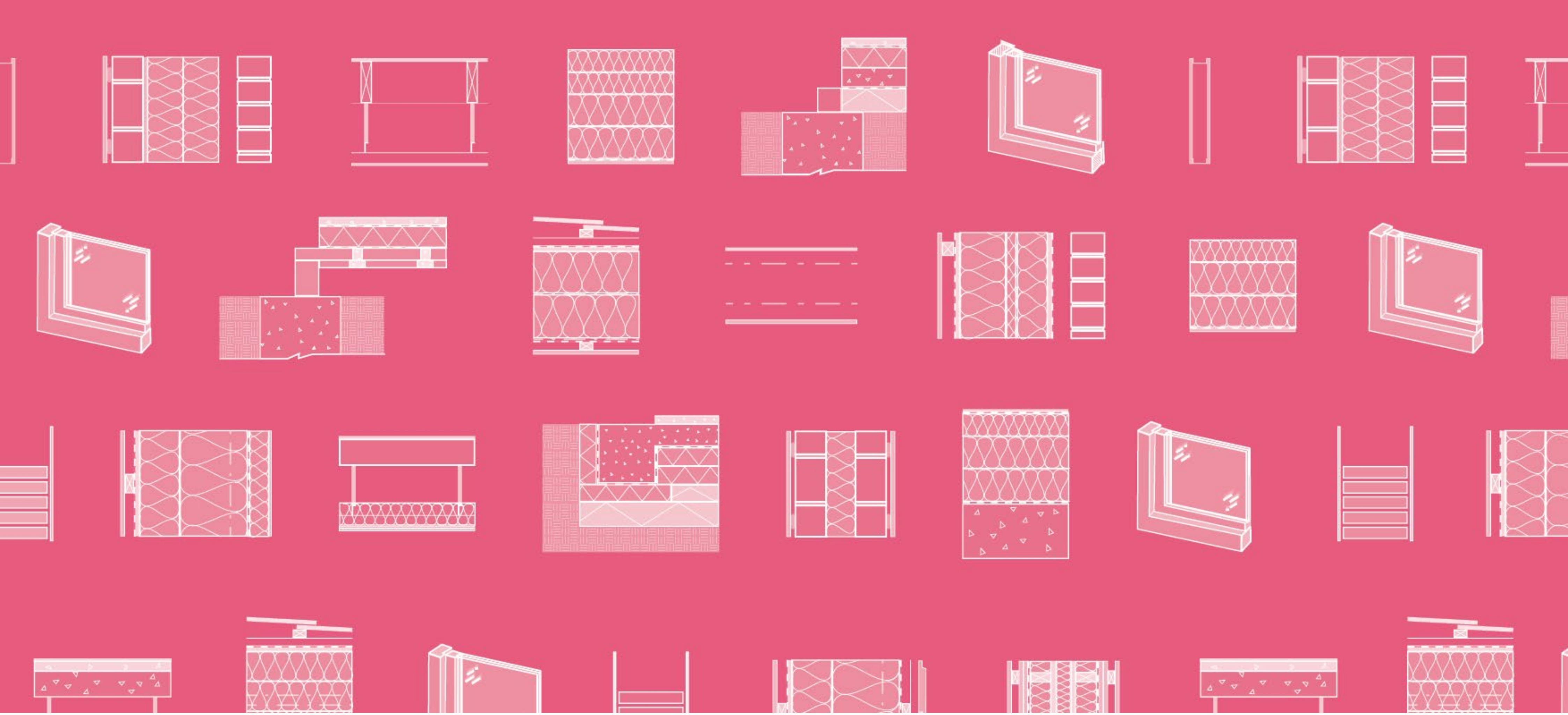

Essex Embodied Carbon Policy Study

A technical evidence base for planning policy

June 2024

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Executive summary – Explainer

The purpose of this study

The purpose of this Embodied Carbon Policy Study is to provide the technical evidence to support the development of a planning policy approach for reducing embodied carbon emissions from developments in Greater Essex.

What is embodied carbon?

The embodied carbon emissions of a building are the total green house gas emissions associated with materials, construction processes, maintenance and demolition.

A full glossary of terms can be found in the Appendix on page 128.

How the study fits in to planning policy in Essex

Addressing carbon emissions through planning policy is vital to meet local and national climate targets. Essex, has already established an evidence-led net zero operational carbon policy, which serves as a model for going beyond regulation. Despite the absence of building regulation in England to reduce embodied carbon, this evidence-base recommends an embodied carbon policy to complement Essex's net zero operational carbon policy. To fully address its Net Zero Carbon commitment, Essex aspires to develop future policies addressing overheating and carbon emissions associated with water use.

Who the study is aimed at

The prime audience is Local Planning Authorities in Greater Essex and planning inspectors examining local plans. The study will also support the development Industry and other stakeholders to reduce embodied carbon emissions from new development. Supplementary design guidance will also be provided for these stakeholders. The study builds upon a body of evidence that is developing nationally, and will be of interest to other Local Authorities, industry bodies and other stakeholders in the UK seeking to address embodied carbon emissions from development.

What the evidence-base covers

The evidence-base provides wider context for the recommended policy requirements set out within in. It also provides a technical evidence base for the introduction of upfront embodied carbon limits (particularly for low-rise residential developments).

Policy requirements for immediate implementation:

1. **Presumption against demolition and promoting circular economy** (parts 1a and 1b)
2. **Lean building design and good material efficiency for lower embodied carbon**
3. **Reducing upfront embodied carbon**

Policy requirements for consideration in the next 3-5 years:

1. **Presumption against demolition and promoting circular economy** (part 1c)
4. **Reporting whole life carbon**

Policy requirements explained further in executive summary (page 4 and Chapter 6 – Policy recommendations).

Further potential work and actions

Future potential work and actions could be developed to support the proposed embodied carbon policy requirements, including:

- Introductory training on embodied carbon would be beneficial (not essential) for planning officers to assess applications.
- User friendly design and reporting guidance to aid applicants in reducing embodied carbon, with potential to include in the Essex Design Guide.
- Produce supplementary guidance to support specific aspects of the recommended policy requirements.
- Commission a supplement to the study to provide a steer on County Planning Minerals and Waste matters in respect of reducing embodied carbon emissions.
- Lobby Government to establish a standard national embodied carbon materials database.

Executive summary – A technical evidence base for planning policy

The Essex Embodied Carbon Policy Study provides an evidence base for the setting of embodied carbon planning policy, to contribute to the delivery of net zero carbon buildings in Essex.

The importance of reducing embodied carbon emissions

Addressing the national carbon emission targets for the building sector has traditionally focused on reducing operational carbon emissions (associated with energy consumed in a building) through regulation and planning policy. However, as buildings become more energy efficient, the operational carbon emissions are reduced. Therefore, embodied carbon emissions associated with the materials are a greater portion of the total carbon emissions of a building.

Addressing embodied carbon and the circular economy through planning policy is vital to meet local and national climate targets.

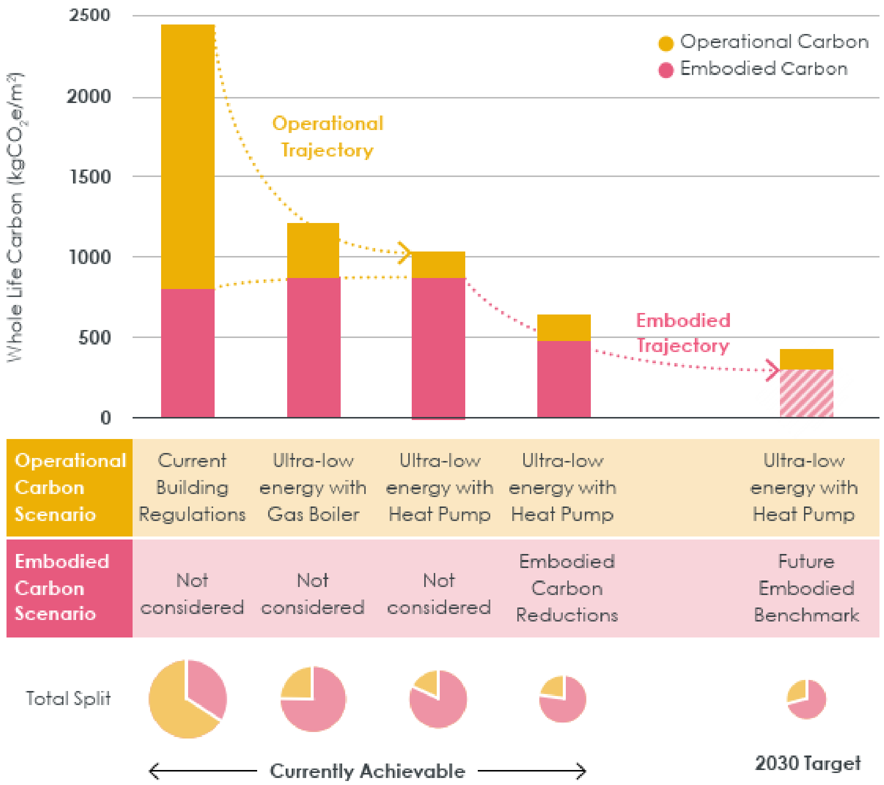
Bringing embodied carbon into policy

Despite the absence of building regulation in England to reduce embodied carbon, local authorities have a duty to mitigate climate change through planning policy. An increasing number of local authorities (Greater London Authority, Westminster City Council, City of London, Bath and North East Somerset and Bristol City Council) are incorporating embodied carbon and/or whole life carbon considerations into planning policy. Essex, has already established an evidence-led net zero operational carbon policy, which serves as a model for going beyond regulation. Therefore this evidence base recommends an embodied carbon policy to complement the net zero operational carbon policy.

To have the greatest immediate influence on the design and construction of buildings in Essex, the primary focus for this evidence base is on upfront embodied carbon. To this end, comprehensive upfront embodied carbon and capital cost modelling has been carried out on three house types to assist in setting policy limits. Policy requirements have been proposed across domestic and non-domestic building types, covering: the retention and retrofit of buildings and circular economy; reduced embodied carbon through design; limiting upfront embodied carbon emissions; and whole life carbon reporting.

Life cycle carbon analysis has also been carried out as part of this study, to begin to inform potential future policy requirements.

The implementation section of this study also makes recommendations for the implementation of the proposed policy for ease of applicants and planning officers.



Operational and embodied carbon trajectories. As operational emissions are reduced in new buildings, the proportion of embodied carbon emissions becomes higher. (Source: LETI)

Executive summary – Proposed policy requirements for embodied carbon

This page summarises the proposed embodied carbon planning policy requirements which cover four main areas: demolition and promoting a circular economy; efficient building design and material efficiency; reducing upfront embodied carbon; and reporting whole life carbon.

Four proposed policy requirements:

1 Presumption against demolition and promoting circular economy

This policy requirement seeks to prevent substantial and total demolition of existing buildings by requiring justification, additional requirements and whole life carbon (WLC) optioneering studies to be carried out, where appropriate.

1a - Justification

Retrofit-first approach before substantial or total demolition. **Justification** to be provided where substantial or total demotion is proposed.

+

1b – Additional requirements

Retrofit-first approach before substantial or total demolition. **Additional requirements** are to be met where substantial or total demotion is proposed.

+

1c - WLC study *(Optional)*

Retrofit-first approach before substantial or total demolition. **Optioneering WLC study** to be carried out where substantial or total demotion is proposed.

2 Lean building design and good material efficiency for lower embodied carbon

This policy requirement seeks to reduce resource use by encouraging all applications to be efficient in their material use, building form and design.

Proposed requirement content:

"All new buildings and developments should demonstrate that upfront embodied carbon has been considered and reduced where possible through good design and material efficiency. As part of the planning application applicants should submit a summary of the efforts made to reduce upfront embodied carbon".

3 Reducing upfront embodied carbon

This policy requirement sets limits on upfront embodied carbon emissions for major applications. It requires calculating and reporting upfront embodied carbon emissions to demonstrate compliance.

Proposed requirement content:

"New major developments, major renovation and rebuild developments should achieve the following set limits for upfront embodied carbon (A1-A5):

- *Low rise residential (up to 11m): ≤500 kgCO_2e/m^2 (GIA).*
- *Mid and high rise residential (over 11m) - ≤500 kgCO_2e/m^2 (GIA) or follow NZCBS limits when available.*
- *Non-domestic buildings:* offices ≤600 kgCO_2e/m^2 (GIA), education ≤500 kgCO_2e/m^2 (GIA), and retail ≤550 kgCO_2e/m^2 (GIA) *or follow NZCBS limits when available.*

New major developments should also report on: the top five materials by upfront embodied carbon emissions, together with their circular economy metrics (% recycled content/ designed for re-use/ recycling/ disassembly); disclose where unusually low embodied carbon products have been intentionally used; and report the embodied carbon of refrigerants in building services.

4 Reporting whole life carbon

This policy requirement seeks reporting of whole life carbon (WLC) emissions. This is to be considered for adoption in future or for particularly large developments.

Proposed requirement content:

''New major developments should:

- *Have met policy requirement 3 – 'Limiting upfront embodied carbon'*
- *In addition, all major developments should calculate and report non-decarbonised and decarbonised emissions against life cycle stages B-C and D (including B6/B7). This should include sequestered carbon."*

Executive summary – Wider considerations for embodied carbon in planning policy

The recommended policy requirements for embodied carbon sit within a wider context with the following considerations:

Links between operational and embodied carbon policies

The focus should be on reducing embodied carbon alongside and in support of ultra-low energy buildings, as opposed to trading one off of another.

Solar PV offers one of the lowest carbon forms of electricity generation available, and it is getting better all the time. For this reason, it is one of the central technologies for decarbonising our energy supply.

To prevent an unwanted trade-off of carbon between the operational energy and embodied carbon policies, PV panels and solar shading have been calculated separately/excluded from calculations. These are necessary elements of a building for net zero operational carbon (*Essex solar design guide*). This is not intended to detract from the use of low embodied carbon materials for solar shading elements.

Net Zero Carbon Building Standard – well evidenced targets

The Net Zero Carbon Building Standard (NZCBS) is work in progress and represents the biggest cross industry working group looking at a net zero carbon standard. The research is a comprehensive review of previous guidance and targets and pulls information from a variety of data sources (including planning submissions, assessment databases) to arrive at proposed limits for different building types. It is proposed that upfront embodied carbon limits for building typologies not modelled in this study are transposed from the NZCBS when available.

Understanding current and future costs and non-cost factors

Reducing the upfront and life cycle embodied carbon of a building does not necessarily mean higher capital costs. Contrary to this, adopting strategies such us lean and circular economy design can reduce capital costs.

Many of the strategies that a contractor might propose to reduce capital and life cycle embodied carbon will have little or no material impact on cost. These might include:

- Resource efficiency and circularity measures that reduce wastage, entail the selection of reused materials or those containing higher levels of recycled content.
- Effective co-ordination of designs and management of site teams to reduce wastage.
- Designing for effective maintenance and disassembly, for example through use of mechanical fixings in cladding systems.

Some specification changes may result in additional costs being incurred, however, it is critical to determine those that are likely to persist over the long term and those where any cost premium should dissipate over time as the supply chain becomes more mature and scale increases.

In much of England timber frame is considered a more expensive solution than the more typical masonry construction, yet in Scotland timber frame is predominant and is cost competitive on this basis. It is therefore important to distinguish between cost premiums that arise due to historic market practice rather than due to an underlying difference in cost base.

While material cost is an important component influencing the viability of a construction method, a range of other factors are also important and should be considered. These include: the ability of a low carbon construction or material solution to meet demand; transition/duplication of costs for organisations with refined existing supply chains; and risk for smaller companies to provide warranties for example.

Encouraging (but not mandating) use of natural building materials in Essex will lead to increased market demand and provide opportunities for new businesses and supply chains to develop in response. Additional scale and local supply chains will help to reduce cost as well as transport related emissions while also supporting economic growth within the county and region.

The role of offsets in embodied carbon

This study notes that offset payments should be considered as a last resort. They are sometimes used for operational carbon to make up for the shortfall of emissions reductions on-site. Offsetting embodied carbon should be used cautiously, to avoid moving an on-site issue elsewhere. At this point in time it is recommended that it would be more constructive to set policy in a way that ensures embodied carbon emissions are reduced as far as possible through the project design and procurement.

Executive summary – Embodied carbon modelling and cost analysis

To support the setting of upfront embodied carbon limits in proposed policy requirement 3, modelling and cost analysis has been carried out.

Typologies modelled

Three residential typologies have been modelled:

- Terrace house (3 bed)
- Semi-detached house (3 bed)
- Block of apartments (1 and 2 beds).

Modelling

The upfront embodied carbon models in this evidence base have been built from the ground up, using widely available industry data and following the RICS methodology to ensure alignment with standard practice. The diagram opposite shows the modelling process, using a 'materials database', which feeds data to an 'element library', which is then used to construct an overall model and 'set menus' for a given building scenario.

Set menus 1 and 2 were formed to bring the higher and lower upfront embodied carbon elements together. Set menu 3 was also created based on combination of cost and carbon optimised building elements.

All typologies modelled for upfront embodied carbon were designed to also meet the Essex recommended planning policy approach for Net Zero Carbon Development (in operation) as set out in the '*Planning Policy Position for Net Zero Carbon Homes and Buildings in Greater Essex*'.

Upfront embodied carbon modelling results

Houses - This study found that the total upfront embodied carbon emissions of a semi-detached and terrace house could be approx. 40% lower, when compared to traditional masonry construction. This is through the use of a timber structure, wood fibre and hempcrete insulation and timber cladding.

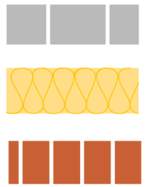
Low-rise apartment block – The total upfront embodied carbon emissions of a low-rise apartment block could be approx. 30% lower, when compared to traditional masonry construction. This is through the same construction method as houses and using cross laminated timber intermediate floors.

For all typologies the top five most carbon intensive materials by total embodied carbon include: concrete (including screed and rebar), bricks, blocks, plasterboard and metal elements.

Modelling process - summary

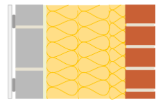
1 Material Database

- Enter A1-A5 and upfront biogenic carbon datapoints ($KgCO_2$ per kg) for each material/product.
- Datapoints entered for lots of materials/ products that represent UK average construction performance.
- Broken down into life stage and fully referenced



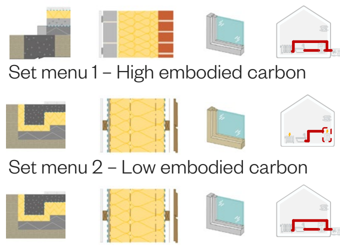
2 Element library

Combine materials to create the elements that are capable of achieving Essex operational carbon policy limits. Calculate the A1-A5 and upfront biogenic carbon of each element per sqm.



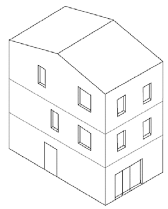
3 Set menus per building typology

Combine the elements to create high, low and cost-carbon optimised upfront embodied carbon set menus for each element and typology. Carry out cost analysis for each set menu.



4 Building models

Categorise the elements according to RICS building elements guidance and analyse the upfront embodied carbon and cost results per set menu, per building typology.



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Policy recommendations

Inform the upfront embodied carbon policy recommendation for setting limits per typology.

Proposed policy requirement
3 Reducing upfront embodied carbon

Executive summary – Embodied carbon modelling and cost analysis

Upfront embodied carbon modelling results

The results opposite show the upfront embodied carbon for three house types under the higher, lower and cost and carbon optimised scenarios tested. The high carbon (set menu 1) and cost and carbon optimised scenarios (set menu 3) both sit below the LETI 2020 target of 500kgCO_2e/m^2.

Cost analysis

The table below the chart shows the percentage impact on overall build costs of each of the modelled scenarios in comparison to either Part L 2021 or 'typical' net zero operational carbon specifications. The total cost for achieving net zero carbon operational and lower embodied carbon policies at the same time is between 8% and 10% depending on house type. The embodied carbon scenarios represent an additional cost uplift of between 2% and 3% on the net zero carbon operational specification. Some construction types and/or materials are considered cost neutral.

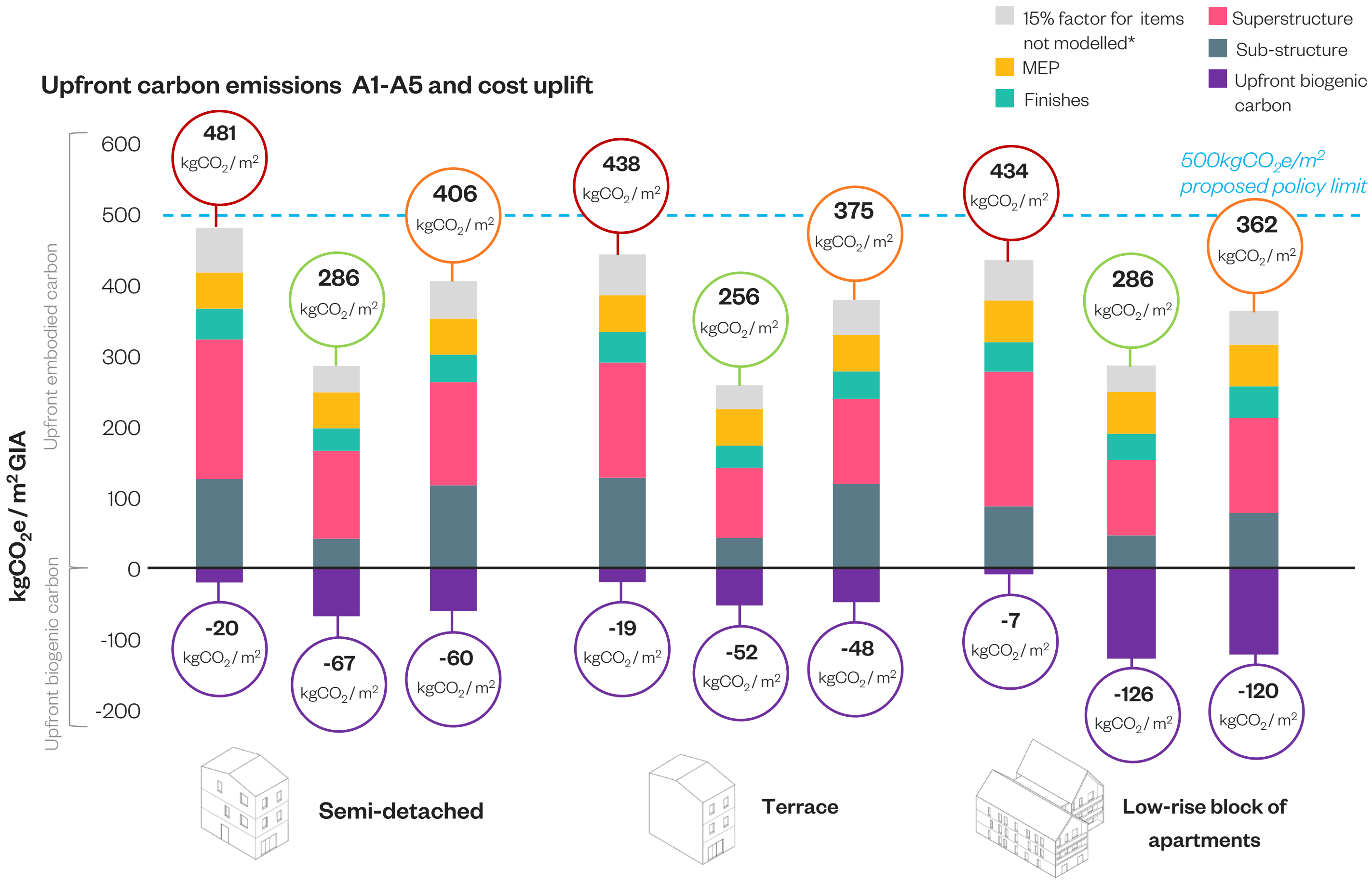
Proposed limit for policy - 500 kgCO_2e/m^2

This study proposes setting the limit for upfront embodied carbon for low-rise housing (under 11m for purposes of building regulations Part B) at 500 kgCO_2e/m^2 GIA. This encourages the consideration of a compact building form and material selection, without seeking to exclude specific materials or designs.

Future limits for consideration

This study recommends reviewing the limit every 3-5 years to determine if it can be lowered or should be altered in planning policy .

A limit of around 400 kgCO_2e/m^2 GIA would allow for a timber structure with brick face, while a limit of 300 kgCO_2e/m^2 GIA would likely exclude the use of brick.



	Set menu 1 Highest embodied carbon mix	Set menu 2 Lowest embodied carbon mix	Set menu 3 Cost and carbon optimised	Set menu 1 Highest embodied carbon mix	Set menu 2 Lowest embodied carbon mix	Set menu 3 Cost and carbon optimised	Set menu 1 Highest embodied carbon mix	Set menu 2 Lowest embodied carbon mix	Set menu 3 Cost and carbon optimised
Cost uplift from Part L 2021	+9.4%	+9.5%	+8.3%	+8.4%	+7.7%	+7.8%	+7.9%	+11.6%	+10%
Cost difference from net zero operational carbon	+2.3%	+1.6%	+1.8%	+3%	+3%	+1%	+1%	+4%	+3%

** RICS PS v2 2023 provides guidance on adding a percentage uplift for contingency and uncertainty. The default contingency of 15% for design stage calculations has been applied to the results above. Applicants should be expected to add a 15% contingency to their results.*

1

The urgency for embodied carbon policies

The need for embodied carbon policy in the UK (part 1/3)

Global climate emergency

There is overwhelming scientific consensus that significant climate change is happening. This is evidenced in the latest assessment of the Intergovernmental Panel on Climate Change (IPCC AR6). The IPCC Synthesis Report, published in 2023, summarises five years of reports on global temperature rises, fossil fuel emissions and climate impacts. To keep within the 1.5°C limit, emissions need to be reduced by at least 43% by 2030 compared to 2019 levels, and at least 60% by 2035. This is the decisive decade to make that happen.

National commitment

The UK's national commitment is set through the Climate Change Act 2008, which was updated in 2019. It legislates that the UK must be net zero carbon by 2050 and sets a system of carbon budgets to ensure that the UK does not emit more than its allowance in the next 27 years. This legal requirement is underpinned by the Climate Change Committee's (CCC) report '*Net Zero: The UK's Contribution to Stopping Global Warming*'. The concept of carbon budgets is absolutely critical to understand. Net Zero is not only about a destination: a very significant and fast decarbonisation pathway is needed.

The CCC *UK's sixth carbon budget* requires emissions to be reduced by 78% by 2035 compared to 1990 levels. The scope of the budget includes the reduction of emissions associated with products manufactured in the UK but not those used in the UK and manufactured elsewhere. By including embodied carbon (emissions from construction process, maintenance and demolition of the building) in planning policy it will not only assist local authorities in meeting the CCC's carbon budget, but could also positively influence the decarbonisation efforts of other countries manufacturing building materials for the UK.

The CCC's *Policies for the Sixth Carbon Budget* suggests that to improve resource efficiency and incentivise material substitution within construction the Government should: agree a standard for the 'whole-life' carbon footprint of buildings and infrastructure with industry; introduce mandatory disclosure of whole-life carbon in buildings and infrastructure; and introduce a mandatory minimum whole-life carbon standard for both buildings and infrastructure which strengthens over time. To date, no building regulations have been introduced to tackle embodied or whole life carbon.

In addition, at COP26 agreements were made for the UK to reduce its carbon emissions by 68% by 2030 compared to 1990 levels. However, national guidance is still needed to set out how these emission targets are met by the built environment industry.

Net Zero: The UK's Contribution to Stopping Global Warming

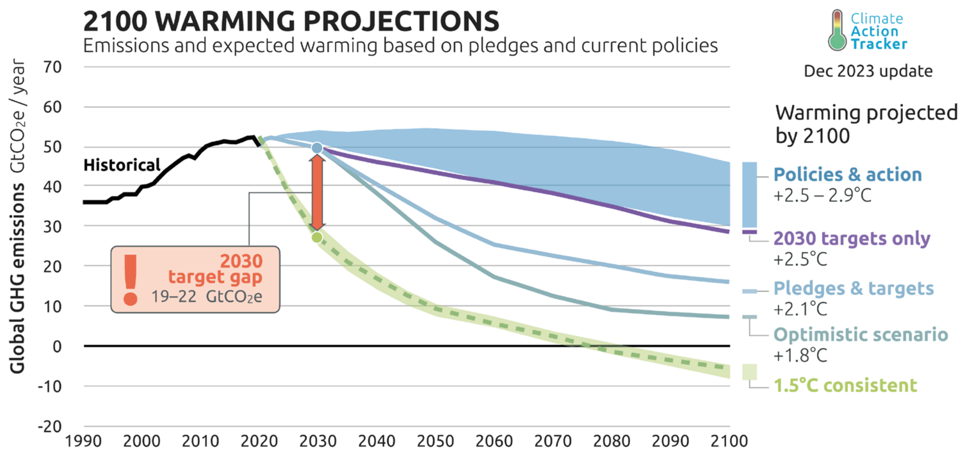
(Source: [CCC, 2019](#))

The sixth carbon budget

(Source: [CCC, 2020](#))

The UK's path to Net Zero

"Our recommended pathway requires a 78% reduction in UK territorial emissions between 1990 and 2035. In effect, it brings forward the UK's previous 80% target by nearly 15 years. Our pathway meets the Paris Agreement stipulation of 'highest possible ambition'."



Global warming projections, highlighting the gap between the predicted temperature rise with policies and action (2.5-2.9°C) and the temperature rise above pre-industrial levels the IPCC recommends (1.5-2°C). A >1°C temperature rise has already been created. (Source: [Climate Action Tracker](#), 2023)

The need for embodied carbon policy in the UK (part 2/3)

Building construction emissions

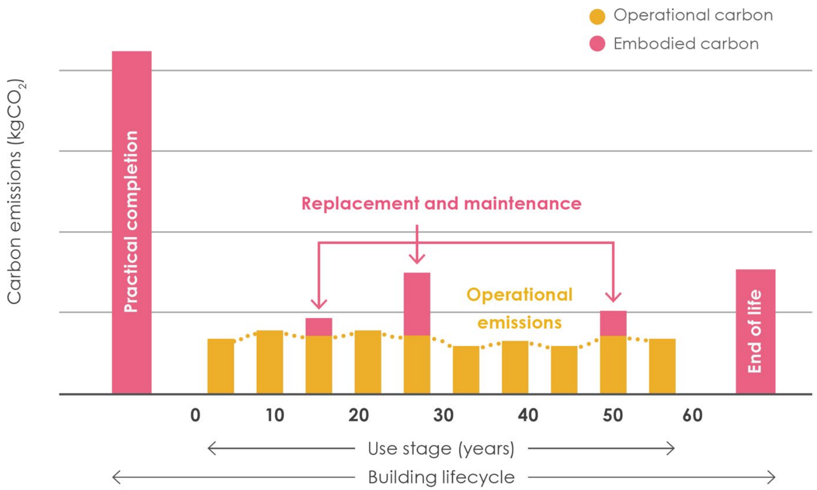
According to the *LETI Climate Emergency Design Guide* the UK building construction industry is responsible for approximately 49% of total UK carbon emissions. Building associated carbon consists of emissions resulting from the operational energy consumption in the day to day running of the building (heating, hot water, lighting, ventilation and plug loads) and emissions resulting from life cycle embodied carbon (construction process, maintenance and demolition of the building).

The importance of embodied carbon emissions

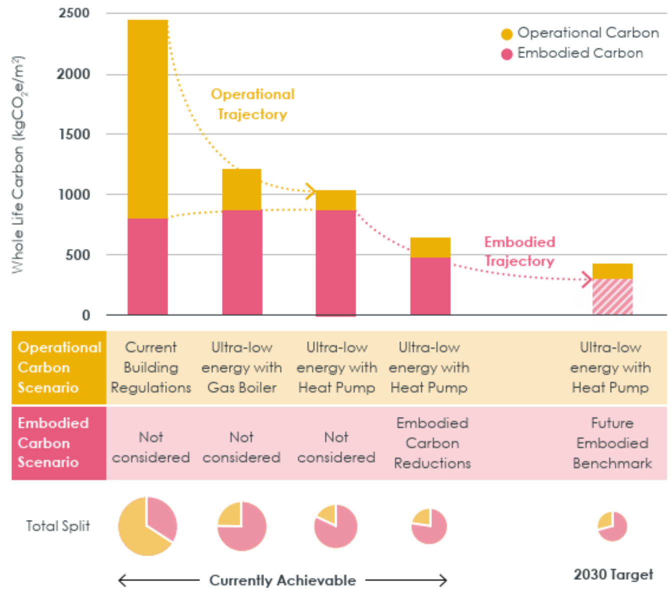
Addressing the national emission targets for the building sector has traditionally focused on reducing operational carbon emissions through their close monitoring in legislation and policy. However, as a building becomes more energy efficient, the operational carbon emissions of new buildings are significantly reduced. This results in embodied carbon emissions representing almost 40-70% of the whole life carbon (WLC) emissions of the building (see bottom right graph).

According to *Net Zero Whole Life Carbon Roadmap* technical report published by the UK Green Building Council in 2021 *"Embodied carbon emissions contribute to some 40-50 million tonnes of CO_2 annually, more than emissions from aviation and shipping combined"*.

Therefore, addressing embodied carbon through legislation and policy is vital to meet local and national climate targets. As embodied carbon relates to materials, it is also important to develop policies that help to transition to a circular economy, in which the resource intensive linear process of use and disposal is stopped.



Interaction between operational and embodied carbon throughout the lifetime of a building (Source: LETI)



Operational and embodied carbon trajectories. As operational emissions are reduced in new buildings, the proportion of embodied carbon emissions becomes higher. The gas boiler scenario is shown only for illustrative purposes . Moving away from fossil fuels (e.g. gas) is essential in achieving net zero carbon (Source: LETI).

The need for embodied carbon policy in the UK (part 3/3)

National policy and regulation does not address embodied carbon

On 13th December 2023, the government published a consultation on the Future Homes and Buildings Standard, which claims that new buildings built from 2025 will produce 75-80% less carbon emissions than buildings delivered under the 2021 Building Regulations. However, the consultation does not address embodied carbon even though the CCC recommended that a whole life carbon standard for homes should be included within the Future Homes Standard, as part of the Policies for the Sixth Carbon Budget.

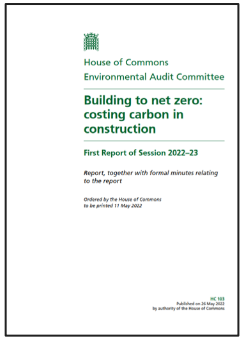
In May 2022, the Environmental Audit Committee (EAC) published a report, urging the government to start acting now on the impact of embodied carbon by stating "*if the UK continues to drag its feet on embodied carbon, it will not meet net zero or its carbon budgets*". The report examines and proposes the best routes to achieve net zero, including:

1. Introducing a mandatory requirement to undertake whole life carbon (WLC) assessments for new buildings as part of the Future Homes Standard.
2. Establishing the RICS methodology as the UK industry standard for WLC assessments and develop a centralised national database of environmental product declarations (EPDs).
3. Learning from international best practice embodied carbon regulation.
4. Investing in research and incentivising low-carbon and re-used materials.
5. Evaluate and inform the impact of permitted development rights on retrofit.
6. Requiring circular economy statements, including pre-demolition audits in planning applications when it entails demolition of existing buildings.

Industry stance

It is important to note that the industry has been asking for a change for years. The efforts have started as early as 2007, when the Department of Communities and Local Government (DCLG) published a report urging the importance of including the embodied carbon of materials as part of the building regulations. However, after 17 years no significant actions have been take by the DCLG.

In addition, the UK's leading embodied carbon experts came together to create Part Z, a building regulation proposal for embodied carbon and relevant guidance around it (see also page 24). In February 2024, the same experts issued a paper to political leaders requesting the inclusion of embodied carbon regulation as part of their manifesto for the upcoming 2025 general elections.


House of Commons
Environmental Audit Committee

Building to net zero: costing carbon in construction

First Report of Session 2022–23

Costing carbon in construction (Source: Environmental Audit Committee (EAC))

EAC- Building to net zero: Costing carbon in construction

"We recommend that the Government introduce, not later than December 2023, regulations to mandate whole-life carbon assessments for buildings above a gross internal area of 1,000m², or which create more than 10 dwellings.

This requirement should be established in Building Regulations, and ought to be reflected in the planning system through national planning policy. Local authorities should be encouraged and supported to include this requirement within their Local Plans ahead of the introduction of national planning requirements."


Policy Position Paper

Embodied carbon regulation – alignment of industry policy recommendations

January 2024: Policy paper by Part Z group of experts

Policy position paper – a call to the party leaders

"The undersigned groups call on party leaders to make the following manifesto commitments

***Key ask:** Our government will move to reduce embodied carbon emissions in building construction within two years of taking office.*

***Specific steps:** Within six months of taking office: Policy signalled confirming the dates and interventions below. By 2026: Mandate the measurement and reporting of whole-life carbon emissions for all projects with a gross internal area of more than 1,000m² or that create more than 10 dwellings. By 2028: Introduce legal limits on the upfront embodied carbon emissions of such projects, with a view to future revision and tightening as required."*

The ability to set local net zero and embodied carbon policy

The role of local authorities

Both operational and embodied carbon must be reduced to address the climate crisis. However, upfront embodied carbon is emitted in the first instance, this means the client/developer has control over emissions.

As embodied carbon is not addressed at the national level it is left for local authorities to fill the gap in their planning policies and decision making. The role of local authorities in mitigating climate change in the UK and delivering sustainable development is articulated in statute and guidance.

A Local Plan would be expected to address:

- **Section 19(1A) of the Planning and Compulsory Purchase Act 2004**, which requires local planning authorities to include in their Local Plans "*policies designed to secure that the development and use of land in the local planning authority's area contribute to the mitigation of, and adaptation to, climate change*".
- The **Climate Change Act 2008**, which establishes a legally binding target to reduce the UK's greenhouse gas emissions by 100% in 2050 from 1990 levels. To drive progress and set the UK on a pathway towards this target, the Act introduced a system of carbon budgets.
- The **National Planning Policy Framework (NPPF),** updated 2023, states that one of the three main objectives of the planning system is environmental, and that 'using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy' form part of this objective. Footnote 56, para 158 also requires local plans' approach to climate change to be in line with the objectives and targets of the Climate Change Act 2008.

By setting an embodied carbon policy in Local Plans, authorities would be responding appropriately to the above statutes. Local authorities have primary powers to act on their duty to mitigate climate change.

To this end, there is a growing number of local authorities requiring embodied carbon and/or whole life carbon in policy (see pages 31-39 for examples).

Essex has already established an evidence led operational carbon policy which goes beyond regulation, therefore, the aim of this evidence base is to recommend an embodied carbon policy to support the operational carbon policy and complete the picture.

Planning and Compulsory Purchase Act 2004

2004 CHAPTER 5

An Act to make provision relating to spatial development and town and country planning; and the compulsory acquisition of land.

[13th May 2004]

Climate Change Act 2008

2008 CHAPTER 27

An Act to set a target for the year 2050 for the reduction of targeted greenhouse gas emissions; to provide for a system of carbon budgeting; to establish a Committee on Climate Change; to confer powers to establish trading schemes for the purpose of limiting greenhouse gas emissions or encouraging activities that reduce such emissions or remove greenhouse gas from the atmosphere; to make provision about adaptation to climate change; to confer powers to make schemes for providing financial incentives to produce less domestic waste and to recycle more of what is produced; to make provision about the collection of household waste; to confer powers to make provision about charging for single use carrier bags; to amend the provisions of the Energy Act 2004 about renewable transport fuel obligations; to make provision about carbon emissions reduction targets; to make other provision about climate change; and for connected purposes. 9

[26th November 2008]

Department for Levelling Up, Housing & Communities

National Planning Policy Framework

Relevant statutes and guidance for planning policy

The evidence of need for embodied carbon policy in Essex

Essex Climate Action Commission (ECAC)

In 2020, an independent group was formed to advise Essex County Council on how to fight climate change. The ECAC is currently funded to run until 2025 and their purpose is to provide expert advice and recommendations to move Essex to net zero by 2050.

Recommendations have been made around six key themes in the Net Zero: Making Essex Carbon Neutral report. This includes recommendations for the 'Built Environment' for which ***"all new homes and non-domestic buildings granted planning permission to be carbon positive by 2030".***

Essex Climate Action Plan (2021-2025)

The Climate Action Plan has been made in response to recommendations made by the ECAC. These recommendations were endorsed by Essex County Council in full in November 2021.

The Climate Action Plan sets out the key activities that have been undertaken to address the challenges facing new build development, which includes:

- The new Climate and Planning Unit (CaPU) to help support local planning authorities with development of climate change local plan policy.
- Development of planning policy and evidence to support operational net zero carbon development.
- Essex Design Guide updates with a dedicated section on climate change.
- Essex Developers Climate Action Charter which has a number of aims relating to climate change and an action plan of how to deliver on these aims.

Essex Developers Climate Action Charter

Essex Developers Group were asked to respond to one of the recommendations from the ECAC by bringing together partners from the public and private sector to deliver a Climate Action Charter with the ambition of becoming zero carbon by 2030.

The Parties acknowledge that each has an important role in addressing climate change and the members have signed up to share the common goals. In particular to minimise "*its environmental impact including reducing the embodied carbon impact of new development*".

Climate emergency declarations in Essex

Nearly all Essex local authorities have made climate emergency declarations.

All new schools commissioned to be carbon zero by 2022 and carbon positive by 2030.

All new homes and all new commercial buildings granted planning permissions to be carbon zero by 2025.

All new homes and non-domestic buildings granted planning permission to be carbon positive by 2030.

The industry needs to secure sustainable building materials with an urgent focus on green procurement standards in place by end of 2022.

ECAC recommendations for all new buildings – specifically relevant to embodied carbon . (Source: Essex County Council)

The **Essex Developers Climate Action Charter**

2.0
The Parties acknowledge that each has an important role in addressing climate change and that:

a. Essex partners have already started to take action on climate change, through the publication of the Essex Climate Action Commission Report (Net Zero: Making Essex Carbon Neutral, July 2021).
b. House builders, contractors and agents are also taking action on climate change, through for example, development of zero carbon housing developments, examples to be shared.
c. Local authorities including Essex County Council, Unitary, City, Borough and District local authorities are developing strategies and programmes to retrofit the existing housing stock, encouraging green developments such as Garden Communities and development of electric vehicle charging infrastructure.
d. Housing associations are also leading the way on pilots designed to retrofit their existing housing stock and developing low / zero carbon housing for the benefit of resident especially those suffering from fuel poverty, examples to be shared.
e. These actions create the foundation for the Parties to be leaders in addressing climate change.

3.0
The members share the common goals of:

a. fostering co-operation across the building sector and inter-governmental relations;
b. aiming to reduce GHG emissions, including both their own and those created by others;
c. removing legislative, regulatory, policy, or other barriers to taking action on climate change;
d. implementing programmes, policies, or legislative actions, that facilitate reduced GHG emissions, where appropriate;
e. encouraging communities that are sustainable, healthy, socially responsive and resilient to a changing climate; and
f. encouraging infrastructure and a built environment that supports the economic and social needs of the community while minimising its environmental impact including reducing the embodied carbon impact of new development;
g. being prepared for the Future Homes/Buildings Standard 2025 and working towards a cost neutral solution to Climate Change;
h. supporting biodiversity and measures to secure net gain in new development;
i. encourage water conservation, water supply and flood protection as part of regional infrastructure, working with the water companies.

Essex Developers Climate Action Charter – roles and goals. (Source: Essex County Council)

Proposed and placeholder net zero carbon policy for Essex

In November 2023 the Essex Climate and Planning Unit produced a Planning Policy Position for Net Zero Carbon. This paper supports a target for all planning permissions for new buildings to be net zero carbon by 2025 and carbon positive by 2030 , recommended by the Essex Climate Action Commission (ECAC). The ECAC recommendations form the basis of the ECC Climate Action Plan and are relevant to all Essex Local Planning Authorities (LPAs). The paper sets out two proposed planning policies:

- **NZ1 - Net Zero Carbon Development – Operational Carbon** – This proposed policy has been developed from an evidence base for a consistent policy approach across Essex towards net zero operational carbon for residential and non-residential development.
- **NZ2 – Net Zero Carbon Development – Embodied Carbon** – This is a 'placeholder' policy for local planning authorities to use for consultation purposes. The aim of the policy is to ensure whole life cycle carbon assessments are carried out using a recognised methodology and that measures are taken in new developments to significantly reduce embodied carbon emissions and meet the current best practice targets.

This evidence base seeks to inform the replacement of the 'placeholder' policy for embodied carbon while supporting the operational carbon policy.

POLICY NZ2: NET ZERO CARBON DEVELOPMENT – EMBODIED CARBON

Proposals for Large scale new-build developments (a minimum of 100 dwellings or a minimum of 5,000m^2 of commercial floor space) must submit a Whole Life-Cycle Carbon Assessment that demonstrates the following buildings targets have been met:

a) 'upfront' embodied carbon emissions;

i. Residential: <500kgCO$_2$/m^2

ii. Non-Residential: <600kgCO$_2$/m^2

and

b) Total embodied carbon

i. Residential: <800kgCO$_2$/m^2

ii. Non-Residential: <970kgCO$_2$/m^2

Essex Planning Policy Position for Net Zero Carbon – 'placeholder' policy NZ2 (Source: Essex County Council)

2

Embodied carbon explained

Embodied carbon in the wider carbon context

The making of materials, their transport, repair and deconstruction affects how much carbon is associated with them. Embodied carbon is assessed through the use of different boundaries. This is a summary of the key boundaries and the terms associated with them. The following pages explain the boundaries and modules in more detail, together with their relevance to planning policy. Upfront and lifecycle embodied carbon is measured in tonnes (tCO_2e) and is normalised to $kgCO_2e/m^2$. For example, if the volume of concrete in one building is the same as that of another, they will emit the same total tCo_2e. However, if one building is twice the area of the other, when normalised, it will become obvious that the smaller building has higher emissions per m^2 GIA ($kgCO_2e/m^2$).

Upfront embodied carbon

Upfront embodied carbon refers to the greenhouse gas emissions associated with material and construction stages: raw material supply, manufacture, transport and construction of all building elements

Life cycle embodied carbon

Life cycle embodied carbon includes both upfront embodied carbon and the embodied carbon associated with:

- In-use - maintenance, replacement and refrigerant leakage.
- End of life - waste processing of demolition/deconstruction and disposal of any products.

Operational carbon

Operation carbon refers to the emissions associated with energy and water use during operation.

User carbon

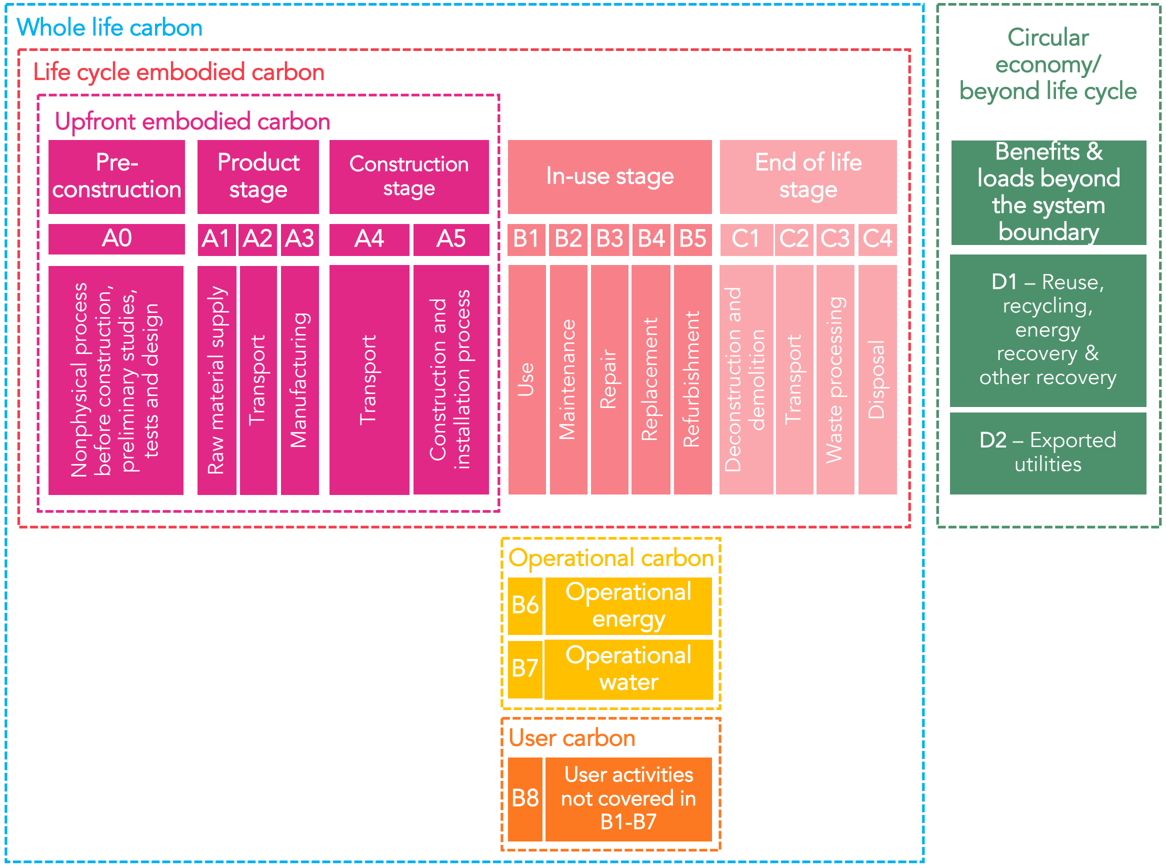
User carbon covers the emissions from user activities, outside of the use of energy and water emissions from the operation of the building. An example includes transport or vehicle charging. This module is typically outside the remit of building design and has not been included on following pages.

Whole life carbon (WLC)

For buildings, whole life carbon is the sum of life cycle embodied carbon and operational carbon.

Circular economy/beyond life cycle

A circular economy seeks to ensure materials can be re-used again and again and are ultimately diverted from landfill or incineration. This builds on embodied carbon principles, such as material re-use, recovery and recycling.



Modular information for the different boundaries of the building assessment. *This version of the diagram is adapted from a combination of the diagram from the BS EN 15978, RICS 2023 and LETI.*

RICS 2023 definitions:

Greenhouse gases (GHGs) (often referred to as 'carbon emissions')

"Constituents of the atmosphere, both natural and anthropogenic (human-created), that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds."

Carbon dioxide equivalent (CO_2e)

"A metric for expressing the impact of all greenhouse gases on a carbon dioxide basis."

Upfront and life cycle embodied carbon explained

Upfront embodied carbon

Upfront embodied carbon refers to the greenhouse gas emissions associated with material and construction stages: raw material supply, manufacture, transport and construction of all building elements.

Designers have the greatest ability to reduce upfront embodied carbon pre/post-planning by considering how a new building can be optimally designed and through the materials specified. This lends itself to benchmarking or target setting through planning policy, as it is the area most easily influenced by policy and addressed by client and design teams during the planning process.

Industry targets such as LETI are framed around upfront embodied carbon (modules A1-A5) (see page 23) and some recently adopted planning conditions also focus on these modules (see pages 31-39).

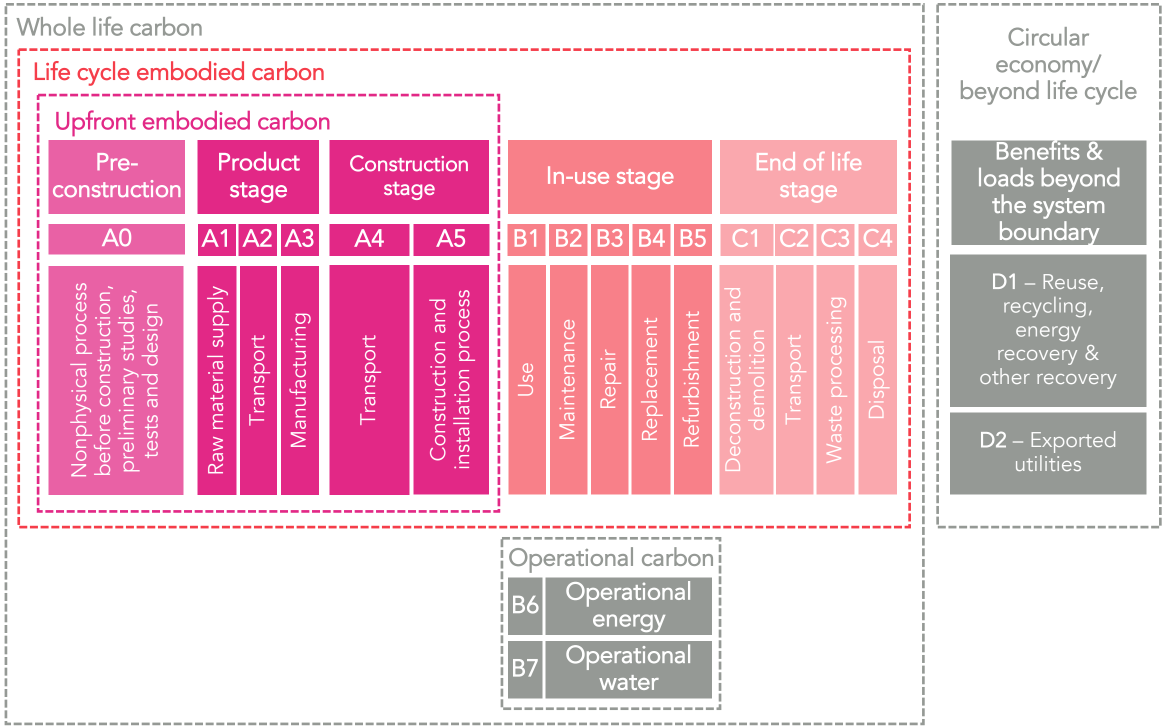
Module A0 (pre-construction stage) covers non-physical pre-construction activities, such as surveys and activities associated with the design of the asset. For buildings, these emissions do not normally have a significant environmental impact and therefore, are assumed to be negligible. Module A0 has a greater significance for larger infrastructure projects.

To have the greatest immediate influence on the design and construction of buildings in Essex, the primary focus for this evidence base will be on upfront embodied carbon. To support this, policy has also been recommended for retention of buildings, whole life carbon and circular economy as incredibly important areas for design and planning policy when considered in the round.

Life cycle embodied carbon

Life cycle embodied carbon includes both upfront embodied carbon (above) and the embodied carbon associated with the building in-use and at the end of life.

While design teams have some influence of the B and C modules in new build (through robust design, specification, and design for deconstruction), building owners and occupiers who will maintain and refurbish the building will have the most influence. This makes life cycle embodied carbon more complex to integrate into planning policy through target setting or benchmarking. Planning policies set around life cycle carbon may benefit from being more qualitative than quantitate. However, examples exist of planning policies and industry targets that consider life cycle carbon (see pages 31-39).



Building assessment modules with a focus on life cycle and upfront embodied carbon. *This version of the diagram is adapted from a combination of the diagram from the BS EN 15978, RICS 2023 and LETI.*

RICS 2023 definition:

Life cycle embodied carbon

> *"The embodied carbon emission of an asset are the total green house gas (GHG) emissions and removals associated with materials and construction processes, throughout the whole life cycle of an asset (modules A0-A5, B1-B5, C1-C4, with A0 assumed to be zero for buildings)."*

Upfront embodied carbon

> *"Upfront carbon emissions are GHG emissions associated with materials and construction processes up to practical completion (modules A0-A5). Upfront carbon excludes the biogenic carbon sequestered in the installed products at practical completion."*

Operational carbon explained

Operational carbon refers to the emissions associated with energy and water use of a building during its operation.

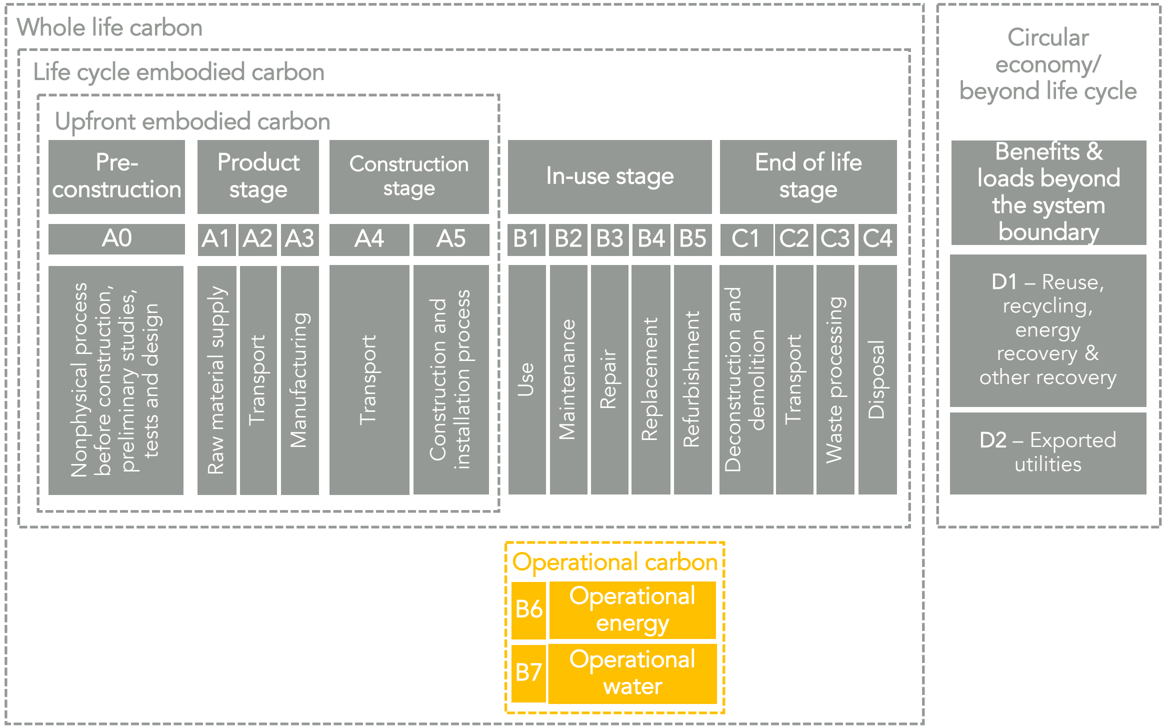
Operational carbon can and should be reduced through planning policy. An evidence base for Essex was commissioned and established by the Climate and Planning Unit at Essex County Council in collaboration with the Essex local authorities. The evidence underpins the Planning Policy Position for Net Zero Carbon published to demonstrate how to set net zero carbon policy that is feasible, viable and justified and aligns with climate targets. Operational water (B7) is out of the scope of this policy, however, it will be addressed in a future water-related policy.

Balancing operational and embodied carbon

Decisions taken during the design of a building to improve operational carbon can have an impact on the resulting embodied carbon. Rather than considering operational carbon and embodied carbon separately a balance needs to be struck across all environmental considerations. Therefore, the focus should be to be on reducing operational carbon in support of ultra-low energy buildings alongside life cycle embodied carbon, as opposed to trading one off of another.

