# Exemplar Case Study: Carpenters Yard, Thornwood, Essex

## Essex Low Energy & Carbon Delivery Support

July 2026

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# 1. Introduction

This case study exemplifies best practice in sustainable construction through an in-depth review of the gs8 Carpenters Yard project, highlighting successes, lessons learned, and the low-carbon strategies adopted to achieve market-leading performance.

It demonstrates the steps taken during the design and delivery process to comply with Essex wide published GE1[1] and GE2[2] policies relating to operational and embodied carbon, while also acting as a roadmap and evidence base for similar initiatives aiming to meet and exceed policy requirements across Essex.

Within this document, technical terms are referred to throughout and will be highlighted **bold**, please refer to the glossary near the end of the document for definitions of these terms.

## 1.1 Core Design Team Members

**gs8** - residential developers and contractors, gs8 are pioneers in developing planet-positive homes, and are the UK market leaders in regenerative development. As part of their commitment to social improvements, all their schemes are community led, where local people play a key role in developing and managing homes to solve housing problems in their area.

**KLH Sustainability** - an award winning sustainability consultancy with 15 years of experience at the forefront of net zero development. As sustainability experts they specialise in producing strategic sustainability frameworks that push the boundaries of planet positive design. KLH have been instrumental in driving the sustainability credentials of the Carpenters Yard project and work closely with gs8 on multiple schemes over the past 8 years.

**Boehm Lynas** - an award-winning architecture practice specialising in innovative, sustainable residential and mixed-use developments. The practice is known for design-led, environmentally responsible architecture that prioritises low-carbon construction, whole-life sustainability and high-quality placemaking

## 1.2 Collaborators

**Octopus Energy** - a UK-based renewable energy supplier providing electricity and gas services, with a focus on affordable green energy, smart technology, and innovative tariffs designed to help customers reduce costs and carbon emissions. They were instrumental in this project by providing zero bills tariffs to residents.

**Epping Forest District Council (EFDC) Planning Services** - the local planning authority responsible for assessing planning applications, developing local planning policy, and guiding sustainable growth for the Epping Forest district alongside Essex County Council. The team supports development through planning advice, policy implementation, and collaboration with stakeholders to ensure proposals align with environmental standards, infrastructure requirements, and long-term community needs.

**Built Environment Planning Unit (BEPU, formally CaPU) -** BEPU works on the delivery of a high quality and healthy built environments via planning across Greater Essex, ensuring homes and buildings are energy efficient, affordable to run, support occupants' wellbeing, use local material and water resources efficiently, reduce waste, incorporate renewable energy, and are resilient. BEPU sits within the Growth and Development team under Essex County Council's Planning Service and works alongside Essex district and unitary authorities and through the Essex Planning Officers Association (EPOA), delivering evidence-based planning policies, guidance and advice.

1 https://www.essexdesignguide.co.uk/media/3278/policyge1_energyandcarbon-oct-2025-v11-april-2026.pdf
2 https://www.essexdesignguide.co.uk/media/3282/policyge2_embodiedcarboncircecon-oct-2025-v11-april-2026.pdf

# 2. Overview of Project

Carpenters Yard is a housing development located in Thornwood, Epping. The site was previously used for agricultural purposes and now consists of 113 new homes built using a planet positive framework developed by gs8 to show that market leading low carbon, low waste and low energy design can be delivered at scale in Essex.

Carpenters Yard is a neighbourhood shaped around shared green spaces, pedestrian streets and a slower pace of life. Woodland walks, a community centre, allotments and play areas are all close at hand, with direct access to Thornwood Common and the wider landscapes of Epping Forest. Connections into Thornwood and Epping are easy, with Epping Central line station a 10 minute cycle, or 5 minute drive away, making this a home that feels both grounded and well connected.

The development is the UK's largest development to offer 2, 3 and 4 bedroom homes with zero-energy bills guaranteed utilising a smart microgrid and centralised battery storage. It also achieves best practice embodied carbon and biogenic sequestration through the sites material selection.


