UNILIN INSULATION

An overview of the process & calculation of embodied carbon in a study of house types

Reduce by Design

ACTION ON EMBODIED CARBON

Project 80, Midland Heart

XCO2

Commissioned by Unilin Insulation

September 2023

In 2021 Unilin Insulation launched our Sustainability Pledge to become a Zero Carbon operation by 2030.

As part of Unilin Group's One Home Sustainability Policy, we pledged to make environmental improvements in all aspect of our operation including insulation products we manufacture.

The ECO360 insulation strategy is a key innovation in our endeavours. ECO360 is evidence of our commitment to continually review and improve the sustainable credentials of our product offering and services, as far as technical advances in manufacturing and circularity allow.

Unilin Insulation commissioned this report as a tool to assist in the understanding of, and to encourage engagement with the accounting of embodied carbon in construction projects. The aim is to gauge the impact of our improving Environmental Product Declarations (EPDs) on a building's Life Cycle Analysis. We worked with industry bodies and software providers to educate our own team in the conventions and methods related to embodied carbon measurement.

This is only the start of a journey. Strong alliances and co-operation between manufacturers, the supply chain, designers, and contractors will be required to address the Climate Challenge crisis. All of the manufacturers we engaged with in the preparation of this report are fully committed to improving their own EPDs along with the continued decarbonising of the grid, and so results for embodied carbon shown will continue to reduce.

We hope this report and accompanying CPD learning will encourage information sharing and engagement with the subject.

UNILIN INSULATION

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Foreword

This publication represents a revision to the original report which was published in 2022. There are 3 principal reasons why we have updated the content along with including an example of the assessment of an as built project.

Embodied Calculation - a work in progress

Life cycle assessments (LCAs) are an emerging discipline. The parameters to which the assessments are calculated are quite fluid & these background changes have a measurable influence on the results. However, as industry comes together to agree the parameters and set conventions for calculation and reporting (Including the publication of Environmental Product Declarations – EPDs for building materials) clarity and recognised norms will allow for greater engagement and simplified methods of calculation.

This is the second edition of a report published in early 2022. The revision has been prompted by a number of changes in the standards, guidance and conventions for LCA calculations. As part of this evolution we foresee another update required once the consultation on the RICS methodology paper has concluded later this year. Embodied carbon accountability is a work in progress.

Within this edition we have also included the indicative targets set by the Future Homes Hub in their project 'Embodied and Whole Life Carbon,' aimed at developing an industry-led proposal for reducing embodied and whole-life carbon in new homes.

An as-built project has also been analysed. Project 80, a collaboration between Birmingham City University Centre for Future Homes and Midland Heart built 12 homes that meet the Future Homes Standard three years ahead of schedule and resulting in 80% less carbon emissions than the 2013 standard. Further LCAs were undertaken to determine progress towards the FHH & RIBA Climate Challenge standards. Unilin Insulation is collaborating with other manufacturers, industry bodies and academia to increase awareness and understanding of calculation.

Please contact Unilin Technical Support if you need information or support.

Good Mews story in Dún Laoghaire, Passive House magazine, April 2019, www.passivehouseplus.ie features four 55 square metre apartments built by Dún Laoghaire-Rathdown County Council, completed December 2017 to nearly zero energy building (nZEB) standards. Photography @DonalMurphy

Executive Summary

XCO2 were commissioned to carry out Life Cycle Assessments (LCA) for four different dwelling types using the typical material specifications to meet the embodied carbon targets set by various organisations. An overview of these targets can be seen in Figure 2.

An LCA was undertaken to account for the embodied carbon content of each dwelling to assess where improvements were required to meet the embodied carbon targets.

The four dwelling types were:

1. Detached house
2. Semi-detached house
3. Mid-terraced house
4. Apartment block

The embodied carbon was calculated initially for a Baseline specification consisting of materials that are commonly specified, but tend to be carbon-intensive due to their use of generic or average manufacturer LCA data.

The most contributing materials were identified and an Improved specification was proposed using materials with improved, verified EPDs including Unilin Insulation products, that help reduce the embodied carbon of the dwelling types.

Additionally, a building services options appraisal has also been carried out to further reduce the carbon emissions associated with the MEP building elements of the dwellings. The options include the use of air source heat pumps (ASHP), passive heating with the use of Mechanical Ventilation with Heat Recovery (MVHR) and an option with electric heaters.

The RIBA 2030 Climate Challenge v2 has set a target of 625kgCO_2/m^2 for residential buildings.

The Future Homes Hub has set a target of 615kgCO_2/m^2 for low rise buildings and 866kgCO_2/m^2 for medium and high rise residential buildings

Figure 1 shows the summary of results of all the dwelling types with the Baseline illustrated in blue. The Improved specification using verified EPDs and various building services options are also illustrated. The results show that for most of the dwelling types the 2030 target can be met with the use of the Improved specification.

Figure 2 compares the embodied carbon targets for residential developments that have been set for the sector by RIBA, LETI, Future Homes Hub (FHH) and the Greater London Authority (GLA).

Overall, with the improved specification and inclusion of sequestration it is expected that typical dwellings will meet the RIBA 2030 embodied carbon target with the use of Unilin insulation boards.

Figure 1 Summary of results of the total embodied carbon for all options of the different dwelling types. Visualisations are indicative only

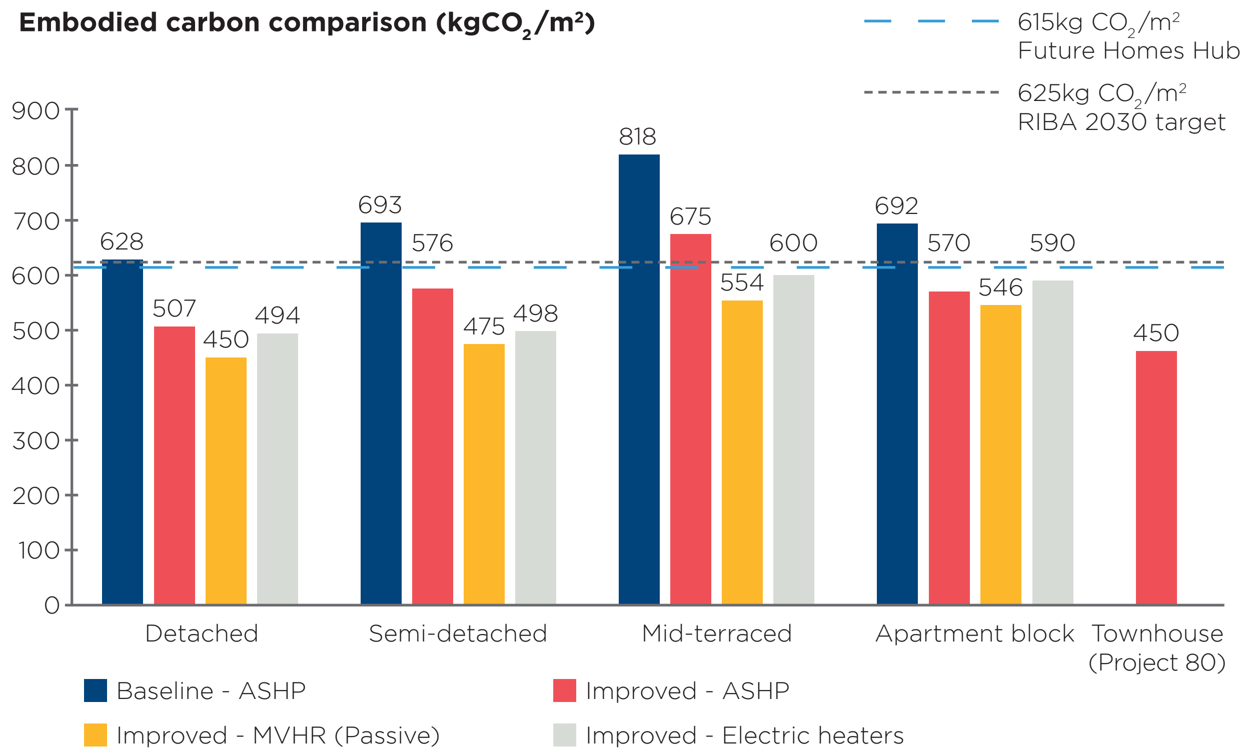
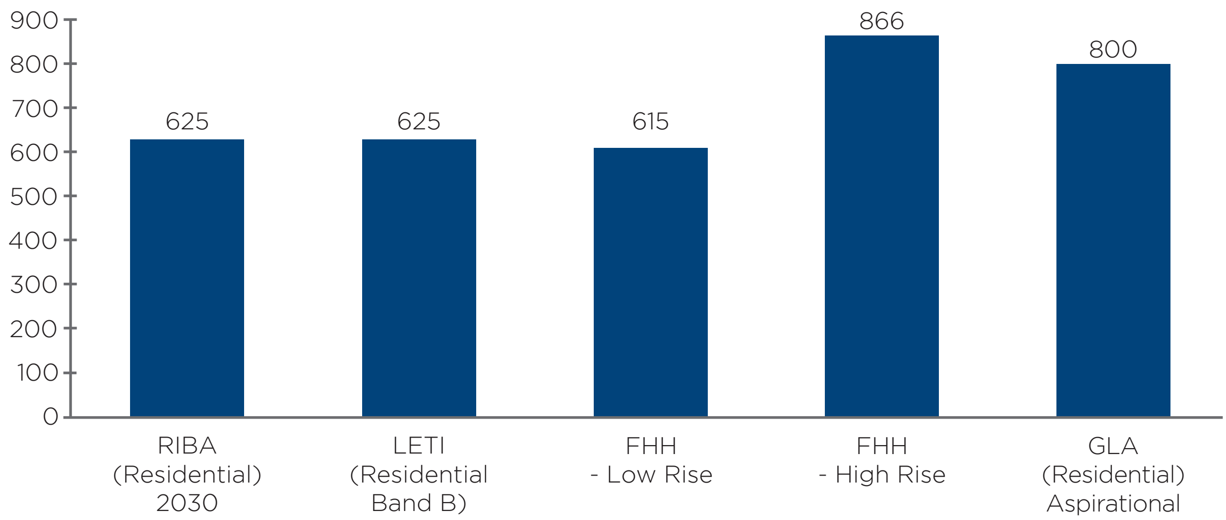


Figure 2 Embodied carbon targets
Visualisations are indicative only



Introduction

Methodology

The methodology followed in preparing this report is in line with the RICS Professional Statement (PS) for undertaking detailed carbon assessments. The RICS Whole Life Carbon Assessment for the Built Environment (2017), follows the European standard EN 15978.

Metrics

The metric used for quantifying the embodied carbon is kilogrammes of CO_2 equivalent ($kgCO_2eq$). This has been normalised in $kgCO_2eq$ per m^2 floor area.

For example, the floor area used for the analysis of the semi-detached house type is 98.9 m^2. This area was measured based on the drawings provided by the design team.

The calculation period for the assessment has been considered to be 60 years for the buildings, which has an impact a number of the use life stage emissions.

One Click LCA Software

The tool used for this assessment is the Bionova One Click LCA tool, which is BRE certified & ensures each EPD included in their database is independently verified. The embodied carbon was calculated based on estimations and material specifications provided by the design team.

Modelling Parameters

One Click LCA allows the use of a number of different calculation parameters as part of the assessment, these parameters are a set of calculation rules which apply different default values to the project. Altering these parameters can result in a different outcome for the assessment.

For the purposes of this project the following parameters were utilised:

- Service life values - 'Technical service life', which represents how long the project materials last in good conditions and is recommended by default (B4-B5 category).

- Transportation distance - 'UK GLA', provides transport distances for project materials appropriate to the UK.

- Material localisation - 'v.1.0 recommended', this is the recommended setting for localising the projects building materials to take account of the energy profile for the UK by adjusting manufacturing electricity to the UK energy mix.

- End of life calculation - 'Material locked (recommended)'. This calculation method influences the C1-C4 and D phase emissions.

Building Elements

The RICS PS outlines the building elements that should be included in a whole life carbon assessment. The building elements considered for the assessment are included in Table 1.

Most of the building elements have been included in the assessment. A Quantity Surveyor was appointed to provide all relevant information for each of the dwelling types. Only the external areas have been excluded from the assessment.

Table 1
Building elements scope (RICS Paper IP 32/2012)

	Building part/Element group	Building element	Included
1	Substructure	1.1 Substructure	Y
2	Superstructure	2.1 Frame	Y
		2.2 Upper floors incl. balconies	Y
		2.3 Roof	Y
		2.4 Stairs and ramps	Y
		2.5 External walls	Y
		2.6 Windows and external doors	Y
		2.7 Internal Walls and partitions	Y
		2.8 Internal doors	Y
3	Finishes	3.1 Wall finishes	Y
		3.2 Floor finishes	Y
		3.3 Ceiling finishes	Y
4	Fittings, furnishings and equipment	4.1 Fittings, Furnishings & Equipment incl. Building-related* and Non-building related**	Y
5	Building services	5.1 - 5.14 Services	Y
6	Prefabricated Buildings and Building Units	6.1 Prefabricated buildings and building unit	N/A
7	Work to existing building	7.1 Minor demolition and alteration works	N/A
8	External works	8.1 - 8.8 External works	N

* Building related items: Building-integrated technical systems and furniture, fittings and fixtures built into the fabric. Building-related MEP and FF&E typically include the items classified under Shell and core and Category A fit-out.

** Non-building related items: Loose furniture, fittings and other technical equipment like desks, chairs, computers, refrigerators, etc. Such items are usually part of Category B fit out.

Introduction

One Click LCA Software

The Bionova One Click LCA tool, is BRE certified ensures each EPD included in their database is independently verified. It allows a project to conduct a building lifecycle assessment that aligns with core industry guidance.

Lifecycle Inventory Databases

One Click LCA integrates data from nearly all available EPD platforms from around the globe as well as EPD data that has not been published under any of these databases. This is done using a 10-point verification process that has been reviewed by the Building Research Establishment (BRE).

These databases are constantly being updated, as EPDs typically only have a validity period of 5 years, meaning that after this period the emissions of the EPD would have to be recalculated for the EPD to remain valid. Any recalculation then carries with it a risk, that the results will differ from those of the previous EPD.

As such, over time it is expected that results for a building life-cycle assessment will also be subject to a certain level of flux as the constituent EPD data is recalculated to remain valid. For instance this may mean that a building life-cycle assessment undertaken a year ago and one today could have different results even if modelled using the exact same materials.

Project Parameters

One Click LCA makes use of calculation parameters which ensure that the calculations used in the assessment use correct default values. The parameters are a set of calculation rules which apply to all designs in a single project. These parameters are as follows:

Service life values
All materials in a project have a certain service life to calculate its impacts for replacement and disposal (B4-B5 category). There are four service life categories to chose from:

- Technical service life -
  It is assumed that the same type of materials have the same service life setting. It represents how long materials last in good conditions. This is recommended by default.

- Commercial service life -
  The commercial service life setting should be selected when doing retail or hotel projects, in which the service life of the interior (and other materials) is shorter (e.g. flooring and finishes will be replaced more often for these building types).

- Product specific service life -
  The service life values vary per manufacture and settings from the EPD will be used.

- RICS default service life -
  The service life values will take the recommended values from the RICS guidance.

Transportation distance
Each materials assigned in an assessment shall come with a defined transport mode and distance from the building material manufacturer to the building site to calculate transport impacts. These vary from country to country but for the purposes of this project the setting has been set to UK - RICS.

Material manufacturing localisation method
Each material in an assessment has its manufacturing impacts largely defined by the energy profile of the country it is manufactured in. This parameter sets a local compensation factor, which adjusts the impact of material manufacturing in another country to represent manufacturing in the chosen location, as such this means that product EPDs from France for example could be used in the UK.

End of life calculation method
The end of life calculation method influence the emissions in modules C1-C4 and D, the default calculation method is the material-locked scenario. However the recommended scenario is the 'Market scenario's, user adjustable' parameter.

Project Parameter updates

One Click LCA are continuously reviewing the underlying rationalisation behind the project parameters and where necessary updating them. As a result the underlying calculations behind the LCA can change over time, this can in consequence result in the results of a previously undertaken building life-cycle assessment within the software to improve or disimprove without any change to the underlying materials used to model the building.

Introduction

RICS Whole Life Carbon Assessment for the Built Environment

Since the release of the 1st edition 'RICS Whole Life Carbon Assessment for the Built Environment guidance' in November 2017 it has become one of the most widely used standards for undertaking building whole life carbon assessments.

The guidance provides a whole life approach with which to reduce carbon emissions within the built environment and sets out specific mandatory principles and supporting guidance for the interpretation and implementation of the EN 15978 methodology.

It has seen strong uptake within the UK over the last 6 years, and for instance forms the underlying methodology for the Greater London Authorities own Whole life-cycle carbon assessment guidance.

RICS (The Royal Institute for Chartered Surveyors), have recently announced consultation on an update of the guidance document to the 2nd edition in order to establish a global benchmark for consistent carbon measurement at all project stages.

