The industry definition of net zero carbon

Industry-led guidance has been developed to set a clear definition of net zero carbon and to bridge the gap where current policy is falling short. These industry defined targets provide a clear pathway to achieve LLDC's 2030 zero carbon ambition.

The future of housing - a clear need to change

Climate change is happening and needs urgent action to slow down unknown and unprecedented impact. In 2019 the UK Government amended the Climate Change Act and adopted a target for achieving net zero emissions by 2050. LLDC has set an ambition to achieve net zero carbon 20 years earlier for new buildings, in 2030 in line with Mayor of London ambitions.

In order to achieve net zero, the Climate Chance Committee (CCC) report "UK housing - Fit for the future?" highlights the need to build new buildings with 'ultra-low' levels of energy use. It also makes specific reference to space heating demand and recommends a maximum of 15-20kWh/m^2.yr for new dwellings. Energy efficiency and a change in approach to design are required to achieve these ambitions. New buildings not achieving this level of energy performance will require retrofit in the period 2030-2040.

The transition to zero carbon housing can also bring benefits in terms of energy bills to residents and local air quality.

Defining net zero carbon buildings

The most recent and detailed definition of net zero carbon in new buildings has been developed by LETI, the UKGBC and the Better Building Partnership (BBP). It is also supported by the RIBA, CIBSE and the Good Homes Alliance. See LETI One Pager opposite.

Both RIBA and LETI have also set target levels for operational energy using an Energy Use Intensity metric (EUI) and an embodied carbon target to achieve net zero carbon in practice. Both give preference to on-site renewable generation and LETI outlines generation intensity targets relating to a building's footprint. Payments into a carbon offset fund is not considered a satisfactory way to achieve net zero carbon. Setting clear targets for both operational energy use and embodied carbon as well as balancing energy use with on-site renewable energy generation has been widely recognised as the way to deliver net zero carbon in practice.

Including unregulated energy

Contrary to previous definitions of zero carbon, the industry definition includes all energy uses and does not exclude unregulated energy (e.g. energy used by appliances and white goods). Accounting for unregulated loads is also necessary to reduce the performance gap between design and reality.

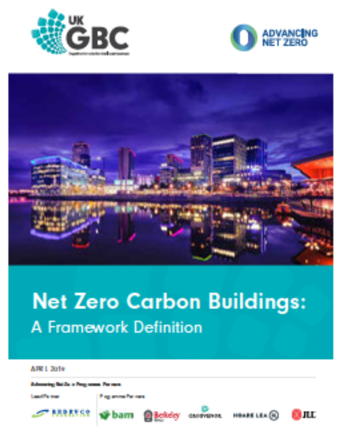
Design guidance

The Net Zero Carbon Buildings Framework developed by the UKGBC clarifies the key elements of any net zero carbon strategy. It sets the strategy for which all buildings should consider when working towards zero carbon.

Additional guidance has been published to supplement this in the last 12 months, on how to achieve net zero carbon (e.g. RIBA Sustainable design outcomes and 2030 Challenge). In particular, the LETI Climate Emergency Design Guide written collectively by more than 100 built environment professionals, considers in detail the design issues (fabric, materials and glazing), energy efficiency (reducing demand) and low carbon heat (different heating sources).

CCC - The UK Government has committed to Net Zero emissions by 2050

CCC - The need to build homes with ultra-low energy use



The Net Zero Carbon Buildings Framework developed by the UK Green Building Council

The 2030 Climate Challenge guide developed by the RIBA

The LETI Climate Emergency Design Guide

Net Zero Operational Carbon

Ten key requirements for new buildings

By 2030 all new buildings must operate at net zero to meet our climate change targets. This means that by 2025 all new buildings will need to be designed to meet these targets. This page sets out the approach to operational carbon that will be necessary to deliver zero carbon buildings. For more information about any of these requirements and how to meet them, please refer to the: UKGBC - Net Zero Carbon Buildings Framework; BBP - Design for Performance initiative; RIBA - 2030 Climate Challenge; GHA - Net Zero Housing Project Map; CIBSE - Climate Action Plan; and, LETI - Climate Emergency Design Guide.

Low energy use

1. Total Energy Use Intensity (EUI) - Energy use measured at the meter should be equal to or less than:
   - **35 kWh/m²/yr** (GIA) for residential[1]

   For non-domestic buildings a minimum DEC B (40) rating should be achieved and/or an EUI equal or less than:
   - **65 kWh/m²/yr** (GIA) for schools[1]
   - **70 kWh/m²/yr** (NLA) or **55 kWh/m²/yr** (GIA) for commercial offices[1 2]

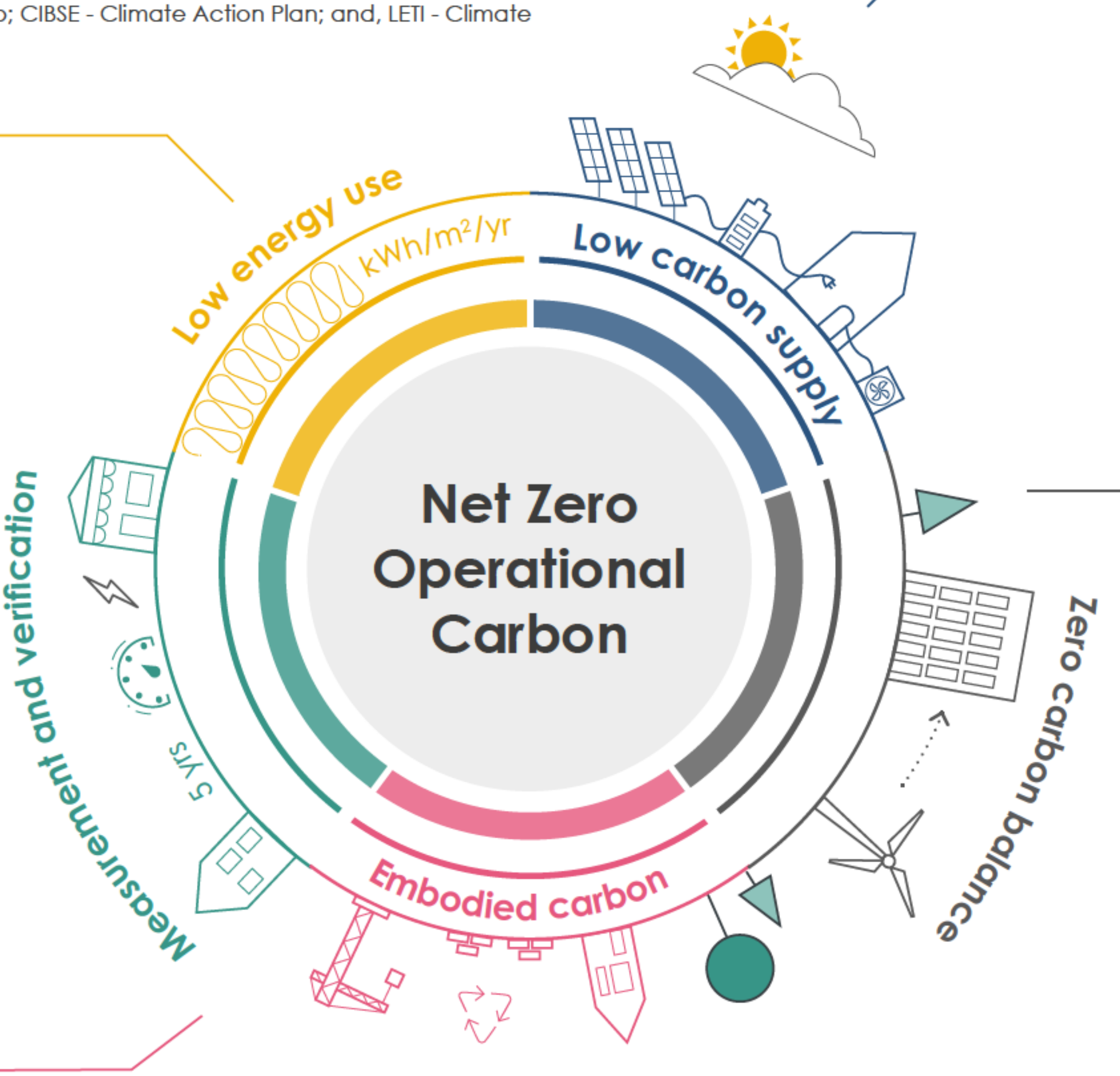
2. Building fabric is very important therefore space heating demand should be less than **15 kWh/m²/yr** for all building types.

Measurement and verification

3. Annual energy use and renewable energy generation on-site must be reported and independently verified in-use each year for the first 5 years. This can be done on an aggregated and anonymised basis for residential buildings.

Reducing construction impacts

4. Embodied carbon should be assessed, reduced and verified post-construction.[3]



Low carbon energy supply

5. **Heating and hot water should not be generated using fossil fuels.**
6. The average annual carbon content of the heat supplied (gCO_2/kWh) should be reported.
7. On-site renewable electricity should be maximised.
8. Energy demand response and storage measures should be incorporated and the building annual peak energy demand should be reported.

Zero carbon balance

9. A carbon balance calculation (on an annual basis) should be undertaken and it should be demonstrated that the building achieves a net zero carbon balance.
10. Any energy use not met by on-site renewables should be met by an investment into additional renewable energy capacity off-site OR a minimum 15 year renewable energy power purchase agreement (PPA). A green tariff is not robust enough and does not provide 'additional' renewables.

Developed in collaboration with:

Developed with the support of:

Notes:

Note 1 – Energy use intensity (EUI) targets
The above targets include all energy uses in the building (regulated and unregulated) as measured at the meter and exclude on-site generation They have been derived from: predicted energy use modelling for best practice; a review of the best performing buildings in the UK; and a preliminary assessment of the renewable energy supply for UK buildings They are likely to be revised as more knowledge is available in these three fields As heating and hot water is not generated by fossil fuels this assumes an all electric building until other zero carbon fuels exist (kWh targets are the same as $kWh_{elec-eq}$) Once other zero carbon heating fuels are available this metric will be adapted

Note 2 – Commercial offices
With a typical net to gross ratio 70 kWh/m² NLA/yr is equivalent to 55 kWh/m² GIA/yr Building owners and developers are recommended to target a base building rating of 6 stars using the BBP's Design for Performance process based on NABERS

Note 3 – Whole life carbon
It is recognised that operational emissions represent only one aspect of net zero carbon in new buildings Reducing whole life carbon is crucial and will be covered in separate guidance

Note 4 – Adaptation to climate change
Net zero carbon buildings should also be adapted to climate change It is essential that the risk of overheating is managed and that cooling is minimised

Net Zero Operational Carbon one pager- Source www.leti.london

Why LLDC need more stretching targets than current planning policy

Leading industry guidance has shown that LLDC must strive for more stretching targets that go beyond current policy and regulations if they wish to achieve their net zero carbon objective. Any developments that do not meet net zero carbon now will require costly retrofitting in future.

Current requirements are not aligned with net zero

There is a number of reasons why complying with the current requirements does not deliver net zero carbon buildings:

- It does not produce net zero carbon on site: a building which achieves a 35% improvement over Part L on-site and offsets its residual regulated emissions is not a net zero carbon building. It relies mainly on offsetting and unregulated emissions (e.g. kitchen appliances) are ignored.
- The LLDC 65% target is not enough: the change of carbon factor means that carbon improvements in excess of 60% can be achieved with a heat pump system alone. This fails to incentivise fabric energy efficiency and PVs sufficiently.
- The relative metric is inadequate: the Building Regulation percentage improvement against a notional building is confusing and misleading. It does not reward efficient designs and forms.
- The Part L tools are not fit for purpose: Part L was never meant to be used to predict energy use but it is being used for this purpose. This often means that an improved building fabric is not incentivised.
- Targeting carbon only for operational energy is not sufficient: using a carbon only metric gives the carbon factors a pivotal role. When the carbon factor used in the building regulations is as outdated as it is now it can lead to the wrong outcomes.

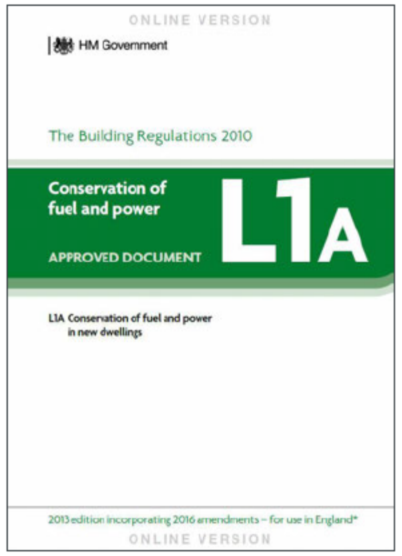
For a better, simpler pathway towards net zero

The following recommendations would help design and construct buildings which are on the right path towards true net zero carbon, and enable requirements to step up over time:

1. Adopt Energy Use Intensity (EUI) requirements: the use of maximum EUIs based on absolute values (e.g. LETI and RIBA recommendation of 35kWh/m^2.yr) would help as it includes all energy use, is an absolute metric, is independent from carbon and can be easily verified by the building/home owner/tenant after completion.
2. Request the prediction of energy use: We recommend to make the estimate of the building's future energy use mandatory. This could be done with PHPP (Passivhaus Planning Package) and/or other tools consistent with the CIBSE TM54 methodology.
3. Improve construction quality and address the performance gap: more accurate energy modelling and quality checks during detailed design and construction would help to reduce the performance gap and deliver better buildings.
4. Target early adoption of performance/EUI targets by including these within client/design brief. We also recommend an early appointment of a consultant with demonstrable experience in delivering low carbon housing (e.g. Passivhaus consultant) to allow low-carbon energy principles to be integrated within the design from concept stage.

Regulatory minimum

Net Zero Carbon?



35% reduction in emissions

10% improvement through fabric energy efficiency

65% reduction in emissions

<39kWh/m² fabric for flats

and mid terrace houses

New targets

Moving away from fossil fuels

To meet net zero carbon targets we need to transition away from burning fossil fuels to heat our buildings.

Fossil fuels and climate change

There is a consensus that fossil fuel use must end by 2050 at the latest. The Committee on Climate Change has set out this recommendation for new housing:

> *'from 2025 at the latest, no new homes should be connected to the gas grid, with ultra-low energy houses and flats using low carbon heat instead'*

Since 2018, electricity has become the low carbon alternative to gas as the fuel for heating. Furthermore, if new buildings are not built or connected with low carbon heating systems now they will likely need to be replaced with low carbon heating at the end of the system life, within 25 years.

The carbon content of gas is not going to change

Electricity used to have a very high carbon content, more than 1,000gCO_2/kWh in the early 1970's. It has become steadily 'greener' since, although it reached a plateau of approximately 500gCO_2/kWh during the 2000's (Part L 2013 carbon factor). At that time, heating systems using gas such as boilers and especially combined heat and power (CHP) were seen as environmentally friendly options.

This has now changed completely. With the de-commissioning of coal-fired power stations and the rise of renewable energy (particularly wind and solar), the annual average carbon content of electricity is now falling to around 150-200gCO_2/kWh and predicted to reduce more in the next decade.

Unlike electricity, the carbon content of gas is not going to change. For every kWh of natural gas burned, approximately 200gCO_2 will be emitted (Part L 2013 carbon factor) – and this will always be broadly the same. The injection of biomethane to reduce the carbon content of gas appears to have only limited potential (approx. 5% replacement), and similar conclusions can be made for hydrogen.

The decarbonisation of the grid

The National Grid produces a set of future energy scenarios every year. These are used to facilitate the understanding of how the UK's electricity generation mix could develop. Using the 'Community Renewables' scenario we can assume that around 70% of annual electricity demand in 2050 will be met by wind and solar power.

Therefore, the carbon content of electricity is likely to be 123gCO2/kWh in 2020, 60 gCO2/kWh in 2030 and 30 gCO2/kWh in 2050. While gas will remain at around 200 gCO2/kWh.

Other alternatives to gas

Hydrogen is not a likely option for London. Ours and LETI's analysis concluded that hydrogen is unlikely to play a significant role as the cost of infrastructure change would be significant and other uses (e.g. industrial heat, back-up power generation and heavy-duty vehicles) would be more appropriate.

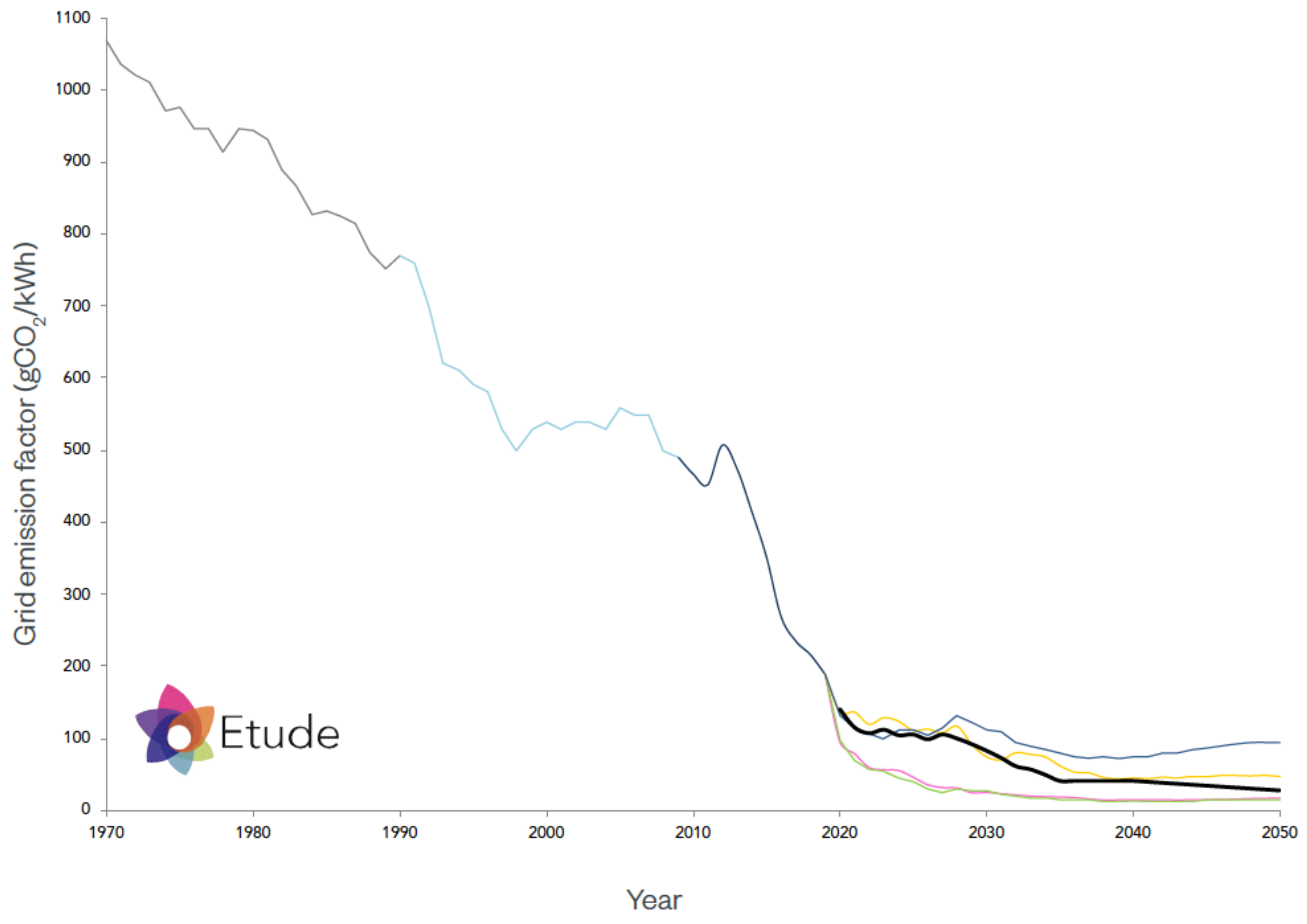
The Park district heat network

Considering the carbon content of gas, as explained above, the Park District heat network as currently run suggests a long-term high CO_2 intensity of heat. Should this be re-calculated using more recent electricity carbon factors produced by the National Grid, the CO_2 intensity of heat from the district heat network would be considerably higher.