*Figure 1 : Carpenters Yard Location Plan*

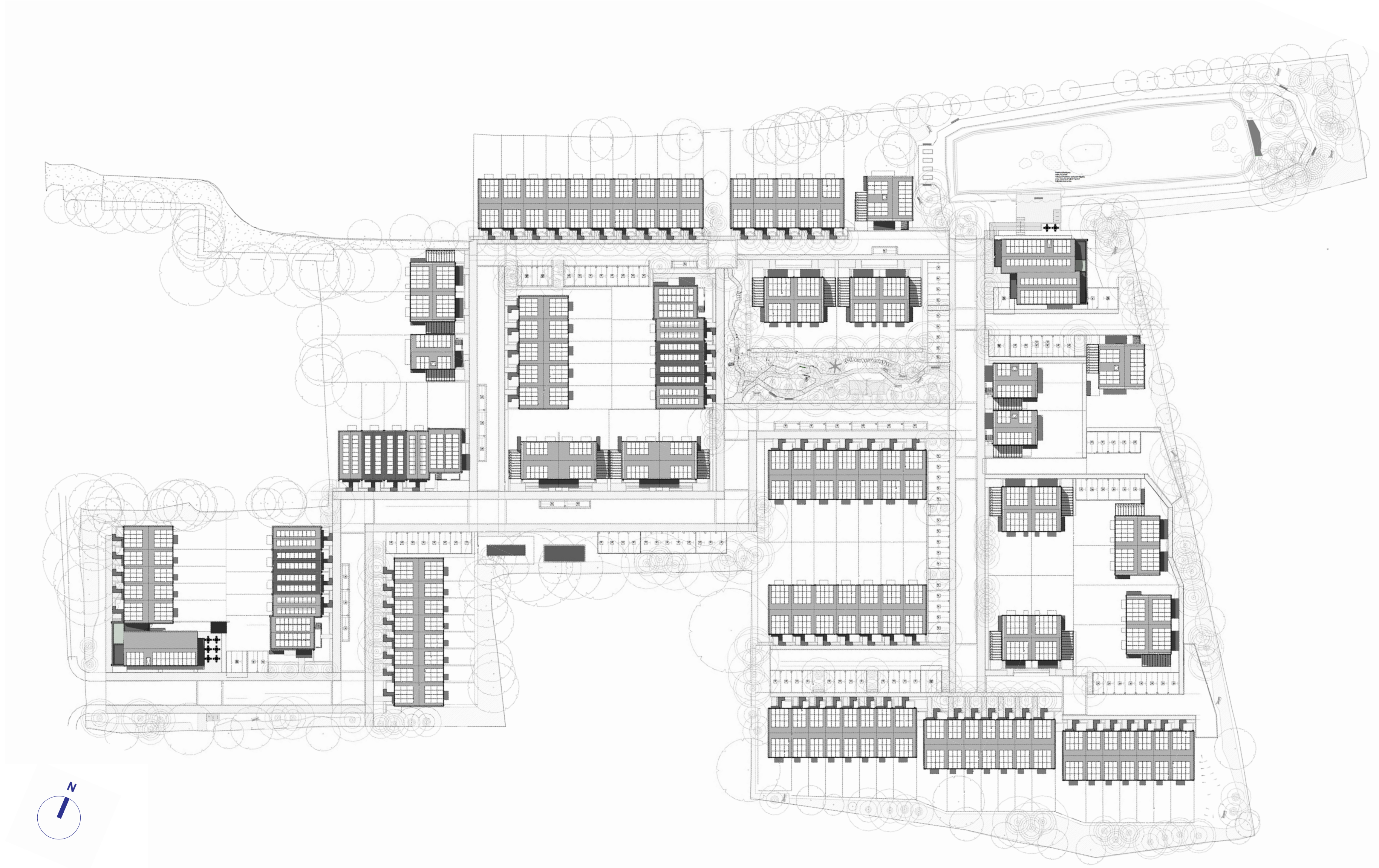



*Figure 2 : Carpenters Yard site plan*

# 3. Design Approach

The homes are designed to have low energy demands, use low carbon materials, have zero construction waste and **sequester** more carbon over their lifetime than they create up front. The homes have also been optimised to reduce energy demand and incorporate renewable energy sources to deliver net zero homes in operation, whilst considering the impact this has on overheating and daylighting. **Sensitivity analysis** has been undertaken which allows for the flexibility in masterplanning to not have to rely on a N-S grid for optimum performance. The houses have been developed through an **iterative design** process to achieve optimal efficiency in **form factor**, daylighting, overheating mitigation, orientation, and resilience to climate conditions.

The results of the design approach enable substantial reductions in **regulated energy** use and will allow for zero energy bills for both private and affordable residents living within the development.

**Passive design principles** have been followed to reduce the requirement for mechanical cooling and highly energy efficient houses. **Circular economy** principles and an iterative design process for material usage has been implemented to reduce the embodied carbon of the dwellings, establishing a good balance between operational and embodied carbon.

## 3.1 Energy

The design approach for the development aims to reduce the operational energy demand of the homes through a **fabric first** approach and ensure power and heat is generated from clean sources. The proposed all-electric services strategy eliminates future dependency on fossil fuels and will benefit from the decarbonisation of the electricity grid and the on site renewable energy generation.

The Site takes a "planet positive" approach. The layout of the homes across the Site is designed to maximise the benefits of passive design strategies and the efficiency of roof-top photovoltaic panels (PVs). Building fabric U-values and airtightness exceed Part L (2021) Building Regulations, delivering a 120% reduction in **regulated energy use** as shown in Figure 3. Thermal bridges have been carefully considered and reduced, further improving energy performance and reducing the risk of surface condensation which contributes to poor indoor air quality (IAQ).

The homes incorporate passive design principles for the thermal envelope, reducing energy demand for heating, lighting and ventilation, while eliminating the need for active comfort cooling. The implementation of efficient building services, including Mechanical Ventilation with Heat Recovery (MVHR) and Air Source Heat Pumps (ASHP), along with a low carbon heating strategy, further limits energy consumption and **operational carbon** emissions. A focus on passive design and excellent fabric performance have the additional benefit that it lowers heating bills for the residents and delivers high comfort levels within the living spaces.

The PV systems on the roofs of the homes are projected to generate enough renewable energy on site each year to balance the modelled regulated energy consumption of the homes. This highlights both the energy efficiency of the homes and the significant renewable energy output.

SAP modelling has been undertaken to assess the schemes operational energy use in the context of part L. PHPP modelling has been undertaken to assess the impacts of **unregulated energy use** and to benchmark the scheme against Essex's GE1.3 requirement, measuring energy use intensity.

## 3.2 Zero Bills

The homes are designed to optimise the number of PVs on roofs and orientated to ensure the highest yield of on-site production. The renewable energy generated by the PVs is estimated to exceed the predicted energy demand of the homes on site, in alignment with Essex's GE1 policy. This allows Carpenters Yard to provide zero energy bills for residents, utilising a smart microgrid with central battery storage.

The development also includes a smart microgrid, a local energy network that manages electricity generation, storage, use, and forecasting at the neighbourhood scale. By combining renewables, batteries, and smart monitoring, the system reduces reliance on imported grid electricity, lowers carbon emissions, and helps households save money. The main goal is to use as much of the locally generated electricity on-site as possible.