Proposed updates as part of the 2nd edition include the following:

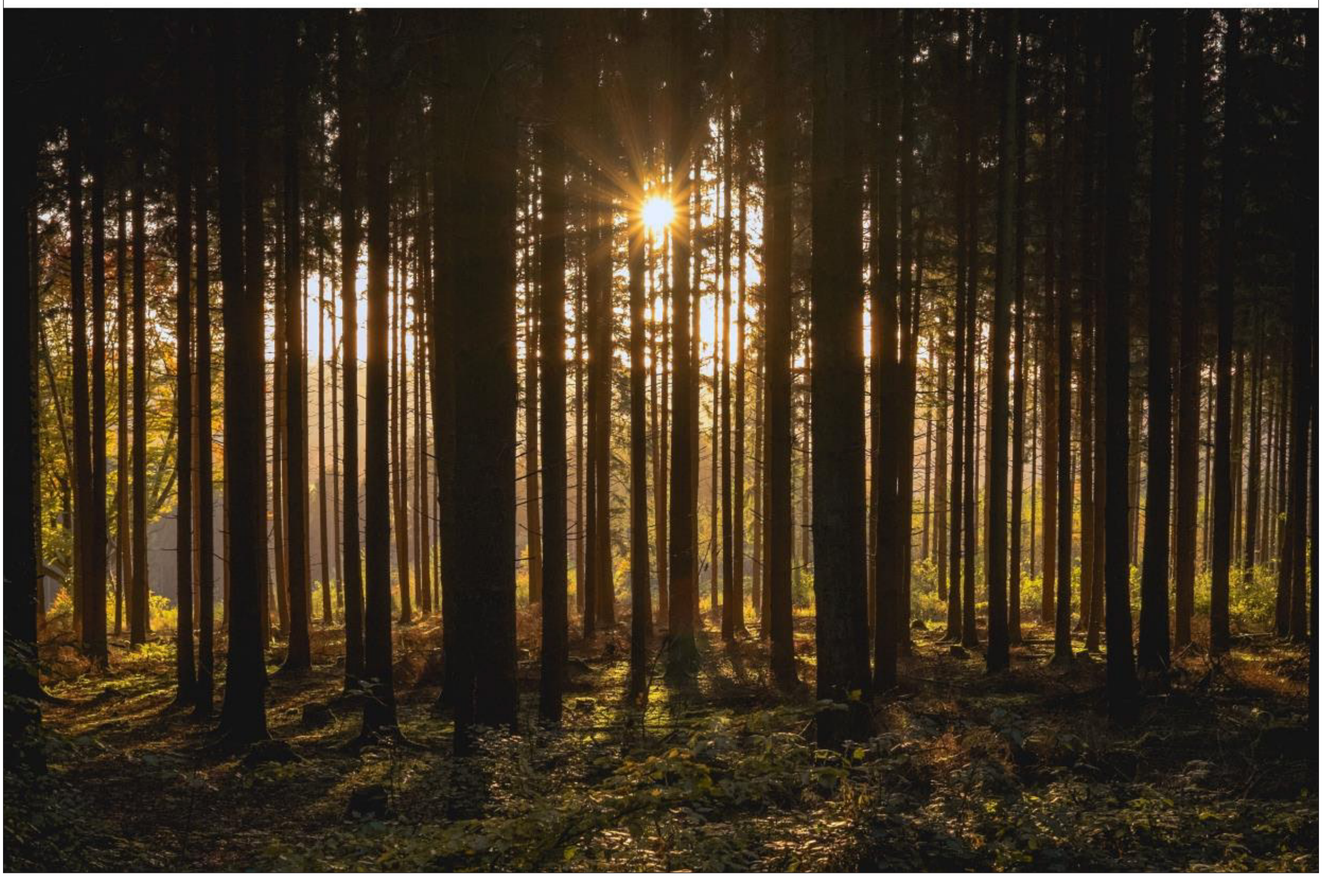
- Incorporation of amendments to the Climate Change Act 2019 and 2021
- Incorporate updates to EN 15978 for buildings; EN 17472 for infrastructure and EN 15804 for construction products and buildings
- Incorporate updates to ICMS3 the International Cost Management Standard
- Making it more internationally facing
- Including specific references to Infrastructure, Housing and Retrofit
- Improving the accessibility of the guidance document
- Better visual guidance (through the use of new diagrams etc.)

RICS

RICS professional standards and guidance, UK

Whole life carbon assessment for the built environment

1st edition, November, 2017



Introduction

EN 15804

EN 15804 is the Environmental Product Declaration (EPD) standard for the sustainability of construction works - environmental product declarations. Globally, it is the most used standard for creating EPDs for construction products.

An EPD is a transparent, objective report that communicates what a product is made of and how it impacts the environment across its entire lifecycle.

Since its original release in 2012 the standard has been amended twice, the current timeline is as follows:

Timeline

- 2012 - EN 15804
- 2013 - 1st amendment to EN 15804+A1
- 2019 - 2nd amendment to EN 15804+A2
- 2022 - Sunset date for EN 15804+A1

EN 15804+A1

The first amendment took place in 2013, which importantly made it mandatory to apply a common set of characterisation factors when undertaking an EPD assessment. Characterisation within an LCA refers to the use of conversion factors being used during EPD impact calculations, for instance these are used to calculate the amount of CO_2 or Methane released from the manufacturing of a construction product.

These characterisation factors are based on something known as the CML methodology developed by the University of Leiden. This methodology helps to ensure a reasonable level of comparability across environmental impacts in most impact categories for EPDs.

EN 15804+A2

The second amendment to EN 15804+A2 was approved July 2019, the update was produced on a mandate from the European Commission to align the standard with the newly released Product Environmental Footprint (PEF) methodology. After July 2022 no new EPDs can be issued to EN 15804+A1.

A number of changes have been made as a result of the standard update. Including:

Global Warming Potential Category removed
The previous 'Global Warming Potential Category' has been removed from the assessment and instead split into 4 new categories:

- Climate change - total (sum of subcategories)
- Climate change - fossil
- Climate change - biogenic
- Climate change - LULUC (land use and land use changes)

Increased number of reported impact categories
EN 15804+A1 previously reported on 7 impact categories, EN 15804+A2 has revised these categories and expanded the number to 13 core environmental impact indicators with 6 additional optional categories.

The update has also replaced all previous environmental impact characterisation factors based on the CML methodology except, abiotic resource depletion.

In total this equates to 49 reporting categories for an assessment.

Mandatory reporting of Modules A1-A3, C1-C4 and D

The minimum scope for an LCA assessment now includes LCA modules A1-A3 (Product Stage), C1-C4 (End-of-life stage) and D beyond the system boundary.

This means that whereas a previous assessment only had to report modules A1-A3 product stage (or cradle-to-gate) emissions, those been undertaken to EN 15804+A2 also need to include the C1-C-4 end-of-life phases as well as any potential impacts outside of the system boundary.

Impact on building LCA calculations?

The update to the standards had brought about complications in life cycle assessments due to the incomparability between the 2 variants of EN 15804.

In May 2023 One Click announced the introduction of a New RICS, GLA & Green Mark tool which supports the use of EPDs according to EN 15804:2012 +A2:2019 standard.

This calculation tool utilizes GWP fossil impact category from the newly supported EPDs in addition to the EPDs according to the older amendment of the EN 15804 standard +A1:2013.

This represents an encouraging step in the improvement in accuracy of LCAs and removes the barrier to entry for manufacturers with EPDs created since July 2022.

Introduction

Life Cycle Stages

The life cycle stages covered by the RICS methodology refer to EN 15978, which includes a modular approach to a built asset's life cycle, breaking it down into different stages. The five main modules are:

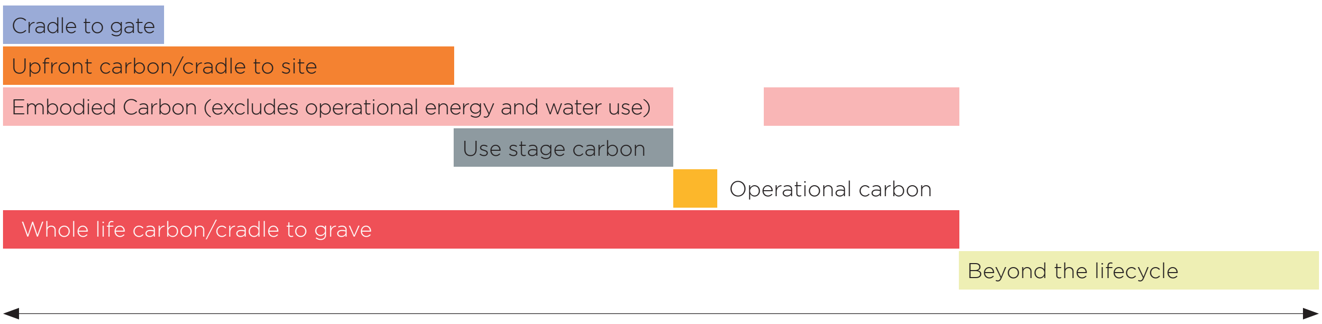
- Product stage [A1 – A3] covers the cradle-to-gate processes, including raw material supply, transport and manufacturing of building materials.
- Construction Process stage [A4 – A5] these modules cover the transportation of the building material products from the factory gate to the project site and their assembly into a building.
- Use stage [B1 – B7] the emissions associated with the operation of the built asset from practical completion to end of service life. This includes the emissions associated with the refrigerant leakage of any heat pump or cooling equipment.
- End of Life stage [C1 – C4] decommissioning, strip out, disassembly, deconstruction and demolition operations at the building's end of life; including the transport and processing of these materials.
- Module D consists of the potential environmental benefits or burdens of materials beyond the life of the project, this is usually reported separately to the cradle to grave modules [A – C].

This analysis includes all life cycle stages corresponding to the Embodied Carbon of the building (A1 - D) referenced in Figure 3.

However, emissions produced from the operational energy and water use (B6 & B7) are excluded.

Figure 3 Life cycle stages (modules) according to EN 15978 and terminology of carbon emissions scopes. Visualisations are indicative only

Product Stage			Construction Process Stage		Use Stage							End-of-Life Stage				Benefits/Loads beyond the system		
Raw material supply	Transport	Manufacturing	Transport to building site	Construction installation process	Use/application	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse	Recovery	Recycling
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D	D	D



* This study accounts for embodied carbon at all stages A1 - D inclusive on Table 1

Introduction

RIBA 2030 Climate Challenge

In response to the climate emergency, the RIBA 2030 Climate Challenge was developed to help leaders in the construction industry to meet zero whole life carbon for new and retrofitted buildings by 2030. It sets target metrics to adopt in order to reduce operational energy, embodied carbon and potable water.

For domestic buildings, the total embodied carbon should be less than 625kgCO_2eq per m^2. The embodied carbon of all of the dwelling types has been estimated and compared against this target.

A proposed Improved specification of materials was developed to further reduce the embodied carbon. Additionally, three different building services options were also assessed to compare the embodied carbon of the dwellings with each option.

Scan the QR code to download:

RIBA 2030
Climate Challenge

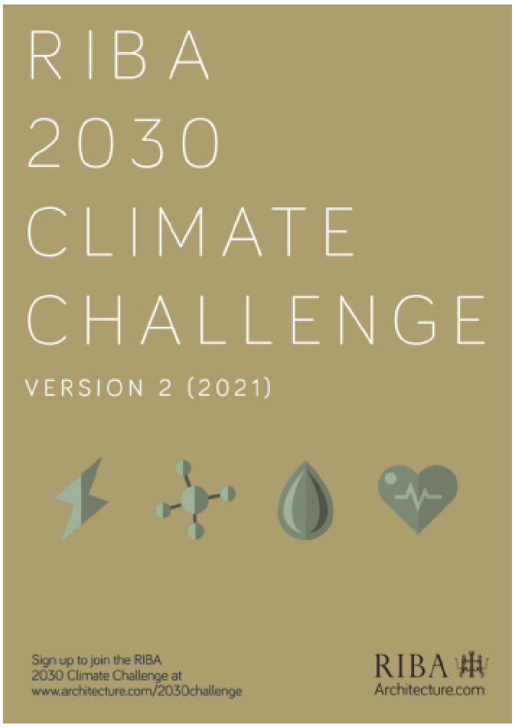
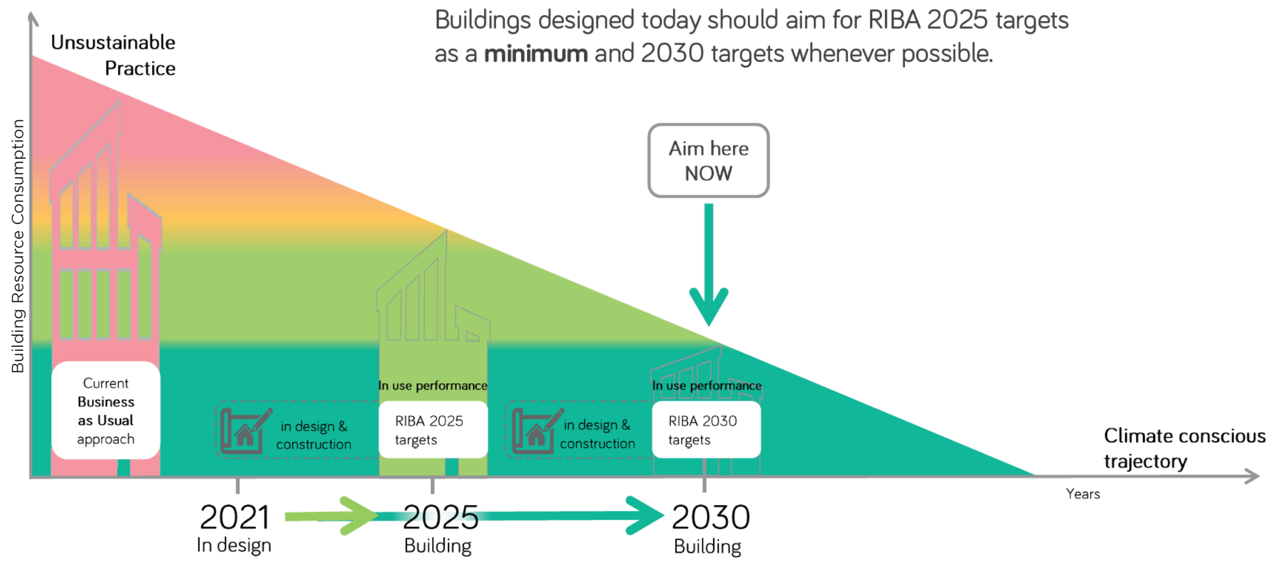


Figure 4 RIBA 2030 Climate Challenge v2 (June 2021)



RIBA Sustainable Outcome Metrics	Business as Usual	2025 Targets	2030 Targets	Notes
Operational Energy $kWh/m^2/y$	120 $kWh/m^2/y$	< 60 $kWh/m^2/y$	< 35 $kWh/m^2/y$	Targets based on GIA. Figures include regulated & unregulated energy consumption irrespective of source (grid/renewables). BAU based on median all electric across housing typologies in CIBSE benchmarking tool. 1. Use a 'Fabric First' approach 2. Minimise energy demand. Use efficient services and low carbon heat 3. Maximise onsite renewables
Embodied Carbon $kgCO_2e/m^2$	1200 $kgCO_2e/m^2$	< 800 $kgCO_2e/m^2$	< 625 $kgCO_2e/m^2$	Use RICS Whole Life Carbon (modules A1-A5, B1-B5, C1-C4 incl sequestration). Analysis should include minimum of 95% of cost, include substructure, superstructure, finishes, fixed FF&E, building services and associated refrigerant leakage. 1. Whole Life Carbon Analysis 2. Use circular economy strategies 3. Minimise offsetting and use as last resort (accredited and verifiable) BAU aligned with LETI band E; 2025 target aligned with LETI band C and 2030 target aligned with LETI band B.
Potable Water Use Litres/person/day	125 l/p/day (Building Regulations England and Wales)	< 95 l/p/day	< 75 l/p/day	CIBSE Guide G.

Introduction

Future Homes Hub

The Future Homes Hub was established in September 2020 in order to facilitate the collaboration needed both within and beyond the new homes sector in order to develop a long term delivery plan for the sector in line with the Government's legally binding net zero and wider environmental targets.

The delivery plan is divided into four main areas with a goal and roadmap for each area:

- High quality homes that are zero carbon ready and sustainable.
- Place and developments that a consistently low carbon, nature rich, resilient, healthy, well designed and beautiful by 2025.
- Production and construction methods that are net zero and sustainable by 2050 with substantial progress by 2025 and 2030.
- Business that are recognised and rewarded for net zero and sustainable performance.

The Future Homes Hub is an independent organisation and seeks to bring together the homebuilding sector with the wider circular of supply chain, infrastructure finance and government organisations that need to collaborate. It currently has over 40 of the largest homebuilders committed as well as many other related organisations.

Embodied Whole Life Carbon Implementation Plan 2023-2025

In order to meet these four key goals, the Future Homes Hub has begun work on an industry led proposal for reducing embodied and whole life carbon in new homes. And In January 2023 the Embodied and Whole Life Carbon 2023-2025 Implementation plan for the homebuilding industry was released.

The standard has set out some key baseline performance targets for the homebuilding industry for reducing embodied carbon.

These targets are divided into 'Upfront embodied carbon' which only includes modules A1 -A5 and Whole Life embodied carbon, which includes modules A1-C4 but excludes modules B6 and B7 (operational energy and water).

The proposed targets for Low rise housing are as follows:

- Upfront embodied carbon: 417kgCO_2 e/m^2
- Whole life embodied carbon: 615gCO_2 e/m^2

The proposed targets for Medium high rise housing are:

- Upfront embodied carbon: 635kgCO_2 e/m^2
- Whole life embodied carbon: 866gCO_2 e/m^2

Scan the QR code to download:

Future Homes Hub
Embodied and Whole Life Carbon

Dwelling Types

In order to aid the understanding of embodied carbon calculations, and to encourage engagement four standard dwelling types were assessed.

The four dwellings that were assessed were:

1. Detached house
2. Semi-detached house
3. Mid-terraced house
4. Apartment block

Figure 5 shows the Gross Internal Area (GIA) of each of the dwellings and the drawings that were used to quantify the materials.

The house types are 2 to 3-storey high homes which share a similar internal distribution and construction system. The apartment block is a 4-storey high building with 16 dwellings, 4 per floor.

Project 80 - Townhouse
In collaboration with Tricas Construction, Birmingham City University and select industry suppliers (including Unilin Insulation) Project 80 has been built.

A LCA of one plot was undertaken to act as an introduction to the subject and to encourage engagement with Whole Life Carbon.

Further details can be found on page 36 of this report.

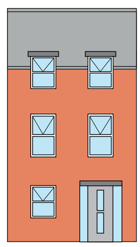
Figure 5
Dwelling types

Detached house
GIA 186.1m^2

Mid-terraced house
GIA 82.4m^2

Semi-detached house
GIA 98.9m^2

Apartment block
GIA 1724m^2



Project 80
GIA 96.5m^2

Baseline Specification

The embodied carbon was initially calculated using a Baseline specification consisting of EPD data sourced from generic databases that tend to be carbon-intensive.