It is understood that ENGIE, the heat network operator, are investigating options to reduce the CO_2 intensity of heat to the targeted values. However, there is currently no legally binding mechanism nor guarantee that these levels of performance will be achieved.

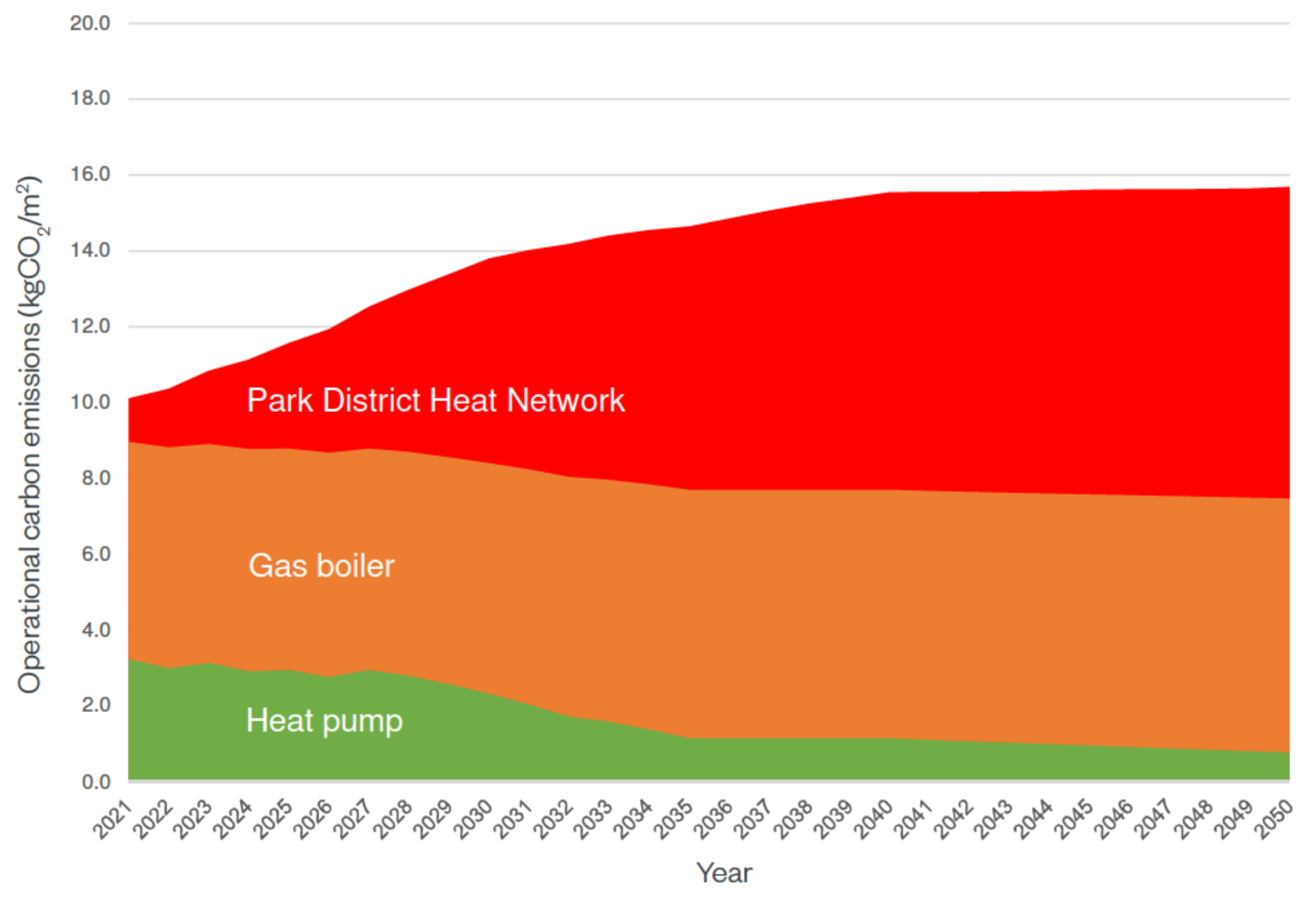
It is for this reason that any development connected or connecting to the district heat network cannot currently be called zero carbon.

Projected grid carbon emissions



The projected carbon emissions for electricity on the UK grid. Highlighting a steep decline in emissions for electricity since 2010.

Carbon emissions per sqm (dwelling)



Comparison of total annual carbon emissions over a 30 year period for the Park district heat network, an individual gas boiler and a heat pump modelled on the same dwelling. The carbon factor of electricity has been changed annually to reflect the 2019 forecast of HM Treasury Green Book for the electricity grid average carbon factor.

District heating and low carbon heat

In order to deliver a 1.5°C future we must rapidly decarbonise our electricity and opt for low carbon heating. Current evidence suggests that heat pumps are the best system to deliver low carbon heat.

District heating used to be the low carbon option

One of the key routes to achieving a zero carbon development, is through the deployment of low carbon heat. Traditionally, district heating networks generating heat through gas and biomass combined heat and power (CHP) technology was seen to be the most appropriate strategy.

The main benefit of adopting CHP historically, was that this system generated electricity though the combustion cycle. Whilst CHP technology does not generate heat efficiently, when taking into consideration the electricity generated, it was considered a low carbon means of generating heat. When considering the carbon factor of electricity being high (0.519 kg/CO_2) compared to gas (0.216 kg/CO_2), the overall carbon content of heat was calculated to be lower than other technological options.

Considering this, the carbon content of heat was assessed for the district heat network which currently provides heat across the LLDC concession area.

As it stands, the Park district heat network suggests a long-term carbon intensity of heat of 0.074 kgCO_2/kW (Park Site) and 0.119 kgCO_2/kW (Stratford City), which is calculated using the Part L 2013 carbon factors.

Delivering low carbon heat

Heating systems are going through a paradigm shift: as the electricity grid is decarbonising, systems using electricity become lower carbon heating solutions than those using fossil fuels including natural gas. With very low heat demands in low energy new buildings, district heat networks and their distribution losses also require more scrutiny.

When evaluating the options for the LLDC, the trajectory of carbon emissions is heavily dependent on the heating systems. The charts opposite (and on the previous page) compare the total annual carbon emissions over a 30 year period, for three different heating systems modelled on the same dwelling. The carbon factor of electricity has been changed annually to reflect the 2019 forecast of HM Treasury Green Book for the electricity grid average carbon factor.

Heat pumps are the best option

The charts clearly illustrate that heat pumps are essential to the delivery of net zero carbon developments in practice.

In contrast connecting to district heat network could lock LLDC into an increasingly carbon intensive system that performs worse than a gas boiler, if a rapid decarbonisation plan is not put in place.

If the network does not change, then the cumulative emissions per dwelling will be 20 times higher compared to the same dwelling heated by a heat pump system.

This approach aligns with the Committee on Climate Change's call for a ban on all fossil fuel based heating systems by 2025.

Total emission factor per unit of heat (kgCO/kW)

0.074

Olympic Park

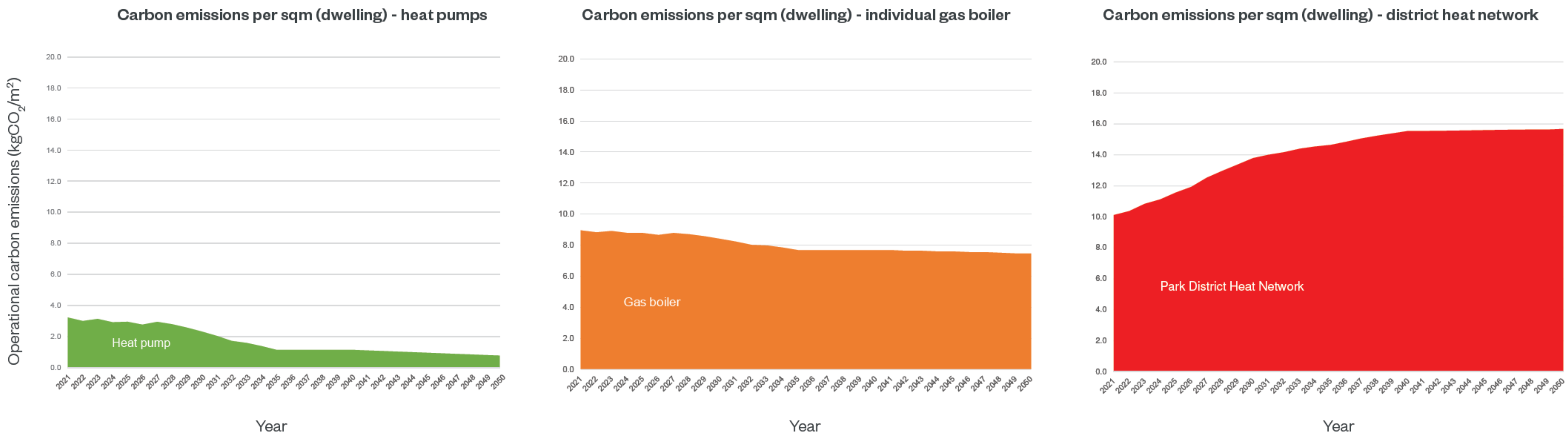
assuming secondary network with 15% losses

0.119

Stratford City

assuming secondary network with 15% losses

Figures taken from ENGIE briefing note for Commercial Developer July 2018. Tables provided in Appendix p54-55.



Comparison of total annual carbon emissions over a 30 year period for the Park district heat network, an individual gas boiler and a heat pump modelled on the same dwelling. The carbon factor of electricity has been changed annually to reflect the 2019 forecast of HM Treasury Green Book for the electricity grid average carbon factor.

Ultra-low energy homes are the new normal

Delivering ultra-low energy homes has become part of mainstream practice. Award winning developments, such as Goldsmith Street built to Passivhaus standard, has shown how energy efficient homes can be of high quality, affordable and desirable places to live. Investing in improving the performance of our buildings is integral to creating zero carbon compatible developments that will retain their value and not require retrofitting in future.

Sustainable and beautiful homes

The UK precedents selected on the right are examples of ultra-low energy design that do not compromise beautiful design. The industry is on a journey to drastically improve the energy performance of our homes whilst continuing to deliver inspiring places to live. An integrated approach to energy efficiency and design excellence is integral to delivering a successful zero carbon future.

Improving the quality of homes

Targeting high energy performance standards such as Passivhaus design can have the added benefit of improving the overall quality of the build. Furthermore the improved energy efficiency and low running cost makes them highly desirable places to live. As home buyers become more conscious of the environmental and cost benefits the market for zero carbon developments will continue to grow.

Zero carbon at scale

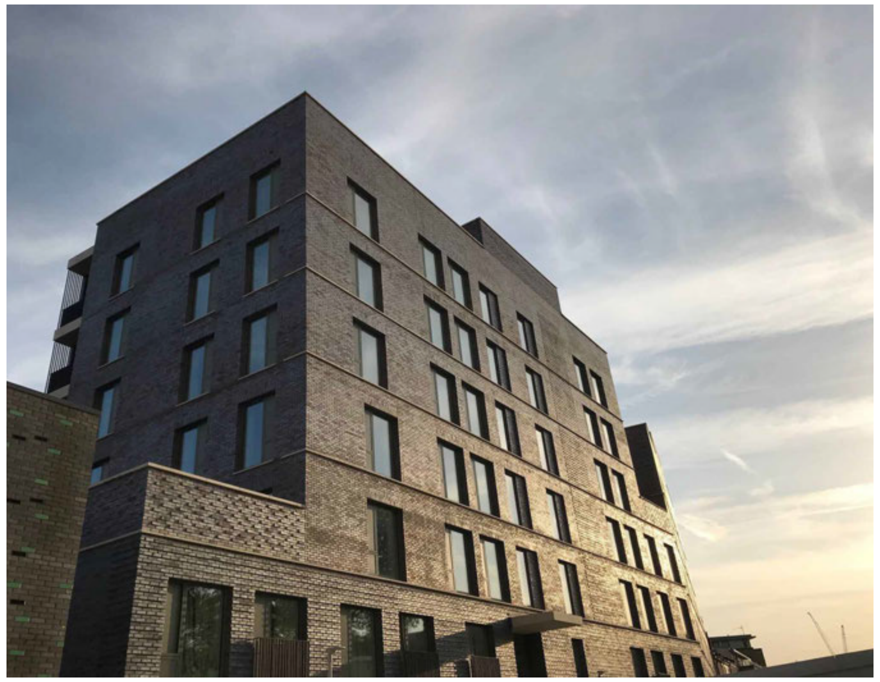
Off the back of Goldsmith Street's success, Mikhail Riches have developed plans for a multi-site housing programme in York, set to be the UK's largest passivhaus and net zero carbon scheme. The plan is to deliver 600 new market sale, social rent and low-cost ownership homes across eight sites over the next five years. This demonstrates how ultra-low energy schemes are the new normal and can be delivered at scale today.

A contextual approach to design

It is important that homes are in keeping with their local context. Ultra-low energy building requires design which takes advantage of their immediate context through well considered orientation, massing and window design. These early strategic decisions, if made by the design team at early concept stage have no additional cost implications to the design but can significantly improve the energy efficiency of a building.

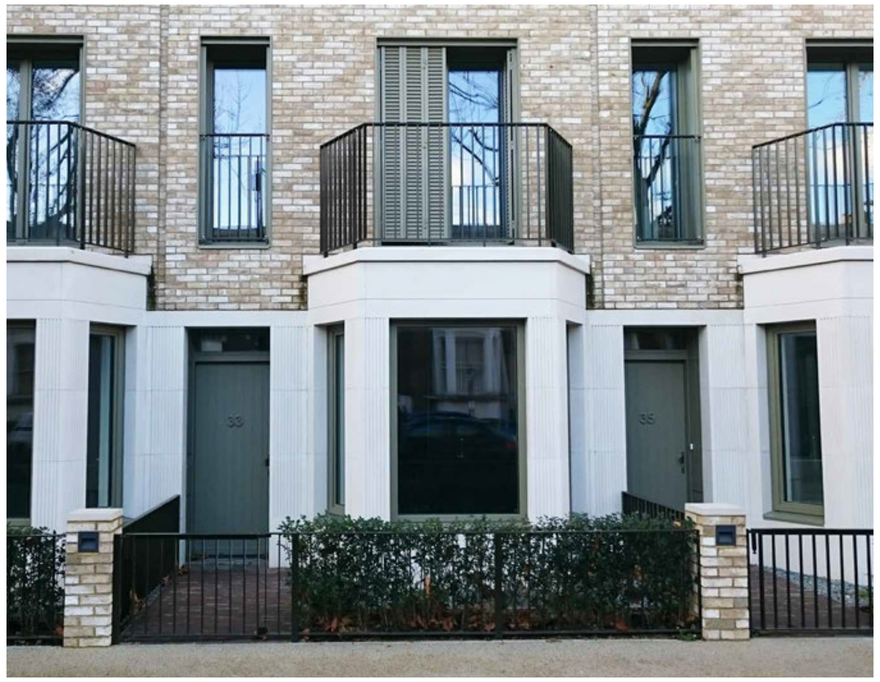
Precedents

Although few residential buildings in the UK have already delivered to this full Net Zero Carbon definition, there are a number of examples of schemes which have delivered exemplar levels of energy efficiency. A good source of examples is the Green Construction Board report on the Buildings Energy Mission 2030.



Agar Grove, Camden
Client:Camden Council
Architect: Hawkins\Brown

Goldsmith Street, Norwich
Client: Norwich City Council
Architect: Mikhail Riches



South Gardens Elephant Park, Southwark
Client: Lend Lease
Architect: Maccreanor Lavington Architects

MelfieldGardens, Lewisham
Client: Phoenix Community Housing
Architect: Levitt Bernstein

Chester Balmore, Camden
Client: Camden Council
Architect: MICA Architects

Darwin House, Westminster
Westminster City Council
Architect: Levitt Bernstein

The importance of design, modelling and quality assurance

There is a clear need to design ultra-low energy buildings to put LLDC on a trajectory to meet net zero carbon. However, there are a number of steps that need to be taken to be sure this can be achieved. This stretches beyond best practice U-values, efficient systems and adding renewables onto to roofs. More emphasis needs to be placed on the early building design decisions, the way buildings are modelled at design stage, and the quality assurance to make sure what is designed is built.

An ultra-low energy building needs to be designed that way

Ultra-low energy building fabric can be defined as meeting the Passivhaus and LETI space heating demand of 15kWh/m^2.yr. This level of energy efficiency is required to meet the LETI and RIBA 2030 energy use intensity (EUI) target mentioned below and ultimately a zero operational carbon balance.

This requires careful consideration to be given to the building form to reduce heat loss areas and to the architectural features and associated junctions for reduced thermal bridging. Orientation of homes and facade design need to carefully balance heat loss and heat gain, with shading considered to reduce overheating. This goes hand in hand with low U-values, extremely low airtightness and an efficient mechanical ventilation system with heat recovery (MVHR).

Beyond efficient systems

Selecting efficient heating and ventilation systems goes a long way to meeting the LETI and RIBA 2030 energy use intensity target of 35kWh/m^2.yr. However, the positioning, location and specification of the system components also affects how efficiently they operate.

This requires careful consideration of length and insulation of pipework runs to reduce distribution losses. location of MVHRs next to external walls and use of efficient heat pumps. Selection of energy efficient lighting and appliances also contributes to the EUI target. Simple controls that residents find easy to use, together with user guides will help to ensure systems are understood and run efficiently in reality.

Renewables are more than a cherry on top

Often renewables such as photovoltaic panels (PV) are laid out on roofs as an afterthought. But in order to maximise the number of panels and therefore their contribution to meeting a zero operational carbon balance they must become an integral part of roof design.

Roof design for PV should become a normal part of building design. There are a number of ways this can be considered including use of pitched roofs, low parapets, careful positioning of lift overruns and plant to prevent overshadowing and use of proprietary PV trays to maximise the number on the roof.

Embodied carbon needs to be significantly reduced

Reduced embodied carbon, similar to ultra-low energy buildings, needs to become part of the design process. Whilst measuring the embodied carbon in a building is helpful to improve material selection at a later design stage, ultimately the more fundamental design decisions need to come earlier than this to have a significant impact.

Collaborating with the structural engineer early and considering how a building can be optimally designed can reduce more embodied carbon than the tinkering of finishing materials later down the line. It is therefore important that embodied carbon is considered before materials are selected and calculations take place.

Embodied carbon reductions should be considered in conjunction with all design considerations and should not compromise other aspects of the building performance e.g. operational performance or combustibility.

The need for more accurate modelling

Building Regulations calculation tools use a standard modelling methodology to show compliance with Part L of the Building Regulations, planning stage compliance (% reduction in carbon emissions) and to generate Energy Performance Certificates (EPC).

For residential buildings SAP modelling is undertaken and for non-residential buildings SBEM modelling is undertaken. The methodology was not developed to predict energy use and thus should not be used to calculate energy consumption, nor predict the EUI target.

If a home has ultra-low energy fabric and a heat pump as well as PV panels on the roof it is possible to achieve over 100% carbon emission reductions using SAP. But SAP only includes regulated carbon emissions (from heating, hot water, lighting, pumps and fans and cooling). This excludes unregulated energy from plug loads and appliances.

Therefore, a 100% improvement over Part L is not equivalent to the industry definition of net zero operational carbon which uses the EUI metric.

To calculate the space heating demand and EUI it is recommended that predictive modelling tools are used. Such as Passivhaus Planning

Package (PHPP) for dwellings or CIBSE TM54 for non-domestic uses. These tools better predict the energy performance of buildings.