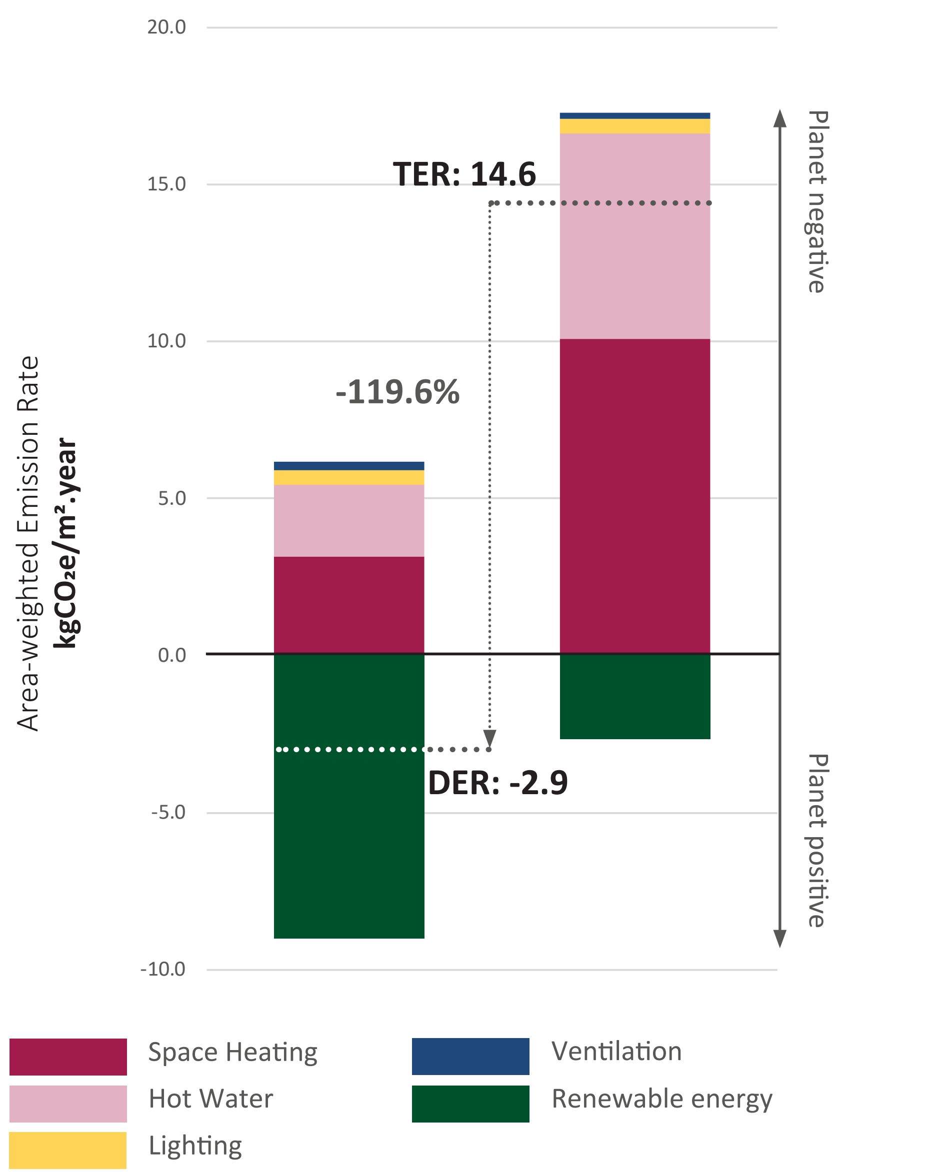



*Figure 3 : Summary of the site wide average difference between* ***TER*** *and* ***DER****, broken down across different carbon sources. The percentage reduced is the average decrease in carbon of dwellings at Carpenter's Yard the over the notional building in Approved Document L1.*

## 3.3 Passive Design

Passive design principles have been followed to reduce requirement for mechanical cooling and create high energy efficiency houses. Key passive design strategies of the development include:

- Airtightness 0.3 ACH at 50pa
- Thermally efficient envelope using natural materials
- Optimised window design
- External shading
- Maximised bedroom ventilation

These elements combined allow for buildings to perform optimally year round, with reduced overheating in the summer and the use of solar gains in winter, reducing the need for active cooling and heating system demand.

## 3.4 Overheating

Overheating mitigation strategy focuses on well proportioned windows to reduce solar gains with shading to south and west facing windows including **brise soleil** and external shutters where required. Sensitivity analysis was undertaken during design stage to figure out the best & worst-case orientation for each house type, to allow for flexibility in home placement across the site. The homes are able to mitigate the overheating risk without active cooling. Overheating calculations were conducted across the site using the TM59 methodology on EDSL Tas software for accurate overheating analysis.

## 3.5 Iterative Design Balance

Regular iterative heat loss, daylight and overheating modelling has allowed for window ratio to be higher than Passivhaus or **LETI standards**.

Window locations and sizes have been prioritised to allow for deeper light penetration into key rooms, with street facing windows sized to reduce heat loss, and rear windows maximised to create a strong visual and spatial garden connection. This approach to window design and the iterative design methodology has allowed for all homes to pass **BRE daylighting standards** as well as achieving the best balance between embodied and operational carbon.

All properties achieve high daylighting levels whilst reducing overheating and remaining compliant with Part O.

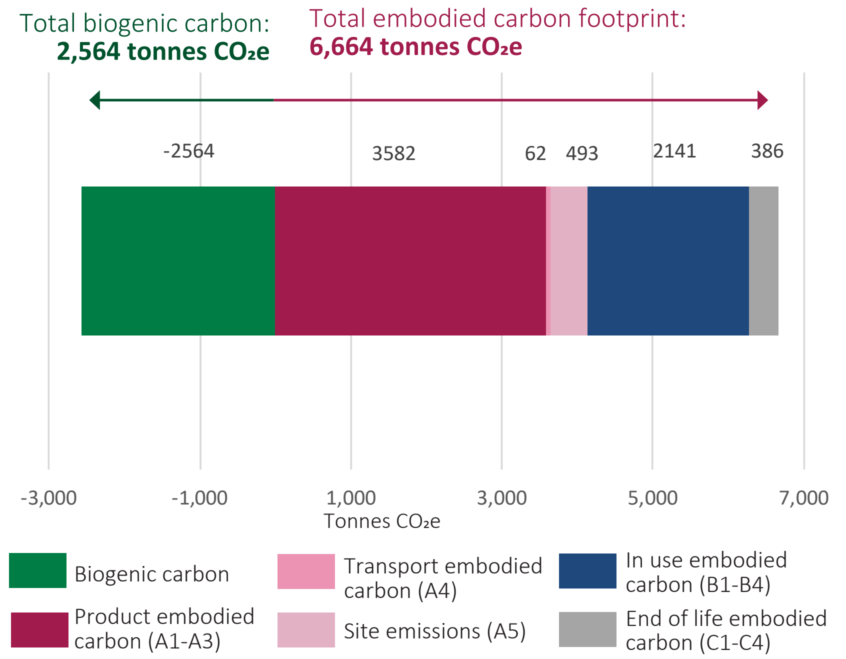



*Figure 4 : Total tonnes of $CO_2$ per life cycle boundary including* **biogenic carbon.**

## 3.6 Embodied Carbon

**Embodied carbon** has been a central consideration during the design process. Throughout every design stage, data has been collected and recorded to support **carbon optioneering**, allowing for a clear overview of carbon intensive materials.

The embodied carbon resource strategy follows the embodied carbon hierarchy (Build less, light, wise, low carbon, for the future), and all calculations have been completed to the standards outlined within **EN15978** & **RICS guidance** (see Figure 5 in Section 5). The calculations were undertaken using a proprietary tool.

The use of timber was a key element of the projects embodied carbon design, serving to reduce the projects climate impact through carbon sequestration. To see the total footprint and biogenic carbon of the scheme see Figure 4.

## 3.7 Circular Economy

The homes have been designed to implement best practice circular economy principles.

They focusing on material efficiency and reuse such as through the use of reclaimed bricks. Through supply chain management, and working directly with manufacturers, efforts have been made to reduce material packaging arriving to site, such as by agreeing to delivery of aggregates without bulk bags. The homes are built for disassembly, with mechanical fixings used throughout and minimal finishes, allowing for the reuse of materials at the end of the buildings' life cycles.

Adaptability has been considered throughout, with flexible layout and home working spaces allowing for residents to customise properties to their needs. And finally, waste from the construction process has been re-imagined as a valuable resource, with efforts made to reuse waste on site, and additional waste being used within a community DIY centre, allowing residents to live a more circular life.

## 3.8 Landscape Design and Flood Risk Management

The site is designed around climate-resilient landscaping, promoting adaptability, sustainability and visual appeal in the face of a changing climate.

The development incorporates native and edible species that require low levels of irrigation and are designed to be self-sustainable once the landscape is established. A pond creates evaporative cooling, allowing trees to absorb the surrounding water, ultimately cleaning and cooling the air.

The potential risk of flooding is mitigated across the site through the integration of **SUDS**, an increased quantum of permeable ground and inclusion of more trees. This allows for a reduced risk of localised flooding through creating a slower permeation of rainfall through the ground and therefore slowing the river down.