Some considerations for reducing upfront embodied carbon, when ensuring the building achieves a net zero operational carbon include:

- An efficient building form almost always emits less upfront embodied carbon than a complex building form. It is also more likely to have lower operational carbon and reduce construction costs.
- Features such as: shading devices to reduce overheating; dual aspect dwellings for cross ventilation and daylight; green and blue roofs for sustainable urban drainage and biodiversity; or renewables should not be traded with embodied carbon. Instead their impact should be recognised and reduced through the consideration of low embodied carbon materials.
- Even though windows typically have a lower upfront embodied carbon than external walls, their total area should not exceed the recommended glazing-to-walls-ratio (north 10-15%, south 20-30%, east and west 10-20% for residential buildings), in order to keep a balance between upfront embodied carbon, the operational energy target, overheating and levels of daylight.
- When choosing different types of façade/external wall build-ups based on the lower upfront embodied carbon, energy performance parameters (u-values /airtightness) should always seek to achieve an ultra-low energy building.



Building assessment modules with a focus on operational carbon. *This version of the diagram is adapted from a combination of the diagram from the BS EN 15978, RICS 2023 and LETI.*

RICS 2023 definition:

Operational carbon

> *"Operational carbon – energy (module B6) refers to GHG emissions arising from all energy consumed by an asset in use, over its life cycle.*
> *- water (module B7) refers to GHG emissions arising from water supply and wastewater treatment for an asset in use, over its life cycle "*

Whole Life Carbon explained

Whole life carbon is the sum of life cycle embodied carbon and operational carbon.

Bringing together operational and embodied carbon

In 2023, LETI shared an opinion piece on the topic of bring together operational and embodied carbon into whole life carbon assessment.

The RICS Whole Life Carbon Assessment for the Built Environment translates international guidance (BS EN15978) into the UK context. The second edition was released in 2023 and is planned to come into effect in June 2024. This industry standard methodology combines operational and embodied carbon to create whole life carbon figures following industry best practice.

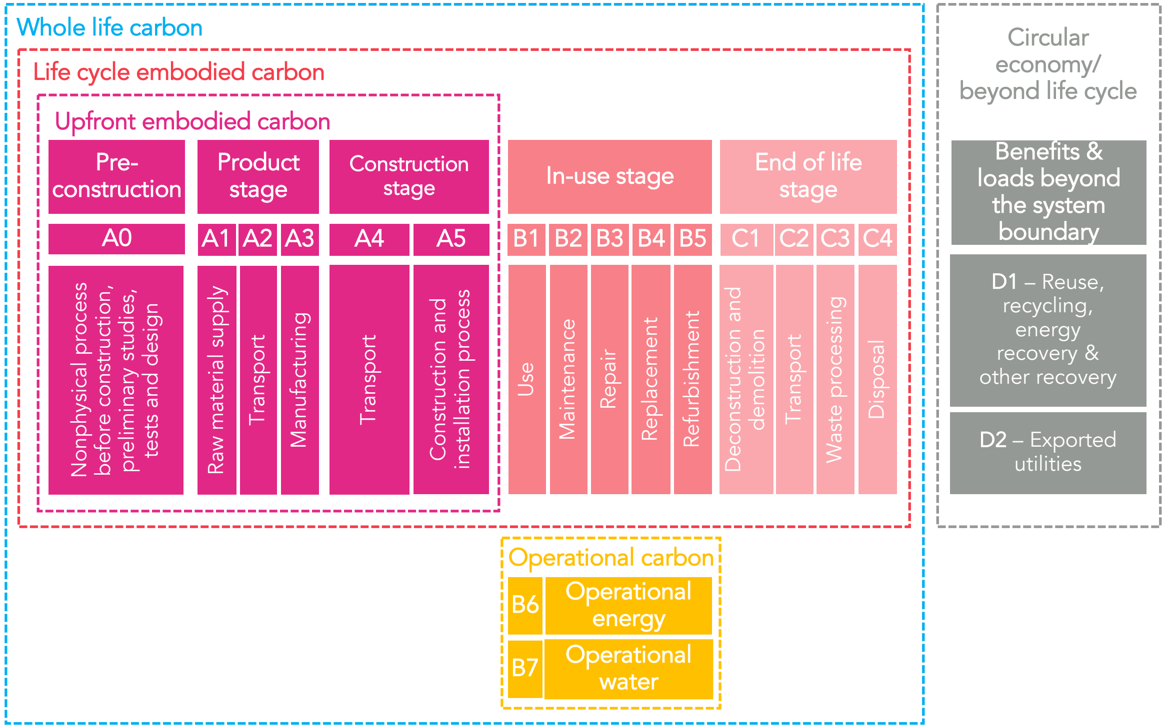
While there are benefits to calculating and reporting whole life carbon figures, if used without interrogation of the embodied and operational components separately they can mask poor design decisions and performance. Allowing embodied carbon to be traded with operational carbon.

The Greater London Authority (GLA) London Plan Policy SI 2 requires the full submission of Whole Life Carbon emissions. This currently applies to large scale, referable applications (see page 31 for more detail).

The campaign to introduce Part Z in to the Building Regulations also proposes the mandatory measurement and reporting of Whole Life Carbon emissions. (see page 24 for more detail).

Current and future considerations for Essex

The Essex policy position approach of calculating and reporting operational energy separately from embodied carbon has the benefit of ensuring each area is optimised and clearly demonstrated in design and construction. It may be that the reporting of whole life carbon figures in addition to the separate calculation of operational energy and embodied carbon could be a useful metric for Essex to consider as part of a stepped approach to policy. To calculate whole life carbon the policy would need to cover: lifecycle embodied carbon (not just upfront embodied carbon); a translation of operational energy into carbon emissions; and the additional calculation of the carbon associated with operational water consumption.



Building assessment modules with a focus on whole life carbon. *This version of the diagram is adapted from a combination of the diagram from the BS EN 15978, RICS 2023 and LETI.*

RICS 2023 definition:

Whole life carbon

> *"Whole life carbon emissions are the sum total of all asset-related GHG emissions and removals, both operational and embodied, over the life cycle of an asset, including its disposal (modules A0–A5, B1–B7, B8 optional, C1–C4, all including biogenic carbon, with A0 assumed to be zero for buildings).*
>
> *Overall whole life carbon asset performance includes separately reporting the potential benefits or loads from future energy or material recovery, reuse, and recycling and from exported utilities (modules D1, D2)."*

Circular economy explained

A circular economy seeks to ensure materials can be re-used again and again and are ultimately diverted from landfill and incineration. This combats planetary resource depletion and excessive waste production.

The cross over between circular economy and embodied carbon

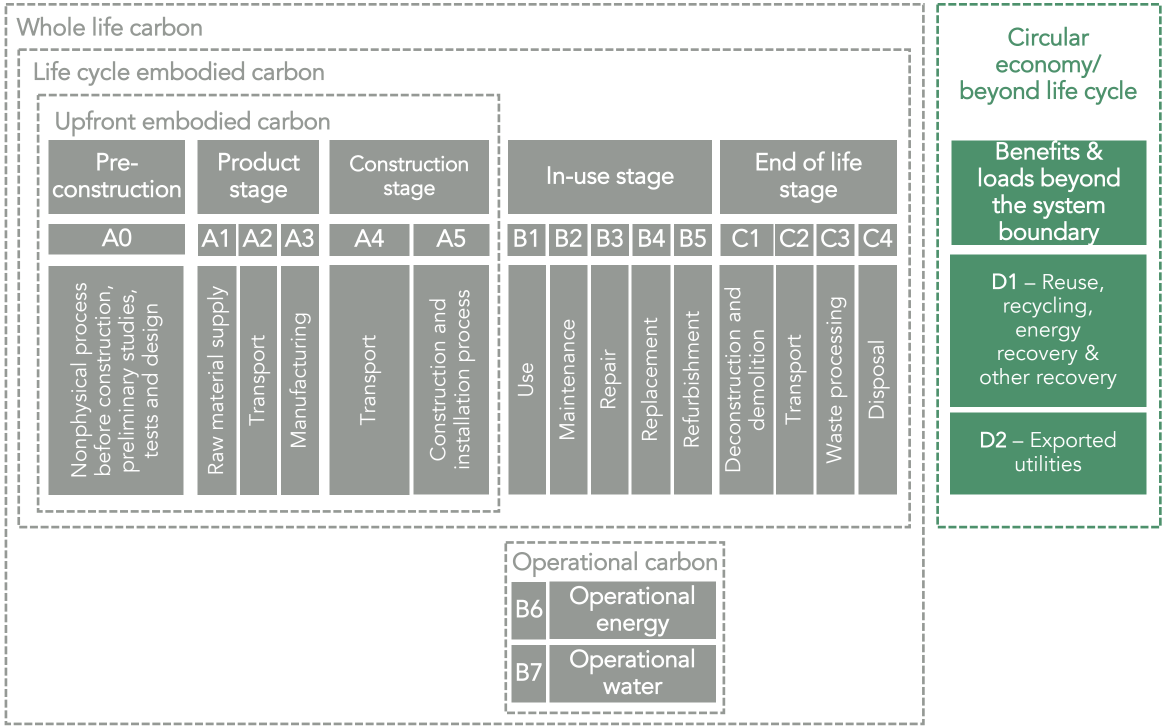
The aims of the circular economy are to minimise resource depletion, increasing biodiversity through reducing material excavation and enabling improvements to ecological systems. The focus of embodied carbon is currently on the requirement to limit carbon emissions through material selection and use. In this context, upfront embodied carbon is often viewed as more critical, because the emissions are more immediate. In 2021, LETI shared a useful opinion piece on this topic.

In some instances, applying circular economy principles could increase upfront embodied carbon:

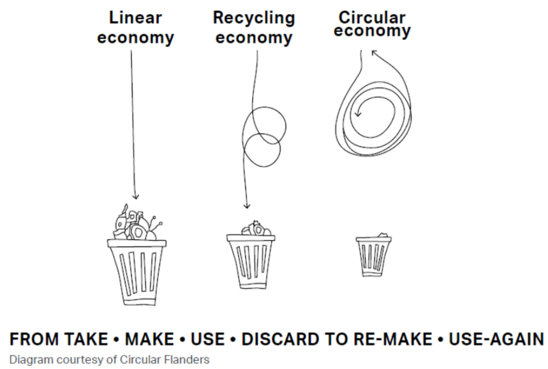
- Designing in flexibility for a potential future use that may not come to fruition e.g. a primary structure with a higher loading or larger grid than needed for the initial use or more central plant for a potential higher energy use.
- Designing for longevity and fewer replacement cycles versus designing for an expected shorter life cycle and allowing for deconstruction.

Conversely, circular economy principles can also be used to create embodied carbon reductions:

- The more building and material re-use on-site the lower the embodied carbon. This is because, less processing, transport and waste emissions are generated, even if new material is needed for repairs or fabric enhancements.
- Similarly, when re-using material from other sites there are generally fewer processing emissions than when using virgin material.
- When specifying materials with high recycled content it is important to check environmental product declaration (EPD) data as these can vary significantly, depending on the processing required to extract using material from existing and re-process.
- In principle, long life and designing for disassembly allows for future adaptation, replacement and maintenance; with less disruption and damage to surrounding material. It is also more likely that materials or elements can be salvaged for re-use elsewhere.



Building assessment modules with a focus on circular economy. *This version of the diagram is adapted from a combination of the diagram from the BS EN 15978, RICS 2023 and LETI.*



The difference between linear and circular economy (Source: Circular Flanders).

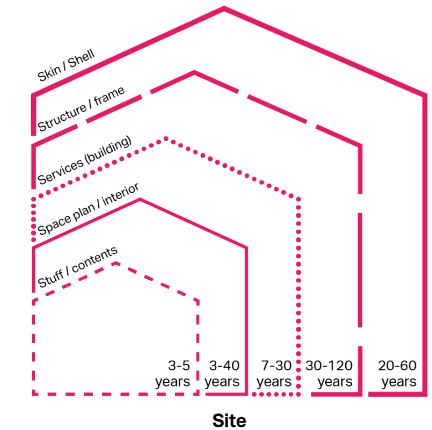


Illustration of building layers and their different lifespans – this will be specific to each development (Source: GLA).

3

Industry guidance on embodied carbon

Existing guidance and standards

RICS - Whole Life Carbon Assessment for the Built Environment

The Royal Institute of Chartered Surveyors (RICS) first published the 'Professional Statement: Whole Life Carbon (WLC) assessment for the built environment' in 2017. It is the industry standard methodology for WLC assessments and provides supporting guidance in line with BS EN 15978 principles. The document outlines the minimum scope required for a WLC assessment, including demolition, facilitating works, substructure, superstructure (structural element, building envelope, internal elements), finishes, fittings, furnishing and equipment (FF&E), services (MEP) and external works within the building's boundary. RICS accounts for sequestered carbon in materials separately but does not account for biogenic carbon losses from the existing site (existing plants, habitats, etc.).

A second edition of RICS Professional Statement was published in September 2023 and is due to take effect in July 2024. Key changes include:

- the separate reporting of buildings within a site
- the introduction of new life-cycle stages, some of which are mandatory to report (e.g. A5.1, demolition)
- the inclusion of return trips in transport emissions
- the alignment of carbon data with the cost plan of the projects
- the separate reporting of carbon offsets and biogenic carbon (biogenic carbon can only be claimed for sustainably sourced materials)
- the rating of quality of data for carbon emissions.

This evidence base for the embodied carbon policy recommendations has followed the RICS methodology, to correlate with the industry standards.

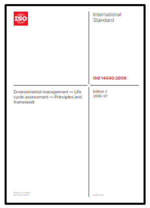
Other useful guidance and targets

Additional useful embodied carbon and circular economy guidance and information can be found from ISO 14040 and ISO 14044, the Royal Institute of British Architects (RIBA), Low Energy Transformation Initiative (LETI), Chartered Institution of Building Services Engineers (CIBSE), Building Research Establishment's BREEAM, the UK Green Building Council (UKGBC), the Institution of Structural Engineers (IStructE) , the Centre for Windows and Cladding Technology (CWCT) , the Concrete Centre, industry proposed Building regulations Part Z, Buildings as Material Banks (BAMB), and the UK Net Zero Carbon Building Standard (NZCBS) currently under development.

Professional standard for assessment:

RICS 2017 (left) and 2023 (right) professional statements: Whole Life Carbon assessment for the built environment. RICS PS v2 2023 is to be implemented from July 2024.

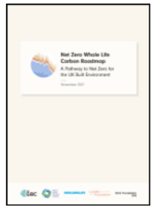
Industry guidance and targets:



ISO 14040-44 Environmental management LCA

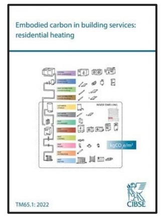
RIBA 2030 climate challenge

LETI embodied carbon primer



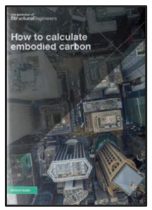
UKGBC – Net zero whole life carbon roadmap

UK Net Zero Carbon Building Standard

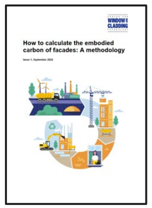


TM 65 – Embodied carbon in building services

Other useful guidance:

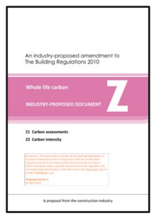


IStructE – How to calculate embodied carbon



CWCT– How to calculate embodied carbon of facades

The concrete centre– Sustainable concrete



Part Z proposed amendment to building regulations

BAMB –Material passports

Existing industry targets and benchmarks

LETI

In 2021, LETI reviewed how targets from different organisations could be reconciled with each other. To do so they consulted other industry groups including CIBSE, RIBA, IStructE, the GLA, and the Whole Life Carbon Network. The Whole Life Carbon Alignment paper set targets for upfront and life cycle embodied carbon and provided a set of reporting templates to help with consistency. The targets from all these organisations represent different life stages, building typologies, building elements and pathways to net zero.

RIBA

RIBA developed voluntary performance targets for embodied carbon, operational energy use and water use which form the basis of the RIBA 2030 Climate Challenge published in 2021. The targets were set after consultations with experts across the industry. The targets are based on a growing database of projects submitted by signatories who have committed to participate the data collection for the initiative.

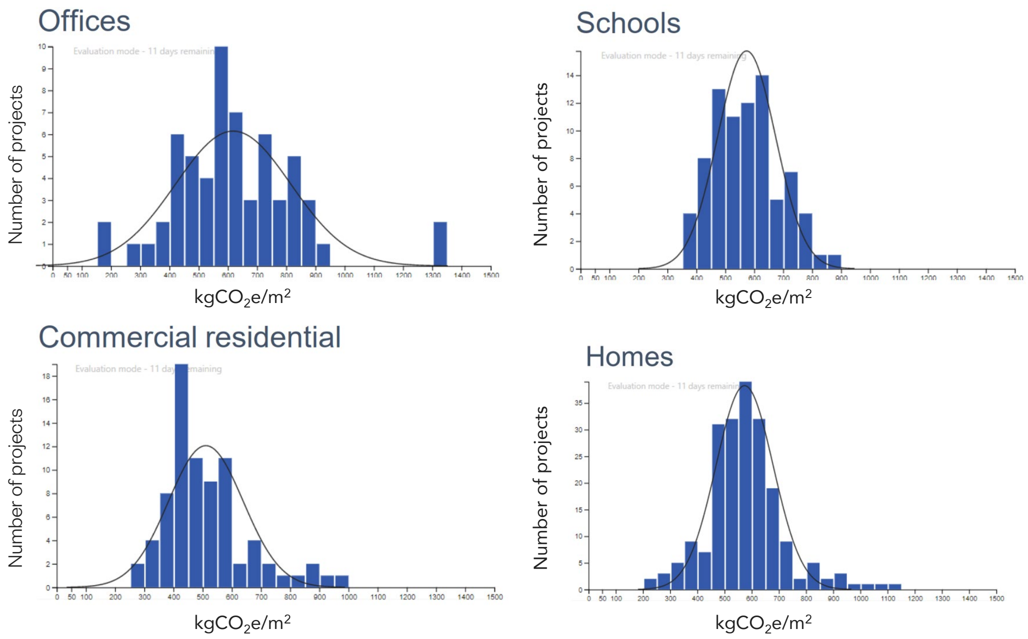
Further work in the industry - NZCBS

The UK Net Zero Carbon Building Standard (NZCBS) is a science-based research project aimed at developing a unified methodology for achieving net zero carbon buildings in the UK. The standard is in development and is in the process of reviewing upfront embodied carbon targets. In a technical study (June 2023) focused on assessing the upfront embodied carbon of new builds, performance levels of recent schemes were reviewed.

The performance levels opposite give an indication of how projects compare for their predicted upfront embodied carbon. The number of schemes submitted was significant across many building typologies. While this evidence base is useful, it also has some limitations in that the quality of the data submitted by design teams could not be verified, nor were the scale of the schemes necessarily comparable. However, this is the first time this number of results were brought together to give an indication of how they compare and their performance.

Upfront embodied carbon, $kgCO_2e/m^2$ (modules A1-A5, excluding upfront biogenic carbon)				
Band	Office	Residential (6+ storeys)	Education	Retail
A++	<100	<100	<100	<100
A+	<225	<200	<200	<200
A (LETI 2030)	<350	<300	<300	<300
B	<475	<400	<400	<425
C (LETI 2020)	<600	<500	<500	<550
D	<775	<675	<625	<700
E	<950	<850	<750	<850
F	<1100	<1000	<875	<1000
G	<1300	<1200	<1100	<1200

Upfront embodied carbon targets for various building typologies. *The residential targets have been set based on data from 6+ storey developments, therefore the applicability to low-rise housing is unknown (Source: LETI)*



Upfront embodied carbon case study analysis (Source: Net Zero Carbon NZCBS)

Part Z and the Net Zero Carbon Building Standard

Outside of the planning system, proposed ways of regulating embodied carbon and whole life carbon have been developed. These initiatives are a step beyond the initial thinking around target setting and are a consensus view formed by many in the industry. Below is a summary of two most relevant:

Part Z – how to regulate the construction industry at scale

The Part Z proposal sought to provide a framework for implementing whole life carbon assessments and embodied carbon targets, for all major development, by suggesting it is embedded into building regulations. The proposed Part Z uses whole life carbon assessment methods to provide a clear and tested way for developers to measure performance at the various stages of a project after planning, including the as-built stage.

The Part Z project was aimed at giving regulators a high-level template for implementing reasonable standards sooner rather than later, instead of a push towards best practice. Planning policy would still have a role in reducing whole life carbon emissions if the recommendations of Part Z were taken forward. As is the case with operational carbon regulation and policy, local authorities may choose to push policy further than the initial Part Z proposals.

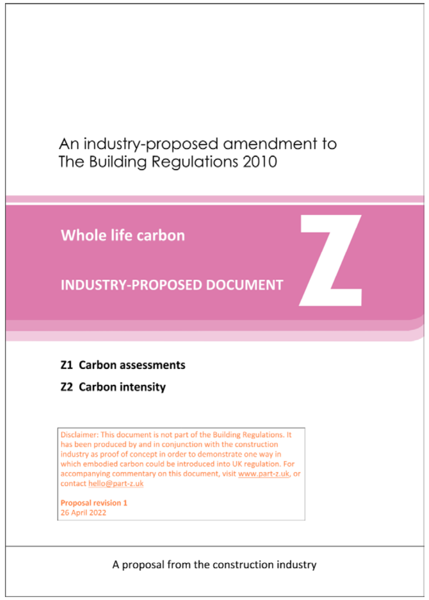
Net Zero Carbon Building Standard – well evidenced targets

This standard is currently being developed and represents the biggest cross industry working group looking at a net zero carbon standard. The research is a comprehensive review of previous guidance and targets and pulls information from a variety of data sources (including planning submissions, assessment databases) to arrive at limits for different building types. In the future NZCBS could be set in policy much like BREEAM or other certification standards.

As the standard is work in progress, only the current findings can be referenced for this evidence base. It is unknown whether it will stay as an industry standard or be adopted by local authorities and/or Government. **This evidence base study is exploring the best approach for Essex and should be compared to the NZCBS targets when the standard is released.**

Encouraging good development whilst preventing the worst

The challenge of introducing ambitious planning policies is that, whilst trying to implement them, poor quality development will continue to be unchallenged. Implementing the policy incrementally is one approach that can help, as is proposed in Part Z. Another, might be to set aspirational standards alongside minimum levels to prevent the worst practice. The minimum standard could then be improved upon over time.



An industry-proposed amendment to
The Building Regulations 2010

Whole life carbon

INDUSTRY-PROPOSED DOCUMENT

Z

Z1 Carbon assessments

Z2 Carbon intensity

Disclaimer: This document is not part of the Building Regulations. It has been produced by and in conjunction with the construction industry as proof of concept in order to demonstrate one way in which embodied carbon could be introduced into UK regulation. For accompanying commentary on this document, visit www.part-z.uk, or contact hello@part-z.uk

Proposal revision 1
26 April 2022

A proposal from the construction industry

Proposed Part Z (Source: Part Z)

The proposed key metrics for the standard are:

- **Energy Use Intensity** (EUI) limits (kWh/m²/yr)
- **Upfront** (A1-A5) **embodied carbon limits** (kgCO_2e/m²)
- **Life cycle** (A1-C4) **embodied carbon reporting** (kgCO_2e/m²)

Other metrics – such as space heating/cooling demand and peak load – are also to being considered,

UK NZCBS periodically release updates on progress and technical reviews. The above are a few metrics to be addressed in the standard (Source: NZCBS).

4

Embodied carbon in design and planning

Embodied carbon in the design and planning process

The diagram on the right illustrates how upfront embodied carbon processes run alongside the planning process. This gives an indication of the types of activities that could be influenced by and checked during the planning process through policy, and the activities that will need to be encouraged and verified through planning conditions.

Pre-planning and during planning – policy and design

Through Local Plans, planning policies could be set to steer design decisions that would reduce the embodied carbon of the buildings. There is a significant opportunity to reduce upfront embodied carbon through good design choices. For example, lean design strategies (where buildings are carefully designed to use less material) are key in reducing the amount of high embodied carbon materials needed in a building, e.g. optimised structure and foundations, less use of metal components in façades and plastics and refrigerants in building services. These design decisions could also be influenced through the Essex Design Guide. Guidance on embodied carbon would assist applicants in considering the impact of their design.

Post-planning – policy and design

Assuming the design of the building has been improved to reduce upfront embodied carbon pre-planning, the focus on policies and conditions should be on verifying that the planning commitments are being delivered and on those which deliver the reduction of embodied carbon during detailed design, specification and procurement.

Design guidance

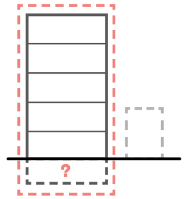
Pragmatic guidance in the Essex Design Guide on delivering exemplar projects is important in assisting the design team to meet embodied carbon alongside net zero operational policies. This guidance should be easy to read and understand, including illustrations and key notes. It should form the basis of project discussions, brief settings, design reviews and pre-planning/ post occupancy audits. It will inevitably need to be tailored to suit each project, but can demonstrate exemplar embodied carbon design techniques.

Upfront embodied carbon processes

Pre-planning and planning

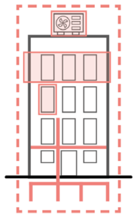
Planning policies

RIBA Stage 1



- Retrofit and re-use over new build.
- Ground condition survey and availability of local materials, which will influence design.
- Recognise the embodied carbon impact of non-typical features (cantilevers, dormers, podiums, basements), pre-determined material choices due to fire regulations and any other required features (shading devices, renewables, etc.).
- Calculate form factor to illustrate efficient building form.

RIBA Stage 2-3

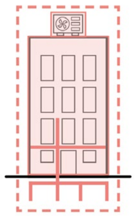


- Structural lean design - including efficient grid, lean specification and material choice. Declare volumes of materials.
- Architectural lean design – including façade studies and material choice. Declare volumes of materials.
- Building services lean design – avoid over sizing, reduce pipework runs and refrigerant selection.
- Highlight areas where embodied carbon is reduced or increased by design.
- External works study.
- Upfront embodied carbon and WLC calculations.

Post-planning

Planning conditions

RIBA Stage 4-7



- More accurate product specification.
- More detail added to materials and quantities.
- Regularly reviewing upfront embodied. carbon to ensure it does not increase through material selection and construction changes on-site.
- Independently verified upfront embodied carbon and WLC calculations at end of construction.

Planning process alongside upfront embodied carbon processes

Measuring and reporting embodied carbon

Measuring embodied carbon is governed by the RICS Whole Life Carbon Assessment for the Built Environment which translates the BS EN15978 international guidance into the UK context. The second edition was released in 2023 and comes into effect in June 2024.

The second edition of the RICS standard (2023) was released to ensure consistent and robust embodied carbon measurement and reporting. It outlines the relationship between embodied carbon and Whole Life Carbon and contains guidance on the following:

- How to carry out assessments at various stages of design and the data to use
- How to break down a building into elements for measurement, benchmarking and carbon emission reduction purposes
- How to measure different types and scales of projects
- What to include in each life cycle stage
- How to account for uncertainty
- How to report the results in a consistent manner.

RICS 2023 Whole Life Carbon Assessment for the Built Environment Professional Statement. (Source: RICS)

Building/infrastructure reporting

- *Raw data*
- *Increasing detail as the design develops*

Summary reporting

- *high level key metrics*
- *can report a number of assets together*
- *decarbonised and non-decarbonised*

Units of measurement

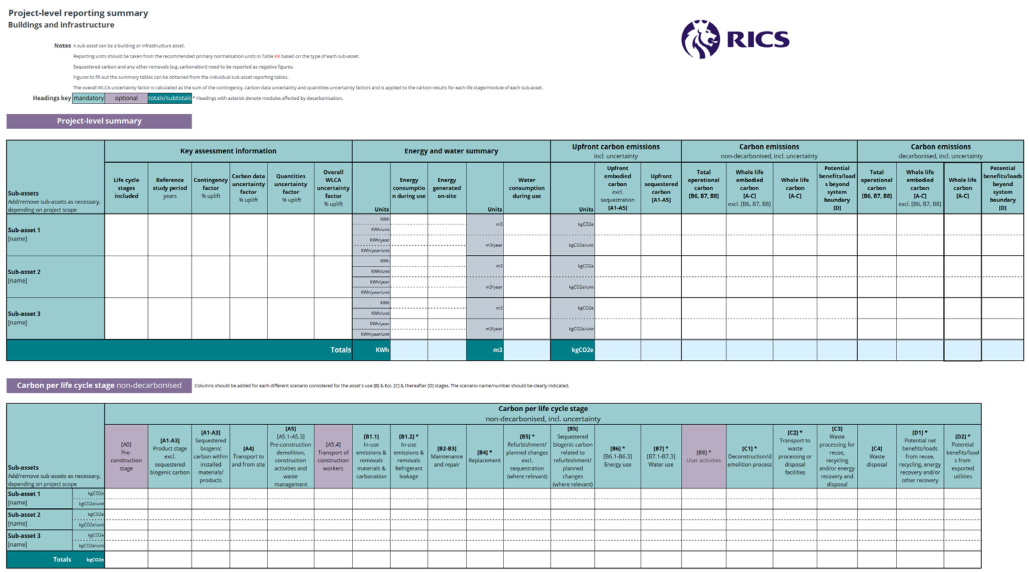
Embodied carbon is reported either as a total in tonnes of CO_2 equivalent (tCO_2e) or is normalised to kilograms of CO_2 equivalent per sqm ($kgCO_2e/m^2$). Carbon equivalent (CO_2e) is the metric for expressing the impact of all greenhouse gases on a carbon dioxide basis. While upfront carbon represents the carbon emitted to the point of the building at Practical Completion, the in-use and end-of-life stages assumes a Reference Study Period of 60 years for buildings - this is for industry consistency. Materials are also assigned a serviceable life as defined by RICS.

Reporting

RICS 2[nd] ed. 2023 contains standard reporting templates for presenting the embodied carbon results. This allows for comparable figures across the industry and could be adopted as a helpful implementation measure in policy.

Influence on policy

A key point for policy to consider is whether it will require the reporting of embodied carbon only, or if it is to cover Whole Life Carbon, drawing in the influence of operational emissions.



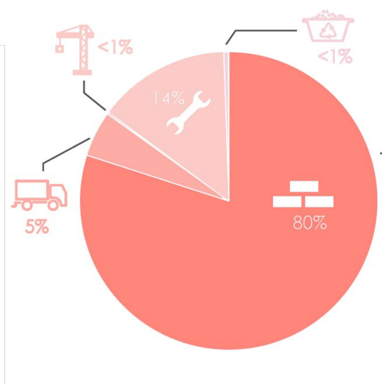
RICS 2023 reporting templates (Source: RICS)

Measuring upfront embodied carbon – materials and quantities

Upfront embodied carbon associated with one particular material is calculated by multiplying its embodied carbon rate by its quantity.

Materials used in superstructure and substructure are generally used in large quantities, so their selection is likely to have a significant impact on the overall upfront embodied carbon.

Using a high embodied carbon material may be acceptable if it is used in small quantities. If used in large quantities, lower carbon alternatives should be investigated.



Average split of embodied carbon per building element:

- **30%** - Superstructure
- **27%** - Substructure
- **20%** - Internal finishes
- **17%** - Façade
- **5%** - MEP

- Products/materials (A1-A3)
- Transport (A4)
- Construction (A5)
- Maintenance and replacements (B1-B5)
- End of life disposal (C1-C4)

Reducing embodied carbon for the largest uses/ greatest quantities *(Source: LETI)*

Pyramid for illustration only

Labels on the right suggest a selection of materials commonly used in the UK:

Metals

Steel structures, slate, aluminium window frames and paint

Brick, PIR insulation, double/triple glazing, composite window frames, plasterboard, concrete

Mineral wool, EPS and XPS insulation

Natural based products

These are Danish figures and are not intended to be used in the UK, but the hierarchy is useful ***as an illustration****. The material selection pyramid illustrates high embodied carbon materials at the top and low embodied carbon materials at the bottom (module A1-A3, based on global warming potential). Follow link www.materialepyramiden.dk to see the pyramid in more detail.*

Reducing embodied carbon through design and the impact on capital cost

Reducing the upfront and life cycle embodied carbon of a building does not necessarily mean higher capital costs. Contrary to this, adopting strategies such us lean and circular economy design can reduce capital costs. This is due to reducing the volume of materials needed in a building and the frequency of maintenance, or allowing the building to be used for multiple purposes.

Where embodied carbon targets are set in planning policy, this has the ability to restrict material selection, unintended or otherwise. Therefore, for viability reasons where targets and benchmarks are used these will be reviewed to check they are stretching but not unintendingly limiting.

Structural lean design

The sub-structure (portion of the building that is below ground, e.g. foundations) and super-structure (portion of the structure that is above ground level, e.g. beams, columns, finishes and windows) often represents >50% of upfront embodied carbon emissions in a building. Designing leaner structure can reduce the volume of overall material used in the building, including less foundations where the building becomes lighter. Considerations for reduction include: structural grid spacing (distance between columns), location of the service core (e.g. staircases, elevators and risers) , structural depth, amount of cantilevers (e.g. projecting balconies). These can all be capital cost saving design exercises.

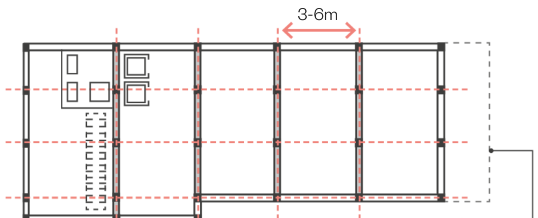
Architectural lean design

Façades often represent 15-20% of the upfront embodied carbon emissions in a building. Considerations for leaner façade designs include: amount of metal components, glazing-to-wall ratio, multi-purpose façade components. Capital cost savings can be made though the reduction of window area, conversely upfront embodied carbon will likely increase. This is an area for considering the balance of wall to window ratios.

Building services lean design

Building services have the least known overall impact on upfront embodied carbon but are made from high carbon materials (metals, plastics, refrigerants) which are replaced multiple times during a building's lifetime. Considerations to reduce these high carbon materials include: passive measures, ducts design, refrigerant specifications. Reductions in the capacity of building services will likely bring capital cost and space savings.

Structural lean design



- Optimisation of column grid to decrease slab thickness and beam depths, e.g. 3-6m column grid is a good starting point.
- Rules of thumbs and unnecessary tolerances on loading assumptions should be avoided.
- Design of structure for 100% utilisation.
- Reduction of spans and overhangs which require more materials, e.g. encouragement of columns to support balconies and walkways externally.

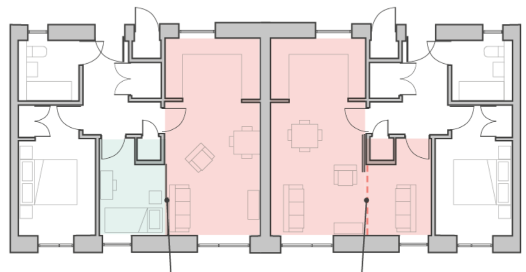
Architectural lean design

- Selection of elements with multiple benefits, e.g. embellishments of the façade also used as shading elements.
- Reduction of quantity of metal components: shelf angles, metal studs and frames.
- Balance between glazing-to-wall ration, between upfront embodied carbon and operational carbon.

Building services lean design

- Prioritisation of passive measures to reduce the need for building services equipment, e.g. optimised glazing ratios, natural ventilation and shading devices.
- Reduction of the need for long pipes and duct runs.
- Specification of low global warming potential refrigerants and reduction of leakage rate.

Circular economy design



- Designing for disassembly and adaptability for easy change of use of the building and re-use or sell materials at the end of its as an alternative to non-profitable, wasteful demolition.
- Selection of durable and easily-maintain materials to reduce maintenance cost and replacement cycles.
- Exploration of modularity and pre-assembly methods for faster and error-reduced construction time.

Key lean and circular economy design considerations for the reduction of upfront and life-cycle embodied carbon.

5

Review of current embodied carbon policies

Greater London Authority – whole life carbon

Embodied carbon is beginning to feature in planning policy with a handful of local authorities having introduced or in the process of introducing embodied carbon policies in their Local Plans. Key examples have been set out and explored below and on the following pages. These include examples of policies:

- Seeking to prevent demolition and re-build
- Seeking to reduce embodied carbon (whether life cycle or upfront embodied carbon)
- Requiring the reporting of whole life carbon against benchmarks.
- Requiring circular economy statements.

Greater London Authority

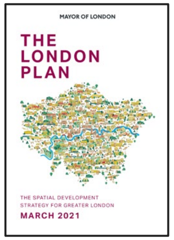
The Greater London Authority (GLA) uses policy SI 2 in the London Plan (2020) to require large scale referable schemes to calculate embodied carbon and whole life-cycle carbon emissions. The policy requires the full submission of decarbonised and non-decarbonised Whole Life Carbon emissions. The GLA published the associated Whole-Life Carbon (WLC) assessment guidance (2022) which includes life cycle carbon and upfront embodied carbon benchmarks to compare against. It is important to note that they are just benchmarks, not targets to be met. A template is provided to aid submission of WLC data. The aim is to collect enough data to allow future policy to set targets.

Calculations are generally not clear or granular enough

The guidance requires WLC assessments to be carried out at a development scale. Some of the early learnings from the collection and review of WLC assessment submissions to the GLA is that there is a lack of granularity and transparency making it very difficult to compare the WLC emissions from one development to another. The GLA policy follows the RICS Professional Statement (PS) 2017 methodology, and use their own template for submissions. RICS PS 2017 allows WLC data per development. Whereas, RICS PS 2023 has developed reporting templates that require buildings to be separately reported.

Ideally the GLA would adopt the new RICS PS 2023 methodology for life cycle carbon reporting to improve granularity and transparency of calculations.

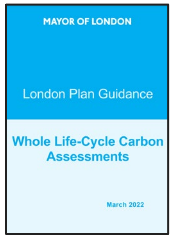
Design features such as basements and podiums or a mix of use classes and scales of development can skew upfront embodied carbon emissions. Without transparency of these design features it makes it difficult to compare developments and their results. This limits the usefulness of the WLC data.



2021 London Plan

The London Plan 2021

The Greater London Authority (GLA) have addressed Whole Life Carbon (WLC) (operational + embodied carbon) and included Circular Economy (CE) principles in policy, in the 2021 London Plan.



Whole Life-cycle carbon assessment guidance - GLA

GLA - SI 2 - Minimising greenhouse gas emissions – F

"Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions."

Upfront embodied carbon benchmarks (modules A1-A5 excluding upfront biogenic carbon):

- Residential <850 kgCO_2e/m^2 (<500 kgCO_2e/m^2 aspirational)
- Offices <950 kgCO_2e/m^2 (<600 kgCO_2e/m^2 aspirational)
- Schools <750 kgCO_2e/m^2 (<500 kgCO_2e/m^2 aspirational)
- Retail <850 kgCO_2e/m^2 (<550 kgCO_2e/m^2 aspirational).

Life cycle embodied carbon benchmarks (modules B-C excluding operational carbon B6 & B7):

- Residential <350 kgCO_2e/m^2 (<300 kgCO_2e/m^2 aspirational)
- Offices <450 kgCO_2e/m^2 (<370 kgCO_2e/m^2 aspirational)
- Schools <250 kgCO_2e/m^2 (<175 kgCO_2e/m^2 aspirational)
- Retail <200 kgCO_2e/m^2 (<140 kgCO_2e/m^2 aspirational).

Life cycle embodied carbon benchmarks (modules A-C excluding operational carbon B6 & B7, including biogenic carbon):

- Residential <1,200 kgCO_2e/m^2 (<800 kgCO_2e/m^2 aspirational)
- Offices <1,400 kgCO_2e/m^2 (<970 kgCO_2e/m^2 aspirational)
- Schools <1,000 kgCO_2e/m^2 (<675 kgCO_2e/m^2 aspirational)
- Retail <1,050 kgCO_2e/m^2 (<690 kgCO_2e/m^2 aspirational).

Greater London Authority – circular economy

Quantifying circular economy principles

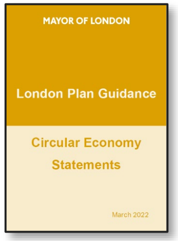
Policy SI 7 of the London Plan covers Waste reduction and the circular economy. It currently requests a statement and completed schedule of data for projects of large scale, referable to the Mayor. Information is required at pre-application, outline and detailed application and post construction stages.

For waste, a mandatory pre-demolition audit for existing buildings is required, plus the following, including % re-used on-site and off-site, recycled on-site and off-site or disposed of elsewhere:

- Min. 95% demolition waste diverted from landfill
- Min. 95% excavation waste diverted from landfill
- Min. 95% construction waste
- Min. 65% municipal waste recycled by 2030
- Min. 20% of building elements recycled content.

For new materials, a description for each building element against the circular economy principle is required. In addition, material types and weights are scheduled against the same building elements as an embodied carbon analysis alongside key indicators at specific life cycle stages:

- Material use intensity (kg/m2)
- Construction waste (kg)
- Recycled content by mass (kg) and %
- Expected lifespan and number of replacements over 60 years
- Expected wastage generated from replacements or refurbishments
- Narrative regarding the assumed end of life scenarios for each element and expected % of re-use, recycling and landfill.



Circular Economy Statements guidance - GLA

GLA - SI 7 – Reducing waste and supporting the circular economy

"Referrable applications should promote circular economy outcomes and aim to be net zero-waste. A Circular Economy Statement should be submitted, to demonstrate:"

- How all materials arising from demolition and remediation works will be re-used and/or recycled
- How the proposal's design and construction will reduce material demands and enable building materials, components and products to be disassembled and re-used at the end of their useful life
- Opportunities for managing as much waste as possible on site
- Adequate and easily accessible storage space and collection systems to support recycling and re-use
- How much waste the proposal is expected to generate, and how and where the waste will be managed in accordance with the waste hierarchy
- How performance will be monitored and reported

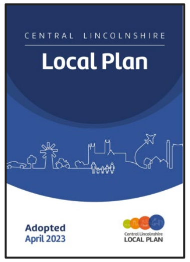
Central Lincolnshire – embodied carbon

Central Lincolnshire Council

Central Lincolnshire updated their Local Plan in 2023 to include a policy on Embodied carbon. The policy encourages the reduction of embodied carbon, with no targets set, but instead requires a more qualitive assessment. The policy requirements are set now and in the future. To begin with applicants are not required to use any specific lower embodied carbon materials, but they are asked to demonstrate consideration of opportunities and options available. However, in 2025 applicants are required to go further and demonstrate how the design and building materials respond to embodied carbon.

Central Lincolnshire also include a clause on 'presumption against demolition' with full justification required where demolition is proposed.

The three Councils of Central Lincolnshire use this policy approach' – as Central Lincolnshire refers to the combined area covered by the City of Lincoln, North Kesteven and West Lindsey. These three Councils have come together in a formal partnership with Lincolnshire County Council to prepare a joint Local Plan for the area.



Central Lincolnshire updated local plan

Central Lincolnshire – S11 – Embodied Carbon

"All development should, where practical and viable, take opportunities to reduce the development's embodied carbon content, through the careful choice, use and sourcing of materials."

"Presumption against demolition:

To avoid the wastage of embodied carbon in existing buildings and avoid the creation of new embodied carbon in replacement buildings, there is a presumption in favour of repairing, refurbishing, re-using and re-purposing existing buildings over their demolition. Proposals that result in the demolition of a building (in whole or a significant part) should be accompanied by a full justification for the demolition. For non-listed buildings demolition will only be acceptable where it is demonstrated to the satisfaction of the local planning authority that:

1. *the building proposed for demolition is in a state of such disrepair that it is not practical or viable to be repaired, refurbished, re-used, or re-purposed; or*
2. *repairing, refurbishing, re-using, or re-purposing the building would likely result in similar or higher newly generated embodied carbon than if the building is demolished and a new building is constructed; or*
3. *repairing, refurbishing, re-using, or re-purposing the building would create a building with such poor thermal efficiency that on a whole life cycle basis (i.e. embodied carbon and in-use carbon emissions) would mean a lower net carbon solution would arise from demolition and re-build; or*
4. *demolition of the building and construction of a new building would, on an exceptional basis, deliver other significant public benefits that outweigh the carbon savings which would arise from the building being repaired, refurbished, re-used, or re-purposed.*

"Major development proposals:

All major development proposals should explicitly set out what opportunities to lower a building's embodied carbon content have been considered, and which opportunities, if any, are to be taken forward... From 1 January 2025, there will be a requirement for a development proposal to demonstrate how the design and building materials to be used have been informed by a consideration of embodied carbon, and that reasonable opportunities to minimise embodied carbon have been taken."

City of London and South West Net Zero Hub – embodied carbon

City of London Corporation

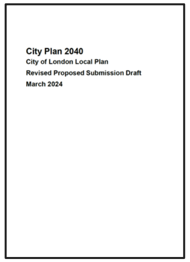
City of London's City Plan 2040 is being taken through committee approval between January and March 2024 and has an anticipated adoption in summer 2025. It includes a policy on retaining and retrofitting existing buildings and a whole life carbon assessment for major developments.

To supplement the policy, a comprehensive Carbon Options Guidance document sets out a robust approach to optioneering evaluations. This provides applicants with guidance on how to compare scenarios for retrofit and rebuild. This ensures a like for like comparison and enables consistency of reporting of carbon emissions.

South West Net Zero Hub

The South West Net Zero Hub provides free strategic and technical support to the public sector and communities to develop, finance and deliver net zero energy projects. They produced the '*Net Zero New Buildings- evidence and guidance to inform Planning Policy*' report, which recommends the following policy requirements:

- Conduct an embodied carbon assessment
- Reporting against industry benchmarks
- Use the data from the embodied carbon assessments to inform own targets.



City of London - Local Plan draft policy

City of London Corporation – Draft policy DE1: Sustainable Design

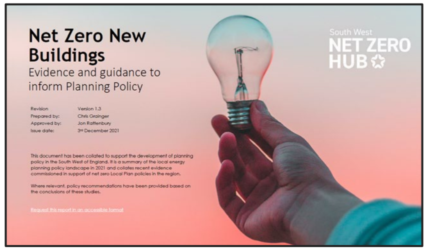
1. *Development proposals should follow a retrofit first approach, thoroughly exploring the potential for retaining and retrofitting existing buildings as the starting point for appraising site options.*
2. *All major development must undertake an assessment of the options for the site, in line with the City Corporation's Carbon Options Guidance Planning Advice Note, and should use this process to establish the most sustainable and suitable approach for the site.*
3. *Development proposals should minimise whole life-cycle carbon emissions. Major developments must submit a whole life-cycle carbon assessment.*

City of London - Carbon Options Guidance

City of London - Carbon Options Guidance

The planning advice note (PAN) is designed to provide guidance for development site WLC optioneering evaluations. The PAN is a first step of carbon evaluation and is designed to enable a consistent, early-stage approach to assessing options. The optioneering exercise is a means of comparing a representative number of development options, in order to find the optimum balance in carbon emissions terms, prior to evaluating other considerations in the planning process.

This guidance was produced by Hilson Moran.



South West Net Zero Hub – Net Zero New Buildings

South West Net Zero Hub

Suggested policy considerations:

"D1 Require a an embodied carbon assessment using a R ICS recognised tool (limited to a 'one one-click' tool for minor developments) and reporting against industry benchmarks.

D2 Consider the introduction of embodied emissions target for major developments (at costed levels or as a cost neutral back stop), setting out how and when future targets will increase in scope

D3 Use data gathered through embodied carbon assessments to inform industry development of robust targets."

City of Westminster – retrofit over demolition and circular economy

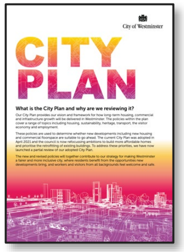
City of Westminster Council

Westminster produced a draft policy for prioritising retrofit over demolition in Nov 2023. The policy requires an optioneering exercise to assess the carbon cost and public benefit of refurbishment, retrofit, deep retrofit or redevelopment options. It states that redevelopment will be resisted.

All major developments and those involving demolition are also required to meet LETI or RIBA 2030 embodied carbon targets. Additional requirements on circular economy and adaptability are also placed on buildings that incur substantial or total demolition.

Westminster City Council have also prepared a Circular Economy Policy Compliance Checklist to ensure that all the London Plan 2021 Policy SI2 and SI7 requirements are met when submitting a planning application.

Supporting documents include the Westminster Embodied Carbon Evidence Base and the Retrofit first topic paper. The retrofit first topic paper contains some useful definitions in section 4.9 of types of demolition (e.g. total and substantial demolition). Westminster City Plan has some useful definitions for levels of retrofit and scale of demolition.



City of Westminster - City Plan draft policy

City of Westminster – Draft policy v4 - Prioritising retrofitting over demolition

"A. Development should adopt a retrofit-first approach, where options for retrofitting existing buildings are considered before total demolition. Where substantial or total demolition is proposed, this should be fully justified through an optioneering exercise, which assesses the carbon cost and public benefits of refurbishment, retrofit, deep retrofit or redevelopment options. Development involving total demolition and redevelopment will generally be resisted, except in the following exceptional circumstances:

1. *It is demonstrated in an optioneering exercise that:*
   - i. *The proposed development will deliver significant public benefits which could not be delivered through a retrofitting option; or*
   - ii. *The whole-lifetime carbon of redevelopment would be less or similar to a retrofit option.*
2. *The development has bespoke operational requirements which could not be provided through the repurposing, adaptation and/or extension of the existing building(s); or*
3. *It is demonstrated that a retrofitting option is not possible or impractical due to structural constraints, demonstrated through a structural engineers report.*

B. All development involving total or substantial demolition, and all major development are required to:

- i. *Submit a Whole Life-Cycle Carbon assessment, which demonstrates how the development will achieve either:*
  - a. *A target upfront embodied carbon equivalent of LETI band "B", with an absolute minimum rating of "C"; or*
  - b. *A target life-cycle embodied carbon equivalent to RIBA 2030 Build Target band "A" or an absolute minimum rating of "B".*
  - c. *For developments following the London Plan's fast track route, the report should demonstrate the maximum embodied carbon reductions deliverable without affecting the delivery of affordable housing.*
- ii. *Where substantial or total demolition has been agreed, applicants must:*
  - a. *Submit a* ***Circular Economy Statement*** *including a pre-demolition and reclamation audit which demonstrates how materials will be reused and repurposed; and*
  - b. *Design any new structures to ensure the longevity of the building, easy adaptation, easily re-usable materials, and capable of adopting new low carbon improvements."*

Bath and North East Somerset – embodied carbon

Bath and North East Somerset Council (B&NS)

The UK's first Net Zero Carbon policy was introduced in January 2023 and covers both operational and embodied carbon. Policy SCR8 on embodied carbon states that all major developments must submit an upfront embodied carbon assessment, demonstrating that less than 900 $kgCO_2e/m^2$ can be achieved. No offsetting is permitted and if the development is not compliant with the policy, a valid justification must be provided with the appropriate reasons and evidences.

This policy is planned to be updated based on the findings of the West of England Embodied Carbon Evidence Base.

Sustainable Construction checklist SPD – B&NES

B&NES - SCR8 - Embodied Carbon

"Large scale new-build developments (a minimum of 50 dwellings or a minimum of 5,000m^2 of commercial floor space) are required to submit an Embodied Carbon Assessment that demonstrates a score of less than 900$kgCO_2e/m^2$ can be achieved within the development for the substructure, superstructure and finishes."

Bristol – whole life carbon, retrofit over demolition and circular economy

Bristol City Council

The 2023 publication version of Bristol Local Plan sets an embodied carbon, materials and circular economy policy. Major developments will be required to undertake an embodied carbon assessment (A1-A5, B1-B5, C1-C4) and are expected to achieve a set of minimum targets. Where policy is not met, carbon offsetting is used. It also provides general principles and guidance for reducing embodied carbon and implement circular economy principles in design.

Bristol City Council Local Plan November 2023

Bristol City Council – Policy NZC3 – Embodied carbon, materials and circular economy

Embodied carbon – general principles

Development will be expected to minimise its embodied carbon. In doing so, development should:

- *Prioritise the renovation or retrofit of existing structures, as part of an efficient use of land, subject to technical feasibility, the other policies and proposals of the local plan and any relevant neighbourhood plans.*
- *Be designed efficiently to minimise the quantity of materials required to meet the building's functional requirements.*
- *Select high quality materials and systems which: Have low embodied carbon; Minimise the need for replacement over the lifetime of the development; and Can be reused, recycled and disposed of sustainably at end of life.*
- *Ensure that new buildings are flexible and adaptable to future uses, reducing the need for future redevelopment.*

*Development should set out through the **Sustainability Statement** how these issues will be addressed.*

Embodied carbon – major applications

Major development will be required to undertake an embodied carbon assessment, submitted as part of the Sustainability Statement using a nationally recognised embodied carbon assessment methodology, and demonstrate actions taken and an ongoing strategy to reduce embodied carbon emissions. New development will be expected to achieve the following targets as a minimum:

Upfront embodied carbon (construction phase) (A1-A5):

- *Residential (4 storeys or fewer) - <400 kgCO_2e/m²*
- *Residential (5 storeys or greater) - <500 kgCO_2e/m²*
- *Major non-residential schemes - <600 kgCO_2e/m²*

Whole life-cycle embodied carbon (A1-A5, B1-B5, C1-C4):

- *Residential (4 storeys or fewer) - <625 kgCO_2e/m²*
- *Residential (5 storeys or greater) - <800 kgCO_2e/m²*
- *Major non-residential schemes - <970 kgCO_2e/m²*

Where these targets cannot be feasibly met, a full justification will be required as part of the embodied carbon assessment. Any shortfall against the upfront embodied carbon targets will be offset through a financial contribution towards the council's carbon offset fund. The value of a tonne of CO_2e is tied to the high scenario in the Valuation of Energy Use and Greenhouse Gas supplementary guidance to the Treasury's Green Book (currently £373).

Refrigerants

In all development with fixed building services that include a refrigerant, the global warming impact of the refrigerants should be minimised by:

- *Designing to minimise the volume and mass of refrigerants.*
- *Selecting equipment that uses refrigerant with low global warming potential.*
- *Implementing measures to minimise the risk of and detect refrigerant leakage.*

Refrigerants and their associated impacts should be included within the embodied carbon assessment.

Materials

Development proposals should seek to minimise the wider environmental impacts arising from their sourcing, manufacture, construction, and end of life demolition and disposal. Development will be expected to minimise the use of tropical hardwoods.

Circular economy and construction and demolition waste

The Sustainability Statement should demonstrate how circular economy principles have been embedded in the design of the proposal, including seeking to maximise re-use of materials, both from any existing development on site and in products and materials imported to the site.

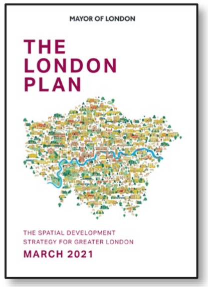
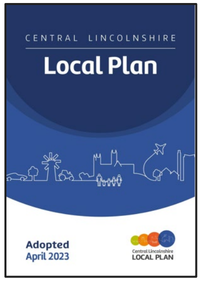
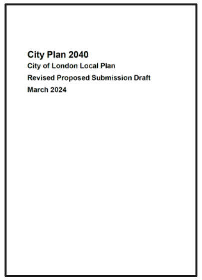
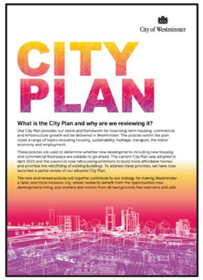
Development proposals should seek to minimise and design-out construction and end-of-life waste, ensuring that waste reduction is planned in from project inception to completion, including consideration of standardised components, modular build, designing for deconstruction, and reuse of secondary products and materials. Where waste is generated, reuse and recycling should be maximised. Where development proposals include demolition, this should aim to maximise the amount of material recovered for reuse and recycling, either on-site or at another site (either directly or via broker). Demolition materials should be recovered at their highest value possible.

Major proposals should submit a site waste management plan as part of their Sustainability Statement.

Summary of existing embodied carbon policies and approaches in UK

Summary

This page summarises the existing embodied carbon approaches to policy in the UK.

						
	Greater London Authority	**Central Lincolnshire Council**	**City of London Council**	**City of Westminster Council**	**Bath and North East Somerset Council (B&NS)**	**Bristol City Council**
Presumption against demolition	✓ (Partially – for affordable housing)	✓	✓	✓	✗	✓ (Partially)
Embodied carbon assessment and reporting	✓ (whole life carbon assessment)	✗ (Seek to reduce only)	✓ (whole life carbon assessment)	✓ (whole life carbon assessment)	✓ (upfront embodied carbon)	✓ (upfront and whole life cycle embodied carbon)
Meet embodied carbon target/limit/benchmark	✓ (benchmarks)	✗ (no targets/limits/ benchmarks)	✓ (benchmarks)	✓ (either upfront of life cycle embodied carbon)	✓ (for substructure, superstructure and finishes only)	✓ (upfront and whole life cycle embodied carbon targets)
Applies to	Referrable schemes	All developments	Major developments must submit a whole life-cycle carbon assessment	Major developments	Large scale new- build developments	Major developments
Other requirements	Demonstrate actions taken to reduce life-cycle carbon emissions	Take opportunities to reduce the development's embodied carbon	Development proposals should minimise whole life-cycle carbon emissions.	Demonstrate the maximum embodied carbon reductions deliverable without affecting the delivery of affordable housing	If the development is not compliant with the policy, a valid justification must be provided with the appropriate reasons and evidences.	Demonstrate actions taken to reduce life-cycle carbon emissions. Full justification is required id targets are not achievable.

The West of England evidence-base (1/2)

This document was commissioned by four local authorities in the West of England (i.e. Bath and North East Somerset Council, Bristol City Council, North Somerset Council and South Gloucestershire Council), and the Combined Authority. The purpose of this embodied carbon evidence-base study was to support policy makers in exploring options for setting embodied carbon planning policies and targets.

Upfront embodied carbon modelling

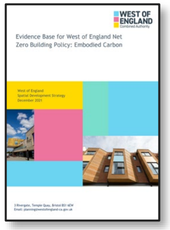
The document sets out the upfront embodied carbon achieved by various low-rise building typologies tested under different design scenarios. The building typologies include: office (4 storeys), school (3 storeys), apartment block (5 storeys <18 m in height) and semi detached house (2 storeys). The cost uplift is also considered for the different design scenarios. All the building typologies have a height of less than 18 meters, to ensure compliance with fire regulations in terms of material combustibility.

The RICS building elements modelled include (RICS category numbers in brackets):

- Sub-structure (1), Super-structure (2) and Finishes (3).
- A percentage increase per building typology was applied to account for Building services (5) and External works (8) emissions (based on LETI's work 'Climate Emergency Design Guide' and 'Embodied Carbon Primer').
- Facilitating works (0), Furnishings fixtures and equipment (FF&E) (4), Prefabricated building and building units (6) and Work to existing buildings (7) emissions were excluded from the calculation.

An analysis of different structural, façade and finishes

As it can be seen on the adjacent table, different designs were compared for each building typology, ranging from a baseline assumed to represent standard practice all the way to a combination of the lowest embodied carbon choices.