It is important to calculate embodied carbon by using the correct tools and methodology. For best practice refer to the LETI Embodied Carbon Primer (2020) - new guidance is expected to be released by LETI in 2021. We recommend seeking a consultant team with experience in whole life carbon design or in-house embodied carbon expertise. Often structural engineers are able to calculate and assess the embodied carbon of structural components. Identify a embodied carbon champion to carry out a comprehensive analysis and identify big ticket items to target.

Prior to carrying out an embodied carbon assessment consider the following:

- Define the goal : what the study is for. e.g a sample assessment to determine the most efficient structural system or compare different façade options
- Define the scope: determine the building elements to be assessed and the life cycle modules (typically A1 to A4, B1 to B4, C1 to C4).
- Define the study period: what is the life-cycle of the building. RICS guidance recommends 60 years

At concept stage calculate embodied carbon of key components focusing on big ticket items e.g. structural components or the facade. As the design progresses carry out a more comprehensive embodied carbon assessment for the whole building, this should be aligned with the EN 15978:2011 and RICS guidance. This method is updated through out the design process through embodied carbon assessments carried at each design stage to make informed decisions based on significant reductions. It may also be worth considering landscape work as part of the assessment although this should not be included as part of embodied carbon total for benchmark comparison.

Use reliable data where possible: select products with an Environmental Product Declaration. Generic information is useful at early design stage while manufacturer specific data should be used to provide more accuracy once materials have been specified.

There a many embodied carbon assessment tools available including: FCBS CARBON tool for concept design and One Click LCA, Etool, Rapiere, and HBERT as the design develops.

The benefits of quality assurance

Where buildings are monitored there is often a significant performance gap between design intention and as-built performance.

Measuring and verifying the design against the completed building can help highlight what environmental strategies have had the greatest impact on energy consumption and occupant comfort and satisfaction. However, this does not always help ensure that the building is constructed to the high standards intended.

Passivhaus is a standard for the design and construction of comfortable, highly energy efficient buildings with set performance targets. It is the gold standard and can be used as one of the first steps towards achieving a net zero operational carbon building.

Passivhaus is also a construction standard. Certification relies on the building being designed so that it can meet the criteria when complete. As part of the standard, certification of the building's performance is carried out upon completion. For this reason a non-certified project cannot be called Passivhaus as construction quality has not been verified.

Whilst this document outlines the guidance to be adopted in order to prepare for a 1.5°C future, we would also recommend that the use of Passivhaus certification is considered as a means to meet the space heating demand KPI and quality assurance during construction. Where this route is followed we recommend the early appointment of a Passivhaus consultant to steer the design from concept stage.

Energy use intensity

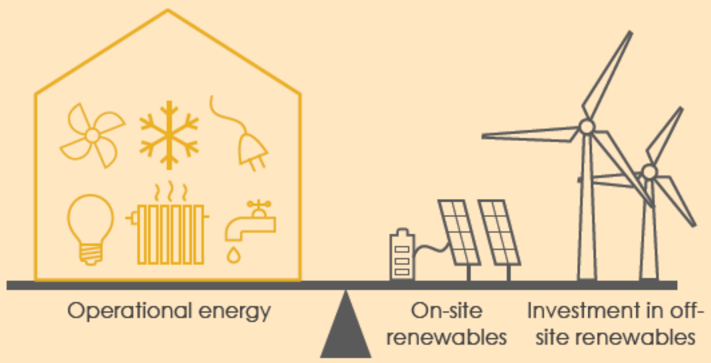
In order for there to be zero carbon emissions associated with a building, over the course of the year a net zero operational balance must be met.

For ultra-low energy detached and terraced housing with a large roof area relative to floor area and a low energy intensity, 100% of the annual energy consumption can be met through on-site renewables, typically PV on the roof of the buildings.

For higher density buildings where roof area is limited and sites are constrained, investment may have to be made in off-site renewables. In the case of the LLDC developments, it is likely that a zero carbon balance may not be met on site, due to the density of development. In these cases developments should report the predicted annual carbon balance for the whole development showing predicted carbon emissions from consumption, carbon saved from generation and net predicted emissions.

It is important that all new buildings become net zero carbon in operation, as the UK has a limited renewable energy resource. In order to achieve a net zero carbon operational balance across the UK, an energy budget must be set, such that there is enough renewable energy UK wide, for all buildings to achieve zero carbon.

Energy budgets are often referred to as energy use intensity (EUI) targets – measured in kWh/m^2.yr. For fossil fuel free buildings, the EUI is measured in-use through the incoming electricity meter. This is a simple metric that can be predicted at the design stage using software such as PHPP or CIBSE TM54.



Net zero operational balance

LETI - Climate Emergency Design Guide

Design guidance

Design checklist

This checklist is designed to supplement the design guidance and key performance indicator targets, to give an indication of what needs to happen and when. It is crucial to review the impact of design at each stage in order to prepare for 1.5°C buildings.

The importance of a strong brief

Buildings should enhance the quality of life of their users by being long-lasting, well designed and inspiring places in which to live, work, learn and play. We encourage setting a strong brief at the outset to encourage the environmental targets LLDC aspires to as described in this document. A strong brief is one that addresses a broad range of topics but is also able to provide tangible guidance on how this can be achieved through good design and specification.

Option for Passivhaus certification

As previously mentioned, whilst this document outlines the guidance to be adopted in order to prepare for a 1.5°C future, we would also recommend that the use of Passivhaus certification is considered as a means to meet the space heating demand KPI and quality assurance during construction. However targeting a fixed standard may not necessarily be appropriate for LLDC. Therefore the strategies in this report have been designed to provide flexibility.

Passivhaus certification provides quality assurance in addition to the targets set, to assist LLDC get the low energy outcomes through design and construction. However, Passivhaus certification does not cover all of the KPI requirements.

Where the certification route is followed we recommend the early appointment of a Passivhaus 'designer' to steer the design from concept stage and carry out PHPP modelling. A Passivhaus 'certifier' will also be required to act as a impartial quality assurance check on design assumptions.

Information provided by the design team

This design checklist provides a list of key actions that should be carried out in addition to those that designers are used to carrying out. The actions are colour coded to match the relevant KPI that the action is targeting. An extractable version of the design checklist and target KPIs are included within the Appendix.

	RIBA Stage 2 - Concept Design	✓
Renewable energy	Optimise building orientation to balance solar gain and increase south facing roof area. Design roof to maximise density of renewables.	
Ultra-low energy buildings	Calculate and report the building form factor for design options.	
Embodied carbon	Arrange embodied carbon workshops with design team to target lean design principles and reduce big tickets items e.g. structure.	
Embodied carbon	Identify design team members to carry out embodied carbon assessment. Carry out multiple embodied carbon calculations of key elements to demonstrate low carbon design choices.	
Ultra-low energy buildings	Mark-up insulation line on all plans and sections. Mark unheated external areas on plans.	
Ultra-low energy buildings	Allow sufficient wall construction thickness for all insulated walls, roofs and floors.	
Ultra-low energy buildings	Mark window openings for providing natural ventilation for summer comfort.	
Ultra-low energy buildings	Identify a location for the MVHR next to an external wall.	
Energy use and efficient heating	Evaluate requirement to connect to the district heating network.	
Overheating	Carry out preliminary overheating risk assessment using the Good Homes Alliance overheating checklist.	
Ultra-low energy buildings	Carry out initial PHPP model.	
Ultra-low energy buildings	For projects using Passivhaus certification this is a good time to consider an appointment.	

Use this checklist to help achieve the KPIs. It includes actions that should be carried out in addition to those that designers are used to carrying out.

Key

- Ultra-low energy buildings
- Embodied carbon
- Energy use and efficient heating
- Renewable energy
- Overheating
- Water demand
- Measurement and verification

RIBA Stage 3 - Spatial Coordination	✓
Review mark-up of insulation line on all plans and sections and carry out initial U-value calculations.	
Carry out heating options appraisal including a low carbon option.	
Hold a thermal bridge workshop. Include the structural engineer for review of columns, masonry support etc.	
Provide MVHR layout including duct distribution and measurement of intake and exhaust duct lengths to external walls for sample dwellings.	
Carry out full embodied carbon assessment of whole building and compare against embodied carbon target. Implement reductions where necessary.	
MEP consultant to review embodied carbon impact of services and reduce the amount of kit where possible. Use CIBSE TM65 embodied carbon in building services to assess impact.	
Carry out PHPP modelling alongside SAP/SBEM calculations. List all model assumptions including U-values, thermal bridges and system specifications etc.	
Carry out overheating assessment and eliminate overheating through passive strategies where possible (TM59 & TM52). Ensure all element assumptions match PHPP and SAP/SBEM models.	
Calculate electricity generation intensity of PV arrays and review against KPI.	
Define airtightness strategy and identify airtightness line on plans and sections.	
Measure heating and hot water pipe lengths for sample dwellings. Minimise distribution or standing losses.	
Demonstrate distribution losses have been calculated and reduced.	
Prepare RIBA Stage 3 report and include predicted operational cost to tenant and LLDC.	

RIBA Stage 3+ - Early Technical Design (and tender)	✓
Detail build-ups of all external elements including thickness and conductivity of all materials.	
Detailed U-value calculations (including masonry support system, etc.).	
Identification of all thermal bridge junction types (e.g. parapet A, parapet B).	
Thermal bridge calculations for a selection of the most important junctions.	
Definition of airtightness testing requirements for contractor.	
Include requirements for Environmental Product Declarations (EPD) in the tender. Make EPDs obligatory for structural materials, primary façade and any other major materials.	
Include KPI requirements in the tender.	
Agree scope of Post-Occupancy Evaluation in tender. Identify level of participation from contractor and design team.	

RIBA Stage 4 - Technical Design (in addition to Stage 3+)	✓
Develop junction details for window and doors.	
Review airtightness line on each drawing and identification of airtightness requirements for service penetrations.	
Carry out a thermal bridge workshop to review thermal bridge lengths and calculate Psi-values for all junctions.	
Review MVHR layout including duct distribution and measurement of length of intake and exhaust ducts for all homes.	
Measure heating and hot water pipe lengths for all communal areas and homes.	
Carry out embodied carbon assessment of whole building using accurate Bills of Quantities.	
Specify high performing PV panels.	

RIBA Stage 5 - Manufacturing and Construction	✓
Run an introduction to ultra-low energy construction workshop on-site.	
Encourage site manager and team training on construction quality requirements covering insulation and airtightness.	
Prepare toolbox talk information for site team inductions on low energy construction quality.	
Review alternative materials or products proposed by the contractor. Ensure substitutions do not compromise the thermal performance or embodied carbon target.	
Carry out regular construction quality assurance site visits and reports (depending on the size of the scheme – at least six) in tandem with regular visits.	
Develop site quality tracker, assess against KPIs and update regularly.	
Require leak finding airtightness tests at first fix and second airtightness test pre-completion.	
Witness commissioning of MVHR systems and heating system.	
Carry out predicted in-use energy model of each building leading to the final 'as built' PHPP model.	
Consider recalculating embodied carbon using 'as built' information.	

RIBA Stage 6 - Handover	✓
Provide building and operational information to residents in the form of site inductions and simple building user guides and instructions (e.g. sticker on MVHR for filter replacement).	
Consider embodied carbon as part of the replacement and maintenance strategy and include in the O&M manual.	
Carry out post-occupancy evaluation during first 5 years of use and verify KPIs have been met.	
Lessons learnt project review with LLDC team.	
Publicly report KPIs.	

Key Performance Indicators

A number of key performance indicators (KPIs) are proposed to support new developments and prepare for a 1.5°C future.

Setting a new performance baseline

The KPIs sets out the baseline performance standards that all new LLDC residential developments can target. The subsequent pages provide step-by-step guidance on how to meet these KPIs in practice.

Key Performance Indicators targets

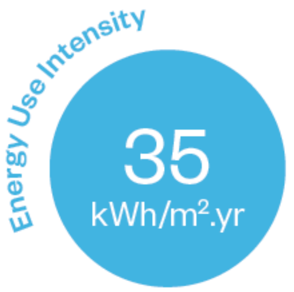
Meeting all of the KPI targets could qualify the development as zero carbon compliant. In this report the industry definition for net zero operational carbon has been used, see section pages 14-15. We have set a specific energy use and efficient heating target for developments outside of the district heat network concession area which may have the option not to connect to the network. Any development that must connect to the district heat network cannot be considered zero carbon, and must report the predicted energy use intensity against the target.

Scope of KPIs

The scope of this report was to target energy efficiency at building level, other aspects which may also form part of a sustainability strategy are excluded from the proposed KPI targets. For example advice on electric vehicle charging, biodiversity, SUDS, street lighting, landscape materials and other external works are excluded from the remit of this report. However these can be measured and reported separately alongside the KPI targets as part of a more comprehensive sustainability strategy.

Ultra-low energy buildings

Follow the ultra-low energy design guidance to achieve the space heating demand target. Make informed decisions at an early stage in the design to significantly reduce the space heating demand and target ultra-low energy design. This is applicable to residential and non-residential buildings.



Energy use and efficient heating*

Where there is potential to have a low carbon on-site solution, aim to meet the energy use intensity target of 35 kWh/m^2.yr for residential buildings. Carry out a heating options appraisal and follow design guidance to minimise distribution and standing loses.

** The Energy Use Intensity target cannot be met inside the district heating network concession area but should be reported and compared against this baseline. A baseline of 55kWh/m^2.yr should be targeted for non-residential.*

Overheating

Where energy efficiency is improved and as the climate changes there is a greater risk of overheating in buildings. Follow the overheating design guidance and carry out dynamic thermal modelling pre-planning to significantly reduce the risk of overheating.

Embodied carbon

Embodied carbon refers to the greenhouse gas emissions associated with the manufacture, transport, construction, repair, maintenance, replacement and deconstruction of all building elements. Follow the embodied carbon guidance relating to the architectural, structural and MEP design from an early stage in order to significantly reduce the embodied carbon emissions associated with materials and building design.

Renewable energy

Follow renewable energy guidance to maximise electricity generation of PV on-site. Consider the roof design and building orientation at concept stage to optimise roof form. Even if PV arrays cannot be installed initially this will make developments ready for future installation. The energy generation intensity on site should equals the total predicted energy use to achieve a zero carbon balance.

Water demand

Follow design guidance and AECB good practice water standards to improve efficiency and minimise distribution losses.

Measurement and verification

Measure and verify the design against the completed building to help highlight what environmental strategies have had the greatest impact on energy consumption, and occupant comfort and satisfaction.

Ultra-low energy design guidance

Target: **Reduce operational energy**

Making informed decisions at an early stage in the design can significantly reduce the space heating demand therefore increase their energy efficiency. This is applicable to residential and non-residential buildings.

Building form

The thermal envelope of the building should be as simple as possible. This reduces the exposed surface area for heat loss and simplifies construction junctions. However, the thermal envelope is often different to the visual massing and is defined by a continuous insulation line enclosing all warm spaces in the building.

The orientation and massing of the building should be optimised to allow solar gains and prevent significant overshadowing in winter.

Window design

The window design should be based on orientation, daylight and summer comfort, and should work in tandem with other architectural design factors like proportion and elevational composition.

Excessive glazing is the main cause of overheating in the summer and heat loss in the winter.

Look for design evidence of:

- Form factor (surface area/GIA) calculated for design options.
- Thermal line and exposed surface area of building identified on early drawings/diagrams.
- Window proportion of external wall area calculated and reported for each elevation.
- Inclusion of external shading on South and West façades.

1 Compact building form

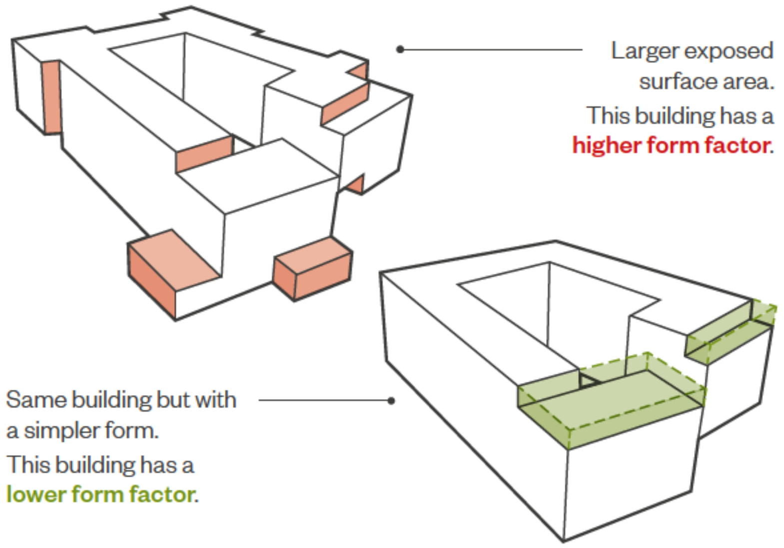
Review the form of buildings at RIBA Stage 2 and as it continues to progress.

Encourage design teams to simplify the form of buildings and be selective about the number of features used.

Decreasing the surface area of the building results in reduced heat loss and therefore less energy consumption for space heating. This can be quantified by the form factor.

The lower the form factor the more energy efficient the building is. A form factor of below two is typically expected for a mid-rise apartment building.

Design teams should be strategic about adding articulation to the building form. Emphasise a few key design features that really matter in the context. The fewer stepped roofs, roof terraces, overhangs and inset balconies, the lower the heat loss from the building.

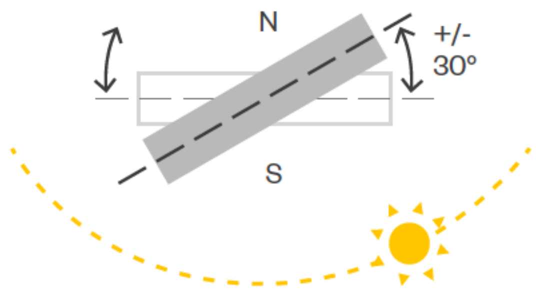


$$\text{Form factor} = \frac{\text{Exposed external surface area}}{\text{Gross internal floor area}}$$

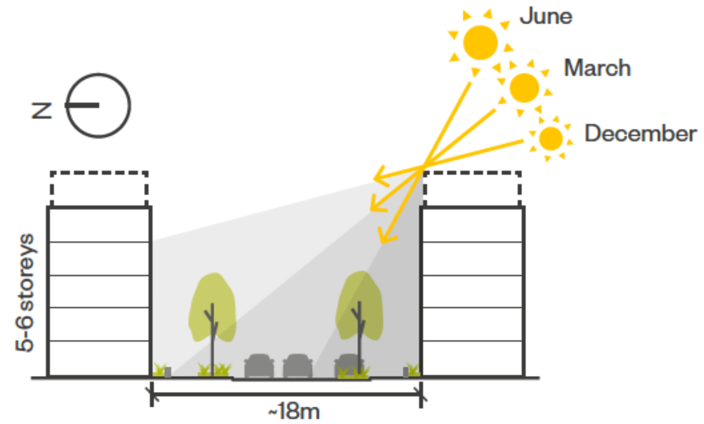
2 Heat from the sun in the winter

Review the orientation of buildings and encourage south facing dwellings.

Prioritise dual aspect, south-facing dwellings. Overheating risk increases proportionally as the building faces away from due south. Anything beyond +/- 30° is no longer a south-facing façade.



Avoid overshadowing of buildings, this reduces the heat gain from the sun in winter. Allow 1-1.5m of distance for every 1m of height.



