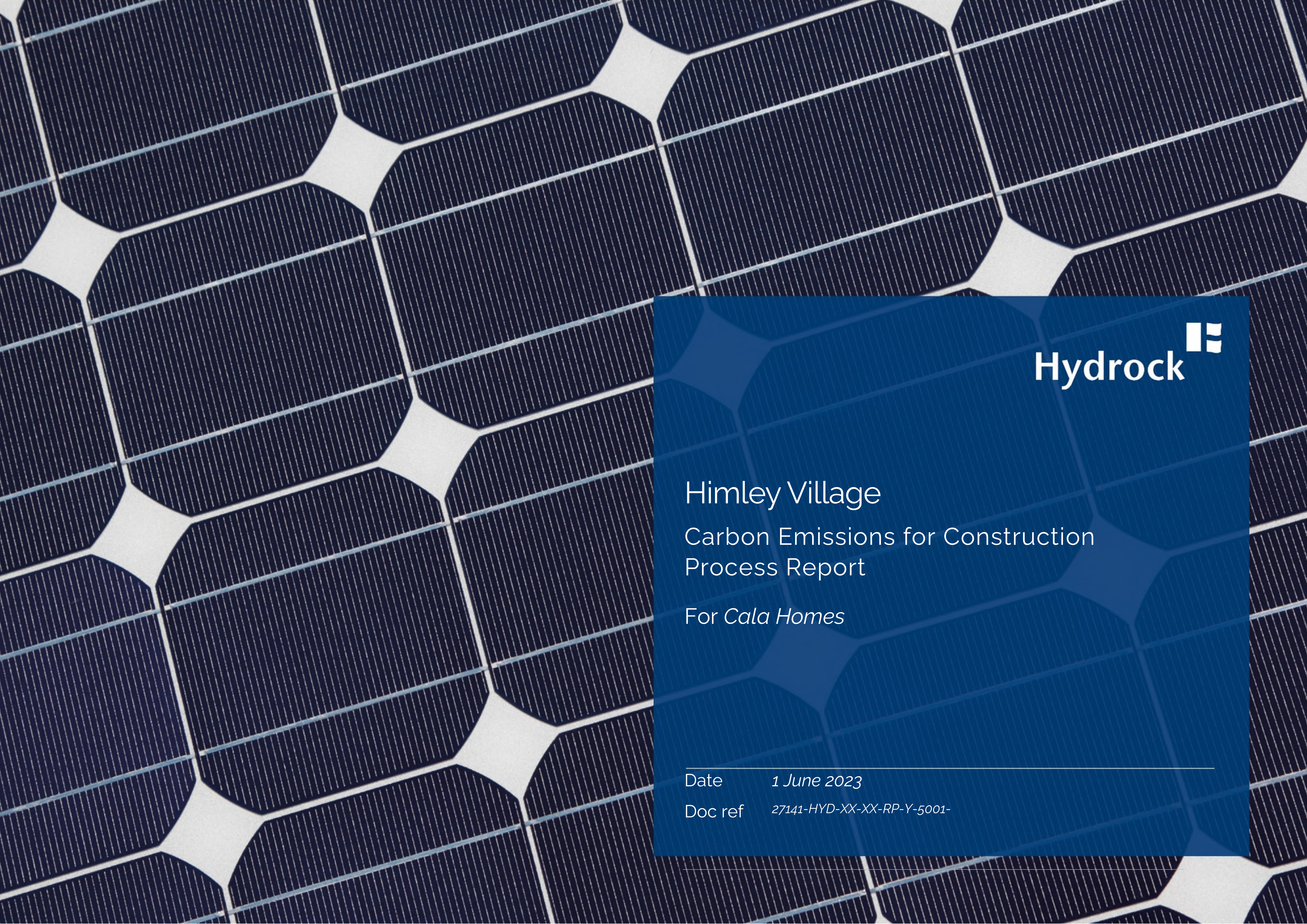

Hydrock

Himley Village

Carbon Emissions for Construction Process Report

For *Cala Homes*

Date	*1 June 2023*
Doc ref	*27141-HYD-XX-XX-RP-Y-5001-*

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Checked by		Charlotte Graimes
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Hydrock has been appointed by Cala Homes to provide planning stage advisory services in relation to the proposed Himley Village development in Bicester, Oxfordshire.

This report will provide a comprehensive assessment of carbon emissions associated with the proposed Phase 1 development, inclusive of Construction Stage Emissions (A1-A5), as well as a Whole Life Carbon (A1-C4) assessment for a representative sample of the 500 dwelling Phase 1 Development.

This report has been produced predominantly to discharge the planning Condition, 20 and of the Outline Permission 14/02121/OUT.

In addition, to this the report seeks to also address the requirements of Conditions 13, outlined in Section 4.

Embodied carbon emissions have been assessed for both the construction stage emissions (A1-A3) and the whole life-cycle embodied carbon (A1-C4).

The results of the assessment show that the embodied carbon performance of the development is around the LETI 2020 design benchmark and better than the business-as-usual benchmarks.

Dwelling Type	Number of dwellings across masterplan	Percentage of dwelling types across materplan	A1-A5 $kgCO_2/m^2$ GIA	Notes
Type 1	42	8%	510	Based on LETI 2020 design benchmark plus missing building elements (FFE & External works) taken from GLA benchmarks
Type 2	48	10%	510	Based on LETI 2020 design benchmark plus missing building elements (FFE & External works) taken from GLA benchmarks
Type 3	93	19%	565	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Type 4	4	1%	510	Based on LETI 2020 design benchmark plus missing building elements (FFE & External works) taken from GLA benchmarks
Type 5	141	28%	604	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Type 6	64	13%	581	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Type 7	96	19%	540	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Type 8	12	2%	533	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Weighted Average for masterplan	**500**	**100%**	**560**	**Weighted average based on the number of dwellings of each type and their upfront carbon performance.**

Himley Village, Bicester

Hydrock has been appointed by Cala Homes to provide planning stage advisory services in relation to the proposed Himley Village development in Bicester, Oxfordshire.

This report will provide a comprehensive assessment of carbon emissions associated with the proposed Phase 1 development, inclusive of Construction Stage Emissions (A1-A5), as well as a Whole Life Carbon (A1-C4) assessment for a representative sample of the 500 dwelling Phase 1 Development.

1. Introduction

1.1 Purpose of Report

This report has been produced predominantly to discharge the planning Condition, 20 and of the Outline Permission 14/02121/OUT.

> *Condition 20*
>
> *No phase of development shall commence until a report has been submitted to and approved in writing by the Local Planning Authority outlining how carbon emissions from the construction process and embodied carbon within that phase will be minimised. The phase of development shall thereafter be carried out in accordance with the approved report.*

In addition, to this the report seeks to also address the requirements of Conditions 13, outlined in Section 4.

1.2 Scope of Report

This report will focus upon carbon emissions derived from the embodied carbon within the construction of products/materials onsite. As well as the carbon associated with construction site activities and the transport of materials to the construction site.

This Carbon Emissions for Construction Process Report will first focus on 'cradle to practical completion' (Construction Stage Emissions A1-A5) when quantifying the carbon emissions for the Himley Village development. This will be explored in more detail in Section 10, Construction Stage Emissions,

Additionally, this report will quantify the Whole Life Carbon (WLC), which concerns the A1-A5, B1-B5, and C1-C4, excluding B6 and B7 (the Operational Carbon). As illustrated in Figure 2, this will just be the Embodied Carbon, in pink, 'cradle to grave'.

Thus, the A1-C4 stages of this Himley Village Development will be calculated, and this will be explored further in Section 12. Where the B6- Operational Energy has already been calculated for the energy strategy report, and will be referenced in this report.

And regarding, B7- Operational Water, we can use a similar methodology to calculate residential water use for the dwellings of this Phase 1 of the Himley Development.

One of the key standards set by the Planning Policy Statement on Eco-Towns is that eco-town developments must be zero-carbon over the course of a year (not including transport emissions). The Himley Village Development wants to be 'Net Zero ready'.

Therefore, the scope of report in analysing the carbon emissions during the construction stage emissions (A1-A5), and also the embodied carbon (A1-C4) of this Himley Village Development is crucial to quantify whether or not this development can be 'Net Zero ready', and zero-carbon over the course of a year.

1.3 Project Description

The proposed Himley Village Phase 1 development consists of 500 dwellings, shown in Figure 1, and forms part of the wider Himley Village Masterplan. The wider masterplan will provide up to 1,700 homes,

schools, and community facilities.

The Himley Village site falls within the remit of Cherwell District Council (CDC).

The site itself is classified as an 'Eco-Town', the requirements of which are outlined in Section 5.

The site will seek to provide a zero-carbon ready development on the outskirts of Bicester.