# 4. Essex Planning Requirements

The preparation of the two policy statements has been led by the Built Environment Planning Unit (formerly Climate and Planning Unit) at Essex County Council, under the guidance of the Essex Planning Officers Association, and in collaboration with officers from the Local Authorities in Greater Essex These two primary low carbon policies are broken down into embodied and operational carbon requirements. The requirements of the policies are based on building performance limits and best practice designs, adherence to the policies is required to gain planning consent in areas where local plans have these incorporated.

Policy GE1 is Essex's Operational Energy and Carbon (Net Zero) planning policy, requiring all new homes and buildings across Greater Essex to meet high energy efficiency and renewable energy generation standards. It was implemented to ensure new developments minimise energy demand, reduce fuel poverty, support national climate targets, and deliver healthier, more resilient homes from the point of occupation.

Policy GE2 is Essex's Embodied Carbon and Circular Economy planning policy, requiring new developments to use materials and resources efficiently, minimise waste, and prioritise low-carbon, locally sourced materials. It was implemented to reduce the carbon emissions embedded within building materials and construction processes, helping Essex meet local and national climate targets while promoting circular economy principles such as lean design and reuse over demolition.

In order for a development to be compliant, it must meet the requirements set out within the policies, or provide adequate explanation as to why the policies could not be achieved. Section 5 of the document explains where the Carpenters Yard development is achieving, under performing or exceeding Essex's GE1 & GE2 policies. Figure 5 shows a summary of life cycle stage terminology for reference in the next Section.

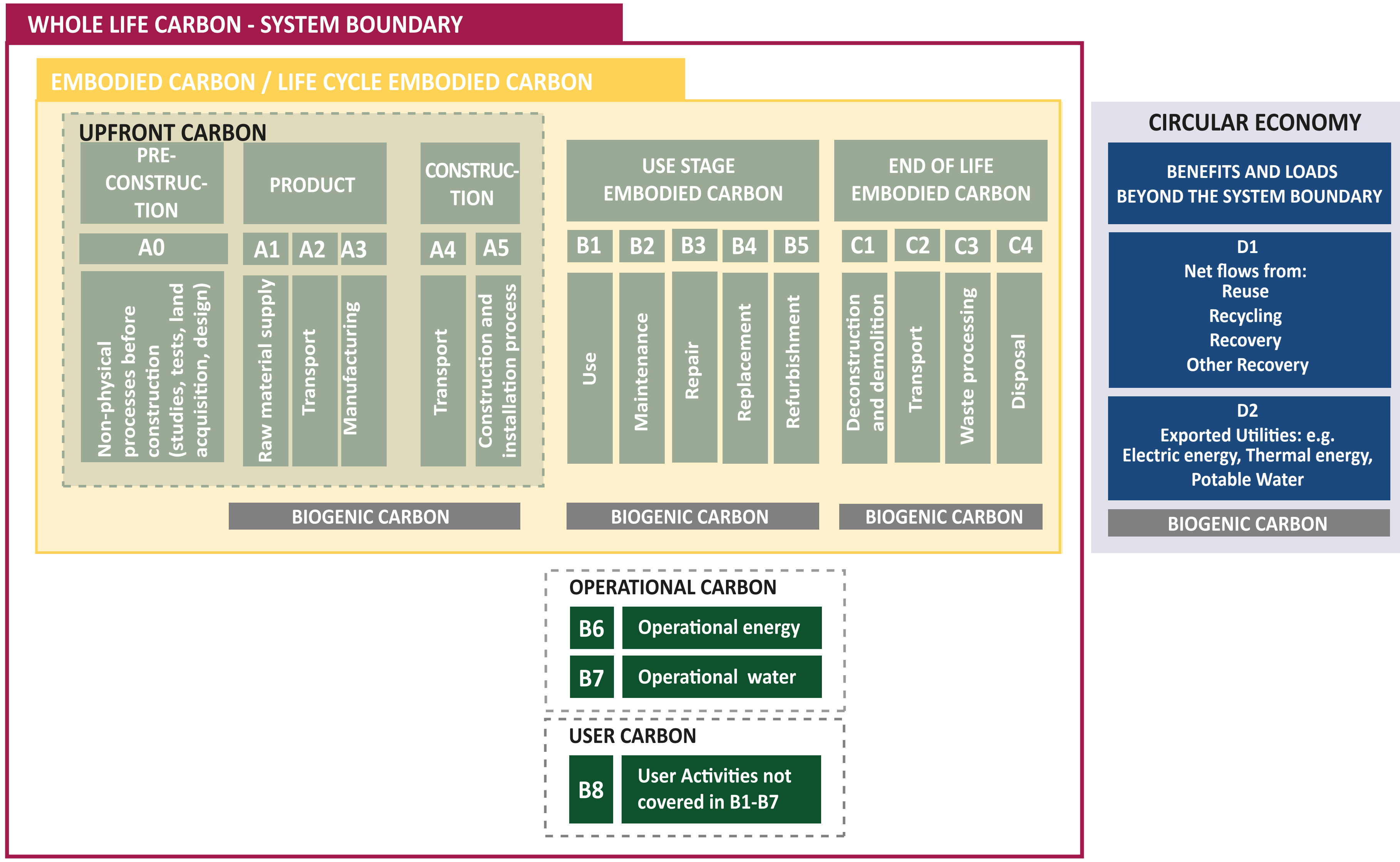



*Figure 5 : Life Cycle stage terminology for RICS v2*

# 5. Achieving GE1 & GE2

## 5.1 Essex Policy GE1 (Operational Energy & Carbon)

GE1 requires all new buildings in Essex be net zero in operation; minimising energy demand, eliminating fossil fuels, and generating renewable energy on-site to reduce carbon emissions and fuel poverty. It plays a key role in Essex achieving their net zero ambitions and reducing the impact of climate change.

*The requirements outlined within GE1 are as follows:*

1. Space Heating Limits: Residential buildings must achieve ≤15 kWh/m²/year (≤20 for bungalows); non-residential buildings must meet the same 15 kWh/m²/year limit.

2. No Fossil Fuels: No gas grid connections permitted; fossil fuels cannot be used for heating, hot water, or cooking.

3. Energy Use Intensity (EUI) Limits: Homes must not exceed 35 kWh/m²/year; non-residential limits vary by type (e.g. offices 70, schools 65, light industrial 35). For larger sites require an average of <45 kWh/m²/yr.

4. On-Site Solar PV: Rooftop solar must be installed generating at least as much energy as the building consumes annually. Where this isn't feasible, a financial offset contribution is required (£1.82/kWh shortfall).

