Energy Use

Energy Use Overview

In this section

This section will detail:

1 / How to approach energy efficiency + renewable energy generation on your project

2 / Alternative low carbon heating and cooling systems

3 / How ‘passive design’ can help your project

4 / How to set and report robust energy targets

5 / Why lifecycle carbon + cost calculations matter

Executive summary

> Renewable generation using photo voltaic (PV) panels is complicated and should not be over-relied on to reach net zero. Reducing energy demand is critical and will reduce the size of the PV array.

> There are a range of alternatives to gas heating which are far more sustainable, and can lower the demand on the national grid at peak times. However the difference in gas and electicity pricing means that efforts to reduce the heating demand are essential to maintaining low running costs.

> The RIBA and LETI provide accessible, achievable energy use targets for different building typologies that can help guide projects from the outset.

> Lifetime cost and carbon analysis is valuable in helping place design and construction choices in context, and determining where the best value lies.

Introduction

Herefordshire Council declared a climate emergency on 8 March 2019. Following this the council committed to becoming carbon neutral and nature rich by 2030/31, launching a Carbon Management Plan with an interim target for a 75% reduction by 2025/26.

Carbon emissions from energy use have reduced due to reductions in demand and the national decarbonisation of the electricity supply. In 2020 over 42% of the UK's grid electricity came from renewable energy *(Energy Savings Trust)*. However there has been less progress in reducing these emissions in relation to gas consumption. The Climate Change Committee (CCC) has advised of the need to eliminate gas from new developments and in response the Government has outlined in the Future Homes Standard that fossil fuel heating, such as gas boilers cannot be installed in new build projects from 2025 onwards. Renewable energy will soon become our only option.

The previous chapter covered the first two steps in the energy hierarchy; to reduce the need for energy and improve energy efficiency. This chapter discusses renewable energy, the next and final step in the energy hierarchy and supports Core Strategy policies SD1, SD2, SS6 and SS7. Core Stratgy policy SS6 requires development proposals to take an integrated approach to environmental components, including renewable energy with the potential for renewable energy generation to be considered from the outset. As set out in Core Strategy policy SD1 development must take into consideration the efficient use of land to enable this, with Core Strategy policy SD2 focussing on renewable and low carbon energy generation and the requirement for efficient connection to the grid without significant detrimental impact upon the landscape character. Ultimately and as set out in SS7 climate change must be addressed and developments must be designed to reduce carbon emissions.

This chapter begins by revisiting the energy hierarchy, followed by an explanation of what is meant by renewable energy. The options for on-site energy generation are discussed, along with the renewable and low energy options available for heating and replacement for the traditional gas boiler, both small scale and at district level. A brief overview of current energy targets follows, set by various UK bodies looking to ensure the UK ends its contribution to global warming by 2050 and achieves net zero targets. The chapter concludes with a description of assessments that enable a developments carbon impact to be analysed and how this can inform the design of a development at the early stages.

Policies

- Policy SS6 Environmental quality & local distinctiveness
- Policy SS7 Addressing climate change
- Policy SD1 Sustainable design and energy efficiency
- Policy SD2 Renewable and low carbon energy

Further Information

- Energy Saving Trust: How can renewable energy help the UK reach net zero?