House types

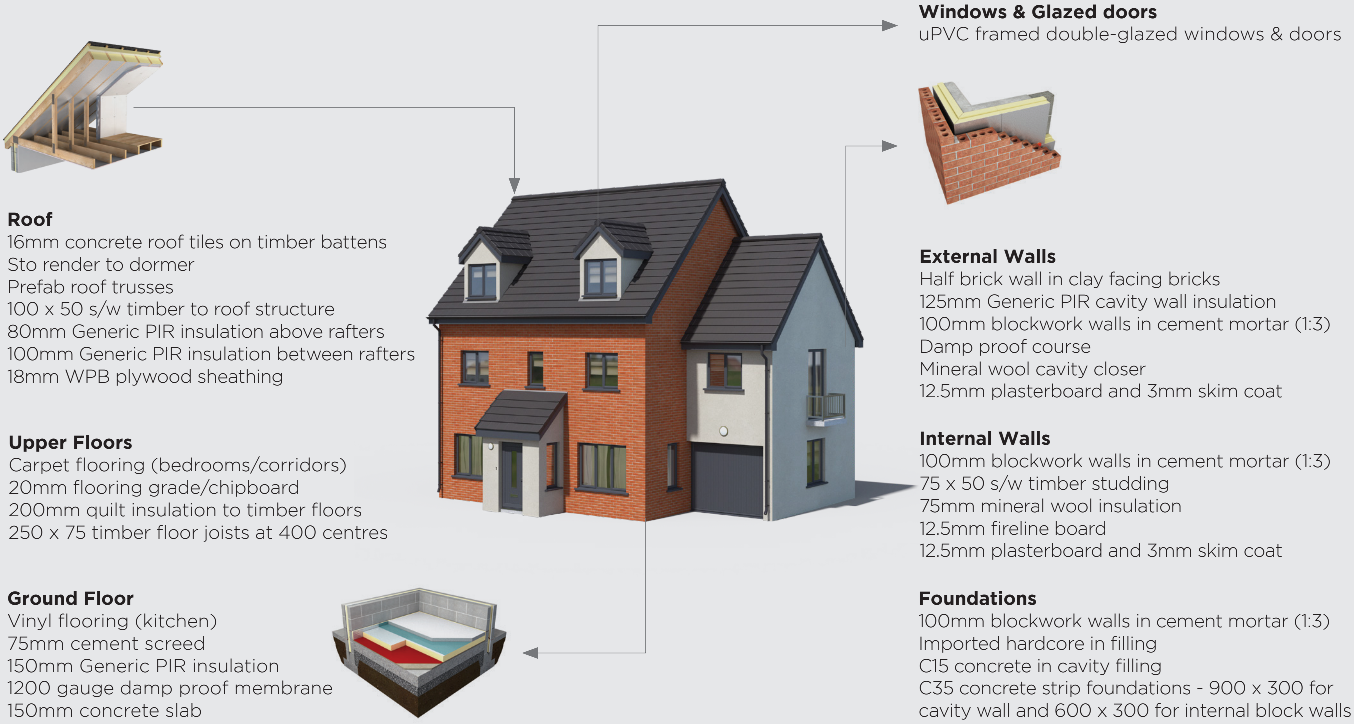
Figure 6 shows the Baseline specification for the Detached house which is consistent across the other two house types. The construction system consists of concrete strip foundations (CEM I) and precast concrete slab for the ground floor, cement screed and the generic PIR insulation. The upper floor consists of a timber floor with 200x75mm timber joists and 400mm centres.

The roof is made of prefabricated roof trusses with concrete roof tiles and generic PIR insulation above and between the rafters. The cavity walls have generic PIR cavity wall insulation and the internal walls consist of 75x50mm timber studding and blockwork in some areas.

Apartment block

The Baseline case for the Apartment block has a similar specification as the houses. CEM I Concrete strip foundations and precast concrete slab at the ground floor with generic PIR insulation. The upper slabs & roof are also 150mm concrete planks with cement screed & generic PIR in the roof. The external walls are blockwork walls with generic PIR cavity wall insulation and the internal walls are 100mm metal stud partitions and blockwork around the lift shaft.

Figure 6 Baseline specification of Detached house type



Improved Specification

The most contributing materials were identified and an Improved specification was chosen and calculated using verified EPDs. This included Unilin insulation, with the aim of reducing the embodied carbon of each dwelling type to reach the embodied carbon targets.

House types

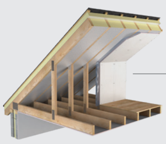
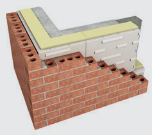
Figure 7 shows the Improved specification for the Detached house. The same specification was used across the other two house types. The concrete used in the strip foundations was replaced with a cement mix with 70% Ground Granulated Blast furnace Slag (GGBS). The generic PIR specification was replaced with the specific Unilin Insulation alternatives in the floor, wall & roof. The cement screed in the ground floor slab was replaced with calcium sulphate screed. The construction of the roof remained the same but the concrete roof tiles were replaced with slate roof tiles.

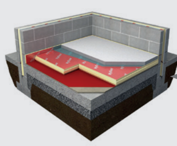
The blockwork in the cavity walls and some partition walls was replaced with a generic precast block based upon an EPD produced by the British Pre-cast Concrete Federation (BPCF).

Apartment block

The concrete in the foundations was also replaced with a mix with 70% GGBS. The cement screed in the ground, upper floor slabs and roof was replaced with calcium sulphate screed and 200mm Unilin Flat Roof Insulation in the roof. The blockwork in the cavity walls and lift shaft was replaced with a generic precast block by the BPCF and the metal studs found in the partitions were replaced with timber stud walls.

Figure 7 Improved specification of Detached house type



Building Service Options

Building services options appraisal

An options appraisal of three different space heating and domestic hot water (DHW) systems was carried out to compare the impact on the embodied carbon of the dwelling.

The building services were modelled based on high level estimates and approximate quantities as the M&E design has not been developed for the house type. The improved materials specifications remained the same to ensure consistency throughout.

The three options are listed below and the description of the items included under each option is shown on the right:

1. Air Source Heat Pump (ASHP)
2. Mechanical ventilation with heat recovery (MVHR) & passive heating
3. Electric heaters

It is worth noting that option 2 is based on Passivhaus principles. The fabric performance for all dwelling types elements is at minimum 0.15W/m²k which correlates with the recommended Passivhaus backstop U-Values.

Option 3 – Electric heaters represent an alternative design to what is typically specified. As with all designs, consideration would be required to ensure it is line with other RIBA targets.

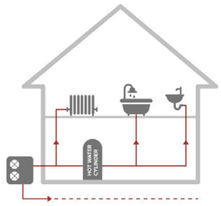


Figure 8
Option 1 - ASHP

Air Source Heat Pump (ASHP)
ASHP supplies space heating and DHW. Includes the following:

- Air-to-water ASHP 5kW
- Refrigerant leakage
- Heat distribution piping network & radiators (6 no.)
- 150-200L hot water cylinder
- Water supply piping network

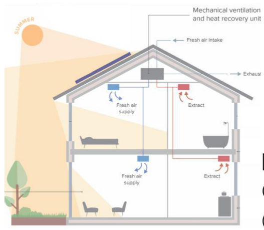


Figure 9
Option 2 - MVHR
(Passive solar heating)

Mechanical ventilation with heat recovery (MVHR) & passive heating
MVHR to provide ventilation with heat recovery. Electric water heater to provide DWH. Includes the following:

- Centralised MVHR unit (690m³/h)
- PVC ductwork for ventilation (supply & return)
- 150-200L electric water cylinder
- Water supply piping network

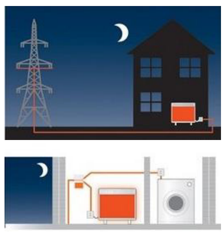


Figure 10
Option 3 - Electric heaters

Electric heaters
Electric heaters to provide space heating. Electric water heater to provide DWH. Includes the following:

- Electric heaters*
- 150-200L electric water cylinder
- Water supply piping network

*Electric heaters were modelled as electric radiators due to limitations of the software.

Building Service Options

Building services options appraisal

The results of the building services options appraisal are shown in the graph below.

The results indicate that the lowest embodied carbon option would be the passive heating option with only an MVHR as it only requires the ventilation unit and PVC ductwork. It does not include any heat distribution piping network, heat pump or refrigerant leakage.

The embodied carbon associated with each of the MEP services follow a similar trend depending on the dwelling construction. While the MVHR is the best performing in this study, each option would appear to represent a viable solution based on the obtained results.

Refrigerant leakage

The emissions produced by the refrigerant found in ASHPs during the In Use phase are a main contributor to the total embodied carbon. Hence, it is important to recognise that refrigerants with low Global Warming Potential (GWP) will help to minimise the emissions produced at this stage (Table 2).

The refrigerant assumed for the Baseline case was taken from a 5kW Daikin ASHP with 1.3kg of R410A refrigerant charge. For the Improved scenario, the manufacturer confirmed that the refrigerant could be replaced by 3kg of R32, a refrigerant with a lower GWP. The emissions associated with the refrigerant leakage dropped significantly from 48 to 36kgCO_2/m^2.

Figure 11 Comparison of total embodied carbon of the servicing options (Detached house)
Visualisations are indicative only

Detached House Building Service Options

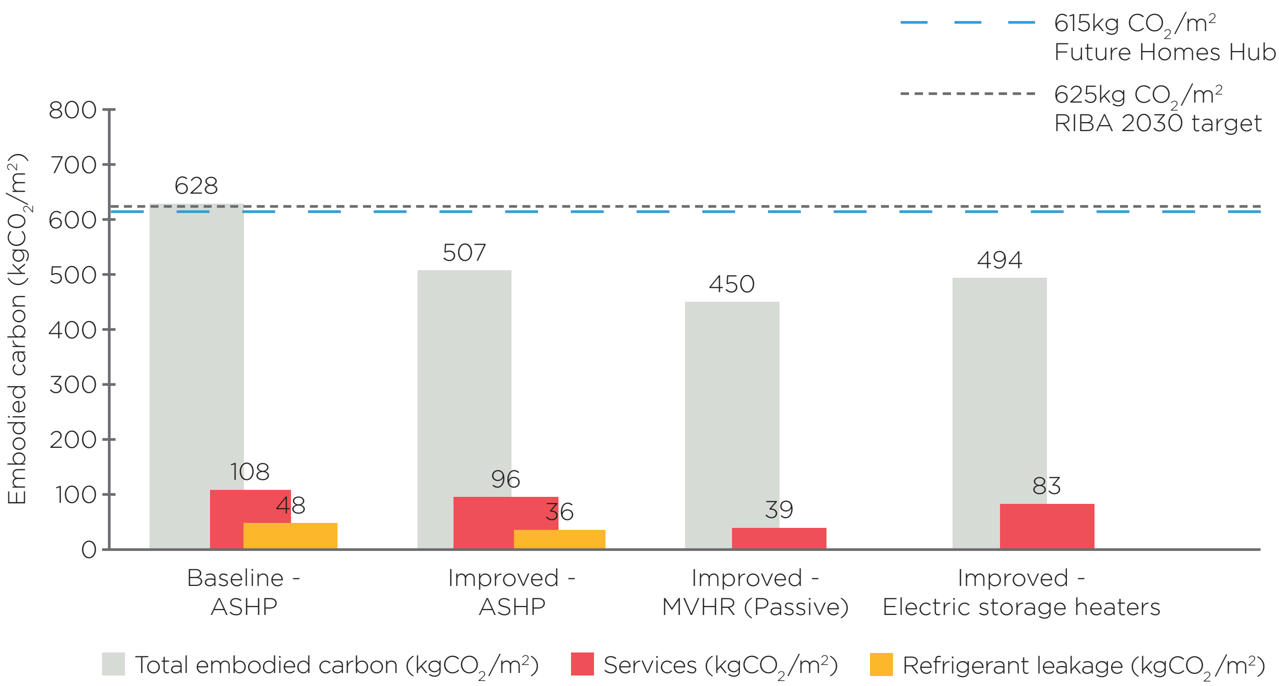


Table 2
Environmental impact of refrigerants

Type	Product R-Number	ODP[1]		GWP[2]	
Natural	717	0	Zero	0	Zero
Natural	744	0	Zero	1	Low
Natural	1270	0	Zero	2	Low
Natural	290	0	Zero	3	Low
Natural	600a	0	Zero	3	Low
Natural	1150	0	Zero	4	Low
HFO	1234yf	0	Zero	4	Low
HFO	1234ze	0	Zero	6	Low
Natural	170	0	Zero	6	Low
HFC	32	0	Zero	675	Medium
HFC	134a	0	Zero	1430	Medium
HFC	407C	0	Zero	1774	Medium
HFC	437A	0	Zero	1805	Medium
HFC	407F	0	Zero	1825	Medium
HFC	442A	0	Zero	1888	Medium
HFC	410A	0	Zero	2088	Medium
HFC	407A	0	Zero	2107	Medium
HFC	427A	0	Zero	2138	Medium
HFC	438A	0	Zero	2265	Medium
HFC	423A	0	Zero	2280	Medium
HFC	417A	0	Zero	2346	Medium
HFC	424A	0	Zero	2440	Medium
HFC	422D	0	Zero	2729	High
HFC	422A	0	Zero	3143	High
HFC	434A	0	Zero	3245	High
HFC	428A	0	Zero	3607	High
HFC	M089	0	Zero	3805	High
HFC	404A	0	Zero	3922	High
HFC	507A	0	Zero	3985	High
HFC	508B	0	Zero	13396	High
HFC	23	0	Zero	14800	High
HCFC	123	0,060	Medium	77	Low
HCFC	402B	0,030	Medium	2416	Medium
HCFC	401A	0,033	Medium	1182	Medium
HCFC	401B	0,036	Medium	1288	Medium
HCFC	409A	0,046	Medium	1909	Medium
HCFC	22	0,055	Medium	1810	Medium
HCFC	402A	0,019	Medium	2788	High
HCFC	408A	0,024	Medium	3152	High

ODP Band	Montreal Protocol Impact
Zero	No restriction
Medium	Subject to consumption phase down
High	100% global production & consumption ban

GWP band	
Less than 150	Low
150-2500	Medium
Greater than 2500	High

EU F-Gas 2 Impact[3]

No controls
Some supply restrictions and new equipment use bans
Substantial supply and use restrictions and new equipment bans

Results - Detached House Type

Baseline case

The embodied carbon of the Detached house type shows an initial result of 628kgCO_2/m^2 with the Baseline specification of materials.

Appendix B shows the breakdown of the embodied carbon by life cycle stage. The Product stage (A1-A3) shows the largest contribution with 47%. Also worth noting is the B1 Use phase, which shows that the refrigerant leakage of the ASHP is contributing to 8% of the overall embodied carbon.

The ten most contributing Resource types have been identified and are listed below:

1. Installations and systems
2. Precast concrete
3. Insulation
4. Doors and windows
5. Bricks and ceramics
6. Flooring
7. Ready-mix concrete
8. Wood
9. Gypsum and plaster
10. Other resource types

The above listed resource types represent a range of different materials. For instance, 'installations and systems' is composed of the consentient parts that form the basis of the residences building services (i.e. ASHP, radiators, pipes, boiler etc.).

Improved case

The embodied carbon of the Detached house type was calculated with the Improved specification of materials which shows a notable reduction of 19% against the Baseline case with a total of 507kgCO_2/m^2.

Figure 12 shows the reduction from the Baseline of the main building categories with the Improved specification.

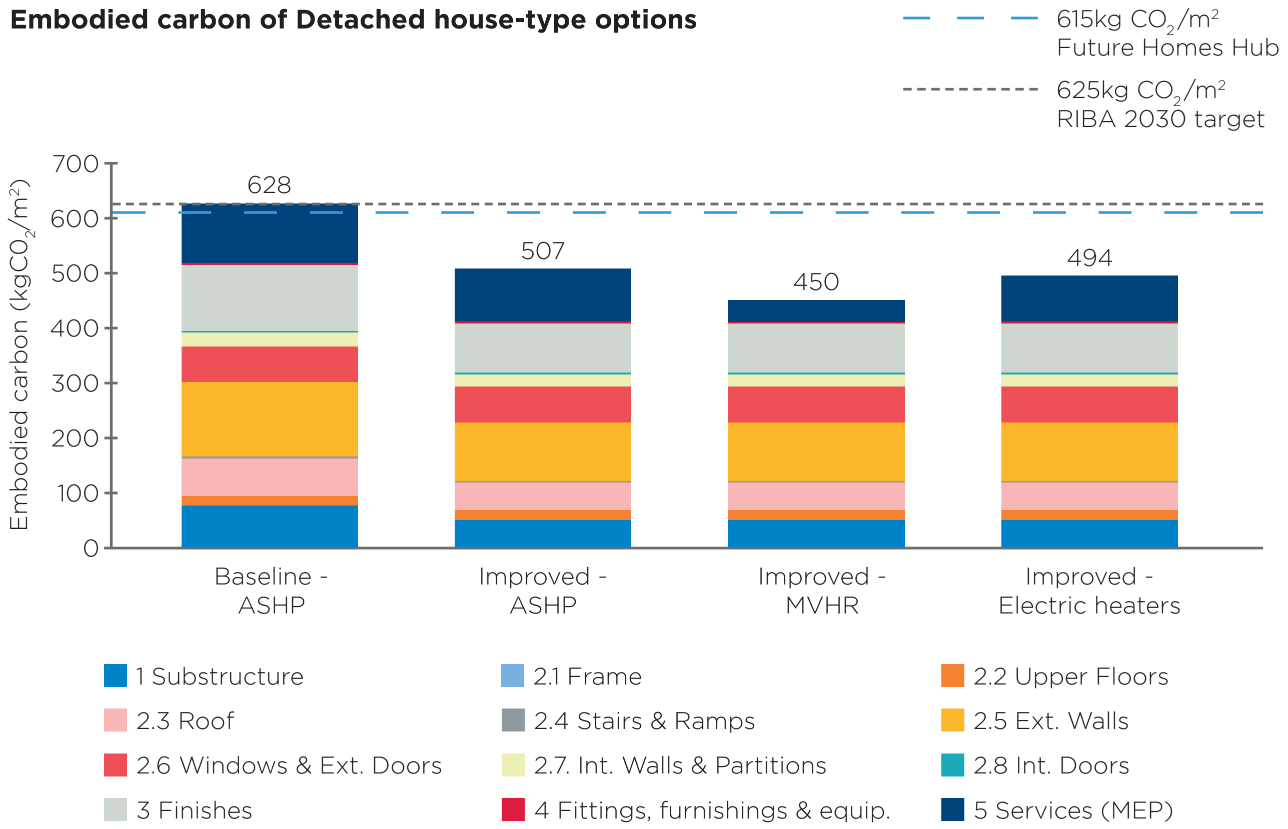
Building services options

Figure 12 shows the comparison of the different building services options. The results show that the MVHR option would further reduce the embodied carbon with the Improved specification of building materials to 450kgCO_2/m^2 which is a 28% reduction from the Baseline. The electric heaters option would result in a total embodied carbon of 494kgCO_2/m^2 which is a reduction of 21% from the Baseline.

Biogenic Carbon

The biogenic carbon stored (sequestered) in timber elements has been deducted. The subtraction of it has resulted in -96kgCO_2/m^2 of the embodied carbon for the Baseline and of -96kgCO_2/m^2 for all the remaining options.

Figure 12 Breakdown of embodied carbon for each of the servicing options.



Results - Semi-Detached House Type

Baseline case

The embodied carbon of the Semi-detached house type shows an initial result of 693kgCO_2/m^2 with the Baseline specification of materials.

Appendix B shows the breakdown of the embodied carbon by life cycle stage. The Product stage (A1-A3) shows the largest contribution with 40%. Also worth noting is the B1 Use phase, which shows that the refrigerant leakage of the ASHP is contributing to 13% of the overall embodied carbon.

The ten most contributing resource types have been identified and are listed below:

1. Installations and systems
2. Insulation
3. Precast concrete
4. Flooring
5. Bricks & ceramics
6. Doors & windows
7. Wood
8. Gypsum & plaster
9. Ready-mix concrete
10. Other resource types

The above listed resource types represent a range of different materials. For instance, 'installations and systems' is composed of the consentient parts that form the basis of the residences building services (i.e ASHP, radiators, pipes, boiler etc.).