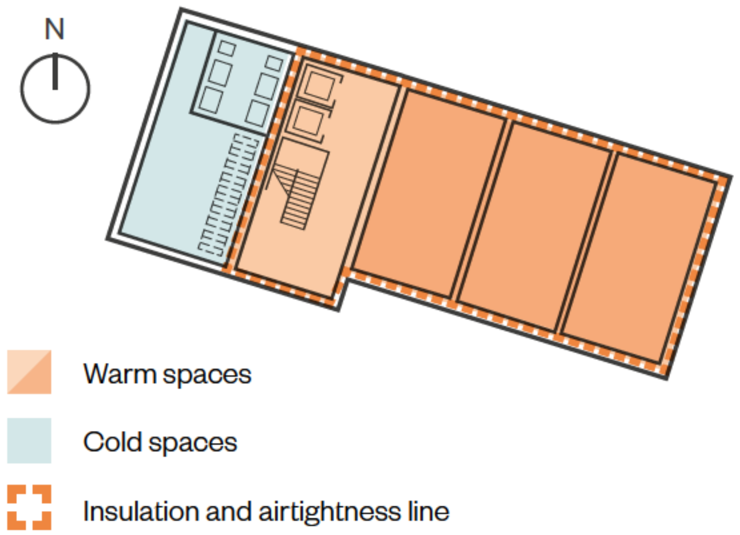
3 Space for unheated facilities

Review where cold spaces are located and ensure they are grouped.

Keep cold spaces, such as bin/bike stores and substations, separate or towards the north end of buildings where possible. Group cold spaces rather than pepper-potting them across the ground floor.

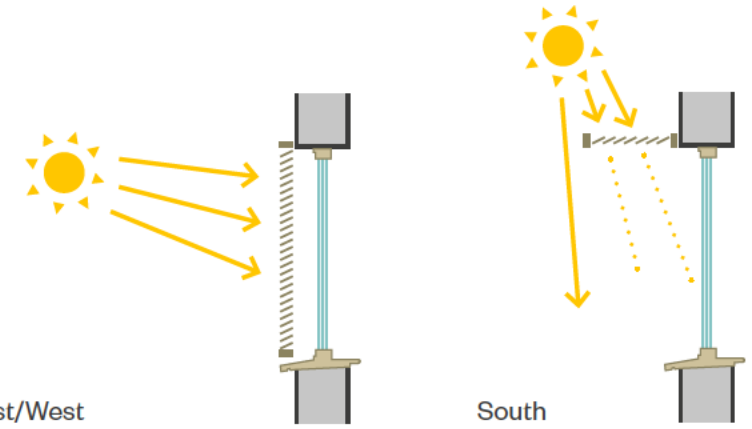
When these spaces are neighbouring a warm part of the building, such as a dwelling, the party wall and separating floor above need to be highly insulated.

Design teams should draw the insulation and airtightness line around dwellings early and consider whether circulation space should be within or outside of the insulated volume.



Solar shading

Prioritise living areas with larger windows on the south. It is easier to design fixed shading on the south in summer while allowing heat gains in winter.



East/west orientations have a higher overheating risk due to low-angle sun. Reduce glazed areas and include shading on the west, e.g. with shutters.

High angle sun can be controlled using horizontal shading or balconies above windows.

4 Elevations to balance heat gain, heat loss and daylight

Review window areas and shading design based on orientation.

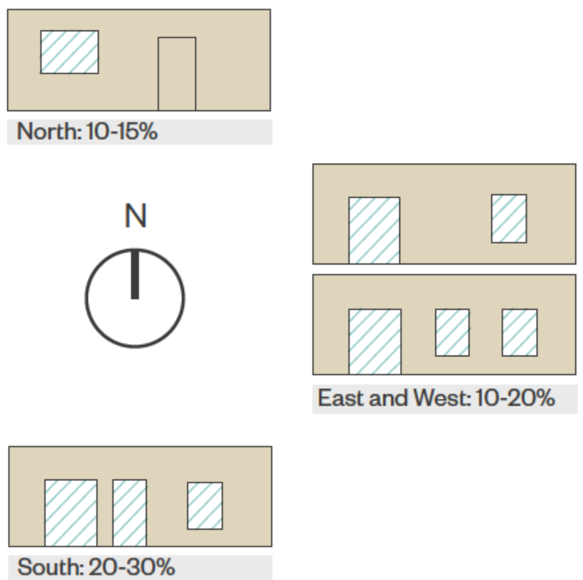
The glazing-to-wall ratios are a key feature of energy efficient design. It is important to minimise heat loss to the north (smaller windows) while providing sufficient solar heat gain from the south (larger windows).

Encourage design teams to consider which way a dwelling faces. It is much easier to design smaller windows facing access decks and larger windows facing balconies. Therefore, try to orientate homes accordingly.

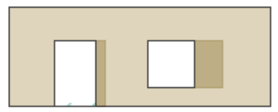
Trick the eye

Windows sized to balance heat loss and gain can sometimes appear ungenerous. Appropriate introduction of architectural features can improve the balance of solid to 'apparent' void. For example, use of stepped reveals or textured panels.

Window proportions of external wall area



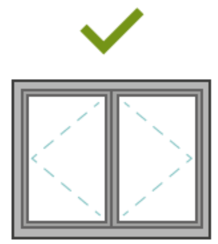
Window proportions of external wall area



Horizontal works better than vertical

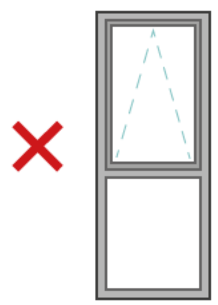
Wider, shorter windows:

- Improve daylight distribution in rooms
- Moderate overheating risk and are typically easier to shade
- Increase openable area for ventilation
- Provide increased privacy to bedrooms.



Local context or other design factors may mean this optimal approach is not always possible.

Consider how windows open for effective ventilation. Side hung provides a larger opening area than top hung. Inward opening is easier for residents to clean than outward opening. Consider clashes with internal or external shading devices.



Ultra-low energy design guidance

Natural and mechanical ventilation

Effective ventilation is vital for ensuring good indoor air quality, the ability to mitigate heat build-up and to remove excess moisture. Homes should include background and purge ventilation:

Background ventilation should provide a constant rate of ventilation throughout the day and across the seasons. All homes will need mechanical ventilation with heat recovery (MVHR) for background ventilation.

Purge ventilation provides bursts of fresh air to rapidly cool or renew the indoor air, typically achieved with openable windows.

Highly insulated building fabric

Homes will require high levels of insulation to reduce heat loss. It is important the zones of insulation are thick enough to meet the U-value required,

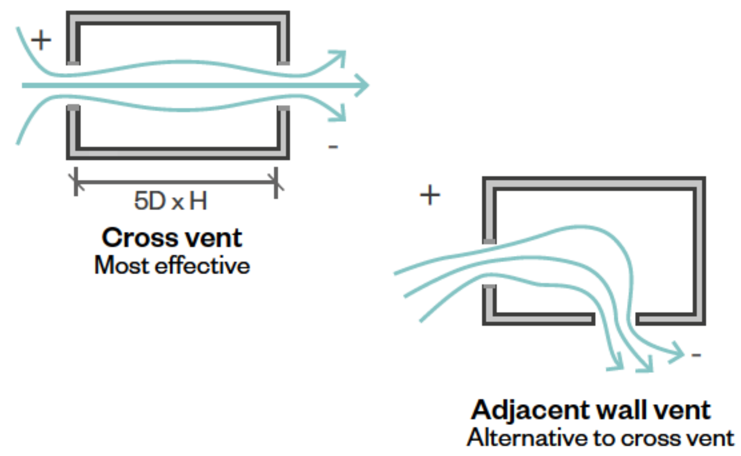
> Look for design evidence of:
>
> - Cross ventilation through windows on opposing façades.
> - MVHR and hot water tanks marked in dwellings, and any central plant areas marked on drawings.
> - Construction build-ups should be thick enough at early design stage. Check extra height has been allowed to insulate any roof terraces.

5 Natural ventilation

Review the natural ventilation strategy and encourage cross ventilation.

All habitable rooms should have openable window(s).

- Dual aspect homes allow for cross ventilation – the most effective form of natural ventilation, particularly when windows are on opposite sides. Encourage design teams to make this the preference. Single aspect homes are the least effective at ventilating and are at risk of overheating.
- Always provide multiple openings, maximum free area and different sizes, to allow the occupant to control their environment.

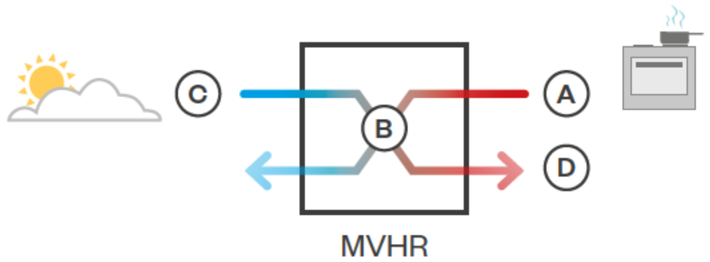


6 Mechanical Ventilation with heat recovery (MVHR)

Review where MVHR units are located and ensure they are close to external walls.

MVHR units provide background ventilation by extracting moist warm air from kitchens and bathrooms A, exchanging the heat B to incoming cold fresh air C, and then supplying the air D to the other rooms in the home.

The heat recovery can be automatically bypassed to provide ventilation without noise or security issues.

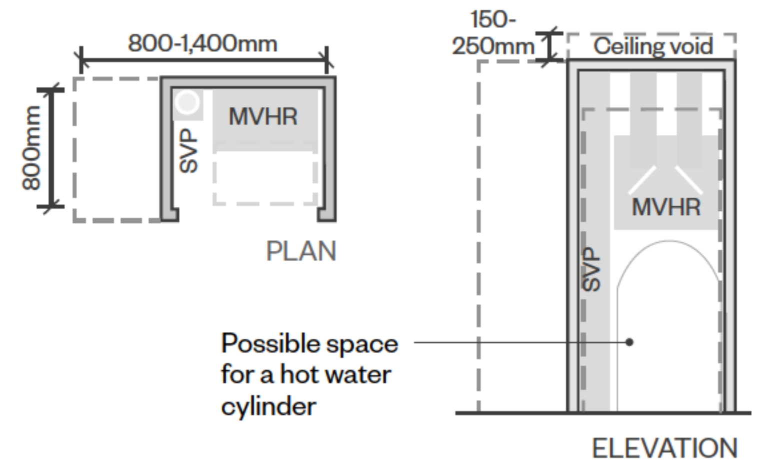


Utility cupboard size

A full height services cupboard is typically 800 x 800mm. To include space for a washing machine or alternative building services strategy, consider increasing it to 1,400 x 800mm.

A location for a hot water cylinder could be allowed for in each flat to give the most flexibility with heating and hot water design. For one bedroom flats, this can fit under the MVHR. Allow 650 x 650mm for a cylinder.

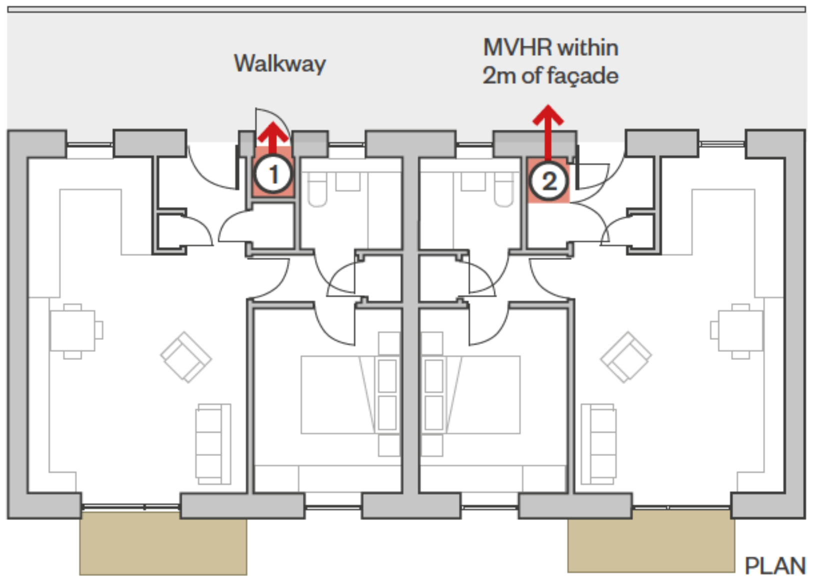
MVHR ducts will be distributed in the ceiling. Allow a minimum of 150-250mm distribution zone above extract rooms in particular (kitchens and bathrooms).



Utility cupboard position

MVHR units can be made accessible internally or externally to suit the client's maintenance and repair preferences. It does not need to be in the same cupboard as the heating equipment or hot water tank. Encourage design teams to locate the MHVR on or within close proximity of an external wall to keep the intake and exhaust ductwork less than 2m long.

Noise from the MVHR should be no more than 35dB(A) to reduce disturbance to occupants. They should not be located in a bedroom or living room.

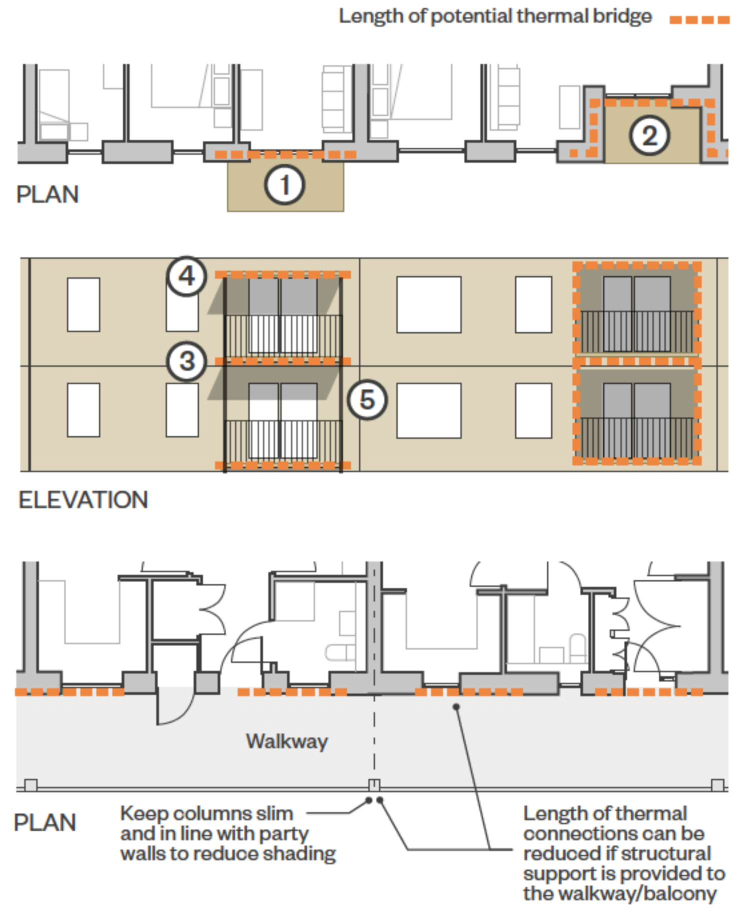


1. MVHR accessed externally
2. MVHR accessed internally

8 Balconies and access walkways

Balconies can have an impact on thermal bridging, encourage design teams to consider the balcony type.

1. Projecting balconies have the least impact on daylight and energy efficiency.
2. Inset balconies increase the form factor, area of external wall and length of thermal bridges. Where inset balconies cannot be avoided, compensations should be made elsewhere.
3. Aim for stacked balconies to give useful shading to south-facing windows below.
4. Consider providing shade for the top floor window.
5. Access walkways should be structurally supported and tied back to the building, rather than cantilevered. This reduces the impact and cost of thermal connectors. However, the structure should be lightweight to avoid heavily shading the façade.

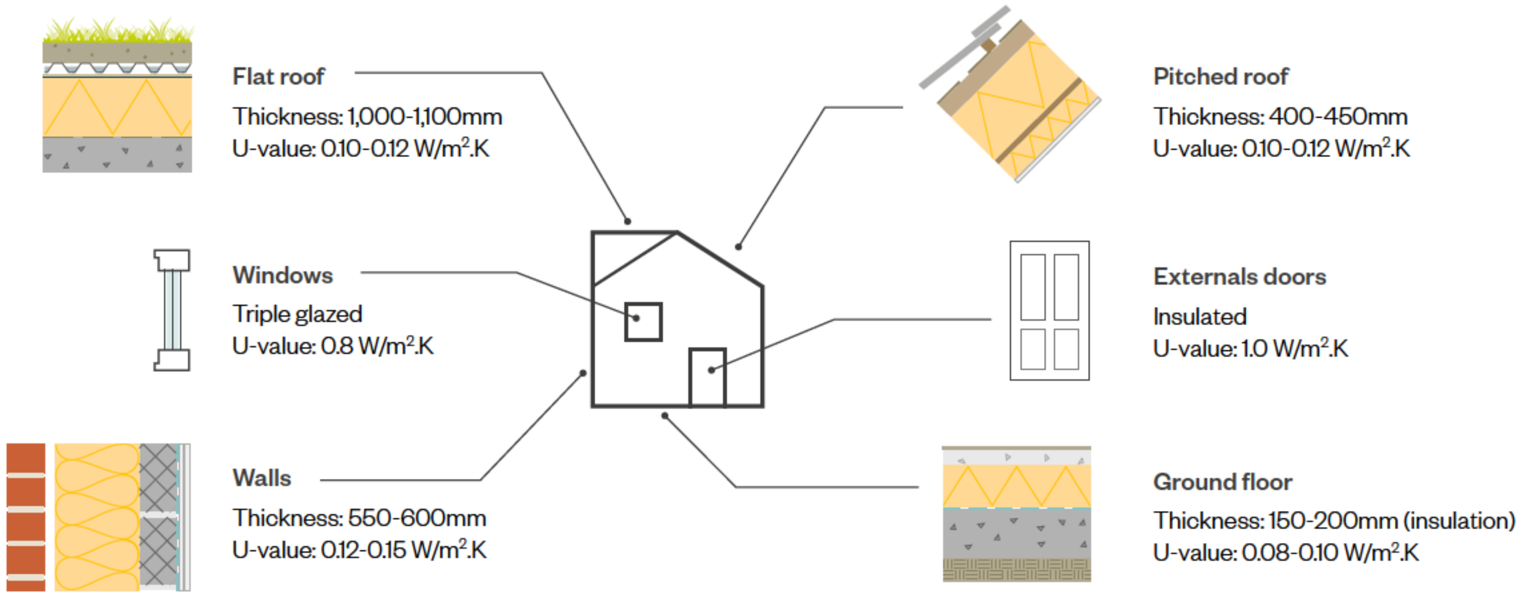


7 Highly insulated building fabric

Review the space allowed for external construction elements.

Element thickness and thermal performance (U-value) will vary depending on the form factor and use of the building. The below construction build-ups are intended to be a useful starting point.

Airtightness - An extremely airtight building fabric of <1 $m^3/h/m^2$ at 50 Pa.



Embodied carbon design guidance

Target: **Reduce embodied carbon**

Making informed decisions at an early stage in the design can significantly reduce the embodied carbon emissions associated with materials and design of a building.

Embodied carbon reductions

Embodied carbon refers to the greenhouse gas emissions associated with the manufacture, transport, construction, repair, maintenance, replacement and deconstruction of all building elements.

To prepare for a 1.5°C future embodied carbon must be drastically curtailed throughout the building life cycle. Identify big ticket items early and target reductions during the design stage for largest impact.

Emerging guidance

Guidance on embodied carbon and calculation methodologies are still in development, but there is expected to be further guidance from LETI in 2021. This page sets out the core design principles to be followed at the outset in order to reduce embodied carbon through the design and specification of materials.

Lean design

Lean design reduces material quantities. It provides an opportunity to reduce the size and number of elements within the building and is also cost effective. Encouraging collaboration to follow lean design principles is a priority to reduce embodied carbon emissions.

Embodied Carbon benchmark (500 $kgCO_2e/m^2.yr$)

This target relates to the 'Upfront embodied carbon emissions (Building Life Cycle Stages A1-A5). This includes the following elements: Substructure, Superstructure, MEP, Facade & Internal Finishes. Aim to meet the embodied carbon benchmark and review annually to align with the latest industry guidance.

1 Refurbishment over new build

New buildings should only be encouraged when reusing or refurbishing the existing is not possible.