Energy efficiency and hierarchy in buildings

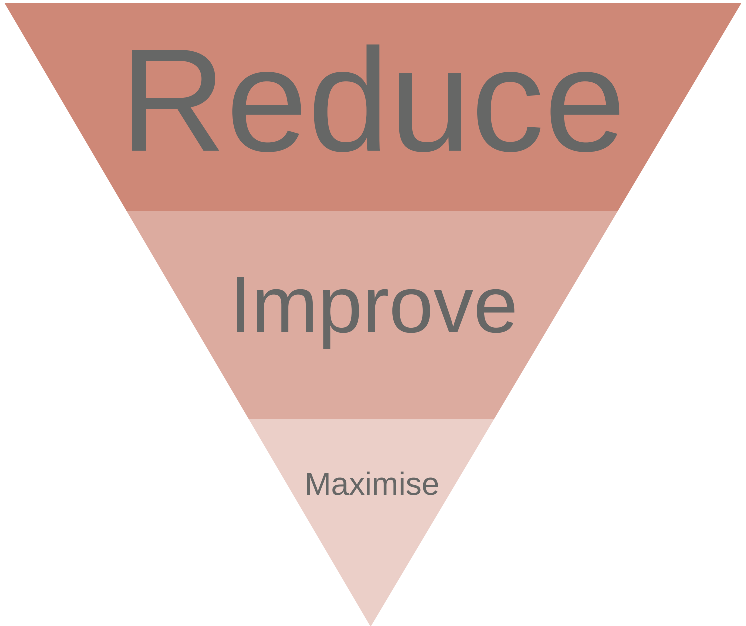
This is a series of steps that minimise the energy consumption in a building.

The energy hierarchy:

1. **Reduce** the need for energy - through passive design measures including form, orientation and fabric.
2. **Improve** energy efficiency - install energy efficient mechanical and electrical systems, including heat pumps, heat recovery ventilation, LED lights, fittings and appliances.
3. **Maximise** renewable energy - through decentralised sources, including on-site generation, community-led initiatives and low and zero carbon technologies.

The first and second steps of the energy hierarchy are to reduce the need for energy through passive design measures and to improve energy efficiency which has been the main focus of the previous chapter. Once the demand has been reduced the next step is to supply energy to the building efficiently and by low carbon and renewable means.

In order to achieve a Zero Carbon development a combined approach to steps one, two and three of the hierarchy will be required, although the emphasis must always be on step one and minimising energy consumption.



38 **Image 38**:
The Energy Hierarchy

Integration of renewables for energy generation

Renewable energy is created from natural sources or processes that are constantly replenished, such as sunlight and wind. Low carbon or zero carbon energy is whereby energy is generated and emits low levels or zero carbon dioxide, such as nuclear power.

Net zero challenges with renewables: The ultimate goal to adding renewables on site is to generate as much energy as your use, this balance between use and generation is often referred to as 'Net Zero Carbon in Operation'. A building designed to use less energy will therefore need less renewable energy generation on site.

However, this approach can be more complicated if looking to achieve a truly new zero development

1. Due to daily and seasonal differences in when renewable energy is generated, and when it is used, and
2. Due to renewable energy generation having an embodied carbon associated that is usually omitted from the renewables calculation.

To achieve true net zero these must also be factored into the amount of renewable installed.

There are a number of methods of electricity generation, but those most feasible for onsite generation are photovoltaic (PV) solar panels or tiles and wind generation. For both the early design decisions regarding site context, building form and orientation are important in establishing the efficiency of the installation.

PV systems are described in terms of the amount of power they generate (kWp). The orientation and angle of installation has an impact on the solar collection efficiency, with a directly south facing 30-40 degree pitch achieving maximum efficiency.

A drop in efficiency will require an increase in panels to achieve the same energy generation.

39 **Image 39**:
PV panels, Beacon View, Architype

In some instances where visual impact must be considered, such as in conservation areas a large array may be deemed inappropriate. In these instances PV tiles, recessed panels or installation on ancillary buildings may instead be possible.

If the building has been designed with a low energy demand, for example a Passivhaus building the number of PV panels required to match the consumption and allowances for embodied energy and seasonal differences should be achievable within the roof area.

Studies show that building to less stringent targets can mean onsite renewables cannot meet the energy demands and alternative options such as funding offsite generation may need to be investigated.

Small-scale wind generation is often considered a less viable solution than PV installation and so in the main wind generation is only considered on larger developments where large scale generation can be installed. Site context is important in deciding whether wind generation is viable, for the siting of the turbines themselves and if the conditions as well as the local context are suitable. Average wind speeds, required separation distances from neighbours, grid connection, site access and environmental and/or landscape designations all need to be considered.