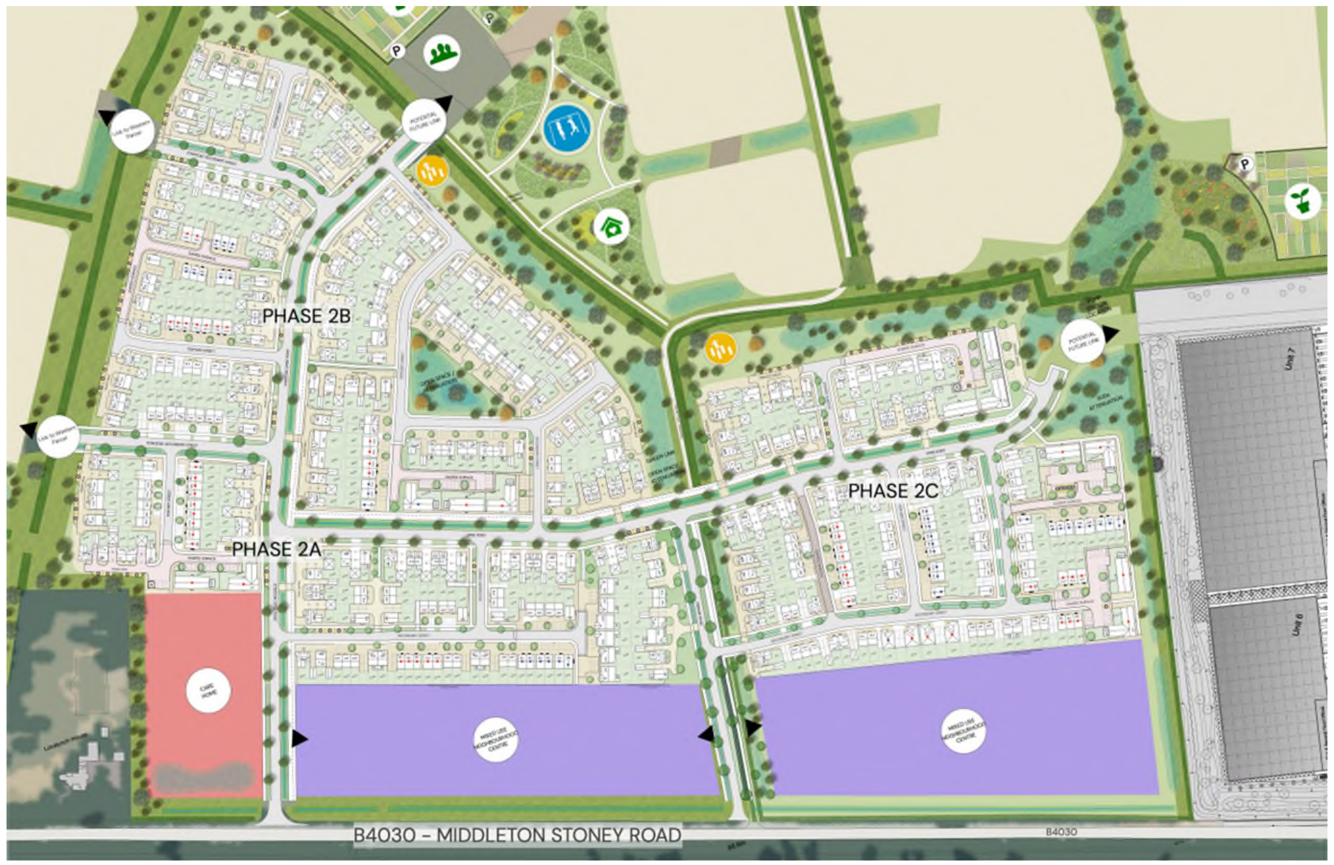

Figure 1, Himley Village, Bicester, Phase 2 500 Testing Layout

1.4 Himley Village Schedule of Accommodation

This Himley Village development will provide 500 dwellings, of which there are 24 different typologies.

In relation to this carbon emissions for construction process report, it was important to segregate these different dwelling types, included in the schedule of accommodation, into definitive dwelling typologies.

The dwelling types were segregated based on number of storey heights and number of bedrooms. This is shown in Table 2, where the chosen dwelling type for each dwelling typology is listed, as well as their associated information.

This will directly impact the number of materials required, as each dwelling typology differs in size and also total count (See Table 2).

Thus, impacting the total Construction Stage Emission (A1-A5) and Embodied Carbon (A1-C4) Emissions, which will be calculated for each dwelling typology, and fundamental to this report.

1.5 Dwelling Typologies

Across the site, there were 8 dwelling typologies chosen to best represent the 24 different dwelling types. These vary in number of beds, and storey heights.

The table below outlines the features of each dwelling typology. Where the total count on site for all dwellings within that typology will be accounted for, inclusive of private, affordable and intermediate housing.

Table 1, The representative sample of dwellings chosen for the Himley Village Development

Dwelling Typology	No. of Beds	Storey Height	Sq. Ft	Total Count on Site
Dwelling Type 1: 1 Bed Flat	1	3 to 4	540	42
Dwelling Type 2: 2 Bed Flat	2	3 to 4	760	48
Dwelling Type 3: Alder/ Aspen	2	2	800*	93
Dwelling Type 4: Bungalow	2	1	850	4
Dwelling Type 5: Everglade	3	2	1085	141
Dwelling Type 6: Laurel	3*	2	1357	64
Dwelling Type 7: Poplar	4	2	1553	96
Dwelling Type 8: Whitebeam	5	2	1957	12

Regulations, Policy and Guidance

This section of the report highlights the relevant national regulations, local policy and guidance that are applicable to the Himley Village development.

2. National Planning Policy

This section sets out a summary of current national guidance and policy in relation to sustainable development.

2.1 National Planning Policy

The National Planning Policy Framework (NPPF) was updated in July 2021 and sets out government planning policy for England, removing all regional level planning policy at this time in favour of 'a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities.'

All Local and Neighbourhood Plans must therefore align with the polices of the NPPF.

The NPPF states clearly that the purpose of planning is to help deliver sustainable developments, and defines three mutually dependent pillars that must be equally considered in order to achieve this:

» Economic
» Social
» Environmental

The NPPF focusses on:

» Promoting high-quality design for new homes and places.
» Offering stronger protection for the environment.
» Constructing the right number of homes in the right locations.
» Focusing on greater responsibility and accountability of councils and developers for housing delivery.

In terms of the environment, the NPPF seeks to further protect biodiversity by aligning the planning system with Defra's 25-year Environment Plan. Not only does this protect habitats, it also emphasises air quality protection in relation to development proposals.

3. Local planning policy

3.1 Cherwell Local Plan, 2011-2031 Part 1 (2015)

The Local Plan for Cherwell District was adopted in 2015 and contains a number of policies relevant to energy and sustainability.

Whilst these policies are outlined below for reference, the expectation for net zero development at Himley Village goes beyond these requirements as a condition of outline planning consent, detail within the S106 agreement and the guidance within the North West Bicester SPD.

3.1.1 Policy ESD1: Mitigating and Adapting to Climate Change

Measures will be taken to mitigate the impact of development within the district on climate change. At a strategic level, this will include:

» Distributing growth to the most sustainable locations as defined in this Local Plan
» Delivering development that seeks to reduce the need to travel and which encourages sustainable travel options including walking, cycling, and public transport to reduce dependence on private cars
» Designing developments to reduce carbon emissions and use resources more efficiently, including water
» Promoting the use of decentralised and renewable or low carbon energy where appropriate.

The incorporation of suitable adaptation measures in new development to ensure that development is more resilient to climate change impacts will include consideration of the following:

» Taking into account the known physical and environmental constraints when identifying locations for development.
» Demonstration of design approaches that are resilient to climate change impacts including the use of passive solar design for heating and cooling
» Minimising the risk of flooding and making use of sustainable drainage methods; and
» Reducing the effects of development on the microclimate (through the provision of green infrastructure including open space and water, planting and green roofs).

Adaptation through design approaches will be considered in more locally specific detail in the Sustainable Buildings in Cherwell Supplementary Planning Document (SPD).

3.1.2 Policy ESD 2: Energy Hierarchy and Allowable Solutions

In seeking to achieve carbon emissions reductions, we will promote an 'energy hierarchy' as follows:

» Reducing energy use by the use of sustainable design and construction measures
» Supplying energy efficiently and giving priority to decentralised energy supply
» Making use of renewable energy
» Making use of allowable solutions (note allowable solutions have since been withdrawn).

3.1.3 Policy ESD 3: Sustainable Construction

All new residential development will be expected to incorporate sustainable design and construction technology to achieve zero carbon development through a combination of fabric energy efficiency, carbon compliance and allowable solutions in line with Government policy.

Cherwell District is in an area of water stress and as such the Council will seek a high level of water efficiency than required in the Building Regulations, with developments achieving a limit of 110 l/person/day.

The strategic site allocations identified in this Local Plan are expected to provide contribution to carbon emissions reductions and to wider sustainability.

All development proposals will be encouraged to reflect high quality design and high environmental standard, demonstrating sustainable construction methods including but not limited to:

- Minimising both energy demands and energy loss
- Maximising passive solar lighting and natural ventilation
- Maximising resource efficiency
- Incorporate the use of recycled and energy efficient materials
- Incorporating the use of locally sourced building materials
- Reducing waste and pollution and making adequate provision for the recycling of waste
- Making use of sustainable drainage methods
- Reducing the impact on the external environment and maximising opportunities for cooling and shading; and
- Making use of the embodied energy within buildings wherever possible and re-using materials where proposals involve demolition or development.

3.1.4 Policy ESD 4: Centralised Energy Systems

The use of decentralised energy systems, providing either heating (District Heating (DH)) or heating and power (Combined Heat and Power (CHP)) will be encouraged in all new developments.

A feasibility assessment for DH/CHP including consideration of biomass fuelled CHP will be required for:

- All residential development for 100 dwellings or more;
- All residential developments in off-gas areas for 50 dwellings or more;
- All applications for non-domestic developments above 1000sqm of floorspace.

3.1.5 Policy ESD 5: Renewable Energy

A feasibility assessment of the potential for significant on-site renewable energy provision will be required for:

- All residential developments for 100 dwellings or more;
- All residential developments in off-gas areas for 50 dwellings or more;
- All applications for non-domestic developments above 1000sqm of floorspace.