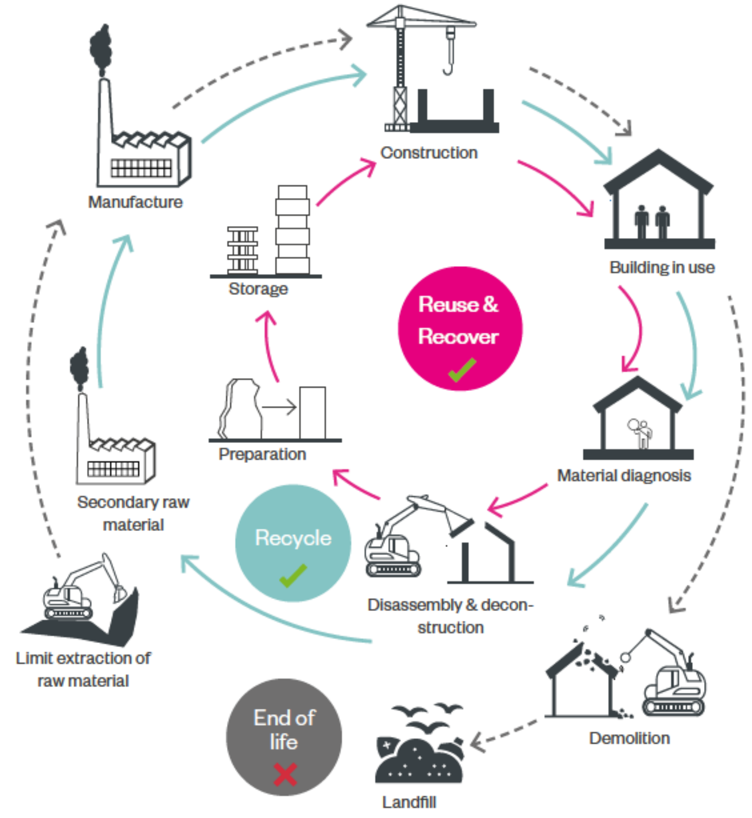
Encourage the design team to retain existing buildings. If this is not possible focus on re-using existing materials and elements from the building and surroundings . Re-use will save the carbon emissions associated with the making, transport and installation of the products.

2 Lean structural design

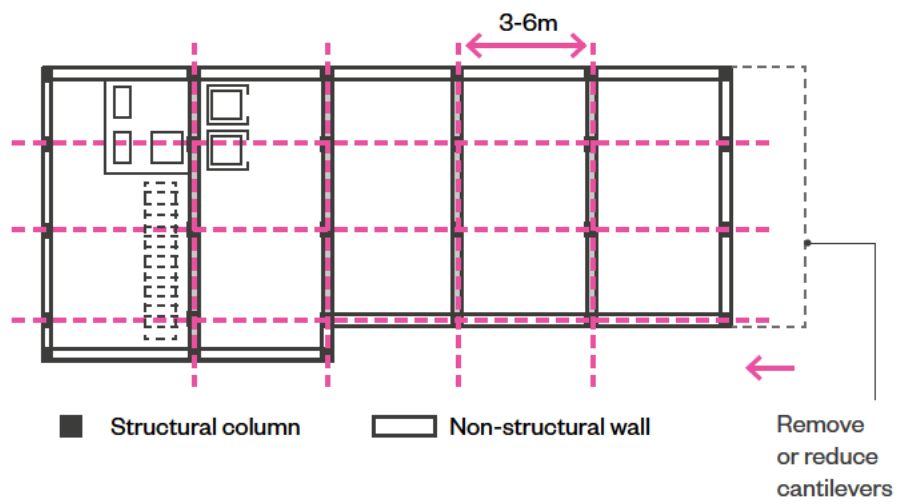
Engage the structural engineer early in the design process to influence structural and material efficiency in design.

The structure represents a big portion of the total embodied carbon emissions of a building. This can be reduced through lean design which will reduce the volume of overall material used. Building lighter will also help reduce the foundations.

- Grid spacing, location of the core and the structural depth all have significant impacts on material volumes. Explore and refine options to ensure efficient building massing
- Horizontal and vertical bay study comparisons by material type should be developed to evaluate embodied carbon
- Optimise column grid to decrease slab thickness and beam depths e.g. 3-6m column grid is a good starting point
- Identify hot spots and build reduction strategies around those. e.g. typically slabs have the highest contribution
- Design the structure for 100% utilisation where possible
- The loading assumptions should be adapted to the building. Avoid rules of thumb and unnecessary tolerances
- Reduce spans and overhangs which require more material. Incorporate columns within flat layout and use columns to support balconies and walkways externally
- Reduce the structure weight through voids where possible. Structural elements such as core walls often include unnecessary structural material.



Building materials should be re used and recovered and then recycled as much as possible to delay their end of life.



3 Architectural Lean Design

Architectural design has a significant impact on embodied carbon as it is responsible for many of the materials in the project.

Façades

Carry out facade embodied carbon studies early in the design process and coordinate with the structural team. Easy wins include:

- Specify materials with multiple benefits, e.g. embellishments on the façade that are also used as shading elements
- Reduce the quantity of metal components: shelf angles, metal studs and frames that make up a large proportion of the total embodied carbon impact.

Interiors

Internal elements are replaced more frequently, and should be considered carefully. Easy wins include:

- Use self-finishing internal surfaces e.g. exposed block work
- Design to standard sizes to reduce waste of materials e.g. design to 600mm stud spacing to accommodate 1,220mm width plasterboard
- Reduce the quantity of metal studs and frames
- Use recycled or up-cycled furniture from a sustainable providers e.g. Rype office.

Collaboration

Collaboration with the design team is key to reducing embodied carbon.

Engineers often follow the criteria set out by the architectural design. A conscious effort to engage all consultants in lean design practice will help to influence the design early.

- Engage the structural engineers early to prioritise a design with a low carbon structure.
- Engage the building services engineer to reduce the heating demand, this will also reduce the MEP equipment.

4 Building Services Lean Design

Building services are mostly made out of metals and plastics. The equipment and ductwork represent high quantities of embodied carbon within buildings, particularly as they are replaced multiple times during a building's lifetime.

Considerations to reduce embodied carbon:

- Target passive measures e.g. natural ventilation and shading devices to prevent overheating to reduce over-reliance on building services equipment.
- Reduce the need for long duct runs and design for efficiency where possible
- Specify low global warming potential (GWP) refrigerant where feasible (max. 150) and ensure low leakage rate
- Use CIBSE TM65 Embodied carbon in building services: a calculation methodology to calculated embodied carbon of MEP equipment.

5 Easy maintenance and use

Encourage the design team to anticipate the maintenance and easy use of the building. Maintenance and access requirements should be considered for all elements of the development.

- Make sure that sections of the façade can be easily replaced. e.g. if one glazing unit fails, then this individual unit can be replaced rather than the whole façade
- Consider alternative procurement routes for products in the communal areas, e.g. specifying products as a service. The manufacturer leases the products and are responsible for any repair and recycling.

Look for design evidence of:

- Elements retained and reused within the development
- Reduction on 'quantity' of material in the structure
- High performing fabric
- Short spans
- Internal partitions designed to standard sizes
- Simple façades with limited shelf angles
- Space provided for maintenance.

Embodied carbon design guidance

Building Futureproof

Anticipating the future by designing for disassembly and reuse is important to reduce waste and minimise embodied carbon emissions. Re-evaluating materials as part of a circular economy is fundamental to achieving sustainable construction. In addition consideration for housing adaptation and flexibility of use will help future proof the design as occupant needs and lease-holders change overtime.

Low embodied carbon materials

Once the quantum of materials have been reduced, the next step is to specify materials that have low embodied carbon impact. This means prioritising re-use or low embodied carbon materials, and focusing especially on big-ticket items such as the building structure and facade.

Look for design evidence of:

- Design scenario adaptation
- Material passports
- Environmental Performance Declarations (EPD) when specifying materials.
- Local, reused or recycled, natural building materials

6 Design for disassembly

Encourage the design team to consider disassembly to allow for reuse at the end of life of the building. Recycle elements that can not be recovered or re-used.

- Explore modularity and pre-assembly methods
- Build in layers so that different elements of the building can be maintained and replaced
- Use dry building methods e.g. mechanical fixtures rather than adhesive, use lime mortar for brick façades so that bricks can be reclaimed
- Provide good access for deconstruction particularly at connections, and reduce the numbers of types of fixtures for building services.

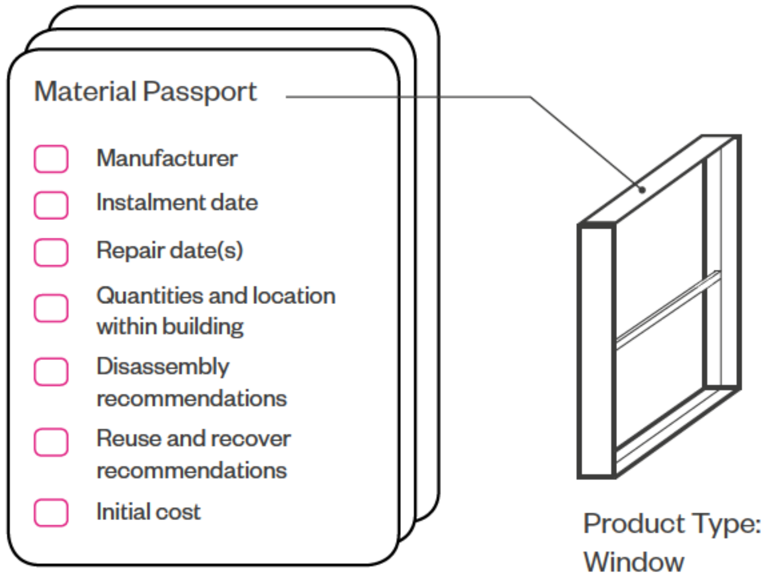
Create material passports for products:

This will improve the ability of disassembled elements to be reused. A material passport provides identification of materials, components and technical characteristics with guidance for deconstruction and applicability of re-use. In this way the building becomes a material bank for future use.

7 Housing adaptation & flexibility

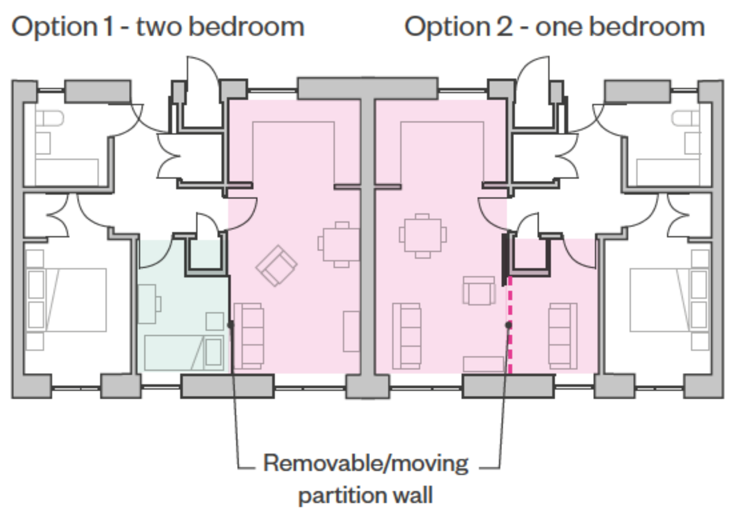
Encourage the design team to allow for flexibility and consider how the layout may be adapted to suit future needs.

- When space planning consider how the space may change e.g. home office, extra bedroom , living space for future carer
- Working to a regular grid with removable partitions will allow adaptation
- Create soft spots in the structure
- Consider taller ceilings heights to allow adaptation for future uses
- Anticipate future plants space and risers requirements through loose fit design.



What is a material passport?

A material passport is a document describing all of the materials in a product (e.g. heat pump) or product type (e.g. window). It consist of a data set of the defining characteristics of materials, which give them value for recovery, recycling and re-use. An example of the data set is listed above, this could be generated from a BIM model or scheduled in excel.



Design for adaptation using a flexible floor plan e.g. one bed flat can be converted to a two bed flat or a one bed flat with space for home working.

8 Follow embodied carbon hierarchy for materials & product specification

Encourage the design team to use an embodied carbon hierarchy to inform material choice particularity for the building structure. Other constraints may eliminate higher options but generally prioritise in this order:

1. Natural materials e.g. timber
2. Concrete and masonry
3. Light gauge/Cold rolled steel
4. Hot rolled steel

Prioritise low embodied carbon materials:

- Reused and recovered existing materials from local area, e.g. reclaimed wood for benches, reclaimed soil and stones for landscape design
- Natural materials from sustainably managed sources

Specify to reduce embodied carbon:

- Use local materials e.g. local brick
- Specify materials with high recycled content
- Specify products which can be recycled e.g. polyester powder coated rather than anodized aluminium

Considerations for selecting manufacturers & products:

- Ask manufacturer for Environmental Product Declarations (EPD) and compare the impacts between products. EPDs produced in accordance with BS EN 15804 (2019) (dated post 2019) are most reliable.
- Make EPDs obligatory for structural materials, primary façade construction and any major materials used.
- Consider service life especially for FF&E and building services. More robust and long lasting materials will require less maintenance and fewer replacements.
- Specify manufactures which recover the materials at end of life of the building

Guidelines to consider when specifying the following materials:

Wood - low embodied carbon

- Prioritise specifying timber/CLT for structure over other high embodied carbon materials where possible
- If CLT is used for structure: encourage deeper skinnier beams and 'rib deck' products and if possible avoid a concrete screed topping to the CLT deck as this increases the overall carbon footprint. Consider the spans required for CLT decks to ensure material efficiency
- Consider hybrid structure e.g. CLT decks with castellated beams
- Specify products from sustainably sourced forest (eg FSC certified) will ensure forest are correctly replanted which reduce carbon emissions
- Reduce the transport distances as much as possible
- Ensure the wood is reused and not burnt at end of life
- Look into which wood treatment are required
- Polyurethane should be used where possible
- Be careful with glues and avoid those high in formaldehyde

Steel - high embodied carbon

- If no alternative prioritise lean design principles
- Specify recycled steel (electric arc furnace) from a region with low electricity grid carbon factor
- Use castellated beams to reduce the steel volume required whilst providing structural depth. These beams can be fabricated from standard EAF sourced sizes
- Materials should be bolted instead of welded to allow reuse for future disassembly
- Follow material hierarchy: light weight concrete blocks or clay blocks such as Porotherm typically have lower embodied carbon than cold rolled steel framing

Glass - high embodied carbon material

- Avoid curtain walling and floor to ceiling glazing if possible
- Specify high quality window units to lengthen life-span. Glazing is not readily recycled

Concrete - high embodied carbon

- Review alternatives with a Life Cycle Assessment expert
- If no alternative prioritise lean design principles
- Give concrete suppliers performance based low carbon concrete specifications and engage early with them to ensure the targets can be met
- For information over 50% cement replacement is typically seen in superstructure elements. Substructure elements have seen over 80% cement replacement. Cement replacement such as Ground Granulated Blast-furnace Slag (GGBS) or Pulverised Fuel Ash (PFA) are commonly used in the UK
- Ensure longer strength times: 56 instead of 28 days. This will allow the concrete supplier to use higher volumes of cement replacement (need more time to cure)
- Use higher strength mix (higher carbon impact but reduces the volume)
- Ensure BES6001 responsible sourcing
- Specify aggregate from specific region. Use recycled aggregates to ensure that the embodied carbon is lower than for virgin aggregates
- Rib deck or pre-cast floors typically have lower embodied carbon than cast reinforced concrete.

Useful links

Construction material pyramid. This diagram provides an idea of which materials contain more or less embodied carbon. Consideration should also be given to the thickness of material too: https://www.materialepyramiden.dk/

Energy use and efficient heating

Target: **Efficient heating system and reduced energy use**

Low carbon heating is an essential step to achieving net zero carbon buildings.

Heating systems

Making informed decisions about the heating system has a significant impact on the overall carbon performance.

Whilst there is a legal obligation to connect to the district heat network within the LLDC concession area, alternatives could be explored outside of the concession area, especially where there is no existing district heat pipework or connection.

The design team should use this guidance to demonstrate design measures used to deliver the most low carbon heat solution possible.

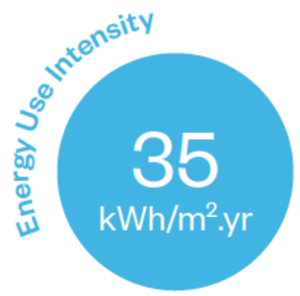
Avoid fossil fuels

Avoid using fossil fuels on-site altogether. In the LLDC concession area this cannot be avoided as the district heat network currently uses gas and biomass combined heat and power (CHP) technology.

Look for design evidence of:

- Identification of whether the development is "inside" or "outside" of the district heating concession area
- A heating options appraisal including low carbon option, consideration of capital costs, cost to residents, maintenance and replacement costs and the buildings carbon emissions using realistic carbon factors.
- Demonstration that distribution losses have been calculated and reduced
- RIBA Stage 3 report showing predicted operational cost to tenant and landlord.

Outside concession area



Where there is potential to have a low carbon on-site solution, aim to meet the energy use intensity target of 35 kWh/m².yr for residential buildings.

Inside concession area

Where the only option is to connect to the district heat network, report and compare energy use intensity against the 35 kWh/m².yr for residential buildings.

1 Evaluate connection to the district heating network

The project team should evaluate whether the scheme is within the concession area of the district heat network.

The energy strategy should clearly outline the following points:

- Whether there is a legal obligation to connect to the district heat network, or not.
- Summarise a heating options appraisal for the project. As a minimum this should evaluate the following points: capital cost, costs to residents, maintenance and replacement costs, and operational carbon emissions using realistic carbon factors.

2 Promote low carbon option

Encourage design teams to propose 'all electric' heating systems when outside the concession area.

Preference should be for using heat pump technology as an alternative low carbon option to connecting to the district heating network. There is a wide range and scale of heating system available.

3 Avoid designs with high 'built-in' losses

While insulation can help, high temperature distribution leads to 'built-in' losses due to the large temperature difference between the distribution temperature and the surroundings (e.g. ground, external space, internal riser). Reducing the distribution temperature and pipework length are key.

Insulate pipework in line with the AECB Water standard (page 47).

4 Reducing hot water demand

Efforts should be made to reduce domestic hot water (DHW) demand.

In very low energy buildings, the energy required for hot water can meet or exceed the amount of energy required for space heating.

Optimisation of hot water systems is therefore important to ensure overall energy use remains low. The following topics should be explored by the design team:

- Flow rates and appliances that use water
- Tertiary distribution pipework
- The need for hot water tanks / heat interface units
- Whether waste water heat recovery (WWHR) is appropriate.

5 If a district or communal heating system is selected:

Consider an ambient temperature network, as heat loss is proportional to the difference between the water temperature and the ground/surrounding temperature.

Consider a lower temperature network, e.g. 50-30°C, if an ambient loop is not possible.

Minimise the length of pipework, optimise the network route and increase the number of vertical risers to avoid horizontal pipe runs.

Minimise the diameter of pipework by correct sizing of peak load.

Insulate the network, including all pipe runs, valves and heat interface units (HIU) in line with best practice.

Carefully select the heat interface unit. Performance and heat losses of different HIUs can vary significantly and also depend on the network flow temperature.

6 Quantify and categorise distribution and standing losses

Heat losses occur at different points between the location where heat is being generated and where it is being used.

Encourage the design team to review:

- Primary losses (generally within the ground)
- Secondary losses (within the building)
- Tertiary losses (within each dwelling)
- Storage losses, heat interface unit (HIU) or hot water tank (within each dwelling), communal buffer tanks.