Improved case

The embodied carbon of the semi-detached house type was calculated with the Improved specification of materials which shows a reduction of 17% against the Baseline case with a total of 576kgCO_2/m^2.

An option modelling the improved case ASHP with a timber frame wall would result in a reduction of the embodied carbon of 17% against the Baseline case with a total of 574kgCO_2/m^2. A comparison between the 2 improved ASHP models can be found in appendix B.

Figure 13 shows the reduction from the Baseline of the main building categories with the Improved specification.

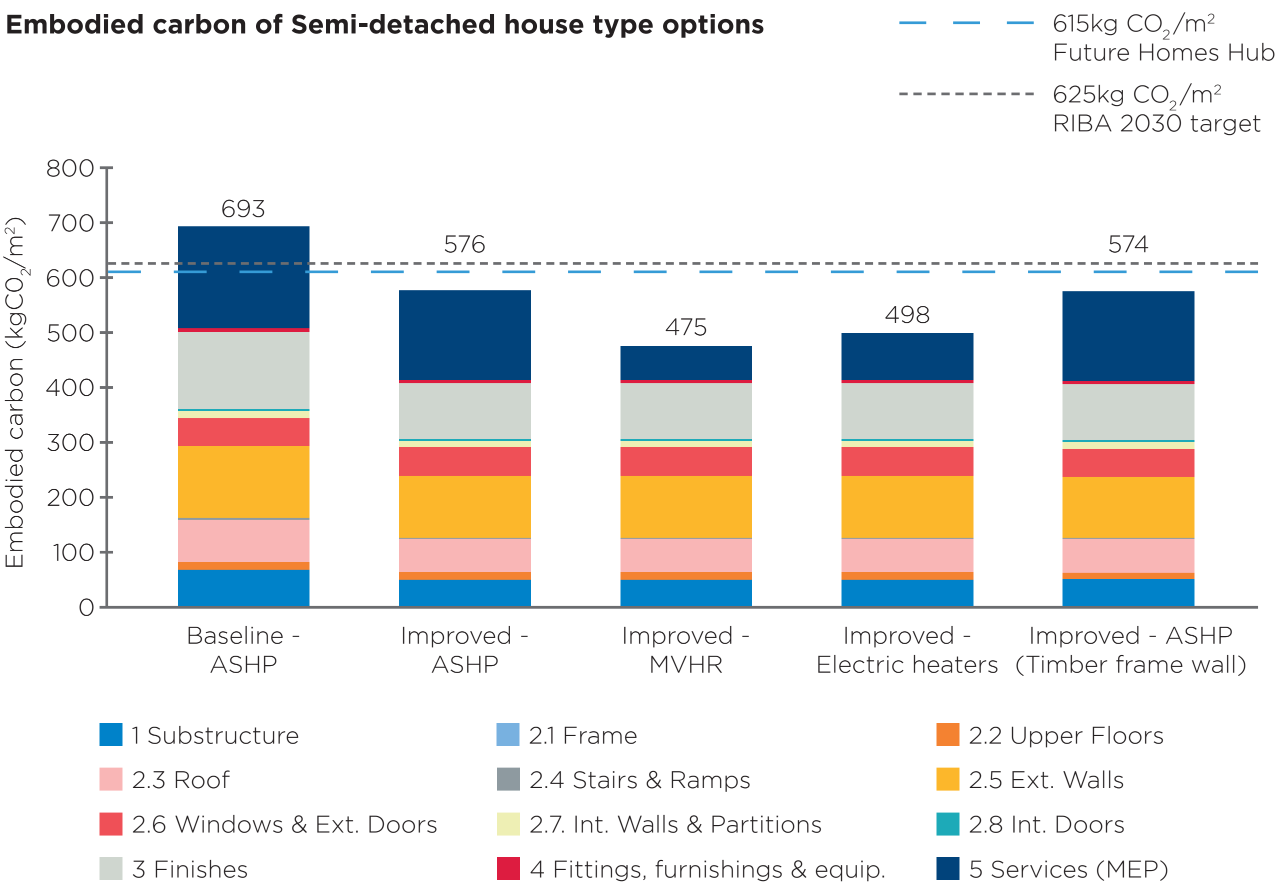
Building services options

Figure 13 shows the comparison of the different building services options. The results show that the MVHR option would further reduce the embodied carbon with the Improved specification of building materials to 475kgCO_2/m^2 which is a 32% reduction from the Baseline. The electric heaters option would result in a total embodied carbon of 498kgCO_2/m^2 which is a reduction of 28% from the Baseline.

Biogenic Carbon

The biogenic carbon stored (sequestered) in timber elements has been deducted. The subtraction of it has resulted in -73kgCO_2/m^2 of the embodied carbon for the Baseline and of -73kgCO_2/m^2 for the MVHR and electric heater options. The biogenic carbon redacted from the Improved ASHP with the timber frame walls option has resulted in -109kgCO_2/m^2 of the embodied carbon. This is due to the increased use of timber.

Figure 13 Breakdown of embodied carbon for each of the servicing options.



Results - Mid-Terraced House Type

Baseline case

The embodied carbon of the Mid-terraced house type shows an initial result of 818kgCO_2/m^2 with the Baseline specification of materials.

Appendix B shows the breakdown of the embodied carbon by life cycle stage. The Product stage (A1-A3) shows the largest contribution with 36%. Also worth noting is the B1 Use phase, which shows that the refrigerant leakage of the ASHP is contributing to 13% of the overall embodied carbon.

The ten most contributing resource types have been identified and are listed below:

1. Installations & systems
2. Insulation
3. Precast concrete
4. Flooring
5. Wood
6. Doors & windows
7. Gypsum & plaster
8. Plastics, membranes & roofing
9. Ready mix concrete
10. Other resource types

The above listed resource types represent a range of different materials. For instance, 'installations and systems' is composed of the consentient parts that form the basis of the residences building services (i.e ASHP, radiators, pipes, boiler etc).

Improved case

The embodied carbon of the Mid-terraced house type was calculated with the Improved specification of materials which shows a reduction of 18% against the Baseline case with a total of 675kgCO_2/m^2.

Figure 14 shows the reduction from the Baseline of the main building categories with the Improved specification.

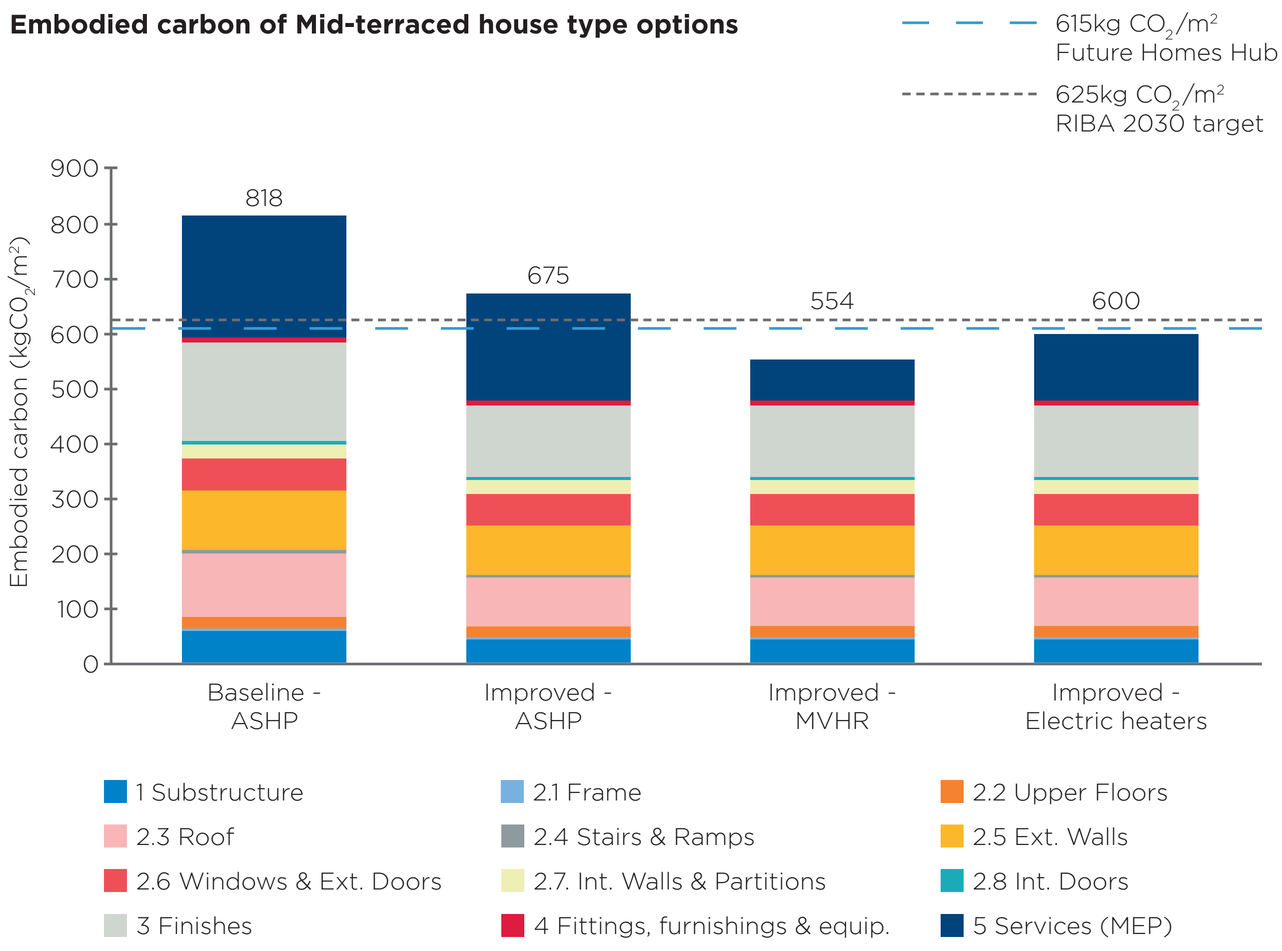
Building services options

Figure 14 shows the comparison of the different building services options. The results show that the MVHR option would further reduce the embodied carbon with the Improved specification of building materials to 554kgCO_2/m^2 which is a 32% reduction from the Baseline. The electric heaters option would result in a total embodied carbon of 600kgCO_2/m^2 which is a reduction of 27% from the Baseline.

Biogenic Carbon

The biogenic carbon stored (sequestered) in timber elements has been deducted. The subtraction of it has resulted in -134kgCO_2/m^2 of the embodied carbon for the Baseline and of -134kgCO_2/m^2 for all the remaining options.

Figure 14 Breakdown of embodied carbon for each of the servicing options.



Results - Apartment block

Baseline case

The embodied carbon of the Apartment block shows an initial result of 692kgCO_2/m^2 with the Baseline specification of materials.

Appendix B shows the breakdown of the embodied carbon by life cycle stage. The Product stage (A1-A3) shows the largest contribution with 51%. Also worth noting is the B1 Use phase, which shows that the refrigerant leakage of the ASHP is contributing to 3% of the overall embodied carbon. This is because it was specified that 4no. 5kW ASHP would serve the whole building (1no. ASHP per 4 dwellings).

The ten most contributing resource types have been identified and are listed below:

1. Precast concrete
2. Installations and systems
3. Insulation
4. Flooring
5. Ready-mix concrete
6. Gypsum & plaster
7. Doors & windows
8. Metals
9. Plastics, membranes & roofing
10. Other resource types

The above listed resource types represent a range of different materials. For instance 'precast concrete' is composed of the various precast products in the building (concrete blocks, ground floor slab etc).

Improved case

The embodied carbon of the Apartment block house type was calculated with the Improved specification of materials which shows a reduction of 18% against the Baseline case with a total of 570kgCO_2/m^2.

Figure 15 shows the reduction from the Baseline of the main building categories with the Improved specification.

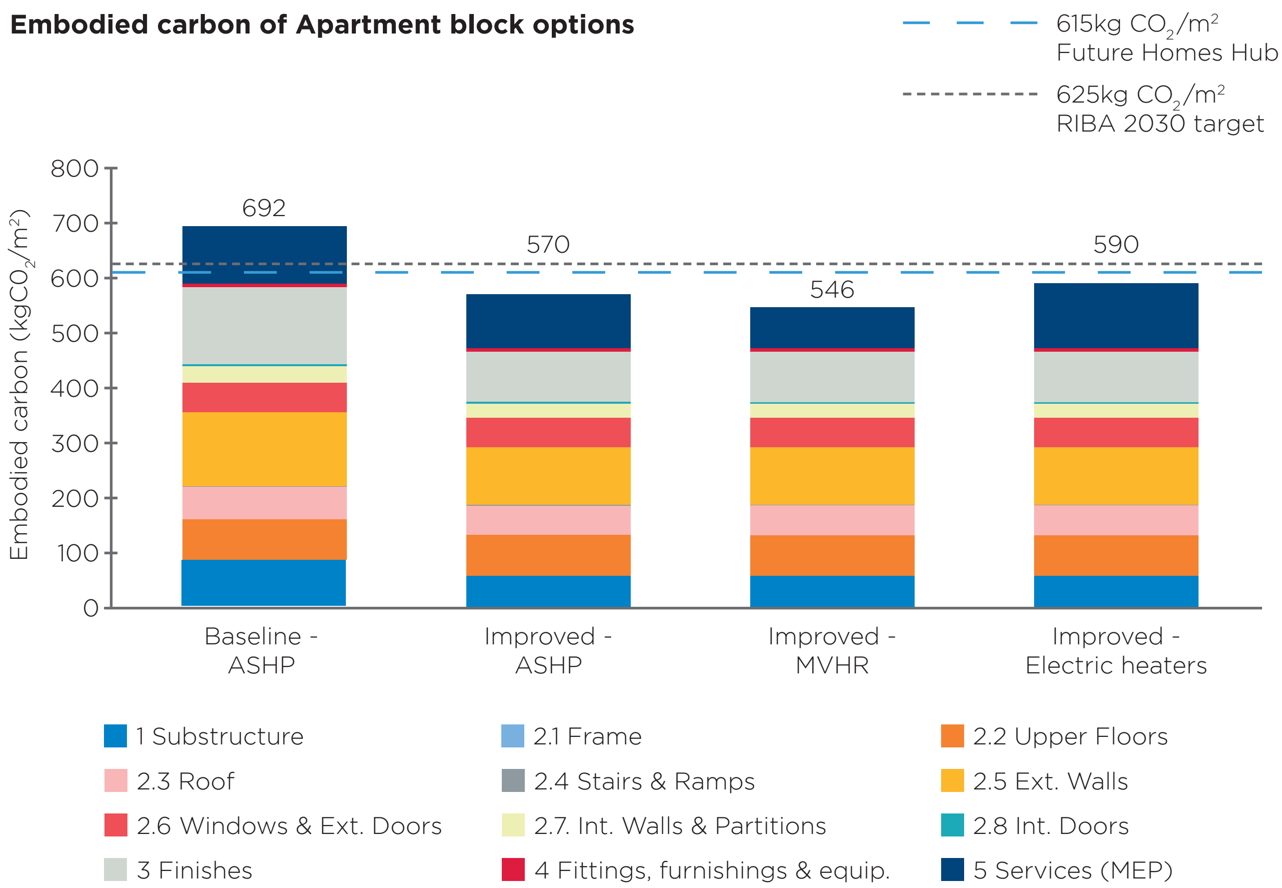
Building services options

Figure 15 shows the comparison of the different building services options. The results show that the MVHR option would further reduce the embodied carbon with the Improved specification of building materials to 546kgCO_2/m^2 which is a 21% reduction from the Baseline. The electric heaters option would result in a total embodied carbon of 590kgCO_2/m^2 which is a reduction of 15% from the Baseline.

Biogenic Carbon

The biogenic carbon stored (sequestered) in timber elements has been deducted. The subtraction of it has resulted in -1kgCO_2/m^2 of the embodied carbon for the Baseline and of -24kgCO_2/m^2 for all the remaining options. This is due to the replacement of the metal studs by timber studs in the partition walls for the Improved specification case.

Figure 15 Breakdown of embodied carbon for each of the servicing options.



Results - Project 80

In collaboration with Tricas Construction, Birmingham City University and select industry suppliers including Unilin Insulation, Midland Heart Housing Association's Project 80 was built to the Future Homes Standard (FHS) 3 years in advance of the 2025 legislation's introduction using masonry construction.

The development of high quality social homes is not connected to the gas grid and designed to provide between 75% to 80% reduction in operational carbon.

The calculation methodology specifies that as part of the LCA process each building element is to be broken down into its components for which embodied carbon factors need to be sourced.

The specification met the Future Homes Standard The materials specified and quantities taken within the calculation were provided by the project SAP Assessors and the project QS.

Applicable verified EPDs were used where available, then as per convention local data was included If neither of the first two were possible regional data was used.

The life cycle of the building was modelled over 60 years (There is a strong and valid case for modelling the extended life time expectancy of masonry construction beyond 100 years this should be considered in further policy development). Birmingham City University oversaw the calculation process.

Baseline

The embodied carbon of the Project 80 was calculated using final quantities taken from the Quantity Surveyor which shows a total of 450kgCO_2/m^2.

The whole life carbon target is 615kgCO_2/m^2 therefore it well achieves it. The other target 417kgCO_2/m^2 is for stages A1-A5 which this house satisfies too.

Figure 16 shows the reduction from the Baseline of the main building categories with the Improved specification.

As is demonstrated by the results, Project 80 has clearly met the Future Homes Hub Target of 615kgCO_2/m^2 and the RIBA Climate Challenge Target of 625 kgCO_2/m^2.