Where feasibility assessments demonstrate that on site renewable energy provision is deliverable and viable, this will be required as part of the development unless an alternative solution would deliver the same or increased benefit.

4. Outline planning consent

The proposed development is subject to outline planning consent 14/02121/OUT which includes the following Conditions:

Condition 13:

Each reserved matters application shall be accompanied by a statement setting out how the design of buildings and the layout has taken account of future climate impacts, as identified in TSB research 'Future Climate Risks for NW Bicester', or any more recent assessment that has been published, and how the proposed development will be resilient to overheating, changing rainfall patterns and higher intensity storm events.

Condition 20

No phase of development shall commence until a report has been submitted to and approved in writing by the Local Planning Authority outlining how carbon emissions from the construction process and embodied carbon within that phase will be minimised. To ensure development achieves a reduced carbon footprint in accordance with Policy Bicester 1 of the Cherwell Local Plan and guidance contained with Government Eco Town PPS.

Condition 38

Each dwelling hereby approved shall be provided with real time energy and travel information prior to its first occupation. Details of the provision for each phase shall be submitted to the Local Planning Authority and agreed in writing prior to the commencement of construction of dwellings above slab level."

5. Eco-Towns

Eco-towns are a government-sponsored programme of new towns to be built in England, which are intended to be specially designed to make it easy for people to live there with as little impact on the environment as possible.

A new Planning Policy Statement (PPS) was published in 2009. Eco-town proposals should meet the standards as set out in the Eco-Town PPS or any standards in the development plan which are of a higher standard.

Eco-towns should develop unique characteristics by responding to the opportunities and challenges of their location and community aspirations.

Eco-towns should have the functional characteristics of a new settlement; that is to be of sufficient size and have the necessary services to establish their own character and identity and so have the critical mass necessary to be capable of self-containment whilst delivering much higher standards of sustainability.

5.1 Eco-Town Standards

The standards eco-towns should meet include the following as set out in the 'draft Planning Policy Statement: eco-towns':

- Affordable housing: a minimum of 30% affordable housing in each eco-town
- Zero-carbon: eco-towns must be zero-carbon over the course of a year (not including transport emissions)
- Green space: a minimum of 40% of eco-towns must be greenspace
- Waste and recycling: eco-towns must have higher recycling rates and make use of waste in new ways
- Homes: homes must reach Code for Sustainable Homes level 4 or higher (surprisingly not the highest standard available, casting doubt on the credibility of these requirements)
- Employment: at least one job opportunity per house accessible by public transport, walking or cycling (although the standards are silent on how housing developers might guarantee this and it is largely discredited in the current economic crisis)
- Services: there must be shops and a primary school within easy walk of every single home, and all the services expected from a town of up to 20,000 homes
- Transition/construction: facilities should be in place before and during construction
- Public transport: real-time public transport information in every home, a public transport link within ten-minute walk of every home
- Community: there must be a mixture of housing types and densities, and residents must have a say in how their town is run, by governance in new and innovative ways.

Whilst these policies listed are outlined for reference, the expectation for a net zero development, one of the Eco-Town requirements, for Himley Village goes beyond these requirements as a condition of outline planning consent, detail within the S106 agreement and the guidance within the North West Bicester SPD.

Embodied Carbon

Embodied carbon refers to all emissions relating to the extraction, processing, transport installation, repair, maintenance and end of life of materials and systems used within the construction of a building.

6. Background

Embodied carbon is an area which has undergone significant development in recent years. With the ongoing decarbonisation of the UK electricity grid, embodied carbon is expected to assume an ever-increasing significance in the overall carbon footprint of developments.

For the purpose of this carbon emission for construction process report, The Royal Institution of Chartered Surveyors (RICS)'s Building Carbon Database Whole Life Carbon (WLC) stages will be assessed.

Figure 2 shows the RICS and BS EN 15978 defined stages for the whole life carbon. Other than operational energy (B6) and operational water (B7), all other whole life carbon emissions (A1-C4) are associated with embodied carbon, listed as follows:

Product Stage:

- A1- Raw Material Supply
- A2- Transport
- A3- Manufacturing

Construction Stage:

- A4- Transport
- A5- Construction and Installation Process

In-use Stage:

- B1- Use
- B2- Maintenance
- B3- Repair
- B4-Refurbishment
- B5-Replacement

End of life Stage:

- C1- Deconstruction and Demolition
- C2- Transport
- C3- Waste Processing
- C4- Disposal

Historically, there has been little guidance and regulation with regards to embodied carbon, therefore, the level of information detail, accuracy and reliability can vary throughout these stages as the industry is still developing knowledge.

For instance, data available for the maintenance (B2) and repair (B3) stages are still under development and may contribute to the performance gap between as built reality and the design estimation.

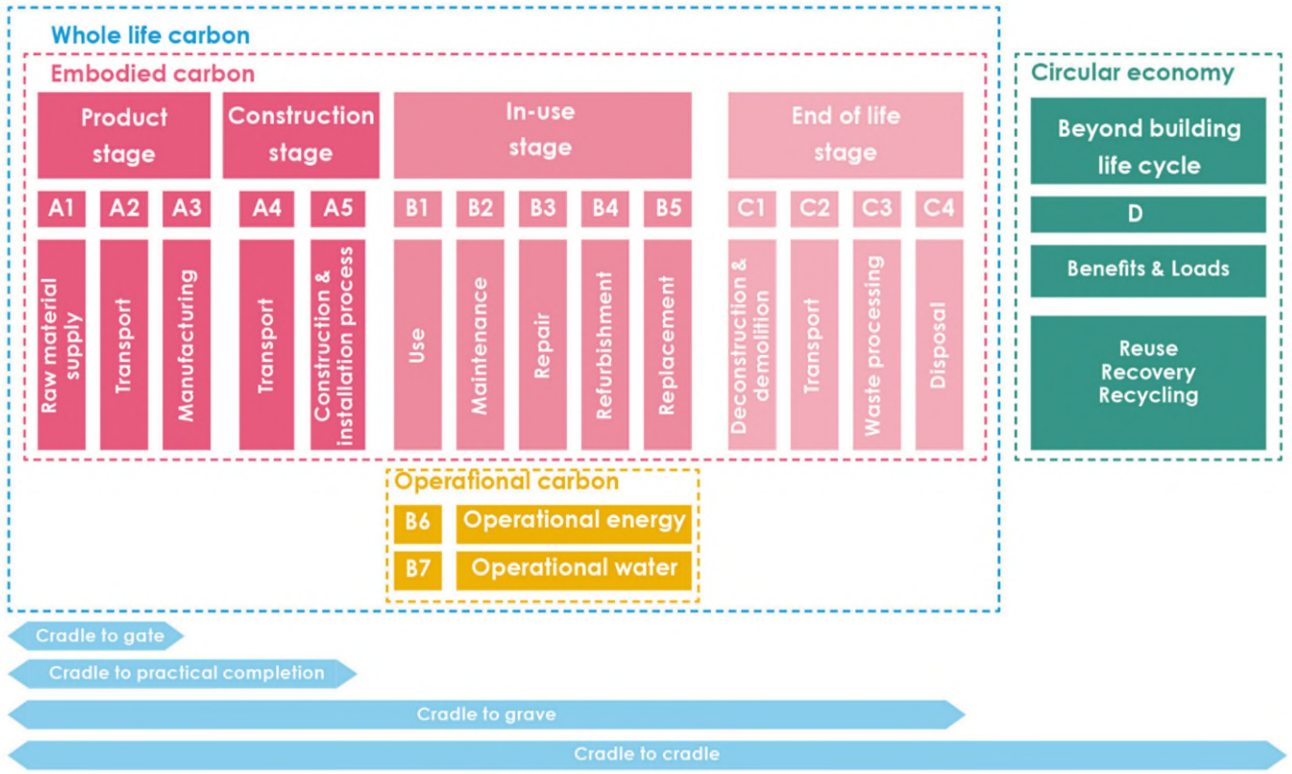

Figure 2, Display of modular information for the different stages of the building assessment. Source: LETI Embodied Carbon Primer

7. Life Cycle Assessment Stages

The Life Cycle Assessment is broken down into stages as detailed in the Figure below. For a full detailed description of what is included in each of these please see Appendix B.

8. Building Elements

Following RICS elemental methodology, embodied carbon analysis within the built environment is broken down in to the following elements:

- **Substructure**: transfers the load of a building to the ground and isolates it horizontally from the ground. Substructures range from strip foundations through to large underground basements and are usually made from concrete, a highly emissive material. The substructure of a building is generally the element where structural performance is the largest design driver.
- **Superstructure**: the frame of the building required to support the suspended slabs, roof and internal finishes, providing stability.
- **Façade:** the external faces of a building.
- **Building Services**: these comprise the lighting, heating, cooling, ventilation, power supply, air conditioning plant any other building system

  Building services have a relatively short lifespan compared to the building itself. Embodied carbon needs to be considered in parallel with operational carbon, lifespan, maintenance, comfort, health and safety, etc.
- **Internal Finishes:** the materials used on all exposed interior surfaces, such as floors, walls and ceilings. These are replaced more frequently and can require significant maintenance.
- **External Works**: This covers hard and soft landscaping on ground floor level, terraces, roofs and also below ground items such as irrigation tanks.