Evidence-base for West of England Net Zero building policy: embodied carbon

Prepared by WSP (embodied carbon analysis) and Gardiner & Theobald (cost analysis)

December 2021

West of England evidence-base for embodied carbon policy

	S1 - BASELINE	S2 – HYBRID TIMBER	S3 – LOW CARBON CONCRETE	S4 – TIMBER FRAME	S5 – LOW CARBON FACADES	S6 – LOW CARBON INT. FINISHES
SEMI DETACHED HOUSE	Load bearing masonry walls, timber floors and roof	-	40% cement replacement (foundation, GF slab)	Timber studs, floor and roof (Sawn timber)	Timber cladding on timber wall assembly; Wood frame windows; Glass wool insulation (replacing rockwool)	Linoleum floors (replacing vinyl)
APARTMENT BLOCK	Concrete frame and hollowcore slabs	-	40% cement replacement (foundation, GF slab, frame, staircase)	Glulam frame, CLT walls CLT floors)	Timber cladding on timber wall assembly; Wood frame windows	Internal timber wall assembly; Linoleum floors (replacing vinyl)
OFFICE / SCHOOL	Steel frame and composite concrete-steel deck floor slabs	Steel frame and CLT floors/roof	40% cement replacement (foundation, GF slab, staircase)	Glulam frame – CLT floor	Timber cladding on timber wall assembly; Wood frame windows	Internal timber wall assembly; Linoleum floors (replacing vinyl); Exposed soffits

Summary of the different scenarios modelled in terms of embodied carbon (upfront and whole life) and costed by WSP and G&T

The West of England evidence-base (2/2)

Modelling results

The results opposite show the carbon reductions per scenario of each building typology and the comparison with the LETI upfront embodied carbon targets.

The baseline office scenario (Office_S1) almost complies with LETI 600 kgCO2e/m2 2020 target, and the most challenging scenario (Office_S6) complies with the LETI 350 kgCO2e/m2 2030 target. For the school typology, the results are similar to the office typology, given that these two typologies share the same baseline. The baseline apartment block scenario (ApartBlock_S1) complies with LETI 500 kgCO2e/m2 2020 target and the most challenging scenario (ApartBlock_S6) complies with the LETI 300 kgCO2e/m2 2030 target. On the other hand, the baseline semi-detached scenario (SemiDetached_S1) almost complies with LETI 500 kgCO2e/m2 2020 target and the most challenging scenario (SemiDetached_S6) almost complies with the LETI 300 kgCO2e/m2 2030 target.

Recommendations of the study

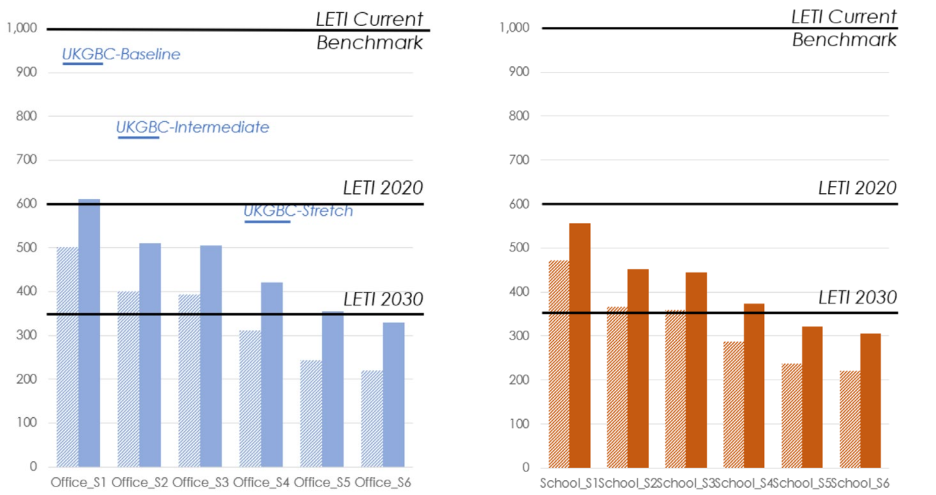
- Conduct and report whole life carbon assessment (including sequestration) and report upfront embodied carbon (modules A1-A5) and circular economy (module D) separately.
- Set upfront (A1-A5) and lifecycle (A1-A5, B1-B5, C, including sequestration) embodied carbon targets.
- Careful investigation of an appropriate carbon offsetting price specific for providing advantage to low carbon alternatives is recommended.

Important limitations raised

Some important limitations were noted:

- The embodied carbon benefits of alternative design choices (e.g. lean design) are not tested.
- As noted in the follow-on Westminster evidence base, the building services additional allowance assumed in this study (15%) consists of much less embodied carbon of building services, than by calculating them using the CIBSE TM65 methodology.

Upfront carbon emissions A1-A5



Non-domestic typologies (office-left and school-right): carbon reduction (kgCO2e/m2) per scenario and comparison with LETI upfront embodied carbon targets

Domestic typologies (apartment block-left and semi-detached-right): carbon reduction (kgCO2e/m2) per scenario and comparison with LETI upfront embodied carbon targets

Detailed analysis Scope – RICS 1-3 (substructure/ superstucture/ finishes)

Extended scope – RICS 1-3, 5, 8 (+ building services, external works)

The Westminster evidence-base (1/2)

A second embodied carbon evidence base was produced by WSP in 2024, aiming to inform Westminster City Council's embodied carbon targets for new builds. It is framed around the first WSP evidence-base report for West of England (WOE), completed in December 2021.

Upfront embodied carbon modelling

This analysis explored the impact of common measures of reducing embodied carbon across three common building typologies in the City of Westminster; an office (7 storeys), a mixed-use (7-storeys) and a high-rise apartments block (8-storeys). The cost impact of these measures was analysed as well.

The RICS building elements modelled include:

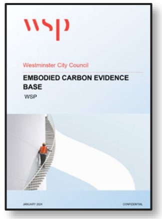
- Sub-structure (1) , Super-structure (2) and Building services (CIBSE TM65 methodology)* (5) emissions.
- Percentage increase per building typology applied to account for the Finishes (3), Fittings, furnishings and equipment (FF&E)* (4) and External works emissions (8) (based on GLA benchmark values, from the GLA's Guidance on Whole Life-Cycle Carbon Assessments).
- Facilitating works (0), Prefabricated building and building units (6) and Work to existing building emissions (7) were excluded from the calculation.

*Methodology upgraded from previous WSP WOE evidence-base, which made allowances for MEP as opposed to calculating it. FF&E wasn't included in WOE, whereas an allowance has been made here.

Scenarios modelled

The adjacent table shows the different design scenarios tested for each building typology, ranging from a baseline assumed to represent standard practice all the way to a combination of the lowest embodied carbon choices – 8 in total. The cost uplift of these scenarios were considered as well.

In its important to mentioned that in this evidence-base the impact of design on upfront embodied carbon has also been assessed through 2 scenarios: 1. reduction in grid spacing 2. including a basement (structure only).



Westminster City Council: embodied carbon evidence-base

Prepared by WSP

January 2024

Westminster embodied carbon evidence-base

	Office	Residential	Mixed-use
S1- baseline	Steel frame and composite concrete-steel deck floor slabs	Concrete frame and reinforced concrete in-situ flat slabs	Steel frame and composite concrete-steel deck floor slabs
S2- reduced grid spacing	Reduction in grid spacing from 12m to 9m	Reduction in grid spacing from 8m to 6m	Reduction in grid spacing from 12m to 9m
S3- low carbon concrete	+25% GGBS replacement added to concrete mixes	+25% GGBS replacement added to concrete mixes	+25% GGBS replacement added to concrete mixes
S4- hybrid timer	Steel frame and CLT floors/ roof	-	Steel frame and CLT floors/ roof
S5- low carbon/ 50% GGBS	+10% steel reuse & +15% EAF steel	+50% GGBS replacement added to concrete mixes	+10% steel reuse & +15% EAF steel
S6- glulam beams and CLT floors	Glulam beams and CLT floors / roof	-	Glulam beams and CLT floors / roof
S7- low carbon facade	Increase recycled aluminium content & replace terracotta rainscreen with timber cladding	Replace window aluminium framing with composite and review external wall build-up including bricks as finishing	Increase recycled aluminium content and review external wall build-up including bricks as finishing
S8- low carbon MEP	Replace fan coil unit HVAC system	Replace ambient loop system with heat pump	Replace ambient loop system with heat pump

Summary of the different scenarios modelled to investigate their upfront embodied carbon and cost.

The Westminster evidence-base (2/2)

Modelling results

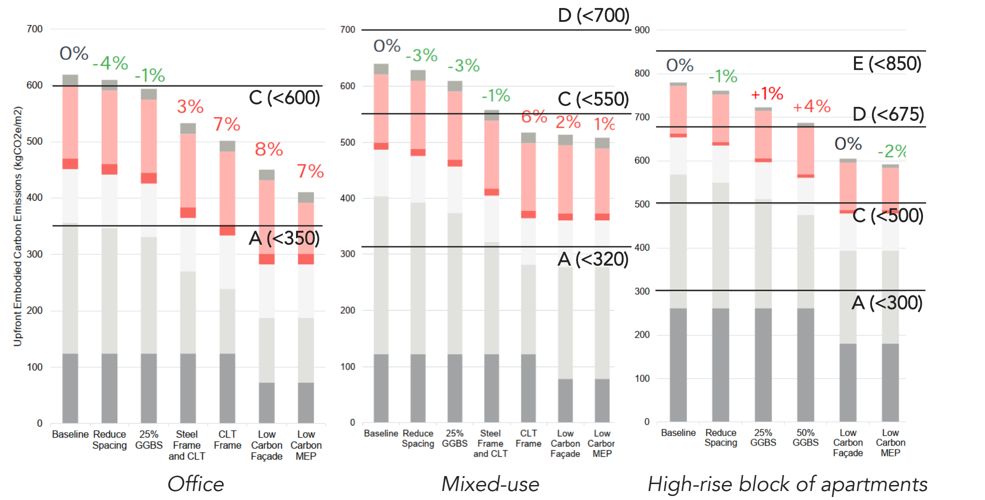
The results align with the previous report by WSP for the West of England, as it shows that all typologies modelled can achieve:

- Upfront carbon to meet LETI band D using typical design practises and at no additional cost.
- Upfront carbon to meet LETI band C with no additional cost uplift, using a mixture of cost saving carbon reduction measures such as: removing basements, reducing grid spans and optimising the façade (not applicable for the office typology) and MEP system.

Further carbon reductions can be achieved for the office and mixed-use typology to achieve LETI band B, with more expensive carbon measures, such us introducing CLT floors, higher percentage of recycled materials and cement replacement. Due to fire restrictions for the residential typology, LETI band B or higher is difficult to be achieved. This might be possible with a high amount of low carbon products, concrete cement replacement or recycled metals. However, due to market volatility and not enough supply chains, this is currently not a deliverable solution at scale.

Recommendations of the study

- For further carbon reduction of the building typologies to achieve LETI band A, re-using structure and materials of existing buildings is necessary.
- Improving work practises and applying circular economy principles (e.g. design for disassembly) will ensure that materials can be recovered at the demolition phase.
- Lean building design results in both carbon and cost reductions.
- Whole life carbon assessments are important in understanding and balancing the embodied carbon emissions with the operational carbon emissions.
- Embodied carbon offsetting is recommended, with careful consideration not to create loopholes or disincentivise comprehensive carbon reduction (sacrifice operation carbon for lower embodied carbon).

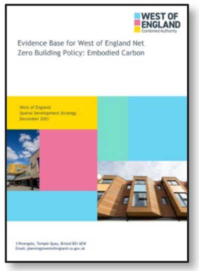


Cost uplift (%) from baseline for each scenario and comparison with LETI letter banding targets (upfront embodied carbon-stage A only). There are fewer structural interventions available for high-rise residential buildings compared to the other two typologies. Many rely on the amount of GGBS to significantly reduce the embodied carbon of this typology, however, GGBS is a finite resource. Alternatively, efficient structural design measures should be considered seriously from the beginning for meaningful carbon reductions in high-rise block of apartments.

Building Typology	D, E, F, G	C	B	A	A+, A++
Upfront Embodied Carbon (A1-A5)					
Office	0%	0%	7%	*Further Measures Necessary*	*Non-compliant*
Mixed Use	0 %	0%	2%	*Further Measures Necessary*	*Non-compliant*
Residential	0%	0%	*Further Measures Necessary*	*Non-compliant*	*Non-compliant*

Cost uplift (%) from baseline per typology, to comply with the LETI letter banding targets (upfront embodied carbon). LETI band C is achieved for all typologies with no additional cost uplift, using a mixture of cost saving carbon reduction measures (removing basements, reducing grid spans and optimising the façade and MEP system.

Summary of existing embodied carbon evidence-base reports in the UK



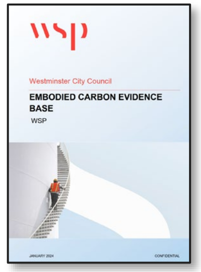


Figure 2.4.13 – Upfront embodied carbon emissions modelling results and limit/ target recommendations	**Evidence-base for West of England net zero building policy: embodied carbon**	**Westminster embodied carbon evidence-base**
Domestic buildings – results	Semi-detached house (<11 m in height): **310-520** $kgCO_2e/m^2$ Low to mid-rise apartment block (<18 m in height): **240-350** $kgCO_2e/m^2$	Mid to high-rise apartment block (>18 m in height): **520-780** $kgCO_2e/m^2$
Mixed-use buildings – results	× n/a	Mixed use - 45% Office, 45% Residential, 10% Retail (>18 m in height): **590-640** $kgCO_2e/m^2$
Non-domestic buildings - results	Office (<18 m in height): **320-610** $kgCO_2e/m^2$ School (<18 m in height): **305-550** $kgCO_2e/m^2$	Office (>18 m in height): **430-670** $kgCO_2e/m^2$
Limit/ target recommended	**All building typologies:** achieve LETI band C (residential 6+ storeys and education: <500 kgCO2e/m2 , office: <600 kgCO2e/m2) as a minimum target and set LETI band A (residential 6+ storeys and education: <300 kgCO2e/m2 , office: <350 kgCO2e/m2) as an aspirational target.	**All building typologies:** adopt NZCBS limits, once released.

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Policies/regulations and work outside UK - Europe

Countries in the EU with policies or regulation

A number of countries have relatively recently introduced embodied carbon calculation into their regulatory environment. This roadmap aligns with EU's overarching goals to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels.

In particular France has brought embodied carbon calculations into their building regulations (see next page), other European counties are exploring the use of embodied carbon policies in regulation, and are considering the setting of limits. Further information on USA and Canada has been provided on page 133.

This page and the next summarises some examples, highlighting that embodied carbon calculation of buildings is becoming more prominent and widespread in Europe. This is relevant to the UK as it may one day influence how and if embodied carbon comes into regulation.

Denmark's National strategy for sustainable construction

Denmark's National strategy for sustainable construction

Introduced in 2021, Denmark's policy applies to all new buildings covered by existing energy regulation. It requires all buildings >1,000m^2 to comply with combined operational and embodied limit values (12 kgCO_2/m^2/year), while buildings under this just must report results of their calculations. The limit is being reduced each year.

The life cycle analysis methodology is standardised with specific calculation requirements. There is no mandatory tool, although there is a public tool developed and accepted for compliance. Authorities provide a database of materials to be used for the calculations. The database is based on generic data, although product specific environmental product declarations (EPDs) can also be used.

Finland's "Ilmastoselvitys"

Finland's "Ilmastoselvitys"

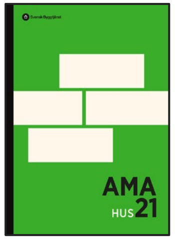
Ilmastoselvitys (2016) will be substantially updated by 2025. This regulation covers all new buildings for which a building permit is needed, except single family homes, wide refurbishments and almost zero energy buildings. It mandates the reporting of Whole Life Carbon metrics alongside climate benefits from the project. The methodology is being standardised and has no mandatory tool, although OneClick LCA software has high popularity.

MilieuPrestatie Gebouwen (MPG)

Netherlands' "Milieuprestatie Gebouwen" (MPG)

MPG (2022) applies to all new residential buildings and office buildings larger than 100m^2. 11 environmental impact categories are monetised and calculated through one final value. Therefore, the final value does not give insights into Whole Life Carbon levels alone.

Checks of the MPG are undertaken on the highest contributing building elements (walls, floors, installations). The final building is compared to the environmental declaration and spot checks can be carried out for more detailed features. One of the limitations is that not all details are known at the design stage when applying for the environmental permit.



Sweden's Environmental Legislation for Construction

Sweden's Environmental Legislation for Construction

Introduced in 2022, Sweden's regulation covers new buildings over 100m^2 requiring building permits, although some exceptions are granted in very specific cases. A climate declaration must be submitted any time before starting the use of the building. There are currently no embodied carbon limits in place, although the collected data will be used to determine limit values in the future.

There is no mandatory tool, although there is a public tool developed and accepted for compliance. Authorities provide a database of materials to be used for the calculations. The database is based on generic data, although product specific EPDs can also be used.

European Union's Roadmap for Whole Life Carbon

European Union's Roadmap for Whole Life Carbon

The EU Roadmap for Whole Life Carbon (2022) relates to all scales and typologies of buildings, including new builds and retrofits. The policy is part of a broader strategy to decarbonize the EU's built environment by 2050. The policy recommends the Commission to establish WLC targets, however, they have not indicated limit values due to lack of data. By 2025 they suggest the reporting of WLC for new, public and larger non-residential buildings.

The Roadmap suggests the need for harmonized methodologies for WLC assessment but does not mandate a single standard. Multiple tools are suggested for assessing WLC, without a single standardised tool. Special mention is given to the Level(s) framework. There is an open-source database being developed that would serve as a network linking all member states databases.

Policies/regulations and work outside UK - France

Réglementation environnementale (RE2020)

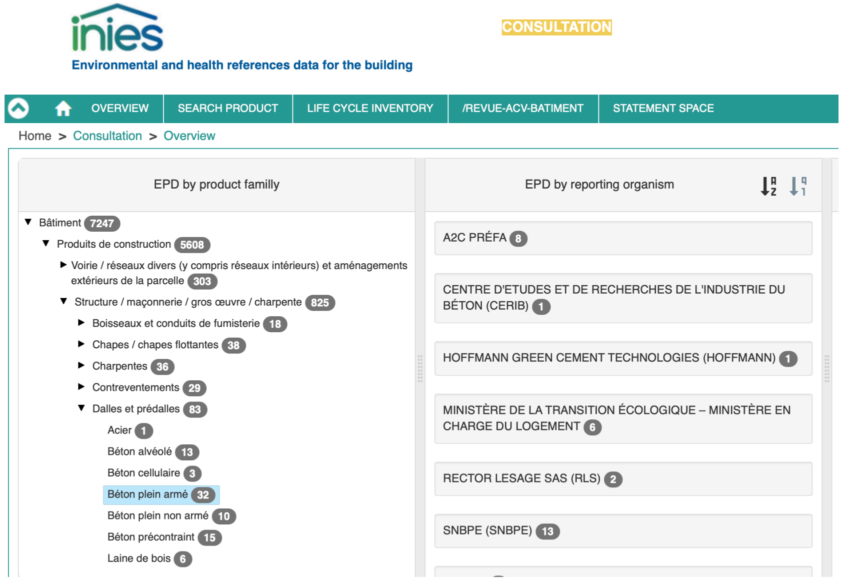
France's "Réglementation environnementale (RE2020)"

France's Building Regulations RE2020 was adopted in 2022 and applies to new residential, office and education buildings. This policy requires the calculation of the embodied carbon impact associated with materials, products and equipment in a project. This is carried out in two stages of the process, upon the request of the construction permit and later on at the final approval request. Threshold carbon emissions levels are set per typology and construction permit year. Specific levels of performance must be achieved that will be incrementally reduced (improved) with a new step every three years until 2031. These levels are being revised and reduced in line with France's low carbon economy transition plan.

A specific indicator ($IC_{construction}$ – *Impact de la construction sur le changement climatique* or Construction impact on climate change indicator) is calculated and applied to 13 component areas, as well as an optional one on refrigerants if they are used. Emissions linked to energy use during the construction phase are also included.

The calculation is based on project specific data for the volumes/quantities of materials, products and equipment which is multiplied by figures from a publicly accessible and free carbon factor database: the INIES database. Default assumptions can be used when a specific material carbon factor cannot be used or is not available. These assumptions are provided and are managed at the national level by the Government. The database is based on generic data, although product specific EPDs can also be used. No standardised calculation tool is in place, but a list of compliant tools exist.

Different parameters influence the targets, including the floor area of the building, the impact of foundations, the presence or absence of basement areas, the inclusion of roads and landscape as well as the proportion of default product data being used in the assessment.



The INIES database provides the information required for the calculation.

Requirements vary between building types. They are scheduled to be stepped down every three years.

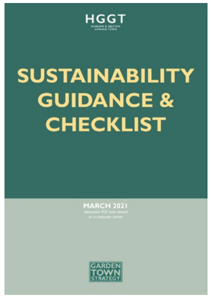
Review of existing local policy across Essex

There are currently no specific embodied carbon policies in the existing Local Plans in Essex, however, there are a few general references which are moving in a positive direction.

Brentwood and Chelmsford Local Plans reference the importance of responsibly sourced materials, low carbon materials or waste reduction - showing a desire to limit the impact of materials and waste.

Epping and Harlow and Gilston Garden Town councils, both have developed thorough sustainability checklists which defines a clear embodied carbon strategy for new schemes.

Epping Sustainability Checklist



Harlow and Gilston Garden Town Sustainability Checklist

Epping & Harlow and Gilston Garden Town sustainability checklists (March 2021)

All design teams are expected to think about, and reduce the embodied energy required to develop their schemes. For example, depending on location, height, and site suitability, materials like timber could be favoured over less sustainable alternatives such as concrete.

A Whole Life Carbon (WLC) Assessment should be undertaken both during the pre-application stages and after practical completion, as new homes are expected to last 60+years, with carbon emission reduction in line with the targets in the Checklist.

Embodied Carbon Reduction Strategy:

1. *Using circular economy principles of reuse and refurbish, and designing for disassembly at end of life with processes including using offsite construction.*
2. *Building low-energy homes, using fossil fuel-free technology to supply heating and power to them.*
3. *Using renewable energy where necessary*

Key Principles expand the Circular Economy process:

1. *Conserve Resources, Increase Efficiency, Source Ethically*
2. *Eliminate waste and ease maintenance*
3. *Manage waste sustainably and at the highest value*

Brentwood Local Plan

Brentwood Local Plan (2016-2033) - BE01: carbon reduction and renewable energy

"Use of materials

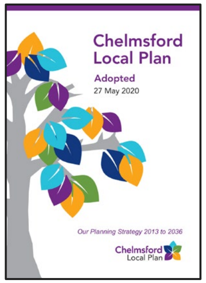
Although this is not a policy requirement, the Council will encourage all developers to maximise resource efficiency and identify, source, and use environmentally and socially responsible materials. There are four principal considerations that should influence the sourcing of materials:

a) *Responsible sourcing – sourcing materials from known legal and certified sources through the use of environmental management systems and chain of custody schemes including the sourcing of timber accredited by the Forestry Stewardship Council (FSC), or the Programme for the Endorsement of Forest Certification (PEFC);*

b) *Secondary materials – reclaiming and reusing material arising from the demolition of existing buildings and preparation of sites for development, as well as materials from other post-consumer waste streams;*

c) *Embodied impact of materials – the aim should be to maximise the specification of major building elements to achieve an area-weighted rating of A or B as defined in the Building Research Establishment (BRE) Green Guide to Specification. Consideration should also be given to locally sourced materials; and*

d) *Healthy materials – where possible developers should specify materials that represent a lower risk to the health of both construction workers and occupants. For example, selecting materials with zero or low volatile organic compound (VOC) levels to provide a healthy environment for residents."*



Chelmsford Local Plan

Chelmsford Local Plan (adopted 27 May 2020) - Appendix B - Development Standards

B.32 Putting materials in the black bin for general waste should be considered a last resort. Disposing of materials in landfill or by other methods such as Mechanical Biological Treatment (MBT) comes at a high cost to the Council and taxpayers and is a poor choice for the environment. Chelmsford offers a comprehensive recycling collection service which allows residents to recycle more materials than many other local authorities, including the kerbside collection of small Waste Electronic and Electrical Equipment (WEEE) and textiles. This saves natural resources and reduces the greenhouse gases associated with creating new products and their disposal.

Different policy approaches – advantages and limitations

Current policy and industry guidance on embodied and whole life carbon have been successful at putting embodied carbon on the radar of project teams. Reporting is now becoming standard practice on major applications in London, and other cities such as Bath and Bristol which have introduced target-based policies. Analysis of planning submissions in London suggests, however, that project teams make limited efforts to reduce upfront embodied carbon: the focus appears to be mainly on reporting. Reporting also appears to be affected by the lack of transparency about the underlying data being used for the assessment.

Potential policies on embodied carbon have been developed based on an analysis of the advantages and limitations of current policy and guidance:

Embodied carbon in demolition and retrofit

Embodied carbon can be used positively as a justification against demolition and a reason to retain and retrofit a building. Central Lincolnshire uses this policy approach, as does City of London and Westminster City Council.

Should benchmarks, targets and limits be used?

Reporting against limits, targets and benchmarks plays a pivotal role in keeping the industry on track towards decarbonisation. It is clear that they will be necessary in the medium to long term. However, while trying to meet targets or limits, it is important to clearly and transparently demonstrate the strategies tested through design, specification and procurement to reduce embodied carbon. Design indicators exist, that can be outputted and compared, such as type and volume of structure or comparisons of façade options. This will help the industry learn together what good looks like and how best to achieve it. However, this approach relies on planning officers assessing the information submitted rather than just comparing to a benchmark or compliance with a target or limit.

Early design consideration on reducing embodied carbon

Encouraging project teams to consider creating buildings that are efficient in material use, form and design from the outset can result in significant embodied carbon and cost reductions. See page 29 for reducing embodied carbon through design.

Collecting data now for policy later

The GLA have taken the approach of requiring WLC assessments for referable schemes to collect data, with the intention to use this data to set targets in policy later. This has been very useful to gather data for the industry too. However, it has a limited impact on influencing the design of buildings in the interim. Analysis of embodied carbon and whole life carbon data submitted to the GLA has shown a huge variation in the predictions.

Determine the boundary of embodied carbon

Some policies seek to reduce upfront embodied carbon and others life cycle or whole life carbon. Each has their advantages, but because designers can have the greatest impact on reducing upfront embodied carbon, our initial recommendation is to focus on upfront embodied carbon in policy, with a view to include whole life carbon in the future.

Standardisation and quality of data

The quality of the upfront embodied carbon results is heavily reliant on the quality of the material data used in the calculation. Generic and specific material data is available and the assessors selection and use of this data can inflate or decrease the overall upfront embodied carbon result. This means that applicants can game the system - should they seek to. To create a standardised database of material would require significant resource and should ideally be done at a national level (such as in France's regulation) rather than locally.

Links between operational and embodied carbon

Decisions taken to reduce embodied carbon should be considered in tandem with decisions taken to reduce operational energy consumption. The focus should be on reducing embodied carbon alongside and in support of ultra-low energy buildings, as opposed to trading one off of another.

The role of offsets in embodied carbon

Offset payments should be considered as a last resort and used cautiously, to avoid moving an on-site issue elsewhere. It would be more constructive to set policy in a way that ensures embodied carbon emissions are reduced as far as possible through the project design and procurement.

6

Policy recommendations

Types of policy requirements

To encourage an overall reduction in embodied carbon through good decision making and design, a range of policy requirements should be considered. These should consider including a mix of qualitative and quantitative requirements to achieve the right outcomes.

Qualitative requirements

Qualitative requirements have the potential to cover a wider spectrum of embodied carbon issues and promote best practice decision making. This includes: retaining buildings; encouraging re-use and retrofit over demolition; good design for lower embodied carbon buildings; disclosure of options considered including basic levels of embodied carbon analysis; and promotion of circular economy. Due to the inevitable variance in developments, more flexibility can be allowed for in these policies to ensure they apply in most cases while promoting best practice.

Quantitative requirements

Quantitative requirements are designed to use figures to limit the embodied carbon of developments. This can work for measurable items, such as: upfront embodied carbon; life cycle embodied carbon; and whole life cycle carbon. In calculating the embodied carbon of a development the figures can be compared to benchmarks or other buildings, be required to meet targets, or be required to perform better than set limits.

While quantitative benchmarks/targets/limits can be used to push towards best practice, they are most likely to be used to prevent worst practice. This is to allow an element of flexibility in design, which may by no fault of the development, face additional challenges (e.g. poorer ground conditions requiring more extensive foundations, required use of certain building forms or materials to satisfy other planning requirements).

Examples of mixing and matching

Certain aspects of embodied carbon do not have to be siloed into qualitative or quantitative policies, it could be that they span both. An example of this could be limits/targets/benchmarks are set for specific life cycle modules of embodied carbon emissions (such as limits for upfront embodied carbon), while a request for reporting could be required for other modules (such as life cycle embodied carbon or whole life carbon).

When to set a benchmark, target or limit for embodied carbon?

Benchmarks

Benchmarks tend to be used as a first step in policy to help build data and understanding in planning and development teams. They are also used when there is a lack of confidence or evidence underpinning the figures being set in policy. The advantage of benchmarks is that they can be used in a less constraining way, acting as a comparator. However, the disadvantage is that they are not as robust at preventing high embodied carbon buildings. As an example, the GLA use benchmarks in embodied carbon policy.

Targets

Targets are normally set as something to aim for and be better than. They are seen as a goal to be achieved. How robustly the targets are enforced through the planning process puts them somewhere between a benchmark to be compared to and a limit that should not be exceeded. Targets need to be backed by evidence to ensure they are set meaningfully and appropriately. If a target is too difficult to achieve it will be fought by developments, however, if it is too loose it will not prevent poor practice.

Limits

Limits send a clear message that it is something not to be exceeded and that action needs to be taken to prevent the worst effects associated with exceeding it. Limits also need to be backed by evidence to ensure the level is set appropriately and can be reasonably achieved by most developments.

Summary of proposed policy requirements

Proposed policy requirements have been set across four main areas:

1. Presumption against demolition and promoting circular economy
2. Lean building design and good material efficiency for lower embodied carbon
3. Reducing upfront embodied carbon
4. Reporting whole life carbon

For each of the policy requirements we have set out:

- The types/scale of development the requirement would apply to
- The timescale of implementation
- The intention
- Proposed requirement wording;
- How success should be judged
- Suggested submission requirements (pre-app, planning submission and discharge of condition)
- Suggested supplementary guidance

Four proposed policy requirements:

1 Presumption against demolition and promoting circular economy

This policy requirement seeks to prevent substantial and total demolition of existing buildings by requiring justification, additional requirements and potentially whole life carbon (WLC) optioneering studies.

2 Lean building design and good material efficiency for lower embodied carbon

This policy requirement seeks to reduce resource use by encouraging all applications to be efficient in their material use, form and design.

3 Reducing upfront embodied carbon

This policy requirement sets limits on upfront embodied carbon emissions for major applications and requires calculations and reporting to demonstrate compliance.

4 Reporting whole life carbon

This policy requirement seeks reporting on whole life carbon (WLC) emissions. This is to be considered for adoption at a later date or for particularly large developments.

Presumption against demolition and promoting circular economy – policy recommendations

Three sub-recommendations seeking to promote retrofit over demolition

The policy recommendation set out on this page ranges from qualitative justifications to quantitative assessment of whole life carbon (WLC). These can be used individually or combined for robustness. Initially we recommend implementing parts 1a and 1b. 1c should be reserved for applications that seek to substantially or totally demolish a locally interesting building that warrants retention in the view of the local authority.

	1a Retrofit-first approach before substantial or total demolition. **Justification** to be provided where substantial or total demotion is proposed.	+ **1b** Retrofit-first approach before substantial or total demolition. **Additional requirements** are to be met where substantial or total demotion is proposed.	+? **1c** *(Optional)* Retrofit-first approach before substantial or total demolition. **Optioneering WLC study** to be carried out where substantial or total demotion is proposed.
Justification for demolition provided	✓	✗	✗
Meet additional requirements	✗	✓	✗
WLC assessment comparison required	✗	✗	✓
Pros of each option	• Requires applicants to engage in an evaluation of refurbishment before considering substantial or total demolition. • Multiple design team members to input into the justification of whether all or parts of the building could be retained.	• Where substantial or total demolition is sought, applicants are to meet minimum requirements for net zero operational carbon, upfront embodied carbon, carry out a pre-demolition and reclamation audit and report materials to be used on/off site.	• Where substantial or total demolition is sought, full WLC comparison between a major renovation option vs re-build option will be required. This should demonstrate WLC is no worse for re-build than retrofit.
Cons of each option	• A qualitative judgement will be required on how strong the justification is.	• A qualitative judgement will be required on whether the additional policy requirements have been met.	• Difficult to determine at early stages of the application (WLC details wont yet be fully developed). • Cost and time implications for developer to assess two different scenarios will be a consideration.

1a Presumption against demolition and promoting circular economy - Justification

Retrofit-first approach before substantial or total demolition. Justification to be provided where substantial or total demotion is proposed.

Applies to

All development scales and building types*

Timescale for adoption into policy

Immediate use

Intention

Developments prioritise retrofit over re-build, thoroughly exploring the potential for retaining and retrofitting existing buildings. Where-substantial or total demolition is proposed, full justification is required.

Proposed requirement wording

Presumption against demolition and in favour of the re-use of existing buildings unless a full justification for demolition is provided. Justification where substantial or total demolition and re-build is sought must include:

- The purpose of the new building and whether this is a change of use.
- How much demolition is proposed:
  - Percentage of envelope and structure to be retained by area?
  - Percentage of internals to be retained by area?
  - Justification of substantial or total demolition by building layer (skin/shell, structure/frame, building services, and space plan/interior).
- Explanation as to why the existing building cannot be retained, providing evidence to this effect. This should go beyond saying a building is 'low quality' or 'not fit for purpose' and include an assessment of:
  - Structural condition - by means of a structural engineers report
  - Contamination (e.g. asbestos)
  - Visual/importance of the architecture in streetscape/location
  - Whether the development will deliver significant public benefits which could not be delivered through a retrofitting option – Is there bespoke operational requirements which could not be provided through the repurposing, adaptation and/or extension of the existing building(s)?
  - Service life/maintenance of fabric and systems – by means of an architectural and building services report.

How to judge success

Demolition has been avoided where possible and robust justification has been provided where re-build is considered.

Submission requirements:

Planning submission	Description	• Description of retrofit measures and level of building retention on-site. Full justification for substantial or total demolition.
	Format	• 1 page as pat of a wider report showing level of building retention, retrofit measures, and/or full justification for any demolition.
Discharge of condition	Description	• Confirmation of alignment with planning permission
	Format	• Short 1 page statement of confirmation and figures as required disclosed.

Supplementary guidance – threshold for demolition

*The threshold for the level of demolition to meet the policy requirements should be determined. Whether a building is seen as significant in its context prior to demolition (e.g. heritage, scale, local character) will need to be considered. E.g. demolition of a small outbuilding on-site or substantial demolition to enable rear or loft extensions may not invoke the use of this policy requirement, whereas the demolition of a house or office building should receive more consideration.

Listed buildings and those otherwise already protected are considered outside of the scope of this policy.

Supplementary guidance – justifications for demolition

Supplementary guidance for local planning authorities to determine what types and level of justification could be acceptable.

1b Presumption against demolition and promoting circular economy – Additional requirements

Retrofit-first approach before substantial or total demolition. Additional requirements are to be met where substantial or total demotion is proposed.

Applies to

All development scales and building types*, that have not sufficiently justified demolition as per policy requirement 1a.

Timescale for adoption into policy

Immediate use

Intention

Developments prioritise retrofit over re-build, thoroughly exploring the potential for retaining and retrofitting existing buildings. Where substantial or total demolition is proposed and justification is not sufficient, then additional requirements are to be met.

Proposed requirement wording

Presumption against demolition and in favour of the re-use of existing buildings unless a full justification for demolition is provided. Additional requirements, where substantial or total demolition and re-build is sought, must be met:

- Where substantial or total demolition is proposed, meet the Essex 'Operational Net Zero' policy for new build.
- Design any new structures to ensure the longevity of the building, easy adaptation, easily re-usable materials, and capable of adopting new low carbon improvements.
- Meet stricter upfront embodied carbon limits for re-build than new build**.
- Carry out a pre-demolition and reclamation audit for existing buildings.
- Where substantial or total demolition is proposed, use the pre-demolition and reclamation audit to carry out detailed material analysis of the existing building and report the percentage of materials (by volume) that will be re-used on and off-site, how much will be recycled on or off-site, and how much will be disposed of elsewhere. Note where the contractor is able to use materials on a different project. Proposed materials considered for re-use should not be not downgraded or be processed further.

How to judge success

Demolition has been avoided where possible and additional requirements have been met where re-build is considered/proposed.

Submission requirements:

Planning submission	Description	• Requirements of policy 1a + description of how additional requirements to be met for substantial or total demolition inkling summary of pre-demolition and reclamation audit.
	Format	• 1 page as apart of a wider report demonstrating additional requirements have been met for any demolition.
Discharge of condition	Description	• Confirmation of which materials have been re-used, recycled or disposed of.
	Format	• Short 1 page statement of confirmation demonstrating that additional requirements were met.

Supplementary guidance – threshold for demolition

*The threshold for the level of demolition to meet the policy requirements should be determined. Listed buildings and those otherwise already protected are considered outside of the scope of this policy.

See previous page for more detail.

Supplementary information required

- **Stricter upfront embodied carbon targets to be developed with an appropriate level determined. Potential to be a percentage improvement over the new build targets.
- Definition of substantial and total demolition to be defined for the purpose of this policy.

Supplementary guidance – pre-demolition and reclamation audits and circular economy

Supplementary design guidance should be created to support this policy recommendations for content of pre-demolition and reclamation audit and how to carry out material analysis. Useful industry guidance - UKGBC Circular economy guidance for construction clients - Opportunities for re-use of materials - https://ukgbc.org/wp-content/uploads/2019/04/Circular-Economy-Report.pdf

1c Presumption against demolition and promoting circular economy – Optioneering

Retrofit-first approach before substantial or total demolition. Optioneering while life carbon (WLC) study to be carried out where substantial or total demotion is proposed.

Applies to

Buildings as determined applicable by the local planning authority (not listed or otherwise protected) , that are proposed to be demolished and have engaged in policy requirements 1a and 1b .

Timescale for adoption into policy

Future consideration as policy landscape develops in next 3-5 years.

Intention

Developments prioritise retrofit over re-build, thoroughly exploring the potential for retaining and retrofitting existing buildings. Where substantial or total demolition is proposed, an optioneering study is carried out comparing whole life carbon scenarios for retrofit vs rebuild..

Proposed requirement wording

- Presumption against demolition and in favour of the re-use of existing buildings unless a Whole Life Carbon (WLC) assessment optioneering comparison is undertaken for different genuine renovation and new build scenarios.
- To proceed with substantial or total demolition the results of the comparison shows that demolition has the same or lower WLC than retention and retrofit of the existing building(s).
- If the existing building on-site is considered for total demolition, a material analysis of the existing building should be carried out and include recommendations for re-use of building materials in a pre-demolition and reclamation audit.

How to judge success

Demolition has been avoided where possible and WLC optioneering has been undertaken to prove the building will be lower carbon under the re-build scenario.

Submission requirements:

Planning submission	Description	• Whole life carbon (WLC) optioneering study has been carried out for substantial or total demolition.
	Format	• Report findings of WLC optioneering study, demonstrating that there are lower WLC emissions for re-build over retention and retrofit.
Discharge of condition	Description	• Confirmation of WLC assessment for re-build.
	Format	• Re-submission of WLC assessment for re-build post-completion.

Optioneering explained

The purpose of the optioneering exercise is to compare bespoke development options for a particular site.

Supplementary guidance – optioneering

Supplementary design guidance should be created to support this policy's recommendations. This could include:

- An explanation of how best go about optioneering. City of London have produced some useful Carbon Options Guidance.

2 Lean building design and good material efficiency for lower embodied carbon

Applies to

All development scales and building types.

Timescale for adoption into policy

Immediate use

Intention

The applicant has sought to reduce resource use by creating a building that is efficient in its material use, form and design. The design should seek to balance the requirements for meeting net zero operational carbon and low upfront embodied carbon.

Proposed requirement wording

All new buildings and developments should demonstrate that upfront embodied carbon has been considered and reduced where possible through good design and material efficiency. As part of the planning application applicants should submit a summary of the efforts made to reduce upfront embodied carbon. This includes:

- A summary of the efforts made to design a lean, low carbon structure and building design. This will take into account efficiency of material use as well as types of material used. Applicants should justify where large volumes of material are proposed to be used due to specific design features (such as basements, podiums, large cantilevers).
- A calculation of the building form factor (exposed external surface area/gross internal floor area).
- An elemental analysis of the upfront embodied carbon (kgCO_2e/m^2) associated with three external wall options and two superstructure options. Include justification for the selected wall and structure type.
- A summary of steps taken to design for and drive a circular economy*.

How to judge success

Designs have been actively improved to reduce upfront embodied carbon. E.g. sub and superstructure have been optimised, building form does not result in excess structure and material use, material choices represent lowest upfront carbon options. Embodied carbon has not be traded with net zero carbon operational carbon, a balance should be sought to achieve both.

Submission requirements:

Planning submission	Description	• Description of efforts made on the building design, material efficiency and material selection, with form factor of buildings declared, three wall type sand two sub and superstructure types analysed and compared with a declaration of which one was chosen and why.
	Format	• 5 pages as part of a wider report and/or mark-up of drawings and diagram with design improvements noted.
Discharge of condition	Description	• Confirmation that measures proposed and described pre-planning were followed. If they were not then why not.
	Format	• Short 1 page statement of confirmation demonstrating that design measures were carried through, if not, then why not.

Supplementary guidance – designing for low embodied carbon

Supplementary design guidance should be created to support this policy's recommendations. This could include:

- An explanation of what good design for material efficiency, material selection and low embodied carbon outcomes looks like. Include information on why material efficiency and form factor are important and how this compares to material selection.
- Examples of upfront embodied carbon figures for wall and structure types
- A summary of circular economy principles.

For example - IStructE have produced some useful guidance Lean design: 10 things to do now

Supplementary guidance – temporary buildings

* Designing for deconstruction and a circular economy is particularly relevant to temporary buildings.

3 Limiting upfront embodied carbon and refrigerant emissions

Applies to
Major developments of all building types. Also applies to major renovation.

Timescale for adoption into policy
Immediate use, with a policy review every three years with potential to strengthen limits based on industry knowledge. Initially the same limits should be set for major renovation and rebuild as they are for new build.

Intention
The applicant has demonstrated that upfront embodied carbon and refrigerant emissions have been reduced, through efficient material use, material selection and design strategies. The applicant has committed to measuring upfront embodied carbon at RIBA stages 2/3, 4 and 6. This should demonstrate that all major developments are within the limits set.

Proposed requirement wording
New major developments, major renovations and rebuild developments should achieve the following set limits for upfront embodied carbon (A1-A5):

- Low rise residential (up to 11m): ≤500 $kgCO_2e/m^2$ (GIA)
- *Mid and high rise residential (over 11m)* - ≤500 $kgCO_2e/m^2$ (GIA) (LETI band C) or *follow NZCBS limits when available*
- Non-domestic buildings: offices ≤600 $kgCO_2e/m^2$ (GIA), education ≤500 $kgCO_2e/m^2$ (GIA), and retail ≤550 $kgCO_2e/m^2$ (GIA) - (LETI band C) or *follow NZCBS limits when available.*

New major developments should also report on the following:

- List the top five materials (I.e. brick, concrete, tile) by upfront embodied carbon emissions (A1-A5).
- To consider how the highest embodied carbon materials will be treated at the end of life, provide circular economy metrics for the top five highest upfront embodied carbon materials reported (% recycled content/ designed for re-use/ recycling/ disassembly).
- Disclose where products of an unusually low embodied carbon have been intentionally used in the calculation (within the 25th percentile).
- Report the embodied carbon of refrigerants in building services and assess how their associated impacts can be prevented/reduced. *Adopt NZCBS global warming potential (GWP) refrigerant limits when available.*

How to judge success
Proposed buildings meet the limits set for upfront embodied carbon and refrigerants and report on high carbon materials and circular economy metrics.

Submission requirements:

Planning submission	Description	• Upfront embodied carbon calculation results carried out in line with RICS WLCA PS v2 2023 (or later versions) demonstrating limits are met for all major building types. • Reporting of top five highest emitting materials by upfront embodied carbon, together with circular economy metrics, and disclosure on unusually low embodied carbon material data. • Embodied carbon calculation for refrigerants carried out using CIBSE TM65 methodology.
	Format	• Use RICS WLCA PS v2 2023 (or later versions) reporting tables for demonstrating compliance with upfront embodied carbon limits. Upload results to the Built Environment Carbon Database (BECD). • Two pages as part of a wider report to summarise results. Screenshots of RICS template results to be included in an appendix.
Discharge of condition	Description	• Confirmation that measures proposed and described pre-planning were followed. If not, provide an explanation as to why not.
	Format	• Re-submission of RICS WLCA PS v2 2023 (or later versions) reporting tables for demonstrating compliance with upfront embodied carbon limits. Upload results to the BECD. • Short two page statement summarising results and confirming they are comparable to planning submission, if not, then why not.

Supplementary guidance – fire regulation

- Up to 11m – no combustibility requirements for walls, other than during construction.
- Over 11m – insulation and external surface of walls should not be combustible.
- Over 18m – whole wall build-up should be non-combustible (some exemptions exist).

See page 141 for more detail.

Supplementary guidance – major developments

- 10 or more dwellings
- More than 1,000m² non-residential

4 Reporting whole life carbon

Applies to

Major developments of all building types. Also applies to major renovation.

Timescale for adoption into policy

To be brought in 3-5 years after introduction of first three policy recommendations. Unless developments in industry guidance or regulation recommend bringing limits in earlier or later. Alternatively it could be brought in for particularly large schemes e.g. 1,000 or more homes and over 5,000sqm of non-domestic.
Once implemented, carry out a policy review every three years with potential to set WLC limits based on industry knowledge and recommendation.

Intention

The applicant has committed to measuring whole life carbon (WLC) at RIBA stages 2/3, 4 and 6 to demonstrate improvements and help inform future reporting for policy.

Proposed requirement wording

New major developments should:

- Have met policy requirement 3 – 'Limiting upfront embodied carbon'
- In addition, all major developments should calculate and report non-decarbonised and decarbonised emissions against life cycle stages B-C and D (including B6/B7). This should include sequestered carbon.

New major developments should also report on the following:

- List the top five materials (i.e. brick, concrete, tile) by lifecycle embodied carbon emissions (A-C, excluding B6-B7). Sequestered carbon should be reported separately.
- List the expected replacement cycle lengths for the top five highest embodied carbon materials.
- To consider how the highest embodied carbon materials will be treated at the end of life, provide circular economy metrics for the top five highest lifecycle embodied carbon materials reported (% recycled content/ designed for re-use/ recycling/ disassembly).

How to judge success

A report has been produced that can be compared to other developments in the future. The figures in these reports can be used to set WLC limits in the future

Submission requirements:

Planning submission	Description	• WLC calculation results carried out in line with RICS WLCA PS v2 2023 (or later versions). • Reporting of top five highest emitting materials by lifecycle embodied carbon, together with circular economy metrics.
	Format	• Use RICS WLCA PS v2 2023 (or later versions) reporting tables for reporting WLC emissions. • 1 page as part of a wider report to summarise results and additional metrics. Screenshots of RICS template results to be included in an appendix.
Discharge of condition	Description	• Confirmation that measures proposed and described pre-planning were followed. Explanation to be provided if they were not, then why not.
	Format	• Re-submission of RICS WLCA PS v2 2023 (or later versions) reporting tables reporting WLC emissions. • Short 1 page statement summarising results and confirming they are comparable to planning submission, if not then why not.

Considerations:

- *Essex will have two complementary policies – operational and embodied carbon. There is a question whether WLC assessments are needed in addition to two separate requirements, other than to allow projects to be compared outside of Essex using a single figure.*
- *NZCBS will likely keep operational and embodied reporting and limits separate (i.e. not combine into a single WLC figure).*
- *This recommendation opens a policy requirement avenue for introducing WLC assessments later. Or for use on particularly large developments e.g. 1,000 or more homes and over 5,000sqm of non-domestic.*

Two complementary policies: Operational and embodied

The current Essex operational carbon policy is an overarching policy with different requirements for achieving net zero operational carbon new buildings. The policy requires that all buildings must be designed and built to be Net Zero Carbon in relation to operational energy. They must be ultra-low energy buildings, be fossil fuel free, and generate renewable energy on-site to at least match annual energy use.

Proportion of embodied carbon vs operational carbon

As new buildings become more efficient, operational carbon emissions increasingly reduce. As a result, embodied carbon emissions make up a greater proportion of the total building whole life carbon. Therefore, it is important that the life cycle carbon emissions are considered, to make sure the built environment industry is designing, constructing and operating buildings that have overall low carbon emissions. The pie charts on the right demonstrate the whole life carbon emissions breakdown for three residential buildings with different energy use intensities (EUIs) for operational carbon.

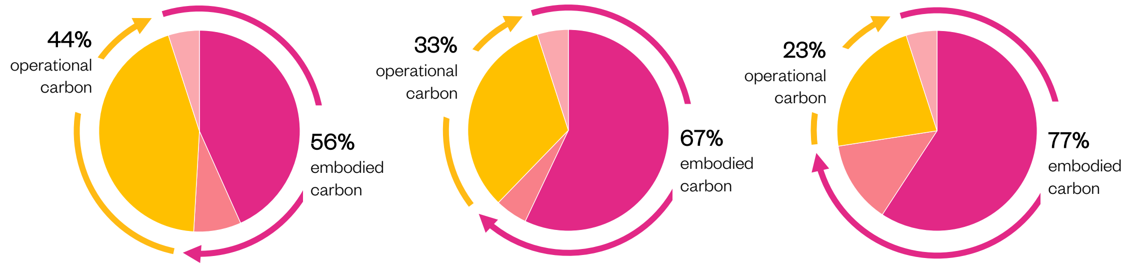
Complementary policies

The current Essex policy approach has requirements for operational and embodied carbon separately. Although they do not overlap in terms of having an overall whole life carbon policy requirement, the two policy requirements complement each other in a way that ensures each area is optimised and clearly demonstrated in design and construction.

Carbon trade-off

To prevent an unwanted trade-off of carbon between policies, the upfront embodied carbon calculations in this report have been carried out on the basis that the homes also meet the operational net zero policy. Therefore, the fabric and system are enhanced accordingly. See *Essex solar design guide* for careful consideration of solar design and reduction of overheating.

PV panels and solar shading have been calculated separately/excluded from calculations as these are necessary parts of the building for net zero operational carbon. In these areas, if not carefully considered by applicants, the calculation of embodied carbon could be viewed as if they are in direct conflict with operational carbon reductions. Reducing the embodied carbon of solar shading should still be considered through multi-purpose design (e.g. balcony can provide solar shading) and low embodied carbon materiality selection.

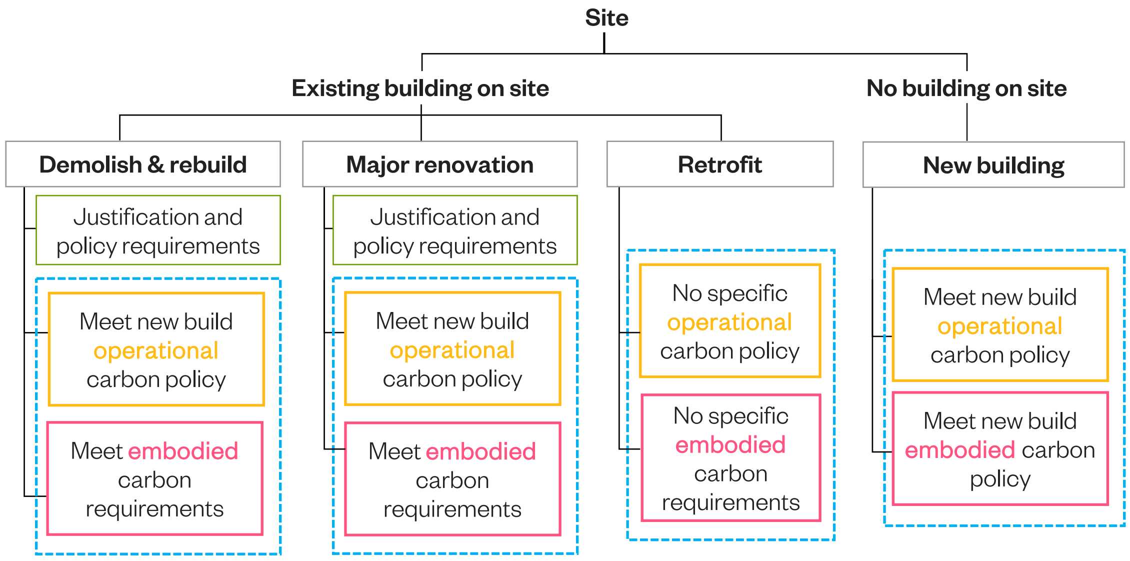


EUI 60 kWh/m^2 – with gas	EUI 60 kWh/m^2 - all electric	EUI 35 kWh/m^2 - all electric
Building regs compliant with gas heating, business as usual embodied carbon Operational carbon (B6) makes up the largest proportion of whole life carbon, due to the inefficiency of the gas heating system	**Building regs compliant with electric heating and improved embodied carbon** Upfront embodied carbon (A1-A5) makes up the largest proportion of whole life carbon.	**Ultra-low energy fabric with heat pump, best practice embodied carbon** Upfront embodied carbon (A1-A5) makes up the largest proportion of whole life carbon.

Key – WLC boundaries

- (A1 – A5) Upfront embodied carbon
- (B6) Operational carbon
- (B1-B5) Maintenance and replacements
- (C1-C4) End of life disposal

Comparison of three options for a residential building, showing the reductions in whole life carbon that may be possible with different reduction targets (decarbonised scenario).



Flow diagram showing example of how Essex operational and embodied carbon policy requirements of different building types could work together.

7

Implementation

Implementation of policy requirements

The overarching purpose of an embodied carbon planning policy is to reduce the embodied carbon emissions associated with buildings. The intent is not to make planning submissions onerous for the applicant or planning team reviewing it. Therefore, this section sets out recommendations for implementation the policy including: a checklist, contents of reports and completion and review of the RICS reporting template.

It is envisaged that a single written report including calculation results will be submitted at planning application stage, which would be conditioned so that the development is built according to the agreed report. The single written report could form a section in a wider 'Energy and Carbon Statement' that addresses both net zero operational and embodied carbon policies.

From the planning officer's perspective

Information needs to be simple to review and clearly set out so that it can be reviewed against policy. Checklists and pointers on how to read the RICS reporting template can assist with this.

Introductory training on embodied carbon would be beneficial (not essential) for planning officers to assess applications.

From the applicants perspective

For the submission: a contents list for reports will assist in keeping reports succinct and provide the applicant with an idea of what the local authority is looking for; a checklist with provide them with pointers for describing how embodied carbon has been reduced; and guidance on which cells to complete in the RICS template will ensure the correct embodied carbon scope is calculated and submitted.

Design guidance would also be beneficial to aid applicants in reducing embodied carbon, we recommend supplementing this evidence base with user friendly guidance that can be included in the Essex Design Guide.

Policy implementation

Policy requirements 1 and 2 require reporting to demonstrate policy compliance, whereas policy requirements 3 and 4 will be focused on reporting of numbers to demonstrate the limits have been met.

The following pages provide some useful tools for policy implementation.

Policy deliverables – single written report at planning and discharge stage:

Policy	Planning application	Discharge of condition
1a	Retrofit approach and robust justification for any demolition.	Confirmation of alignment with planning permission – statement and metrics
1b	Demolition justification and additional performance including destination of removed materials.	Confirmation of alignment with planning permission – statement and metrics
1c	Summary of results from design calculations	Summary of results from as-built calculations
2	Strategies used to reduce embodied carbon based around checklist. Explanation of why specific envelope and structural solutions were chosen.	Confirmation of alignment with planning permission, transparency where as-built differs from design strategies.
3	Summary of results from design calculations	Summary of results from as-built calculations
4	Summary of results from design calculations	Summary of results from as-built calculations

Policy deliverables – calculations and reporting using templates:

Policy	Planning application	Discharge of condition
1c	WLC optioneering and results for chosen option.	Final WLC assessment
2	Upfront embodied carbon (modules A1-A5) calculation results for three external wall types and two structural types. Report form factor.	-
3	Upfront embodied carbon (modules A1-A5) calculation results (using RICS template) for proposed building. Plus data for top five carbon emitting materials.	Upfront embodied carbon (modules A1-A5) calculation results (using RICS template) for completed building using as-built material quantities and specifications.
4	Lifecycle carbon (modules A-C excluding B6/B7) calculation results (using RICS template) for proposed building.	Lifecycle carbon (modules A-C excluding B6/B7) calculation results (using RICS template) for completed building using as-built material quantities and specification.

Typical report size and content - Policy requirements 1,2,3 and 4

The below sets out suggested content and number of pages for reporting against the policy requirements at planning application and discharge of condition stages.

Suggested typical planning application submission report:

Page 1	**Policy 1**	Approach to retrofit, including percentage of gross internal area (GIA) demolished from any existing building if applicant is intending to demolish.
Page 2	**Policy 1**	Results of pre-demolition and reclamation/ refurbishment audit and destination of materials removed from site. (If green/ brownfield not required).
Page 3	**Policy 2**	Whole building strategies used to reduce embodied carbon based around checklist.
Page 4	**Policy 2**	Structural strategies used to reduce embodied carbon based around checklist.
Page 5	**Policy 2**	Architectural strategies used to reduce embodied carbon based around checklist.
Page 6	**Policy 2**	MEP strategies used to reduce embodied carbon based around checklist.
Page 7	**Policy 2**	Upfront embodied carbon (modules A1-A5) calculation results for three external wall types and two structural types. Justification of chosen solutions.
Page 8	**Policy 3**	Summary of upfront embodied carbon (modules A1-A5) calculation results for proposed building. Confirmation that proposed building meets the Policy 3 requirement limits.
Page 9	**Policy 3**	Schedule of data related to top five carbon emitting materials within the A1-A5 calculation.
Page 10	**Policy 4**	Summary of whole life carbon (WLC) (modules A-C, including B6/B7) calculation results for proposed building. Confirmation that proposed building meets the Policy 4 requirement limits.
Appendix	***Policy 3***	*Screenshots showing 'Summary' and 'Building' level upfront embodied carbon (modules A1-A5) results for the proposed building, presented in the RICS WLCA PS v2 2023 template (or later version).*
Appendix	***Policy 4***	*Screenshots showing 'Summary' and 'Building' level WLC carbon (modules A-C, including B6/B7) results for the proposed building, presented in the RICS WLCA PS v2 2023 template (or later version).*

Suggested typical conditions discharge report:

Page 1	**Policy 1**	Confirmation of % GIA demolished from any existing building if relevant.
Page 2	**Policy 1**	Confirmation of destination of materials removed from site (not required if green/ brownfield site).
Page 3	**Policy 2**	Statement/checklist confirming strategies used to reduce embodied carbon compared to planning application.
Page 4	**Policy 3**	Upfront embodied carbon (modules A1-A5) post completion assessment presented in required template (for comparison with planning figures and confirmation that required limit has been achieved).
Page 5	**Policy 3**	Schedule of data related to top five carbon emitting materials within the A1-A5 calculation.
Page 6	**Policy 4**	Whole life cycle carbon (modules A-C, including B6/B7) post completion assessment presented in required template (for comparison with planning figures and confirmation that required limit has been achieved).