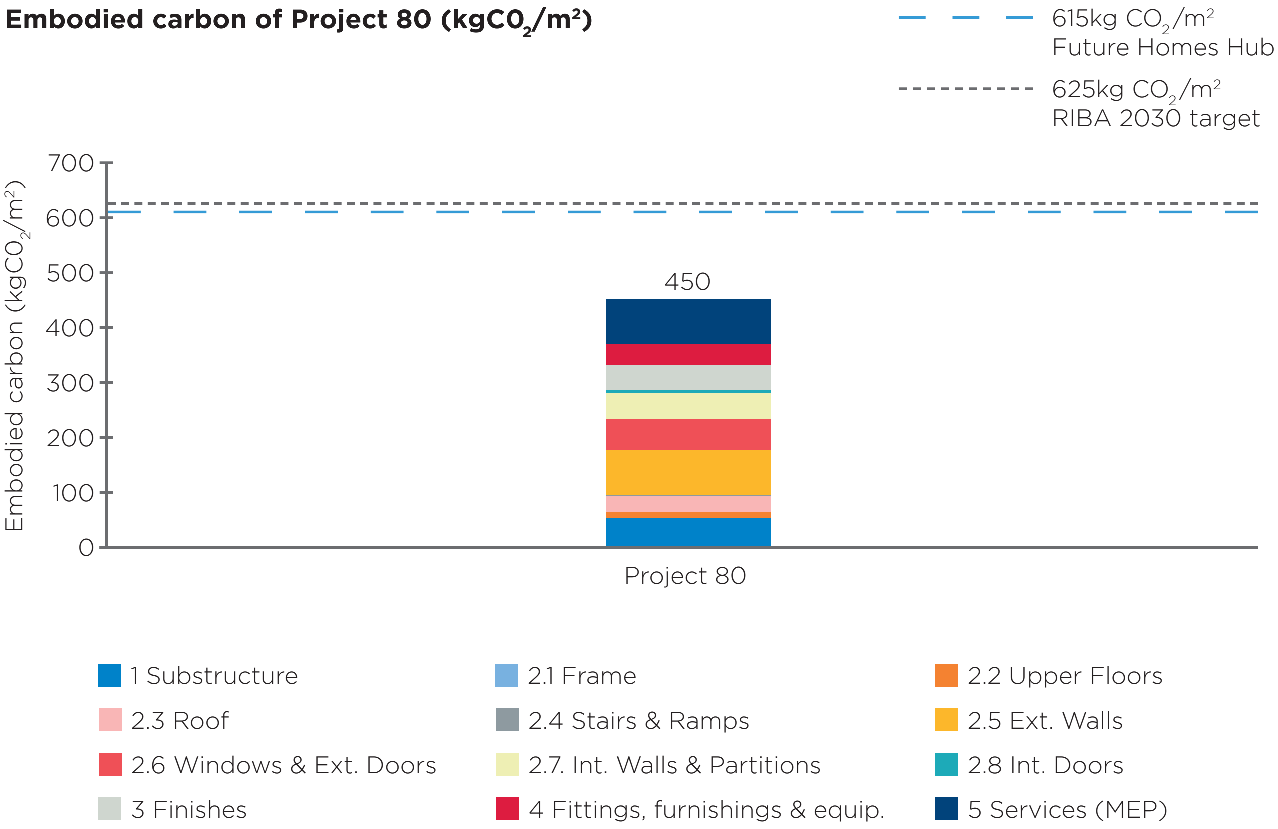
Building services options

The results show that the ASHP building services option utilised for Project 80 contributes 82kgCO_2 per m^2.

Biogenic Carbon

The biogenic carbon stored (sequestered) in timber elements has been deducted, the subtraction of it has resulted in -95kgCO_2/m^2 of the embodied carbon.

Figure 16 Breakdown of embodied carbon for each building element category. Visualisations are indicative only



Conclusions

The life cycle assessment (LCA) of the four dwelling types was carried out using typical construction systems with the incorporation of the following Unilin insulation products:

- Unilin Insulation Thin-R for ground floors and roofs and;
- CavityTherm insulation for cavity walls

The Environmental Product Declarations (EPD) for these products were used in the assessment.

Baseline and Improved specification

The results of the LCA of the dwelling types with the Baseline specification helped identify the most contributing materials. These were then replaced by materials which are less carbon-intensive to help reduce the overall embodied carbon of the dwellings.

The use of the Improved specification ensures that the RIBA 2030 target can be met for all dwellings aside from that of the Mid terrace House - Improved ASHP.

Biogenic carbon sequestration

Biogenic carbon is the carbon that is stored in biological materials, such as timber. This process is commonly referred to as sequestration.

Carbon accumulates in plants through the process of photosynthesis. Therefore, wood products can contribute to reducing the levels of carbon dioxide in the atmosphere and help mitigate climate change.

When a bio-based material is used for a building product, the carbon will be stored as long as the material service life or until the end of life of the building.

When comparing the Semi- detached Improved ASHP Masonry wall option with that of the Semi- detached Improved ASHP Timber frame wall option it was noted, that comparatively the results were similar despite the increased use of timber in the second option.

While it was initially expected that the increased use of timber elements would have a larger impact on reducing the Timber frame wall options associated embodied carbon, on review of the results it is detailed that any sequestered carbon is re-released into the atmosphere via the assumed incineration of the timber elements at their end of life (C1-C4 stage).

Building services

The results of the building services options appraisal show that for all of the dwellings the passive heating option with an MVHR would be the option with the lowest embodied carbon. This is mainly because of the reduced equipment and pipework required.

It is worth noting that for this option the fabric performance of the dwellings would need to be at a premium level as demonstrated in the insulation specification of each house type. This re-emphasises the importance of a fabric first approach when combating the climate challenge.

A notable trend across all specifications and building typologies indicates that the use of an ASHP system comes with a higher embodied carbon cost than the MVHR.

The electric heaters option while offering an improvement on the ASHP in the majority of cases would possibly not match its operational carbon performance.

Overall, the inclusion of the Unilin insulation can be seen to have a marked improvement on all dwelling types & contributes positively to each dwelling achieving the desired embodied carbon targets.

It should not be forgotten that it is important to balance the need to reduce the embodied carbon of a built asset against those to reduce operational carbon. Adopting a holistic approach to this and considering both in context is an important component to deciding on the correct building services option for a development.

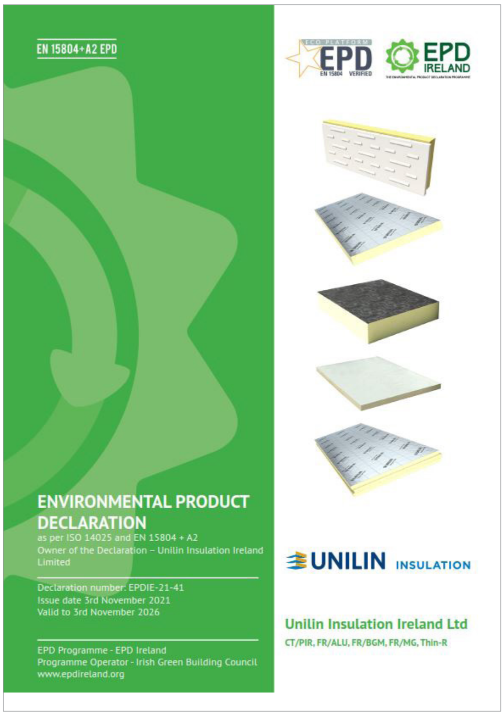
Future developments

Life cycle assessments are still a relatively new discipline. The parameters to which the assessments are calculated are quite fluid and these background changes have a measurable influence on the results.

However, as time goes on it is expected that these will normalise & the quality and breadth of material data available through One Click LCA will only increase.

The introduction of embodied carbon to governmental regulations, such as that proposed in the form of Part Z will only hasten the adoption of LCAs within the industry.

With this then, combined with the recent revision of the EN15804 standard to EN15804+A2, which means EPDs will be required to declare modules C1-C4 and module D. As well as the ongoing and future decarbonisation of the UK's electrical grid, it is expected that the overall embodied carbon of the modelled dwellings will decrease with time going forward.



Appendix. A - Detailed Results

Detached
Baseline ASHP

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	-265	12,201	715	581
2.2 Upper Floors	-8,947	2,794	28	389
2.3 Roof	-6,219	4,844	32	369
2.4 Stairs & Ramps	-598	342	4	63
2.5 Ext. Walls	0	21,438	223	1,058
2.6 Windows & Ext. Doors	-670	3,537	12	0
2.7 Int. Walls & Partitions	-1,106	2,819	51	221
2.8 Int. Doors	104	341	5	0
3 Finishes	-171	3,654	35	554
4 Fittings, furnishings & equipments	-30	135	1	6
5 Services (MEP)	0	3,446	162	31
TOTAL kg CO_2e	-17,901	55,552	1,269	3,272
TOTAL kg CO_2e/m^2				

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	1,021	14,254
0	0	0	0	9,039	3,303
0	3,504	876	1,757	7,741	12,905
0	0	0	0	605	417
0	0	0	189	2,417	25,325
0	3,910	978	3,639	759	12,165
0	0	0	1,215	1,228	4,428
0	0	0	362	-89	723
0	1,462	365	15,247	1,292	22,439
0	0	0	554	31	698
8,955	0	0	7,435	109	20,139
8,955	8,876	2,219	30,398	24,155	116,796
					628

Appendix. A - Detailed Results

Detached
Improved ASHP

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	-265	7,659	704	417
2.2 Upper Floors	-8,947	2,794	28	389
2.3 Roof	-6,219	3,670	31	348
2.4 Stairs & Ramps	-598	342	4	63
2.5 Ext. Walls	0	16,909	190	893
2.6 Windows & Ext. Doors	-670	3,537	12	0
2.7 Int. Walls & Partitions	-1,106	2,459	42	220
2.8 Int. Doors	104	341	5	0
3 Finishes	-204	2,180	36	429
4 Fittings, furnishings & equipments	-30	135	1	6
5 Services (MEP)	0	3,446	162	31
TOTAL kg CO_2e	-17,934	43,473	1,215	2,797
TOTAL kg CO_2e/m^2				

Detached
Improved MVHR

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
5 Services (MEP)	0	2,173	161	11
TOTAL kg CO_2e	-17,934	42,199	1,214	2,777
TOTAL kg CO_2e/m^2				

Detached
Improved Electric Heaters

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
5 Services (MEP)	0	4,804	166	183
TOTAL kg CO_2e	-17,934	44,830	1,219	2,949
TOTAL kg CO_2e/m^2				

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	1,005	9,519
0	0	0	0	9,039	3,303
0	2,085	521	1,166	7,739	9,342
0	0	0	0	605	417
0	0	0	189	1,593	19,775
0	3,910	978	3,639	759	12,165
0	0	0	1,215	1,216	4,046
0	0	0	362	-89	723
0	1,462	365	10,580	1,627	16,476
0	0	0	554	31	698
6,683	0	0	7,435	109	17,866
6,683	7,458	1,864	25,139	23,634	94,329
					507

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	4,871	102	7,318
0	7,458	1,864	22,576	23,627	83,781
					450

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	10,190	125	15,468
0	7,458	1,864	27,894	23,650	91,931
					494

Appendix. A - Detailed Results

Semi-detached
Baseline ASHP

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	0	11,315	594	483
2.2 Upper Floors	-6,008	2,169	19	291
2.3 Roof	-6,061	5,215	32	425
2.4 Stairs & Ramps	-523	316	4	58
2.5 Ext. Walls	0	21,340	216	1,071
2.6 Windows & Ext. Doors	-344	2,077	6	0
2.7 Int. Walls & Partitions	-1,294	1,091	12	136
2.8 Int. Doors	73	241	4	0
3 Finishes	-184	4,668	44	707
4 Fittings, furnishings & equipments	-59	271	2	11
5 Services (MEP)	0	5,718	322	46
TOTAL kg CO_2e	-14,401	54,421	1,255	3,228
TOTAL kg CO_2e/m^2				

Semi-detached
Improved ASHP

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	0	7,936	584	362
2.2 Upper Floors	-6,008	2,169	19	291
2.3 Roof	-6,061	4,236	30	413
2.4 Stairs & Ramps	-523	316	4	58
2.5 Ext. Walls	0	17,728	183	974
2.6 Windows & Ext. Doors	-344	2,077	6	0
2.7 Int. Walls & Partitions	-1,294	1,091	12	136
2.8 Int. Doors	73	241	4	0
3 Finishes	-226	2,678	45	537
4 Fittings, furnishings & equipments	-59	271	2	11
5 Services (MEP)	0	5,718	322	46
TOTAL kg CO_2e	-14,443	44,462	1,212	2,828
TOTAL kg CO_2e/m^2				

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	964	13,356
0	0	0	0	6,070	2,541
0	4,670	1,168	1,992	8,092	15,533
0	0	0	0	529	384
0	0	0	697	2,746	26,069
0	4,823	1,206	2,125	386	10,279
0	0	0	1,172	1,364	2,481
0	0	0	255	-63	510
0	1,340	335	19,347	1,645	27,902
0	0	0	1,108	63	1,396
17,911	0	0	12,500	209	36,707
17,911	10,833	2,708	39,197	22,005	137,158
					693

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	950	9,833
0	0	0	0	6,070	2,541
0	3,151	788	1,359	8,089	12,006
0	0	0	0	529	384
0	0	0	697	2,700	22,282
0	4,823	1,206	2,125	386	10,279
0	0	0	1,172	1,364	2,481
0	0	0	255	-63	510
0	1,340	335	13,211	2,085	20,005
0	0	0	1,108	63	1,396
13,365	0	0	12,500	209	32,161
13,365	9,314	2,328	32,428	22,383	113,878
					576

Appendix. A - Detailed Results

Semi-detached
Improved MVHR

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
5 Services (MEP)	0	3,543	321	19
TOTAL kg CO_2e	-14,443	42,287	1,210	2,801
TOTAL kg CO_2e/m^2				

Semi-detached
Improved Electric Heaters

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
5 Services (MEP)	0	5,035	324	125
TOTAL kg CO_2e	-14,443	43,779	1,214	2,907
TOTAL kg CO_2e/m^2				

Semi-detached
Improved ASHP with Timber

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	0	7,936	584	362
2.2 Upper Floors	-6,008	2,169	19	291
2.3 Roof	-6,061	4,236	30	413
2.4 Stairs & Ramps	-523	316	4	58
2.5 Ext. Walls	-7,060	16,492	158	1,118
2.6 Windows & Ext. Doors	-344	2,077	6	0
2.7 Int. Walls & Partitions	-1,294	1,091	12	136
2.8 Int. Doors	73	241	4	0
3 Finishes	-226	2,678	45	537
4 Fittings, furnishings & equipments	-59	271	2	11
5 Services (MEP)	0	5,718	322	46
TOTAL kg CO_2e	-21,504	43,225	1,186	2,972
TOTAL kg CO_2e/m^2				

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	8,129	201	12,213
0	9,314	2,328	28,057	22,375	93,930
					475

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	11,153	217	16,855
0	9,314	2,328	31,081	22,391	98,572
					498

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	950	9,833
0	0	0	0	6,070	2,541
0	3,151	788	1,359	8,089	12,006
0	0	0	0	529	384
0	0	0	697	10,447	21,852
0	4,823	1,206	2,125	386	10,279
0	0	0	1,172	1,364	2,481
0	0	0	255	-63	510
0	1,340	335	13,211	2,085	20,005
0	0	0	1,108	63	1,396
13,365	0	0	12,500	209	32,161
13,365	8,314	2,329	32,427	30,129	113,448
					574

Appendix. A - Detailed Results

Mid-terraced
Baseline ASHP

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	0	4,195	213	178
2.1 Frame	0	307	1	10
2.2 Upper Floors	-5,454	1,380	16	213
2.3 Roof	-3,571	3,245	21	264
2.4 Stairs & Ramps	-542	322	4	60
2.5 Ext. Walls	0	7,542	99	379
2.6 Windows & Ext. Doors	-172	961	3	0
2.7 Int. Walls & Partitions	-1,163	946	10	118
2.8 Int. Doors	61	201	3	0
3 Finishes	-143	2,388	22	364
4 Fittings, furnishings & equipments	-30	135	1	6
5 Services (MEP)	0	2,860	161	25
TOTAL kg CO_2e	-11,014	24,483	553	1,616
TOTAL kg CO_2e/m^2				

Mid-terraced
Improved ASHP

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	0	3,025	209	137
2.1 Frame	0	307	1	10
2.2 Upper Floors	-5,454	1,380	16	213
2.3 Roof	-3,571	2,479	19	252
2.4 Stairs & Ramps	-542	322	4	60
2.5 Ext. Walls	0	5,920	79	343
2.6 Windows & Ext. Doors	-172	961	3	0
2.7 Int. Walls & Partitions	-1,163	946	10	118
2.8 Int. Doors	61	201	3	0
3 Finishes	-171	1,396	23	278
4 Fittings, furnishings & equipments	-30	135	1	6
5 Services (MEP)	0	2,860	161	25
TOTAL kg CO_2e	-11,042	19,934	529	1,440
TOTAL kg CO_2e/m^2				

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	396	4,982
0	0	0	0	5	324
0	0	0	0	5,508	1,664
0	2,988	747	1,352	4,661	9,706
0	0	0	0	548	392
0	0	0	0	1,018	9,038
0	2,222	555	984	192	4,744
0	0	0	1,016	1,223	2,151
0	0	0	213	-52	425
0	769	192	10,408	894	14,892
0	0	0	554	31	698
8,955	0	0	6,252	105	18,358
8,955	5,978	1,495	20,778	14,530	67,374
					818

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	391	3,761
0	0	0	0	5	324
0	0	0	0	5,508	1,664
0	2,016	504	947	4,659	7,305
0	0	0	0	548	392
0	0	0	0	991	7,333
0	2,222	555	984	192	4,744
0	0	0	1,016	1,223	2,151
0	0	0	213	-52	425
0	769	192	7,142	1,103	10,732
0	0	0	554	31	698
6,683	0	0	6,252	105	16,085
6,683	5,006	1,252	17,107	14,703	55,612
					675

Appendix. A - Detailed Results

Mid-terraced
Improved MVHR

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
5 Services (MEP)	0	1,781	160	10
TOTAL kg CO_2e	-11,042	18,855	529	1,425
TOTAL kg CO_2e/m^2				

Mid-terraced
Improved Electric Heaters

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
5 Services (MEP)	0	3,008	163	92
TOTAL kg CO_2e	-11,042	20,083	531	1,508
TOTAL kg CO_2e/m^2				

Apartment block
Baseline ASHP

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	0	131,975	7,164	5,888
2.2 Upper Floors	0	108,893	2,739	1,397
2.3 Roof	0	60,695	1,598	2,035
2.4 Stairs & Ramps	-233	1,951	28	21
2.5 Ext. Walls	0	168,425	2,011	7,893
2.6 Windows & Ext. Doors	0	20,345	52	0
2.7 Int. Walls & Partitions	0	25,901	255	1,912
2.8 Int. Doors	654	2,146	33	0
3 Finishes	-1,462	52,959	599	7,767
4 Fittings, furnishings & equipments	-472	2,164	20	89
5 Services (MEP)	-23	34,212	2,590	186
TOTAL kg CO_2e	-1,537	609,666	17,089	27,188
TOTAL kg CO_2e/m^2				

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	4,084	101	6,136
0	5,006	1,252	14,939	14,699	45,663
					554

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	6,569	113	9,945
0	5,006	1,252	17,424	14,711	49,473
					600

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	6,319	151,346
0	0	0	10,324	5,119	128,473
0	15,825	3,956	8,236	8,459	100,803
0	0	0	0	277	2,043
0	14,533	3,633	9,364	23,735	229,594
0	40,391	10,098	20,807	410	92,103
0	0	0	22,970	1,184	52,223
0	0	0	2,276	-557	4,551
0	8,784	2,196	158,321	13,760	242,924
0	0	0	8,861	503	11,165
35,822	20,794	5,199	77,049	1,746	177,574
35,822	100,327	25,082	318,209	60,955	1,192,799
					692