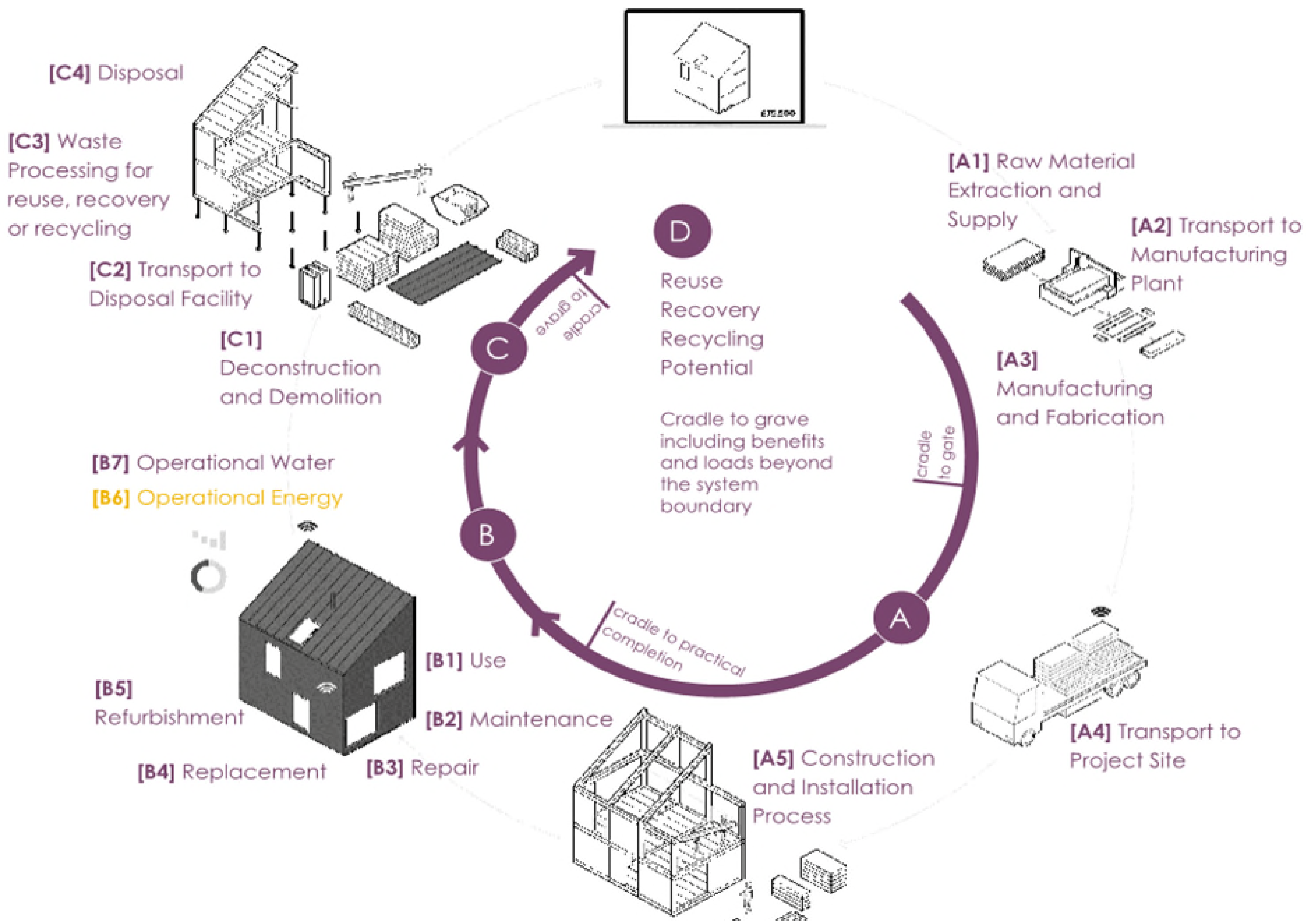

Figure 3 - Life Cycle Assessment stages

These building elements are the materials which will be used during the construction of the various dwellings. The bill of quantities provided us the quantity of each material required per dwelling type.

Using OneClick LCA, the carbon emissions were calculated per dwelling for the construction stage emission assessment (A1-A5). To quantify the carbon emissions associated with the material product (A1-A3) and construction stage (A4-A5).

Additionally, the A1-C4 Embodied Carbon stages for the development were also calculated.

9. Carbon Emission Benchmarks

9.1 Benchmark Targets

At present, there are no benchmarks or guidance for embodied carbon covered by national legislation of policy.

The London Energy Transformation Initiative (LETI) and the Greater London Authority (GLA) have produced benchmarks and targets for different buildings uses. The benchmark relevant do this development is the residential buildings.

Table 2, LETI target values for embodied carbon in residential buildings

	Business as usual	2020 design target	2030 design target
Residential	800 $kgCO_2e/m^2$	500 $kgCO_2e/m^2$	300 $kgCO_2e/m^2$

Figure 4 shows the Product and Construction Stage (here referred to as 'Upfront Carbon') A1-A5 performance grading metric for residential developments, measured in $kgCO_2/m^2$.

These documents put forward how the industry could define 'good' for embodied carbon for residential buildings, that are designed in 2020, and through to 2030.

Current best-practice performance in the design phase is considered to be a 'C' rating, while future LETI Design Targets aspire to reach 'A':

- LETI 2020 Design Target- C
  - <500 $kgCO_2/m^2$
- LETI 2030 Design Target- A
  - <300 $kgCO_2/m^2$

Figure 5 plots the Embodied Carbon (A1-A5) for residential developments, where the following carbon target should be obtained:

- RIBA 2030 Build Target- B
  - <625 $kgCO_2/m^2$

The results from this report will quantify the Himley Village carbon emissions for both the upfront emissions, A1-A5, and Embodied Carbon, A1-C4, and will be compared against these LETI residential benchmark figures.