5. Performance Verification: As-built performance data must be submitted before occupation; developments of 100+ homes must monitor energy use across 10% of dwellings for 5 years.

| Policy | Essex Requirement | GS8 Submission at planning (21.12.2023) | GS8 During Construction |
|---|---|---|---|
| GE1 | Operational Energy & Carbon (Net Zero) – Planning Policy Statement October 2025 | | |
| GE1.1 | Space Heating Demand <15kWh/m²/yr | Site average space heating of 21kWh/m²/yr (modelled in PHPP) allowing for a range of orientations and housing types | Currently achieving site wide average space heating demand of 20 kWh/m²/yr. Whilst the initial space heat demand target of 15 kWh/m²/yr is not met, this is due to the design balancing better than best practice performance in other areas including exceeding Essex requirements in energy generation, providing zero bills for residents, and far exceeding embodied carbon levels meaning this is still considered an exemplar case study. |
| GE1.2 | Fossil fuel free site | Fossil fuel free site from construction through to in operation | Site is fossil fuel free |
| GE1.3 | Site wide EUI <35 kWh/m²/yr<br>Larger sites require an average of <45 kWh/m²/yr | Targeting a site wide average energy use intensity of 31 kWh/m²/yr (modelled in PHPP) | Currently achieving site wide average of 31 kWh/m²/yr with results ranging from 28 to 33 kWh/m²/yr. |
| GE1.4 | Energy generation to match or exceeds energy use per year | On-site renewables to produce double the energy consumption onsite within a year. Renewable energy to be generated using rooftop solar. | Excess solar PV generation to allow for zero bills in use in partnership with Octopus |
| GE1.5 | As-built energy modelling and in-use monitoring | Commitment to energy modelling update through all Stages of design including as-built | Have undertaken modelling at every RIBA stage to understand any design or specification change during procurement |

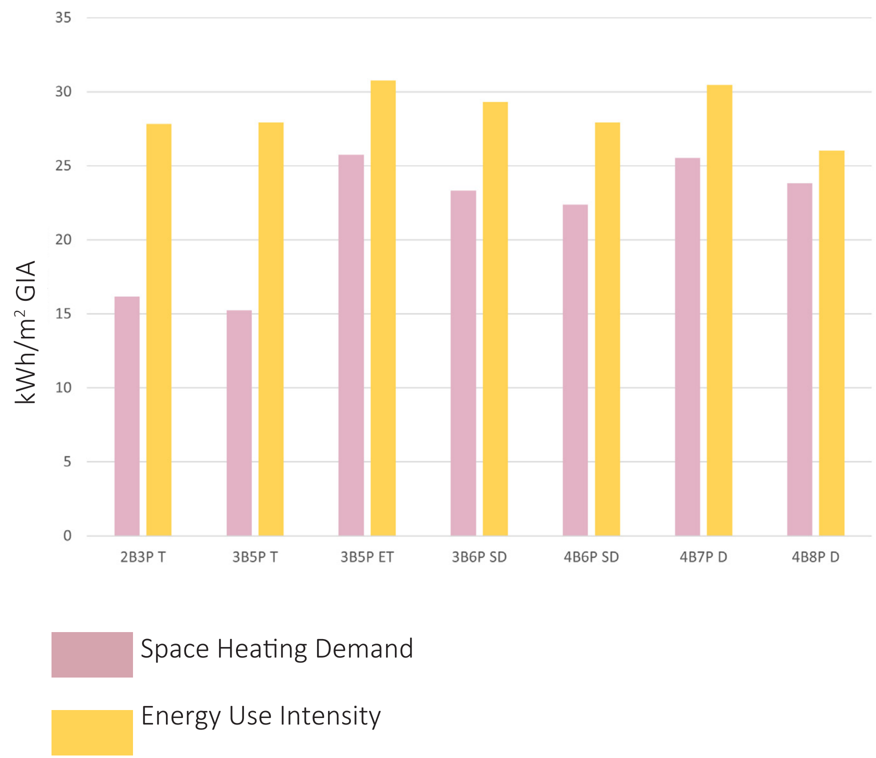



*Figure 6 : Carpenters yard energy use and space heating demand per typology types across all life stages.*

## 5.2 Essex Policy GE2 (Embodied Carbon & Circular Economy)

GE2 requires reducing the environmental impact of construction itself by minimising embodied carbon, prioritising reuse over demolition, and embedding circular economy principles into building design and material use.

*The requirements outlined within GE2 are as follows:*

1. Prioritise Reuse & Retrofit: Existing buildings and structures should be reused, renovated or retrofitted where possible. Any demolition must be justified to the Local Planning Authority.

2. Embodied Carbon Reduction: All new builds, extensions, renovations and conversions must demonstrate that upfront embodied carbon has been considered and minimised through lean design, sustainable material procurement and waste reduction.

3. Carbon Assessment for Major Developments: Major developments must submit a formal embodied carbon assessment using a RICS or nationally recognised methodology, with the following up front carbon limits:

- Low-rise residential (up to 11m): ≤500 $kgCO_2e/m^2$
- Mid/high-rise residential (over 11m): ≤500 $kgCO_2e/m^2$
- Offices: ≤600 $kgCO_2e/m^2$
- Education: ≤500 $kgCO_2e/m^2$
- Retail: ≤550 $kgCO_2e/m^2$
- Global warming potential of refridgerants used in building services must meet limits outlined in **NZCBS.**

The development significantly exceeds GE2 policy requirements and acts as a best practice for how developments should be targeted within the Essex region.

| Policy | Essex Requirement | GS8 Submission at Planning (21.12.2023) | GS8 During Construction |
|---|---|---|---|
| GE2 | Embodied Carbon & Circular Economy – Planning Policy Statement October 2025 | | |
| GE2.1 | Existing buildings and structures should be reused, renovated or retrofitted | Not applicable as a new building development site. | Not applicable as a new building development site. |
| GE2.2 | Upfront embodied carbon has been considered and minimised | Best practice upfront carbon figures targeted, see GE2.4. | Best practice upfront carbon figures achieved through supply chain management and the use of lower embodied carbon materials such as timber and wood fibre insulation. Results see GE2.4. |
| GE2 | All proposals must show how circular economy principles have been embedded into the design. | Incorporating circular economy principles was key in the design of the site including:<br>• Considering material efficiency and reuse<br>• Designing out construction waste<br>• Designing for adaptability<br>• Design for disassembly<br>• Waste as a resource | These ambitions were achieved and built upon during construction:<br>• Reclaimed materials were incorporated throughout including reclaimed brickwork for the facades.<br>• Construction waste was limited through supply chain management, take back schemes and engagement with suppliers on packaging waste. Subcontractors signed up to the GS8 zero waste charter which ensures no single use plastic on site and correct recycle practices for individuals.<br>• Homes are designed with flexible layouts included home working spaces.<br>• Mechanical fixings and minimal finishes are incorporated within the homes to enable disassembly at the end of life.<br>• Waste as a resource was realised through on-site reuse in the hard landscaping, as well as enabling circular lifestyles through establishing a community DIY centre. |
| GE2.3 | Upfront embodied carbon emissions <500 $kgCO_2e/m^2$ | Targeting 349 $kgCO_2e/m^2$ upfront carbon average across the site for the homes (A1–A5) | Range of upfront values across the site with combination of different build-ups with procurement and design decision with Upfront 297 $kgCO_2e/m^2$ predicted 2.5% Stage 5 uplift included. |
| GE2.3 | GWP limit for refrigerant systems < 677 $kgCO_2e/kg$ | No active cooling systems to be installed in the houses and ASHP to have low GWP refrigerants | Overheating strategy doesn't require active cooling systems to mitigate risks. Propane ASHP installed with a GWP 3 $kgCO_2e/kg$ |