Additional information - Policy requirement 1

Policy requirement 1 necessitates assessment from both applicant and planning officer to determine whether appropriate steps have been taken to justify the need for demolition.

Justification of substantial or total demolition could be for a number of reasons, such as: building/room sizes not suitable for change of use; ceiling heights not high enough for particular use; uninhabitable beyond repair; contamination (asbestos); structurally unsuitability.

The policy does not seek to ban demolition, whether substantial or total, its aim is to require applicants to carefully consider if demolition is really necessary, or whether retrofit could be reasonably considered instead.

Examples of useful considerations have been taken from Westminster City Council's, City Plan 2040, to highlight the considerations for applicants and planning officers.

This list is not exhaustive.

	Example from Westminster City Council
Policy requirement 1a - Tests for demolition	• Where retrofitting is unfeasible due to structural or safety concerns, applicants should demonstrate this through a structural statement from a suitably qualified engineer. Where structural reinforcement is possible, but the extent of which would make the development unviable to retrofit, this should be supported by a viability report. Some purpose-built structures may pose technical challenges for retrofitting, such as multi-storey car parks, and single storey garages – and redevelopment may be acceptable in these instances, provided that all options for material re-use from the existing structure are utilised through a pre-demolition and reclamation audit. • Newbuilds can bring opportunities for significant public benefits, such as the delivery of new public infrastructure, the provision of affordable workspace, significant uplifts in jobs, affordable housing and estate regeneration. Applicants for developments incorporating such benefits as a result of demolition should demonstrate how these benefits could not practicably or viably be realised through a retrofit scheme. Any economic benefits would need to be fully justified and the applicant must demonstrate to the council's satisfaction why they could not be achieved through a retrofit option through a meaningful and honest comparison. • Applicants should fully assess the suitability of a site for a proposed use when justifying operational requirements which could not be met through retrofit. Where bespoke operational requirements are relied upon to support demolition, these should be demonstrated as unachievable through a retrofit, alteration or extension to an existing building. Operational requirements may include: development phasing in order to maintain an important public service, and necessary design requirements without which the proposed use could not function. Where a change of use is proposed that requires bespoke design requirements, applicants should demonstrate the suitability of the site through a Site Selection Statement and set out why those design requirements are integral to the proposed use or operations of the building, providing evidence of any technical requirements or standards. • Securing extensions alongside newly retrofitted buildings will enable continued sustainable growth. Where applicants can demonstrate that an extension or external alteration is required to deliver a viable retrofit, we will consider the benefits of securing a lower carbon development when considering its design impacts – in particular, where buildings may otherwise meet the tests for demolition. Applicants should demonstrate how any harm identified from the development has been avoided, mitigated, or minimised, and identify the potential carbon reduction benefits that the development will deliver, considering both embodied carbon and operational carbon.
Policy requirement 1c – comparison of retrofit and rebuild	• When presenting comparisons between retrofit and newbuild options, a realistic whole life cycle for a retrofit scheme should be used which accounts for the extended life of a building resulting from a high-quality retrofit; and how the material choices for a retrofit option and a newbuild both aim to deliver the lowest embodied carbon achievable.

Checklist - Policy requirement 2

Policy requirement 2 necessitates assessment from both applicant and planning officer to determine whether appropriate steps have been taken to reduce upfront embodied carbon through design.

The checklist opposite provides some suggested areas for commentary/demonstration by applicant and areas for review by the planning officer.

This list is not exhaustive.

Element of building	Example embodied carbon reduction strategies
Whole building	• Efficient form factor – building has been designed to reduce external surface area. • Omit basements, podiums and retaining structures where possible and practical, these contribute to significant embodied carbon emissions. • Review development brief for spatial efficiency • Amount of re-used materials from existing buildings in-situ, on-site re-use or from other sites • Use of renewable and/or bio-based materials where possible • Use of recycled content materials where the design team has influence over construction specification • Consider benefits of off-site construction/repeating modules • Compare product environmental product declarations (EPDs) before confirming material selection and consider whether the design team has influence over construction specification • Consider design for deconstruction and maintenance (this will assist in reducing life cycle emissions less than upfront emissions)
Sub-structure	• Use lightweight primary structure to reduce loads on the sub-structure and material volumes of the sub-structure • Carry out early ground condition investigations and reduce piles to minimum possible
Primary structure	• Balance columns and grid of structure to reduce slab depths but allow spatial adaptability (grid 3-6m preferred) • Confirm structural loadings are appropriate for use – aim for 100% utilisation of structure • Design for minimal transfer structures and cantilevers, ideally none. • Consider specification of material
External envelope and roof	• Balance the ratio between solid and glazed areas with average 40% glazing for non-domestic buildings and glazing to suit orientation for domestic (10-15% glazing area to north, 10-20% east/west, 20-30% south) • Reduce secondary framing for envelope construction through load-bearing solutions, larger cladding modules or standard sizes. • Review implications of fire regulations and whether natural and lower embodied carbon materials can be used in walls for the size of building. • Seek to limit high load roof systems e.g. green/ blue roofs, photovoltaics, heat pumps
Internal partitions/ finishes/ furniture, fixings and equipment (FF&E)	• For buildings of lower scale consider cement free boards and timber, avoid metal studs/components • Reduce glazed partitions if possible and explore timber framing • Consider eliminating cosmetic covering materials e.g. exposing structure or services and utilise self-finishing materials • Use off the shelf FF&E, avoid excessive built in, bespoke solutions • Consider longevity (to reduce life cycle emissions)
MEP	• Avoid over-provision of plant by promoting passive design and fewer, simpler systems • Avoid long duct and pipework runs • Specify low global warming potential (GWP) refrigerants
External works	• Avoid excessive land works and areas of hardstanding • Choose permeable/ lightweight solutions with less sub-structure requirements • Choose natural planting/tree balls without sub-structure/complex drainage • Provide natural attenuation for surface water rather than tanks

Measuring and reporting embodied carbon as the design develops – Policy requirement 3

The table opposite outlines the embodied carbon deliverables, appropriate data sources, material quantities and uncertainty of a building (retrofit or new build) or collection of buildings across a masterplan.

Design stage	Embodied carbon deliverable	Data source	Material quantities	Uncertainty
Early stage/ concept design (pre-application Stage 1)	• Elemental comparisons for major emission sources.	• Generic data (not specific EPDs).	• Estimated quantities, can use cost plan. Or base on indicative bay drawn or modelled in 3D rather than whole building.	• 15% contingency factor included as per RICS PS v2 2023 guidance (section 4.10) (or later version).
Early stage/ concept design (pre-application Stage 2)	• Completed RICS PS v2 reporting templates (or later version) for concept level. (Granularity 1) building reporting and project summaries.	• Generic data (not specific EPDs).	• Design drawings or 3D model and aligned cost plan from which to generate carbon measurement.	• 15% contingency factor included as per RICS PS v2 2023 guidance (section 4.10) (or later version).
Planning application	• Completed RICS PS v2 reporting templates (or later version) for planning level (Granularity 2) building reporting and project summaries. • Report summary aligned with RICS v2 (or later version) for embodied carbon emissions.	• Mixture of generic data and specific product EPDs where elements are more defined (likely to be those related to planning application and construction).	• Design drawings or 3D model, specifications for key elements and aligned cost plan from which to generate carbon measurement. Travel and construction emissions estimated for upfront carbon.	• 6% contingency factor included as per RICS PS v2 2023 guidance (section 4.10) (or later version), as well as: • carbon data uncertainty factor • quantities uncertainty factor
Conditions approval	• Completed RICS PS v2 reporting templates (or later version) for construction level (Granularity 2) building reporting and project summaries. • Report summary aligned with RICS v2(or later version) for embodied carbon emissions with narrative if significant changes against original application.	• Expect specific product EPD data sources based on procurement. This allows officers to confirm carbon implications of the proposed built asset against the planning application.	• Design drawings or 3D model, specifications for all elements and aligned cost plan from which to generate carbon measurement. Travel and construction emissions estimated.	• 6% contingency factor included as per RICS PS v2 2023 guidance (section 4.10), (or later version). as well as: • carbon data uncertainty factor • quantities uncertainty factor
Post-completion reporting	• Completed RICS PS v2 reporting templates (or later version). for post-completion level (Granularity 2 as minimum, preferable Granularity 3) building reporting and project summaries. • Report summary aligned with RICS v2 (or later version). for embodied carbon emissions with narrative if significant changes against original application.	• Specific product EPD data sources. This allows officers to compare the built asset against the planning application.	• As built drawing or 3D model, as-built material procurement data and aligned cost plan from which to generate carbon measurement. Full travel distances, modes, site emissions and wastage can also be used.	• 0% contingency/ uncertainty included for upfront carbon included as per RICS PS v2 2023 guidance (section 4.10) (or later version). • Uncertainty may still apply to in-use/ end-of-life calculations.

RICS 2023 Reporting template for buildings - Policy requirement 3

Summary reporting – buildings tab 1

This reporting template should be completed by the applicant, per building for the given site.

Key

- All cells in white should be completed upon planning submission.
- Cells in purple are optional
- When summed, these cells should be equal to or less than the set limits for upfront embodied carbon (A1-A5) in policy requirement 3.

Assessment information, energy and water

	Key assessment information			Energy consumption					Energy generation				Water	
Description	Life cycle stages included	GIA/ unit	Reference study period/ years	Units	Energy consumption during use (electricity)	Energy consumptio n during use (gas)	Energy consumption during use (other fuel)	Total energy consumptio n during use	Renewable energy generated on site	Renewable energy generated that is used on site	Renewable energy generated that is exported to the grid, but then re-imported and used over the course of a	Excess renewable energy generated that is exported to the grid	Units	Water consumptio n during use [B7]
Building (new build or aggregrated refurbishment project)				KWh/ yr									m3/ day	
				KWh/ yr/ unit									m3/ day/ unit	
External works within red line boundary				KWh/ yr									m3/ day	
				KWh/ yr/ unit									m3/ day/ unit	
External works outside red line boundary														
Totals				KWh/ yr									m3/ day	
				KWh/ yr/ unit									m3/ day/ unit	

Summary of carbon emissions by element and life cycle stage/module (non-decarbonised)

Note: For a refurbishment project the upper rows of this table would be completed twice - for the refubished GIA and new build GIA, the results would then be aggregated when reporting for the overall assets. For a masterplan project complete a version for each individual asset and report the total external works separately.

Columns should be added for each different scenario considered for the asset's use & EoL stages. The scenario name/number should be clearly indicated.

* Headings with asterisk denote modules affected by decarbonisation.

Building elements		Carbon per life cycle stage – non-decarbonised																				
		A0 Pre-construction stage	[A1-A3] Product stage excl. sequestered carbon	[A1-A3] Sequestered carbon within installed materials/ products	[A4] Transport to and from site	[A5] [A5.1-A5.3] Pre-construction demolition, construction activities and waste management	[A5.4] Transport of construction workers	[B1.1] In-use emissions & removals materials & carbonation	[B1.2] * In-use emissions & removals Refrigerant leakage	[B2-B3] Maintenance and repair	[B4] * Replacement	[B5] * Refurbishment / planned changes excl. sequestration (where relevant)	[B5] Sequestered carbon related to refurbishment/ planned changes (where relevant)	[B6] * [B6.1-B6.3] Energy use	[B7] * [B7.1-B7.3] Water use	[B8] * User activities	[C1] * Deconstruction/demolition process	[C2] * Transport to waste processing or disposal facilities	[C3] Waste processing for reuse, recycling and/or energy recovery and disposal	[C4] Waste disposal	D1 * Potential net benefits/loads from reuse, recycling, energy recovery and/ or other recovery	D2 * Potential benefits/loads from exported utilities
Asset level emissions																						
0.1 Demolition works																						
0.2 Facilitating works																						
1 Substructure																						
2 Superstructure - Structural elements																						
2 Superstructure - Building envelope																						
2 Superstructure - Internal elements																						
3 Finishes																						
4 Fittings, furnishings and equipment (FF&E)																						
5 Services (MEP)																						
6 Pre-fabricated buildings and units																						
7 Works to existing buildings																						
Sub-total	kgCO2e																					
8 External works associated with the project (within boundary)																						
8 External works associated with the project (outside of boundary)																						
Total	kgCO2e																					

RICS 2023 Reporting template summary - Policy requirement 3

Project level summary tab

This reporting template should be completed by the applicant, as a summary where multiple buildings are to be built on the same site.

Project-level summary

Sub-assets Add/remove sub-assets as necessary, depending on project scope	Key assessment information							Energy and water summary					Upfront carbon emissions incl. uncertainty			Carbon emissions non-decarbonised, incl. uncertainty				Carbon emissions decarbonised, incl. uncertainty			
	Life cycle stages included	Reference study period years	Contingency factor % uplift	Carbon data uncertainty factor % uplift	Quantities uncertainty factor % uplift	Overall WLCA uncertainty factor % uplift	GIA sqm/ normalised unit	Units	Energy consumption during use	Energy generated on-site	Units	Water consumption during use	Units	Upfront embodied carbon excl. sequestration [A1-A5]	Upfront sequestered carbon [A1-A5]	Total operational carbon [B6, B7, B8]	Whole life embodied carbon [A-C] excl. [B6, B7, B8]	Whole life carbon [A-C]	Potential benefits/loads beyond system boundary [D]	Total operational carbon [B6, B7, B8]	Whole life embodied carbon [A-C] excl. [B6, B7, B8]	Whole life carbon [A-C]	Potential benefits/loads beyond system boundary [D]
Sub-asset 1 [name] (1)								KWh KWh/unit KWh/year KWh/year/unit			m3 m3/year		kgCO2e kgCO2e/unit										
Sub-asset 2 [name]								KWh KWh/unit KWh/year KWh/year/unit			m3 m3/year		kgCO2e kgCO2e/unit										
Sub-asset 3 [name]								KWh KWh/unit KWh/year KWh/year/unit			m3 m3/year		kgCO2e kgCO2e/unit										
Aggregated and normalised totals (optional)								KWh/ unit			m3		kgCO2e/ unit										
Totals								KWh			m3		kgCO2e										

Carbon per life cycle stage non-decarbonised

Columns should be added for each different scenario considered for the asset's use [B] & EoL [C] & thereafter [D] stages. The scenario name/number should be clearly indicated.

Sub-assets Add/remove sub-assets as necessary, depending on project scope		Carbon per life cycle stage non-decarbonised, incl. uncertainty																				
		[A0] Pre-construction stage	[A1-A3] Product stage excl. sequestered biogenic carbon	[A1-A3] Sequestered biogenic carbon within installed materials/ products	[A4] Transport to and from site	[A5] [A5.1-A5.3] Pre-construction demolition, construction activities and waste management	[A5.4] Transport of construction workers	[B1.1] In-use emissions & removals materials & carbonation	[B1.2]* In-use emissions & removals Refrigerant leakage	[B2-B3] Maintenance and repair	[B4]* Replacement	[B5]* Refurbishment/ planned changes excl. sequestration (where relevant)	[B5] Sequestered biogenic carbon related to refurbishment/ planned changes (where relevant)	[B6]* [B6.1-B6.3] Energy use	[B7]* [B7.1-B7.3] Water use	[B8]* User activities	[C1]* Deconstruction/demolition process	[C2]* Transport to waste processing or disposal facilities	[C3] Waste processing for reuse, recycling and/or energy recovery and disposal	[C4] Waste disposal	[D1]* Potential net benefits/loads from reuse, recycling, energy recovery and/or other recovery	[D2]* Potential benefits/loads from exported utilities
Sub-asset 1 - raw data [name]	kgCO2e kgCO2e/unit																					
Sub-asset 1 - inc Uncertainty [name]	kgCO2e kgCO2e/unit																					
Sub-asset 2 [name]	kgCO2e kgCO2e/unit																					
Sub-asset 2 - inc Uncertainty [name]	kgCO2e kgCO2e/unit																					
Sub-asset 3 [name]	kgCO2e kgCO2e/unit																					
Sub-asset 3 - inc Uncertainty [name]	kgCO2e kgCO2e/unit																					
Totals (including	kgCO2e/ unit																					
Totals (including	kgCO2e																					

Key

All cells in white should be completed upon planning submission.

Cells in purple are optional

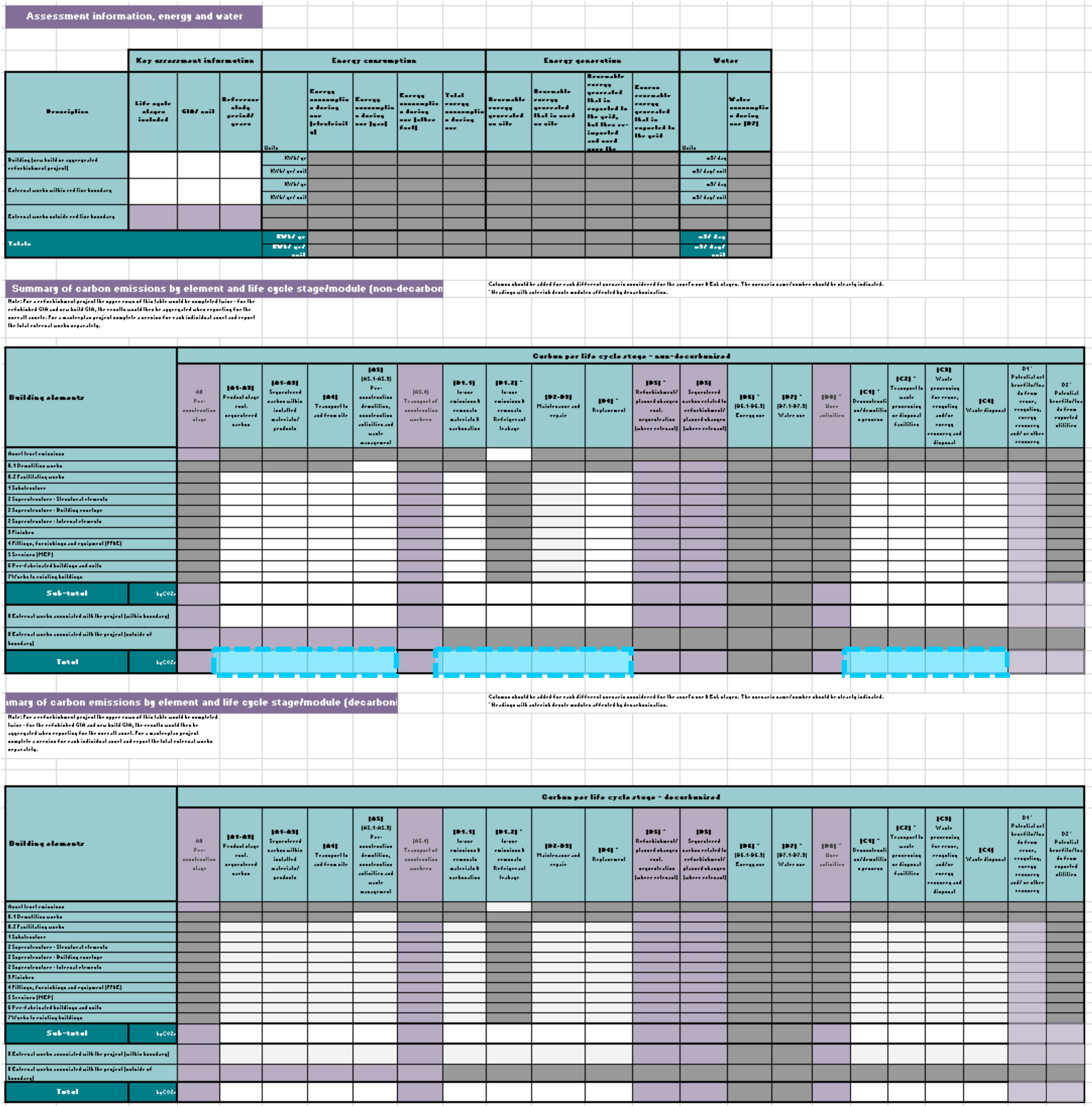
This cell should be equal to or less than the set limits for upfront embodied carbon (A1-A5) in policy requirement 3.

(1) These rows should be completed per building design on-site

RICS 2023 Reporting template for buildings - Policy requirement 4

Summary reporting – buildings tab 1

This reporting template should be completed by the applicant, per building for the given site.



Key

All cells in white should be completed upon planning submission.

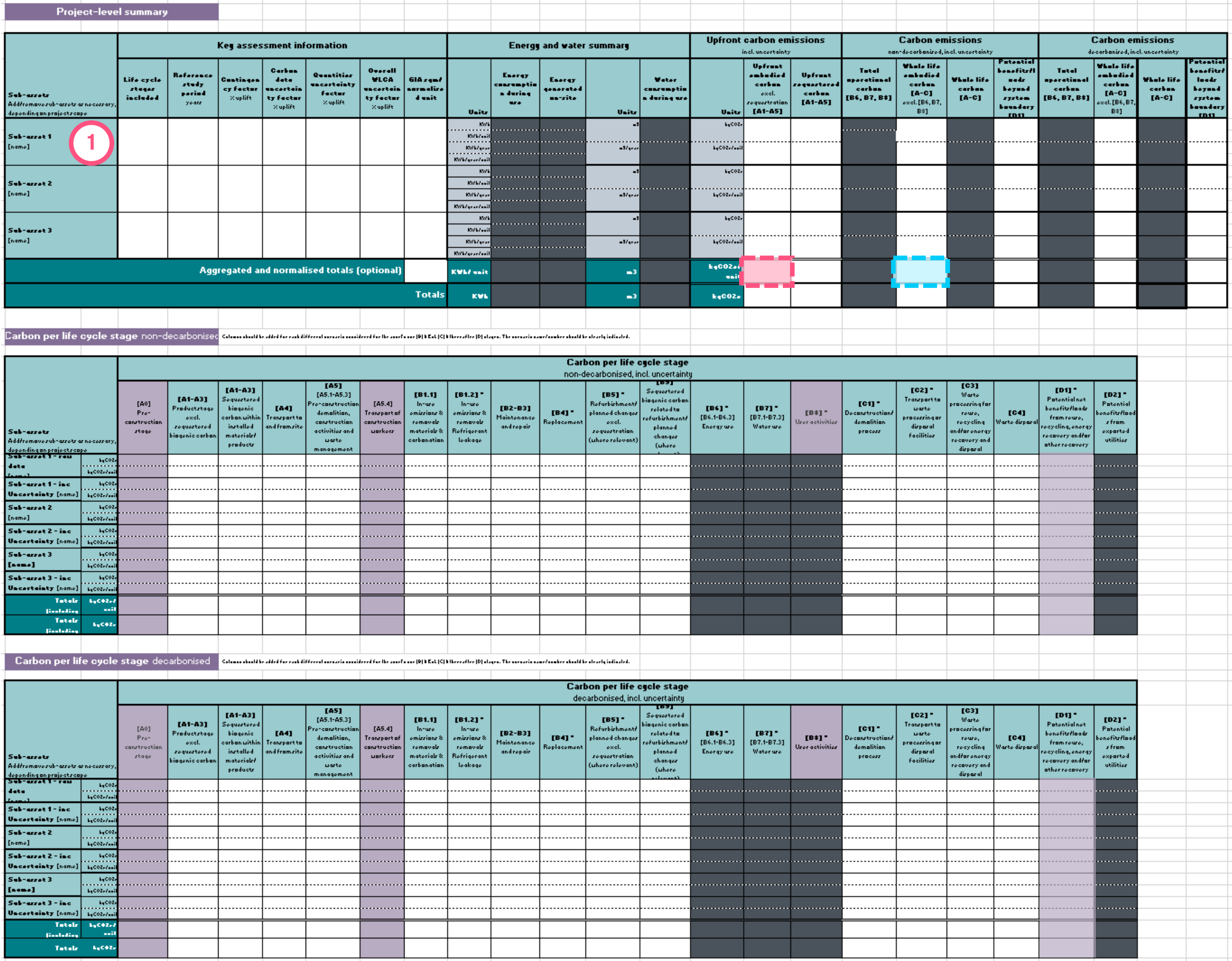
Cells in purple are optional

When summed, these cells should be equal to or less than the set limits for lifecycle embodied carbon (A1-A5, B1-B5, and C1-C4) in policy requirement 4.

RICS 2023 Reporting template summary - Policy requirement 4

Project level summary tab

This reporting template should be completed by the applicant, as a summary where multiple buildings are to be built on the same site.



Key

- All cells in white should be completed upon planning submission.
- Cells in purple are optional
- This cell should be equal to or less than the set limits for upfront embodied carbon (A1-A5) in policy requirement 3.
- This cell should be equal to or less than the set limits for lifecycle embodied carbon (A1-A5, B1-B5, and C1-C4) in policy requirement 4.
- (1) These rows should be completed per building design on-site

8

Upfront embodied carbon modelling for policy

Upfront embodied carbon modelling - purpose and context

Purpose of upfront embodied carbon and cost analysis

The purpose of this modelling analysis is to investigate the upfront embodied carbon (modules A1-A5) for three residential building typologies. The results have been used to inform the proposed upfront embodied carbon target policy. Capital cost modelling has been carried out to understand how cost and viability may affect policy. Supplementary life cycle embodied carbon calculations have also been carried out.

Context - Essex domestic building stock

A review of the data collected from the 2021 census showed the most common residential types in Essex to be the semi-detached (32%) and detached houses (31%). The remainder were terraced houses (21%) and flats, maisonettes or apartments (17%).

In addition, the data collected from Chelmsford Garden Community illustrates that common home sizes at outline planning application stage are 2 bedroom (38%) and 3 bedroom (34%).

The data from the census and example data from the representative development in Chelmsford have been used to inform the selection of building typologies modelled for this evidence base.

Essex net zero policy

The local authorities in Greater Essex have worked collaboratively through the Essex Planning Officers Association and with funding from the Essex Climate Action Commission to establish a robust evidence base and common planning policy approach for net zero carbon development (in operation). The policy proposes that all new buildings should be designed and built to be Net Zero carbon in operation and must demonstrate compliance with the following:

Requirement 1: A space heating demand limit

Requirement 2: Be fossil fuel free

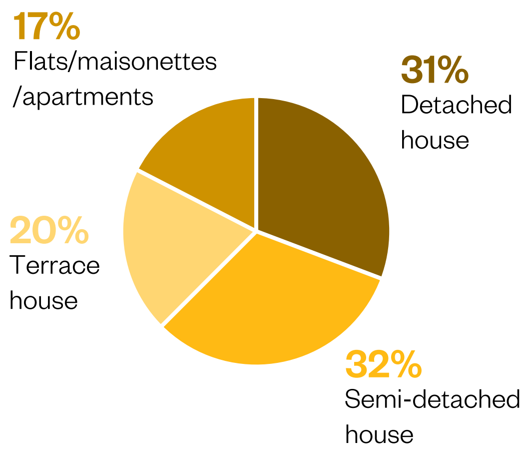
Requirement 3: An energy use intensity (EUI) limit

Requirement 4: An on-site renewable energy generation balance

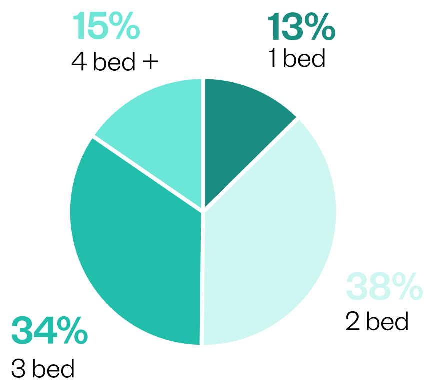
Requirement 5: Provide as-built performance confirmation and in-use monitoring

Requirement 6: Use energy offsetting as a last resort

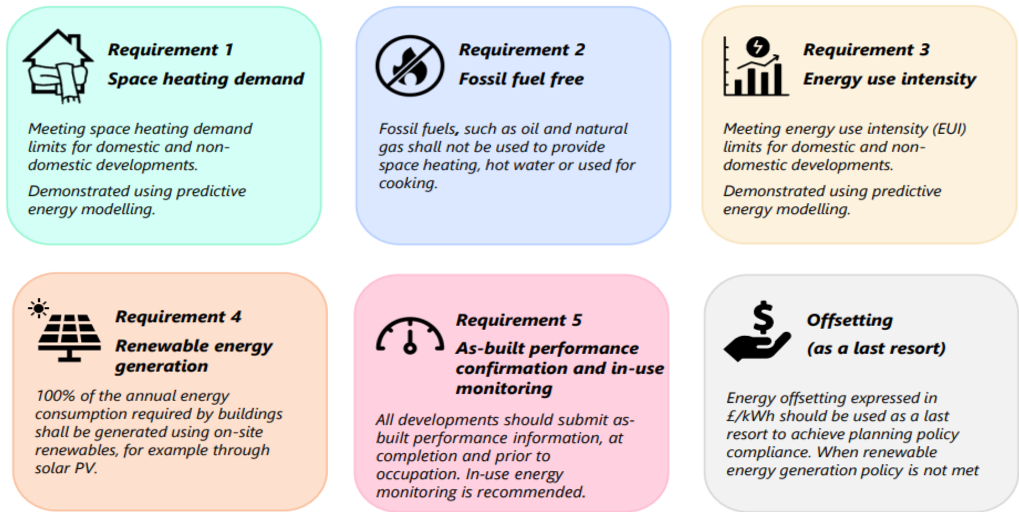
All embodied carbon modelling in this evidence base has been carried out on the assumption that the designed dwellings meet net zero operational policy requirements 1-4.



Essex accommodation types from the 2021 census



Spread of home sizes at Chelmsford Garden Community at outline planning application stage



Essex Net Zero Policy – Space heating demand, fossil fuel free and energy use intensity requirements explained. (Source: Essex Net Zero Policy).

Building typologies modelled

Typologies modelled

Three main residential typologies have been identified and assessed for the embodied carbon and cost modelling:

- 3 bed terrace house
- 3 bed semi-detached house
- Block of apartments (1 and 2 beds).

The data from the census and example data from the representative development in Chelmsford were used to inform the selection of building typologies modelled for this evidence base. All typologies modelled for upfront embodied carbon meet the Essex recommended planning policy approach for Net Zero Carbon Development (in operation).

How building form affects operational and embodied carbon

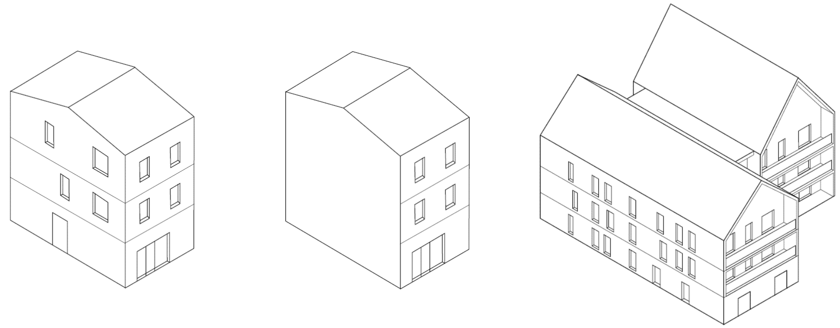
An efficient building form (lower form factor) is more likely to have lower operational carbon, reduce construction costs and emit less upfront embodied carbon than a complex building form (higher form factor).

Therefore, to meet the space heating demand and energy use intensity limits recommended in the Net Zero Carbon operational policy, it may be that terraced homes should become a more common house type in Essex. By joining houses together under one thermal envelope this reduces the exposed heat loss area. Therefore, they will more easily meet the operational carbon policy with thinner walls and will be more cost effective for housebuilders to build than detached or semi detached houses.

Where other home typologies are built, such as detached houses or bungalows, policy will cover these through the extrapolation of data from the modelling results in this report.

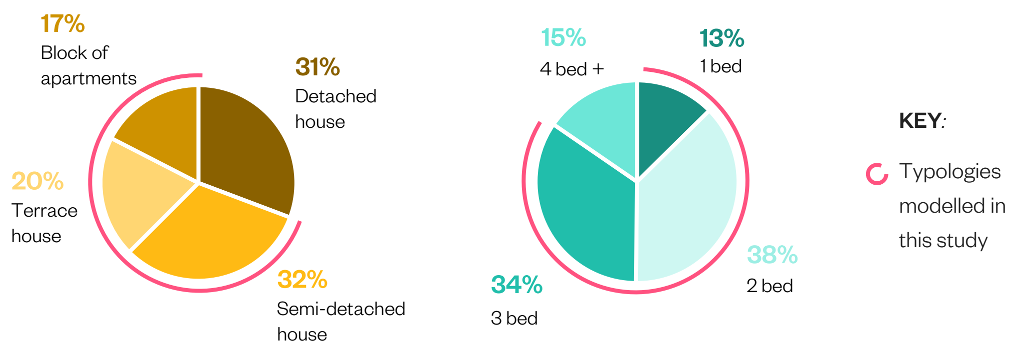
Building on modelled data from this report

Data submitted as part of planning applications could be used in future to supplement the results from this evidence base.



	Semi-detached	Terrace	Block of apartments
Number of storeys	3	3	3
Dwelling size	3 bedroom, 5 person	3 bedroom, 5 person	8 x 2 bedroom, 3 person 3 x 1 bedroom, 2 person
GIA (m^2)	114	114	1,019
Ground to top floor height (m)*	9.2m *(<11m)*	9.2m *(<11m)*	9.5m *(<11m)*
Form factor	2.2	2.1 (3-terraced houses) 1.9 (6-terraced houses)	2

Building typologies modelled, general information.
**This information is for the purpose of understanding fire regulation Part B – Volume 1: Dwellings, 2019 edition inc. 2020 & 2022 amendments.*



Comparison of typologies modelled when overlayed onto the 2021 census data and Chelmsford Garden Community home types at outline planning application stage.

Lifecycle stages modelled

To determine which lifecycle stages and building elements were part of this embodied carbon modelling, the guidance from RICS Professional Statement (PS) v2 2023 was followed.

Upfront embodied carbon

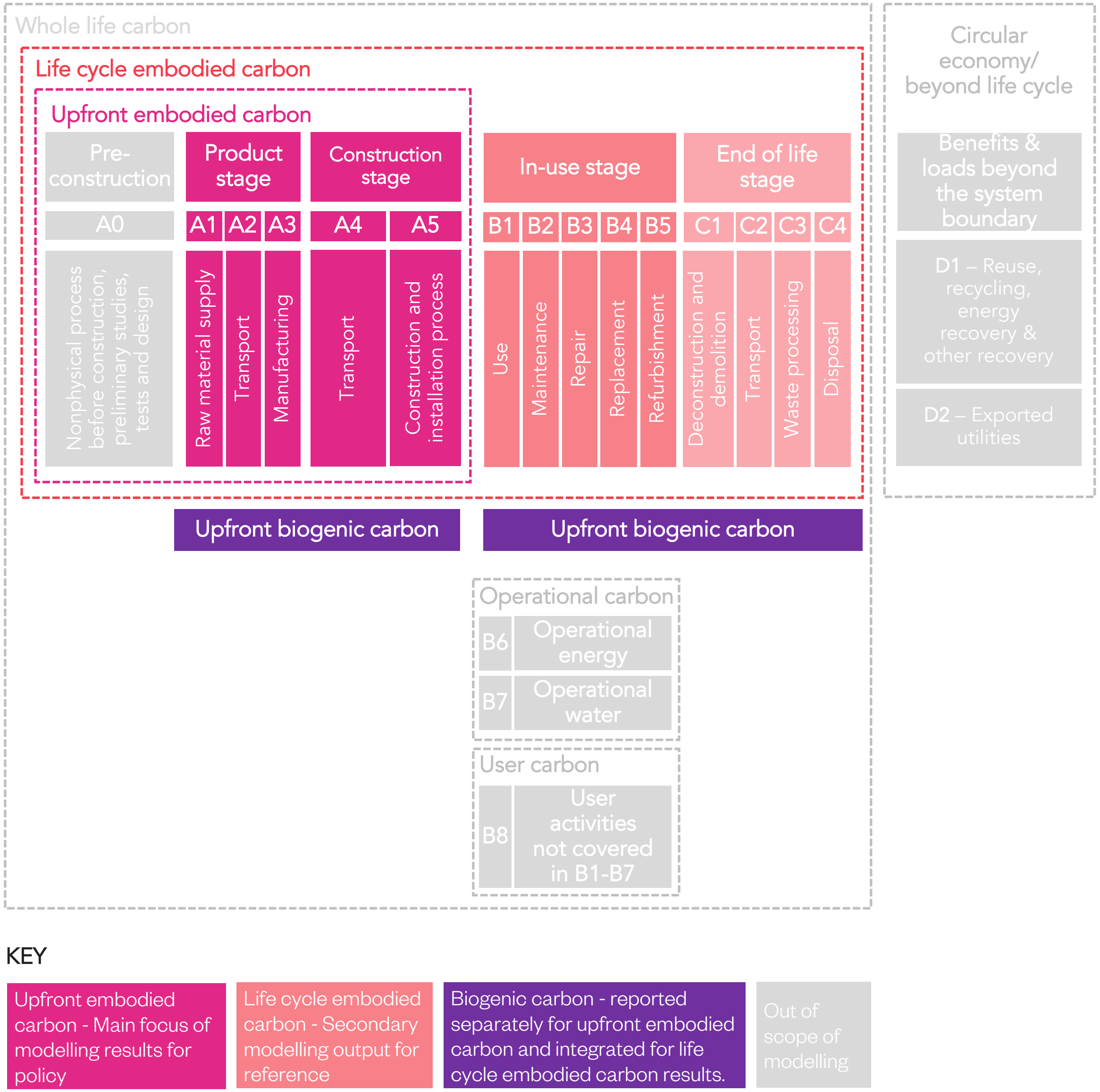
The primary aim of the modelling is to use it to inform planning policy embodied carbon limits. In turn, planning policy has the most influence over the design of buildings, with early design decisions being locked in through planning approvals. Upfront embodied carbon (stages A1-A5) can be heavily influenced through design. Therefore, it was determined that upfront embodied carbon would be the focus of this modelling exercise and policy. Upfront embodied carbon has been calculated, reported per typology and compared to LETI targets (see page 118).To date, upfront embodied carbon has more stable material databases available for the industry to use in the UK, in contrast with lifecycle data (B1-B5 and C1-C4) , which has limited and variable data sets available.

Life cycle embodied carbon

While the primary purpose of this modelling is to understand upfront embodied carbon (A1-A5), lifecycle embodied carbon (stages B and C) has also been included and reported. Total lifecycle figures per building typology have been reported and compared against RIBA 2030 Climate Challenge targets (see page 124). This is due to the importance of understanding the full impact of materials and products on the whole life cycle of a building (for example, building services where replacement cycles are more frequent than the building fabric). This report recommends requiring whole life carbon (WLC) reporting as part of future policy or for larger development schemes.

Biogenic carbon

Biogenic carbon is the sequestered carbon stored within biogenic construction materials incorporated into the building, such as timber. It has been included in the assessment and reported separately for stages A1-A5, in accordance with the RICS PS v2 2023 guidance. In this instance an apportionment was made for stages A1-A5 where materials data was only available for all life stages (A-C). For lifecycle carbon reporting, biogenic has been included within the results, in accordance with RICS PS v2 2023.



Life-cycle stages in and out of the scope of the embodied carbon modelling. This version of the diagram is adapted from a combination of the diagram from the BS EN 15978, RICS 2023 and LETI.

Building elements modelled

To determine which building elements were part of this upfront embodied carbon modelling, the building element categories from RICS Professional Statement (PS) v2 2023 were used.

Building element categories - Modelled

The modelling has covered as much of the upfront embodied carbon emissions from the sub-structure, super-structure, finishes and building services (MEP) as possible for each building typology.

Building element categories – Assumed

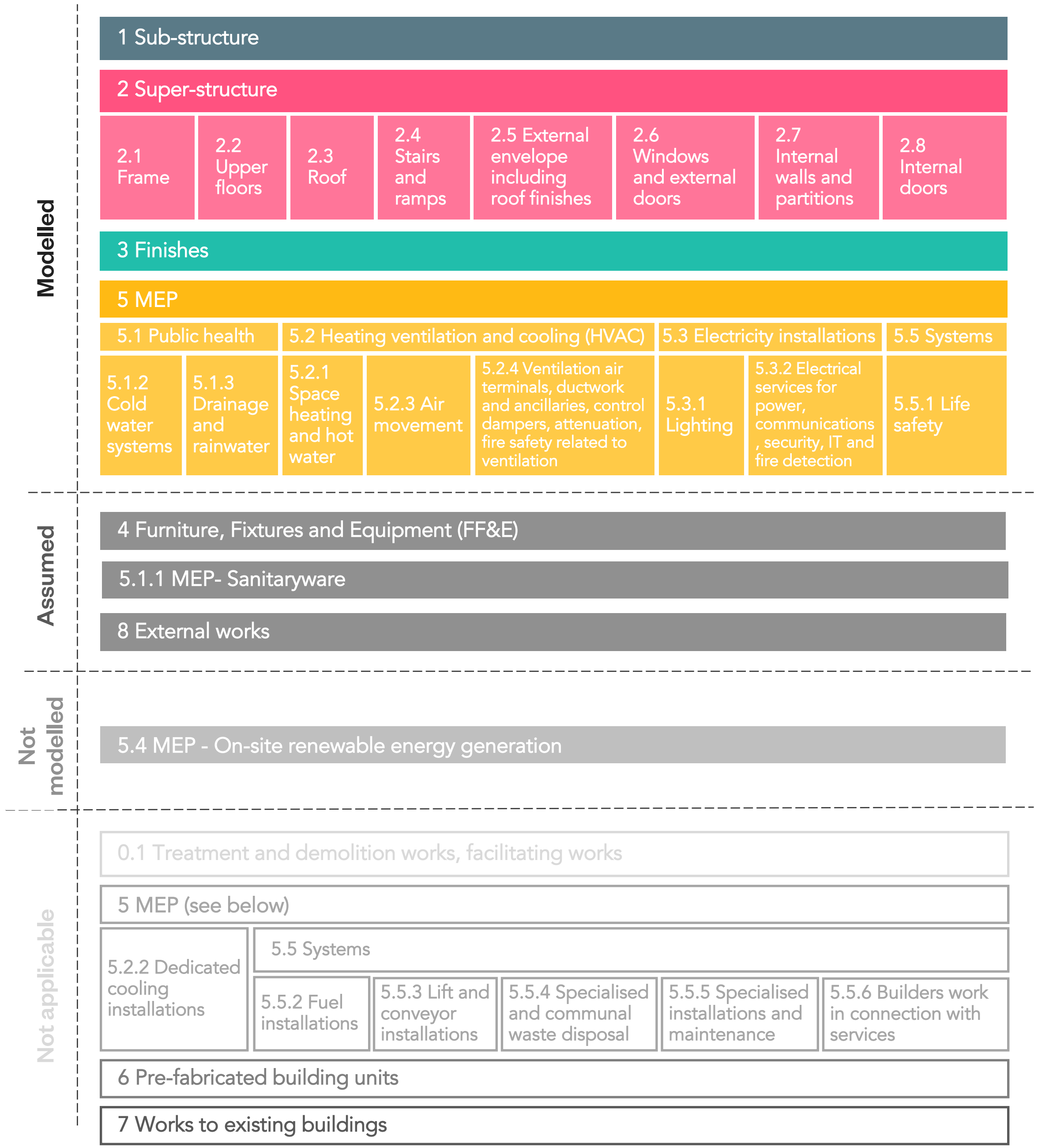
The upfront embodied carbon emissions from furniture, fixtures and equipment (FF&E), sanitaryware and external works have not been modelled. There was a lack of industry data for FF&E and sanitaryware. External works were not modelled because individual homes have been modelled and this would require understanding of external works associated with a whole site. Following the RICS methodology, a 15% contingency factor has been applied to the total calculated upfront embodied carbon to account for these building elements and any other uncertainties.

Building element categories - Not modelled

On-site renewable energy was excluded due to the conflict between the operational energy policy and embodied carbon policy. However, separate analysis of PV has been carried out to show the potential impact on buildings.

Building element categories - Not applicable

In addition, on the right there is a list of all building elements that are not applicable for the building typologies modelled.



Building elements in and out of the scope of the upfront embodied carbon modelling following the RICS building element categories.

Upfront embodied carbon modelling process - summary

Model structure and rationale

The upfront embodied carbon models in this evidence base have been built from the ground up, using widely available industry data at its heart to ensure it aligns with standard practice. The diagram opposite shows the modelling process, using a 'materials database', which feeds data to an 'element library', which is then used to construct an overall model for a given building scenario. The flexibility of the modelling tool is important to accommodate updates and variations efficiently, enhancing the adaptability of the models to changing data or scenario.

The 'materials database'

The materials used in the study were mostly sourced from the OneClick database (a commonly used software) or Inventory of Carbon and Energy (ICE) free to access database. Both databases are well understood by assessors and used in most concept stage assessments of whole life carbon.

The 'materials database' includes materials and products useful for testing the various building upfront embodied carbon scenarios. The upfront embodied carbon datapoints for materials, are considered to represent the typical UK performance for each material or product. For some of the more bespoke products, a typical value was not available and a suitable environmental product declaration (EPD) was used. For more information on EPD's see page 92.

The 'element library' and 'set menus'

The materials and products in the database are combined in the 'element library' to create a range of building elements (e.g. walls, floor, roof, and building services). Several build-ups have been created in each building element category to present values from standard practice to best practice, this includes consideration of thermal performance and likely embodied carbon content (See page 80). All element build-ups achieve the Essex net zero operational carbon policy limits, so are considered to be equitable.

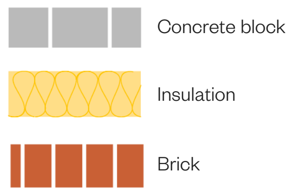
A comparison and sensitivity analysis between the building element build-ups was carried out to identify the typical highest to lowest upfront embodied carbon range in each element category. Set menus 1 and 2 were formed to bring the higher and lower upfront embodied carbon elements together. Set menu 3 was also created based on combination of cost and carbon optimised building elements.

The element library has been multiplied up and combined per building typology to inform policy recommendations.

Modelling process - summary

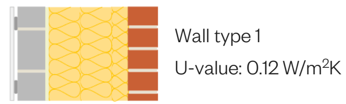
1 Material Database

- Enter A1-A5 and upfront biogenic carbon datapoints ($KgCO_2$ per kg) for each material/product.
- Datapoints entered for lots of materials/ products that represent UK average construction performance.
- Broken down into life stage and fully referenced



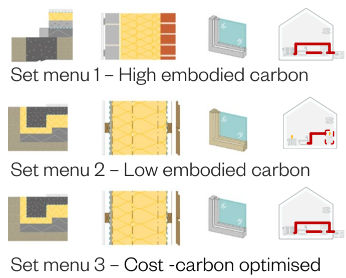
2 Element library

Combine materials to create the elements that are capable of achieving Essex operational carbon policy limits. Calculate the A1-A5 and upfront biogenic carbon of each element per sqm.



3 Set menus per building typology

Combine the elements to create higher, lower and cost-carbon optimised upfront embodied carbon set menus for each element and typology. Carry out cost analysis for each set menu.



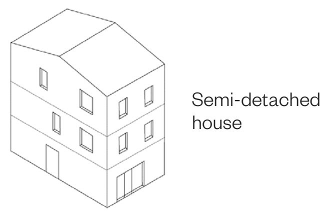
4 Building models

Categorise the elements according to RICS building elements guidance and analyse the upfront embodied carbon and cost results per set menu, per building typology.

↓

Policy recommendations

Inform the upfront embodied carbon policy recommendation for setting limits per typology.



Upfront embodied carbon modelling – building services

The MEP (mechanical, electrical, and plumbing) upfront embodied carbon methodology followed three steps:

1. Quantifying the components

The building typologies analysed followed different approaches for quantifying the MEP components.

- Semi-detached and terraced house - the MEP components were estimated from the MEP design of a similar building. This was possible due to the relative simplicity of the houses when compared to a block of flats.
- Block of flats - MEP quantities were extracted from a previously designed stock model. These components were divided between the residential and communal areas to allow better scalability to other building sizes.

The building elements included in the MEP calculations are listed on page 100.

2. Calculating the carbon emissions per component

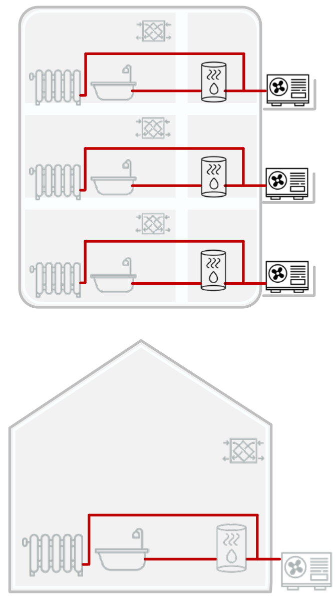
To obtain the upfront embodied carbon emissions associated with each component, Chartered Institution of Building Services Engineers (CIBSE) TM65 methodology, for the calculation of embodied carbon in building services, was used. This methodology was applied to over 100 different product types from more than 80 manufacturers, providing the generic data points used in this study. It was important to use typical data points, as opposed to manufacturer specific, to account for the possible ranges in emissions between manufacturers. The following assumptions were made during the process:

- Transportation emissions (A4) were estimated to be 5% of A1-3 emissions.
- Construction stage emissions (A5) were omitted from the assessment as they are negligible in most MEP components.

3. Categorisation

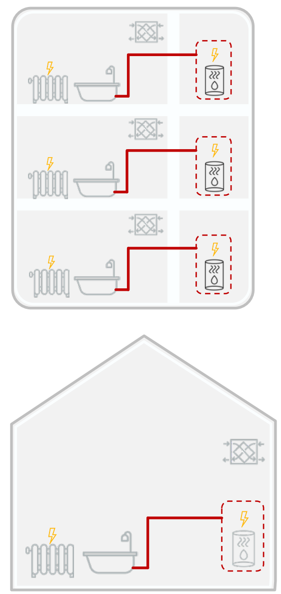
The different components were then grouped according to the RICS Planning Stage building element categories, which can be found on page 73. The data at this stage was broad enough to be scaled to other buildings, while specific enough to determine which areas are more critical.

The components are also organised around the two different heating and hot water scenarios being considered for each building. These are an individual Air Source Heat Pump (ASHP) per dwelling or a Direct Electric system (DE).



MEP-01: An individual Air Source Heat Pump (ASHP) is used for heating (distributed using a wet system through radiators) and hot water with a water storage tank installed. Mechanical ventilation with heat recovery was used for background ventilation.

These systems combined are deemed to meet Essex net zero operational limits.



MEP-02: Direct electric is used for heating (electric panel heaters) and hot water with a water storage tank installed. Mechanical ventilation with heat recovery was used for background ventilation.

These systems combined are assumed not to meet Essex net zero operational limits. However, direct electric was tested to determine sensitivity of systems on the upfront embodied carbon emissions.

Upfront embodied carbon modelling – Costing approach

Many of the strategies that a contractor might propose to reduce capital and life cycle embodied carbon will have little or no material impact on cost. These might include:

- Resource efficiency and circularity measures that reduce wastage or entail the selection of reused materials or those containing higher levels of recycled content.
- Effective co-ordination of designs and management of site teams to reduce wastage.
- Designing for effective maintenance and disassembly, for example through use of mechanical fixings in cladding systems

Some specification changes may result in additional costs being incurred, however, it is critical to determine those that are likely to persist over the long term and those where any cost premium should dissipate over time as the supply chain becomes more mature and scale increases.

Understanding both current and future costs

A good example of this issue is the use of timber frame solutions for domestic superstructures. In much of England timber frame is considered a more expensive solution than the more typical brick and block construction, yet in Scotland timber frame is the predominant form of structural solution and is cost competitive on this basis. It is therefore important to distinguish between cost premiums that arise due to historic market practice rather than due to an underlying difference in cost base.

Importantly, where a low carbon product or supply chain is currently more expensive because it is relatively small scale or immature, then there is an opportunity to achieve both economic development and carbon savings by incentivising the use of these solutions within the market. As these products scale they become more cost competitive in other locations (outside Essex) and will be increasingly deployed even where there is no formal embodied carbon requirement.

In this study we aim to identify the current cost implications of the different set menus (specification options) and also the longer term costs and potential for economic benefits linked to scale. Although the future costs of any product or technology are inherently uncertain the potential for cost reductions will be estimated using the principles of learning rates / experience curves and, where appropriate, by reference to other locations where these solutions are more mature (for example open or close timber frame systems).

Experience curves are an economic modelling tool for estimating the future change in the costs of a product or activity as its overall market scales. These methods have been successfully used to project the future costs of a wide range of products including photovoltaics and batteries. In this study experience curves help to demonstrate the potential scale of deployment that might be needed to achieve comparable cost base for low carbon solutions compared to current business as usual solutions.

Non cost factors

While material cost is an important component influencing the viability of a construction method, a range of other factors are also important and should be considered. These include:

- Ability to meet demand – some low carbon solutions could not immediately be deployed for a large proportion of new construction and so their use would need to be incentivised / encouraged in a way that provides the opportunity for capacity to develop.
- Transition / duplication costs for organisations with refined existing supply chains – this is particularly the case with large developers who have well developed delivery processes and regional / national supply chains. Even if lower carbon products are not more expensive there is additional cost associated with adding to or changing these existing practices particularly where their installer base may be less familiar with the new approach.
- Risk – these might take many forms but would include the ability of smaller companies to provide the necessary warranties or assurance for their products.

These additional factors are identified for each specification where they are an important consideration influencing update of low carbon solutions.

Upfront embodied carbon – cost analysis – trends and opportunities

Future costs for low carbon construction materials

The costs presented in this report reflect current pricing and market conditions in Essex and surrounding areas.

It is notable that several of the lower carbon specification options considered in this study currently have relatively low levels of market uptake and associated scale in the region.

In some cases, costs of specifications are likely to remain relatively consistent because each option has achieved considerable scale and maturity. An example of this would be window systems where the relatively costs of both the higher and lower carbon options (timber and aluminium) are likely to remain significantly above those of the lower cost uPVC options.

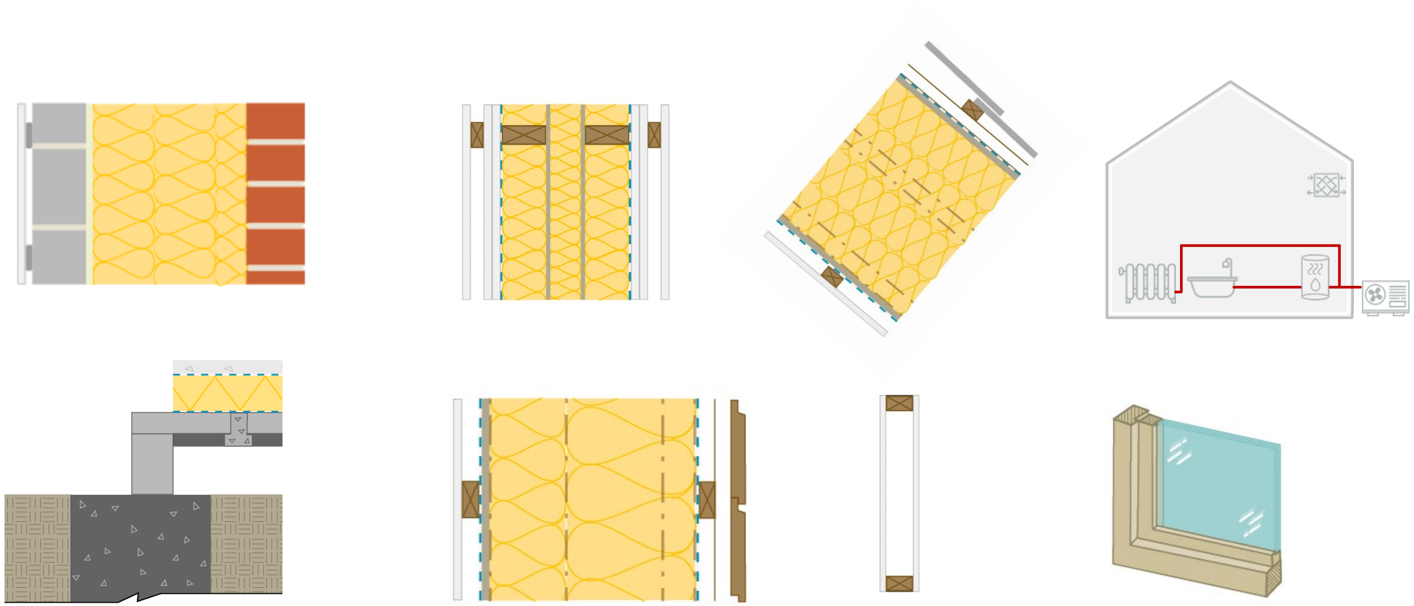
However, for other materials the situation is less clear and there is potential for cost reductions as products become more established in the national and local market. Examples of this would include timber frame solutions and natural insulation products.

- **Timber framing** – in some locations in the UK timber frame is the dominant structure type used for house building, most notably Scotland where it is used in around ¾ of new homes. Volume builders including Cala, Barratt and others are committing to using timber frames in the portfolio demonstrating that cost is not an insurmountable barrier when delivered at scale. Other non-cost related barriers may be more significant such as cash flow and ability to flex build programmes during construction.
- **Hemp based products** – whilst the use of hemp in construction is growing it is still a very small component in the overall market and is typically produced in small facilities and using relatively unsophisticated processes. Whilst hemp production is likely to remain a locally sourced and supplied product due to its mass, there is ongoing development in advancing the production process increasing productivity and ability to scale.

Encouraging (but not mandating) use of natural building materials in Essex will lead to increased market demand and provide opportunities for new businesses and supply chains to develop in response. Additional scale and local supply chains will help to reduce cost as well as transport related emissions while also supporting economic growth within the county and region.

Traditional masonry homes (Source: Bloomberg/Dominic Lipinski)

Timber homes (Source: Greencore Homes Ltd)



Element library

Comparisons of building elements

Comparing the upfront embodied carbon of building elements

Introduction

This section explores the upfront embodied carbon emissions per material (from the 'materials database' collated for this study) and per building element. Several build-ups have been created in each building element category (walls, floors roofs etc.) to represent standard practice to best practice, in terms of upfront embodied carbon content and thermal performance. All element build-ups are designed to achieve the Essex operational carbon policy limits so are considered to be equitable.