It is acknowledged that the suitability of technologies may change over time and new technologies may also be developed.

Orientation Chart showing output for different orientation and tilt angles (% of maximum)																			
Tilt (°)	West								South									East	
	90	80	70	60	50	40	30	20	10	0	10	20	30	40	50	60	70	80	90
0	87	88	90	91	92	92	93	93	93	93	93	93	92	92	91	90	89	87	86
10	84	87	90	92	94	95	95	96	96	97	97	96	95	94	93	91	89	87	84
20	82	85	90	93	94	96	97	98	99	99	98	97	96	95	93	91	88	84	81
30	78	83	87	91	93	96	97	98	99	100	98	97	96	95	93	89	85	81	78
40	75	79	84	87	92	94	95	96	96	96	96	95	94	92	90	86	82	77	72
50	70	74	79	83	87	90	91	93	94	94	94	93	91	88	83	80	76	73	70
60	65	69	73	77	80	83	86	87	87	87	88	87	85	82	78	74	71	67	63
70	59	63	66	70	72	75	78	79	79	79	79	79	78	75	72	68	64	61	56
80	50	56	60	64	66	68	69	70	71	72	72	71	70	67	66	60	57	54	50
90	41	49	54	58	59	60	61	61	63	65	65	63	62	59	60	52	50	47	44

Image 40:
40 UK Solar Orientation Chart from PVNI.org.uk

Low carbon heating and cooling systems

The heating demand of buildings currently accounts for more than 40% of UK energy consumption *(LETI)* with the majority still coming from fossil fuelled natural gas. This will change when natural gas boilers can no longer be installed from 2025.

In applying the first two steps of the energy hierarchy, reducing the need for energy and improving energy efficiency the amount of heat actually needed will also reduce. All electric solutions seem a possibility, as they are readily available and can provide an approach to net zero due to the decarbonisation of the grid.

However, if we were all to take this approach the demand would soon outweigh the supply capacity, with other large sectors such as transport also reliant on access to renewable energy sources, with fewer other opportunities available.

The UK government has also committed to making the cost of electricity more competitive vs gas, however currently electricity is four times more expensive than gas and so switching directly to electric heating without reducing consumption will drastically increase energy bills. Other heating options need to be considered although selection of these will need to be carefully considered and likely require specialist input.

Solar thermal

how it works: Solar thermal panels use the suns energy to directly heat up water, offsetting the carbon emissions due to gas water heating. The heat from the sun is absorbed through the panel, called collectors. The heated water or heat transfer fluid then runs to a hot water cylinder or thermal store, with a boiler or immersion heater often used to heat the water further if needed.

41 **Image 41**:
Rooftop Solar Thermal Panels at Wahroonga

considerations: Although they have low maintenance costs, solar thermal panels do not offer a solution for heating a building and rarely a complete solution for the hot water system (as they are less effective during the winter months) and for this reason other solutions are deemed more favourable.

Hydrogen The development of hydrogen boilers as an alternative to a gas boilers is still in development. The Government 10-point plan for a green industrial revolution puts investment in low carbon hydrogen high on its agenda, aiming to develop capacity to power 1.5 million homes by 2030. Producing hydrogen at a scale to decarbonise heating is not simple; hydrogen is currently expensive to produce (although costs are expected to fall) and currently it is not low carbon.

how it works: Hydrogen produced from natural gas contains no carbon itself, but carbon is given off in the process. That carbon must be captured and stored indefinitely for use as a low carbon gas ('blue' hydrogen). It is also possible to produce low carbon 'green' hydrogen through a process called electrolysis, using renewable electricity to extract hydrogen from water.

However, the renewable capacity requirements would be huge to produce enough 'green' hydrogen to replace all existing natural gas boilers.

considerations: Current thinking is that hydrogen could be used in areas where electrification will be difficult.

In some respects the switch from gas boilers to hydrogen could be straightforward with gas boilers replaced with hydrogen with the infrastructure to supply hydrogen in place, but as yet there is no precedent for changing a gas grid to hydrogen.