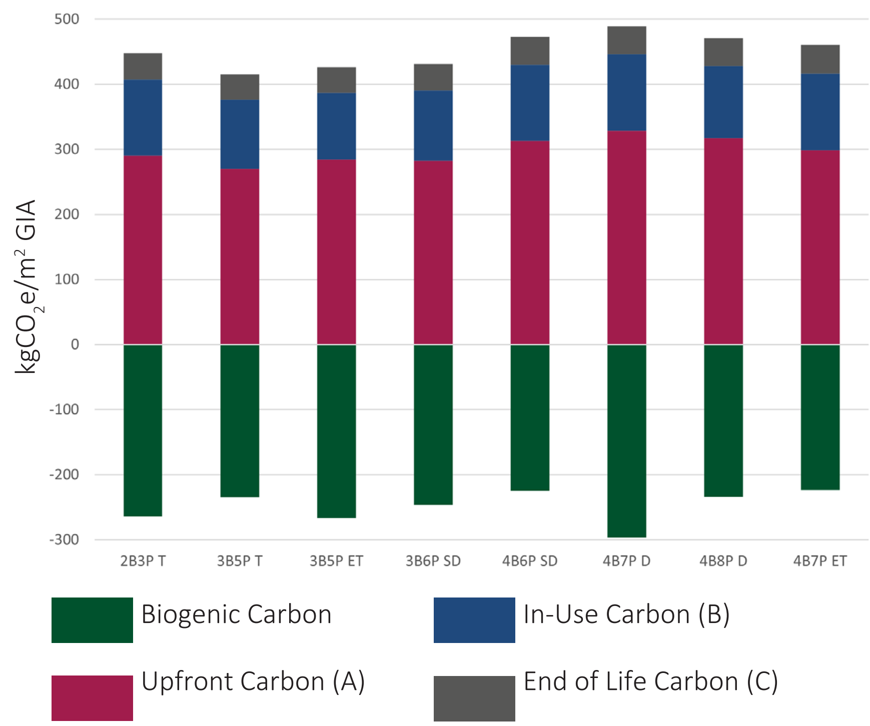



*Figure 7 : Carpenters yard embodied carbon breakdown per typology types across all life stages.*

# 6. Other Sustainability Targets & Outcomes

As well as broadly meeting and often exceeding Essex's GE1 & GE2 policy requirements, the Carpenters Yard development also aimed to achieve a range of additional targets, going over and above the minimum requirements established by the council and building regulations.

## 6.1 Energy

Developing a low-energy approach was a key additional aim of the Carpenters Yard development, with plans for a **smart microgrid** and zero bills for residents, in addition to the implementation of ASHP with a minimum **COP** of 4 and MVHR installed in all properties.

The initial aims in this area were achieved, with a UK first pilot, in partnership with Octopus Energy, guaranteeing zero energy bills for all resident for at least 5 years. ASHPs and MVHRs have been installed across the site, with COPs of 4 and efficiencies of 90% respectively.

## 6.2 Embodied Carbon

Minimising embodied carbon was another central aim, with an initial target of 562 $kgCO_2e/m^2$ average emissions per house type (A-C), alongside an ambition to sequester more carbon through materials than was emitted during the upfront construction stages.

The development achieved 447 $kgCO_2e/m^2$ across stages A-C (including a predicted 2.5% stage 5 uplift), against the original target of 562 $kgCO_2e/m^2$. Total carbon sequestered reached 303 $kgCO_2e/m^2$, surpassing the upfront carbon figure of 297 $kgCO_2e/m^2$ shown in the GE2.3 section in the table on Page 10, meaning the development sequesters more carbon than it emits, excluding any additional **landscape sequestration.**

## 6.3 Green Infrastructure & Biodiversity

Enhancing green infrastructure and biodiversity was a key target of the development, with an initial target of 40% habitat net gain set against the baseline site assessment.

This ambition remains unchanged, however a final figure is yet to be confirmed as landscaping works across the site are not yet complete.

## 6.4 Sustainable Movement

Promoting sustainable movement and active travel was an additional aim of the Carpenters Yard development, with plans for the implementation of both a bike and car sharing club on site.

This ambition was achieved, with both a bike and car sharing club successfully implemented and a management company appointed to oversee operations.

## 6.5 Water Conservation

Water conservation was a core objective of the development, with all dwellings to be fitted with low consumption fittings targeting 75 litres per person per day. Non-domestic areas were targeted at 10 litres per person per day, and water butts were planned to provide 5 litres per person per day for irrigation purposes.

These ambitions were largely achieved. All dwellings were fitted with low consumption fittings, though the inclusion of a larger bath in certain house types resulted in a slightly higher predicted consumption of 79 litres per person per day against the original 75 litre target. These figures are calculated using the Part G water calculator. Non-domestic areas remain on track to meet their target, and water butts have been successfully installed across the site.

## 6.6 Climate Change Resilience

Building resilience to climate change was another aim, with ambitions centred on dynamic overheating modelling and a range of landscape-led measures to reduce the impact of a warming climate on residents.

These ambitions were achieved. All houses were delivered as Part O compliant without active cooling systems. A very small portion of the site had acoustic constraints due to noise from the road meaning night time cooling was not able to be provided by opening windows. For this run of 5 terrace houses and 2 flats, additional purge ventilation was included. All landscape-based resilience measures were incorporated within the final landscape design.

## 6.7 Health, Wellbeing & Social Value

Finally health and wellbeing ambitions spanned daylighting optimisation, elimination of **VOC**-containing materials, and a 60/40 private to affordable housing ratio dispersed throughout the site.

These ambitions were mostly achieved. Daylighting compliance was confirmed, most materials were procured VOC-free. 42% affordable housing was delivered, comprising 35 affordable rent and 12 shared ownership properties.

# 7. Lessons Learned

To achieve the high levels of performance at the Carpenters Yard development, and as previously mentioned, an iterative design was followed. The iterations were born out of a number of lessons learned throughout the project and looked to find solutions to key challenges.

In order to achieve the high targets, changes to both the design and procurement process were required. Specific design changes and construction variations across the site are outline on the following page.

## 7.1 Design Changes

Design changes incorporated variations to the construction of the house types in order optimise energy performance, renewable capacity, material usage and allow for the homes to be applicable to the needs of both the private and affordable sectors.

These changes were brought in at various stages across the site as design evolved with feedback on buildability and cost from the site team. Figure 8 shows the variations of build-up across the site.

## 7.2 Procurement Changes

Significant effort was made in bolstering the supply for high carbon value items to ensure the impact of these was reduced, allowing for a strong balance between embodied and operational carbon emissions through circular economy principles and material substitutions.