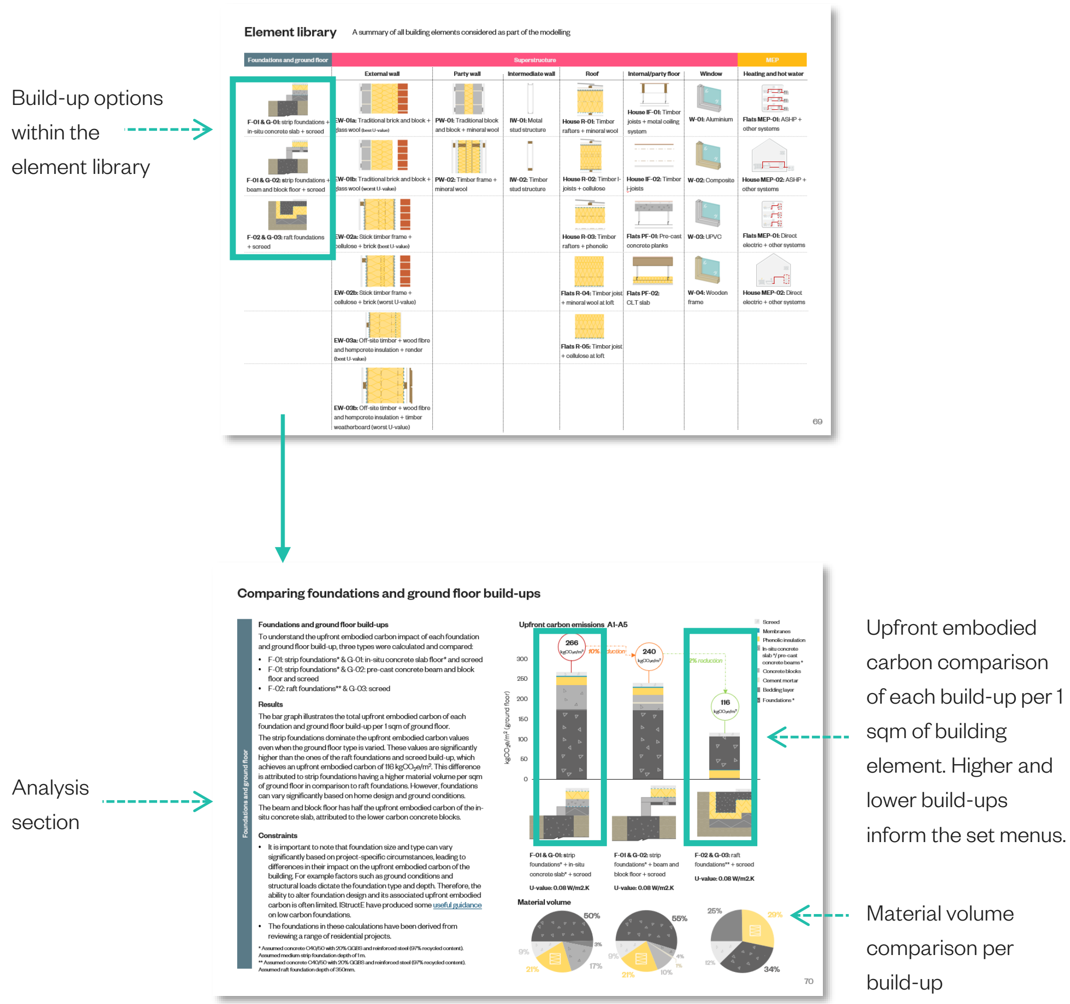
Element library

The following page sets out the full library of building elements used in this study.

Comparison of building elements

The pages that follow analyse the similarities and differences between comparable element build-ups. This includes a comparison of:

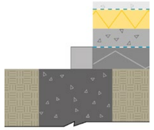
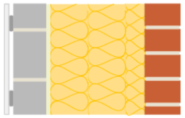
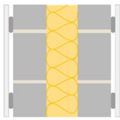
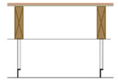
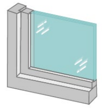
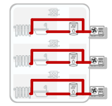
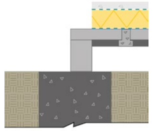
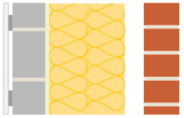
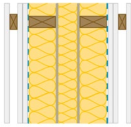
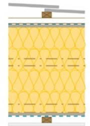
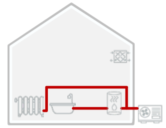
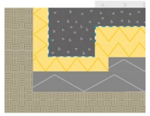
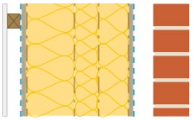
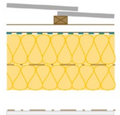
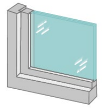
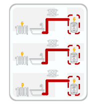
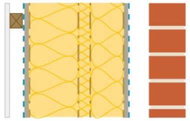
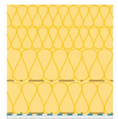
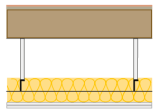
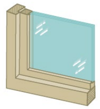
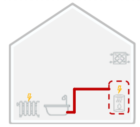
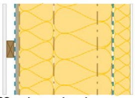
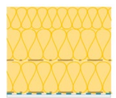
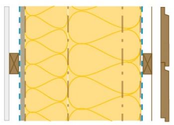
- Foundation and ground floor build-ups
- External walls with improved and standard thermal performance
- Party walls
- Internal walls
- Roofs
- Internal floors
- Triple-glazed windows
- Mechanical, electrical and plumbing



Comparing the upfront embodied carbon of building elements

Element library

A summary of all building elements considered as part of the modelling

Foundations and ground floor	Superstructure						MEP
	External wall	Party wall	Intermediate wall	Roof	Internal/party floor	Window	Heating and hot water
 **F-01 & G-01:** strip foundations + in-situ concrete slab + screed	 **EW-01a:** Traditional brick and block + glass wool (best U-value)	 **PW-01:** Traditional block and block + mineral wool	 **IW-01:** Metal stud structure	 **House R-01:** Timber rafters + mineral wool	 **House IF-01:** Timber joists + metal ceiling system	 **W-01:** Aluminium	 **Flats MEP-01:** ASHP + other systems
 **F-01 & G-02:** strip foundations + beam and block floor + screed	 **EW-01b:** Traditional brick and block + glass wool (worst U-value)	 **PW-02:** Timber frame + mineral wool	 **IW-02:** Timber stud structure	 **House R-02:** Timber I-joists + cellulose	 **House IF-02:** Timber i-joists	 **W-02:** Composite	 **House MEP-02:** ASHP + other systems
 **F-02 & G-03:** raft foundations + screed	 **EW-02a:** Stick timber frame + cellulose + brick (best U-value)			 **House R-03:** Timber rafters + phenolic	 **Flats PF-01:** Pre-cast concrete planks	 **W-03:** UPVC	 **Flats MEP-01:** Direct electric + other systems
	 **EW-02b:** Stick timber frame + cellulose + brick (worst U-value)			 **Flats R-04:** Timber joist + mineral wool at loft	 **Flats PF-02:** CLT slab	 **W-04:** Wooden frame	 **House MEP-02:** Direct electric + other systems
	 **EW-03a:** Off-site timber + wood fibre and hempcrete insulation + render (best U-value)			 **Flats R-05:** Timber joist + cellulose at loft			
	 **EW-03b:** Off-site timber + wood fibre and hempcrete insulation + timber weatherboard (worst U-value)						

Comparing foundations and ground floor build-ups

Foundations and ground floor

Foundations and ground floor build-ups

To understand the upfront embodied carbon impact of each foundation and ground floor build-up, three types were calculated and compared:

- F-01: strip foundations* & G-01: in-situ concrete slab floor* and screed
- F-01: strip foundations* & G-02: pre-cast concrete beam and block floor and screed
- F-02: raft foundations** & G-03: screed

Results

The bar graph illustrates the total upfront embodied carbon of each foundation and ground floor build-up per 1 sqm of ground floor.

The strip foundations dominate the upfront embodied carbon values even when the ground floor type is varied. These values are significantly higher than the ones of the raft foundations and screed build-up, which achieves an upfront embodied carbon of 116 $kgCO_2e/m^2$. This difference is attributed to strip foundations having a higher material volume per sqm of ground floor in comparison to raft foundations. However, foundations can vary significantly based on home design and ground conditions.

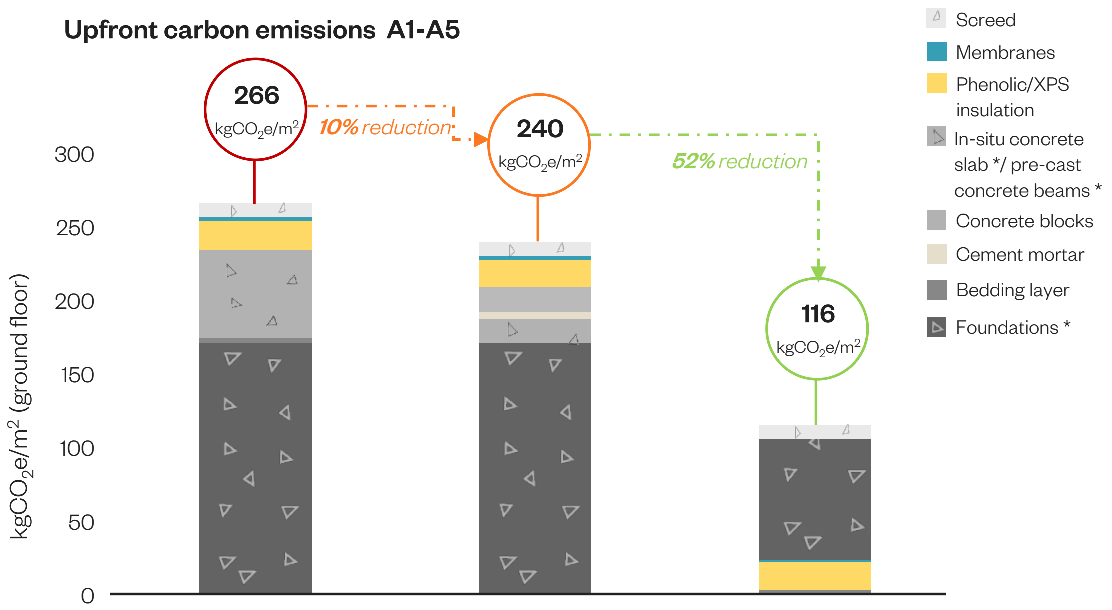
The beam and block floor has half the upfront embodied carbon of the in-situ concrete slab, attributed to the lower carbon concrete blocks.

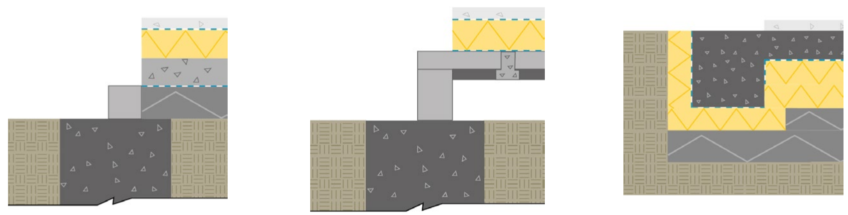
Constraints

- It is important to note that foundation size and type can vary significantly based on project-specific circumstances, leading to differences in their impact on the upfront embodied carbon of the building. For example factors such as ground conditions and structural loads dictate the foundation type and depth. Therefore, the ability to alter foundation design and its associated upfront embodied carbon is often limited. IStructE have produced some useful guidance on low carbon foundations.
- The foundations in these calculations have been derived from reviewing a range of residential projects.

* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed medium depth strip foundation of 1 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.

Upfront carbon emissions A1-A5





F-01 & G-01: strip foundations* + in-situ concrete slab* + screed

U-value: 0.08 W/m2.K

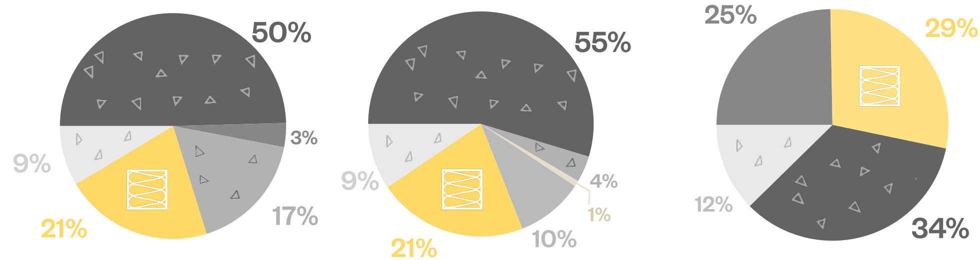
F-01 & G-02: strip foundations* + beam and block floor + screed

U-value: 0.08 W/m2.K

F-02 & G-03: raft foundations** + screed

U-value: 0.08 W/m2.K

Material volume



Comparing external wall build-ups (semi-detached house)

External wall build-ups

To understand the impact of different external wall constructions on upfront embodied carbon, three construction types were analysed and compared:

- EW-01a: traditional brick and block build-up with glass wool insulation
- EW-02a: stick timber frame with cellulose insulation and brick on the outer leaf
- EW-03a: off-site timber structure with a combination of wood fibre and hempcrete insulation, with two external finish options; render and timber weatherboard. Based on Greencore Homes Ltd (GCH) construction.

Two sets of U-values were identified and analysed for each external wall build-up, to ensure all building typologies could pass the net zero operational carbon targets. The difference in heat loss between these typologies means that a semi-detached, detached or bungalow house would likely need more wall insulation (better U-value) than a terraced house or apartment block (see also page 83):

- Best U-value (0.12-0.13W/m^2.K) – thicker insulation layer (applied to the semi-detached house due to higher heat loss)
- Worst U-value (0.14-0.15W/m^2.K) – relatively thinner insulation layer (applied to the terraced house and block of apartments due to lower heat loss)

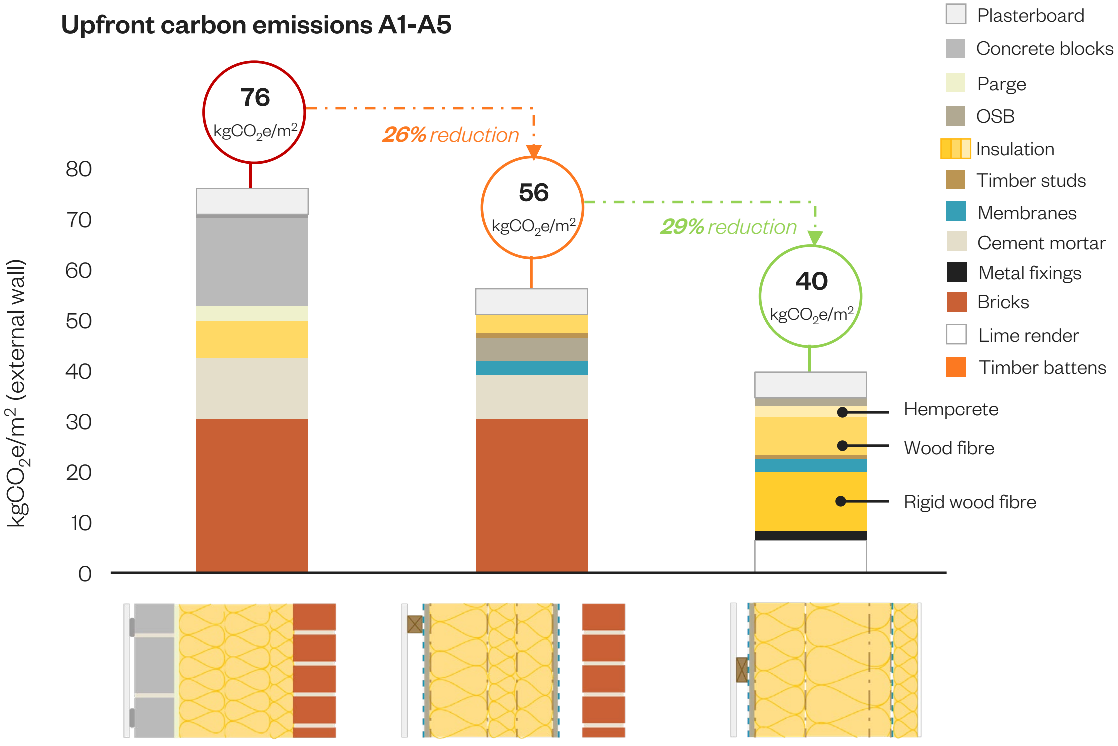
Results for the best U-value build-ups

The graph illustrates the total upfront embodied carbon of each external wall build up (best U-value) per 1 sqm of external wall.

The traditional brick and block construction with glass wool insulation has the highest upfront embodied carbon of 76 kgCO$_2$e/m^2. Stick timber frame structure with cellulose insulation and off-site timber structure with wood fibre and hempcrete insulation, achieve lower upfront embodied carbon of 56 and 40 kgCO$_2$e/m^2, respectively.

Brick and concrete blocks are the major contributors to the higher upfront carbon footprint of the traditional build-up, due to their carbon intensive production processes. However, it's important to note that bricks offer some benefit. When used as external leaf, bricks act as a non-combustible, durable, low maintenance material during their lifecycle. They also provide an aesthetic finish, traditional in the UK.

Upfront carbon emissions A1-A5



EW-01a: Traditional brick and block + glass wool

U-value: 0.12 W/m2.K

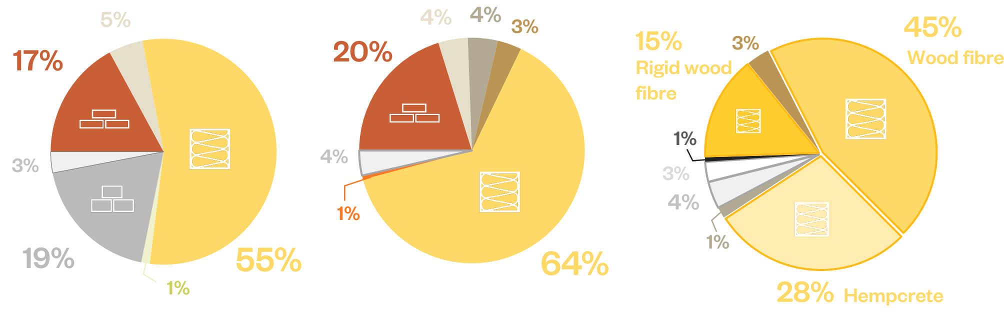
EW-02a: Stick timber frame + cellulose + brick

U-value: 0.13 W/m2.K

EW-03a: Off-site timber + wood fibre and hempcrete insulation + render (GCH)

U-value: 0.13 W/m2.K

Percentage material volume



Comparing external wall build-ups (terrace and low-rise apartment block)

The build-ups with the timber structures have significantly lower upfront embodied carbon compared to traditional brick and block build-up, attributed mainly to timber's ability to store carbon dioxide.

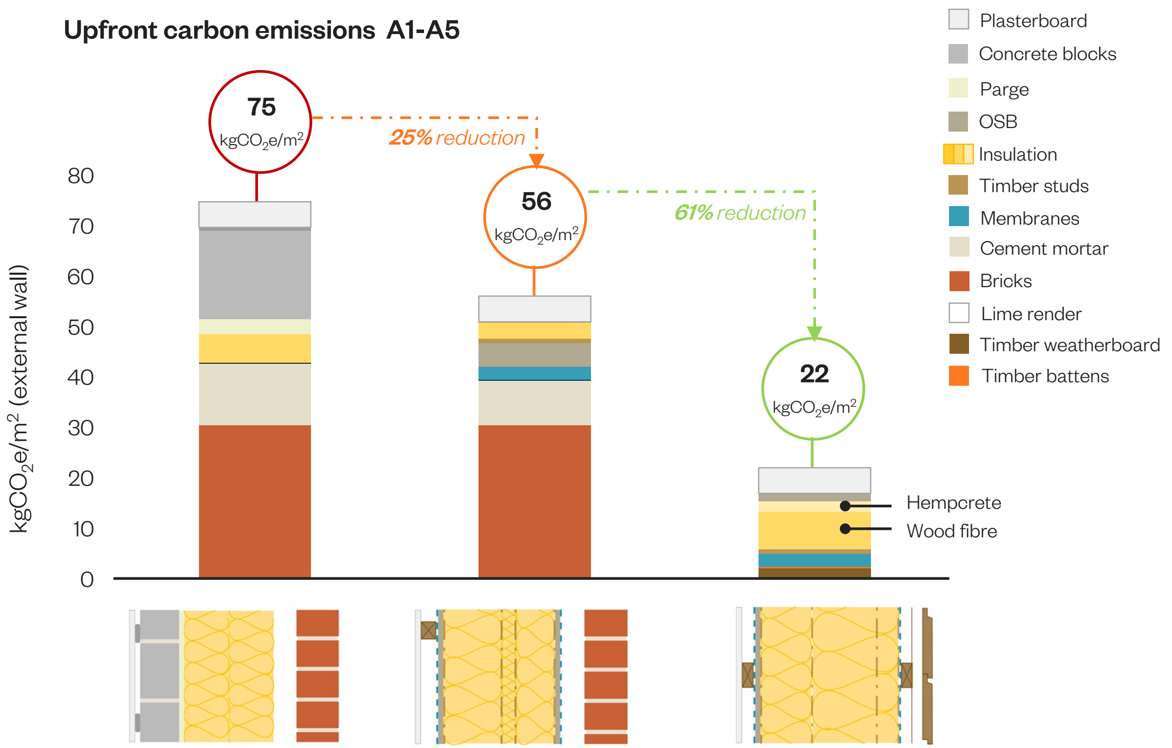
It is observed that even though insulation constitutes a large percentage of material volume per build-up, for the traditional and stick timber frame constructions, it does not have a significant impact on their upfront embodied carbon. This is due to the more carbon intensive materials, like brick, concrete block and cement mortar present in the build-ups. For more information on the comparison of different insulation types and their effect on upfront embodied carbon see page 98.

Results for the worst U-value build-ups

This graph illustrates the upfront embodied carbon reduction of external wall build-ups with a worse u-value. The results show overall lower upfront embodied carbon compared to the better u-value build-ups due to less insulation volumes assumed.

Lime render has a significantly higher impact on upfront embodied carbon of the off-site timber structure build-up compared to timber weatherboard. This is due to the carbon intensity of the extraction and processing the limestone, in contrast to timber weatherboard which involves less manufacturing processes.

Upfront carbon emissions A1-A5



EW-01b: Traditional brick and block + mineral wool

U-value: 0.14 W/m2.K

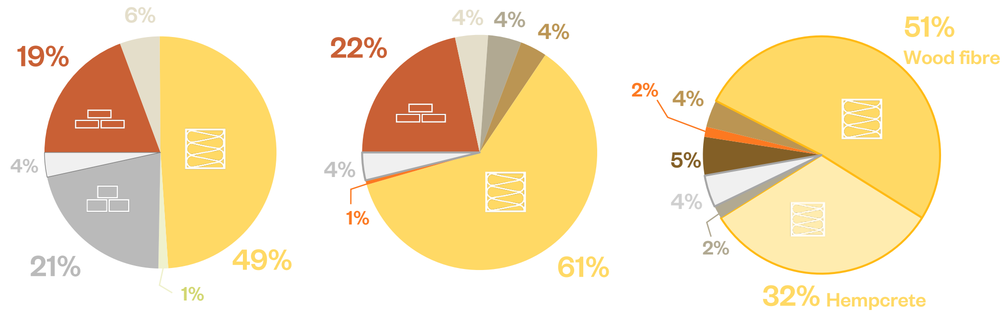
EW-02b: Stick timber frame + cellulose + brick

U-value: 0.15 W/m2.K

EW-03b: Off-site timber + wood fibre and hempcrete insulation + timber weatherboard (Greencore)

U-value: 0.15 W/m2.K

Percentage material volume



Comparing party wall build-ups

Superstructure – party walls

Party wall build-ups

To understand the impact of different party wall constructions on upfront embodied carbon reduction, two types were analysed and compared:

- PW-01: traditional block and block with glass wool
- PW-02: timber frame with glass wool

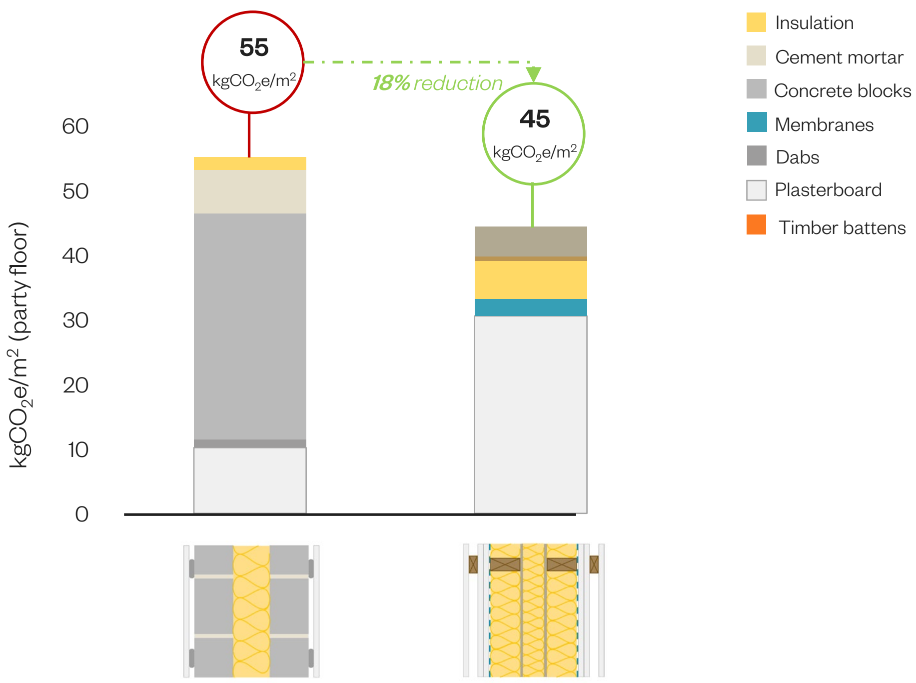
Results

The bar graph illustrates the upfront embodied carbon of the party wall build-ups.

The traditional block and block construction has an upfront embodied carbon 18% higher than that of timber frame build-up. Blocks are the highest contributor to the higher carbon footprint of the traditional block and block build-up, due to their carbon intensive production processes, where non-renewable energy sources are often used.

However, an interesting observation is that the plasterboard component of the timber frame construction accounts for almost as much upfront embodied carbon as the block for the first build-up. Plasterboard has a relatively high carbon manufacturing process, and in this instance six layers have been used. Four layers are required to meet fire regulations and two to provide an additional building services zone each side of the party wall.

Upfront carbon emissions A1-A5



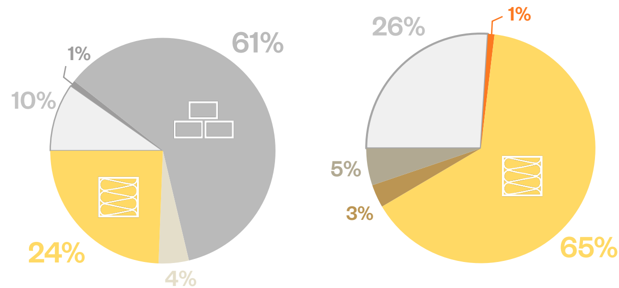
PW-01: Traditional block and block + glass wool

Thickness: 325 mm

PW-02: Timber frame + glass wool

Thickness: 400 mm

Percentage material volume



Comparing internal wall build-ups

Internal wall build-ups

To understand the impact of different internal wall constructions on upfront embodied carbon reduction, two types were analysed and compared:

- IW-01: metal stud structure
- IW-02: timber stud structure

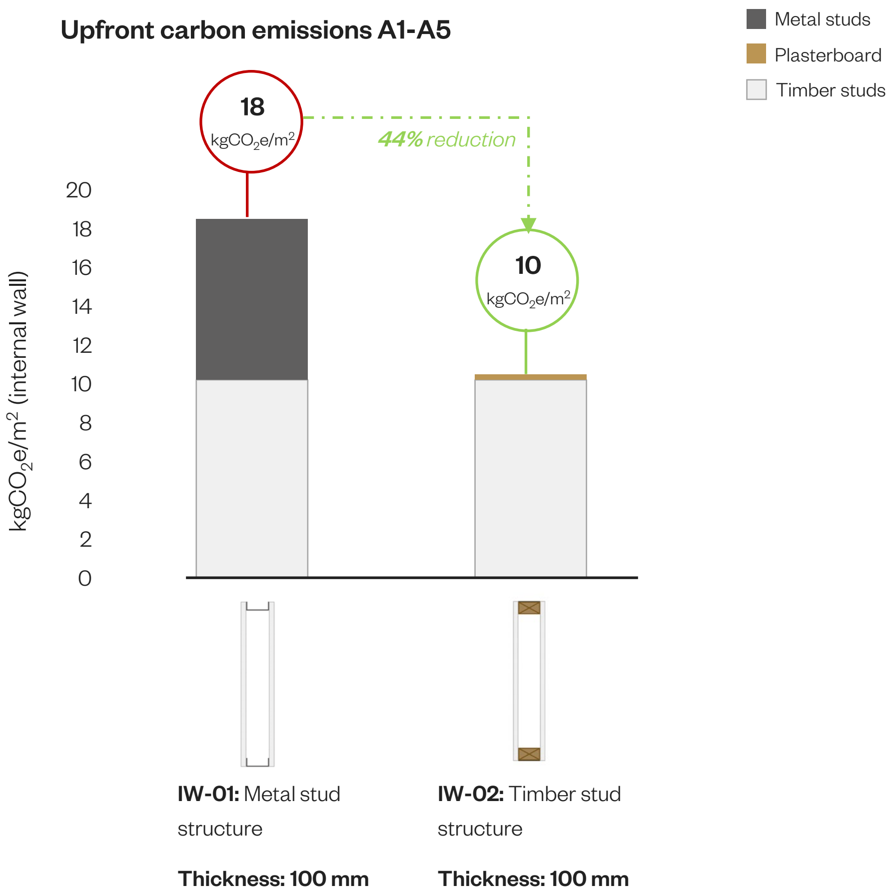
Results

This graph illustrates the upfront embodied carbon reduction of the internal wall build-ups.

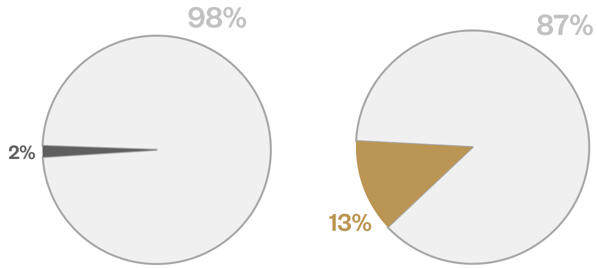
The metal stud structure has an upfront embodied carbon 44% higher than the timber stud structure build-up. Metal studs has a significantly higher upfront embodied carbon than timber studs (97%), even though their volume consists only 2% in the build-up, whereas timber studs consist of 13%. This is due to the energy intensive processes involved in mining, refining and manufacturing metals like steel and aluminium. In contrary, timber acts as a carbon sink, sequestering carbon dioxide from the atmosphere as it grows.

However, when comparing the upfront embodied carbon of internal wall build-ups (10-18 $kgCO_2e/m^2$) with, for example, external wall build-ups (109-22 $kgCO_2e/m^2$), it is observed that the impact will be minor in comparison when the build-ups are applied on a building scale.

Upfront carbon emissions A1-A5



Percentage material volume



Comparing roof build-ups

Roof build-ups

To understand the impact of different roof constructions on upfront embodied carbon reduction for the house typologies, three types were analysed and compared:

- R-01: timber rafters and mineral wool insulation
- R-02: timber I-joists and cellulose insulation
- R-03: timber rafters and phenolic insulation

Results

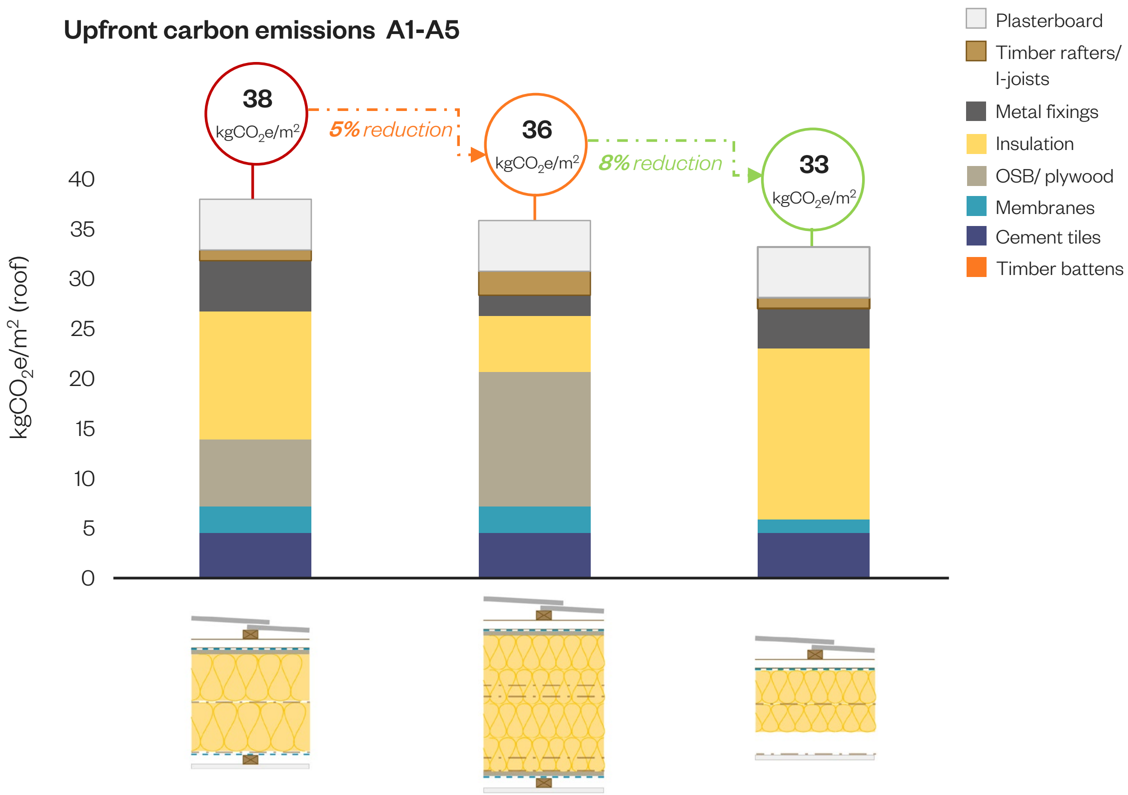
The bar graph illustrates the total upfront embodied carbon of each roof build up per 1 sqm of roof.

All three build-ups have similar upfront embodied carbon, ranging from 38-33 kgCO_2e/m^2.

Although, the timber rafters and phenolic insulation achieve the lowest upfront embodied carbon of 33 kgCO_2e/m^2, the phenolic insulation has the highest upfront embodied carbon out of all three insulation types. This is due to phenolic being a petroleum based product with a carbon intensive production process.

Interestingly, the orientated strand board (OSB)/plywood and vapour control membranes contribute to the higher upfront embodied carbon of roof types 1 and 2. OSB and plywood are one of the main contributors of upfront embodied carbon due to their carbon intense manufacture and process. It should be noted that the average material data point has been chosen for OSB and plywood in this analysis. Further sensitivity analysis was carried out on OSB (page 99). The broad conclusion from this is that the upfront embodied carbon for OSB was relatively consistent across a number of data sources.

Upfront carbon emissions A1-A5



House R-01: Timber rafters + mineral wool

U-value: 0.10 W/m2.K

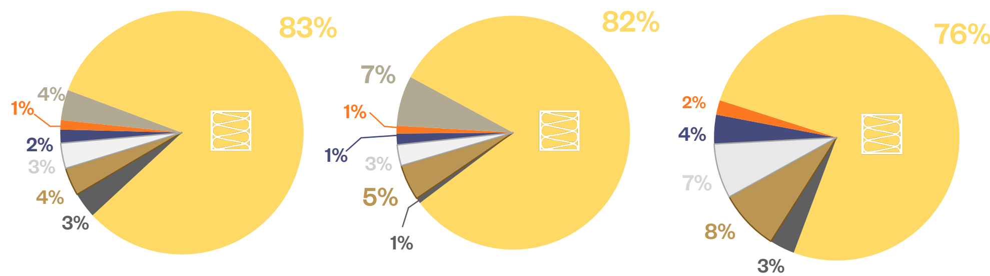
House R-02: Timber I-joists + cellulose

U-value: 0.10 W/m2.K

House R-03: Timber rafters + phenolic insulation

U-value: 0.10 W/m2.K

Percentage material volume



Comparing internal floor build-ups

Superstructure – internal floor

Internal floor build-ups

To understand the impact of different internal floor constructions on upfront embodied carbon reduction, two types were analysed and compared:

- IF-01: timber joists with metal ceiling system
- IF-02: timber i-joists

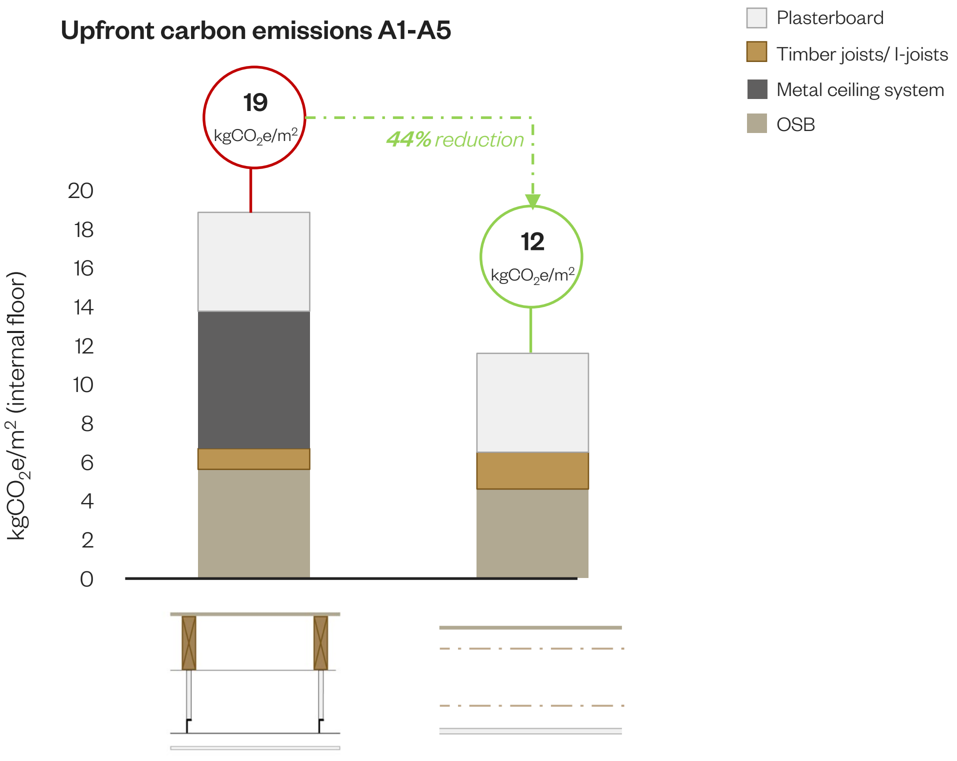
Results

The bar graph illustrates the upfront embodied carbon reduction of the internal floor build-ups.

It is observed that the timber joists with a metal ceiling system have 37% higher upfront embodied carbon than the timber i-joist build-up The metal ceiling frame is the greatest contributor to the higher carbon footprint of the build-up, due to the energy intensive processes involved in mining, refining and manufacturing metals like steel and aluminium.

However, it is important to note that ceiling systems have the benefit of providing a service void, for the accommodation and easy access of electrical cables, ducts and pipes.

Upfront carbon emissions A1-A5



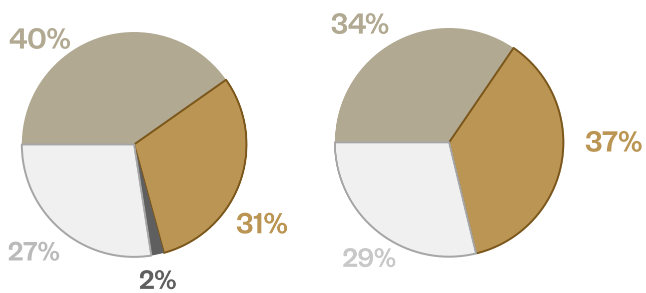
IF-01: Timber joists + metal ceiling system

Thickness: 490 mm

IF-02: Timber i-joists

Thickness: 440 mm

Percentage material volume



Comparing triple-glazed windows

Triple glazed windows

To understand the impact of different triple-glazed window frames on embodied carbon reduction, four types were analysed and compared:

- W-01: Aluminium frame
- W-02: Composite frame (wood and aluminium)
- W-03: UPVC frame
- W-04: Timber frame

Results

This graph illustrates the upfront embodied carbon and capital cost of triple-glazed windows with various frame materials.

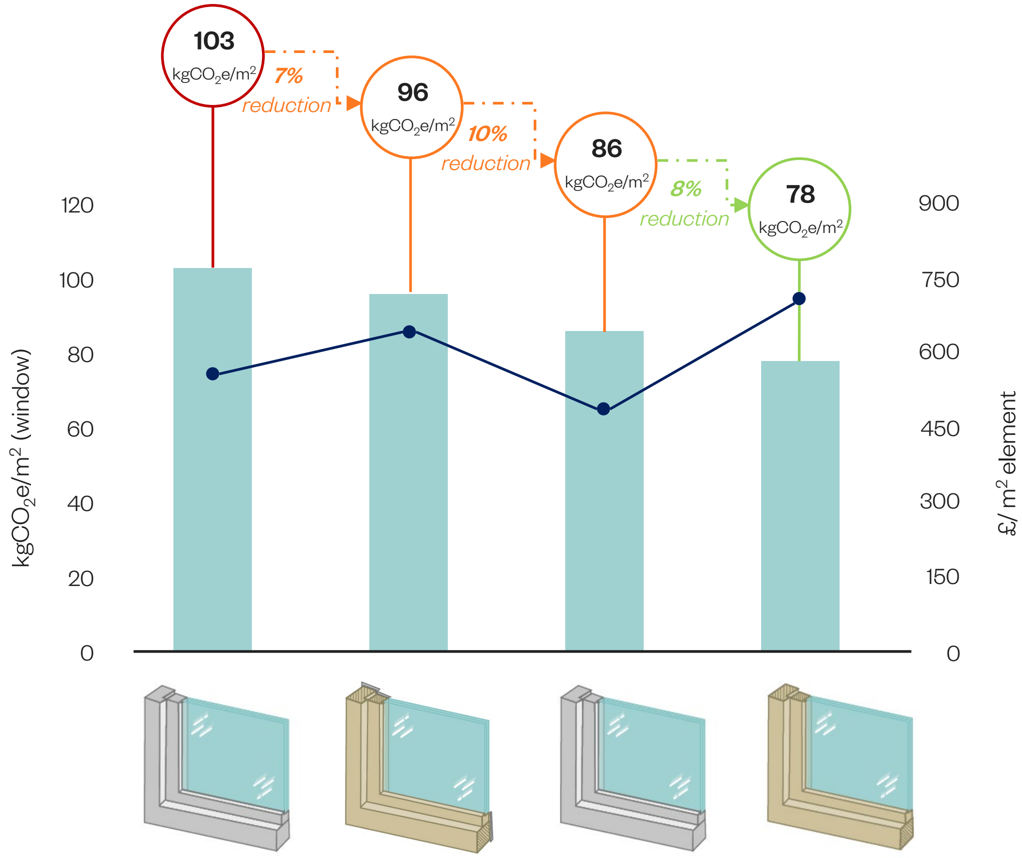
There is a marginal step change in upfront embodied carbon between each window type, with aluminium frame windows having the highest upfront embodied carbon and wooden frame the lowest. This is due to the energy intensive processes involved in mining, refining and manufacturing aluminium.

With a relatively small difference in upfront embodied carbon between window types there are likely to be other factors, such as capital cost, which will influence the choice of window. In this case, the lowest carbon window system (timber frame) is also currently the highest cost. While, UPVC framed windows are the cheapest but second lowest upfront embodied carbon.

Although the UPVC appears to have relatively low upfront embodied carbon, it is worth noting this is a petroleum based material. Therefore its use is supporting the continued extraction of crude oil.

Upfront carbon emissions A1-A5 and cost

Glazing + frame
Cost (£)



W-01:	W-02:	W-03:	W-04:
Aluminium	Composite	UPVC	Timber frame
U-value: 0.8 W/m².K	**U-value: 0.8 W/m².K**	**U-value: 0.8 W/m².K**	**U-value: 0.8 W/m².K**

Comparing MEP options

Building Services

Building services

The analysis of the mechanical, electrical, and plumbing (MEP) systems focuses primarily on the heating and hot water systems, due to their significant carbon footprint. Two individual systems have been evaluated for this purpose:

- ME-01: Air-to-water heat pump (ASHP)
- ME-02: Direct electric (DE) system

These were selected for their individual applicability to each dwelling, compatibility with low energy performance standards, and scalability.

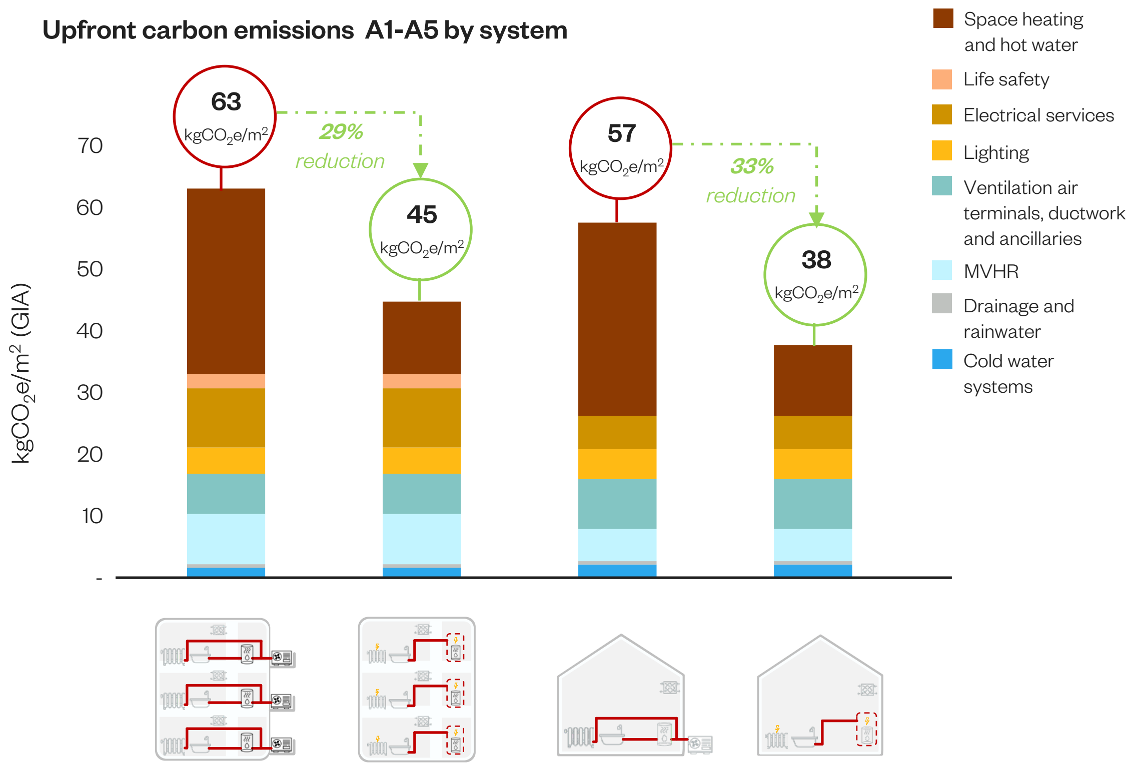
Results

The comparison of upfront carbon emissions highlights significant differences, particularly in the space heating and hot water category, which has the highest impact. ASHP models vary based on dwelling types, with a 14kW unit for terraced houses—larger than the common 6-7kW units due to the house's larger gross internal area (GIA)—while a 3kW pump suffices for low-energy flats. The ASHP's capacity significantly influences upfront carbon emissions, accounting for 18% of such emissions in terraced houses alone.

Comparing ASHPs to DE systems reveals a considerable reduction in upfront carbon emissions—29% for flats and 33% for terraced houses—primarily due to the fewer components required, underscoring the efficiency and reduced complexity of DE systems over ASHPs. However, this analysis should not overlook the broader context of energy consumption, where ASHP systems significantly outperform DE systems in efficiency, while also meeting the net zero carbon operational policy requirements. .

Other systems like cold water, drainage, rainwater, and mechanical ventilation heat recovery (MVHR) show less variability in carbon emissions across scenarios. The MVHR system, standardized at 90 L/s across all cases, yields lower emissions per square meter in terraced homes due to their larger GIA. Similarly, components such as ventilation air terminals, ductwork, ancillaries, and lighting demonstrate minor variations in carbon emissions, largely dependent on the project's specific architectural design. Electrical services contribute higher upfront carbon emissions in flats, attributed to the greater number of electrical components, including extensive cabling and systems in communal areas. Life safety systems, although having a minor impact on overall emissions, are notably present only in flats, reflecting the differentiated requirements between dwelling types.

Upfront carbon emissions A1-A5 by system

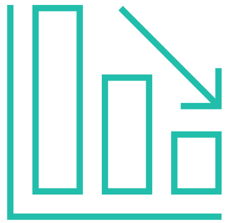


Flats MEP-01: ASHP + other systems

Flats MEP-02: DE + other systems

House MEP-01: ASHP + other systems

House MEP-02: DE + other systems



Sensitivity analysis

Data comparison of materials

Sensitivity of modelling to material data

Embodied carbon coefficients

The embodied carbon of a building is affected by the type of materials used to construct the building, the quantities of these materials and in the case of lifecycle carbon; the repair and replacement of these materials.

When carrying out an embodied carbon assessment the assessor selects an embodied carbon coefficient for each material or product used in the building. The selection of this embodied carbon coefficient can greatly affect the embodied carbon of the building. Similar materials/products can show different embodied carbon results. This is due to the fact that the embodied carbon could actually be different, which could be due to the following reasons:

Geographical variability – different raw material location sources which would impact transport distance, transport mode, manufacturing vs assembly locations and supply chain routes.

Technical variability – due to varying raw material ingredient inputs, varying amounts of recycled content, Energy sources of the manufacturing plant and manufacturing process difference

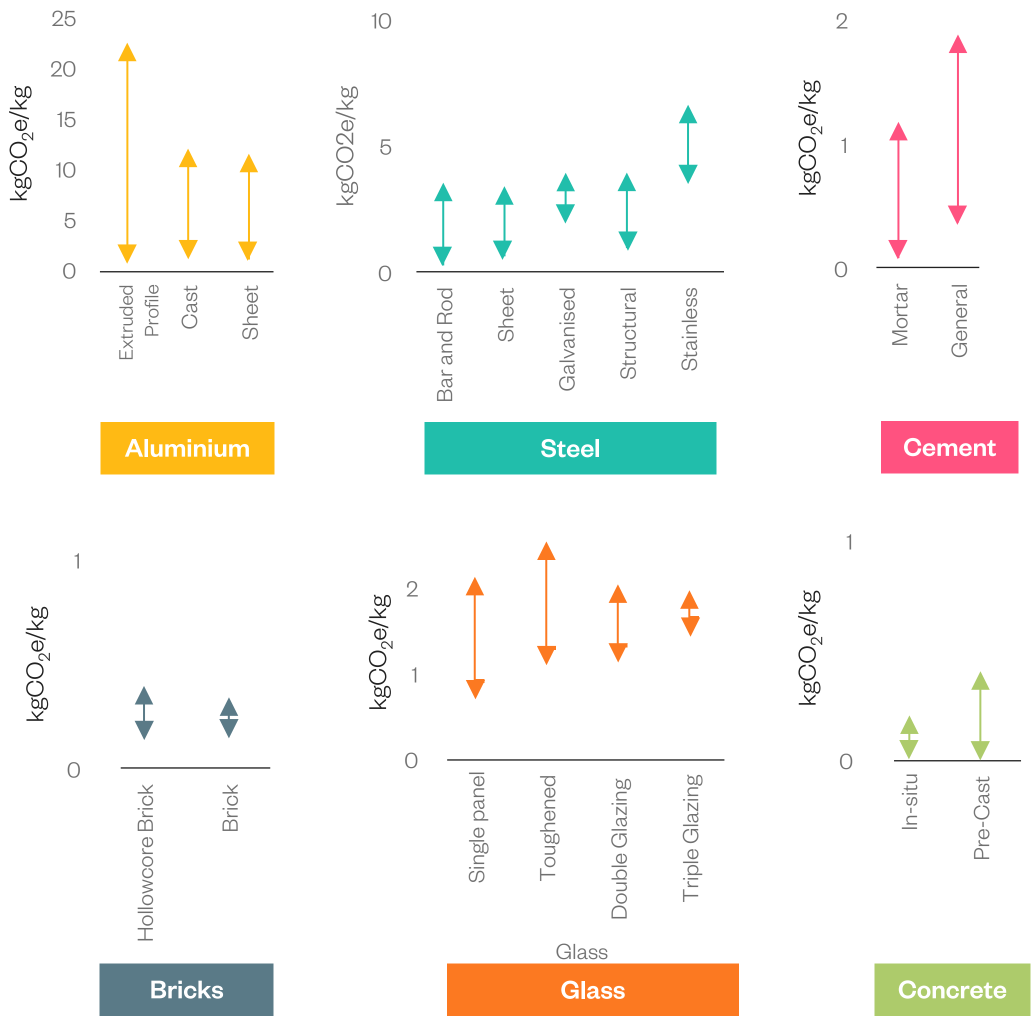
Variations due to methodologies

However, it is crucial to acknowledge that differences in embodied carbon results can also arise from methodological variations in the assessment processes. These variations include:

- Standards followed for calculations (e.g., ISO vs. EN) which affect the mandatory vs. optional inputs.
- Methodologies used to assess the embodied carbon impact (e.g. TRACI vs. CML).
- The type of inputs used, whether generic or product-specific. For instance, a product Environmental Product Declaration (EPD) from a specific manufacturer may not show the same results as an industry estimate.

A study conducted by Dr. Jane Anderson and Derek Jones highlighted that variations within EPDs caused by differences in technology and geography led to the greatest differences between materials/products, whereas the methodological differences were less significant.

This section of the modelling study explores the sensitivity of our calculations to: the selection of different material/product data points; variations through design and specification; influence of biogenic carbon; consideration of lifecycle data; and how renewable technology fits in.



The charts above illustrate embodied carbon coefficients of different materials and the sensitivity of calculations to the chosen coefficients. For each material type, an example of the variance in embodied carbon is presented. The results show the impact that the embodied carbon coefficients could have on the variance of the embodied carbon of a building, depending on the coefficient chosen when carrying out the assessment.

Variance in embodied carbon coefficient (Stages A1-A3) for different material types, based on ICE Database [https://circularecology.com/wp-content/uploads/2023/03/ICE-DB-V3.0.zip]

Levers in modelling to define targets and benchmarks

When carrying our embodied carbon assessments, the embodied carbon coefficients (carbon per unit of material) has a significant effect on the embodied carbon results.

Different embodied carbon coefficients

Coefficients range from generic data sets product specific environmental product declarations (EPD). It is important to note that the first two data sources below be used with care, as they are not necessarily verified, and can be inconsistent with one another (i.e. not standardised like EPDs). This is problematic, for instance, when a building services engineer wishes to compare two types of MEP product and is using data from different and inconsistent datasets.

What is an environmental product declaration (EPD)

An EPD is a document which publishes the environmental performance and impact of a product/material, or a group of products/materials throughout their lifetime. These documents aim to help the audience make an informed decision about the things they are procuring.

EPDs provide detail on several environmental indicators. The one of most relevant to this evidence base is the 'global warming potential' which provides a standard way of declaring the amount carbon emission equivalent.

Although EPDs aim to allow comparison, all EPDs are not identical: they include an element of human error; and some do not provide everything needed for a full life cycle assessment. EPDs are still uncommon for most construction products but are increasingly being created by industry.

	Type of data	Description	Calculation methodology	When is this data type used
Generic data	**Generic LCA datasets or embodied carbon databases**	Databases where multiple performance characteristics have been analysed to create a single datapoint considered representative of a particular material or product. Examples of this included The Inventory of Carbon and Energy (ICE) or OneClick software's generic datapoints.	Produced using a consistent methodology, but not necessarily with direct data from manufacturers. The data is likely to be specific to a region and may not have been peer reviewed or regularly reviewed and updated.	Generic data is used as the primary source prior to planning approval, unless particular manufacturers are in the developers supply chain and have been used on previous schemes.
	Generic data from industry created by an industry group (e.g. World Steel LCI database),	Inventories of data developed by industry groups to try and capture performance across a wide range of manufacturers. An example is the World Steel Life Cycle Inventory.	May be inconsistent due to different methodologies. It may cover a very wide range of products within a category and may not have been peer reviewed.	
	Average/generic/ industry average EPDs	An EPD document from particular industry groups that captures the average performance across a group of manufacturers for a particular product or material. An example is the Brick Development Association's EPD for UK bricks.	All types of EPDs follow the same standards, methodology and format.	
Specific data	**Product-specific EPDs**	An EPD relevant to a specific product from a manufacturer.	All types of EPDs follow the same standards, methodology and format.	Specific data used post planning approval for signing off conditions and post-completion reporting
	Manufacturer-specific EPDs	An EPD that provides a weighted average for a range of similar products from a specific manufacturer.	All types of EPDs follow the same standards, methodology and format.	

Table comparing different types of material data available for use in upfront embodied carbon assessments.

Should the policy define what embodied carbon data to use?

Some regulations and policies define a material dataset of generic materials, and the calculations must use this common dataset within the regulatory calculations, for example in Sweden, France and Denmark. Others ask that project specific data is used where possible and known, and does not restrict embodied carbon data sets, for example the GLA London Plan.

The RICS PS V2 2023 methodology used in the UK sets the methodology of embodied carbon assessments, it does not give guidance on embodied carbon data types that should be used for the purpose of an embodied carbon assessment, as this is out of scope of the purpose of the document.

We recommend the use of a standard material/product embodied carbon database to bring assessments on to a level playing field

However, this database would need developing, and would require substantial fee and resource for Essex to carry this out alone. Thus we suggest that in the short term, no restrictions should be put on the use of data from various sources. But that policy is updated in Essex should a national standard material carbon database to be developed.

Our recommendation is that Essex encourages the government to fund/ support a standard material database

In the meantime, as there is not a standard database, it is suggested that a post completion upfront embodied carbon assessment is conditioned, with an expectation that the limit is met upon completion. This is to encourage the planning stage upfront embodied carbon assessment to carefully consider material selection, without heavily relying on unusually low embodied carbon products that may not be used during construction. Another option is that Essex could develop a generic list of embodied carbon coefficients for a selected list of materials that are often used (e.g. concrete, steel, rebar, brick, different types of insulation), and required that this dataset is used for these materials, and the remaining materials are unrestricted.

The use of unusually low product specific data (compared to other similar products) is risky

We recommend that the policy requires assessors to disclose if they are knowingly using usually low embodied carbon (within the 25th percentile) data points compared to other similar products.

	Assessor using a standard set of generic carbon data	Assessor has freedom to choose from any carbon data sets
Benefits	• Quicker to carry out the assessment as there is a single data source. • The design of the building and the choice of material type affects the results accordingly.	• This gives the assessor the freedom to select a specific product or generic coefficient from a database, depending on if a specific product is selected yet or not to best match the materials used in the building.
Disadvantages	• Does not drive procurement choices. • Less accurate - Not representative of a prediction of the embodied carbon.	• Assessor could game the system and choose a particularly low embodied carbon product, e.g. Aluminium doors are typically high embodied carbon, low embodied carbon products exist, (where the factory generates renewable energy on site).
Guidance	• If chosen, additional guidance on procurement choices at a later design stage should be provided as well as relevant uncertainty factors.	• If chosen, an uncertainty factor should be disclosed along with the calculations following RICS guidance (see also page 73). • Encourage government to fund or support a standard material database.