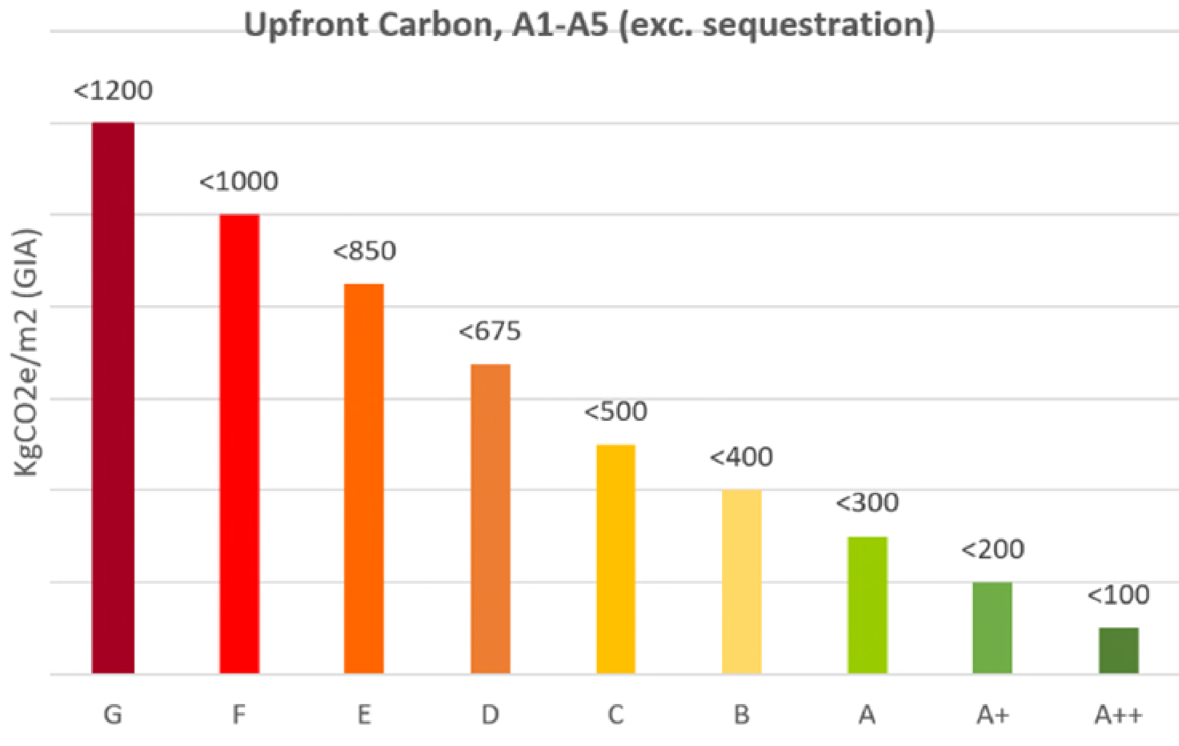

Figure 4, Upfront Carbon, A1-A5 Carbon Emission Benchmarks

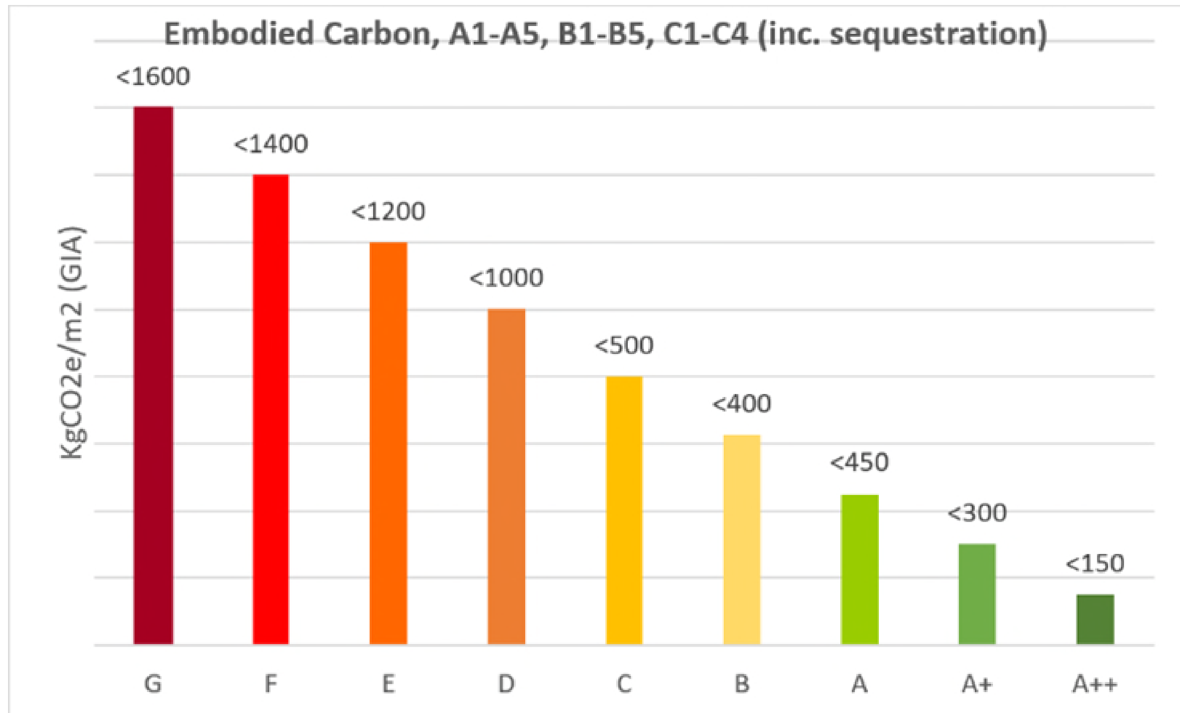

Figure 5, Embodied Carbon A1-C4 Carbon Emission Benchmarks

Carbon emissions associated with construction and embodied emissions (A1-C4)

This section of the report outlines the methodology for both the A1-A5, construction stage emissions and the embodied carbon A1-C4 emissions for the sample dwellings in Himley Village Phase 1 Development

10. Construction Stage Emissions

10.1 Methodology

The assessment has taken all construction stage emissions into account to calculate carbon emissions for the A1-A5 stage on-site. The carbon emission sources considered include the following, and will be split into these categories:

» Carbon embedded in the materials used in the construction of the proposed development (A1-A3)

» Carbon from transport movements during construction of the proposed development (A4)

» Carbon from construction site activities (A5)

In order to estimate total lifecycle carbon emissions, this assessment projects emissions across the construction and takes account of relevant changes that are projected by UK Government in relation to building standards and the carbon intensity of grid electricity.

10.2 Carbon emissions from the materials used in construction (A1-A3)

Emissions associated with this construction phase of the development are based on the latest available carbon emission for each material considered.

This provides a conservative assessment, as emissions associated with the manufacturing of construction materials and transport are projected to reduce with time. Where construction, with the various phases to this development, is expected to last for a few years.

The carbon emissions associated with the construction of the Application Site relate to those embedded in the construction materials and with traffic movements generated during the construction activities.

These will be calculated based on the bill of quantities provided for each representative dwelling type, providing the quantity of materials required for dwelling. Thus, the associated carbon emission factors can be calculated, using the OneClick LCA.

When inputting the OneClick House Typology floor areas, the square foot area provided to us within the 'Bill of Quantities' spreadsheet, was converted to metres squared and inputted into the OneClick software. This was instead of us measuring and calculating our own gross internal floor areas, to avoid inconsistency in the recorded floor areas.

Secondly, when selecting the correct materials for each building construction element to input into OneClick, the information included in the 'Bill of Quantities' was used to find generic materials with general carbon factors to best match the specific material.

Once this process is complete, the results would show which building elements are above the benchmark emissions (See Table 7), and a more specific material which will closer match the one in the 'Bill of Quantities' construction element spreadsheet can be chosen.

The reason for choosing generic materials at this stage is because we did not want to commit the building design to specific material manufacturers and types, which would most likely overestimate the carbon emission results to an unreasonably low figure. Therefore, it proves valuable to overcompensate, and be able to improve the results at a more detailed design stage once the specific material specifications are chosen.

This can be classed an assumption, as where possible we tried to best match the materials included in the 'Bill of Quantities' spreadsheet and the architectural drawings, specifically the wall general arrangement plans, with the options listed in OneClick.

10.3 Carbon emissions from the transportation of materials onto site (A4)

Trip distances are estimates, as vehicle trips to and from the Site during the construction works will vary greatly in origin and destination, based on the source location of the material.

The transportation distance default value for materials was set to 'UK- RICS' on OneClick LCA, and adjusted manually when applicable for specific materials which can be sourced more locally than 300km, 'Carbon only- Heavy Goods Vehicle' (the RICS standard).

10.4 Carbon emissions from on-site construction activities (A5)

Emissions from on-site construction activities have been estimated based upon the benchmarks within OneClick which are updated values against the 'Whole life carbon assessment for the built environment' guidance published by Royal Institution of Chartered Surveyors (RICS) in 2017. This corresponds to some industry construction data. Total A5 values are based on two factors calculated separately. These are; A5a, the direct emissions of site activities and A5w, the carbon associated with wastage of materials on site (transport of this wastage is also factored into A4 transport).

10.5 Embodied Carbon (A1-C4)

As previously highlighted, the Embodied Carbon stages of the building assessment include A1-C4, but excludes the Operational Carbon (B6- Operational Energy, and B7- Operational Water).

The Construction Stage Emissions will report, emissions associated with the upfront materials and building construction which is inclusive of A1-A5 stages of the building assessment (this is to PC). Therefore, the Product and Construction stage, results are still applicable for the A1-A5 stages of the Embodied Carbon assessment.

Therefore, the remaining stages of the building assessment left to analyse the

Embodied Carbon of the Himley Village Development includes:

- In-use stage (B1-B5)
- End of life stage (C1-C4)

An estimation of operational carbon associated with Water use (B7) has also been included in this assessment.

10.6 In use stage (B1-B5)

10.6.1 B1

This relates to the carbon associated with product or pollutant emissions for example refrigerants required for HVAC equipment. Due to the design stage there is little or no design data available to assess B1 emissions, therefore it has been excluded from this assessment.

It is recommended that in order to limit carbon emissions refrigerants with low GWP (Global Warming Potential) are specified. Where possible it is recommended that refrigerants with a GWP less than 700 are used and refrigerant volumes are minimised where possible, as well as using systems to avoid leakage during operation and replacement of systems.

10.6.2 B2-B5

Over the lifetime of the Site there will be carbon emissions associated with the maintenance, repair, refurbishment and replacement of the dwellings (B2-B5).

These emissions are effectively 'unregulated' as there is no policy or standard for establishing compliance, nor is there published data on good practice against which developments can be benchmarked.

GHG emissions relating to the repair, maintenance and refurbishment of the Proposed Development over its lifetime have been estimated based on expected life spans of materials and products in line with the 'Whole life carbon assessment for the built environment' guidance published by Royal Institution of Chartered Surveyors (RICS) in 2017 and the product EPD information from OneClick. Standard benchmark rates for B2 and B3 have been used from the GLA Whole life-cycle carbon assessment guidance.

10.7 End of life stage (C1-C4)

- End of life emissions include demolition of the buildings, transport of, processing of and the disposal of waste.
- The UK has committed to achieve net zero carbon emissions from 2050 onwards, therefore by the end of the buildings' life (at least 60 years from completion) it can reasonably be expected that emissions from demolition, transport and waste processing will be net zero.
- Any residual emissions from waste disposal will be minimal as the waste is largely inert and recyclable and any such emissions will represent a very small proportion of the total.
- Nonetheless, likely end-of-life scenarios have been selected for each material type and associated default impacts generated through OneClick.,

10.8 Limitations and Assumptions

It is important to highlight what assumptions have been made during the analysis of the construction stage emissions.

Transport distances, material lifespans and waste factors are assumed as per default figures with the LCA software tool where applicable. Recycled contents and recycle rates at end of life for all metals are as per RICS methodology default recommendations.

In addition to the on-site sources of emissions listed above, there are some minor construction stage carbon emissions sources (such as waste disposal during construction, and operation and water consumption during construction) that have been scoped out of the assessment. It is anticipated that these emissions will only make up a small component of the overall construction stage total emissions.

Such as, when inputting the material construction data into OneClick, it was necessary to assume the density of some materials (for example the concrete block), using available industry material density information, to convert it into the 'kg' unit required for this specific material.

It is necessary to make a number of assumptions when carrying out the assessment. In order to account for some of the uncertainty in the approach, as described above, assumptions made have generally sought to reflect a realistic worst-case scenario.

As mentioned for the construction stage emission section, assumptions made in carrying out this assessment include:

- OneClick default estimate construction vehicle travel distances;
- Operational life of the Proposed Development, as the future condition and lifespan of the dwellings are unknown

In addition, there are several components that contribute to the uncertainty of embodied carbon emissions as a result of the assumptions above.

These limitations include:

- The accuracy of future emissions, though these are based on best available data which aims to provide a best estimate through professional judgement;
- The proportions and origin/destination of construction traffic;
- The accuracy of estimated unregulated energy use as this is highly dependent on end user behaviour.

Results

All embodied carbon LCA models have been completed using OneClick LCA software and OneClick's Database Version 7.6, which is compliant with EN15804.