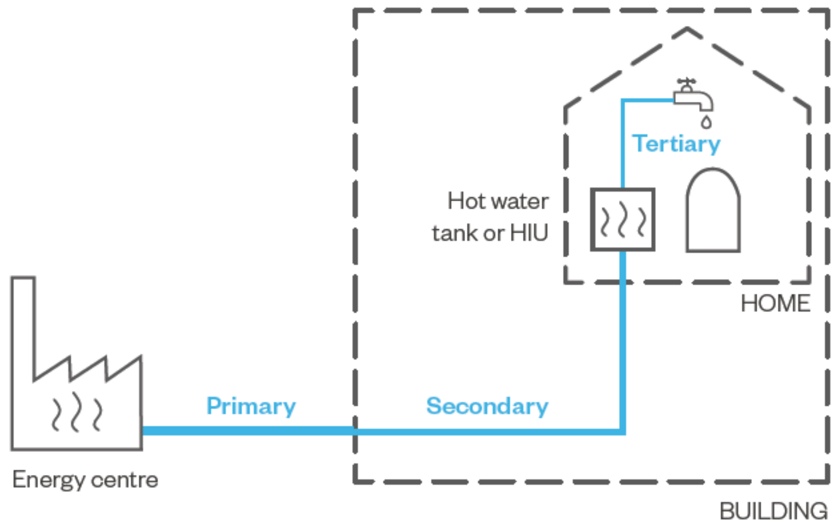
Target: **Non-domestic energy use**

Inside concession area:

For commercial and other non-domestic uses, aim to meet the energy use intensity target of 55 kWh/m^2.yr when there is potential to have a low carbon on-site solution.

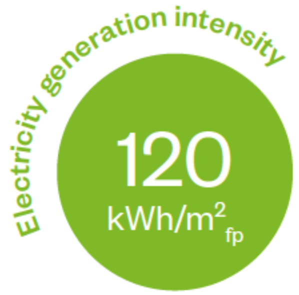
Outside concession area:

Where the only option is to connect to the district heat network report and compare energy use intensity against the 55 kWh/m^2.yr



Renewable energy design guidance

Target: **Maximise renewable energy**



Making informed decisions at an early stage in the design can significantly increase the electricity generation of PV on-site.

Consider PV panels as part of concept design

Net zero carbon can only be achieved by intensifying electricity generation on site, which is best achieved through considering opportunities for PV at an early design stage.

Designing for more PV electricity generation

Considering the roof design to maximise PV panels and minimise over-shading can significantly increase the total amount of solar energy generated on-site. The performance should be assessed using solar electricity generation per square metre of projected building footprint (kWh/m$^2_{fp}$).

PV specification

The energy generated over the lifetime of a PV system, based on the latest solar technology, could be twice as high as the energy generated by a poorly specified system. Fortunately, the cost differences associated with specifying higher performance components are often marginal when comparing costs per unit of energy produced.

Look for design evidence of:

- Roof designed to maximise renewable density
- Orientation of building to maximise South facing roof area where possible.
- Energy consultant engaged early to predict and maximise electricity generation intensity of PV arrays
- Optimised roof form - even if the full PV array is not initially installed this will be an asset for future installation.

1 Maximise PV panel density

Where suitable encourage the design team to consider a large South facing mono-pitch roof to maximise solar electricity generation.

Alternatively for flat roofs use an east/west concertina PV array to maximise density and avoid inter-row shading.

Typical mounting system (© K2 systems)

2 Simplify roof form

Minimising stepped roofs and built in terraces which will reduce the available roof area for solar panels.

3 Minimise shading

Reduce parapet heights or replace with guard rails to minimise shading PV panels.

Reposition plant areas, stair cores and lift overruns to the north of the roof where possible.

4 Consider facade mounted PVs

There are some precedents for vertically mounted PV panels on façades in UK. Although this approach is uncommon, this could enable many more buildings to achieve net zero on site.

Where veritcal PV is considered, check the panels are not overshadowed by neighbouring buildings.

5 Specify high performing PV

Three key elements of PV system specification should be optimised:

High efficiency solar panel selection

Specify high efficiency monocrystalline silicon solar panel panels from a reputable manufacturer. High efficiency solar panels can deliver excellent levels of efficiency while maintaining their performance over several decades. Bifacial panels are able to absorb light on both sides of the panel, which can boost energy generation. It is recommended to specify high efficiency panel with an output of at least 300W.

Power output warranty

The power output warranty for a solar panel provides an indication of how it will perform over time. Lower performing solar panels have 'stepped' warranties that usually guarantee a percentage of the original power production at 10 and 25 years.

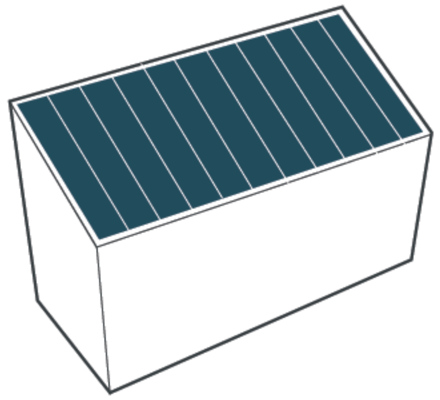
Higher performing solar panels have 'linear' warranties that guarantee higher levels of power production throughout the lifetime of the panel. Some manufacturers now offer 30-year warranties, though 25 years is the industry standard.

Module Level Power Electronics (MLPE)

Module Level Power Electronics (MLPE) refer to technologies that manage power production individually for each solar panel. This is a feature that ensures each solar panel operates at its peak power output. There are two main MLPE options: Microinverters or DC Optimisers.

PV design

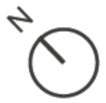
Three common PV design approaches are illustrated to demonstrate the relative expected percentage of the building consumption for a medium density apartment block and to guide the design team towards best practice.

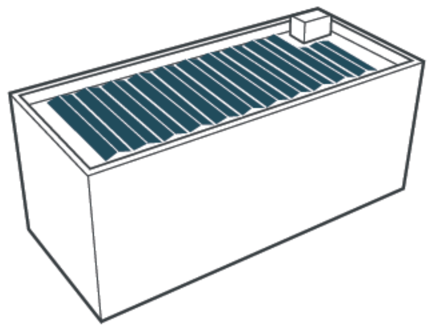


105% of demand met by PV

Best practice

- Solar roof is designed with a large south facing pitched plane to maximise solar generation.
- The PV could be part of the roof structure or a separate structure on top.
- Plant areas, stair cores and lift overruns should be located in a strip along the north side of the building under the solar roof structure.
- When combined with the recommended PV specification it could be possible for many buildings to achieve net zero operational energy on-site.

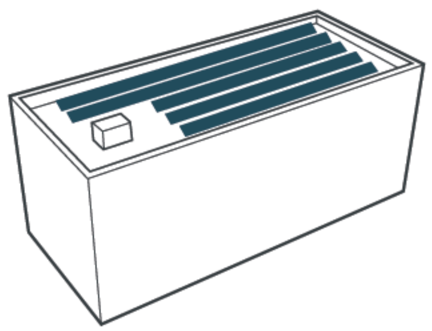




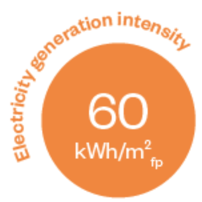
60% of demand met by PV

Good practice

- For a typical flat roof design, using concertina PV array achieves a high panel density as inter-row shading is eliminated.
- Solar array is at a 10-15 degree tilt angle and oriented to the east/ west (+/- 45 degrees orientation is acceptable).
- Services and lift over-runs are located on the north side of the building to minimise shading. The parapet still creates a large unusable border but could be replaced with a guard rail.



30% of demand met by PV



Business as usual

- Outdated approach where the solar array is at a 30 degree tilt angle and oriented to the South.
- Density of panel is not optimised as this approach requires larger gaps between rows to avoid inter-row shading.
- This results in low power density based on the overall roof area.
- Plant located on the south and the high parapet shades large areas roof space that could have otherwise been used for solar generation.

6 Check zero carbon balance

Where possible the designed energy generation intensity on-site should equal the total predicted energy use, in order to achieve a zero carbon balance.

Post-completion a carbon balance calculation should be made on an annual basis to determine if the building or development achieves a net zero carbon balance in reality.

Report predicted annual carbon balance for the whole development showing predicted carbon emissions from consumption, carbon saved from generation and net predicted emissions.

Report planning carbon calculations and total predicted carbon calculations separately.

Use of a green tariff alone is not robust enough and does not provide 'additional' renewables.

The electricity generation density is based on a footprint metric as it is understood that not every development will be able to meet a zero carbon balance on-site. This is typically due to density and the roof space available for PV.

Overheating

Target: **Reduce overheating risk**

Modelling for compliance

TM59 & 52

Where energy efficiency is improved and as the climate changes there is a greater risk of overheating in buildings. Carrying out dynamic thermal modelling pre-planning can significantly reduce the risk of homes overheating.

Overheating in homes is not a stand alone issue, it crosses paths and often conflicts with daylight, energy efficiency and acoustics, making it a complex design issue.

At early design stage overheating should be mitigated through appropriate orientation, massing, facade design, home design and shading. Mitigation measures should be included where possible to prevent overheating in future climate scenarios. This may include the flexibility of designs to have future measures installed at a later date.

Overheating calculations should be carried out as part of detailed planning submissions and reconfirmed pre-commencement.

Look for design evidence of:

- Good façade design with moderate glazing areas on south and west façades.
- Shading strategies for south and west façades.
- Evidence of dynamic modelling with measures taken to reduce overheating.

1 Design to reduce overheating

Encourage design teams to reduce the need for additional mechanical ventilation and cooling through passive building design.

Overheating can be significantly reduced through the following good design measures:

- Façade design that relates to orientation. Balance heat gain with heat loss by ensuring glazing areas are not excessive (ideally not more than 25% of facade) on south or west façades.
- Where glazing is provided on south façades include horizontal shading over the window e.g. brise soleil or deep reveals . Where glazing is west facing include vertical shading to shade the full height of window e.g. shutters.
- Select a g-value for glass of around 0.5 where possible. This balances heat gain and loss. G-values below 0.5 begin to reduce winter solar gains and daylight in homes.
- Dual aspect homes to allow for effective cross ventilation.
- Avoid fixed panes and maximise opening areas of windows. Side hung windows typically allow more ventilation than top hung.
- Avoid relying on internal blinds, which can be removed or changed by residents. Closed blinds should not be relied on for long periods of time.

Encourage design teams to use the Good Homes Alliance overheating tool to understand the risk posed to the buildings/ development.

2 Consider potential conflicts

Daylight, acoustics and ultra-low energy design often conflict with overheating.

Acoustics

Identify early whether the external environment is particularly noisy. Use the Acoustics and Noise Consultants (ANC) Acoustics, Ventilation and Overheating Guide to determine an approach to acoustic assessments for new residential development. Where it is determined that windows should not be opened for extended periods of time due to excess noise, consider window sizes, ways to mechanically ventilate and shade, prior to considering comfort cooling.

Daylight

In high density developments it is unlikely that internal daylight compliance with BRE guidelines will be achieved in tandem with reduced overheating risk. In this case a qualitative assessment of daylight should be considered, this could include the following: reducing floor plan depths; ensuring dual aspect homes with natural light from both sides; light coloured finishes internally and on balconies; and increased distances form neighbouring overshadowing buildings.

3 Carry out modelling

Dynamic modelling using standardised inputs should be carried out by a consultant.

Modelling should be undertaken prior to submitting for planning to show compliance with CIBSE TM59 guidance for residential and TM52 guidance for non-residential.

Future climate scenarios should be modelled to determine the likely future impact of climate change. However, the focus should remain on achieving compliance with the current weather files.

A statement should be produced demonstrating the strategies that have been implemented. This will also need to be submitted to the GLA and LLDC for planning permission.

Water demand

Target: **Reduce hot and cold water demand**

Good practice water standards

AECB

Making informed decisions and following good practice water standards will improve efficiency and minimise distribution losses.

Take extra steps to target energy efficiency

In addition to insulating pipework in line with AECB Water standards further measures should be targeted to significantly reduce distribution losses.

Design and select heating systems appropriately

As industry targets shift towards ultra-low energy design the heat lost during distribution becomes proportionally more significant. For some heating systems, it is possible that the total heat lost could match the heating and hot water demand, of an ultra-low energy home, thereby doubling the amount of energy that needs to be generated.

High temperature distribution will inherently have high losses due to the large differential between the distribution temperature and its surroundings (e.g. ground, external space, riser). It important that heat losses are mitigated or designed out by following best practice guidance summarised on this page.

Look for design evidence of:

- Elimination or minimisation of distribution losses or standing losses as much as possible. Calculate losses at RIBA stage 3.
- Insulation of pipework
- Specification of low flow rates

1 Reduce hot water demand

In addition to AECB water standards, efforts should be made to reduce domestic hot water (DHW) demand.

In ultra-low energy buildings, the energy required for hot water can meet or exceed the amount of energy required for space heating. Optimisation of hot water systems is therefore important to ensure overall energy use remains low.

2 Reduce flow rates

The AECB water standards (opposite) provide clear guidance on sensible flow rates for showers and taps in low energy buildings, which are consistent with what is required to achieve net zero carbon buildings.

Shower head flow rates generally have the greatest impact and should be limited to a maximum of 6 litres/min.

3 Reduce distribution heat losses

The volume of distribution pipework has a significant effect on overall system losses.

Heat losses should be minimised by clustering tapping points as close as possible to the hot water tank or source. Floor to ceiling pipe drops should be kept to a minimum and use of small diameter piping, 15mm or less, is an effective way to reduce losses.

4 Minimise losses from hot water tanks

The standby losses of hot water tanks are highly variable, and can have a significant impact on overall energy use.

Minimising losses reduces energy waste. It also reduces overheating risk due to unwanted heat gains in warmer months. A tank heat loss of less than 0.8 kWh/day should be targeted if a standalone direct electric hot water tank is installed.

5 Waste water heat recovery (WWHR)

Shower drain waste water heat recovery systems are very simple, with no moving parts.

WWHR can reduce heat loss from showers by up to 60%, although savings of 25-40% are more common using horizontal heat recovery systems required in flats. This technology is still developing, so efficiencies may be expected to increase.

Fixture/ fitting	**AECB** Good Practice Fittings Standard
Showers	6 to 8 l/min measured at installation. Mixer to have separate control of flow and temperature although this can be achieved with a single lever with 2 degrees of freedom (lift to increase flow, rotate to alter temperature). All mixers to have clear indication of hot and cold, and with hot tap or lever position to the left where relevant.
Basin taps	4 to 6 l/min measured at installation (per pillar tap or per mixer outlet). All mixers to have clear indication of hot and cold with hot tap or lever position to the left.
Kitchen sink taps	6 to 8 l/min measured at installation. All mixers to have clear indication of hot and cold with hot tap or lever position to the left.
White Goods	Best energy class available, see energy standard for details.
WCs	≤ 6 l full flush when flushed with the water supply connected. All domestic installations to be dual flush. All valve-flush (as opposed to siphon mechanism) WCs to be fitted with an easily accessible, quarter turn isolating valve with a hand-operated lever. Where a valve-flush WC is installed, the Home User Guide must include information on testing for leaks and subsequent repair.
Baths	≤ 180 litres measured to the centre line of overflow without allowing for the displacement of a person. Note that some product catalogues subtract the volume of an average bather. A shower must also be available. If this is over the bath then it must be suitable for stand-up showering with a suitable screen or curtain.

Full © AECB document available from: https://www.aecb.net/aecb-water-standard/

Measurement and verification

Target: **Measure how the building performs in-use and compare it to the design predictions**

Measuring and verifying the design against the completed building can help highlight what environmental strategies have had the greatest impact on energy consumption and occupant comfort and satisfaction.

In order to prepare for a 1.5°C future not only do the buildings need to be designed to meet the net zero carbon targets, they also need to aim to operate to meet the targets.

The publicly accessible data on how buildings perform post-completion has shown that where buildings are monitored there is a significant performance gap between design and as-built. But in many cases the actual performance of buildings is broadly unknown and unquantified.

By measuring and verifying the performance of buildings, LLDC will be taking a significant step in the right direction. It is acknowledged that to begin with not all schemes will meet the KPI's when measured. However, this will provide an opportunity to learn from and engage with the design, construction and completion of buildings to put LLDC on a path to zero carbon.

Measuring and verifying how a building performs will assist in the data completion required for the London Plan - Be Seen compliance.

Look for evidence of:

- Inclusion of monitoring and reporting in the design, tender and programme.
- Inclusion of measurement, verification and reporting in appointments.
- A metering strategy that aligns with the KPIs.

1 Design for monitoring

Use the key performance indicators set at design stage to prepare for measurement and verification post-completion.

Identify targets and desired outcomes at an early stage. Use these to develop the design of the project so that it has every chance of meeting the requirements post-construction.

Identify areas of the design that need particular attention and protection as the project progresses. This could include the buildability of a detail, the location of an airtightness line, the specification of simple controls, the location of building services to maximise efficiency or measures to improve thermal comfort and reduce overheating, such as external shading.

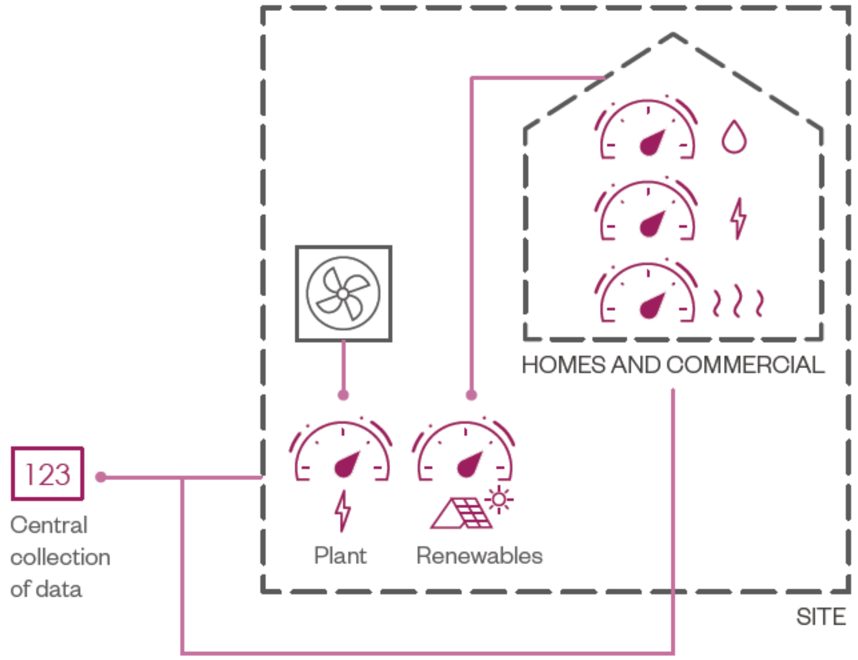
Set out a plan for monitoring the building post-completion. This should include what data will need to be collected, how to collect it, who will collect it and the processes for monitoring and verifying data. Review lessons learned from past projects.

2 Meters and sub-meters

Determine what meters and sub-meters will be required during design.

The metering strategy should consider:

- The central collection of data to make it easy to process.
- Homes - Install electric, heat and water meters for all individual homes. For best practice consider separate meters for space heating and hot water. Where electricity is used as a heating fuel consider sub-metering usage.
- Commercial areas - Install electric, heat and water meters. For best practice sub-meter appropriate uses, such as ventilation and lighting.
- Site - At a site level meter the renewable energy generation, consumption from landlord areas and plant rooms. For best practice also measure other uses such as electric vehicle charging and landscape lighting.



3 Preparing for site and build quality

Encourage high levels of build quality.

Consider the construction contract used to determine how prescriptive design teams can be with building products and mechanical services and controls. Where performance specifications are used, consider areas where the contractor can propose alternatives and determine whether this will still allow the building to meet the KPIs.

Incorporate the performance objectives, handover and commissioning into the tender and programme.

Consider the use of Passivhaus certification as a route to ensure construction quality on site.

Consider appointing a clerk of works to oversee the quality of construction.

4 Handover and commissioning

Ensure commissioning is carried out and prepare user guides for residents.

Ensure commissioning of heating, hot water, controls and mechanical ventilation takes place. With any performance issues rectified.