Appendix. A - Detailed Results

Apartment block
Improved ASHP

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	0	82,323	7,164	3,832
2.2 Upper Floors	0	107,353	2,739	1,197
2.3 Roof	0	52,985	1,597	1,726
2.4 Stairs & Ramps	-233	1,951	28	21
2.5 Ext. Walls	0	122,281	1,480	5,720
2.6 Windows & Ext. Doors	0	20,345	52	0
2.7 Int. Walls & Partitions	-39,067	25,972	318	2,938
2.8 Int. Doors	654	2,146	33	0
3 Finishes	-2,410	32,768	610	5,663
4 Fittings, furnishings & equipments	-472	2,164	20	89
5 Services (MEP)	-23	34,212	2,590	186
TOTAL kg CO_2e	-41,552	484,500	16,630	21,371
TOTAL kg CO_2e/m^2				

Apartment block
Improved MVHR

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
5 Services (MEP)	-23	29,027	2,585	78
TOTAL kg CO_2e	-41,552	479,316	16,626	21,263
TOTAL kg CO_2e/m^2				

Apartment block
Improved Electric Heaters

	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
5 Services (MEP)	-23	56,786	2,680	1,499
TOTAL kg CO_2e	-41,552	507,075	16,720	22,684
TOTAL kg CO_2e/m^2				

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	9,521	102,840
0	0	0	10,324	5,119	126,731
0	15,825	3,956	8,235	8,459	92,784
0	0	0	0	277	2,043
0	14,533	3,633	9,364	22,980	179,993
0	40,391	10,098	20,807	410	92,103
0	0	0	13,903	40,527	44,591
0	0	0	2,276	-557	4,551
0	8,784	2,196	94,819	15,491	157,921
0	0	0	8,861	503	11,165
26,730	20,794	5,199	77,049	1,746	168,482
26,730	100,327	25,082	245,639	104,476	983,204
					570

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	20,794	5,199	66,623	1,723	126,005
0	100,327	25,082	235,214	104,453	940,730
					546

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	20,794	5,199	113,193	2,119	202,246
0	100,327	25,082	281,783	104,850	1,016,968
					590

Appendix. A - Detailed Results

Project 80 Townhouse

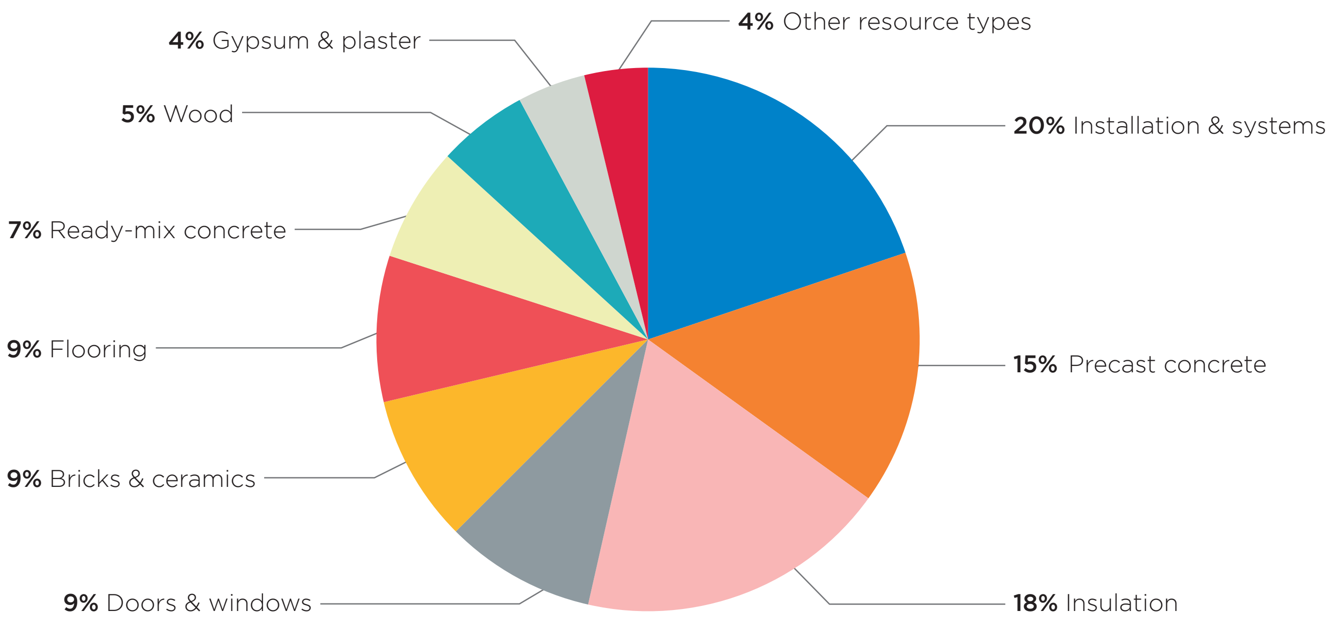
	Sequestered carbon	A1-A3 Product Stage	A4 Transportation to site	A5 Site operations
1 Substructure	0	4,007	306	309
2.2 Upper Floors	-5,195	934	15	164
2.3 Roof	-2,049	893	15	61
2.4 Stairs & Ramps	-554	65	4	13
2.5 Ext. Walls	0	6,821	83	530
2.6 Windows & Ext. Doors	-129	1,368	3	0
2.7 Int. Walls & Partitions	-495	2,521	35	239
2.8 Int. Doors	-469	270	4	0
3 Finishes	-135	1,366	14	184
4 Fittings, furnishings & equipments	-125	682	3	28
5 Services (MEP)	0	3,023	6	14
TOTAL kg CO_2e	-9,152	21,949	487	1,542
TOTAL kg CO_2e/m^2				

B1 Use Phase	B2 Maintenance	B3 Repair	B4-B5 Replacement	C1-C4 End of Life stage	TOTAL kg CO_2e
0	0	0	0	426	5,047
0	0	0	0	5,247	1,165
0	825	206	488	2,333	2,772
0	0	0	0	561	89
0	0	0	0	657	8,091
0	2,069	517	1,386	145	5,358
0	0	0	1,638	609	4,546
0	0	0	285	480	569
0	210	52	2,575	173	4,440
0	0	0	2,757	130	3,474
0	0	0	4,856	14	7,913
0	3,104	776	13,984	10,774	43,465
					450

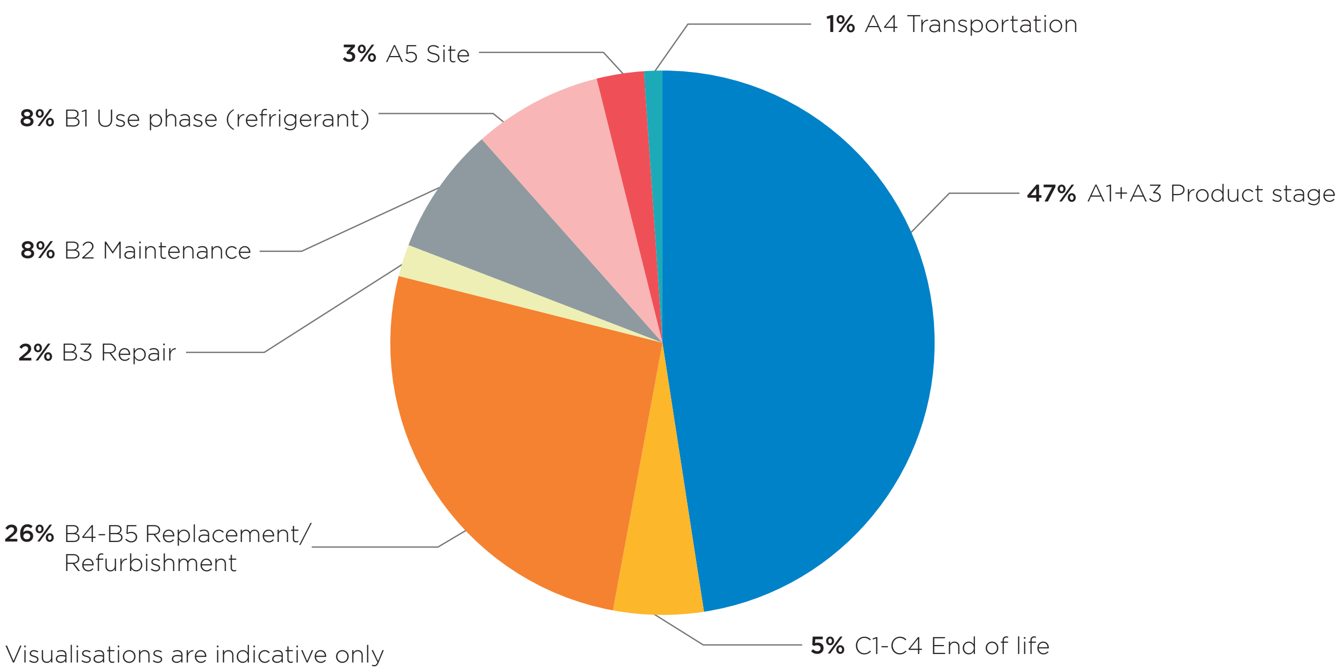
Appendix. B - Detailed Results

Detached House Type
Most contributing materials (Baseline)

Most contributing resource type



Total carbon lifecycle stages

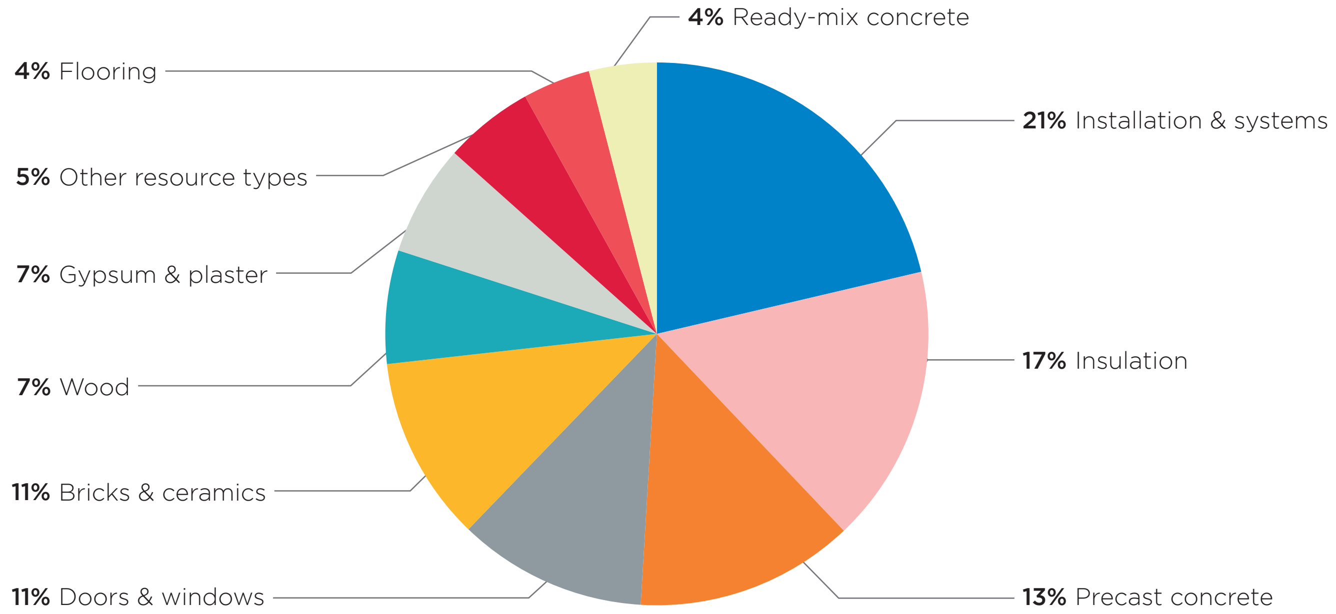


Visualisations are indicative only

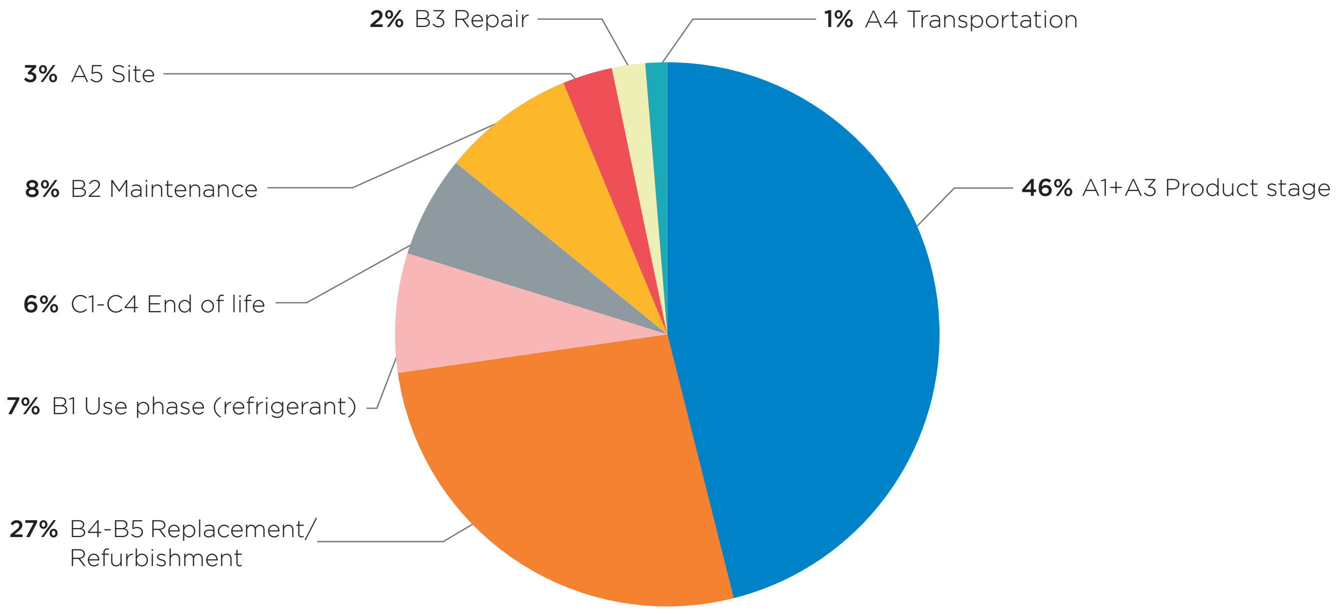
Appendix. B - Detailed Results

Detached House Type
Most contributing materials (Improved ASHP)

Most contributing resource type



Total carbon lifecycle stages



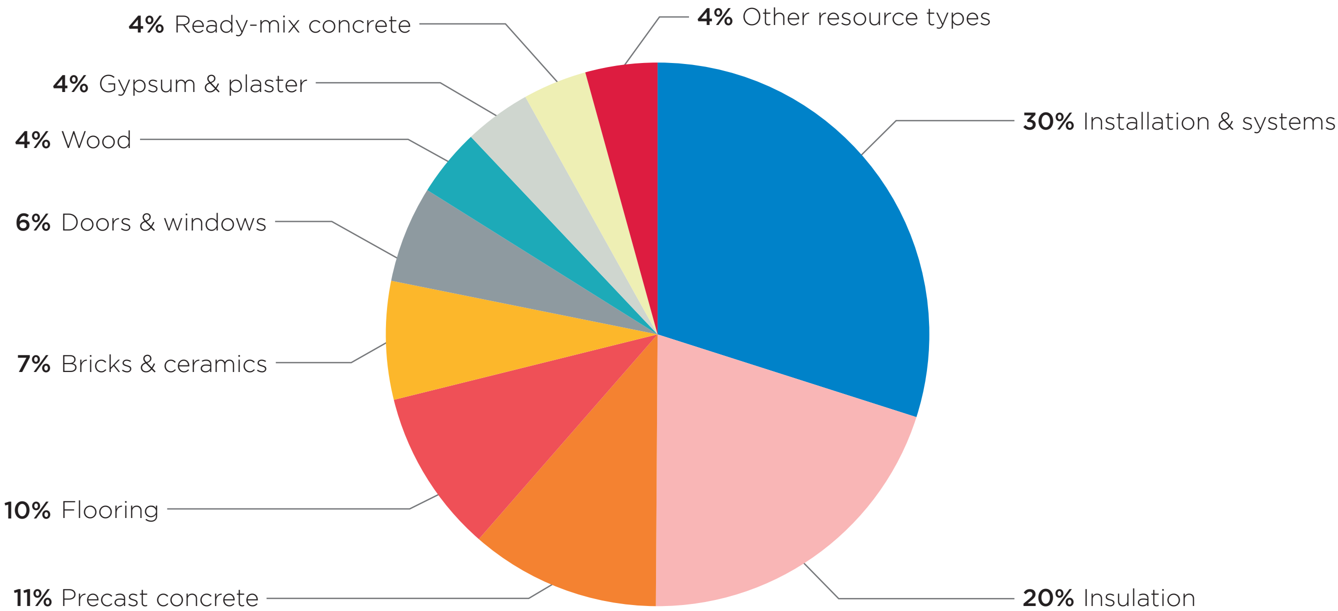
Visualisations are indicative only

Appendix. B - Detailed Results

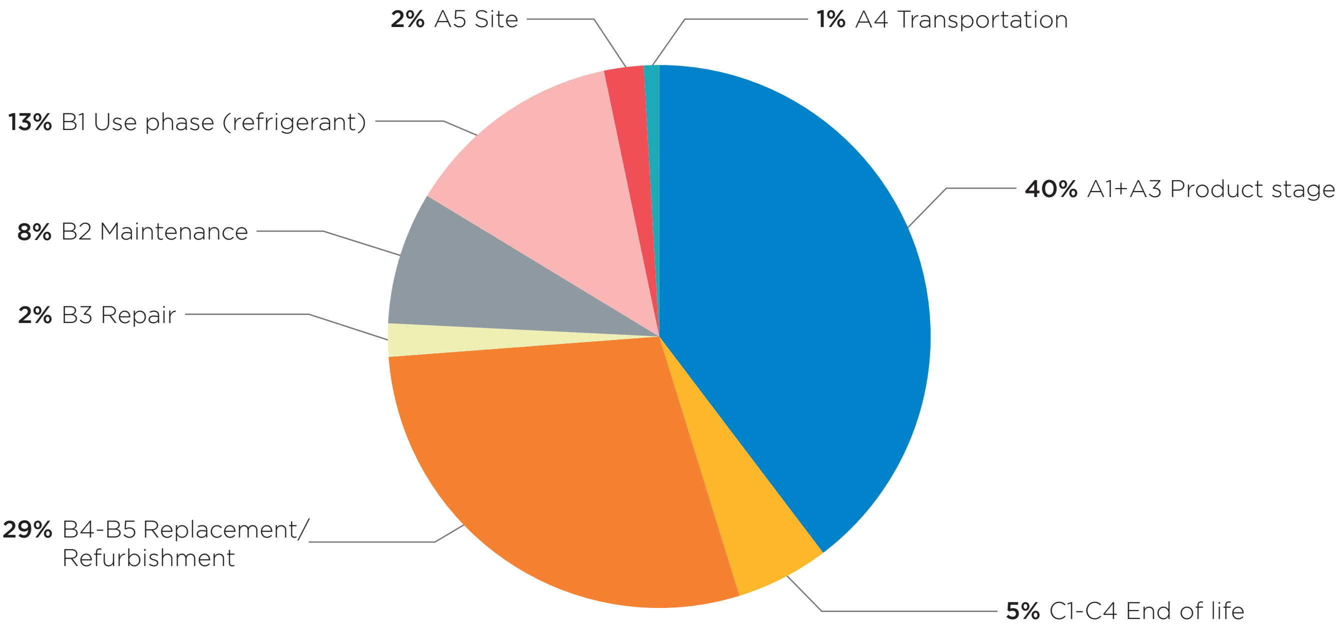
Semi-Detached House Type

Most contributing materials (Baseline ASHP)