Heat Pumps (Low Carbon Heating Solutions)
There are a number of heat pump solutions as set out below. To coincide with the decarbonisation of new developments from 2025 and regulations updated to require low carbon heating solutions instead, it is likely that heat pumps will become commonplace on most, if not all new developments.

Air Source Heat Pumps (ASHP)
how it works: ASHP's absorb heat from the outside air to heat the building and provide hot water. They are able to extract heat during temperatures as low as minus 15 degrees. An ASHP does need electricity for power, but as they are extracting heat from the external environment the heat input is greater than the electrical and therefore renewable. The ratio of electrical energy needed to power the pump to the amount of energy produced for the building is called the Coefficient of Performance (CoP).

Higher CoPs equate to higher efficiency, lower energy (power) consumption and thus lower o perating costs. An ASHP replace gas energy and can be used to heat the building and hot water. As an ASHP is subject to fluctuating temperatures during the winter months it will use more electricity as it works harder to produce heat.

considerations: The positioning of the ASHP needs to be considered as they can have a negative visual impact as well as creating a modest amount of noise. Different ASHP require slightly different installation requirements and locations, but all should be located away from opening windows a nd doors and sewer systems. Manufacturer's state required clearance distances from the unit, but if these are met the pump can be screened to minimise visual impact. The external unit is then connected to a thermal store containing a heat exchanger and sometimes an electrical heating element which allows the heated water to be stored until it is needed.

Image 42:
42 ASHP. Image Source: Nu-Heat.

There are 2 types of ASHP air-to-water and air-to-air, the first being the most common in the UK.

Exhaust Air Heat Pumps (EAHP)

how it works: EAHP's combines the functions of an ASHP with those of a mechanical ventilation heat recovery system.

The technology uses the wasted warm stale air found in areas such as bathrooms and kitchens, and transfers the air through a series of ducts which run within the walls and floor. They comprise of a hot water cylinder, heating coil, extract fan, and a heat pump.

considerations: An exhaust air heat pump unit can also work alongside a standard air source heat pump, providing hot water storage and hot water production at times when the air source heat pump unit is not required for heating, usually during the summer months. These systems are generally suited to smaller buildings, for example flats where the heating requirement is low and there is not available space externally for an ASHP.

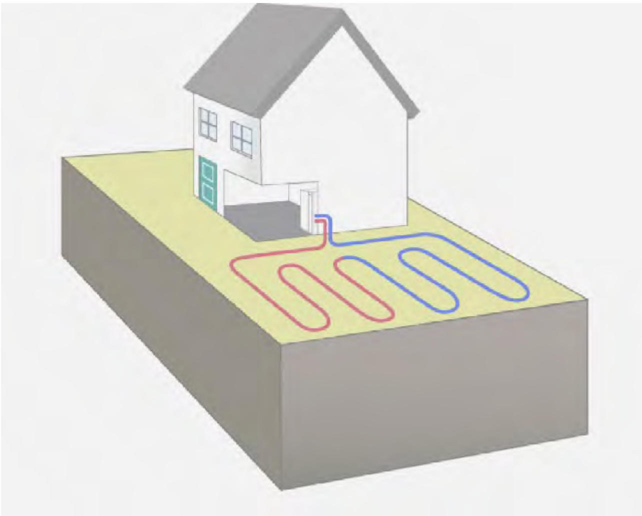
Ground Source Heat Pumps (GSHP)

how it works: GSHP's use pipes that are buried underground to extract heat from the ground for space heating and hot water.

A mix of water and antifreeze is circulated around the pipe work, called a ground loop, which is buried in the ground external to the building. The heat from the ground is then absorbed into the fluid which then passes through a heat exchanger and into a heat pump. The length of the loop is dependent on the size of the building to be heated but is typically around 1m below the surface.