Check and record test results and compare to required performance levels. This should include the airtightness test results.

Provide building and operational information to residents in the form of site inductions and building user guides. Ensure they understand how the building and systems are designed to operate. Guides should include photos and instructions of actual systems and controls installed.

5 Monitor and report against targets

Monitor the project post-completion and report on the findings.

Monitor and collect data on the building for the first five years post-completion. Follow London Plan 'Be Seen' guidance.

Compare the data against KPI targets and outcomes set at design stage as well as regulation.

Where energy consumption data is considered sensitive, buildings and dwellings can be aggregated to anonymise the data.

Report on the data collected and any lessons learned for future projects.

For best practice carry out user satisfaction surveys and compare monitored data against user feedback.

6 Publicly disclose

Share the findings with the industry.

Consider publishing the headline figures and findings from the development to demonstrate best practice. Share lessons learned.

Encourage data to be shared on the GLA London Data Store.

Appendix

Baseline review of LLDC targets

A baseline review of LLDC current targets was carried out to establish the new criteria for Key Performance Indicators. The existing targets were compared against the new London Plan and the latest guidance by LETI and RIBA as summarised in the table on the following page.

Review of LLDC current targets

LLDC have a track record of setting exemplar performance targets. As demonstrated by the summary table, LLDCs current targets either match or exceed the new London Plan requirements. For example the Fabric Energy Efficiency Standards for space heating will out perform a 10% Lean reduction in emissions. However, if you compare the current LLDC targets to the latest industry guidance by LETI and RIBA, the targets fall short of the requirements to achieve net zero carbon. The proposed KPIs aim to bridge this gap and bring LLDC in line with the latest industry targets and move towards a 1.5°C future.

	GLA London Plan	**LLDC** Current target	**LETI** Climate Emergency Design Guide	**RIBA 2030** Climate challenge	**KPIs** Proposed targets
Ultra-low energy buildings	Be Lean: **10% reduction for domestic** Be Lean: **15% reduction for non-domestic**	Fabric Energy Efficiency Standards (FEES): Space heating demand **< 39kWh/m²** for flats and mid terrace houses **<46kWh/m²** for end terraces and detached homes	Space heating demand **<15 kWh/m²/yr**	Space heating demand **<15 kWh/m²/yr**	Space heating demand **<15 kWh/m²/yr** *Use PHPP to calculate EUI* Space heating demand 15 kWh/m².yr
Embodied carbon	**Calculate whole life-cycle carbon emissions** *Use a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce emissions* *Referable developments only*	**15% reduction in embodied carbon** in new construction *At least 25% recycled content of aggregate within new buildings and infrastructure (by weight).* *At least 20% of construction materials to be from a reused or recycled source (by value).*	Embodied carbon should be **assessed, reduced and verified post-construction** 2020 - 40% reduction over baseline or **<500 $kgCO_2e/m^2/yr$** *2030 - 65% reduction over baseline or <300 $kgCO_2e/m^2/yr$*	**< 300 $kgCO_2e/m^2$** (minimum 50-70% reduction in embodied carbon) *Using RICS Whole Life Carbon Analysis (A-C)*	Compare and aim to meet the benchmark of **500 $kgCO_2e/m^2/yr$** *Using RICS Whole Life Carbon Analysis (A-C)* Follow guidance on good practice **design for low embodied carbon** Report improvements achieved during design Embodied carbon benchmark 500 $kgCO_2e/m^2.yr$
Energy use and efficient heating Outside of concession area	Emissions reduction **35% reduction** Be clean: **exploit local energy resources** (such as secondary heat) and supply energy efficiently and cleanly Use zero or low-emission decentralised energy where feasible, **prioritising connection to district heating and cooling networks**	Emissions reduction for Queen Elizabeth Olympic Park Domestic target: **65% reduction** in emission over Building Regulations 2010 *Up to 35% of emissions mitigation through allowable solutions in surrounding communities* Non-domestic target: **40% reduction** in emission over Building Regulations 2010	Energy Use Intensity Domestic Target: **<35 kWh/m²/yr** Commercial Office Target: **<55 kWh/m²/yr (GIA)** **Heating and hot water should not be generated using fossil fuels**	Energy Use Intensity Domestic Target: Energy Use Intensity **< 0 to 35 kWh/m²/yr** *Minimum 75% reduction compared to current Ofgem benchmarks or the equivalent of Passivhaus* Non-domestic Target: **<55 kWh/m²/yr** Display Energy Certificate (DEC) A rating	Energy Use Intensity Domestic target: **<35 kWh/m²/yr** *Equivalent to Passivhaus standard of performance* Non-domestic Target: **<55 kWh/m²/yr (GIA)** *Use PHPP to calculate EUI* *Target low carbon heat source ie heat pump* Report % reduction over Part L 2013 Energy Use Intensity 35 kWh/m².yr
Inside of concession area		**Support and encourage connection** to and extension of the district heating network			Energy Use Intensity target cannot be met inside the district heating network concession area **Report and compare against 35 or 55 kWh/m²/yr benchmarks** Report % reduction over Part L 2013 Report Energy Use Intensity and compare Report kWh/m².yr 35 kWh/m².yr

	GLA London Plan	**LLDC** Current target	**LETI** Climate Emergency Design Guide	**RIBA 2030** Climate challenge	**KPIs** Proposed targets
Renewable energy	Be green: **maximise renewable energy** on-site **Offset remaining 65%** of emissions **at £60/t** for 30 years (soon to be £95 per tonne)		**Maximise renewable energy** on-site **Offset at £60/t** where targets cannot be met on site	**Maximise renewable energy** on-site **Balance carbon on an annual basis** *Energy use not met by on-site renewables should be met by an investment into additional renewable energy capacity off-site*	Achieve an **electricity generation intensity** of more than **120kWh/m² building footprint/yr** **Report predicted annual carbon balance** for the whole development showing predicted carbon emissions from consumption, carbon saved from generation and net predicted emissions. *Report planning carbon calculations and total predicted carbon calculations separately.* Electricity generation intensity 120 kWh/m^2_{fp}
Overheating	Domestic: Demonstrate through a **TM59 assessment** how they will reduce the potential for internal overheating and reliance on air conditioning systems			Domestic: **CIBSE TM59** 25-28 °C maximum for 1% of occupied hours	Domestic: **CIBSE TM59** Clearly describe summer comfort strategy and avoid use of comfort cooling Domestic and non-domestic: **CIBSE TM52** Modelling for compliance TM59 & 52
Water use	Domestic: Optional Requirement of Building Regulations Part G mains water consumption of **105l/p/d** (excluding allowance of up to five litres for external water consumption)	Mains water consumption of **105l/p/d** (excluding allowance of up to five litres for external water consumption)		**< 75 l/p/day** Potable Water CIBSE Guide G	Follow **AECB water standards** and achieve 'good practice' requirements Best practice water standards AECB
Measurement and verification	Be seen: monitor, verify and **report on energy performance for the first 5 years** post construction.	Record and **report annually** in sustainability report	**Annual energy use and renewable energy generation** on-site reported and independently verified in-use each year for the **first 5 years** *This can be done on an aggregated and anonymised basis for residential buildings*	Undertake **light touch post occupancy evaluation** to gather predicted and actual performance of existing and new building projects	Predicted energy performance calculation and report at planning, tender and end of construction **5-year energy monitoring post-construction** Report embodied carbon for building life cycle stages A1-A5 Report annually against KPIs Collect data in-use for first 5 years KPIs in-use

Total emission factor

Total emission factor per unit of heat (kgCO/kW) quoted in the district heating a low carbon heat section p20.

0.074

Olympic Park

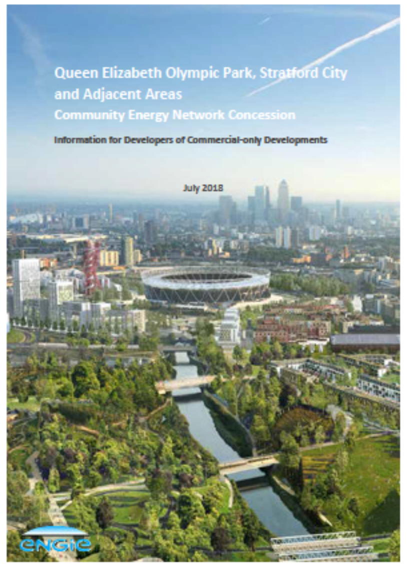
assuming secondary network with 15% losses

0.119

Stratford City

assuming secondary network with 15% losses

Figures taken from ENGIE briefing note for Commercial Developer July 2018 illustrate below. Extracts of Tables 1 and 6 provided overleaf.



	Olympic Park (ODA Site) Assuming secondary network with 15% losses	Olympic Park (ODA Site) Assuming no secondary network	Stratford City Stratford City Assuming secondary network with 15% losses	Stratford City Assuming no secondary network
Heat split				
Proportion of heat from biomass	20.5%	20.5%	4.9%	4.9%
Proportion of heat from gas boilers	10.8%	10.8%	22.0%	22.0%
Proportion of heat from CHP	68.7%	68.7%	73.1%	73.1%
Heat losses (% of heat generated)				
Primary Heat losses % of heat generated	6.5%	6.5%	5.5%	5.5%
Secondary Heat losses % of heat supplied to secondary network	15.0%	0.0%	15.0%	0.0%
Total Heat losses % of heat generated	20.5%	6.5%	19.6%	5.5%
Distribution loss factor	1.258	1.069	1.245	1.058
Generator and network efficiencies				
Energy Centre Biomass Boiler Efficiency	79.88%	79.88%	79.88%	79.88%
Energy Centre Gas Boiler Efficiency	82.33%	82.33%	84.80%	84.80%
Energy Centre CHP Thermal Efficiency	36.89%	36.89%	37.20%	37.20%
Energy Centre CHP Electrical Efficiency	39.40%	39.40%	38.38%	38.38%
Parasitic' electricity factor	0.010	0.010	0.010	0.010
Total Emission Factor per Unit of Heat (kgCO /kWh)	**0.074**	**0.063**	**0.119**	**0.101**

Table 1: Summary of long term data provided by ENGIE

	Olympic Park (ODA Site)	Olympic Park (ODA Site) No Secondary Network	Stratford City	Stratford City No Secondary Network	
Heat split					
Proportion of heat from biomass	20 5%	20.5%	4.9%	4 9%	
Proportion of heat from gas boilers	10 8%	10.8%	22.0%	22 0%	
Proportion of heat from CHP	68.7%	68.7%	73.1%	73.1%	
Delivered heat					
Delivered heat from biomass boilers	0.205	0 205	0.049	0.049	kWh
Delivered heat from gas boilers	0.108	0.108	0.220	0.220	kWh
Delivered heat from CHP	0.687	0.687	0.731	0.731	kWh
Total heat delivered	**1.000**	**1.000**	**1.000**	**1.000**	**kWh**
Heat losses (% of heat generated)					
Primary Heat losses % of heat generated	6 5%	6.5%	5.5%	5 5%	
Secondary Heat losses % of heat supplied to secondary network	15 0%	0.0%	15.0%	0 0%	
Total Heat losses % of heat generated	20 5%	6.5%	19.6%	5 5%	
Distribution loss factor	1.258	1 069	1.245	1.058	
Heat generated					
Heat generated by biomass boilers	0.258	0 219	0.061	0.052	kWh
Heat generated by gas boilers	0.135	0.115	0.274	0.233	kWh
Heat generated by CHP	0.865	0.735	0.910	0.773	kWh
Total heat generated	**1.258**	**1.069**	**1.245**	**1.058**	**kWh**
Generator and network efficiencies					
Energy Centre Biomass Boiler Efficiency	79.88%	79.88%	79 88%	79.88%	
Energy Centre Gas Boiler Efficiency	82.33%	82.33%	84 80%	84.80%	
Energy Centre CHP Thermal Efficiency	36.89%	36.89%	37 20%	37.20%	
Energy Centre CHP Electrical Efficiency	39.40%	39.40%	38 38%	38.38%	
Parasitic' electricity factor	1.00%	1.00%	1 00%	1.00%	
Delivered fuel					
Biomass fuel delivered	0.323	0 274	0.076	0.065	kWh
Gas delivered to gas boilers	0.164	0.140	0.323	0.274	kWh
Gas delivered to CHP engines	2.344	1 992	2.446	2.079	kWh
Electricity generated from CHP	0.923	0.785	0.939	0.798	kWh
Electrical energy for heat distribution	0.013	0 011	0.012	0.011	kWh
Carbon emission factors					
Biomass	0.016	0 016	0.016	0.016	kgCO /kWh
Mains Gas	0.216	0 216	0.216	0.216	kgCO /kWh
Grid Supplied Electricity	0.519	0 519	0.519	0.519	kgCO /kWh
Grid Displaced Electricity	0.519	0 519	0.519	0.519	kgCO /kWh
Carbon emissions					
Biomass carbon emissions	0.005	0 004	0.001	0.001	kgCO /kWh
Gas boiler carbon emissions	0.036	0 030	0.070	0.059	kgCO /kWh
Gas CHP carbon emissions	0.506	0.430	0.528	0.449	kgCO /kWh
Emissions for heat distribution	0.007	0 006	0.006	0.005	kgCO /kWh
Gas CHP electricity credit emissions	-0.479	-0.407	-0.487	-0.414	kgCO /kWh
Total emissions factor (kgCO /kWh)	**0.074**	**0.063**	**0.119**	**0.101**	**kgCO /kWh**

Table 6 Derivation of Carbon Factors for Use in Preparing Energy Statements

LLDC zero carbon workshop

A ‘zero carbon workshop’ was held on the 14th December 2020 to discuss the approach for the guidance and gain feedback from LLDC stakeholders. The guidance was generally well received and the feedback has been summarised on this page.

Workshop agenda

The workshop session provided stakeholders with an opportunity to help shape and give feedback on the emerging guidance document. During the workshop the industry definition of net zero carbon was presented and the next steps LLDC would need to take to align themselves to this goal. The key performance indicators and the design guidance to deliver a zero carbon development were also discussed. Separate energy use targets were shown for inside and outside the district heat network concession area. The main feedback from the session is summarised below and has been assimilated into the final guidance document.

Feedback summary

- **Key Performance Indicators (KPIs)** - there was wide consensus on the proposed KPIs although there were some anticipation over whether these targets could be met in practice, especially relating to supply of heat.

  We have given practical steps within the guidances to demonstrate how KPIs can be delivered in practice. Any future shortfalls from in-use performance should form part of the annual learning and reporting in order to encourage improvement on subsequent developments.
- **Zero carbon trajectory** - general concern was expressed over pressure to connect to the district heat network which could jeopardise meeting LLDC’s 2030 zero carbon target.

  LLDC will continue to have discussion with the heat network operator and seek low carbon options where possible.
- **Evidence base for zero carbon pathway**- it was discussed that this report would provide an objective evidence base for LLDC to promote the case for a more rapid decarbonisation strategy for the heat network and the means to move away from carbon hungry approaches wherever possible.
- **Honesty and integrity** - it was recognised that being upfront about LLDC current zero carbon trajectory was the first step to shifting mindsets towards an alternative net zero carbon pathway.
- **Development guidance rather than policy** - there were questions over whether the proposed KPIs could be used to inform LLDC policy.

  Whilst this could be the case it was acknowledged that the intention of this document was to provide pragmatic guidance specifically for the development arm of LLDC.

Opinion poll on the emerging design guide

80%	The guidance covers relevant topics that are useful to my role
90%	The guidance clearly demonstrates how net zero carbon developments can be delivered in practice
70%	I believe I can follow guidance to achieve all key performance indicator targets
100%	The guidance gives a clear idea of what ultra low energy design is
90%	The format of the guide seemed accessible and easy to use
50%	I am confident that all of LLDC energy and carbon aspirations can be met by following this guidance
80%	I can imagine this guide being used to set briefing criteria for all LLDC developments
70%	I can imagine using this guide on a day-to-day basis
80%	I can imagine giving this guide for others to use
80%	I would be confident to explain best practice sustainable design to others with the help of the guide.

Possible concern around running costs of electric system,but that resolved by very low energy demand

Embodied energy is the elephant in the room. We could get distracted by operational energy (DEN in particular) when the closer we get to net zero operational energy, the more important embodied carbon is.

Should LLDC be considering medium/tall builidngs without steel/ concrete frames? What are alternatives? Should they be ruling out buildings with large glazing area?

Reducing (eliminating?) the performance gap is a big challenge. We're currently doing post occupancy evaluation on a number of areas, including sustainability, and I predict our challenge will be to achieve net zero as-built, not as-designed. Approaching developments to manage this challenge is difficult, because of timelines, and that no development launches stating it's not going to achieve its designed targets.

Is there any data/recommendations for public realm energy usage? Eg external lighting?

Are there discussions with GLA about DH connection and the difficulties?

I think our main challenge (DEN aside) is knowing what the implications will be in terms of feasibility for zero carbon building (cost, time, procurement, commercial).

We have a similar issue (performance gap) on PML and BW and have been looking at this but the answer is a little unknown currently

Why are we asking for impending developments to connect to the CHP system if we know it's not sustainable?

Unlike other developer's and schemes, LLDC's position is unique and more challenging as we are a Mayoral Development Corporation. So we have a political context others don't have and LLDC cannot ignore.

So within the concession area we cannot achieve zero carbon - thinking of Aquatics Triangle where we will be procuring a developer, what do we ask the developer to deliver if zero carbon is not possible?

Will your report be considering external works or just buildings?

Tell us what challenges you or others might face when implementing low carbon in practice?

LETI Archetypes

The LETI Climate Emergency Design Guide contains guidance on four building archetypes that make up the majority of new buildings in the UK. Taken together they represent 75% of the new buildings likely to be built between now and 2050.

LETI Archetypes

We have included copies of three of the most relevant archetypes on the pages that follow:

- Small scale housing
- Medium and large scale housing
- Commercial offices.

These archetypes contain many of the figures used to help guide the KPIs set out in this report.

More information can be found here: https://www.leti.london/cedg

Small scale housing

Operational energy

Implement the following indicative design measures:

Fabric U-values (W/m².K)

Walls	0.13 - 0.15
Floor	0.08 - 0.10
Roof	0.10 - 0.12
Exposed ceilings/floors	0.13 - 0.18
Windows	0.80 (triple glazing)
Doors	1.00

Efficiency measures

Air tightness	<1 (m³/h. m²@50Pa)
Thermal bridging	0.04 (y-value)
G-value of glass	0.6 - 0.5
MVHR	90% (efficiency) ≤2m (duct length from unit to external wall)

Window areas guide (% of wall area)

North	10-15%
East	10-15%
South	20-25%
West	10-15%

Balance daylight and overheating

Include external shading

Include openable windows and cross ventilation

Reduce energy consumption to:

35 kWh/m².yr

Energy Use Intensity (EUI) in GIA, excluding renewable energy contribution

Reduce space heating demand to: 15 kWh/m².yr

Maximise renewables so that 100% of annual energy requirement is generated on-site

Form factor of 1.7 - 2.5

Heating and hot water

Implement the following measures:

Fuel
Ensure heating and hot water generation is fossil fuel free

Heating
Maximum 10 W/m² peak heat loss (including ventilation)

Hot water
Maximum dead leg of 1 litre for hot water pipework

'Green' Euro Water Label should be used for hot water outlets (e.g.: certified 6 L/min shower head – not using flow restrictors).

Demand response

Implement the following measures to smooth energy demand and consumption:

Peak reduction
Reduce heating and hot water peak energy demand

Active demand response measures
Install heating set point control and thermal storage

Electricity generation and storage
Consider battery storage

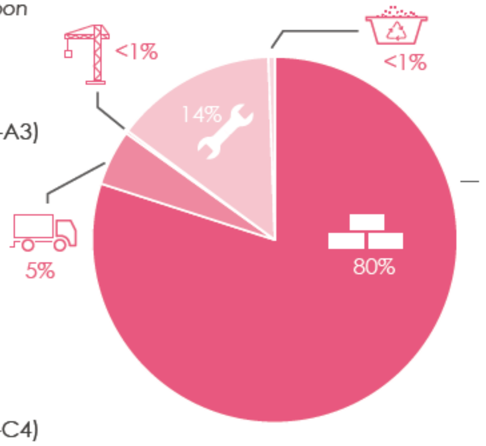
Electric vehicle (EV) charging
Electric vehicle turn down

Behaviour change
Incentives to reduce power consumption and peak grid constraints.