For GS8 designs, the procurement changes focused on finding lower carbon alternatives for a few key materials:

- Concrete
- Blockwork
- Woodfibre
- Softwood

These materials made up a large portion of the total materials on site, so working with the supply chain to encourage the production and use of lower carbon alternatives was key to the projects success.

| **Key Design Changes** | |
|---|---|
| Construction changes to reduce carbon | Wall build ups for several properties across the site were changed from a thickness of 300mm to 140mm, this was done to combat logistics challenges and had the additional benefit of providing design efficiencies. The U-values of the wall remained unchanged at 0.15W/m$^2$K |
| | Due to the reduction in wall thicknesses, the concrete foundations for those dwellings could also be made thinner which allowed for greater reductions in embodied carbon than had initially been estimated. |
| | Multiple floor types across the site were changed from suspended timber to a beam and block alternative, this allowed these elements be more easily constructed, leading to time efficiencies and reduced costs. |
| | The loft spaces were initially designed to be fully fitted out, this design was adapted to be minor loft boarding instead with insulation at ceiling level. This change led to a reduction in thermal envelope, reduced thermal bridging and reductions in embodied carbon through materials saved with no loss of GIA. |
| | The original design at planning had the Solar PV on every roof in every orientation to maximise the generation on site. Due to the high carbon content of PV, and the inefficiencies in generation in certain orientations, it was agreed with Octopus to optimise the PV installed on site whilst still providing zero energy bills to residents. |
| Accommodating future owners | Provision for hatches and entry into the loft was removed for the properties planned for social rent, this was done to accommodate the associations preference that social rented tenants did not have access to lofts. |
| | It was initially planned that each property would be fitted with a 116-litre bath, due to the residents desire for a larger bath, the plans were updated to accommodate a 169-litre bath instead. |

| **Key Procurement Changes** | |
|---|---|
| Accommodating future owners | The design and specification for finishes in the affordable houses was changed to be a lower spec due to the housing providers desire for an easier and cheaper maintenance schedule. Efforts have been made to maintain a similar finish and embodied for the affordable housing types where possible within these parameters. |
| Improving indoor air quality (IAQ) | Softwood timber was initially proposed for the skirting and architraves, however after significant snagging issues, this design was reverted to MDF. To maintain a good IAQ, low formaldehyde MDF (<0.08mg/m$^3$) was used. |
| Procurement changes to reduce carbon | The supplier of wood fibre products to the site was changed to a lower carbon alternative to allow for benefits in embodied carbon. Engagement with the supply chain enabled the most up to date EPDs for all products to be able to make an accurate assessment of impact. |
| | Updates to EPD of softwood timber supplier. |


*Figure 8 : Breakdown of variations in construction type across Carpenters Yard.*

# 8. Conclusion

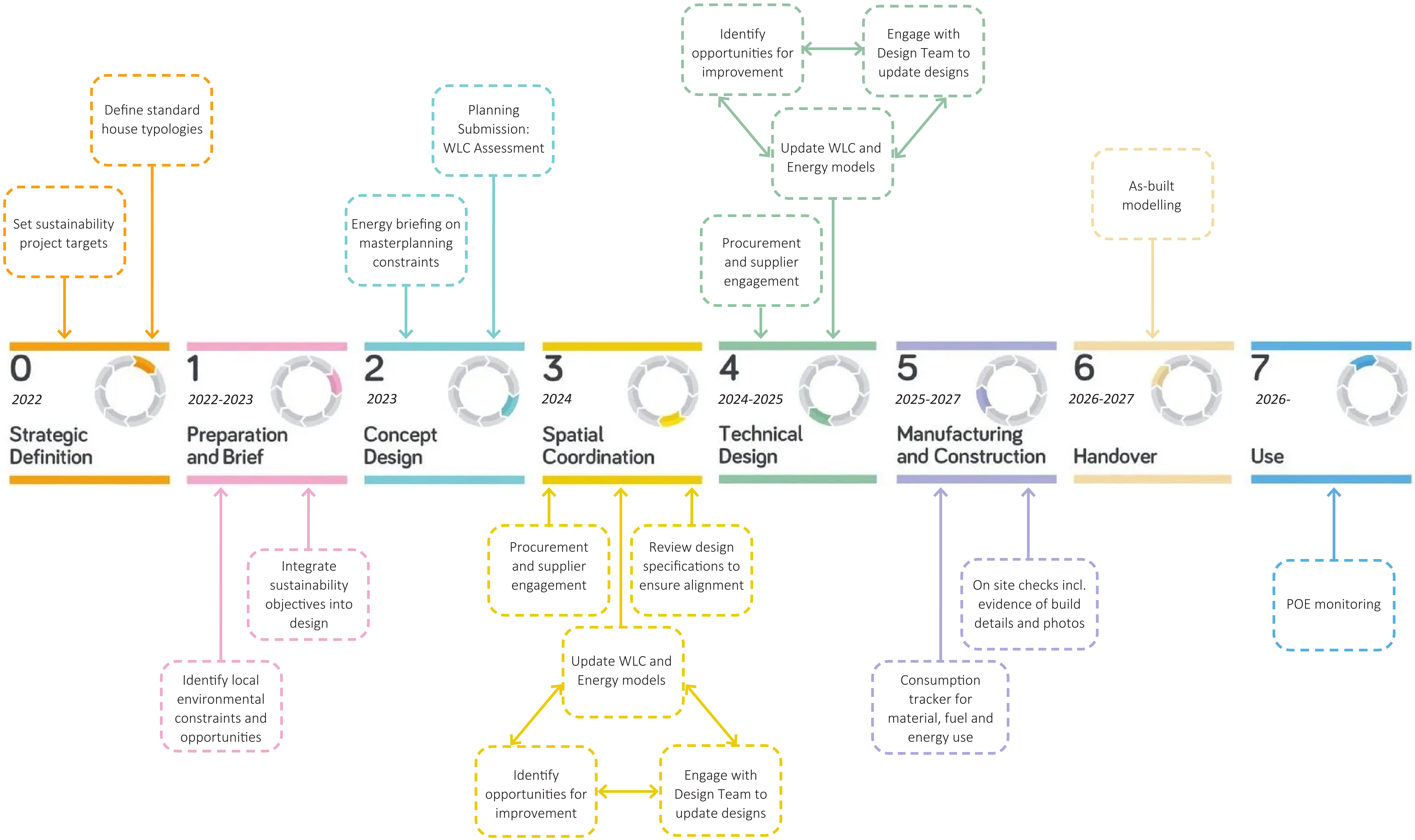
The Carpenters Yard development offers a unique exemplar for how low carbon housing can be achieved. With innovative techniques and technologies, such as the zero energy bills agreement with Octopus, in combination with a smart microgrid and centralised battery storage, it offers a unique look into how housing construction can be tailored to meet the demands of a changing climate.