11. Carbon results per Dwelling Typology

The results show that the upfront carbon for each of the house types is similar and that these are comparable to the LETI 2020 design guide and RIBA 2020 build targets for upfront and whole life respectively.

The larger houses Type 7 & 8 have a lower carbon intensity per m² GIA area. This is likely because although they will require a larger quantity of materials to build, the house area increase is proportionally greater.

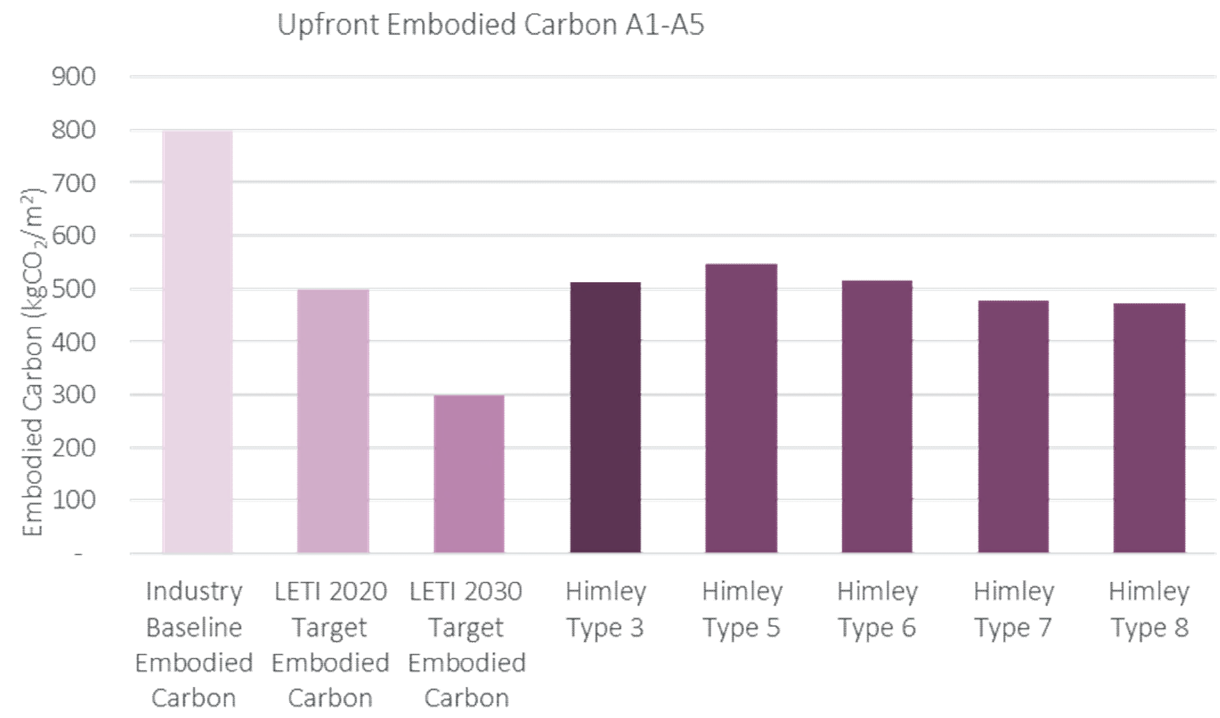

Figure 4 - Upfront carbon for HImley Village house types compared with a number of benchmarks

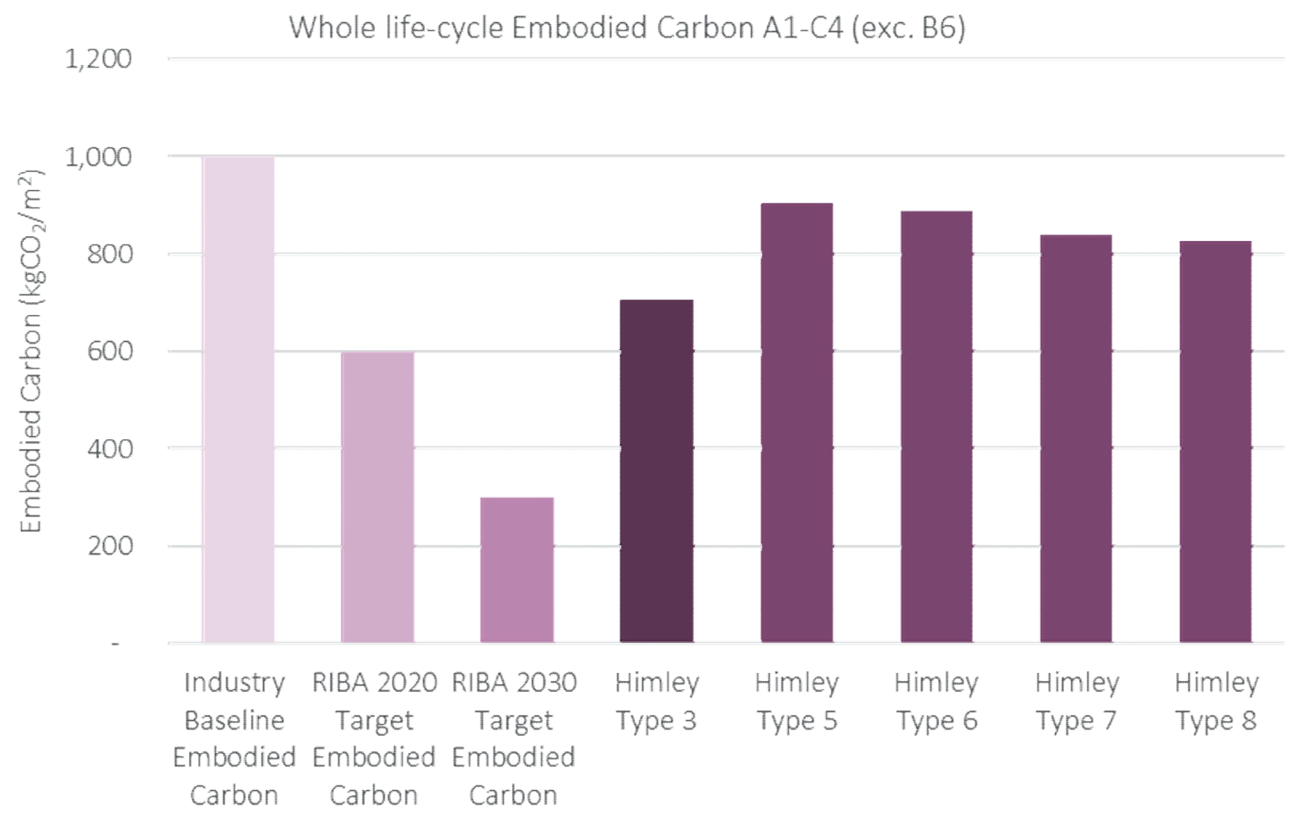

Figure 5 - Whole Life Carbon for Himley Village house types compared with industry benchmarks

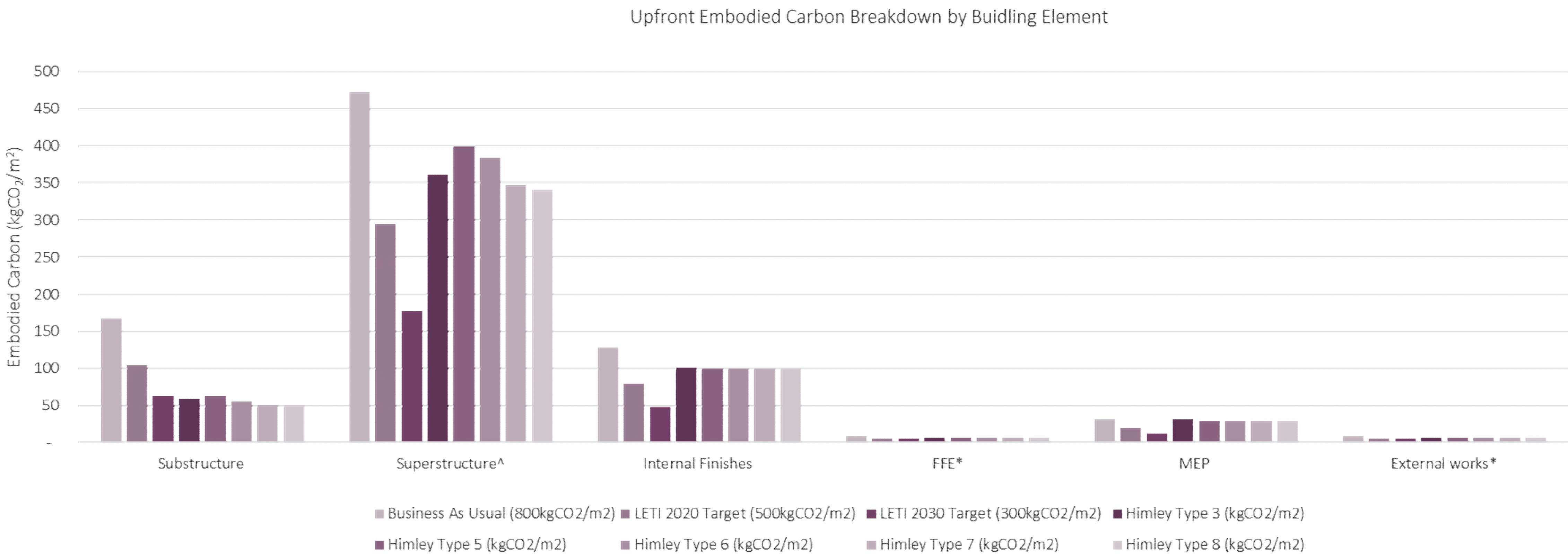

Figure 6 - Embodied carbon breakdown by building element

Superstructure has included the carbon associated with the façade as many of the external walls also form part of the structure.