Most contributing resource type



Total carbon lifecycle stages

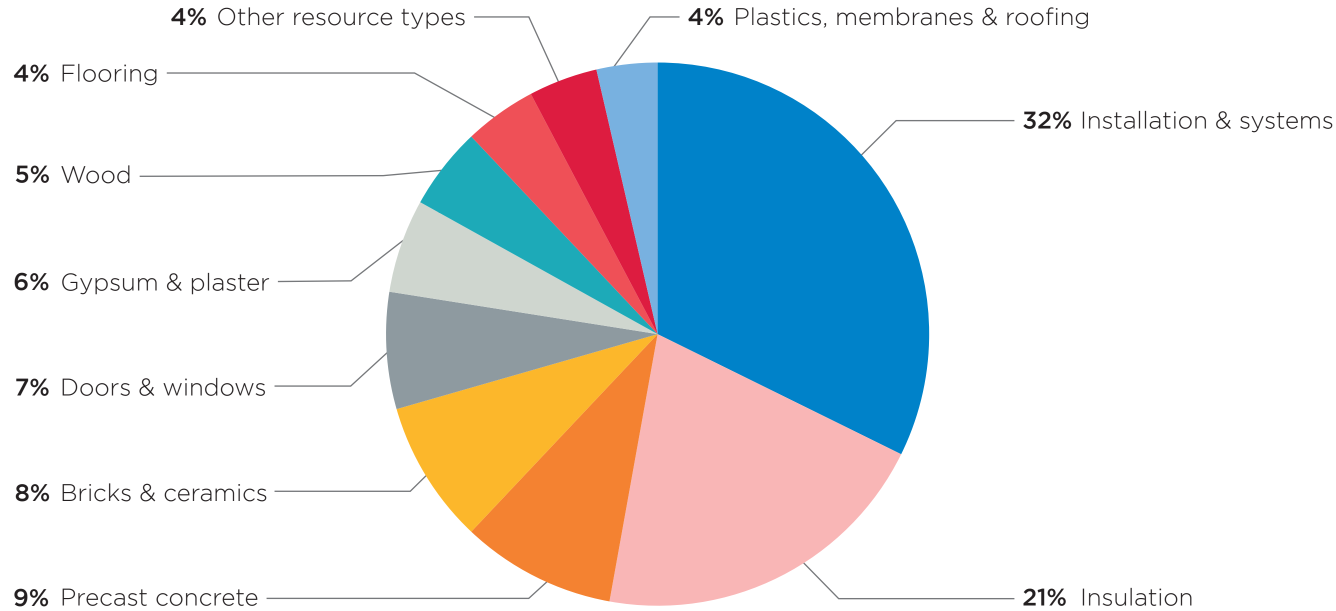


Visualisations are indicative only

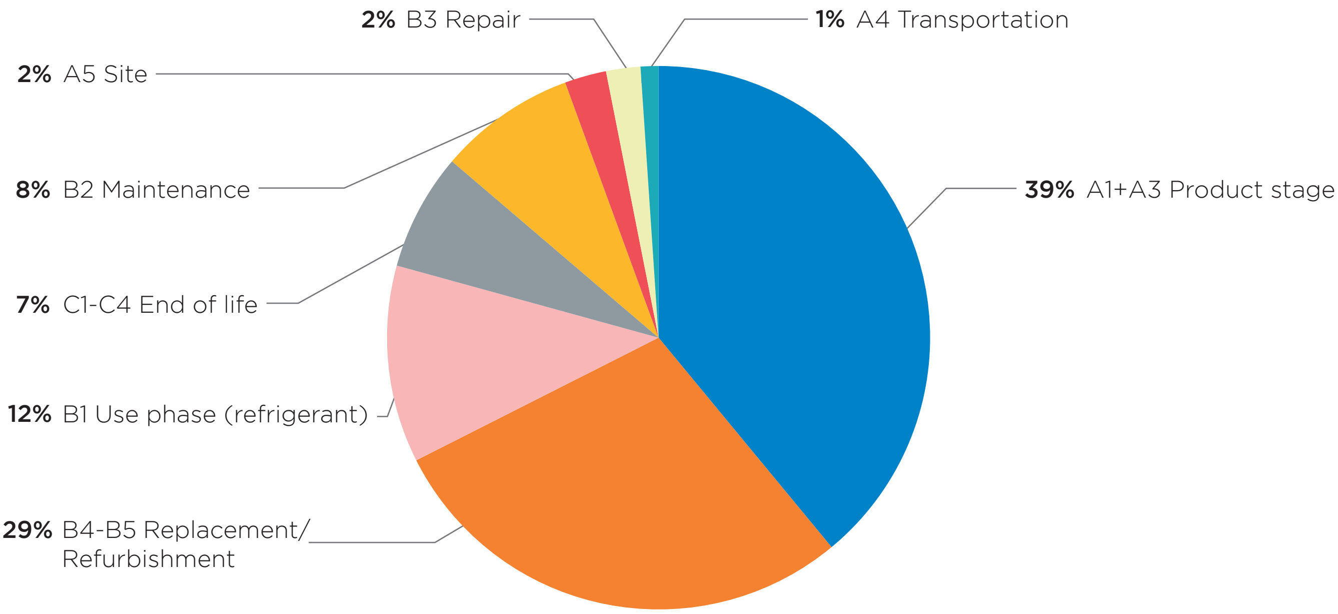
Appendix. B - Detailed Results

Semi-Detached House Type
Most contributing materials (Improved ASHP - Masonry Wall)

Most contributing resource type



Total carbon lifecycle stages

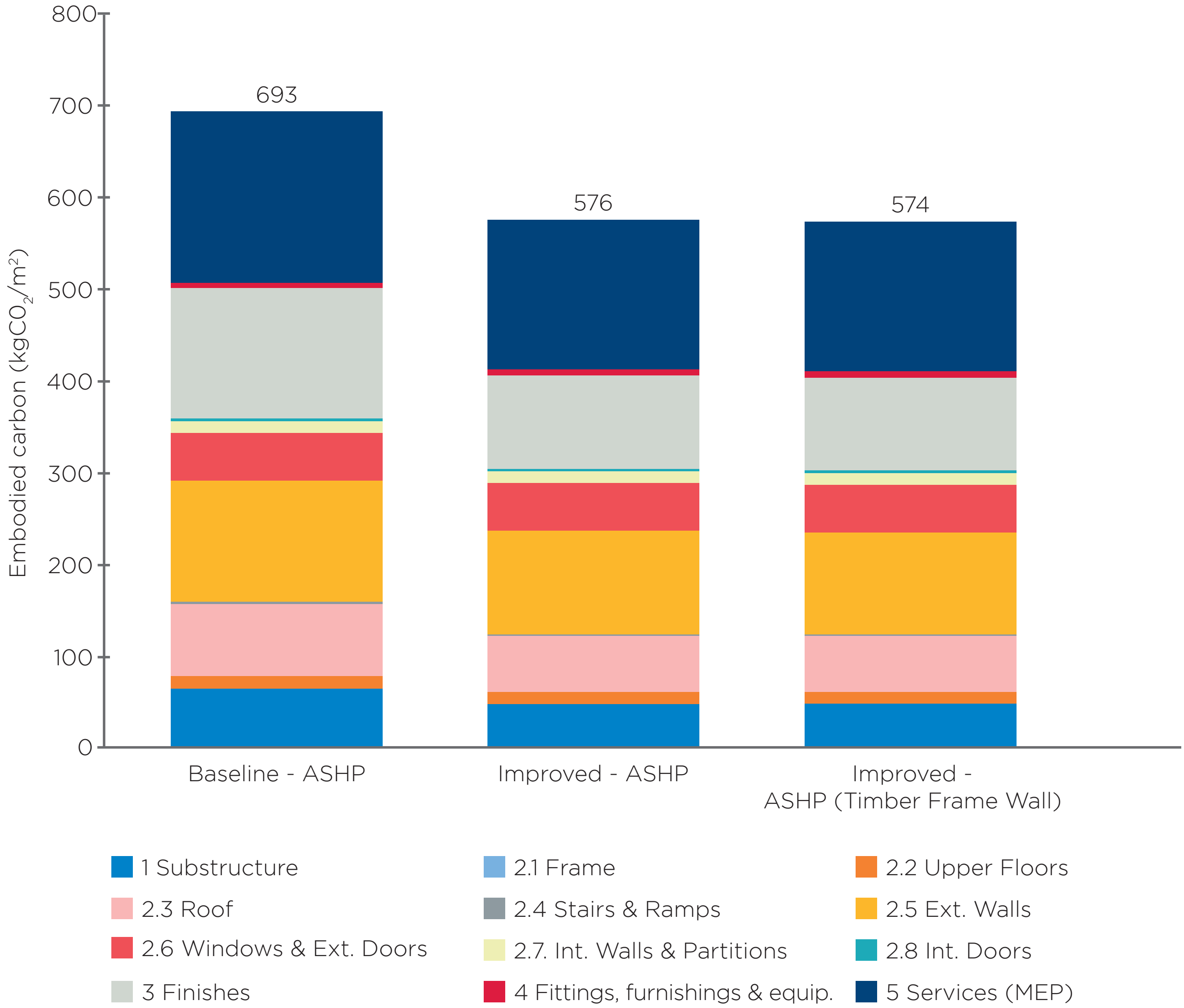


Visualisations are indicative only

Appendix. B - Detailed Results

Semi-Detached House Type
Embodied carbon comparison of Improved ASHP
(Masonry wall vs Timber frame wall)

Embodied carbon comparison of Semi-detached house type options

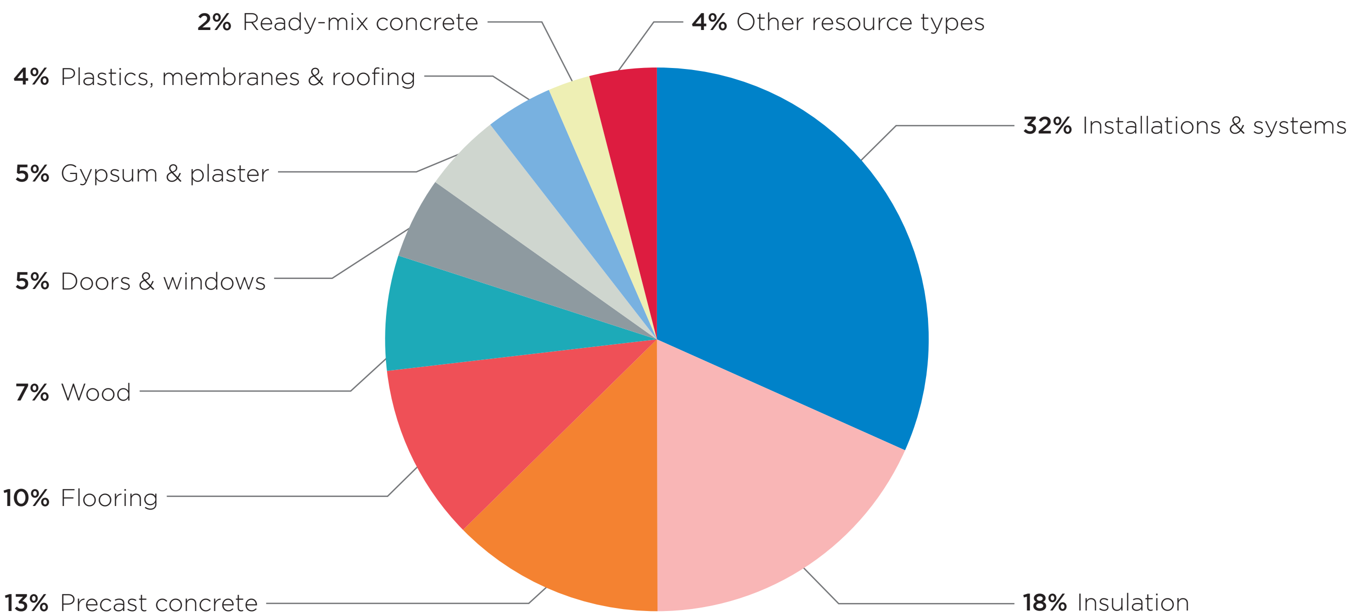


Visualisations are indicative only

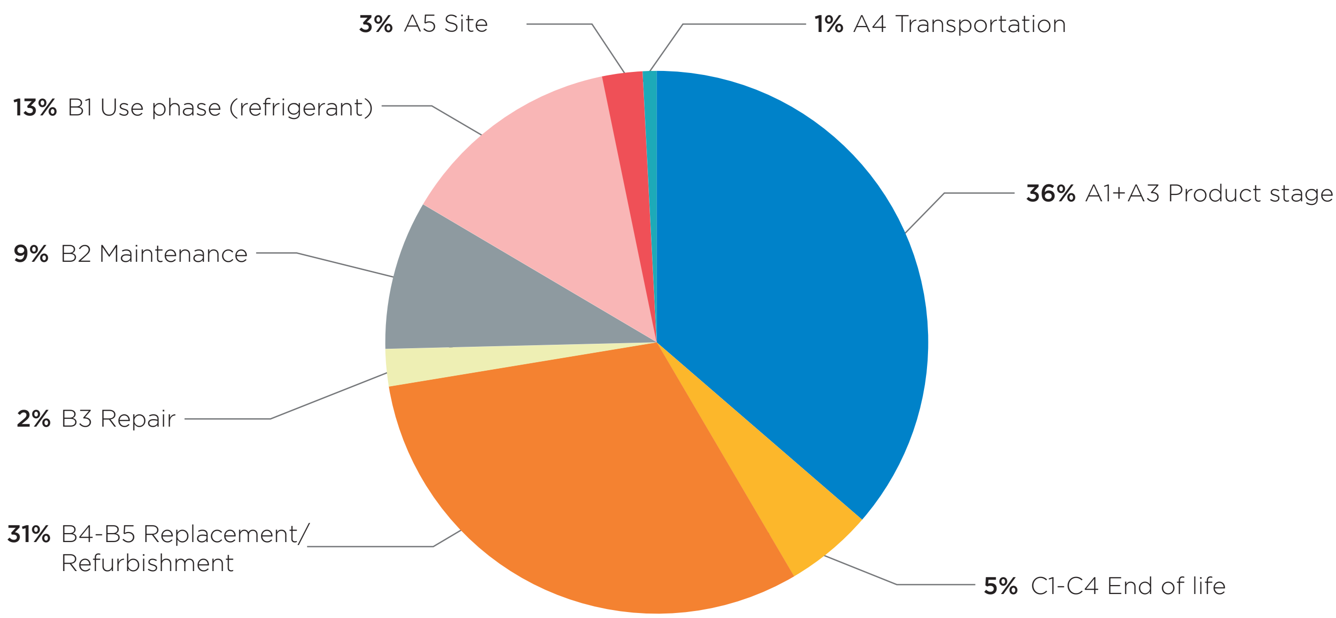
Appendix. B - Detailed Results

Mid-Terraced House Type
Most contributing materials (Baseline ASHP)

