rise in line with the goals of the Paris Agreement.

As set out in this report, decarbonising the whole lifecycle of buildings and infrastructure by 2050 is possible if all stakeholders across the value chain work together, with multiple and significant benefits to the market.

But we must start today. Our vision relies on business, government and NGOs, including GBCs, working collaboratively together to move net zero carbon buildings from exceptional market-leading projects to the new business-as-usual.

We invite you to join us.

WorldGBC invites everyone along the building and infrastructure value chain, whether an investor, developer, designer, contractor, manufacturer or representatives of national government, states and cities, to work with us, our local GBCs, us and our partners to ensure that all our buildings, everywhere, are net zero carbon – operational and embodied – before 2050. We are committed to working for sustained change towards achieving the targets set out in this report.

Contact your local GBC or WorldGBC to join us on this important journey.

ADVANCING NET ZERO

WORLD GREEN BUILDING COUNCIL

www.worldgbc.org