*FFE (Fittings, furnishings & equipment) and External works have been included based on data from Greater London Authority guidance.

The figure showing breakdown by building element shows how the carbon is associated with different building elements and how that compares to the target benchmarks.

As can be seen in the graph, the substructure is lower than the LETI 2020 benchmark, This might be due to limited information in the bill of quantities.

The superstructure is higher than the LETI 2020 benchmark. This might be because of limited specification information in the bill of quantities and assumptions that had to be made. This element should be considered going forward to try and reduce material quantities and specify lower carbon alternatives to the baseline materials used.

For a number of other building elements benchmark data had to be used as the information provided was limited. As the design is developed quantity and specification data should be identified and included.

12. Site Wide Embodied Carbon

Dwelling Type	Number of dwellings across masterplan	Percentage of dwelling types across materplan	A1-A5 $kgCO_2/m^2$ GIA	Notes
Type 1	42	8%	510	Based on LETI 2020 design benchmark plus missing building elements (FFE & External works) taken from GLA benchmarks
Type 2	48	10%	510	Based on LETI 2020 design benchmark plus missing building elements (FFE & External works) taken from GLA benchmarks
Type 3	93	19%	565	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Type 4	4	1%	510	Based on LETI 2020 design benchmark plus missing building elements (FFE & External works) taken from GLA benchmarks
Type 5	141	28%	604	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Type 6	64	13%	581	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Type 7	96	19%	540	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Type 8	12	2%	533	Embodied carbon assessment carried out for information in the Bill of Quantities, supplementary information provided by benchmarks.
Weighted Average for masterplan	**500**		**560**	**Weighted average based on the number of dwellings of each type and their upfront carbon performance.**

It can be seen that when considering the number of the different dwelling types across the site the weighted average for upfront carbon is 560 $kgCO_2/m^2$ GIA.

12.1 A1-A3 Carbon emissions embedded in construction materials

The calculation of the carbon emissions embedded in construction materials are shown in the Table below. This is the carbon associated with the material extraction, processing and manufacture (A1-A3).

Table 3, Construction material embedded carbon emissions for the proposed development

House Type	A1-A3 (kgCO2/m2 GIA)
Type 3	414
Type 5	451
Type 6	426
Type 7	399
Type 8	393
Average	416

13. Construction Process Carbon Emissions

13.1 A4- Construction Transport

The calculation of construction transport related GHG emissions for the Himley Village development are presented in Table 4. This is based on HGV average laden (50% capacity to and from site) to account for wastage transport and return journeys.

Table 4, Emissions associated with construction site activities

House Type	A4 ($kgCO_2/m^2$ GIA)
Type 3	74
Type 5	85
Type 6	85
Type 7	76
Type 8	75
Average	79

This carbon has been proportionally spread across building elements in the breakdown given in section 11.1.

A4 carbon can be reduced through the use of low or zero emission vehicles for delivery of materials to and from site.

Electricity can then also be offset to reduce carbon emissions further.

13.2 A5- Construction Activities

The calculation of the GHG emissions from construction activities at the site are shown in Table 5.

Table 5, Emissions associated with construction site activities

House Type	A5a ($kgCO_2/m^2$ GIA)	A5w ($kgCO_2/m^2$ GIA)	A5 Total ($kgCO_2/m^2$ GIA)
Type 3	30	48	78
Type 5	30	39	69
Type 6	30	40	70
Type 7	30	36	66
Type 8	30	36	66
Average	30	40	70

This carbon has been proportionally spread across building elements in the breakdown given in section 11.1.

Measures to reduce material wastage, such as just-in-time delivery to site or modern methods of construction, including pre-fabrication can reduce the A5w contribution.

A5a can be reduced through committing to a zero emissions site or using electric vehicles and equipment on site.

14. Operational Carbon

Operational carbon refers to the emissions associated with the energy consumed by a building during its use (B6 and B7, See Figure 2).

This includes the energy consumed by heating, hot water, cooling, ventilation, and lighting systems. Any plug-in devices such as fridges, washing machines, TVs, IT facilities, lifts, cooking and process loads are also accounted for.

Operational energy influences a building's ability to achieve a net zero balance through a number of different interdependent factors. It is denotes significant ongoing environmental impact that a building has during its operation and is directly related to the ways in which we occupy and interact with buildings.

14.1 B6- Operational Energy

Regulated and unregulated carbon emissions are not included in this report. This information can be found in the energy strategy report. This data can be used to determine B6a regulated and B6b unregulated carbon associated with operational energy use.

14.2 B7- Operational Water

The operational water use for each dwelling type was based on the water neutrality assessment undertaken for the illustrative Himley Village development. Details of this can be found in the water neutrality statement. For this assessment the proposed water demand level was assumed (84 l/person/day) to match the Water neutrality statement.

Conclusions and Recommendations

The Himley Village development has considered carbon emissions across both the construction stage emission (A1-A5) building assessment stages, and Embodied Carbon (A1-C4), and has addressed potential impacts these have on the local and national carbon budgets.

The carbon emissions have been assessed against relevant policy, guidance and technical evidence relevant to the proposed development.

The results show that the 5 typologies assessed are largely aligned with key current good practice industry benchmarks for residential dwellings of 500 and 817 $kgCO_2e$(when additional scope is included) for upfront and whole life embodied carbon respectively. They are all below the business-as-usual scenarios. Below is a summary figure.

Carbon hotspot elements from those that have been assessed are in the superstructure, transport and construction.

The following is a summary of recommendations to reduce the carbon across different building elements and stages as well as some recommended next steps;

- Review superstructure material quantities and specify low carbon material alternatives for elements such as bricks and mortar, blockwork and higher GGBS content for concrete
- Consider low carbon transport plan and use of electric delivery vehicles where possible
- Consider low or zero carbon site emissions, using electric construction vehicles and dry fix approach ton construction
- Consider MMC and pre-fabrication for key elements to reduce onsite emissions and reduce wastage.
- Specify low GWP for refrigerants and calculate B1 emissions.
- Calculate remaining dwelling types (1, 2 & 4)

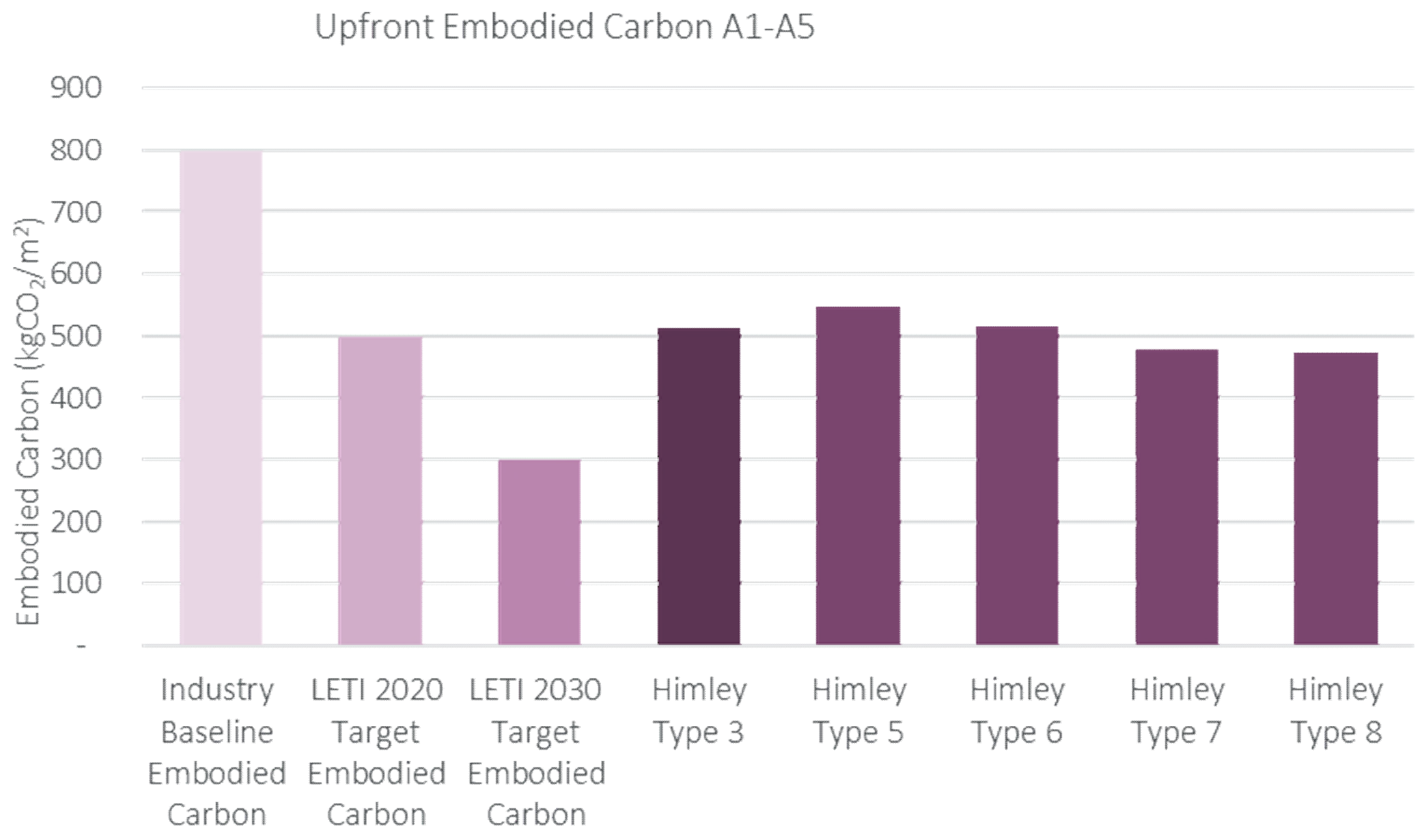

Figure 7 - Embodied (upfront) carbon emissions for the proposed development compared to a number of difference benchmarks