Embodied carbon

Focus on reducing embodied carbon for the largest uses:

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



Average split of embodied carbon per building element:

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

Reduce embodied carbon by 40% or to:

<500 $kgCO_2/m^2$

Area in GIA

Data disclosure

Meter and disclose energy consumption as follows:

Metering

1. Submeter renewables for energy generation
2. Submeter electric vehicle charging
3. Submeter heating fuel (e.g. heat pump consumption)
4. Continuously monitor with a smart meter
5. Consider monitoring internal temperatures
6. For multiple properties include a data logger alongside the smart meter to make data sharing possible.

Disclosure

1. Collect annual building energy consumption and generation
2. Aggregate average operational reporting e.g. by post code for anonymity or upstream meters
3. Collect water consumption meter readings
4. Upload five years of data to GLA and/or CarbonBuzz online platform
5. Consider uploading to Low Energy Building Database.

LONDON ENERGY TRANSFORMATION INITIATIVE

Medium and large scale housing

Operational energy

Implement the following indicative design measures:

Fabric U-values (W/m².K)

Walls	0.13 - 0.15
Floor	0.08 - 0.10
Roof	0.10 - 0.12
Exposed ceilings/floors	0.13 - 0.18
Windows	1.0 (triple glazing)
Doors	1.00

Efficiency measures

Air tightness	<1 (m³/h.m²@50Pa)
Thermal bridging	0.04 (y-value)
G-value of glass	0.6 - 0.5
MVHR	90% (efficiency) ≤2m (duct length from unit to external wall)

Maximise renewables so that 70% of the roof is covered

Form factor of <0.8 - 1.5

Window areas guide (% of wall area)

North	10-20%
East	10-15%
South	20-25%
West	10-15%

Balance daylight and overheating

Include external shading

Include openable windows and cross ventilation

Reduce energy consumption to:

35 kWh/m².yr

Energy Use Intensity (EUI) in GIA, excluding renewable energy contribution

Reduce space heating demand to: **15** kWh/m².yr

Heating and hot water

Implement the following measures:

Fuel
Ensure heating and hot water generation is fossil fuel free

Heat
The average carbon content of heat supplied (gCO_2/kWh.yr) should be reported in-use

Heating
Maximum 10 W/m² peak heat loss (including ventilation)

Hot water
Maximum dead leg of 1 litre for hot water pipework

'Green' Euro Water Label should be used for hot water outlets (e.g.: certified 6 L/min shower head – not using flow restrictors).

Demand response

Implement the following measures to smooth energy demand and consumption:

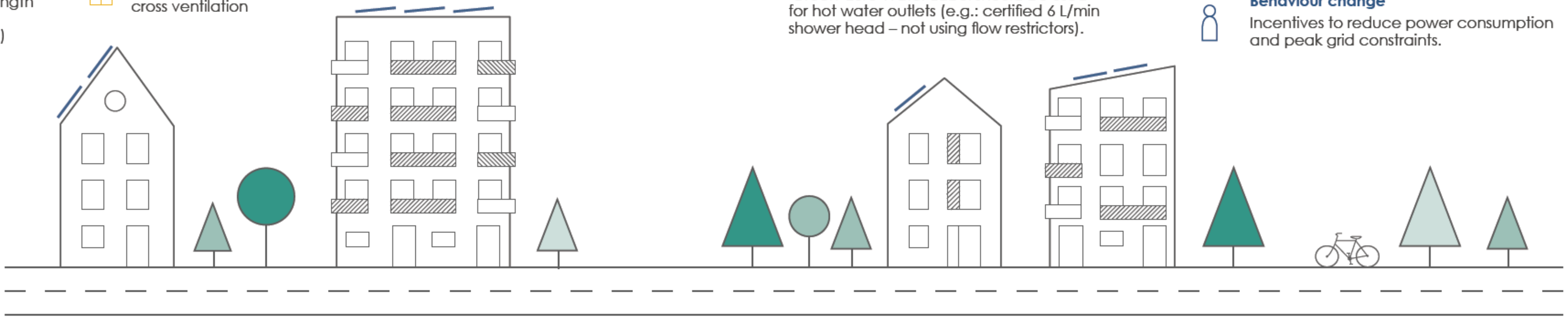
Peak reduction
Reduce heating and hot water peak energy demand

Active demand response measures
Install heating set point control and thermal storage

Electricity generation and storage
Consider battery storage

Electric vehicle (EV) charging
Electric vehicle turn down

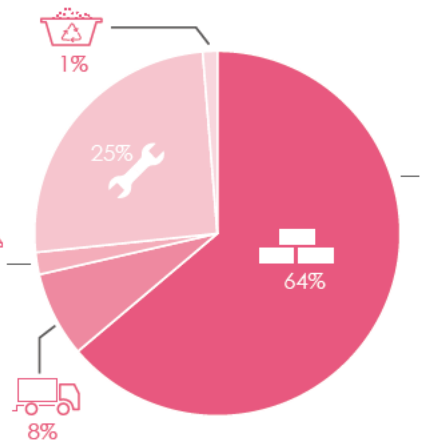
Behaviour change
Incentives to reduce power consumption and peak grid constraints.



Embodied carbon

Focus on reducing embodied carbon for the largest uses:

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



Average split of embodied carbon per building element:

- **46%** - Superstructure
- **21%** - Substructure
- **16%** - Internal finishes
- **13%** - Façade
- **4%** - MEP

Reduce embodied carbon by 40% or to:

<500 $kgCO_2/m^2$

Area in GIA

Data disclosure

Meter and disclose energy consumption as follows:

Metering

1. Submeter renewables for energy generation
2. Submeter electric vehicle charging
3. Submeter heating fuel (e.g. heat pump consumption)
4. Continuously monitor with a smart meter
5. Consider monitoring internal temperatures
6. For multiple properties include a data logger alongside the smart meter to make data sharing possible.

123 **Disclosure**

1. Collect annual building energy consumption and generation
2. Aggregate average operational reporting e.g. by post code for anonymity or upstream meters from part or whole of apartment block
3. Collect water consumption meter readings
4. Upload five years of data to GLA and/or CarbonBuzz online platform
5. Consider uploading to Low Energy Building Database.

LONDON ENERGY TRANSFORMATION INITIATIVE

Commercial offices

Operational energy

Implement the following indicative design measures:

Fabric U-values (W/m².K)

Walls	0.12 - 0.15
Floor	0.10 - 0.12
Roof	0.10 - 0.12
Windows	1.0 (triple glazing) - 1.2 (double glazing)
Doors	1.2

Fabric efficiency measures

Air tightness	<1 (m³/h. m²@50Pa)
Thermal bridging	0.04 (y-value)
G-value of glass	0.4 - 0.3

Power efficiency measures

Lighting power density	4.5 (W/m² peak NIA)
Lighting out of hours	0.5 (W/m² peak NIA)
Tenant power density	8 (W/m² peak NIA)
ICT loads	0.5 (W/m² peak NIA)
Small power out of hours	2 (W/m² peak NIA)

System efficiency measures

MVHR	90% (efficiency)
Heat pump SCoP	≥ 2.8
Chiller SEER	≥ 5.5
Central AHU SFP	1.5 - 1.2 W/l.s
A/C set points	20-26°C

Window areas guide (% of wall area)

North	25-40%
East	25-40%
South	25-40%
West	25-40%

Balance daylight and overheating

Include external shading

Include openable windows and cross ventilation

Maximise renewables to generate the annual energy requirement for at least two floors of the development on-site

Form factor of 1 - 2

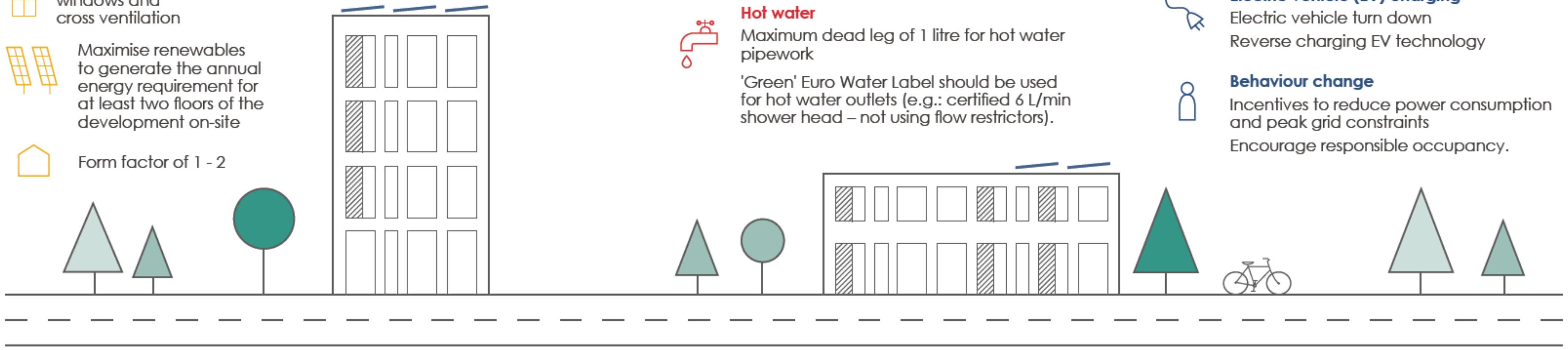
Reduce energy consumption to:

55 kWh/m².yr

Energy Use Intensity (EUI) in GIA, excluding renewable energy contribution

Reduce space heating demand to:

15 kWh/m².yr



Heating and hot water

Implement the following measures:

Fuel
Ensure heating and hot water generation is fossil fuel free

Heat
The average carbon content of heat supplied (gCO_2/kWh.yr) should be reported in-use

Heating
Maximum 10 W/m² peak heat loss (including ventilation)

Connect to community wide ambient loop heat-sharing network to allow excess heat from cooling to be made available to other buildings

Hot water
Maximum dead leg of 1 litre for hot water pipework

'Green' Euro Water Label should be used for hot water outlets (e.g.: certified 6 L/min shower head – not using flow restrictors).

Demand response

Implement the following measures to smooth energy demand and consumption:

Peak reduction
Reduce heating and hot water peak energy demand

Active demand response measures
Install heating and cooling set point control

Reduce lighting, ventilation and small power energy consumption

Electricity generation and storage
Consider battery storage

Electric vehicle (EV) charging
Electric vehicle turn down

Reverse charging EV technology

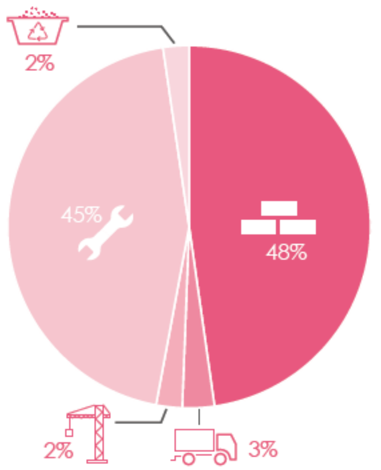
Behaviour change
Incentives to reduce power consumption and peak grid constraints

Encourage responsible occupancy.

Embodied carbon

Focus on reducing embodied carbon for the largest uses:

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



Average split of embodied carbon per building element:

- 48% - Superstructure
- 17% - Substructure
- 16% - Façade
- 15% - MEP
- 4% - Internal finishes

Reduce embodied carbon by 40% or to:

<600 $kgCO_2/m^2$

Area in GIA

Data disclosure

Meter and disclose energy consumption as follows:

Metering *(Metering strategy following BBP Better Metering Toolkit guidance)*

1. Record meter data at half hourly intervals
2. Separate landlord and tenant energy use meters and clearly label meters with serial number and end use
3. Submeter renewable energy generation
4. Use a central repository for data that has a minimum of 18 months data storage
5. Provide thorough set of meter schematics and information on maintenance and use of meters
6. Ensure metering commissioning includes validation of manual compared to half hourly readings.

123 **Disclosure**

1. Carry out an annual Display Energy Certificate (DEC) and include as part of annual reporting
2. Report energy consumption by fuel type and respective benchmarks from the DEC technical table
3. For multi-let commercial offices produce annual landlord energy (base building) rating and tenant ratings as well as or instead of a whole building DEC
4. Upload five years of data to a publicly accessible database such as GLA and/or CarbonBuzz.

LONDON ENERGY TRANSFORMATION INITIATIVE

RIBA Stage 2 - Concept Design	✓
Optimise building orientation to balance solar gain and increase south facing roof area. Design roof to maximise density of renewables.	
Calculate and report the building form factor for design options.	
Arrange embodied carbon workshops with design team to target lean design principles and reduce big tickets items e.g. structure.	
Identify design team members to carry out embodied carbon assessment. Carry out multiple embodied carbon calculations of key elements to demonstrate low carbon design choices.	
Mark-up insulation line on all plans and sections. Mark unheated external areas on plans.	
Allow sufficient wall construction thickness for all insulated walls, roofs and floors.	
Mark window openings for providing natural ventilation for summer comfort.	
Identify a location for the MVHR next to an external wall.	
Evaluate requirement to connect to the district heating network.	
Carry out preliminary overheating risk assessment using the Good Homes Alliance overheating checklist.	
Carry out initial PHPP model.	
For projects using Passivhaus certification this is a good time to consider an appointment.	

Use this checklist to help achieve the KPIs. It includes actions that should be carried out in addition to those that designers are used to carrying out.

Key

- Ultra-low energy buildings
- Embodied carbon
- Energy use and efficient heating
- Renewable energy
- Overheating
- Water demand
- Measurement and verification

RIBA Stage 3 - Spatial Coordination	✓
Review mark-up of insulation line on all plans and sections and carry out initial U-value calculations.	
Carry out heating options appraisal including a low carbon option.	
Hold a thermal bridge workshop. Include the structural engineer for review of columns, masonry support etc.	
Provide MVHR layout including duct distribution and measurement of intake and exhaust duct lengths to external walls for sample dwellings.	
Carry out full embodied carbon assessment of whole building and compare against embodied carbon target. Implement reductions where necessary.	
MEP consultant to review embodied carbon impact of services and reduce the amount of kit where possible. Use CIBSE TM65 embodied carbon in building services to assess impact.	
Carry out PHPP modelling alongside SAP/SBEM calculations. List all model assumptions including U-values, thermal bridges and system specifications etc.	
Carry out overheating assessment and eliminate overheating through passive strategies where possible (TM59 & TM52). Ensure all element assumptions match PHPP and SAP/SBEM models.	
Calculate electricity generation intensity of PV arrays and review against KPI.	
Define airtightness strategy and identify airtightness line on plans and sections.	
Measure heating and hot water pipe lengths for sample dwellings. Minimise distribution or standing losses.	
Demonstrate distribution losses have been calculated and reduced.	
Prepare RIBA Stage 3 report and include predicted operational cost to tenant and LLDC.	

RIBA Stage 3+ - Early Technical Design (and tender)	✓
Detail build-ups of all external elements including thickness and conductivity of all materials.	
Detailed U-value calculations (including masonry support system, etc.).	
Identification of all thermal bridge junction types (e.g. parapet A, parapet B).	
Thermal bridge calculations for a selection of the most important junctions.	
Definition of airtightness testing requirements for contractor.	
Include requirements for Environmental Product Declarations (EPD) in the tender. Make EPDs obligatory for structural materials, primary façade and any other major materials.	
Include KPI requirements in the tender.	
Agree scope of Post-Occupancy Evaluation in tender. Identify level of participation from contractor and design team.	

RIBA Stage 4 - Technical Design (in addition to Stage 3+)	✓
Develop junction details for window and doors.	
Review airtightness line on each drawing and identification of airtightness requirements for service penetrations.	
Carry out a thermal bridge workshop to review thermal bridge lengths and calculate Psi-values for all junctions.	
Review MVHR layout including duct distribution and measurement of length of intake and exhaust ducts for all homes.	
Measure heating and hot water pipe lengths for all communal areas and homes.	
Carry out embodied carbon assessment of whole building using accurate Bills of Quantities.	
Specify high performing PV panels.	

RIBA Stage 5 - Manufacturing and Construction	✓
Run an introduction to ultra-low energy construction workshop on-site.	
Encourage site manager and team training on construction quality requirements covering insulation and airtightness.	
Prepare toolbox talk information for site team inductions on low energy construction quality.	
Review alternative materials or products proposed by the contractor. Ensure substitutions do not compromise the thermal performance or embodied carbon target.	
Carry out regular construction quality assurance site visits and reports (depending on the size of the scheme – at least six) in tandem with regular visits.	
Develop site quality tracker, assess against KPIs and update regularly.	
Require leak finding airtightness tests at first fix and second airtightness test pre-completion.	
Witness commissioning of MVHR systems and heating system.	
Carry out predicted in-use energy model of each building leading to the final 'as built' PHPP model.	
Consider recalculating embodied carbon using 'as built' information.	

RIBA Stage 6 - Handover	✓
Provide building and operational information to residents in the form of site inductions and simple building user guides and instructions (e.g. sticker on MVHR for filter replacement).	
Consider embodied carbon as part of the replacement and maintenance strategy and include in the O&M manual.	
Carry out post-occupancy evaluation during first 5 years of use and verify KPIs have been met.	
Lessons learnt project review with LLDC team.	
Publicly report KPIs.	

Space heating demand

15 kWh/m².yr

Ultra-low energy buildings

Follow the ultra-low energy design guidance to achieve the space heating demand target. Make informed decisions at an early stage in the design to significantly reduce the space heating demand and target ultra-low energy design. This is applicable to residential and non-residential buildings.

Energy Use Intensity

35 kWh/m^2.yr

Report Energy Use Intensity and compare

Report kWh/m^2.yr

35 kWh/m2.yr

Energy use and efficient heating*

Where there is potential to have a low carbon on-site solution, aim to meet the energy use intensity target of 35 kWh/m^2.yr for residential buildings. Carry out a heating options appraisal and follow design guidance to minimise distribution and standing loses.

** The Energy Use Intensity target cannot be met inside the district heating network concession area but should be reported and compared against this baseline. A baseline of 55kWh/m^2.yr should be targeted for non-residential.*

Modelling for compliance

TM59 & 52

Overheating

Where energy efficiency is improved and as the climate changes there is a greater risk of overheating in buildings. Follow the overheating design guidance and carry out dynamic thermal modelling pre-planning to significantly reduce the risk of overheating.

Embodied carbon benchmark

500 $kgCO_2e/m^2.yr$

Embodied carbon

Embodied carbon refers to the greenhouse gas emissions associated with the manufacture, transport, construction, repair, maintenance, replacement and deconstruction of all building elements. Follow the embodied carbon guidance relating to the architectural, structural and MEP design from an early stage in order to significantly reduce the embodied carbon emissions associated with materials and building design.

Electricity generation intensity

120 kWh/m^2_{fp}

Renewable energy

Follow renewable energy guidance to maximise electricity generation of PV on-site. Consider the roof design and building orientation at concept stage to optimise roof form. Even if PV arrays cannot be installed initially this will make developments ready for future installation. The energy generation intensity on site should equals the total predicted energy use to achieve a zero carbon balance.

Best practice water standards

AECB

Water demand

Follow design guidance and AECB good practice water standards to improve efficiency and minimise distribution losses.

Collect data in-use for first 5 years

KPIs in-use

Measurement and verification

Measure and verify the design against the completed building to help highlight what environmental strategies have had the greatest impact on energy consumption, and occupant comfort and satisfaction.

New buildings

LLDC KPIs Preparing for a 1.5°C future

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