As shown in this development, achievement of these high standards is dependent upon a rigorous design approach, which incorporates an action plan to tackle not just operational and embodied carbon, but also water efficiency, biodiversity, social value, and flood risk management. All of these are best achieved by implementing an iterative design process to find the best balance between competing priorities.

Through this unique design approach, the Carpenters Yard development has managed to exceed the majority of Essex's GE1 & GE2 policy requirements, with a small exceedance of the sitewide average space heat demand target. This shows that these targets are achievable in practice, and with a forward-thinking design approach, have the ability to be rolled out at scale. To achieve the best balance between buildability and performance, an adaptable design approach is necessary, utilising a range of element build-ups and making adaptations to the design where cost and buildability permit. The nature of this approach has allowed for the Carpenters Yard development to boast a wide range of building typologies and element construction types.

The site is currently still in construction, with some residents already moved into the earlier completed phases of the site. The next steps for assessing the real life performance of the development will be to undertake post occupancy evaluation and surveys for residents after the site has been occupied for over 12 months.

# 9. Process Roadmap



# 10. Project Information

| Item | Details |
|---|---|
| Sustainability Consultant | KLH Sustainability |
| Developers | gs8 |
| Architects / Design Team | Boehm Lynas |
| Other Consultants (please include all) | Match Landscape Architects, BWM, MWL, Inkling LLP |
| Location | Thornwood, Epping, Essex |
| RIBA Stage Current for Site | 5-7 |
| Date Completed | On-going |
| Parish Council | North Weald Bassett Parish Council |
| Meterage / Number of Dwellings | 113 |
| Postcode | CM16 6LT |
| Local Planning Authority | Epping Forest District Council |
| Application Type | Full detailed planning application |
| Use Class | Use Class C3 for new dwellings and Use Class E for the community space |
| General Use of Site | Residential |
| Budget | - |

# Appendix A - Glossary

**BRE Daylighting Standards -** Guidelines from the Building Research Establishment setting acceptable natural light levels in buildings, assessed via metrics such as daylight factor and vertical sky component.

**Biogenic Carbon** - Carbon dioxide that is absorbed and stored by biological materials, such as timber, straw or hemp, during their growth, and released again when the material decays or is burned at end of life.

**Brise Soleil -** An architectural shading device, typically comprising horizontal or vertical fins fixed to a building's facade, designed to reduce solar heat gain whilst maintaining daylight and views.

**Carbon Optioneering -** A process of modelling and comparing multiple design or material options to identify the combination that achieves the greatest reduction in embodied and/or operational carbon emissions.

**Circular Economy -** An approach to construction that prioritises the reuse, remanufacture and recycling of materials to minimise waste and keep resources in use for as long as possible.

**COP (Coefficient of Performance) -** A measure of the efficiency of a heat pump, expressed as the ratio of heat energy delivered to electrical energy consumed. A COP of 4, for example, means 4 units of heat are produced for every 1 unit of electricity used.

**DER (Dwelling Emission Rate) -** A calculated figure representing the predicted carbon dioxide emissions per square metre of a dwelling, based on its design specification and energy systems.

**Embodied Carbon -** The carbon emissions associated with the manufacture, transport, installation and disposal of building materials and components, excluding operational emissions produced during the building's life.

**EN15978 -** A European standard that establishes the methodology for calculating the environmental performance of buildings across their whole life cycle, providing a consistent framework for measuring and reporting embodied and operational carbon emissions.

**Fabric First -** A design philosophy that prioritises the performance of a building's physical fabric such as walls, roof, floors, windows and airtightness before considering mechanical or renewable energy systems.

**Form Factor -** The ratio of a building's total external surface area to its internal floor area. A lower form factor indicates a more compact building with less exposed surface area relative to its size, which generally results in reduced heat loss and improved energy efficiency.

**Iterative Design -** A cyclical design process whereby proposals are repeatedly tested, reviewed and refined to progressively improve performance outcomes across energy, comfort and sustainability criteria.

**Landscape Sequestration -** The capture and long-term storage of carbon dioxide from the atmosphere through the planting and maintenance of trees, shrubs and other vegetation within a development's landscaped areas.

**LETI Standards -** Guidelines published by the Low Energy Transformation Initiative setting out ambitious energy and carbon performance targets for new buildings, covering operational energy, embodied carbon and renewable energy generation, intended to support the transition to net zero construction.

**NZCBS (UK Net Zero Carbon Building Standard) -** A nationally recognised framework establishing consistent definitions, metrics and performance limits for net zero carbon buildings in the UK, covering both operational and embodied carbon across all building types.

**Operational Carbon -** The carbon emissions produced by a building during its occupation, primarily through energy used for heating, cooling, ventilation, lighting and appliances.

**Passive Design Principles -** Design approaches that reduce a building's energy demand through its physical form and fabric, such as orientation, insulation, airtightness and shading, rather than relying on mechanical systems.

**Regulated Energy Use -** The energy consumed by fixed building systems covered under Part L of the Building Regulations, including heating, cooling, ventilation, hot water and fixed lighting, excluding appliances and other occupant controlled equipment.

**RICS Guidance -** Publications issued by the Royal Institution of Chartered Surveyors setting out industry-recognised methodologies for assessing and reporting embodied carbon in construction projects, ensuring consistency and transparency in how carbon assessments are undertaken and compared across developments.

**Sensitivity Analysis -** A process of testing how changes to design variables, such as insulation levels or window sizes, affect a building's overall energy performance, helping designers identify the most impactful design decisions.

**Sequester -** The capture and long-term storage of carbon dioxide, either naturally through vegetation growth or through engineered systems; in construction, this typically refers to carbon stored in timber, bio-based materials and landscaping.

**Smart Microgrid -** A localised energy network that connects on-site renewable energy generation, storage and demand within a defined area, using intelligent management systems to optimise energy distribution, reduce grid dependency and minimise energy costs for residents.

**SUDS (Sustainable Urban Drainage Systems) -** An approach to managing surface water runoff that mimics natural drainage using features like permeable paving, swales and ponds, reducing flood risk and improving water quality.

**Supply Chain Management** - The coordination and oversight of the flow of materials, information and resources from suppliers through to final delivery on site, aimed at ensuring efficiency, quality and reliability throughout a construction project.

**Unregulated Energy Use -** Energy consumed within a building for services and equipment not included in Building Regulations compliance calculations, typically due to occupant behaviour or operational processes.

**TER (Target Emission Rate) -** The minimum acceptable carbon dioxide emission rate for a dwelling as set by Building Regulations, against which the DER is measured to demonstrate compliance.

**VOC (Volatile Organic Compounds) -** Chemical substances emitted as gases from certain building materials, adhesives, paints and finishes, which can accumulate indoors and negatively affect air quality and occupant health. Specifying low or zero-VOC materials in construction helps to maintain healthy indoor environments.

**Whole Life Carbon (WLC) -** The total carbon emissions associated with a building across its entire lifespan, encompassing both embodied carbon from materials and construction, and operational carbon from energy use in occupation, through to eventual demolition and disposal.

sustainability

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