Most contributing resource type



Total carbon lifecycle stages

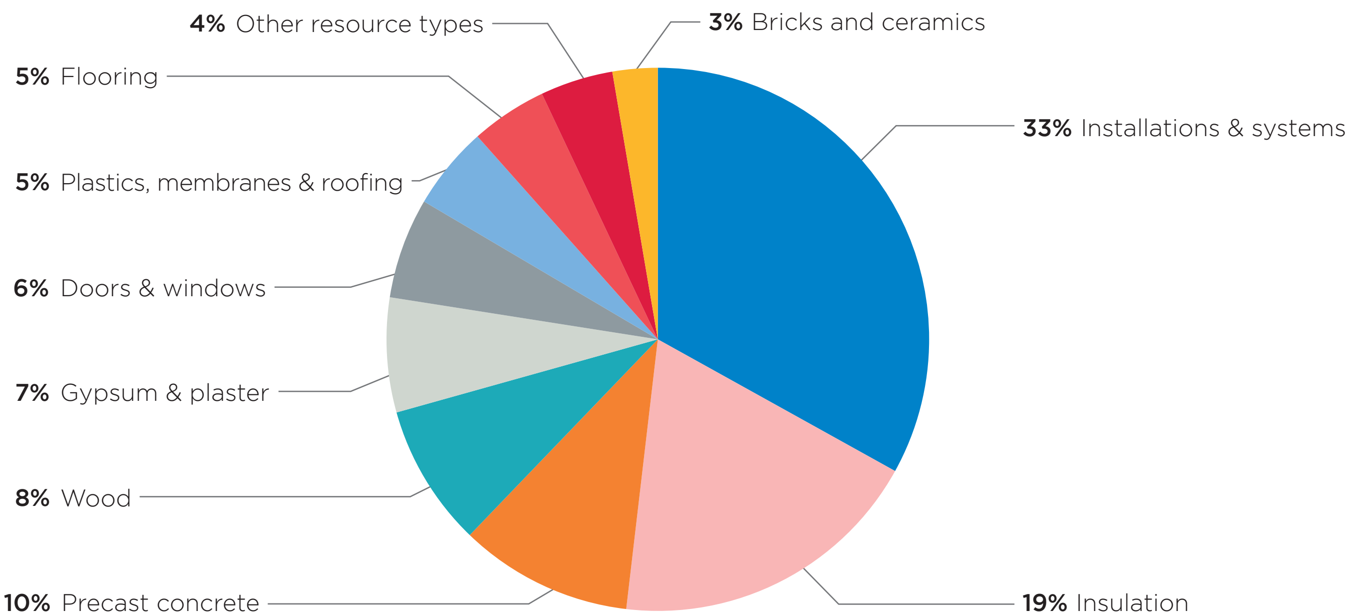


Visualisations are indicative only

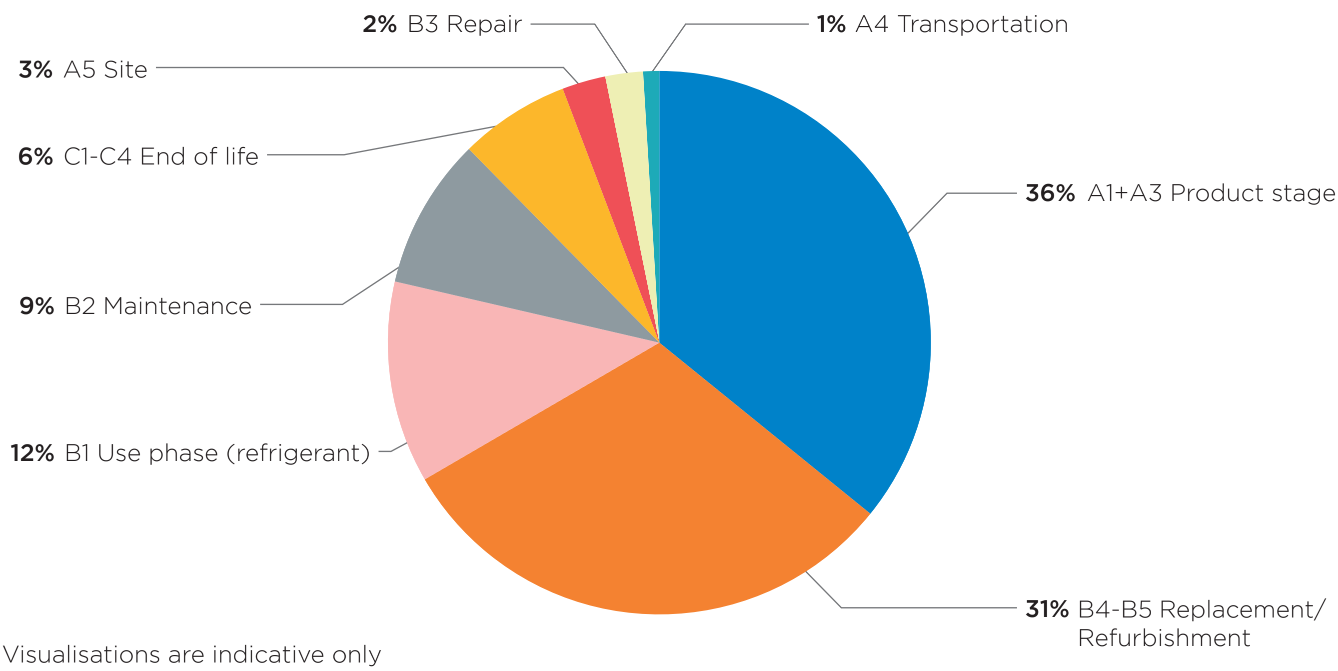
Appendix. B - Detailed Results

Mid-Terraced House Type
Most contributing materials (Improved ASHP)

Most contributing resource type



Total carbon lifecycle stages

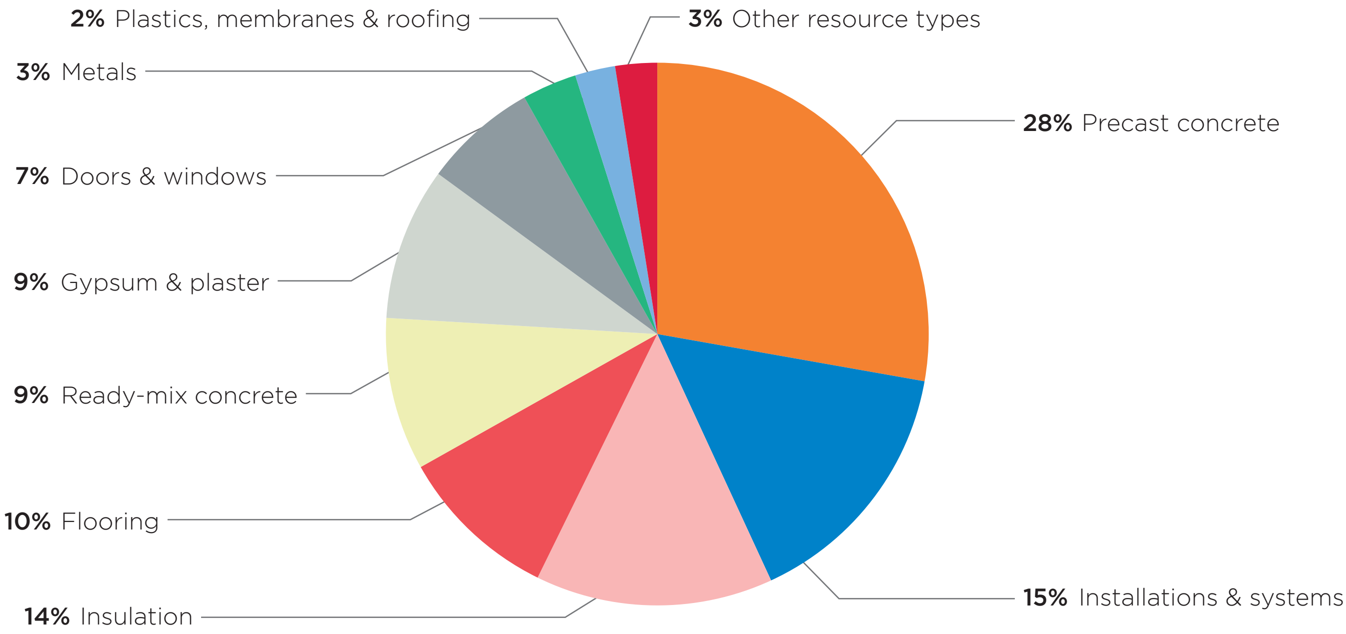


Visualisations are indicative only

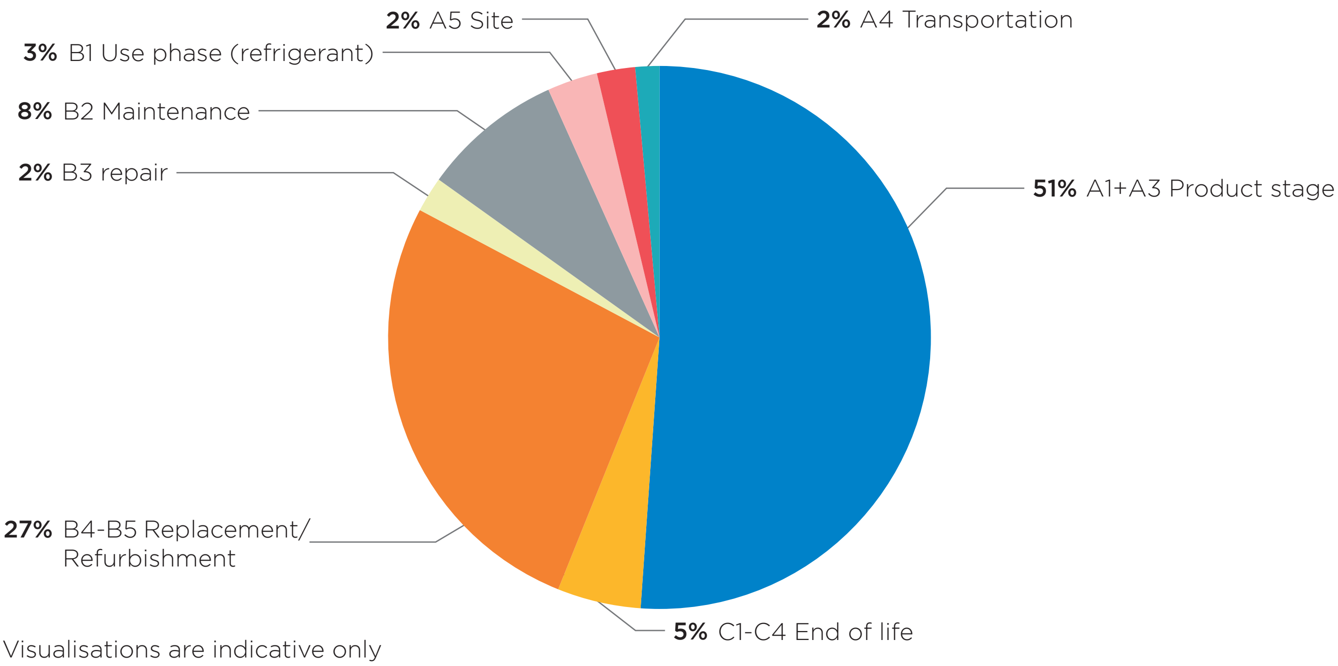
Appendix. B - Detailed Results

Apartment Block
Most contributing materials (Baseline ASHP)

Most contributing resource type



Total carbon lifecycle stages



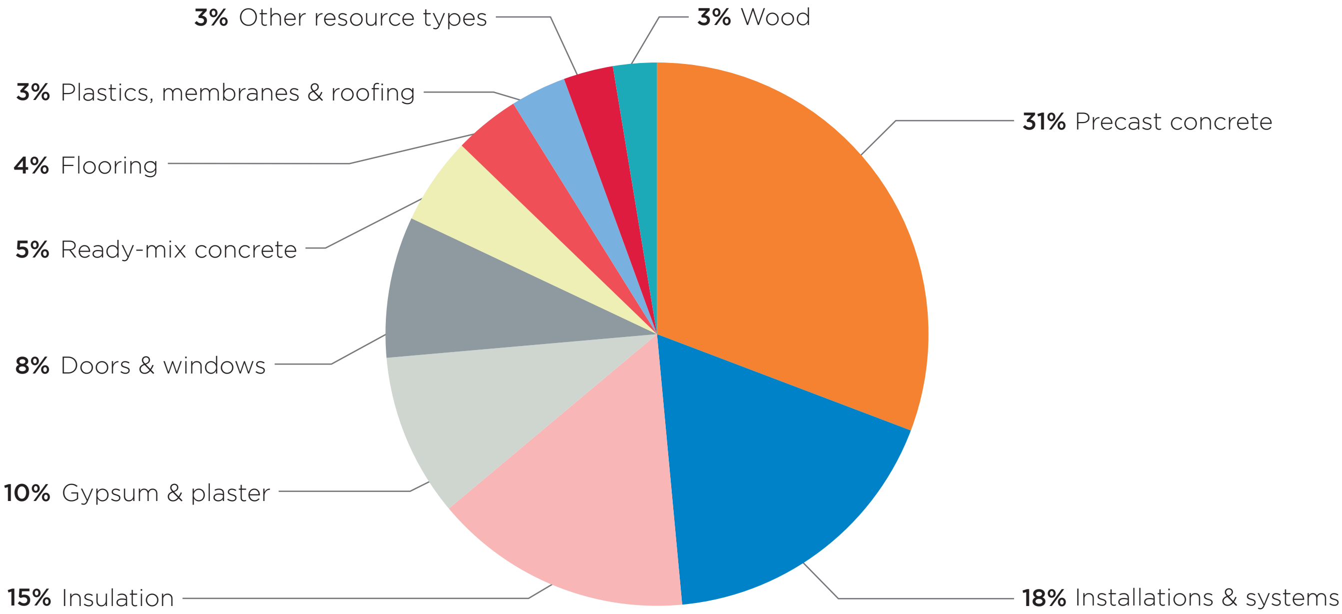
Visualisations are indicative only

Appendix. B - Detailed Results

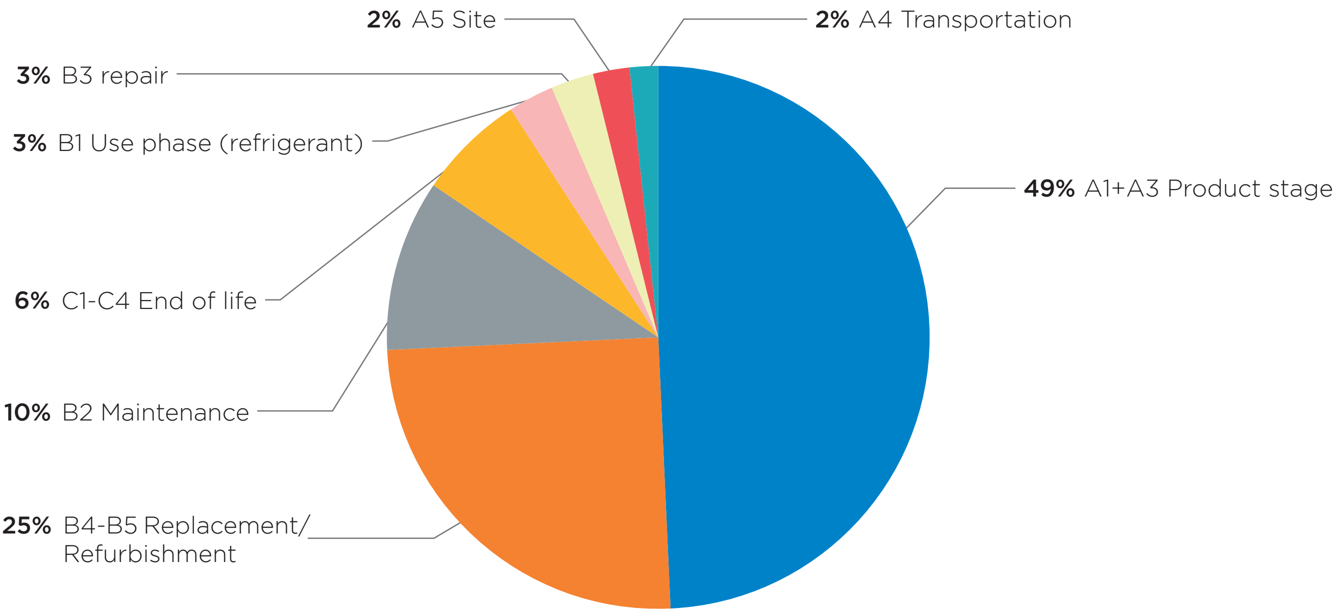
Apartment Block

Most contributing materials (Improved ASHP)

Most contributing resource type



Total carbon lifecycle stages



Visualisations are indicative only

Notes

Reduce by Design

ACTION ON EMBODIED CARBON

ECO360

BIO-ENHANCED PIR INSULATION

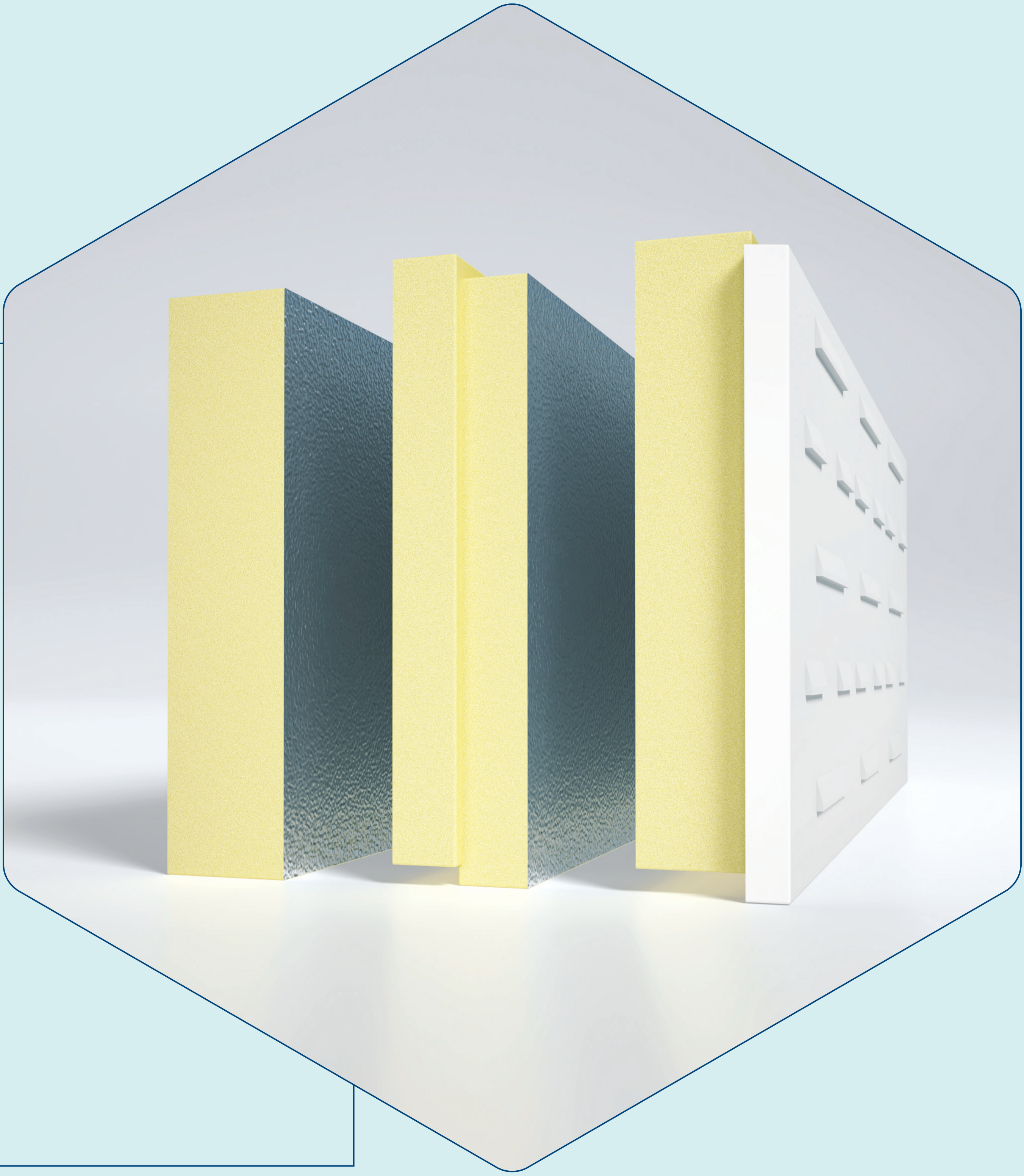
The ECO360 strategy is a commitment by Unilin Insulation to continually review and improve the sustainable credentials of our product offering and services, to reduce the environmental impact of the projects we work on in terms of operational energy and embodied carbon.

Our ECO360 Range sees pioneering environmental improvements in the manufacturing, delivery and use of PIR insulation.

- **Bio-enhanced formulation**
- **Helps achieve RIBA, FHH, LETI & RIAI targets**
- **Halogen free formulation**
- **Improved thermal performance of 0.020 W/mK**
- **Bio-degradable packaging materials**
- **Verified EPD available**

HIGH THERMAL EFFICIENCY

LOW EMBODIED CARBON



0.020
W/mK

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