Table of benefits and disadvantages of using standardised material data sets (e.g. France in regulation) or freedom to use any material data (as is the case currently in the UK, due to lack of regulation).

Why the use of unusually low product specific data (compared to other similar products) is risky

- The requirement of specific products at planning stage, puts pressure and limitations on procurement which can cause delays to the project
- This specific product might not actually be procured, thus the Embodied Carbon savings not realised
- Using specific low carbon products, rather than using a material pallet / designing a building in a way that is inherently low carbon, does not 'teach' or support the industry to deliver low carbon buildings as a whole.

Sensitivity – Foundation depth and type

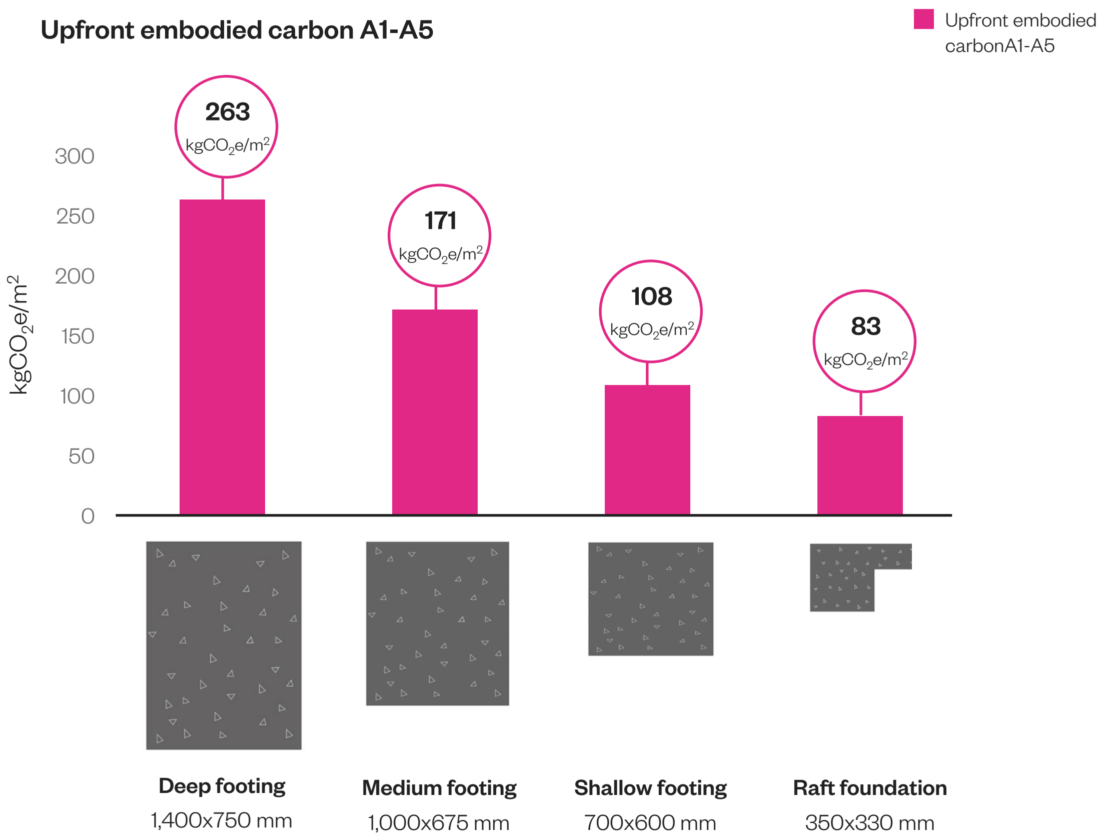
The chart opposite shows sensitivity analysis testing the upfront carbon impact of different foundation options/sizes. The size of the foundations in these calculations have been derived from a review of a range of residential projects. Four types were analysed and compared:

- Deep footing 1400 x 750 mm
- Medium footing 1000 x 675 mm
- Shallow footing 700 x 600 mm
- Raft foundation 350 x 330 mm

Results

As expected, the larger the footing, the more the concrete and rebar content, the higher the upfront embodied carbon. Foundation size and type can vary significantly based on project-specific circumstances, leading to differences in their impact on the upfront embodied carbon of the building. Ground conditions and structural loads dictate the foundation type and depth, with few design options to mitigate this. Therefore, the ability to alter foundation design and its associated upfront embodied carbon is often limited. For this reason the policy limits will take deep foundations into account.

The deep footing option has been applied on the worst case upfront embodied carbon scenario for all typologies and the raft foundation has been applied on the best case scenario.



Sensitivity – Cement replacement

Using ground granulated blast-furnace slag (GGBS) or fly ash (FA) for cement replacement is a simple way to reduce the embodied carbon impact of concrete, by replacing a portion of the commonly used portland cement.

The chart opposite shows the sensitivity analysis of the upfront carbon impact of different percentages (0%, 20% and 38%) of GGBS used as cement replacement. The higher the percentage of GGBS the lower the upfront embodied carbon.

Results

As expected, the upfront embodied carbon of concrete is reduced when the GGBS content is increased. This decrease in emissions is seen in the A1-A3 emissions stage (product supply/manufacture). The Institute of Structural Engineers (IStructE) have developed a comparison table which concludes the same. To standardise calculations RICS PS v2 2023 states that a default GGBS content of 25% should be used until the assessor can confirm the actual percentage replacement value. This default value would therefore be appropriate and advisable for use in planning stage assessments.

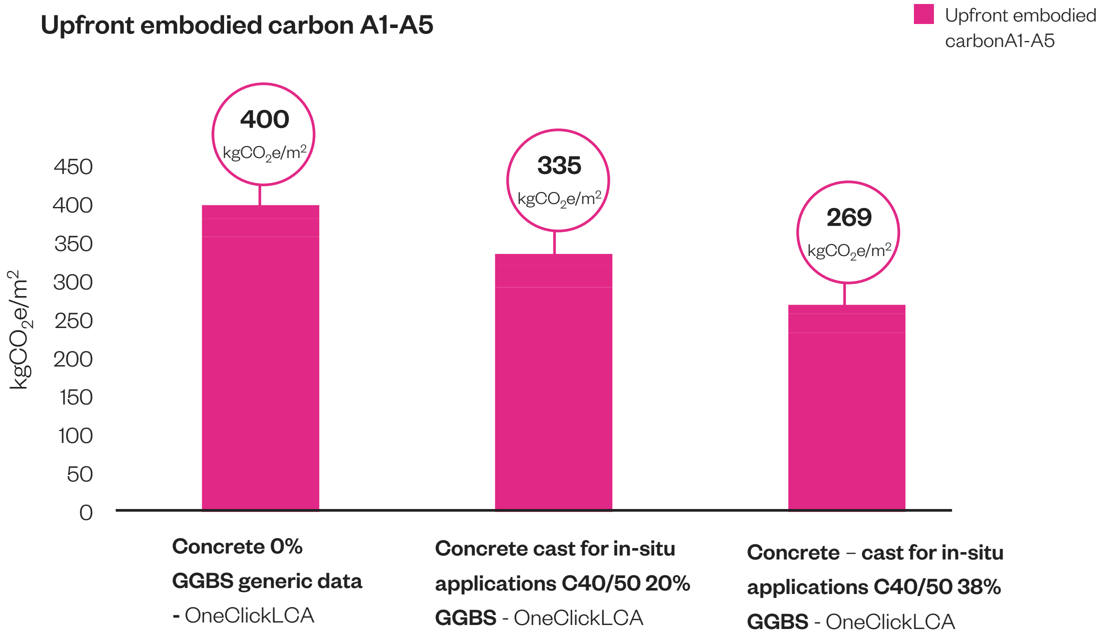
Supplies of GGBS and FA are constrained

GGBS and FA are product waste from other processes. GGBS is a by-product from iron and steel production from the blast furnaces. FA comes from the burning of coal in power plants.

Blast furnaces are closing down and being substituted with greener alternatives like Electric Arc Furnaces, which do not produce GGBS as a waste product. Coal plants are closing in an effort to decarbonise the national grid. This means that both GGBS and FA supplies are limited. While the use of GGBS and FA reduces the embodied carbon of concrete in the short term and on specific projects, it does not reduce the embodied carbon of building materials globally. This is because more buildings seek to use GGBS and FA than is available. In addition, their continued use encourages the carbon intensive process from which they are derived.

Reducing the quantity of concrete should be the priority over replacement with a constrained material

The specification of cement replacements on larger schemes is very common now, however, it is proving more scarce during construction. Smaller schemes are less likely to have it in a normal batch of ready-mix concrete.



Upfront embodied carbon comparison of concrete with various GGBS proportions showing the reductions in embodied carbon due to GGBS. The study was conducted using One Click LCA software and assuming a service life of 60 years. The transport and waste factors (A4 & A5) have been following the latest RICS Ps v2 2023 guidance.

Broad designation of cement type in concrete	Percentage of addition	Embodied CO2 $kgCO_2/m^3$ of concrete
CEM1	0%	283
IIA	6-20%	228 - 277
IIB	21-35%	186 - 236
IIIA	36-65% GGBS	120 - 198
IIIB	66-80% GGBS	82 - 123
IVB	36-65% fly ash or pozzalana	130 - 188

Embodied carbon of UK concretes (based on a cement content of $320kg/m^3$ of concrete), Source: The Institute of Structural Engineers

Sensitivity - Bricks

Brick is a traditional and incredibly robust and durable façade material in the UK. It is commonly used for loadbearing walls in homes. However, it also has relatively high embodied carbon, contributing to 40-50% of the upfront carbon emissions of a wall (depending on overall wall build-up).

While brick has high upfront embodied carbon, the longevity of use and low maintenance properties mean it lasts well. Therefore, its replacement and maintenance carbon is low (hence embodied carbon of stage for maintenance is 0). This should be weighed up when designing brick buildings.

As with all materials there is variability in the upfront embodied carbon depending on the product selected. Studies[1] have shown that environmental product declarations (EPDs) for facing bricks can vary in their A1-A3 emissions (supply and manufacture) by approx. 0.12-0.31 kgCO_2e/kg.

Four common/generic bricks compared

To support this, four common brick options have separately been compared that could be used in embodied carbon calculations:

- Red brick, average production, UK, 215 mm x 102.5 mm x 65 mm, 2.13 kg/unit, 1,485 kg/m^3 by Brick Development Association (BDA) Ltd (2019)
- Generic brick, UK average by IStructE
- Clay, Brick, 2.13 kg/unit by ICE
- Clay brick by One Click LCA

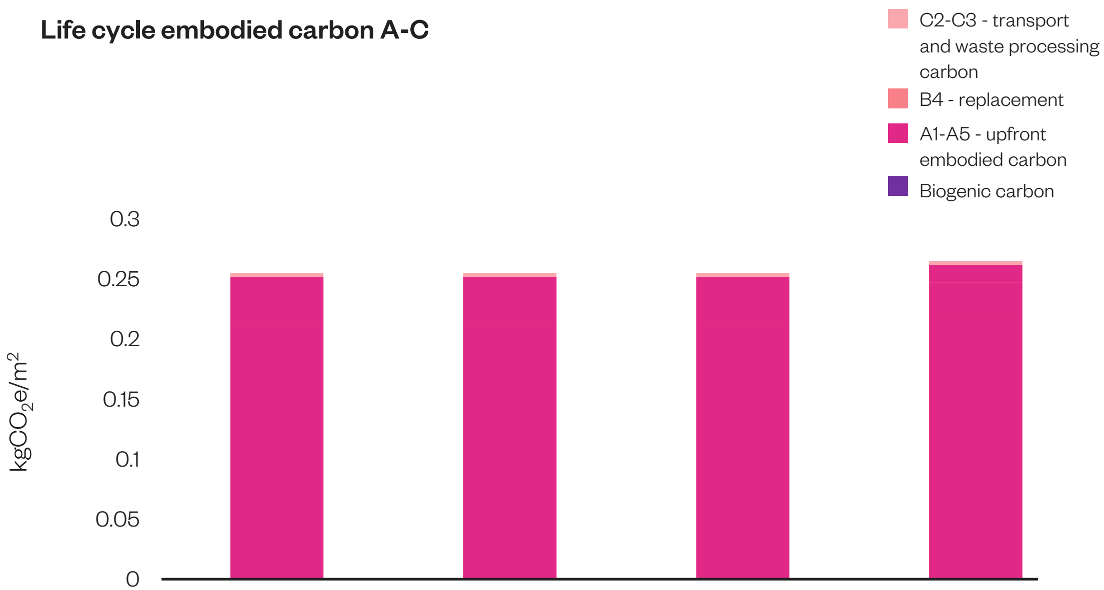
The biggest contributor in all brick options is the upfront emissions. The four materials reviewed have similar carbon coefficients, around 0.21kgCO_2/kg. In terms of lifecycle emissions, all the bricks compared have similar results around 0.26kgCO_2/kg. Therefore, while brick forms a relatively large portion of emissions from walls the data behind it is likely to be relatively stable.

Mortar, restraint and support

It is worth also considering that cement based mortar can form around 15% of the upfront embodied carbon of a wall. Therefore, mortar adds to the impact of bricks as well as wall ties and steel restraint systems for taller non-loadbearing buildings.

[1] Reducing Embodied Carbon in the Built Environment: The Role of Environmental Product Declarations, Jane Anderson and Derek Jones, 2023

Life cycle embodied carbon A-C



	Red brick data BDA	Generic brick data IStructE	Clay brick data	Clay brick data OneClickLCA
A1-A3	0.21	0.21	0.21	0.22
A4	0.026	0.026	0.026	0.026
A5	0.015	0.015	0.015	0.015
B4	0	0	0	0
C2	0.0029	0.0029	0.0029	0.0029
C3	0.00035	0.00035	0.00035	0.00035
Biogenic carbon	0	0	0	0

A calculation period of 60 years has been used, together with waste, transport and service life factors following latest RICS PS WLCA guidance v2 2023. No data were available for modules B1, B2, B3, B5, C1 and C4.

Sensitivity analysis – Upfront biogenic carbon

What is upfront biogenic carbon

When trees and plants grow they capture and store atmospheric carbon dioxide. This benefit is not captured in the calculation of the upfront or lifecycle embodied carbon of materials. Therefore, as a way to demonstrate the benefit of using natural materials the sequestered carbon is calculated and disclosed separately.

This sensitivity analysis demonstrates the benefit of the use of biogenic materials, showing that when taken into account the materials can be carbon neutral or positive as a result. However, should a biogenic material be incinerated at the end of its life, the benefits of carbon sequestration are reversed. This means that life cycle assessments often show less benefit for the use of biogenic materials (see page 123).

Results

The graphs opposite highlight the potential savings of biogenic carbon for the timber and natural build-ups.

RICS 2023 definitions:

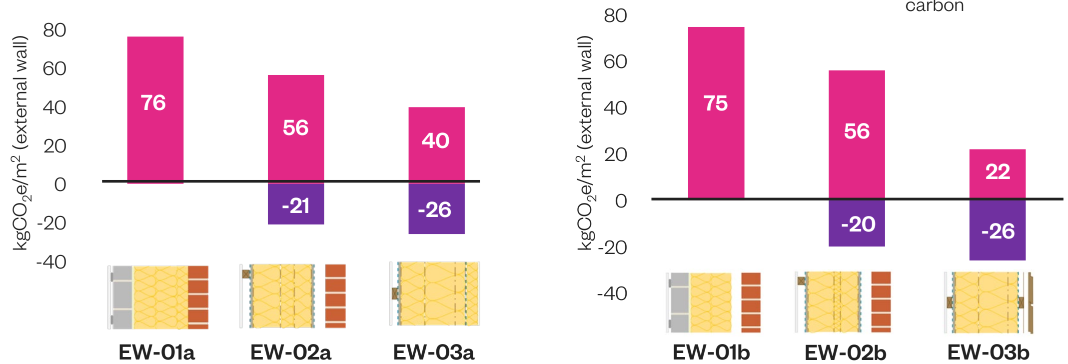
> **Biogenic carbon**
>
> *"Carbon removals associated with carbon sequestration into biomass, as well as any emissions associated with this sequestered carbon. Biogenic carbon must be reported separately if reporting only upfront carbon, but should be included in the total if reporting embodied carbon or whole life carbon.*
>
> **Carbon sequestration**
>
> *"The process by which CO_2 is removed from the atmosphere and stored within a material, for example by being stored in biomass as biogenic carbon by plants.*

Upfront embodied carbon A1-A5 and upfront biogenic carbon

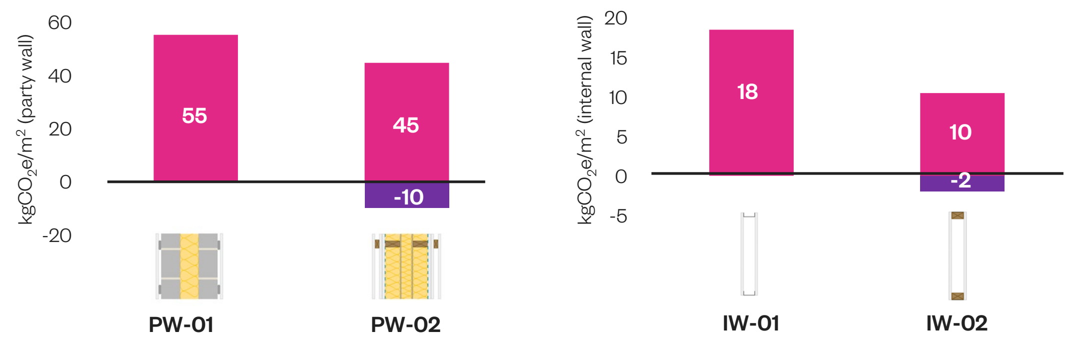
Upfront embodied carbonA1-A5

Upfront biogenic carbon

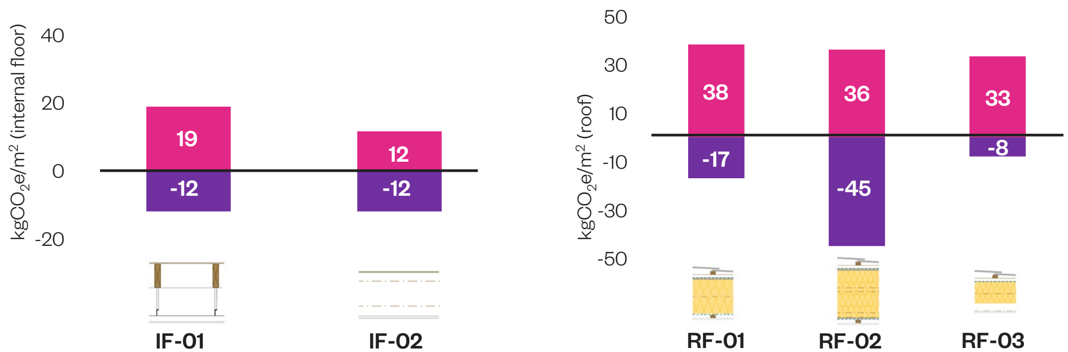
External wall build-ups



Party and internal wall build-ups



Internal floor and roof build-ups



Sensitivity – Different insulation types

Why insulation is important?

Insulation plays a key role in ensuring a building meets net zero operational carbon. It improves internal comfort while reducing heating and cooling loads. Certain insulation types also reduce noise breakout, making them suitable for intermediate partitions requiring sound insulation.

Insulation types

To understand the impact of insulation on upfront embodied carbon, eight types used were compared using generic data points: PIR (polyisocyanurate), phenolic, EPS (expanded polystyrene), wood fibre, hempcrete, mineral wool, glass wool, and cellulose. Insulation types were normalised by their U-value (0.15 W/m^{2}K) , in order to make them thermally comparable.

Results

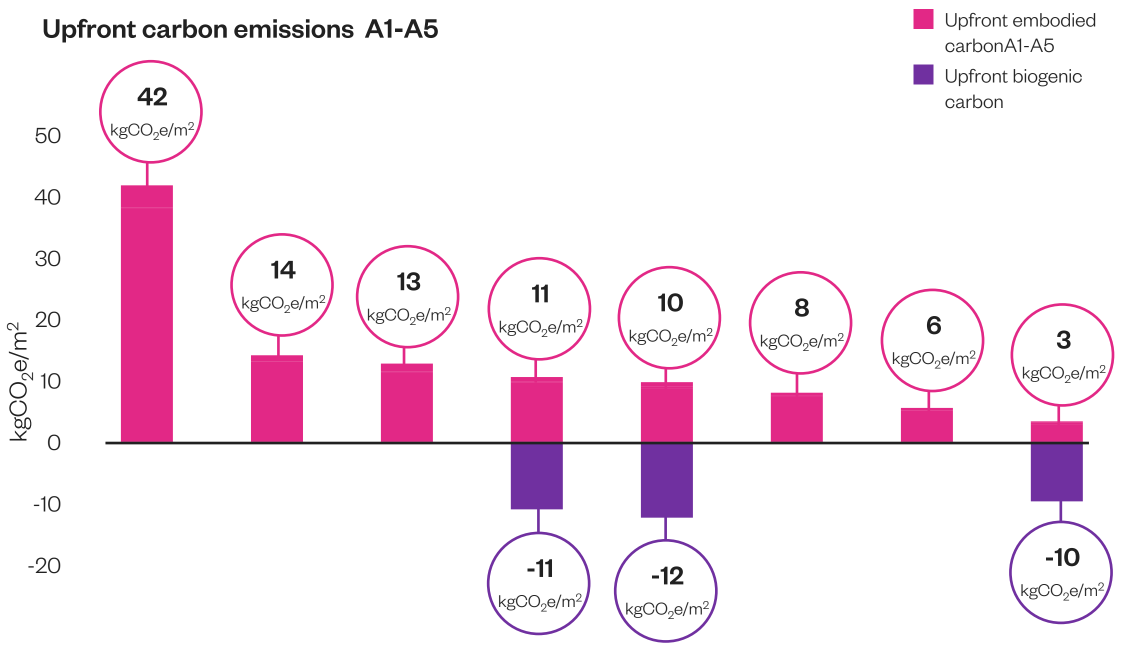
The graph opposite illustrates the upfront embodied carbon of various insulation types per square meter of wall.

PIR insulation exhibits notably higher upfront embodied carbon than the others, primarily due to its carbon-intensive manufacturing process and fossil fuel based origins. However, on page 86 of the report it is observed that despite petroleum-based insulation having the highest upfront embodied carbon, its overall impact in roof build-ups is slightly lower in comparison with mineral wool and cellulose insulation.

Even though more environmentally friendly insulation types, like wood fibre, hempcrete and cellulose, need almost double the thickness of PIR to achieve a U-value of 0.15 W/m^{2}K, their upfront embodied carbon is less than a tenth of PIR's. This is attributed to their simpler manufacturing process and natural origins. The upfront embodied carbon is low even before the upfront biogenic carbon is taken into account.

Transitioning to net-zero carbon necessitates reducing reliance on fossil fuels. Therefore, minimizing the use of petroleum-based insulation in favour of environmentally-friendly options like wood fibre, mineral wool, and hempcrete is essential (see page 137).

* For more information on Part B fire regulations and materials see page 141.



	PIR	Phenolic	EPS	Wood fibre	Hempcrete	Mineral wool	Glass wool	Cellulose
Thermal conductivity (W/m.K)	0.022	0.019	0.034	0.038	0.065	0.035	0.032	0.039
Thickness (mm)	140	130	230	250	490	230	210	250
U-value (W/m^2.K)	0.15							
Source	Fossil-fuels	Fossil-fuels	Fossil-fuels	Trees	Hemp shives & lime	Basalt rock & steel slag	Sand & lime-stone	Waste news-paper
Part B fire regulations restrictions*	Not above 11m	Not above 11m	Not above 11m	Not above 11m	Not above 11m	No restriction	No restrict-ion	Not above 11m

Sensitivity of key materials – Oriented Strand Board (OSB)

This study has shown that for timber based intermediate floors and roofs, plywood and oriented strand board (OSB) can contribute up to 37% of upfront embodied carbon emissions. The number of layers of these boards for linings and structural rigidity means they feature as quite a large proportion of the upfront emissions of the construction build-up.

To determine the variability in emissions across material options when carrying out embodied carbon calculations, four common OSB boards have been compared.

OSB

Four common brick options have been separately compared that could be used in embodied carbon calculations:

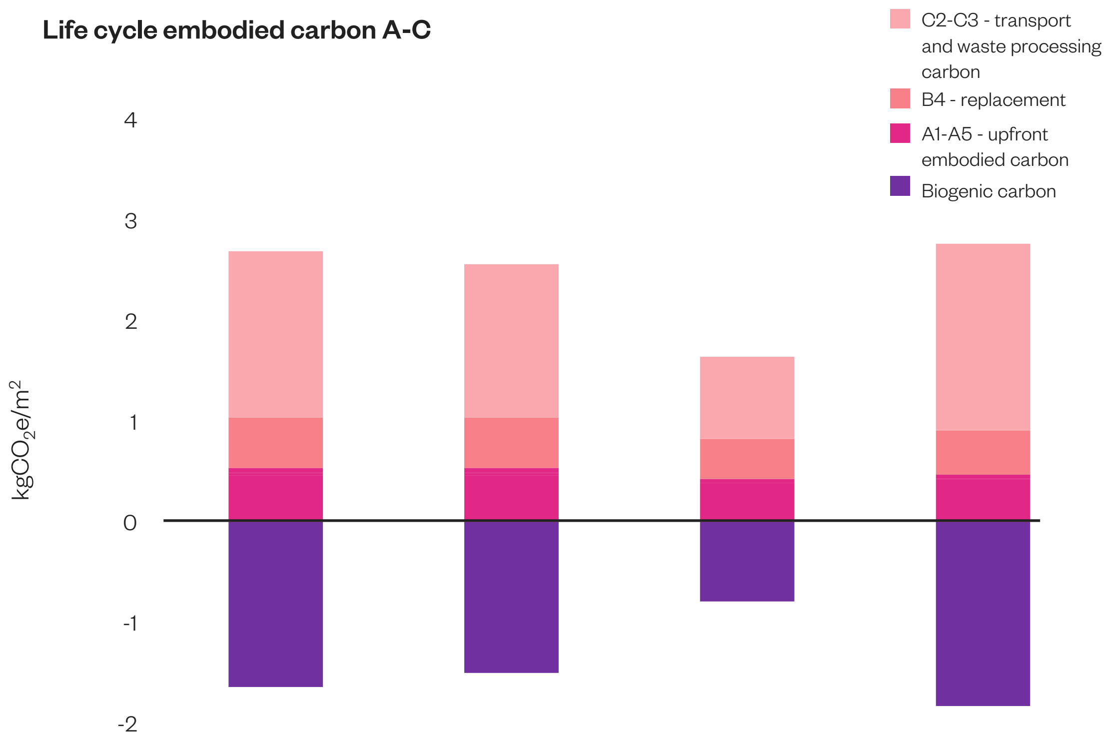
- Oriented Strand Board (OSB), 100% FSC/PEFC by IStructE
- Timber, OSB by ICE database
- Oriented strand board (OSB), generic, 9.5-28.5 mm, 610 kg/m^3, min. G4-2, average by OneClickLCA software database
- Oriented strand board (OSB), 8-30 mm by Nordboard, from Inverness mill)

For upfront embodied carbon, the four OSB boards have similar results at 0.4-0.5kgCO_2/kg. They also have similar biogenic carbon, which has been calculated separately, to show the benefit of bio-based materials which absorb carbon dioxide during the growth of the tree .

For lifecycle carbon, the biggest contributor to emissions was stage C3 which includes incineration as the end of life scenario.

This comparative study highlights the stability of OSB upfront emissions across different material choices in calculations. When lifecycle emissions are reviewed, there is potential for applicants calculations to vary slightly for lifecycle emissions for OSB.

Life cycle embodied carbon A-C



	OSB data I-StructE	OSB data ICE Database	OSB data OneClickLCA	OSB data Nordboard EPD
A1-A3	0.46	0.46	0.36	0.4
A4	0.026	0.026	0.026	0.026
A5	0.05	0.05	0.04	0.044
B4	0.5	0.5	0.4	0.44
C2	0.0038	0.0038	0.0038	0.0038
C3	1.65	1.52	0.81	1.85
Biogenic carbon	-1.64	-1.5	-0.79	-1.83

A calculation period of 60 years has been used, together with waste, transport and service life factors following latest RICS PS WLCA guidance v2 2023. No data were available for modules B1, B2, B3, B5, C1 and C4.

Sensitivity – Lifecycle of building services

Considering the lifecycle emissions of Mechanical, Electrical, and Plumbing (MEP) components, as opposed to their upfront embodied carbon, is crucial due to their relatively low service life. This is because they are replaced at a higher rate compared to other building components. The service life of different MEP components has been calculated to align with the RICS PS v2 2023 guidance.

Lifecycle embodied carbon results

The lifecycle carbon emission results follow the same trend as the upfront carbon emissions. The comparison between the ASHP and DE systems show a reduction of 32% for flats and 46% for houses.

The increase in lifecycle results over upfront highlight the frequent replacement of MEP components. An example is the air source heat pump (ASHP), which requires replacement approximately every 15 years. Given a building's estimated lifetime of 60 years, this means a new ASHP is needed four times during this period. This frequent replacement significantly impacts stage B emissions, which account for around 58-62% of the total emissions in the ASHP scenarios, and around 66% in the DE scenarios, excluding refrigerant leakage. When refrigerant leakage is factored in, stage B emissions in ASHP scenarios increase to around 67-73%.

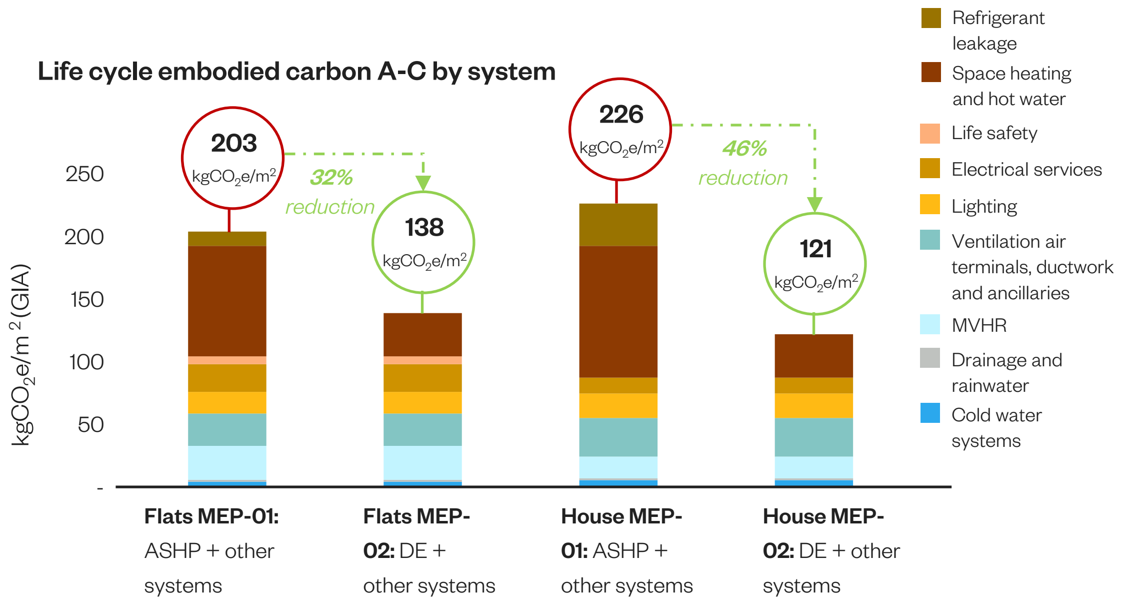
Stage C emissions, which are associated with the end of life of components, are relatively minor. They consist of 2% of the total emissions in all scenarios.

The impact of refrigerant leakage

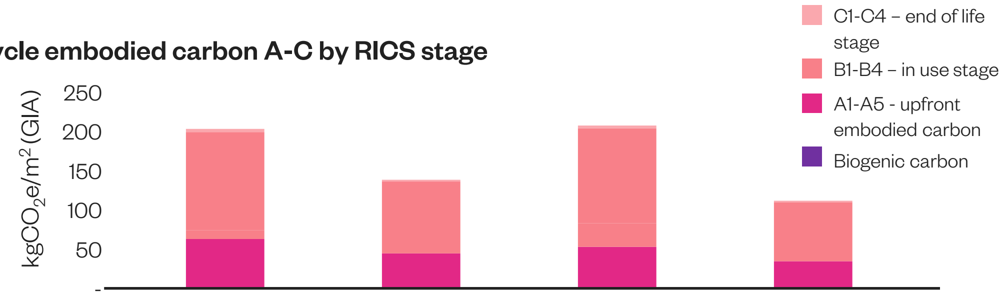
The proportion of each individual component remains fairly constant between upfront and lifecycle emissions, with the only major change in results being the inclusion of refrigerant leakage. Refrigerant leakage is only applicable in ASHP scenarios since direct electric (DE) scenarios do not utilise refrigerants. Results indicate the importance of prioritising factory-sealed heat pumps and refrigerants with a low Global Warming Potential (GWP). For a block of flats, refrigerant leakage accounts for 5% of total lifecycle emissions, while for a terraced house, it represents 14%. This discrepancy is attributed to the varying power capacity of the ASHP; higher power requires more refrigerant, leading to increased leakage.

In this study, R32 refrigerant, with a GWP of 675 $kgCO_2eq/kg$ over 100 years and an assumed annual leakage rate of 2%, is used.

Life cycle embodied carbon A-C by system



Life cycle embodied carbon A-C by RICS stage



	Flats MEP-01 ASHP + other systems	Flats MEP-02 DE + other systems	House MEP-01 ASHP + other systems	House MEP-02 DE + other systems
A1-A5	63	45	57	38
B1 (refrigerant leak)	11	-	33	-
B2-B4	125	91	132	4
C1-C4	4	2	4	2
Biogenic carbon	0	0	0	0

A calculation period of 60 years has been used, together with waste, transport and service life factors following latest RICS PS WLCA guidance v2 2023.

Sensitivity – other MEP scenarios – upfront embodied carbon

The carbon footprint of various other heating arrangements beyond the initial scope was also analysed. To maintain consistency in the analysis, all other systems were kept constant, allowing for the exclusive testing of different heating methods. The heating systems analysed included:

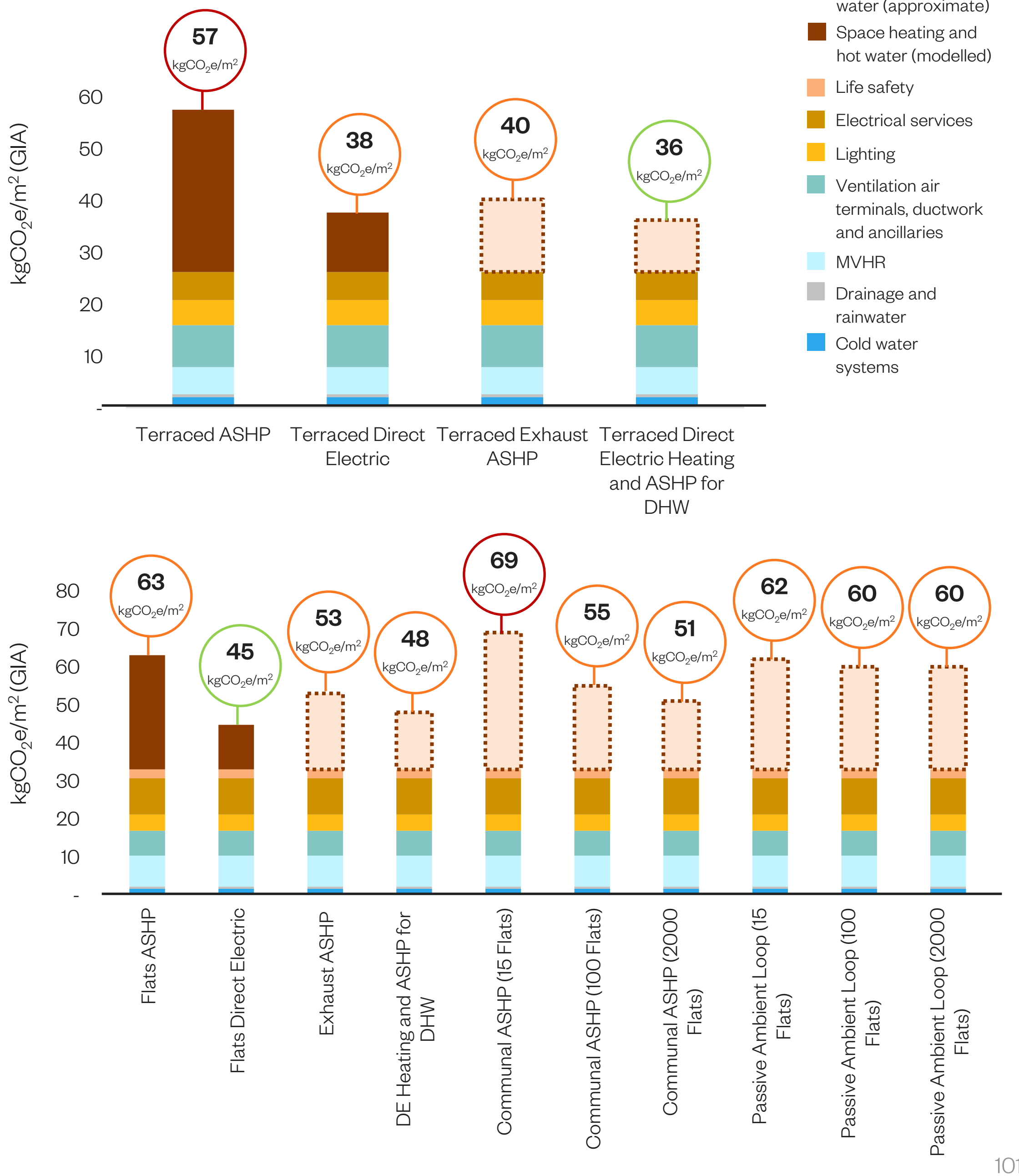
- MEP-03: Exhaust ASHP (ExASHP)
- MEP-04: Direct electric heating alongside ASHP for domestic hot water
- MEP-05: Communal ASHP systems serving different numbers of flats (15, 100, and 2000)
- MEP-06: Passive ambient loops serving different numbers of flats (15, 100, and 2000)

Higher and lower embodied carbon heating systems

It was noted that exhaust ASHP systems tend to have lower upfront emissions compared to air-to-water ASHP systems, though this advantage diminishes when lifecycle emissions are considered, especially in multi-flat buildings. Meanwhile, direct electric systems consistently resulted in reduced embodied carbon emissions, as well when combined with ASHP for domestic hot water. The analysis also highlighted the scalability of communal ASHP systems' efficiency; the carbon emissions per square meter decrease as the number of flats increases, showcasing a broad range in potential carbon intensity. In contrast, the benefits of scaling up passive ambient loop systems, while still positive, were less pronounced due to the presence of a heat pump in each flat.

The carbon emissions for these systems were derived from the CIBSE TM65.1 study titled "Embodied carbon in building services: residential heating". It is important to highlight the limitations concerning the CIBSE values, as they are broad estimates and not specific measured quantities. Achieving a comparable precision to the values obtained in this study would necessitate additional calculations beyond the current scope. This limitation was notably relevant for communal heating systems, which typically require custom calculations based on the specific materials used in a particular building, making it challenging to apply these findings universally.

Upfront carbon emissions A1-A5 by system



Sensitivity – other MEP scenarios – life cycle embodied carbon

This page focuses on the lifecycle carbon emissions of MEP components beyond the initial scope of work. The graphs included on this page are intended to provide a detailed visualization of the lifecycle emissions associated with each heating system evaluated, allowing for a comprehensive understanding of their environmental impact over time.

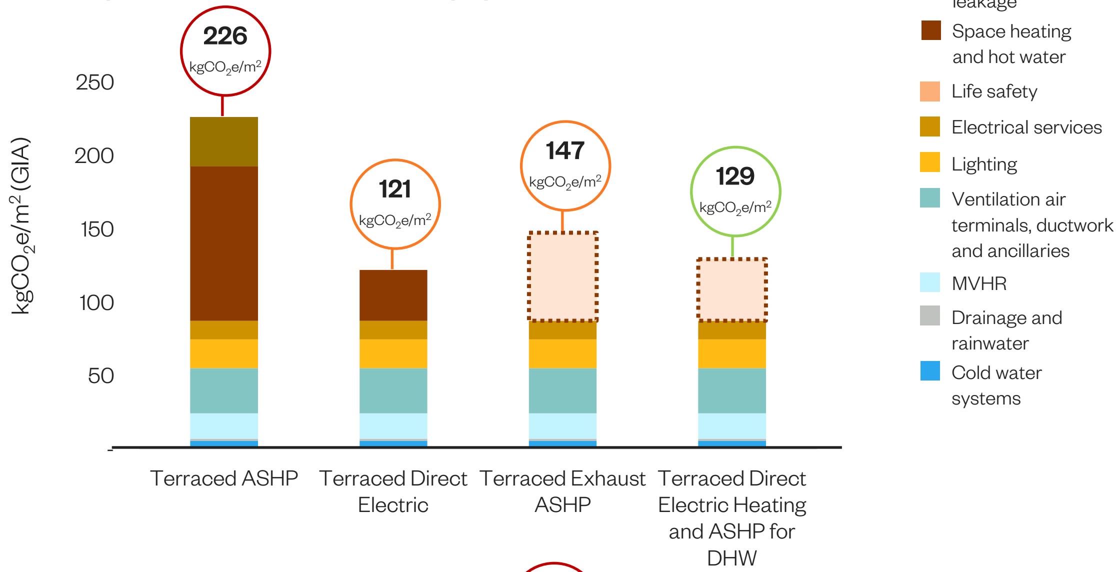
Life cycle emissions of MEP systems is important

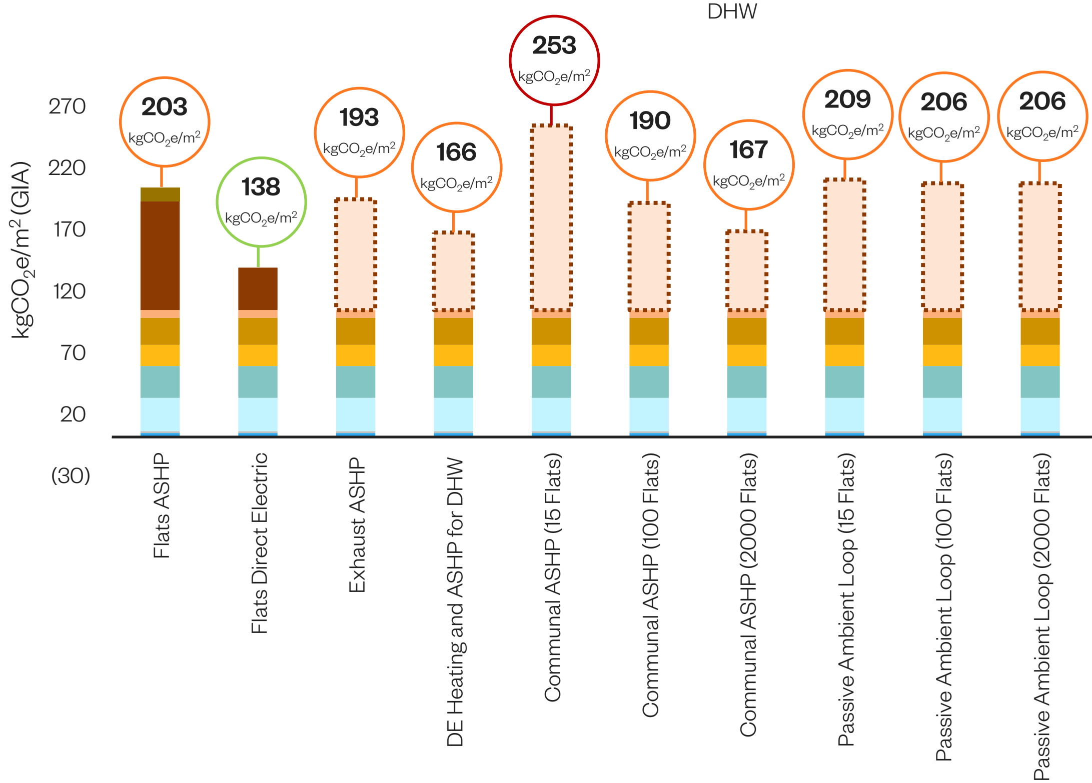
Focusing on lifecycle emissions of MEP systems is essential due to their shorter lifespan relative to a building's structural components. Given their frequent need for updates or replacements, it's crucial to consider their entire environmental footprint over their operational life.

The analysis reveals that differences between the upfront and lifecycle carbon emissions of the examined MEP scenarios are slight, with the main variance stemming from the impact of refrigerant leakage. The refrigerant chosen for this study is R32, which has a Global Warming Potential (GWP) of 675 kg CO_2 equivalent per kilogram over a 100-year period, and an assumed annual leakage rate of 2%. It's noteworthy that changes in the type of refrigerant or its leakage rate could significantly alter the lifecycle emissions results, emphasizing the importance of selecting refrigerants wisely to minimise environmental impact. This point underscores the dynamic nature of lifecycle assessments, where multiple factors can influence outcomes.

Nonetheless, it's important to recognise the limitations of our analysis. The presented data are based on broad estimates and lack the specificity needed for a precise impact evaluation. This limitation highlights the necessity for detailed, building-specific calculations that take into account the particular materials and operational profiles to accurately determine the lifecycle carbon emissions.

Life cycle embodied carbon A-C by system





Sensitivity – Photovoltaics (PV)

The commonly used embodied carbon data for upfront carbon of PV is often wrong

Embodied carbon of PV is evaluated per kWp output, as this linked the embodied carbon to the electricity generation of the panel. Our calculations indicate that the embodied carbon of solar in 2020 was around 615 $kgCO_2$/kWp. This is 76% lower than the 2,560 $kgCO_2$/kWp that is commonly referenced in calculations. This may drop to 325 $kgCO_2$/kWp by 2040 and 205 $kgCO_2$/kWp by 2050.

The importance of PV for net zero

Solar PV offers one of the lowest carbon forms of electricity generation available, and it is getting better all the time. For this reason, it is one of the central technologies for decarbonising our energy supply.

According to the Climate Change Committee, the UK's solar capacity needs to increase by around six times to achieve net zero. At current build rates this will take 40 years, so these rates must increase. Building mounted PV represents one of the quickest and lowest cost ways to meet this need.

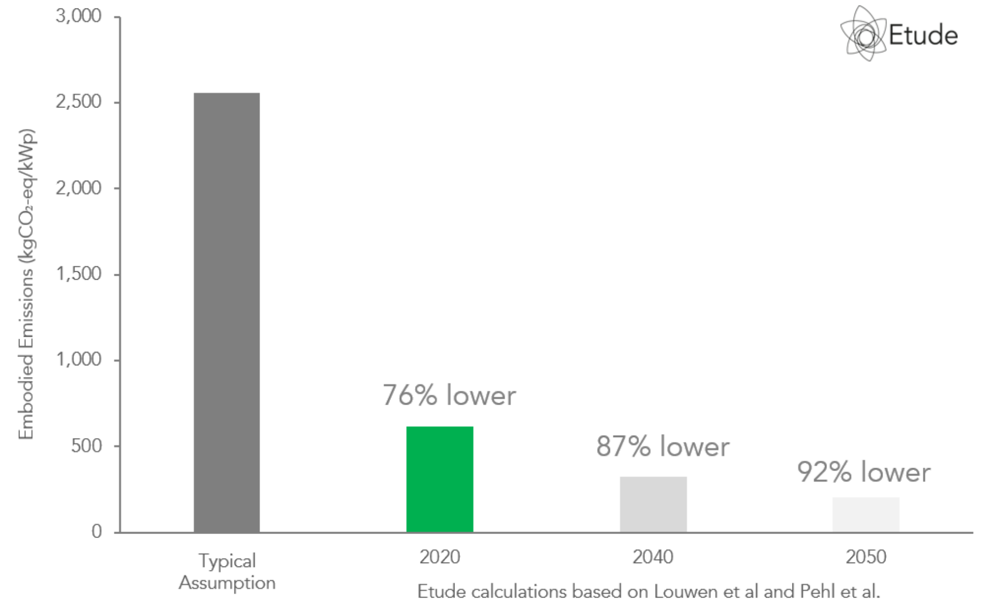
Low embodied carbon PV panels

PV is quite energy intensive to manufacture, hence factories that use renewable electricity to power their factories produce lower embodied carbon PV panels.

Embodied carbon is also reduced by maximising the efficiency of the PV panel, this could be through the use of reducing mounting structures and specifying microinverters or DC optimisers, this increases the energy generation per panel. Building mounted solar is often lower embodied carbon than ground mounted solar as less material is required to structurally support the panels. In addition to this solar panels can substitute roof materials, further reducing embodied carbon.

PV has been excluded from the results in this study and planning policy limits

PV has been calculated excluded from the final embodied carbon calculation results, as these are necessary for net zero operational carbon. If not carefully considered by applicants, the calculation of embodied carbon could be viewed as if they are in direct conflict with operational carbon reductions.



The embodied carbon of solar PV has fallen rapidly and is expected to continue to fall in the future. However, outdated figures are often used in upfront carbon assessments. The resulting embodied carbon estimates are typically three to five times higher than actually expected.

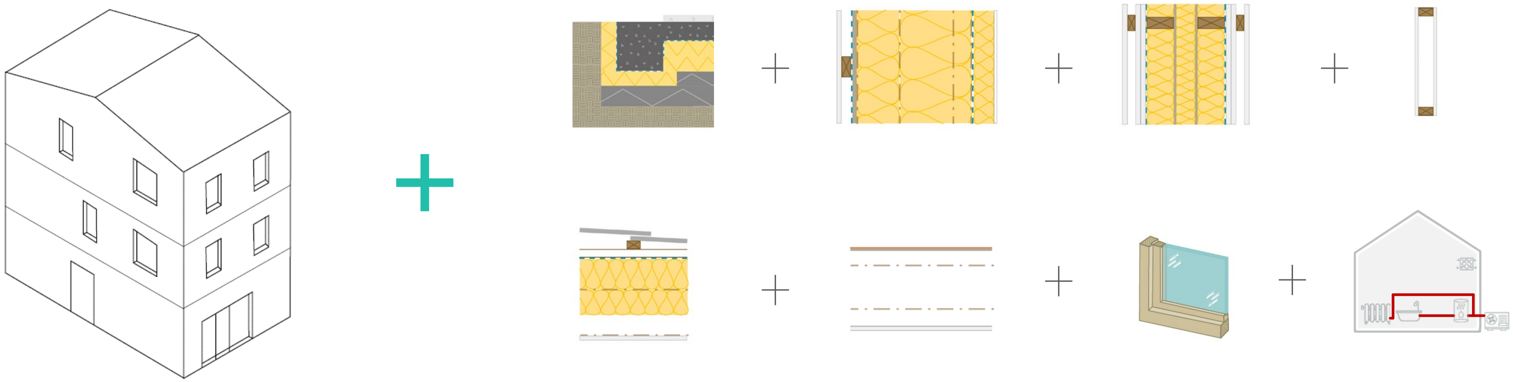
<630 kg CO_2e/ kWp

EPEAT Low carbon standard for PV panels

<400 kg CO_2e/ kWp

EPEAT ultra-Low carbon standard for PV panels

A low embodied carbon PV standard has been developed by the Global Electronics Council, PV panels can receive two levels of low embodied carbon certification.



Set menus and results

Upfront embodied carbon and construction cost per typology

Set menus and upfront embodied carbon with costings

Introduction

This section combines the materials and building elements into set menus, providing upfront embodied carbon figures for each typologies, together with capital cost estimations and percentage uplifts.

Set menus

The highest and the lowest upfront embodied carbon building elements have been taken forward to form high and low 'set menus' per building typology. Following cost analysis, a third set menu has been added to represent cost and carbon optimised. These menus have informed the upfront embodied carbon limits to be used in policy.

The menus have been formed by putting together combinations of elements that belong together for construction purposes while also forming the lowest, highest or cost-carbon optimised in their element category.

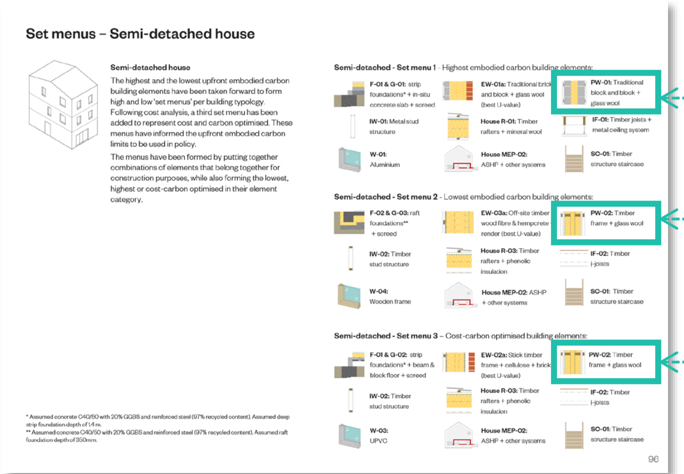
Scope of cost analysis

Cost analysis has been carried out for different construction options for foundations, ground floors, external and party walls, roofs, internal floors, internal walls, windows and heating systems. The composition of each element was specified so as to achieve high standards of energy efficiency – e.g. wall u values of 0.12-0.15 Wm2K and triple glazed windows.

Between two and six options were considered for each element and costs produced using a detailed schedule of components. Cost models are based on a combination of in-house project data on different components and specifications and first principles cost planning for specifications that are not widely constructed at present.

Costs are based on a Q3 2022 base prices for Southeast England. Costs reflect developer housebuilder costs and therefore exclude separate overheads and profit associated with a main contractor delivery model.

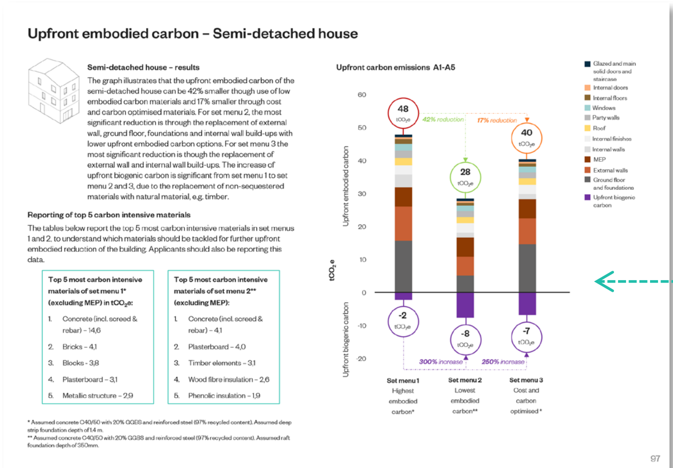
To contextualise the significance of changes in elemental costs between options an overall build cost was defined for each home, £2,020 m^2 for houses and £2,200 for low rise apartment blocks.



Highest upfront embodied carbon consists of the highest build-ups

Lowest upfront embodied carbon consists of the lowest build-ups

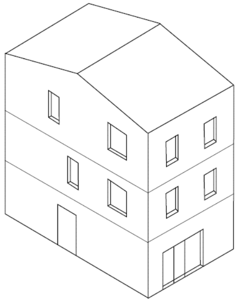
Cost and carbon optimised consists of the elements that are lower costs and lower carbon



Each set menu gives a total upfront embodied carbon figure per building typology

Results of upfront embodied carbon for set menus

Set menus – Semi-detached house



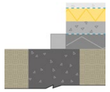
Semi-detached house

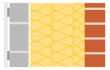
The highest and the lowest upfront embodied carbon building elements have been taken forward to form high and low 'set menus' per building typology. Following cost analysis, a third set menu has been added to represent cost and carbon optimised. These menus have informed the upfront embodied carbon limits to be used in policy.

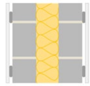
The menus have been formed by putting together combinations of elements that belong together for construction purposes, while also forming the lowest, highest or cost-carbon optimised in their element category.

Set menus 1, 2 and 3 have been shown opposite for the semi-detached house.

Semi-detached - Set menu 1 - Highest embodied carbon building elements:

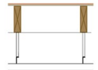

F-01 & G-01: strip foundations* + in-situ concrete slab + screed


EW-01a: Traditional brick and block + glass wool (best U-value)

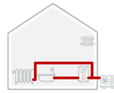

PW-01: Traditional block and block + glass wool

IW-01: Metal stud structure


House R-01: Timber rafters + mineral wool

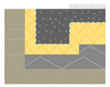

IF-01: Timber joists + metal ceiling system

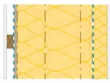

W-01: Aluminium

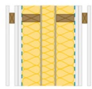

House MEP-02: ASHP + other systems


SC-01: Timber structure staircase

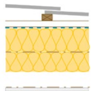
Semi-detached - Set menu 2 - Lowest embodied carbon building elements:


F-02 & G-03: raft foundations** + screed


EW-03a: Off-site timber + wood fibre & hempcrete + render (best U-value)

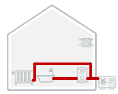

PW-02: Timber frame + glass wool

IW-02: Timber stud structure


House R-03: Timber rafters + phenolic insulation

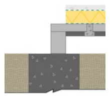

IF-02: Timber i-joists

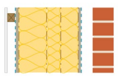

W-04: Wooden frame

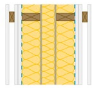

House MEP-02: ASHP + other systems


SC-01: Timber structure staircase

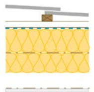
Semi-detached - Set menu 3 – Cost-carbon optimised building elements:


F-01 & G-02: strip foundations* + beam & block floor + screed


EW-02a: Stick timber frame + cellulose + brick (best U-value)

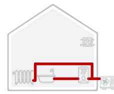

PW-02: Timber frame + glass wool

IW-02: Timber stud structure


House R-03: Timber rafters + phenolic insulation


IF-02: Timber i-joists


W-03: UPVC

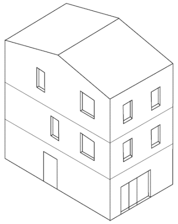

House MEP-02: ASHP + other systems


SC-01: Timber structure staircase

* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.

** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.

Upfront embodied carbon – Semi-detached house



Semi-detached house – results

The graph illustrates that the upfront embodied carbon of the semi-detached house can be 42% smaller though use of low embodied carbon materials and 17% smaller through cost and carbon optimised materials. For set menu 2, the most significant reduction is through the replacement of external wall, ground floor, foundations and internal wall build-ups with lower upfront embodied carbon options. For set menu 3 the most significant reduction is though the replacement of external wall and internal wall build-ups. The increase of upfront biogenic carbon is significant from set menu 1 to set menu 2 and 3, due to the replacement of non-sequestered materials with natural material, e.g. timber.

Reporting of top five carbon intensive materials

The tables below report the top five most carbon intensive materials in set menus 1 and 2, to understand which materials should be tackled by applicants for further upfront embodied reduction of the building. Applicants should also be reporting this data as part of policy recommendation 3. .