Appendix A OneClick Input Data

Substructure	
100mm block (party wall)	
100mm aircrete block (outer leaf)	Density of AAC Concrete Block assumed at 617.6
100mm aircrete block (inner leaf)	Density of AAC Concrete Block assumed at 617.6
70mm Non-load bearing blockwork buttress wall	Density of AAC Concrete Block assumed at 617.7
Screed	Assumed Jet Floor Depth (once measured from drawing) of 150mm including insulation
Superstructure	
Facing Brickwork	
100mm aircrete block (inner leaf)	Density of AAC Concrete Block assumed at 617.7
steel lintols - NOT ALL PLOTS PRICED	Assumed Nr is kg of steel. Assume 300mm wide- size of a door/ window.
COURSING BRICKS, supplied with blocks	
Stone	
Aircrete Blocks	
Brick Specials	What does this mean?
Sundries	
215mm Brick soldier Head	
140mm Brick Cut Cill	
Bed Joint Reinforcement - Bricktor	Bricktor assumed 60g/m2. And we have m- so work out m2, and then divide through
DPC	Assumed 1.4mm dimension
DPC	Assumed 1.4mm dimension
DPC	
Roof windows	Window schedule indicates 1 rooflight
Movement Joints	We assume 10mm gap, 10mm x 300mm multiplied by depth of the wall 2.3), and then work density from EPC- to get the kilos.
Movement joint wall ties	What is mm of the mesh, or weight per linear metre. Mm2, and 100mm wide- can work out the thickness. ASSUME 2mm thick, and its width of the wall, and we have linear m.
Cavity wall ties	Assuming Nr is kg
Padstones	
GPR Products	
Cavity Tray	

Hydrock

Mortar	
Superstructure Plain Mortar Mix	
Facing Brickwork	Assumed 100mm thick from drawings
100mm aircrete block (inner leaf)	
Substructure Mortar Mix	
100mm block	
100mm block (party wall)	Not great Carbon Factor for this polyolefin
100mm Sleeper wall	
215mm Sleeper wall	
100mm aircrete block (outer leaf)	
100mm aircrete block (inner leaf)	
70mm Non-load bearing blockwork buttress wall	
Roughing Pack	
Chipboard Flooring FF	
Chipboard Flooring SF	
D4 Glue	Assumed Nr is m2
D4 Glue	
Ceiling Perimeter Battens (38mm x 63mm CLS Timber)	Can calculate volume of timber from the measurements (38mm x 63mm). Assuming length is in metres
Pipe boxing timbers	Assuming the same CLS Timber dimensions as above.
Metal Stud Partitions	Assumed dimension of 100mm from drawing?
Joist Pack	
Roof Trusses	
Window board	
Stairs	find the unit for the staircase- GF TO GF height. Information given: total rise of 2722mm, going - 234mm

Plasterboard	
2.4m Tapered edge - Ceiling 15mm -	Assumed m2 unit, and the sheets quantity is the m2
2.4m Duplex tapered edge - External Walls (12.5mm) -	Assumed m2 unit, and the sheets quantity is the m2
2.4m Tapered edge - Internal Walls (12.5mm) -	Assumed m2 unit, and the sheets quantity is the m2
ADDED Metal framing components for gypsum	Posts in every 1.2m? Measure linear meter of internal partition walls- need a post every 1.2m, posts are floor to ceiling height. Will also need linear top and bottom length of internal walls. Measured- GF internal wall total length: 15.71m, 1F: 18.76. total internal walls 34.47m
Separation wall - internal wall	
2.4m Moisture resistant - Wet Room Walls (12.5mm) -	Assumed m2 unit, and the sheets quantity is the m2. Square edge chosen in oneclick, and 12.5mm dimension inputted
Ingoes & Cills - (27.5mm) - (min R Value 0.54 m2K/W)	Assumption on PVC- but OneClick assumed dimension but we don't know it. We assumed it was linear m of sills
Insulation	
External wall insulation	Mineral Fibre Wool for walls. Assumed depth from drawings (100mm for external wall)
Separation wall	
Attic Insulation	Mineral Fibre Wool for walls. Assumed depth from drawings, thicker insulation for attic measured at 450mm
Finishing Packs	
Internal Doors	
Skirtings	
Linen Cupboard shelving	Assumed width of 20mm to calculate m2 with length. Total for shelving and batons
Linen Cupboard Battens	This was joined with shelving above
Loft Access Hatch	
Ironmongery	
Cladding	
External Doorsets	
Fascia	Assumed width from drawings is 175mm to give m2 with length
Soffit's	Assumed width from drawings is 300mm to give m2 with length
Guttering	

Appendix B Life Cycle Stage Descriptions

1. Construction Stage Emissions (A1-A5)

1.1 Product Stage (A1-A3)

Firstly, the modules A1-A3, the product stage carbon factors, are the largest contributor to the Embodied Carbon Factor (ECF) of a structure.

This is dependent on:

- Material specification- varying with constituent materials
- And, how and where the material is manufactured

Thus, the ECF for concrete (and the various cement contents, and replacement percentage) greatly contrasts to that for steel sections high in recycled content and produced via a different production method.

The ECF for A1-A3 is calculated by multiplying the material quantity to give an estimate of the embodied carbon produced during the construction of the material.

1.1.1 Carbon Sequestration in Timber

Carbon sequestration is the removal of carbon dioxide from the atmosphere via photosynthesis, and the temporary storage of this carbon within the timber.

As Figures 4 and 5 show, the upfront carbon (A1-A5) report sequestration separately alongside the A1-A5 value reported. While the Embodied Carbon A1-C4 include sequestration within the total embodied carbon reported. Is there plans to sequester carbon in timber?

With no product-specific data, carbon sequestered can be taken as -1.64kgCO2e/kg (factor based on standard timber properties). This sequestration factor is multiplied by the timber material quantity in the same way as the ECF for A1-A3.

1.2 Transport (A4)

This carbon factor concerns the transport of materials and products from factory to site, and typically constitutes to <10% of the total embodied carbon of a structure.

This is dependent on the mode of transport and distance travelled. Where the most accurate estimate is made once the material or product source has been identified.

Again, the A4 ECF is multiplied by the material quantity to give an estimate of the embodied carbon due to the transport of that material.

1.3 Construction and Installation Process (A5)

The Embodied Carbon Factor (A5 process emissions) are likely to account for a small, but not insignificant, percentage of structural embodied carbon over the lifecycle of a project.

The emissions vary on a project and site basis, dependent on:

- Construction methods
- Material choices
- Site set-up

A5 is split into two parts:

- A5w- Emissions associated with materials wasted on site
- A5a- Emissions due to site activities (construction machinery, site offices, etc.).

1.3.1 A5w Material Wastage

This accounts for the carbon emissions released during the production, transportation, and disposal of wasted material.

A Waste Factor (WF) represents the percentage estimate of how much material brought to site is wasted, and can be multiplied by the same material quantity used for the A1-A3 calculations.

1.3.2 A5a Site activities

Site activity emissions are estimated from on-site electricity consumption and fuel use, and should be monitored during construction to contribute to an accurate 'As-built' embodied carbon calculation.

The A5a site activity emission data is collected and can be used to inform estimates of emissions for future similar industry projects.

Embodied Carbon Emissions (A1-C4)

As previously highlighted, the Embodied Carbon stages of the building assessment include A1-C4, but excludes the Operational Carbon (B6- Operational Energy, and B7- Operational Water).

Therefore, it is referred to as Embodied Carbon, as opposed to Whole Life Carbon, which is inclusive of this Operational Energy.

1.4 B1- Use

This module covers the release of carbon emissions or global warming potential from products, pollutants and materials during the normal operation of the building. These will include refrigerant, paints, and off gases from product such as carpets, to name a few.

1.5 B2- Maintenance

This module covers the carbon emissions of all maintenance activities, encompassing the energy and water use associated with them.

1.6 B3-B5- Repair, Refurbishment and Replacement

This module involves any emissions arising from the repair and replacement of relevant building components. Which incorporates the supply of new products (A1-A5 previously).

For consistency, it is assumed that repair and replacement are 'like for like'. Any known refurbishment scenarios going forward should be incorporated, which would cover a planned future extension or change to the building.

1.7 C1- Deconstruction and Demolition

This module includes all emissions associated with dismantling a building that has reached its end of life.

1.8 C2- Transport

This module refers to transport emissions arising from removing redundant material from the building site and taking it to a disposal site.

1.9 C3- Waste Processing

This is the carbon cost of processing redundant materials for repurposing, reuse or recycling. It is the carbon cost to bring materials to the 'out-of-waste' state.

It is important to note that this C3 Module is directly linked to Module D, within the Circular Economy aspect of the building assessment.

1.10 C4- Disposal

This module includes any emissions arising from the disposal of materials to landfill or incineration.