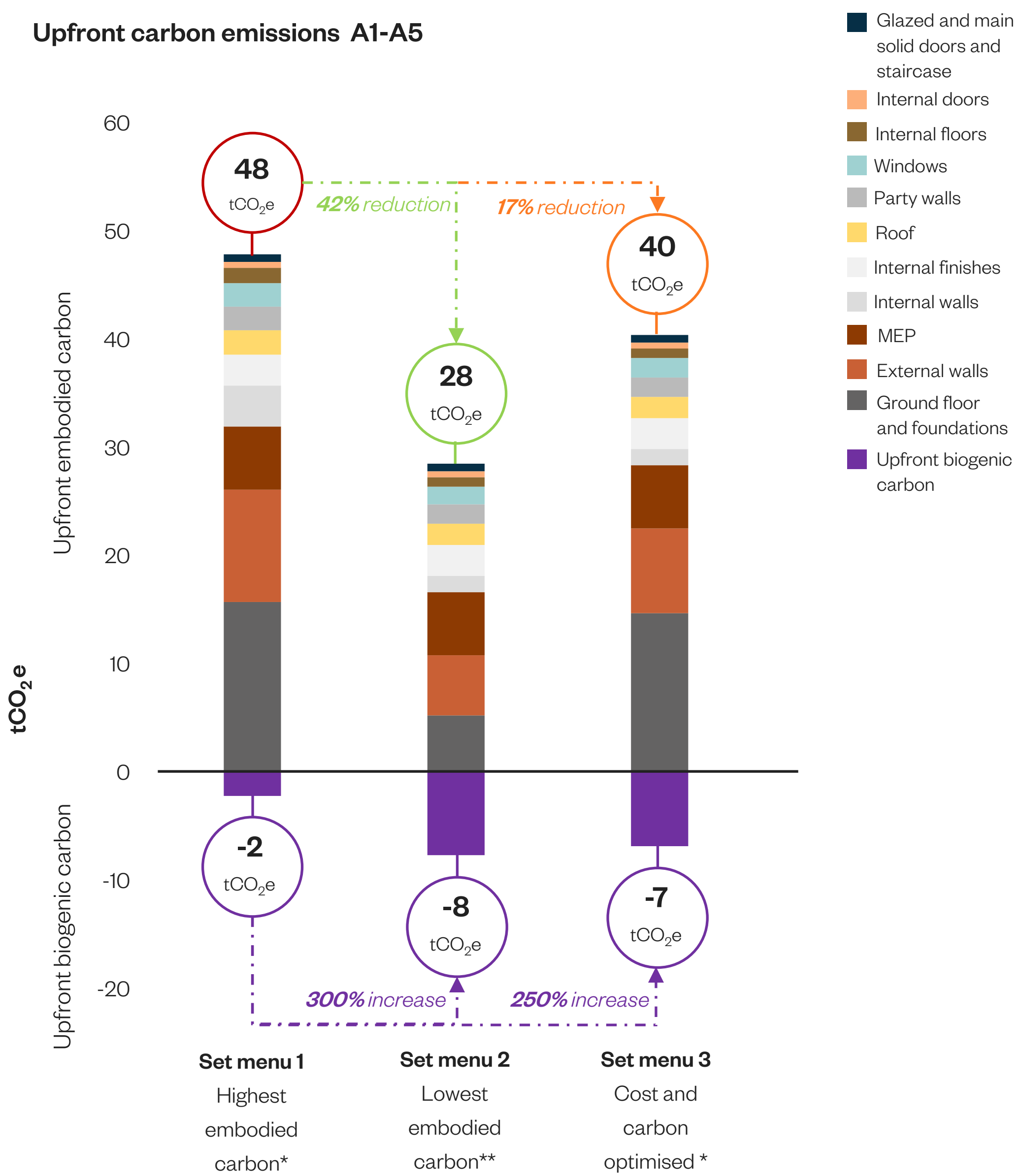
Set menu 1 - Top five most carbon intensive materials (excluding MEP) in tCO_2e:

1. Concrete (incl. screed & rebar) – 14.6
2. Bricks – 4.1
3. Blocks – 3.8
4. Plasterboard – 3.1
5. Metallic structure – 2.9

Set menu 2 - Top five most carbon intensive materials (excluding MEP) in tCO_2e :

1. Concrete (incl. screed & rebar) – 4.1
2. Plasterboard – 4.0
3. Timber elements – 3.1
4. Wood fibre insulation – 2.6
5. Phenolic insulation – 1.9

Upfront carbon emissions A1-A5



* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.

Construction costs – Semi-detached house

The two charts to the right present the cost analysis for different 'set menu' options for the semi-detached house typology. The top chart shows overall build costs including an allowance for 'other costs' ' – i.e. those items not varying between set menu options (such as external and internal doors and finishes). The bottom chart excludes these other items enabling differences between options to be seen more clearly.

In each chart the construction costs of five options are shown: a home built to the current Part L 2021 regulations (with an estimated build cost of £2,110 per m²); a home built to Essex's planned net zero operational carbon policy, using typical specifications; and then three homes built to the net zero operational carbon standard but with different approaches to upfront embodied carbon (set menu's 1-3).

Results

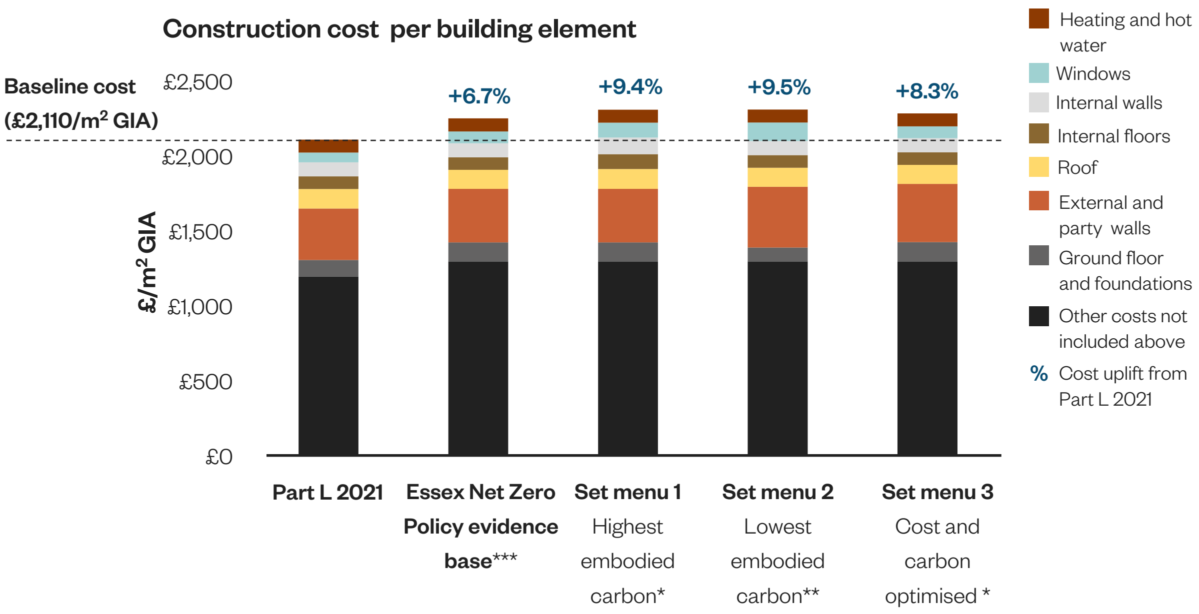
There is very little difference in overall cost between the highest and lowest carbon scenarios. The difference between the three set menus is less than 1% of their total capital cost. However, all three set menus are 1.5%-2.7% more expensive than the 'typical' net zero specification of solid floor slab and deep strip foundations, masonry construction, uPVC windows, timber internal walls and floors.

The similarity in overall costs disguises variations within the build-up of the total. The raft foundation used in set menu 2 is less expensive than those used in set menu's 1 & 3. This offsets the additional costs of the timber windows and timber / hempcrete construction method used in the lowest carbon option.

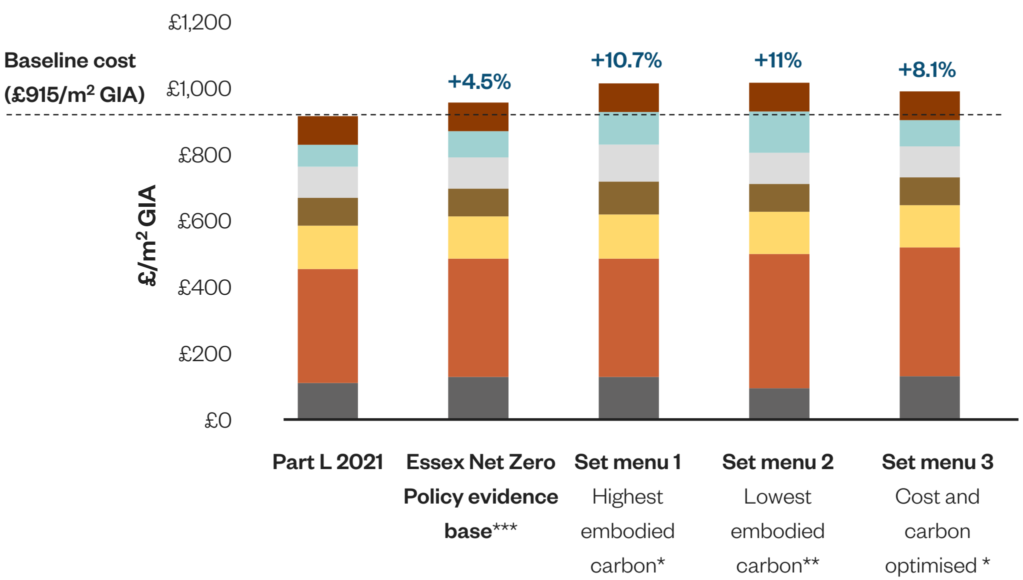
The cost and carbon optimised scenario (set menu 3) is similar to a 'typical' new build construction but includes a timber frame rather than masonry construction and so is slightly more expensive overall by c.£33 per m².

* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.
*** These costings are a version of set menu 3, but with traditional masonry external and party walls (higher upfront embodied carbon than set menu 3). This is comparable to the Essex Net Zero Policy Technical Evidence Base costings, but using the build-ups and quantities from the embodied carbon study. House type differs from the one used in the Essex Net Zero-evidence base.

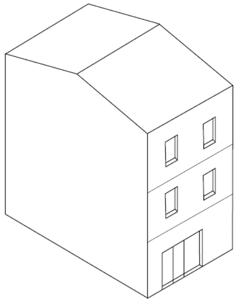
Construction cost per building element



Construction cost per building element - excluding '*other costs*'



Set menus – Terraced house



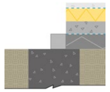
Terraced house

The highest and the lowest upfront embodied carbon building elements have been taken forward to form high and low 'set menus' per building typology. Following cost analysis, a third set menu has been added to represent cost and carbon optimised. These menus have informed the upfront embodied carbon limits to be used in policy.

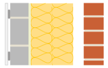
The menus have been formed by putting together combinations of elements that belong together for construction purposes while also forming the lowest, highest or cost and carbon optimised in their element category.

Set menus 1, 2 and 3 have been shown opposite for the terraced house.

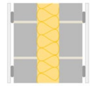
Terrace - Set menu 1 - Highest embodied carbon building elements:



F-01 & G-01: strip foundations* + in-situ concrete slab + screed



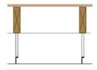
EW-01b: Traditional brick and block + glass wool (worst U-value)



PW-01: Traditional block and block + glass wool

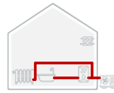
IW-01: Metal stud structure

House R-01: Timber rafters + mineral wool



IF-01: Timber joists + metal ceiling system

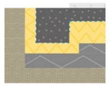
W-01: Aluminium



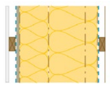
House MEP-02: ASHP + other systems

SC-01: Timber structure staircase

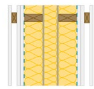
Terrace - Set menu 2 - Lowest embodied carbon building elements:



F-02 & G-03: raft foundations** + screed

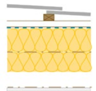


EW-03b: Off-site timber + wood fibre and hempcrete insulation+ timber weatherboard (worst U-value)



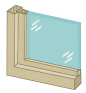
PW-02: Timber frame + glass wool

IW-02: Timber stud structure

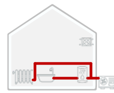


House R-03: Timber rafters + phenolic insulation

IF-02: Timber i-joists



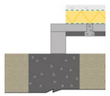
W-04: Wooden frame



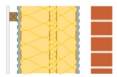
House MEP-02: ASHP + other systems

SC-01: Timber structure staircase

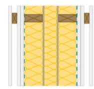
Terrace - Set menu 3 – Cost and carbon optimised building elements:



F-01 & G-02: strip foundations* + beam & block floor + screed

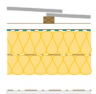


EW-02b: Stick timber frame + cellulose + brick (worst U-value)



PW-02: Timber frame + glass wool

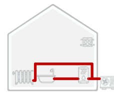
IW-02: Timber stud structure



House R-03: Timber rafters + phenolic insulation

IF-02: Timber i-joists

W-03: UPVC

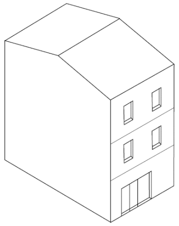


House MEP-02: ASHP + other systems

SC-01: Timber structure staircase

* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.

Upfront embodied carbon – Terraced house



Terraced house – results

The graph illustrates that the upfront embodied carbon of the terraced house can be 43% smaller though use of low embodied carbon materials and 16% smaller through cost and carbon optimised materials. . The difference between the terrace and the semi-detached gives an indication of how a detached house of similar proportions would perform. On this basis it could be assumed that a detached house, built with set menu 1, would have upfront embodied carbon emissions of approx. 52 tCO_2e. The increase of upfront biogenic carbon is significant from set menu 1 to set menu 2 and 3, due to the replacement of non-sequestered materials with natural material, e.g. timber.

Reporting of top five carbon intensive materials

The tables below report the top five most carbon intensive materials in set menus 1 and 2, to understand which materials should be tackled by applicants for further upfront embodied reduction of the building. Applicants should also be reporting this data as part of policy recommendation 3.

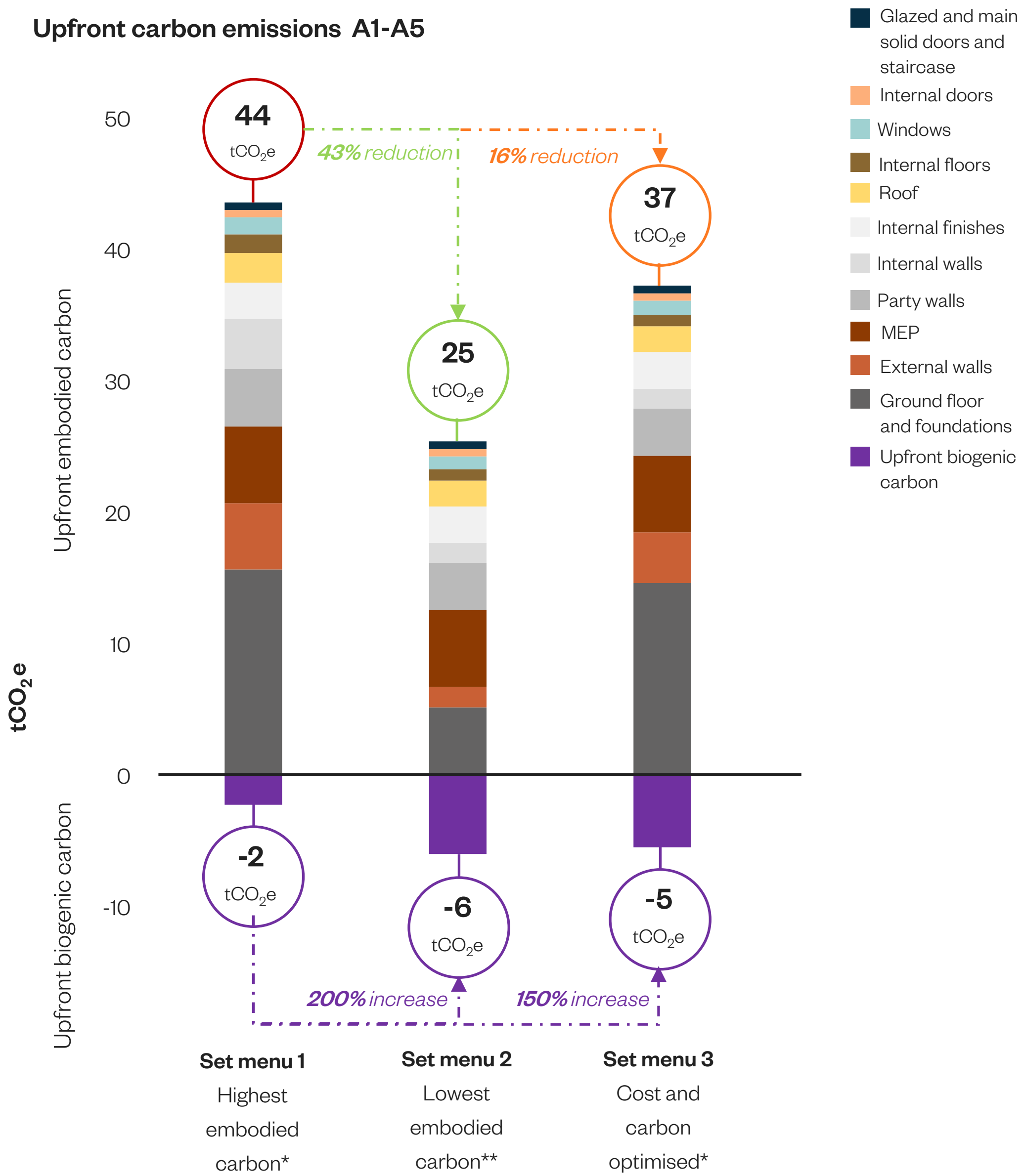
Set menu 1 - Top five most carbon intensive materials (excluding MEP) in tCO_2e:

1. Concrete (incl. screed & rebar) – 14.6
2. Blocks – 4.0
3. Plasterboard – 3.2
4. Metallic structure – 2.9
5. Aluminium – 2.6

Set menu 2 - Top five most carbon intensive materials (excluding MEP) in tCO_2e :

1. Plasterboard – 4.8
2. Concrete (incl. screed & rebar) – 4.1
3. Timber elements – 2.2
4. Phenolic insulation – 1.9
5. Carpet- 1.4

Upfront carbon emissions A1-A5



* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.

Construction costs – Terraced house (1/3)

The two charts to the right present the cost analysis for different 'set menu' options for the terraced house typology. The top chart shows overall build costs, including an allowance for 'other costs' – i.e. those items not varying between set menu options (such as external and internal doors, staircase, and finishes). The bottom chart excludes these other items, enabling differences between options to be seen more clearly.

In each chart the construction costs of five options are shown: a home built to the current Part L 2021 regulations (with an estimated build cost of £2,020 per m²); a home built to Essex's planned net zero operational carbon policy, using typical specifications; and then three homes built to the net zero operational carbon standard but with different approaches to upfront embodied carbon (set menu's 1-3).

Results

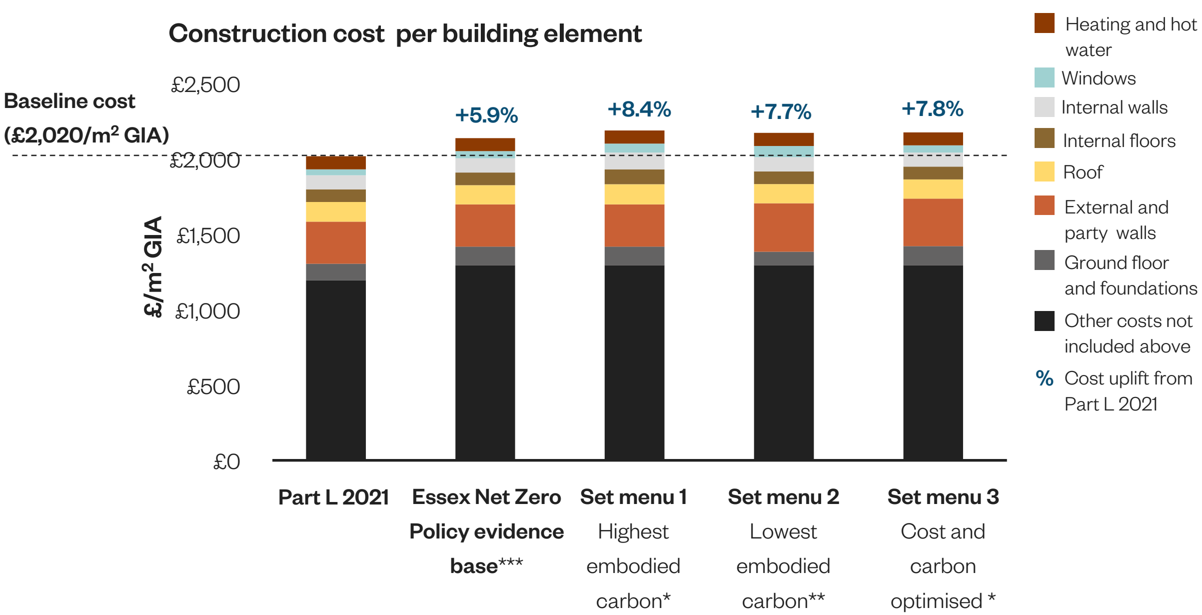
The highest embodied carbon scenario (set menu 1) is the most expensive of the net zero specifications assessed. This is because of the more expensive specifications for internal walls, intermediate floors and foundations. Overall, the difference between the three set menus is less than 1% of their total capital cost. However, all three set menus are 1.7%-2.5% more expensive than the 'typical' net zero specification of solid floor slab and deep strip foundations, masonry construction, uPVC windows, timber internal walls and floors.

The raft foundation system used in the lowest carbon scenario is substantially less expensive than the deep strip foundation systems in the other scenarios. Without this saving, the lowest carbon scenario could be around £2.3k (£18 per m²) more expensive than the highest carbon scenario. This is largely a result of the additional cost of the timber frame / hempcrete structure and timber windows.

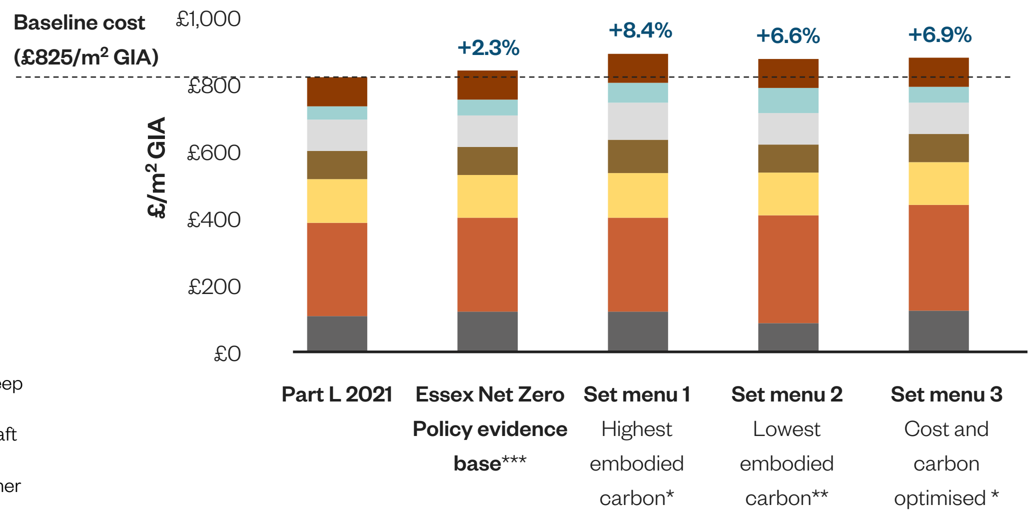
The cost and carbon optimised scenario (set menu 3) deliver carbon reductions using timber frame and cellulose insulation, and retains the strip foundation and concrete floor while still being comparable in cost to set menu 1.

* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.
*** These costings are a version of set menu 3, but with traditional masonry external and party walls (higher upfront embodied carbon than set menu 3). This is comparable to the Essex Net Zero Policy Technical Evidence Base costings, but using the build-ups and quantities from the embodied carbon study.

Construction cost per building element



Construction cost per building element - excluding '*other costs*'



Construction costs – Terraced house (2/3)

The chart on the right shows the range of costs per m^2 of built area estimated for each building element, illustrating the range of costs existing within the specifications modelled.

It is notable that lowest cost options do not directly correlate with highest carbon. For example, for foundations, internal walls and intermediate floors the lowest cost option is also lowest carbon. For windows, the lowest cost specification (uPVC) is the second lowest carbon and is substantially less expensive than the highest carbon option (aluminium framed) and other options (composite and timber).

Variation in the costs of foundations and ground floor options are in part a reflection of different specification options and in part the use of different foundation depths. Therefore at least in part, the cost of these systems will be dictated by ground conditions as well as a carbon objective.

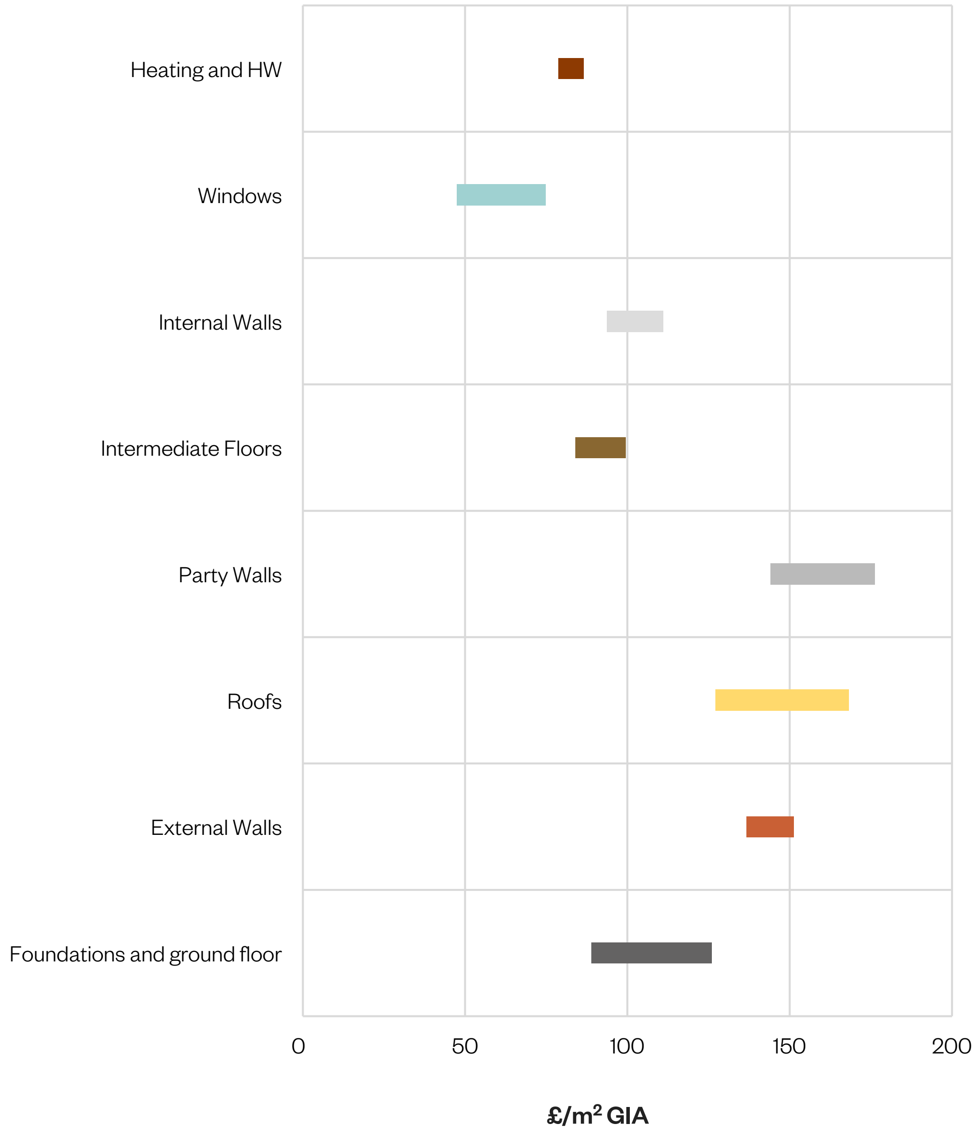
Primary structural options

The external and party wall options are typically aligned so as to have a consistent walling system throughout. The masonry system is the lowest cost option followed by standard timber frame with cellulose and then the timber and hempcrete MMC solution. Part of the variation in cost is a result of the use of cellulose or hempcrete/wood fibre insulation products with the timber-based structures rather than the choice of structural system.

It is also important to note that timber framed walls EW02/03 options are typically faster to construct on-site and so enable reduced construction programmes. The value of the site speed offered by timber frame in comparison to masonry can be positive or negative depending on the nature of the development site and the developers cash flow requirements.

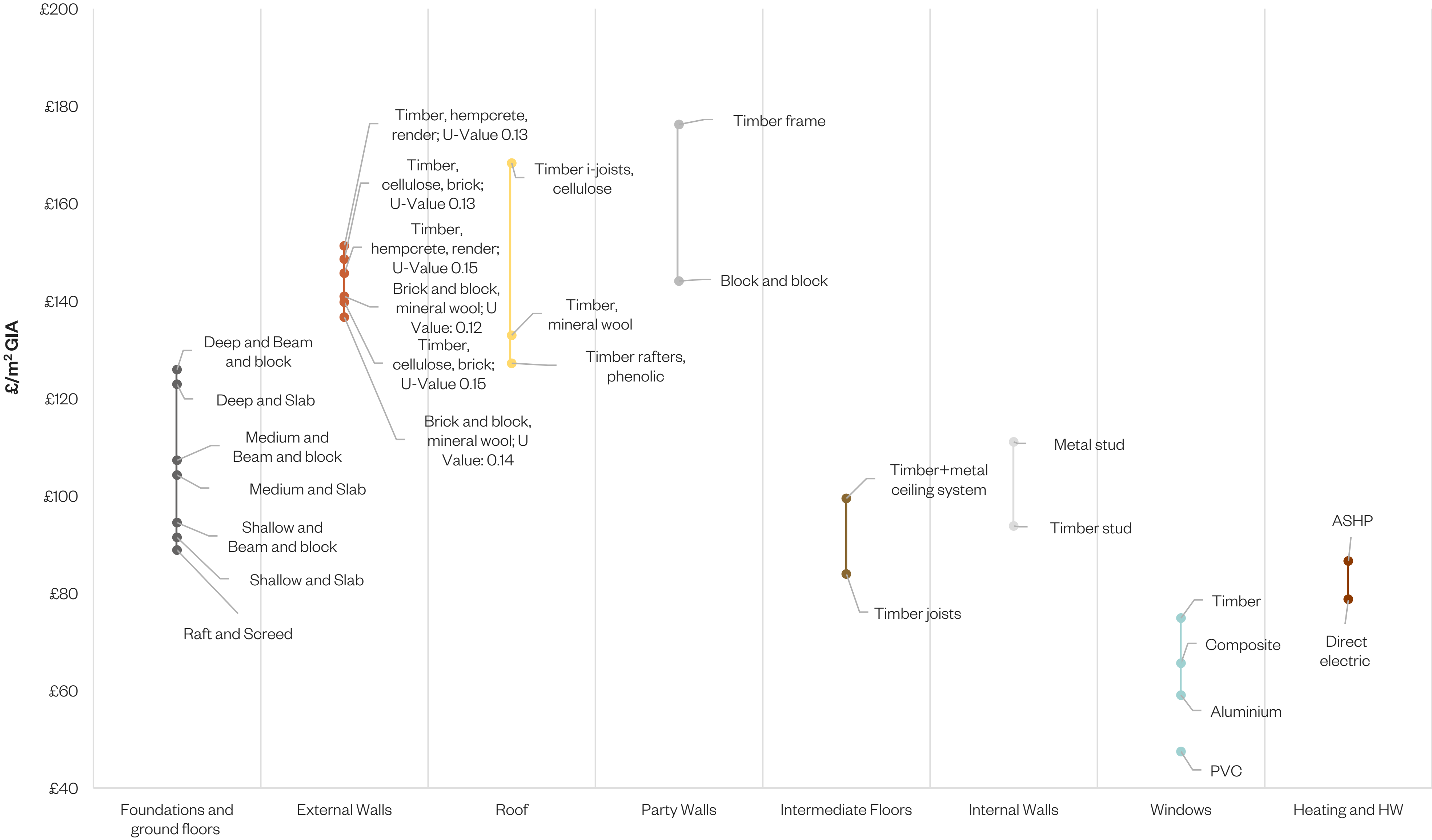
For example, for larger developments there is likely to be a net disbenefit from timber frame due to the greater upfront investment and faster, less controllable build rates which are more difficult to adjust in response to sales rates. However, for a smaller development of a few homes an accelerated ability complete development and repay borrowings is likely to mean a positive value from faster timber frame construction.

Range of costs by building elements

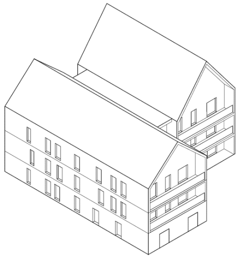


Construction costs – Terraced house (3/3)

Cost of different building elements per m² built area in terraced house



Set menus – Low-rise apartment block



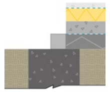
Low-rise apartment block

The highest and the lowest upfront embodied carbon building elements have been taken forward to form high and low ‘set menus’ per building typology. Following cost analysis, a third set menu has been added to represent cost and carbon optimised. These menus have informed the upfront embodied carbon limits to be used in policy.

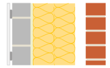
The menus have been formed by putting together combinations of elements that belong together for construction purposes while also forming the lowest, highest or cost and carbon optimised in their element category.

Set menus 1, 2 and 3 have been shown opposite for the low-rise block of apartments.

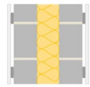
Low-rise apartment block - Set menu 1 - Highest embodied carbon building elements:



F-01 & G-01: strip foundations* + in-situ concrete slab + screed



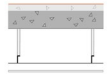
EW-01b: Traditional brick and block + glass wool (worst U-value)



PW-01: Traditional block and block + glass wool

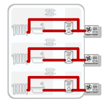
IW-01: Metal stud structure

Flats R-04: Timber joist + mineral wool at loft



PF-01: Pre-cast concrete planks

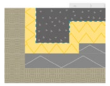
W-01: Aluminium



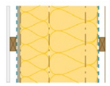
Flats MEP-02: ASHP + other systems

SC-02: In-situ concrete staircase

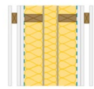
Low-rise apartment block - Set menu 2 - Lowest embodied carbon building elements:



F-02 & G-03: raft foundations** + screed

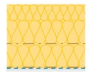


EW-03b: Off-site timber + wood fibre and hempcrete insulation+ timber weatherboard (worst U-value)

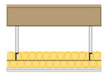


PW-02: Timber frame + glass wool

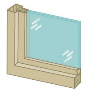
IW-02: Timber stud structure



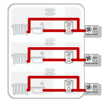
Flats R-05: Timber joist + cellulose at loft



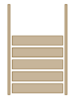
PF-02: CLT slab



W-04: Wooden frame

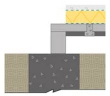


Flats MEP-02: ASHP + other systems

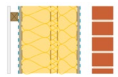


SC-01: Timber structure staircase

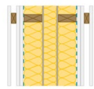
Low-rise apartment block - Set menu 3 – Cost and carbon optimised building elements:



F-01 & G-02: strip foundations* + beam & block floor + screed

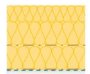


EW-02b: Stick timber frame + cellulose + brick (worst U-value)

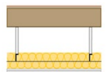


PW-02: Timber frame + glass wool

IW-02: Timber stud structure

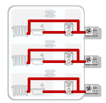


Flats R-05: Timber joist + cellulose at loft



PF-02: CLT slab

W-03: UPVC

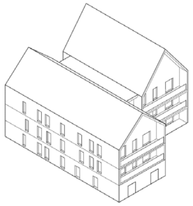


Flats MEP-02: ASHP + other systems

SC-01: Timber structure staircase

* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.

Upfront embodied carbon – Low-rise apartment block



Low-rise apartment block – results

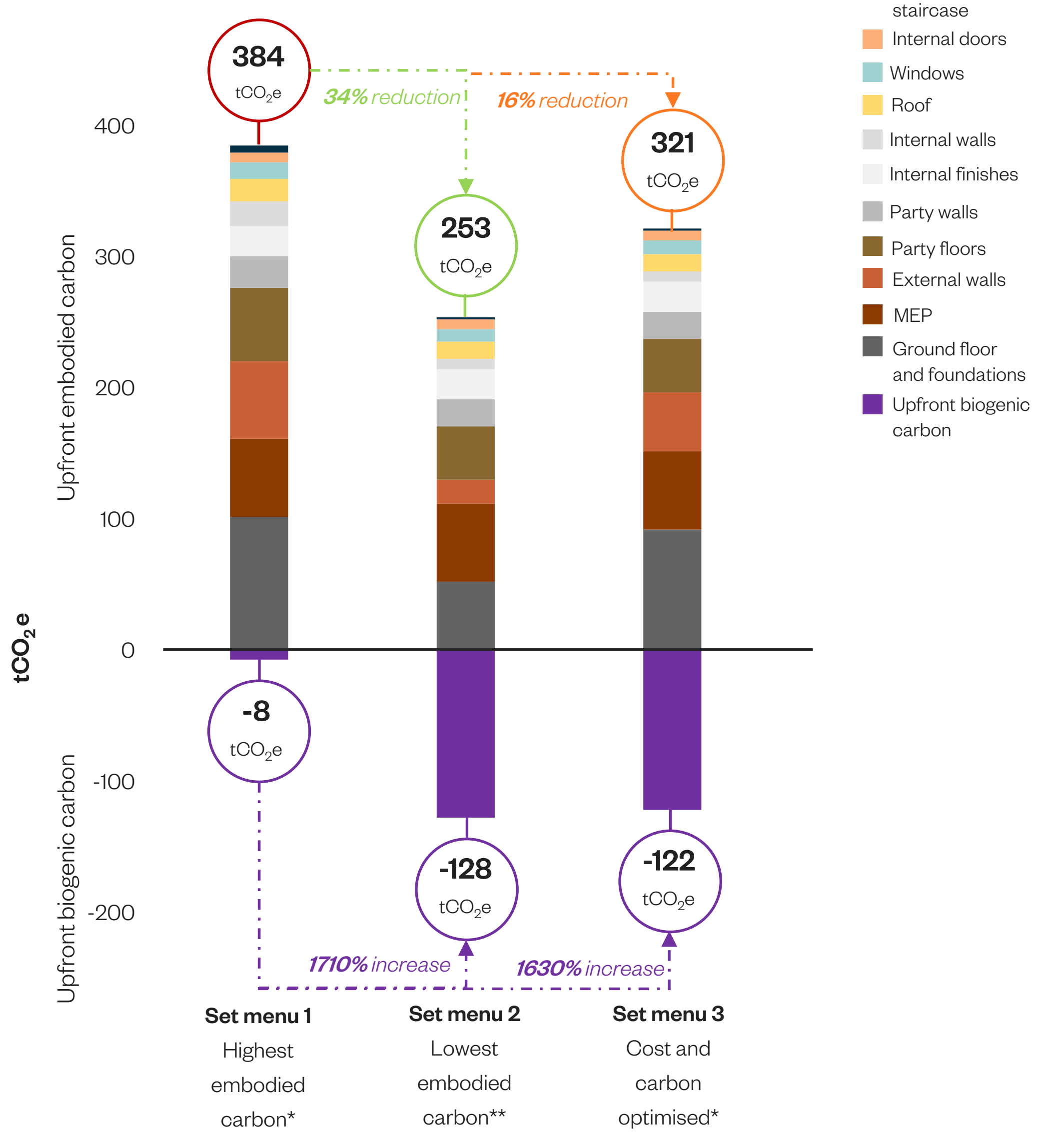
The graph illustrates that the upfront embodied carbon of the apartment block can be 34% smaller through the use of low embodied carbon materials and 16% smaller through cost and carbon optimised materials. For set menu 2, the most significant reduction is through the replacement of ground floor, foundations, external wall, and party floor build-ups with lower upfront embodied carbon options. For set menu 3 the most significant reduction is though the replacement of external wall, party floor and internal wall build-ups. The increase of upfront biogenic carbon is significant from set menu 1 to set menu 2 and 3, due to the replacement of non-sequestered materials with natural material, e.g. timber.

Reporting of top five carbon intensive materials

The tables below report the top five most carbon intensive materials in set menus 1 and 2, to understand which materials should be tackled by applicants for further upfront embodied reduction of the building. Applicants should also be reporting this data as part of policy recommendation 3.

Set menu 1 – Top five most carbon intensive materials (excluding MEP) in tCO_2e:	Set menu 2 – Top five most carbon intensive materials (excluding MEP) in tCO_2e:
1. Concrete (incl. screed & rebar) – 142.0	1. Plasterboard – 49.8
2. Blocks – 29.0	2. Concrete (incl. screed & rebar) – 41.9
3. Bricks – 24.0	3. Plaster board – 30.7
4. Plasterboard – 24.0	4. Carpet- 12.8
5. Metallic structure – 18.9	5. Membranes – 8.2

Upfront carbon emissions A1-A5



* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.

Construction costs – Low-rise apartment block

The two charts to the right present the cost analysis for different 'set menu' options for the low-rise apartment typology. The top chart shows overall build costs including an allowance for 'other costs' ' – i.e. those items not varying between set menu options (external and internal doors and finishes). The bottom chart excludes these other items enabling differences between options to be seen more clearly.

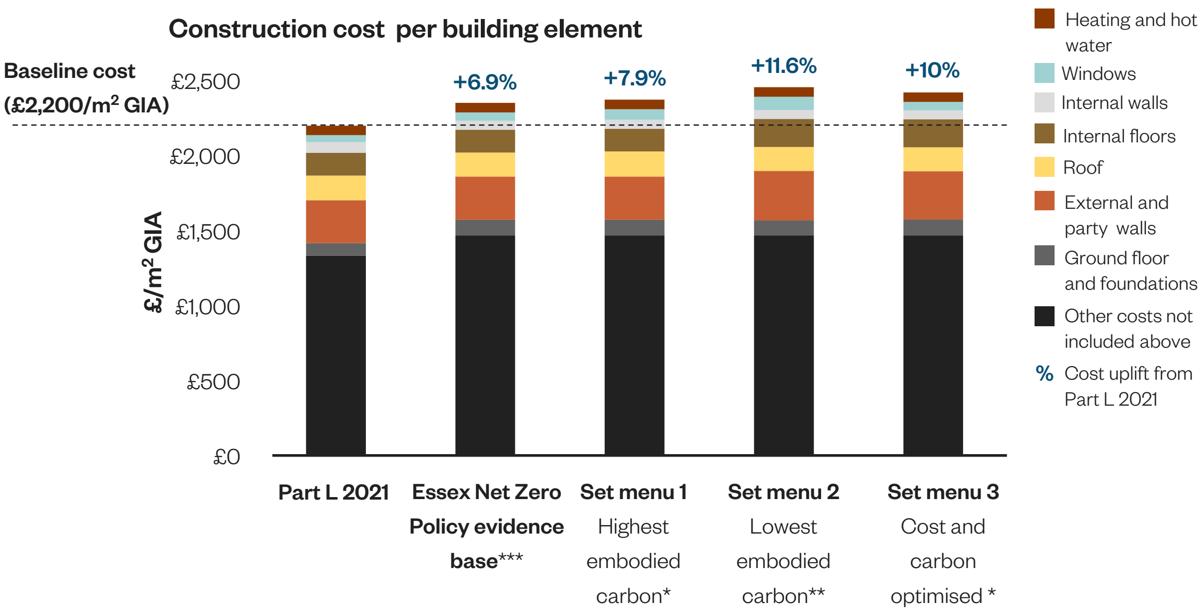
In each chart the costs of five options are shown, a home built to the current Part L2021 regulations (with an estimated build cost of £2,200 per m^2), a home built to Essex's planned net zero operational carbon standard using typical specifications and then three homes built to the net zero operational carbon standard but with different approaches to embodied carbon (set menu's 1-3).

Results

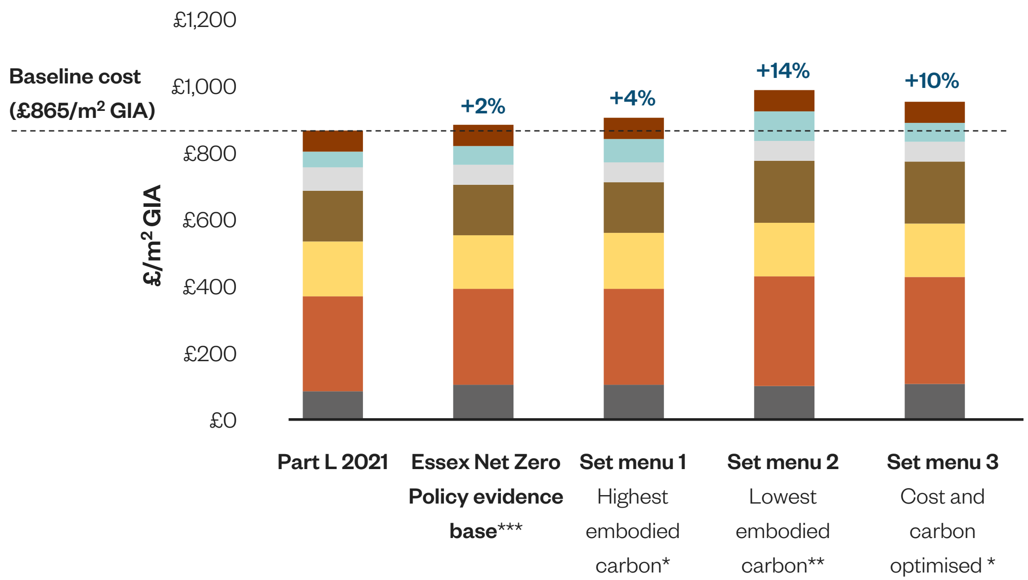
Of the three embodied carbon set menu's the highest carbon scenario is the least expensive. This is due to the savings from the masonry structure in comparison to timber framing. Nonetheless, the highest carbon scenario is still more expensive (and higher in carbon) than the 'typical' specification.

As with the housing typologies, the raft foundation system used in set menu 2 is less expensive than the deep strip foundation systems in the other options, however the difference is smaller than for the houses. As a result, set menu 2 is the most expensive of the scenarios assessed.

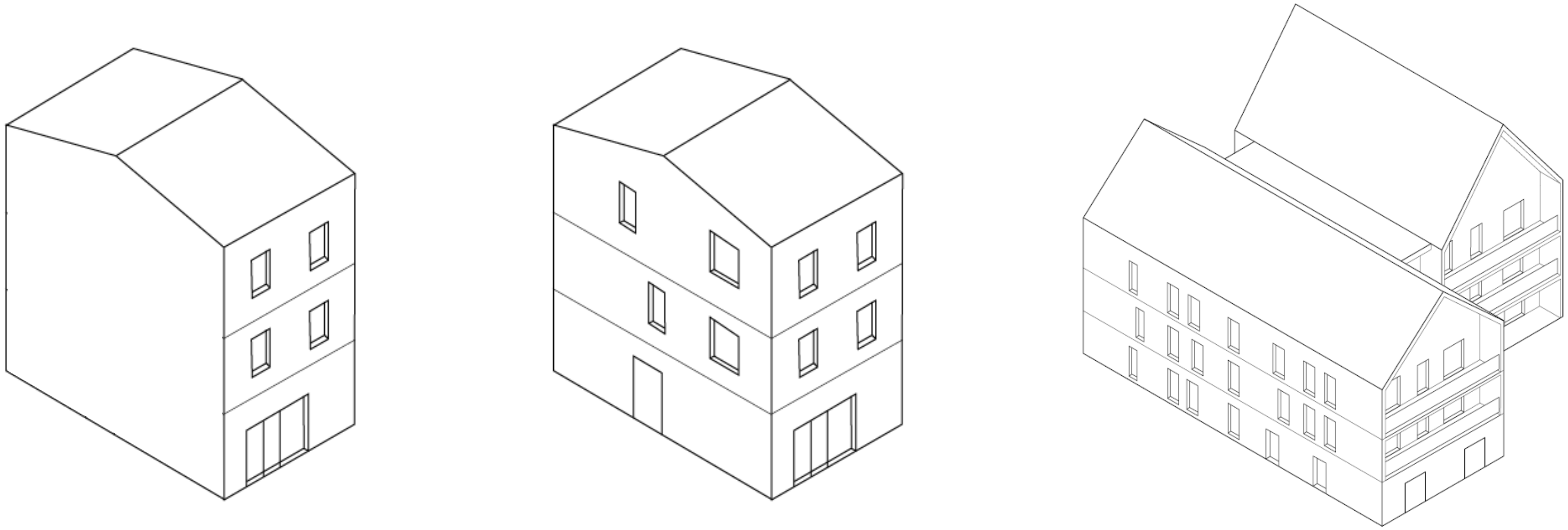
Construction cost per building element



Construction cost per building element - excluding '*other costs*'



* Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed deep strip foundation depth of 1.4 m.
** Assumed concrete C40/50 with 20% GGBS and reinforced steel (97% recycled content). Assumed raft foundation depth of 350mm.
*** These costings are a version of set menu 3, but with traditional masonry external and party walls (higher upfront embodied carbon than set menu 3). This is comparable to the Essex Net Zero Policy Technical Evidence Base costings, but using the build-ups and quantities from the embodied carbon study.



Modelling results per GIA

Upfront embodied carbon and construction cost per typology

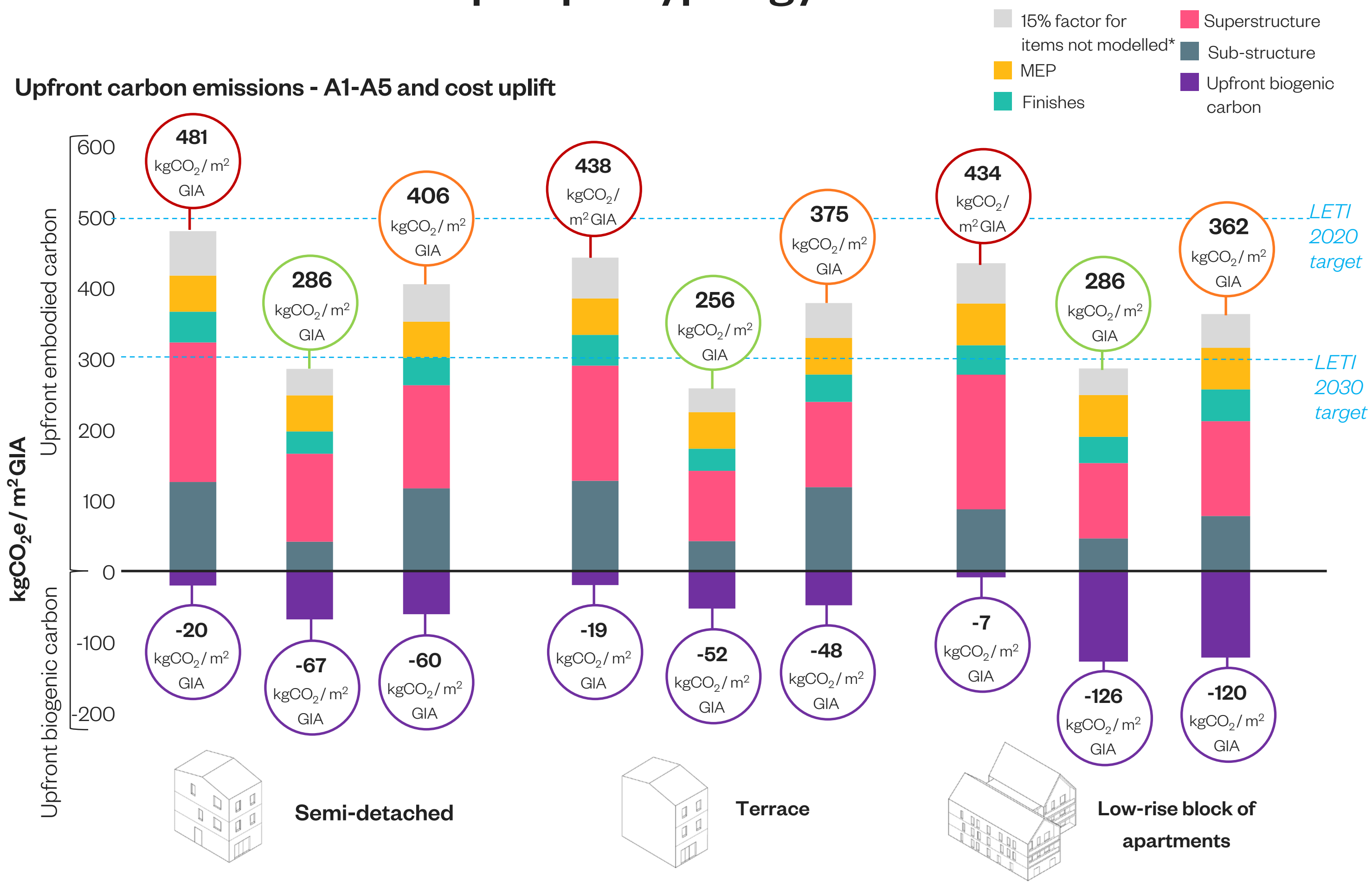
Comparison of upfront embodied carbon and cost uplift per typology

The results opposite show the high, low and cost and carbon optimised upfront embodied carbon for the semi-detached house, terraced house and low-rise apartment block. Biogenic carbon has been reported separately. Cost uplifts from Part L 2021 are also listed below the set menus of each building typology.

Observations

The high carbon (set menu 1) and cost and carbon optimised scenarios (set menu 3) both sit within the LETI 2020 target of 500kgCO_2e/m^2. Whilst the lowest carbon (set menu 2) sits within the LETI 2030 target of 300kgCO_2e/m^2.

Lowest carbon (set menu 2) shows negligible variation in overall cost from the highest scenario (set menu 1) for the housing typologies. This is largely due to the cost savings delivered by the relatively shallow raft foundation in comparison to a deep strip foundation and floor slab. For the houses a construction cost saving could be achieved by specifying cost and carbon optimised building elements (set menu 3). For the low-rise block of apartments, both set menu 2 and set menu 3 are more expensive than the highest carbon scenario (set menu 1).



	Set menu 1 Highest embodied carbon	Set menu 2 Lowest embodied carbon	Set menu 3 Cost and carbon optimised	Set menu 1 Highest embodied carbon	Set menu 2 Lowest embodied carbon	Set menu 3 Cost and carbon optimised	Set menu 1 Highest embodied carbon	Set menu 2 Lowest embodied carbon	Set menu 3 Cost and carbon optimised
Cost uplift from Part L 2021	**+9.4%**	**+9.5%**	**+8.3%**	**+8.4%**	**+7.7%**	**+7.8%**	**+7.9%**	**+11.6%**	**+10%**

* RICS PS v2 2023 provides guidance on adding a percentage uplift for contingency and uncertainty. The default contingency of 15% for design stage calculations has been applied to the results opposite. Applicants should also be adding a 15% contingency to their results.

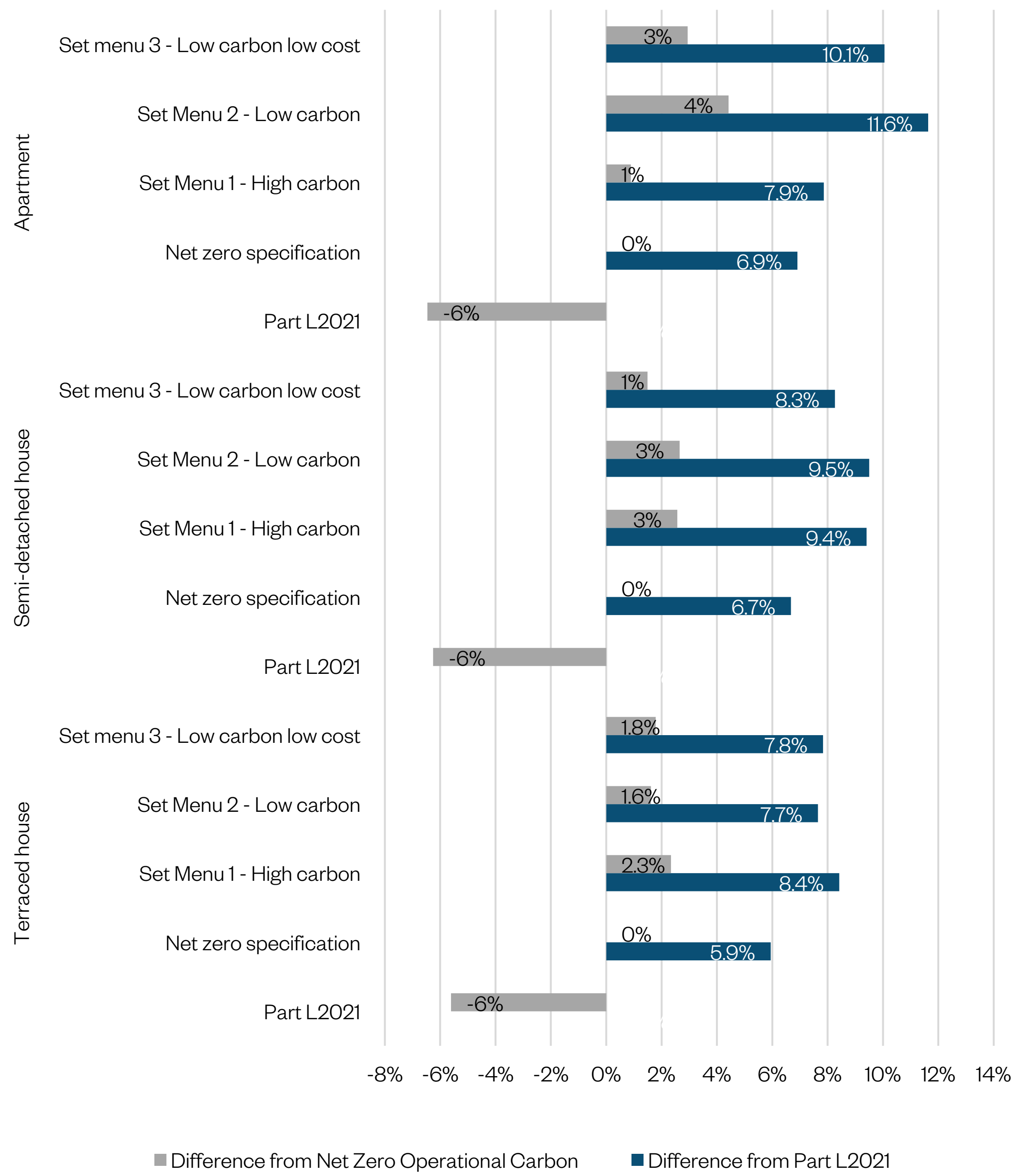
Upfront embodied carbon – cost analysis – summary

The chart on this page shows the percentage impact on overall build costs of each of the modelled scenarios in comparison to either Part L 2021 or 'typical' net zero operational carbon specifications. The total cost for achieving net zero carbon operational and lower embodied carbon policies at the same time is between 8% and 10% depending on house type. The embodied carbon scenarios represent an additional cost uplift of between 2% and 3% on the net zero carbon operational specification.

Costs uplifts are broadly similar across the different building typologies, albeit the lower carbon scenarios (set menus 2 and 3) are more expensive for the low-rise apartments than for the houses. This combined with the relatively lower cost of set menu 1 for the low-rise apartment means that the cost differential between each embodied carbon option is greater for the low-rise apartment than for the other building typologies.

This study is not designed to test the embodied carbon and cost benefits of alternative building designs (e.g. lean structural, architectural and building services design) (see page 29). Westminster evidence-base (see pages 41-42) has proved that a mixture of these design measures can achieve a significant reduction in embodied carbon with no additional cost uplift. These measures include: removing basements, reducing grid spans and optimising façade and MEP systems. To be effective, these should always be considered from an early design stage.

Percentage additional cost compared to current regulations or net zero operational carbon



Modelling conclusions – upfront embodied carbon

Using the modelling results to set limits in planning policy

When setting limits for upfront embodied carbon through policy, there are a few considerations to take into account:

- An upfront embodied carbon limit has the ability to encourage lower embodied carbon buildings, but as a consequence can inadvertently restrict material choice. For example the lowest embodied carbon scenario (Set menu 2) prevents the use of brick facades.
- The substructure can form a significant portion of the upfront embodied carbon of a home/building. Therefore, the depth of foundations, which is reliant on ground conditions, can make the building appear higher or lower embodied carbon. However, applicants may not have much choice over which foundations are most suited to the site.
- While the modelling demonstrates what is reasonably achievable for given typologies, the materials chosen in calculations could inflate or deflate the outcomes for applicants (see pages 91-93). Design and size of dwelling can also alter the perception of results.
- For a net zero operational carbon home, as per the current Essex policy position, the cost difference between high, low and cost and carbon optimised is negligible. Therefore, when developers/builders are selecting their construction type, the choice is likely due to other factors, like speed of build, supply chain or construction skills of workforce.

Proposed limit for policy - 500 $kgCO_2/m^2$ GIA

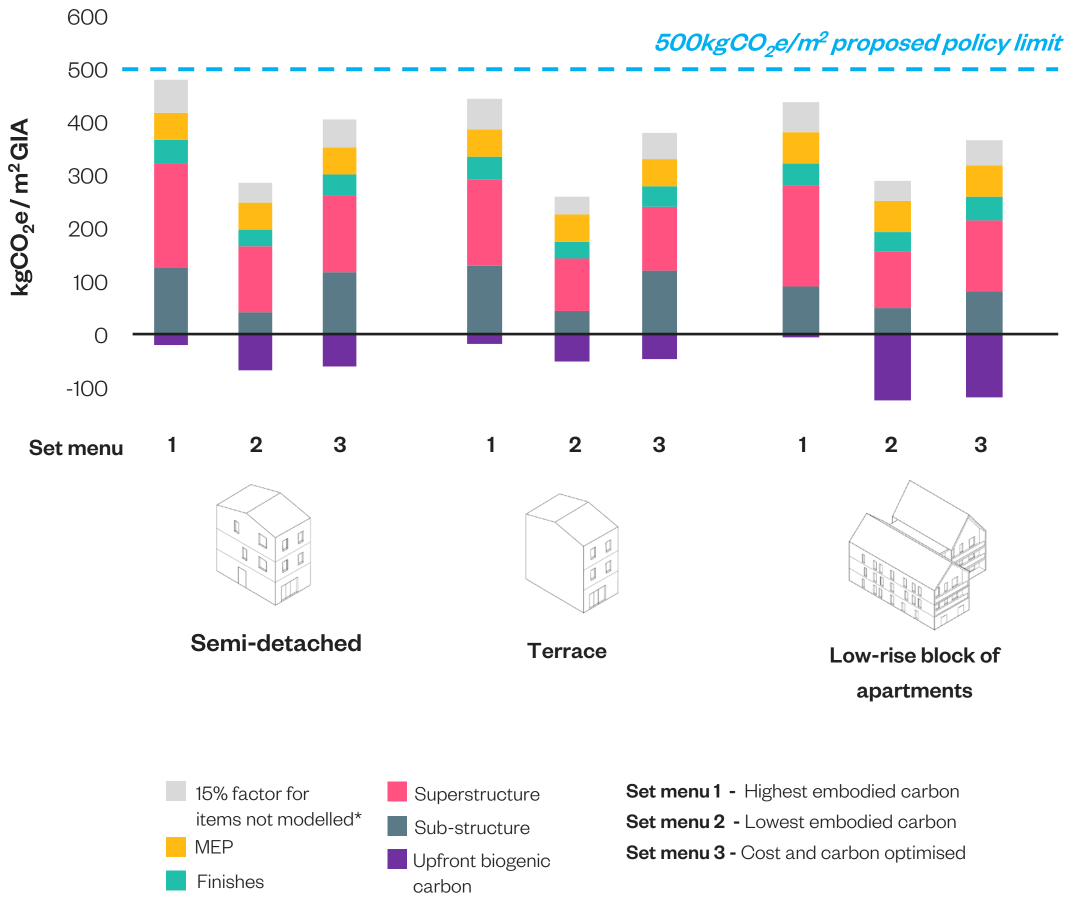
Initially we propose setting the limit for low-rise housing (under 11m for purposes of building regulations Part B – see page 141) at 500 $kgCO_2/m^2$ GIA. This would be a relatively loose limit to begin with to allow applicants and planning officers in Essex to get used to carrying out or reviewing upfront embodied carbon calculations. It has the advantage of ensuring there is some consideration of building form, typology and material selection, without seeking to exclude specific materials or designs.

Future limits for consideration

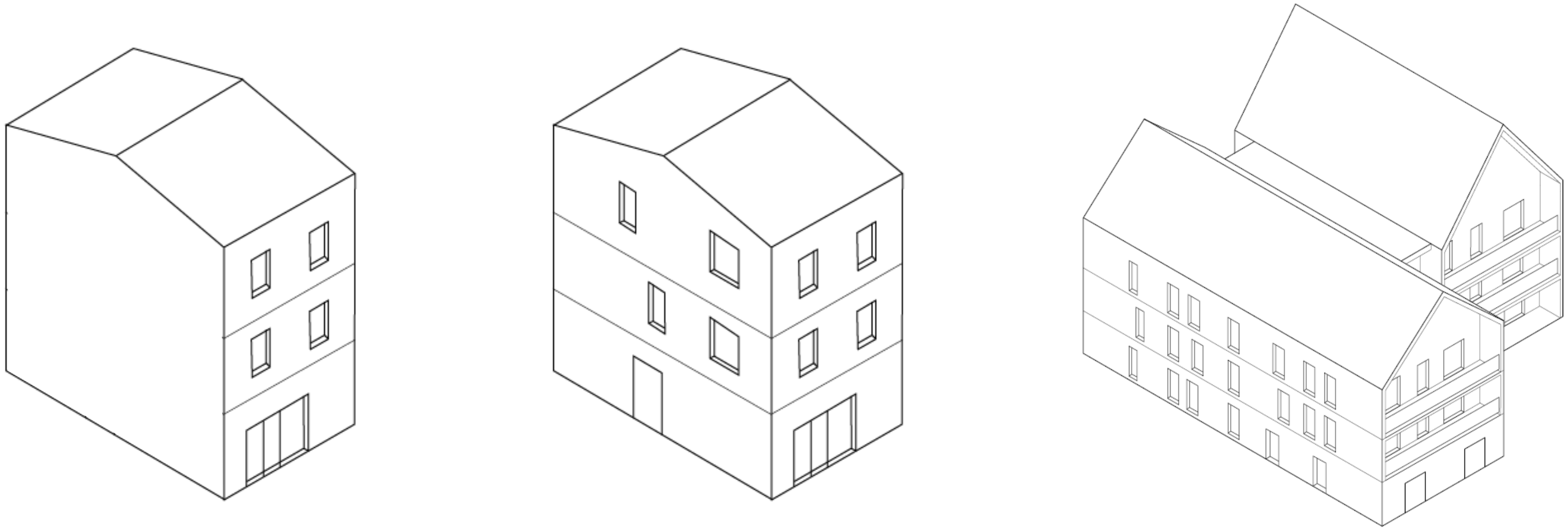
We recommend reviewing the limit every 3-5years to determine if it can be lowered or should be altered.

A limit of around 400 $kgCO_2/m^2$ GIA would allow for a timber structure with brick face, while a limit of 300 $kgCO_2/m^2$ GIA would likely exclude the use of brick.

Upfront carbon emissions (A1-A5) – proposed policy limit



* RICS PS v2 2023 provides guidance on adding a percentage uplift for contingency and uncertainty. The default contingency of 15% for design stage calculations has been applied to the results opposite. Applicants should also be adding a 15% contingency to their results.



Modelling results per GIA

Life cycle embodied carbon per typology

Lifecycle embodied carbon analysis - methodology

Lifecycle stages modelled

Total lifecycle figures per building typology have been calculated, reported and compared against RIBA 2030 Climate Challenge targets. This is due to the importance of understanding the full impact of materials and products on the whole life carbon of a building. The life cycle stages included in the scope of this modelling were: A1-A5 (upfront embodied carbon), B2-B5 (in-use stages) and C1-C4 (end of life stages). Life cycle biogenic carbon was also reported separately and combined. For more detail on the lifecycle calculation methodology for MEP see page 100.

B2 and B3 calculations

Following RICS PS v2 2023 guidance, the calculation of modules B2 and B3 were carried out as following:

B2 – '*for module B2 impacts in the UK, a total figure of 10 kgCO_2e/m^2 gross internal area (GIA) may be used to cover all building element categories, or 1% of modules A1–A5, whichever is greater – as per the London Plan Guidance for Whole Life-Cycle Carbon Assessments (March 2022)*'. The total value was then pro-rated based on service life of each category.

B3 - "*the UK repair impacts should be assumed as equivalent to 25% of B2 maintenance impacts for the relevant items*'.'

B4 & B5 calculations

The replacement emissions for the components were based on the expected lifespan as per Table 20 of RICS PS v2 2023 guidance. These were input in OneClick LCA software, and calculated accordingly by the tool.

C1 calculations

The new RICS PS v2 2023 guidance derives the C1 figure from A5.1, which was not available at this point in time. Therefore, as an alternative method, the C1 calculation was based on RICS PS v1 2017:

C1 - '*An average rate of 3.4 kgCO_2/m^{2}GIA (rate from monitored demolition case studies in central London) based on aggregate data should be used in the absence of more specific information'.* The total value was then pro-rated based on the A1-A5 contribution of each category.

Building part	Building elements/components	Expected lifespan
Substructure	Piling and foundations Lowest ground floor	60 years (or building lifespan)
Superstructure: frame, upper floor and roof structure	Structural elements, e.g. columns, walls, beams, upper floor and roof structure	60 years (or building lifespan)
Facade	Opaque modular cladding:	
	Rain screens, timber panels	30 years
	Brick, stone, block and precast concrete panels	60 years
	Glazed cladded/curtain walling	35 years
	Windows and external doors:	
	Hardwood/steel/aluminium windows	30 years
	Doors	20 years
Roof	Roof covering:	
	Single-ply membrane	30 years
	Standing seam metal	30 years
	Tiles, clay and concrete	60 years
Superstructure	Internal partitioning and dry lining:	
	Studwork	30 years
	Blockwork	60 years
Finishes	Wall finishes:	
	Render/paint	30/5 years respectively
	Floor finishes:	
	Carpet/vinyl	7 years
	Stone tiles	25 years
	Raised access floor (RAF) pedestal/tile	50/30 years respectively
	Ceiling finishes:	
	Substrate/paint	10 years
	Suspended grid (ceiling system)	25 years

Table 20: Indicative component lifespans (Source: RICS WLC assessment 2nd edition 2023)

Comparison of life cycle embodied carbon per typology

The results opposite show the high and low life cycle embodied carbon (stage A,B and C) scenarios for the semi-detached house, terraced house and low-rise apartment block. Total life cycle biogenic carbon is also reported separately. Construction costs remain the same but are less relevant to the life cycle embodied carbon, without the calculation of maintenance and repair and demolition/end of life.

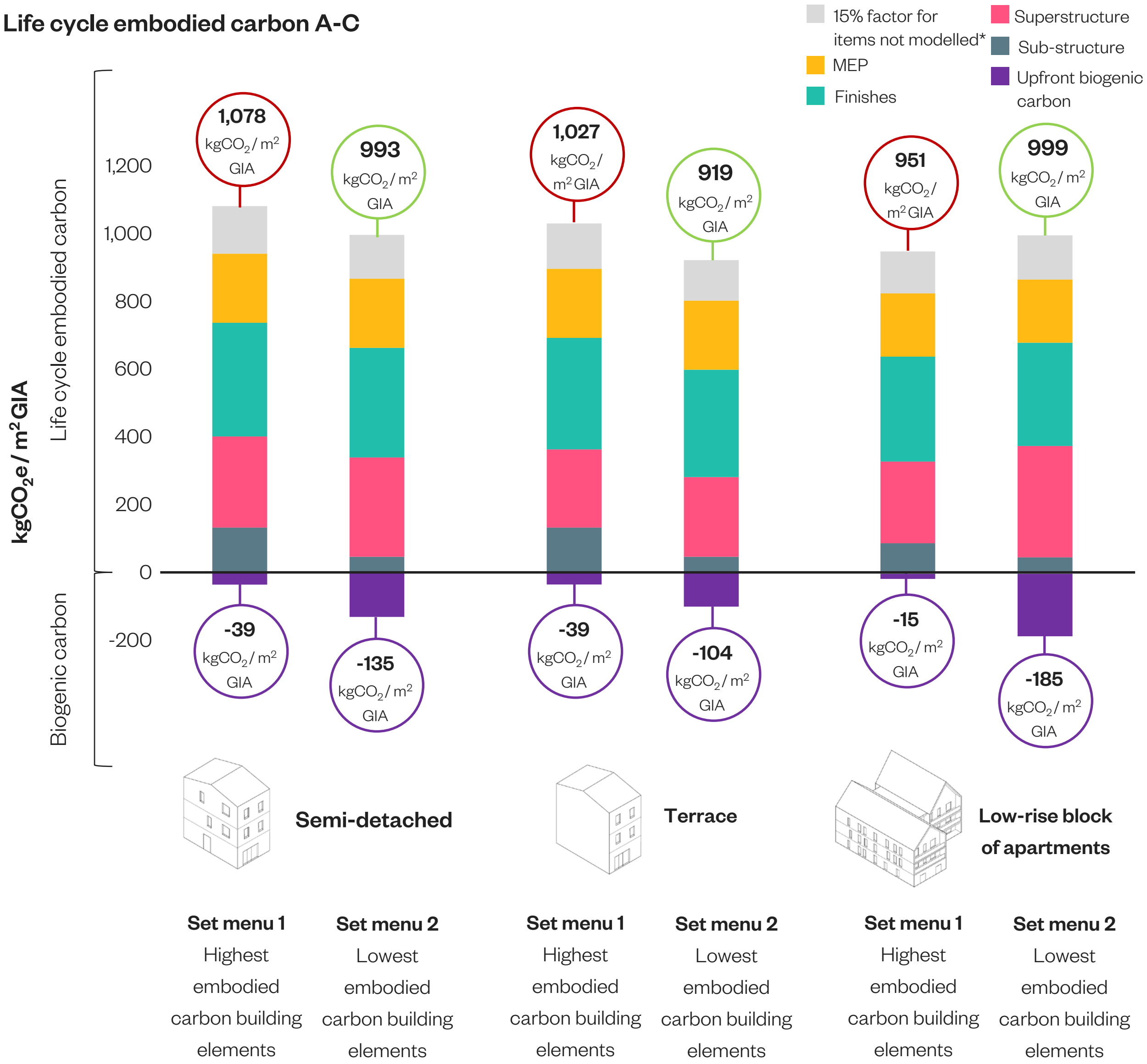
Observations

Across all typologies there is a significant decrease in the life-cycle carbon of sub-structure from the high to low scenario. This is due to the foundation size and ground floor selection in the low scenario compared to the high scenario.

The use of timber within the buildings shows a similar (semi-detached and terrace), or greater life cycle embodied carbon impact (block of apartments) compared to conventional construction methods (reinforced concrete or steel) – when sequestration is excluded. This is due to current carbon modelling software and guidance assuming an end-of-life scenario of either total or partial incineration for timber. As such, the benefit of wood based products, the sequestration, is negated within it's C3 module (the point at which when the material's stored carbon is assumed to re-enter the atmosphere during incineration).

Multiple industry players (mass-timber contractors, designers, circular economy bodies) state the potential for structural mass-timber elements to be re-used in perpetuity, assuming the elements are built, waterproofed, and protected correctly. This therefore introduces the argument that the C3 emissions could be omitted on certain projects if a future donor project is highlighted, or if a circularity body takes ownership. At present, some carbon modelling software offer an alternative 'wood recycling' end-of-life scenario, however, these also often have an adverse effect on the results . The re-use industry will continue to improve as existing timber projects age and become obsolete, at which point more accurate data for modelling end-of-life scenarios will become available.

Life cycle embodied carbon A-C



* RICS PS v2 2023 provides guidance on adding a percentage uplift for contingency and uncertainty. The default contingency of 15% for design stage calculations has been applied to the results opposite. Applicants should also be adding a 15% contingency to their results.

Comparison of life cycle embodied carbon per typology – RIBA targets

RIBA 2030 Climate Challenge – embodied carbon targets

In 2021 RIBA 2030 Climate Challenge (version 2) introduced three performance targets for embodied carbon for new residential buildings. The targets were set after consultations with experts across the industry and are based on a growing database of projects submitted by signatories who have committed to participate the data collection for the initiative.

RIBA 2030 Climate Challenge target metrics for domestic / residential

RIBA Sustainable Outcome Metrics	Business as usual (new build, compliance approach)	2025 Targets	2030 Targets
Embodied Carbon $kgCO_2e/m^2$	1200 $kgCO_2e/m^2$	< 800 $kgCO_2e/m^2$	< 625 $kgCO_2e/m^2$

The RIBA targets above include:

- RICS modules A1-A5, B1-B5, C1-C4 and include biogenic carbon
- RICS categories substructure, superstructure, finishes, fixed FF&E, building services and associated refrigerant leakage.

How results compare to RIBA targets

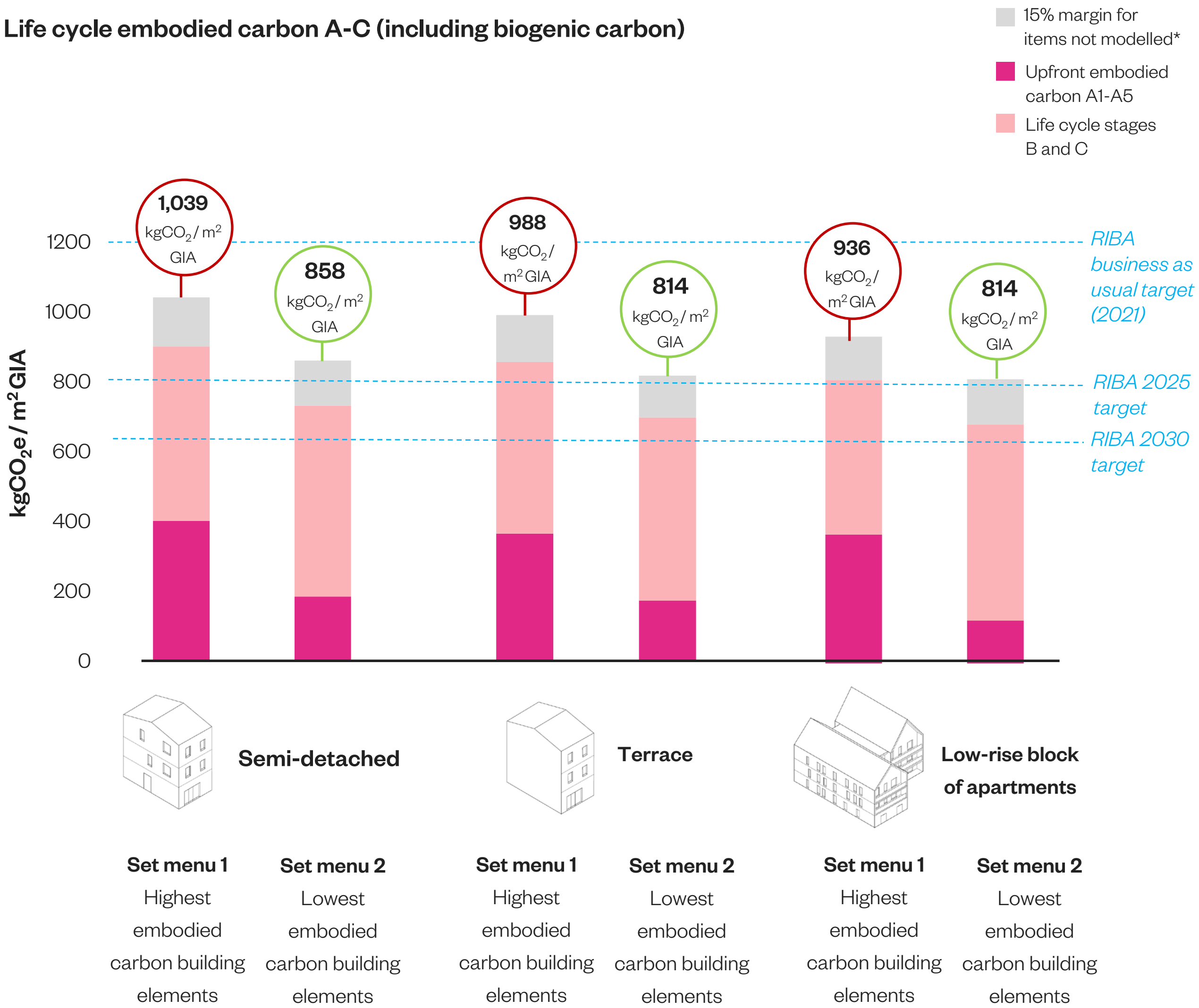
The graph to the right presents the high and low life cycle embodied carbon scenarios for all three building typologies, with the biogenic carbon included, capturing the importance of natural materials. The final results have been compared against RIBA 2030 embodied carbon targets.

The high and low scenarios all sit within the RIBA 2021 business as usual target of 1,200 $kgCO_2e/m^2$. Currently, none of the scenarios meet the RIBA 2025 target of 800 $kgCO_2e/m^2$ nor RIBA 2030 target of 625 $kgCO_2e/m^2$. In addition, upfront embodied carbon provides the greatest reduction in life cycle carbon, in comparison to the life cycle stages, which remain similar across the high and low scenarios (set menus 1 and 2). A few considerations have been suggested that aim to decrease the embodied carbon of these typologies even lower:

- As existing timber projects age and become obsolete, industry to research and improve the accuracy of end-of –life carbon data
- Increase the use of recycled and/or re-usable materials to decrease upfront embodied carbon even further

These results can be used to inform future Whole life carbon policy in Essex.

Life cycle embodied carbon A-C (including biogenic carbon)



* RICS PS v2 2023 provides guidance on adding a percentage uplift for contingency and uncertainty. The default contingency of 15% for design stage calculations has been applied to the results opposite. Applicants should also be adding a 15% contingency to their results.

Modelling conclusions – life cycle embodied carbon

Using the modelling results to set limits in planning policy

Our recommendation is to bring in whole life carbon (WLC) assessments in to policy in the future or only for particularly large schemes initially, e.g. 1,000 or more homes and over 5,000sqm of non-domestic. This is because:

- Similar policy outcomes (improved building design and selection of materials) to reduce embodied carbon can be achieved from assessing upfront embodied carbon and life cycle embodied carbon.
- The scope for lifecycle and WLC modelling is greater than for upfront embodied carbon, so to reduce burden on applicants and planning officers, a future transition for applicants from upfront to WLC may be helpful.
- The data available to applicants for assessing life cycle stages B (in-use) and C (end of life) is patchy and will likely gain accuracy in years to come.
- WLC assessments include operational emissions. Essex has net zero operational metrics included in a separate planning policy. Therefore, this element of WLC assessments is less critical in the short/medium term. However, long term it would be useful for local authorities to be able to compare a scheme's WLC emissions nationally using the same methodology. NZCBS will likely keep operational and embodied reporting and limits separate (i.e. not combine into a single WLC figure)

Future limits for consideration

We have not gone as far as suggesting limits should be set on WLC or life cycle carbon emissions at this point, just that it could be reported in future.

We recommend reviewing this every 3-5years to determine the next steps for life cycle and WLC assessments.

9

Appendix

9.1
Glossary of terms, abbreviations and links

Glossary of terms

Biogenic/ sequestered carbon – '*Carbon removals associated with carbon sequestration into biomass, as well as any emissions associated with this sequestered carbon. Biogenic carbon must be reported separately if reporting only upfront carbon, but should be included in the total if reporting embodied carbon or whole life carbon.'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Carbon sequestration – '*The process by which CO2 is removed from the atmosphere and stored within a material, for example by being stored in biomass as biogenic carbon by plants.'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Chartered institute of Building Services Engineers (CIBSE) TM65 methodology - '*A calculation methodology (TM65) outlines the need for assessment of embodied carbon of products linked to building services engineering systems, to increase knowledge and facilitate research related to whole life carbon.'* Source: CIBSE

Circularity – '*A process that considers the potential for recovery, reuse and recycling of items following circular economy principles.'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Circular economy – '*An economy that is restorative and regenerative by design, and that aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles.'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Deep retrofit – '*Development involving the re-use of as much of the existing building as possible, but may involve substantial demolition and replacement of parts of (but not all of) the façade, core, floor and slab, and which results in significant energy, performance, and climate adaptation upgrades, comparable to those a new building, dramatically reducing carbon emissions from the building and prolonging its usable lifespan*.' Source: *Westminster City Plan Retrofit first Topic Paper, City Plan 2024*.

Demolish and recycle - '*Traditional demolition, with elements and materials processed into new elements, materials and objects for use on the site or on another site.'* Source: *CE Statement 2022.*

Disassemble and reuse - '*Disassemble sections of a building and enable their direct reuse ideally on the site or, where this is not possible, off site (with nearby sites preferred). This approach also includes careful selective deconstruction of the building and material types i.e. taking apart each layer and material type as much as possible, minimising damage to parts and maintaining their value, and then reusing those elements and materials. If reuse is not possible, materials may be carefully and selectively separated for processing and recycling into new elements, materials and objects*.' Source: *CE Statement 2022*.

Embodied carbon – '*The embodied carbon emissions of an asset are the total GHG emissions and removals associated with materials and construction processes, throughout the whole life cycle of an asset (modules A0–A5, B1–B5, C1–C4, with A0[2] assumed to be zero for buildings.'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Environmental Product Declaration (EPD) – '*A document that clearly shows the environmental performance or impact of any product or material over its lifetime'..* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Inventory of carbon & energy (ICE) database – '*The Inventory of Carbon and Energy (also know as the ICE database) is an embodied carbon database for building materials which is available for free on this page. It contains data for over 200 materials, broken down into over 30 main material categories.'* Source: ICE

Life Cycle embodied carbon – *See 'embodied carbon'*

Major development – '*Development greater than or equal to: – 10 residential units; or – 0.5 hectares site area (residential) or 1 hectare (non-residential); or – gross floorspace of 1,000 sqm (GIA)*.' Source: *Westminster City Plan Draft 2024*.

Major renovation – '*Defined in regulation 35 as the renovation of a building where more than 25% of the surface area of the building envelope undergoes renovation*.' Source: *Approved Document Part L 2021.*

One Click LCA - ' *One Click LCA is an all-in-one software to automate Life Cycle Assessment (LCA) and Environmental Product Declaration (EPD) generation. Schedule a time to get help for your LCA, EPD, and sustainability needs*.' Source: One Click LCA

Operational carbon – '*Operational carbon – energy (module B6) refers to GHG emissions arising from all energy consumed by an asset in use, over its life cycle.'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Oriented Strand Board (OSB) – '*Oriented strand board is a composite engineered wood panel made of long strands (also called wafers or flakes) of wood, bonded together with synthetic resin adhesive.* 'Source: Timber Development UK

Partial retention and refurbishment – '*Significant quantities of carbon-heavy aspects of the building are retained in place, such as the floors and substructure, with replacement of some elements of the building, such as walls or roofing. More significant refurbishment can involve adding floors or extensions*.' Source: *CE Statement 2022*.

Photovoltaics (PV) – solar panels converting sunlight into electricity.

Glossary of terms

Responsible retrofit – '*Responsible retrofitting is an informed and integrated attitude to retrofit in a way that enables people to reduce the operational carbon of a building, improve energy efficiency, and/or improve a building's resilience to the impacts of climate change. Responsible retrofit will take into account the building's location, context, design, construction, materials and use, to ensure retrofit measures perform well and avoid adverse impacts to health, heritage and the natural environment.'* Source: *Westminster City Plan Retrofit first Topic Paper, City Plan 2024.*

Retain and retrofit - *'The vast majority of the building's fabric is retained, with the building refurbished for the same or new uses through restoring, refinishing and future-proofing. This also encompasses retrofitting, where new technology or features are added to existing buildings to make them more efficient and to reduce their environmental impacts.'* Source: *Circular Economy (CE) Statement 2022.*

Retrofit – '*Development involving the re-use of at least 50% of the existing building in-situ (by mass or volume), retaining as a minimum the foundations, core, and floor slabs, and which results in energy, performance, and climate adaptation upgrades, which will reduce carbon emissions from the building and prolong its usable lifespan.'* Source: *Westminster City Plan Retrofit first Topic Paper, City Plan 2024.*

RICS - the Royal Institution of Chartered Surveyors

RICS Professional Standard (RICS PS v2 2023)– '*Sets requirements or expectations for RICS members and regulated firms about how they provide services or the outcomes of their actions. RICS professional standards are principles-based and focused on outcomes and good practice. Any requirements included set a baseline expectation for competent delivery or ethical behaviour. They include practices and behaviours intended to protect clients and other stakeholders, as well as ensuring their reasonable expectations of ethics, integrity, technical competence and diligence are met. Members must comply with an RICS professional standard.'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Substantial demolition – '*Development consisting of the demolition of 50% or more of existing above ground structures, by area or volume, but not constituting total demolition.'* Source: *Westminster City Plan Retrofit first Topic Paper, City Plan 2024.*

Total demolition – '*The removal, deconstruction or demolition of an existing building, which will entail the removal of all of its fit out, superstructure, cores, and basement slab(s), but which could involve the retention of parts or all of the façade.'* Source: *Westminster City Plan Retrofit first Topic Paper, City Plan 2024.*

Upfront embodied carbon – '*Upfront carbon emissions are GHG emissions associated with materials and construction processes up to practical completion (modules A0–A5). Upfront carbon excludes the biogenic carbon sequestered in the installed products at practical completion.'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Whole life carbon (WLC) - '*Whole life carbon emissions are the sum total of all asset-related GHG emissions and removals, both operational and embodied, over the life cycle of an asset, including its disposal (modules A0–A5, B1–B7, B8 optional, C1–C4, all including biogenic carbon, with A0[2] assumed to be zero for buildings). Overall whole life carbon asset performance includes separately reporting the potential benefits or loads from future energy or material recovery, reuse, and recycling and from exported utilities (modules D1, D2).'* Source: *RICS Whole life carbon assessment for the built environment, 2nd edition*

Abbreviations

B&NS: Bath and North East Somerset

BAMB: Buildings as Materials Banks

CCC: Climate Change Act

CE: Circular Economy

CES: Circular Economy Statement

CIBSE: Chartered Institution of Building Services Engineers

CLT: Cross Laminated Timber

CO_2e: Carbon dioxide equivalent

CWCT: Centre of Window and Cladding Technology

EAC: Environmental Audit Committee

EPD: Environmental Product Declaration

EUI: Energy Use Intensity

FF&E: Fittings, furnishing and equipment

GGBS: Ground Granulated Blast-furnace Slag

GHG: Greenhouse gas

GLA: Greater London Authority

IPCC: Intergovernmental Panel on Climate Change

IStructE: Institution of Structural Engineers

KPI: Key Performance Indicator

LETI: Low Energy Transformation Initiative

LLDC: London Legacy Development Corporation

MEP: Mechanical, electrical and plumbing

NPPF: National Planning Policy Framework

NZCBS: UK Net Zero Carbon Buildings Standard

PAN: Planning Advice Note

RIBA: Royal Institute of British Architects

RICS: Royal Institute of Chartered Surveyors

RICS PS: RICS Professional Statement

SDS: Spatial Development Strategy

SPD: Supplementary planning document

UKGBC: The UK Green Building Council

WBLCA: Whole Building Life-Cycle Assessment

WLC: Whole life carbon

WOE: West of England

Useful links

- B&NES - Sustainable Construction checklist SPD
- BAMB –Building as material passports
- BECD – Built Environment Carbon Database
- Brentwood Local Plan
- Bristol City Council draft Local Plan
- Building to net zero: costing carbon in construction: Government Response to the Committee's First Report – Environmental Audit Committee
- Central Lincolnshire updated local plan
- Chelmsford Local Plan
- CIRCuIT
- City of London - Carbon Options Guidance
- City of London City Plan 2024
- City of Westminster - City Plan 2019-2040
- Climate action tracker 2023
- Climate Change Committee - the sixth carbon budget
- CWCT– How to calculate embodied carbon of facades
- Epping Sustainability Checklist
- Essex Climate Action Charter 2022
- Essex Climate Action Plan 2021-2025
- Essex Climate and Planning advice and guidance
- Essex Net Zero Evidence | Essex Design Guide
- Essex net zero policy | Essex Design Guide
- Essex Planning Policy Position for Net Zero Carbon
- European Union's Roadmap for Whole Life Carbon
- GLA - Whole Life-cycle carbon assessment guidance
- Greencore Homes – low carbon offsite construction
- Harlow and Gilston Garden Town Sustainability Checklist
- IStructE – How to calculate embodied carbon 2nd edition
- IStructE Lean design: 10 things to do now
- LETI - Circular economy 1 pager
- LETI Climate emergency design guide
- LETI opinion piece - Circular economy and carbon in construction
- LETI opinion piece – operational carbon in whole life carbon assessments
- LETI The Whole Life Carbon Alignment paper
- Net Zero: Making Essex Carbon Neutral report 2023
- Net Zero: The UK's Contribution to Stopping Global warming
- Part B building Regulations Volume 1: Domestic
- Part Z proposed amendment to building regulations
- Policy paper by Part Z group of experts , January 2024
- RIBA 2030 climate challenge
- RICS Whole Life Cycle assessment 2017, 1st edition
- RICS Whole Life Cycle Assessment 2023, 2nd edition
- Southwest Net Zero Hub – Net Zero New Buildings Evidence and guidance
- The concrete centre– Sustainable concrete
- The construction material pyramid
- TM 65 – Embodied carbon in building services
- UK Net Zero Carbon Building Standard
- UKGBC - Circular economy guidance for construction clients
- UKGBC - Circular economy metrics for buildings
- UKGBC – Net zero whole life carbon technical study
- West of England Embodied Carbon Evidence Base 2021

9.2
Additional information on policies outside the UK

Policies/regulations and work outside UK - United States and Canada

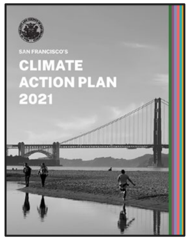
States in the US and Canada with policies or regulation

The United States and Canada do not have a comprehensive federal policy specifically targeting embodied carbon in construction. However, there has been a growing awareness and interest driven by local governments, industry organizations, and individual companies. Example have been provided here.

Oakland 2030 Equitable Climate Action Plan

Oakland 2030 Equitable Climate Action Plan

The Oakland 2030 Equitable Climate Action Plan (2020) includes four actions to address embodied carbon and waste in construction. The intended results are to gradually adopt more robust requirements for materials with lower embodied carbon, reduce waste by stimulating the local repair economy, and improve building codes for improved recycling and reuse of building materials during deconstruction.

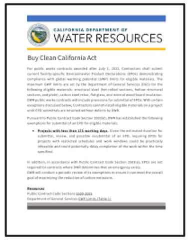


San Francisco Climate Action Plan

San Francisco Climate Action Plan

The San Francisco Climate Action Plan (2021) addresses embodied carbon by aiming for total carbon balance across the buildings and infrastructure sectors by 2030. The plan proposes a timeline by which they increase the requirements until the proposed deadline. Actions include:

- Establishing a maximum allowance for embodied carbon of buildings by 2025.
- Require deconstruction of buildings and increase of source separation by 2025.
- Expand and cultivate regional building material reuse markets by 2025.
- Phase in policies to reduce embodied carbon more than 10% per project in at least three product categories by 2026.



Buy Clean California

Buy Clean California

Buy Clean California (2017) sets the maximum allowable Global Warming Potential (GWP) for key materials if purchased for the California state buildings. The materials include structural steel, concrete reinforcing steel, flat glass, and mineral wool board insulation.

Seattle Priority Green Expedited

Seattle Priority Green Expedited

Priority Green Expedited (2021) shortens the time it takes to obtain a building permit for new contraction in exchange for meeting green building requirements. This program relies on third-party green building certifications.

Vancouver Building By-Law Amendment

Vancouver Building By-Law Amendment

The Vancouver Building By-Law was updated in 2022 to increase the sustainability requirements of buildings. The changes regarding embodied carbon, effective since 2023, include the following:

- Completing a Whole Building Life-Cycle Assessment (WBLCA) at the time of building permit to compare the embodied carbon against a standardized baseline.
- Demonstrate via the WBLCA that the proposed building is not more than double that baseline. Starting in 2025, embodied carbon must be reduced by 10-20% compared to the baseline.
- Starting in 2025, buildings must also comply with one of three options for responsible materials, including sustainable sourcing standards, disclosure of material ingredients, or construction waste diversion and design for disassembly.

9.3 Additional information on circular economy

Quantifying circular economy principles

Quantifying circular economy benefits is an emerging field so there is not yet an industry standard. There are a few examples that can be drawn upon.

GLA - London Plan

Policy SI 7 of the London Plan covers Waste reduction and the circular economy. It currently requests a statement and completed schedule of data for projects of large scale, referable to the Mayor. Information is required at pre-application, outline and detailed application and post construction stages.

For waste, a mandatory pre-demolition audit for existing buildings is required, plus the following, including % re-used on-site and off-site, recycled on-site and off-site or disposed of elsewhere:

- Min. 95% demolition waste diverted from landfill
- Min. 95% excavation waste diverted from landfill
- Min. 95% construction waste
- Min. 65% municipal waste recycled by 2030
- Min. 20% of building elements recycled content.

For new materials, a description for each building element against the circular economy principle is required. In addition, material types and weights are scheduled against the same building elements as an embodied carbon analysis alongside key indicators at specific life cycle stages:

- Material use intensity (kg/m^2)
- Construction waste (kg)
- Recycled content by mass (kg) and %
- Expected lifespan and number of replacements over 60 years
- Expected wastage generated from replacements or refurbishments
- Narrative regarding the assumed end of life scenarios for each element and expected % of re-use, recycling and landfill.

Metrics examined in the deep dive

1. **Dematerialisation (Upfront)**
   Kg/m2 GIA
2. **Dematerialisation (Life Cycle)**
   Kg/m2 GIA
3. **Design for Disassembly & Reuse**
   % (tonnes)
4. **Material**
   Re-used % tonnes, Remanufactured % (tonnes) and Recycled % (tonnes)
5. **Material Database and Passport**
   % (tonnes)
6. **Design for Adaptability**
   % (area)
7. **Embodied Carbon**
   kgCO2e/m2 GIA

UKGBC circular economy metrics for buildings *- The London Plan requirements emphasise the understanding of waste reductions, while the current UKGBC circular economy metrics emphasise the above. (Source: UKGBC).*

Metrics

There are multiple relevant metrics for circularity. LETI proposes the following:

A. Indicators of material use circularity:

- % of materials and elements reused (aim for 100%)
- % of materials and elements designed to be reusable at end-of-life (aim for 100%)

B. Indicators of embodied carbon:

- Changes in carbon values in Product, Construction and Use stages of the BS EN 15978 standard, due to incorporation of CE features
- Carbon value of BS EN 15978 Module D, which represents the benefits of passing material into the next use cycle.

LETI circular economy 1 pager *- LETI proposes the above metrics. (Source: LETI).*

Quantifying circular economy principles

A further well-respected industry research project called CIRCuIT (Circular Construction in Regenerative Cities) suggested further metrics. This was a collaborative project that ran from 2019-2023 and involved 31 ambitious partners across the built environment chain in Copenhagen, Hamburg, the Helsinki region and Greater London. It was funded by the European Commission's Horizon 2020 programme and supported the creation of regenerative cities by implementing sustainable and circular construction practices. At the building scale, the project recommended the indicators opposite.

Building level indicators				
Category	**Indicator name**	**Indicator description**	**Suggested unit**	**Stakeholder relevance / benefit**
Building design	Design for disassembly	Proportion of building components that are reversible from the wider building without significant damage to either the removed component or its wider assembly. This indicator should be linked to BIM and guidelines to ensure stakeholder down the supply chain can optimise the building end of life. This indicator is measured using ISO20887. % of the building that can be disassembled at end of life	% of the building that can be disassembled	Designers can demonstrate to urban planners that the building can be disassembled at the end of its life. This will support building level assessments, such as DGNB. This information will also inform LCA and LCC studies
	Design for adaptability (transformation capacity)	The spatial and technical aspects of building design allow for adaptation to another function (as designed). This indicator is measured using ISO20887. % of the building that can be adapted at end of life	% of the building that can be adapted at end of life	Designers can demonstrate to urban planners that the building can be disassembled at the end of its life. This will support building level assessments, such as DGNB. This information will also inform LCA and LCC studies
Material inputs to building	Reused content	Proportion of the building that is formed of reused products and product components % reused content	% reused content	These will enable contractors to demonstrate compliance with local requirements, such as the GLA circular economy statement. This indicator will also inform policy makers to set future targets. This information will also inform LCA studies
	Recycled content	Proportion of the building that is formed of recycled/upcycled products and product components (exclude downcycling). % recycled content	% recycled content	
Circular potential (as built)	Reuse potential	The percentage (by mass) of products which can be reused at the end of the life of the building	% by mass of products that can be reused	These will enable contractors to demonstrate compliance with local requirements, such as the GLA circular economy statement.
	Recycling potential	The percentage (by mass) of products which can be recycled at the end of the life of the building	% by mass of products that can be recycled	
Material outflows and recirculation	Total material arisings (whole life)	The amount of waste materials from the building across its lifetime, including during future refurbishment, repair phases.	Tonnes of waste arising	Policy makers will be able to understand quantities of wastes generated. This information will also inform LCA and LCC studies
	% reused, remanufactured, recycled	The percentage of materials which were reused, remanufactured or recycled at the end of the life of the building	% reused, remanufactured, recycled	Policy makers will be able to validate their targets for recycling and reuse against those numbers. This information will also inform LCA studies

***CIRCuIT**- Shortlist of core indicators at building and materials/products/components level , from D3.3 Recommendations on circularity indicators WP8 (Source: CIRCuIT).*

The importance of natural materials

The importance of natural materials

The significance of using natural materials becomes particularly evident when considering their upfront (modules A1-A5), end of life (modules C1-C4) and beyond life cycle carbon emissions (module D). Wide environmental and health benefits of natural materials include the creation of healthy buildings in terms of indoor air quality and enhancing the breathability of the building.

Some natural building materials come from an abundant source (rammed earth) and others from a renewable source due to their ability to be re-grown (timber, straw, hemp, bamboo, cork, mycelium). Whereas, synthetic materials like petroleum-based insulation (PIR, phenolic and EPS) come from a non-renewable fossil fuels, which significantly contribute to climate change.

Confusion and conflict can arise where synthetic materials appear lower embodied carbon than natural materials. This can be due to their end of life scenario, such as the incineration of timber. However, we ultimately need to consider the impact of the base materials used (such as fossil fuel oils) in contributing to climate change. Therefore, the selection of materials should first prioritise the use of natural materials while considering embodied carbon emissions.

The importance of locally sourced materials

Using locally sourced materials, obtained from a defined radius around project sites, promotes sustainability principles by reducing transportation and energy carbon emissions and costs, while supporting local economies. However, it presents challenges such as variability in material quality and limited availability, which can complicate construction planning and increase construction costs.

Encouraging (but not mandating) use of natural building materials in Essex will lead to increased market demand and provide opportunities for new businesses and supply chains to develop in response. Additional scale and local supply chains will help to reduce cost as well as transport related emissions while also supporting economic growth within the county and region.

Broader environmental and health benefits of using natural materials

- **Reduced upfront embodied carbon:** natural materials typically require less energy for extraction, processing, and transportation compared to synthetic materials.
- **End-of-life embodied carbon:** unlike synthetic which end up in landfills, natural materials are often biodegradable or can be easily repurposed, minimizing landfill waste and reducing end-of-life emissions.
- **Enhanced circular economy integration:** natural materials, such as reclaimed wood, can be more effectively upcycled or reused, supporting the principles of the circular economy and reducing overall material waste. In contrast, synthetic materials like PVC often faces challenges in recycling due to contamination and degradation.
- **Improved indoor air quality:** natural materials like wool insulation emit fewer volatile organic compounds (VOCs) compared to synthetic alternatives like spray foam insulation, contributing to healthier indoor environments.
- **Improved building breathability:** natural materials allow for moisture to travel through the building elements, rather than being trapped within the construction, increasing the risk of condensation, mould growth and structural damage.

9.4
Additional information on RICS WLC reporting

Reporting embodied carbon – project types

Different project types can be measured, but until now they were often reported as a combined site figure, which lacked transparency. RICS PS v2 2023 requires buildings to be measured separately from each other, and to their external works, public realm, highways or utilities works. This is for transparency and improved understanding to set consistent industry benchmarks.

Individual buildings or assets

For new-buildings all elements within the project site boundary (red line or equivalent) are included for the purposes of a whole life carbon assessment (WLCA). The impacts of facilitating and external works are included and reported separately. The upfront carbon of external works outside the site boundary can also reported separately. If there is an existing building on the site prior to construction, the emissions arising from demolition should be included.

Retrofit projects

There are often multiple scopes of work related to retrofitting a building, including various ranges of new-build, in addition to retaining existing elements. However, for the purposes of reporting embodied carbon, all retrofit/refurbishment projects should be treated as new projects, and report against all life cycle stages and module D (reported separately) over the consistent 60 year reference study period. Emissions arising from any demolition, facilitating works or strip out should be accounted for but the overall benefit of retrofit is the expected reduction in upfront carbon due to re-use of existing material in-situ. RICS PS v2 2023 requires the separate reporting of emissions related to refurbished GIA and new/ additional GIA, prior to aggregating. This is to avoid concealing a high carbon new element across a large existing asset, which may have relatively minor enhancements.

Masterplans

Measure and report each building individually using the Building Reporting Template. This allows each building to be benchmarked against those of similar typology or scale. Include the impacts of facilitating and external works and report this separately. The upfront carbon of external works outside the site boundary is also reported separately. The figures can be aggregated as required to report the emissions for the whole masterplan, but also reported as separate assets.

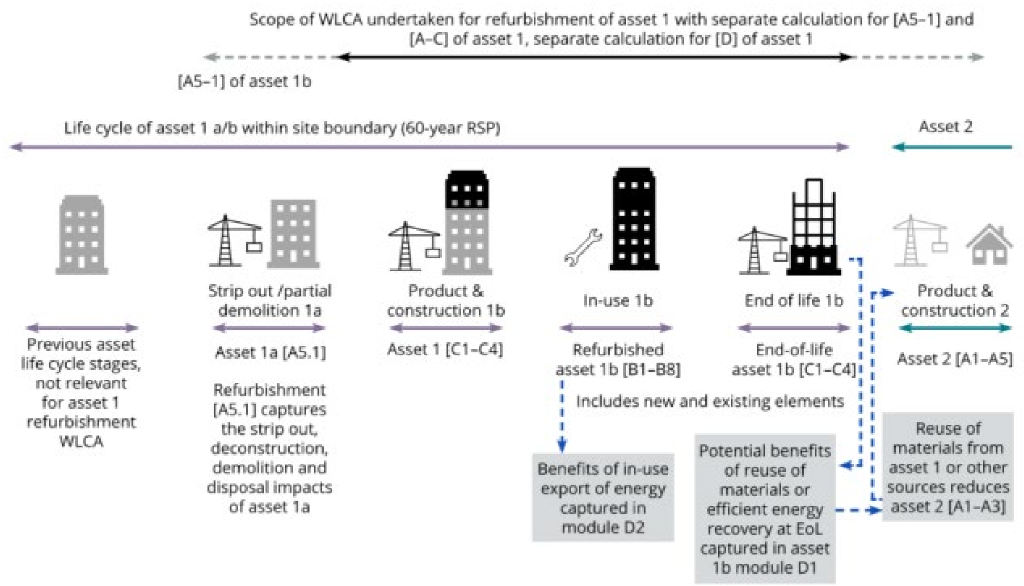
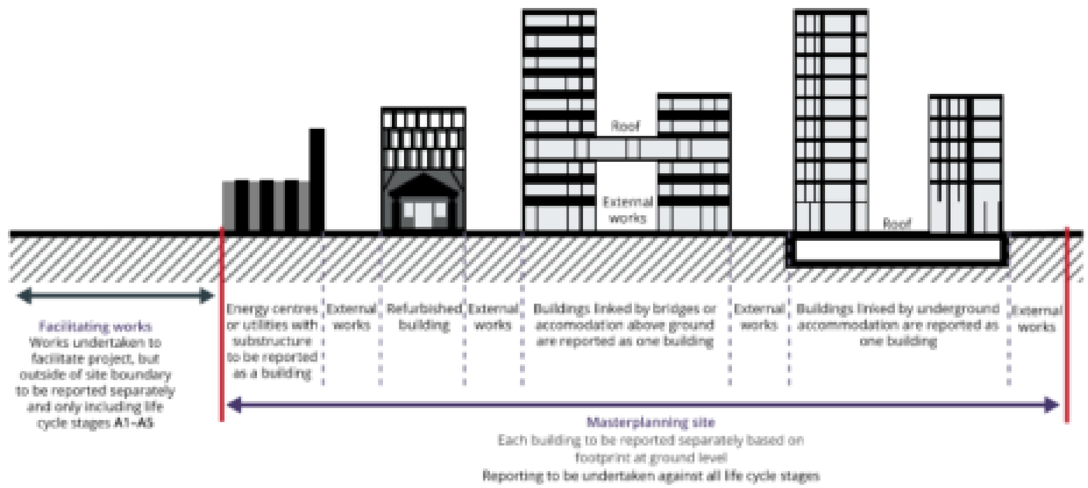


Figure 6: An illustrative life cycle sequence for a building that evolves through a subsequent refurbishment; it shows how that interrelates with the modular structure for each generation in the life cycle



RICS Whole life carbon assessment for the built environment, 2nd edition

9.5
Additional information on Approved Document Part B fire regulations

Part B Fire Safety – conflicts and opportunities in embodied carbon

New residential buildings above 11m height

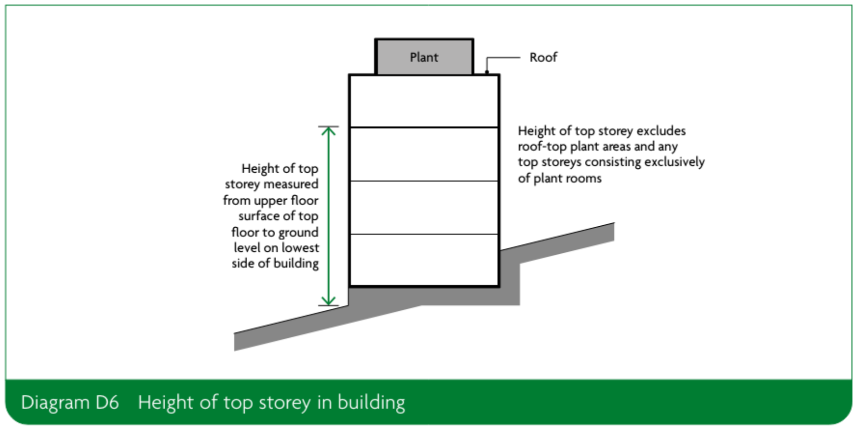
The embodied carbon of new residential buildings is significantly influenced by the UK Part B fire regulations V1. In 2020, Part B received significant updates which, in certain situations, limit material choice and specification.

For example, new residential buildings between 11-18m in height (measured to top occupied storey), the external surface of walls and any insulation product used in the external wall should be Class A2-s1, d0 or better (non-combustible). New residential buildings with a top occupied storey of 18m or more above ground should have non-combustible materials in the construction of all its external walls (with minor exceptions for cavity materials for specific types of masonry cavity walls). Balconies and spandrel panels should also be non-combustible over 11 m.

In such cases, certain low embodied carbon materials, like timber structure or wood fibre, hempcrete and cellulose insulation, are no longer allowable options above 11m. Bricks and concrete are the most used materials in high-rise residential, due to their high level of fire resistance and durability, but both typically carry a substantial carbon footprint.

New residential buildings below 11m height

For new residential buildings below 11m in height, Class B-s3, d2 materials can be used (combustible and non-combustible). Therefore, there is an opportunity to encourage the use of low embodied carbon natural materials in areas where low-rise residential types are most common, e.g. Essex.



Building height measurement from Building regulations Part B volume 1, 2019 edition incorporating 2020 & 2022 amendments

Part B Building regulations, Volume 1: Dwellings, 2019 edition incorporating 2020 & 2022 amendments

Number of storeys and height of top storey in building

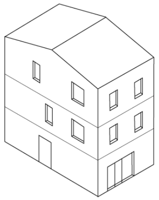
"To count the number of storeys in a building, or in a separated part of a building, count only at the position which gives the greatest number and exclude any basement storeys… Height of top storey measured from upper floor surface of top floor to ground level on lowest side of the building. Height of top storey excludes roof-top plant areas and any top storeys consisting exclusively of plant rooms."

External wall build-ups	Structure	Insulation	Finish
Below 11 m in height	• Timber structure • Brick and block • Concrete structure + steel infill • Steel structure	• Petroleum based (e.g. phenolic insulation) • Wood fibre • Mineral and glass wool • Hemp/ hempcrete • Cellulose • Other natural insulations	• Brick • Render • Timber rainscreen • Metal rainscreen • Concrete panels • Other cladding systems
Between 11-18 m in height	• Timber structure • Brick and block • Concrete structure + steel infill • Steel structure	• Mineral and glass wool	• Brick • Render • Metal rainscreen • Concrete panels • Other non-combustible cladding systems
Above 18 m in height	• Concrete structure + steel infill • Steel structure	• Mineral and glass wool	• Brick • Render • Metal rainscreen • Concrete panels • Other non-combustible cladding systems

Example of materials within an external wall build-up, per building height (and according to Part B fire safety regulations)

9.6
Modelling and cost results tables

Upfront embodied carbon and cost results table – semi-detached

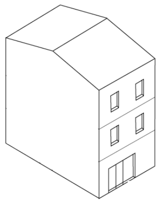


The table below shows the upfront embodied carbon and cost analysis results for different 'set menu options' for the semi-detached house typology.

	Part L 2021 (baseline cost)	**Essex Net Zero Policy evidence base**	**Set menu 1** – highest embodied carbon			**Set menu 2** – lowest embodied carbon			**Set menu 3** – cost and carbon optimised		
	Construction cost - £/m^2 GIA	**Construction cost -** £/m^2 GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost -** £/m^2 GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost -** £/m^2 GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost -** £/m^2 GIA
Sub structure	109	128	126	0.00	128	42	0	94	118	0	130
Super structure	719	741	197	-20	798	124	-67	835	146	-60	772
Finishes	-	-	44	0.00	-	32	0	-	39	0	-
MEP	87	87	51	0.00	87	51	0	87	51	0	87
TOTAL	**915**	**956**	**418**	**-20**	**1,013**	**249**	**-67**	**1,016**	**354**	**-60**	**989**

Cost data for Part L 2021 and Essex Net Zero Policy evidence base scenarios have been added for comparison purposes. The cost analysis results shows overall build costs excluding allowance for 'other costs' ' – i.e. those items not varying (such as kitchens, bathrooms, doors, pipes and wires, floor finishes). This is to enable differences between options to be seen more clearly.

Upfront embodied carbon and cost results table – terraced house

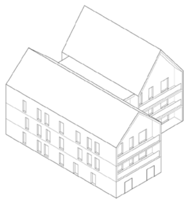


The table below provides the final results from the upfront embodied carbon and cost analysis for the terraced house typology.

	Part L 2021 (baseline cost)	**Essex Net Zero Policy evidence base**	**Set menu 1** – highest embodied carbon			**Set menu 2** – lowest embodied carbon			**Set menu 3** – cost and carbon optimised		
	Construction cost - £/m² GIA	**Construction cost** - £/m² GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost** - £/m² GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost** - £/m² GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost** - £/m² GIA
Sub structure	109	123	126	0	123	42	0	89	118	0	126
Super structure	628	633	161	-19	683	98	-52	702	119	-48	668
Finishes	-	-	43	0	-	31	0	-	38	0	-
MEP	87	87	51	0	87	51	0	87	51	0	87
TOTAL	**824**	**843**	**381**	**-19**	**893**	**222**	**-52**	**878**	**326**	**-48**	**881**

Cost data for Part L 2021 and Essex Net Zero Policy evidence base scenarios have been added for comparison purposes. The cost analysis results shows overall build costs excluding allowance for 'other costs' ' – i.e. those items not varying (such as kitchens, bathrooms, doors, pipes and wires, floor finishes). This is to enable differences between options to be seen more clearly.

Upfront embodied carbon and cost results table – low-rise block of apartments



The table below provides the final results from the upfront embodied carbon and cost analysis for the low-rise block of apartments.

	Part L 2021 (baseline cost)	**Essex Net Zero Policy evidence base**	**Set menu 1** – highest embodied carbon			**Set menu 2** – lowest embodied carbon			**Set menu 3** – cost and carbon optimised		
	Construction cost - £/m^2 GIA	**Construction cost -** £/m^2 GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost -** £/m^2 GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost -** £/m^2 GIA	**Upfront embodied carbon** (A1-A5) - $kgCO_2e/m^2$ GIA	**Upfront biogenic carbon** - $kgCO_2e/m^2$ GIA	**Construction cost -** £/m^2 GIA
Sub structure	84	104	88	0	104	47	0	100	79	0	106
Super structure	718	715	189	-7	736	106	-126	824	133	-120	782
Finishes	-	-	41	0	-	37	0	-	44	0	-
MEP	63	63	59	0	63	59	0	63	59	0	63
TOTAL	**865**	**882**	**377**	**-7**	**903**	**249**	**-126**	**987**	**315**	**-120**	**951**

Cost data for Part L 2021 and Essex Net Zero Policy evidence base scenarios have been added for comparison purposes. The cost analysis results shows overall build costs excluding allowance for 'other costs' ' – i.e. those items not varying (such as kitchens, bathrooms, doors, pipes and wires, floor finishes). This is to enable differences between options to be seen more clearly.

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