Alternatively vertical boreholes can be drilled typically between 90 and 160m if clear space is limited.

considerations: An advantage of a GSHP is the consistency of ground temperature, allowing this system to be used throughout the year and be unaffected by external changes in temperature. As with an ASHP electricity is required to run the system but the heat extracted is constantly being renewed.



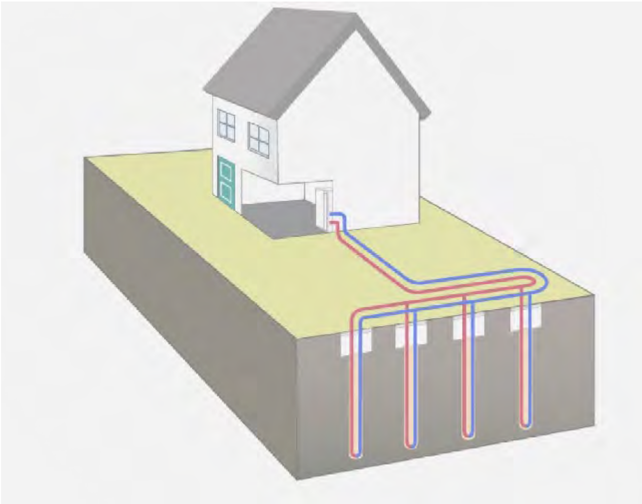


Image 43:
Ground Loop and Bore Hole GSHP.
Image source: Nu-Heat

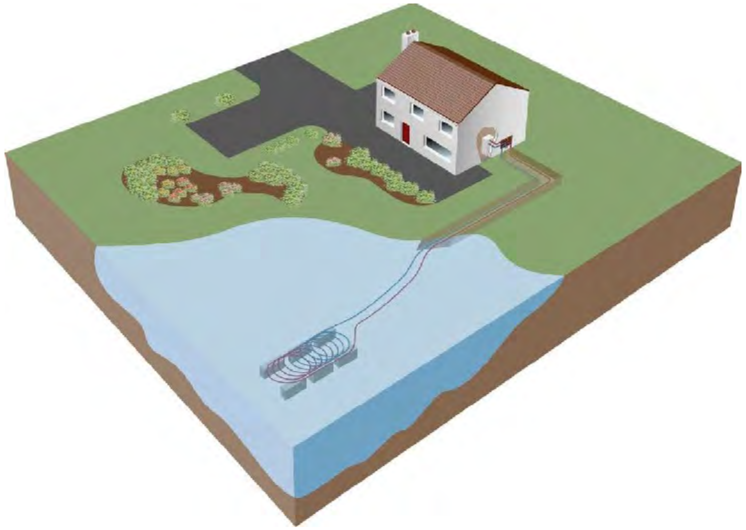


Image 44: https://www.treco.co.uk/news/article/systems-approach-installing-biomass-boiler

Water Source Heat Pumps (WSHP)

how it works: WSHP's work on a similar principle to GSHP's whereby heat is extracted from a body of water and converted into useful heat for space heating and hot water. A series of submerged pipes containing a working fluid absorb the heat from a river, lake, large pond or borehole. This fluid is then compressed so that emits the heat at a higher temperature.

considerations: WSHP's require a specific set of requirements and so for this reason are infrequently used. Only certain bodies of water can be utilised, to avoid the temperature of natural water courses and features increasing. There also needs to be a substantial volume of water available to limit water temperatures increasing, which would reduce the efficiency of the system.

In 2015, the UK government drafted a map for water source heat pump suitability, recommending that urban areas on fast-flowing rivers were the most suited for this technology and that it would be more suited to larger scale development.

Biomass

how it works: There are two main types of fuel used to fuel a biomass boiler, biodiesel and wood pellet. Either of these fuels may be referred to as bioheat, they are both renewable forms of fuel.

Biodiesel is made out of animal fat, and oils. These fuels can be made very quickly, and are biodegradable.

considerations: The scale of the biomass requirement depends on the size of the building, with even a private dwelling requiring the space equivalent to a single garage for storage of fuel and the unit itself. Delivery and the position of the flue also needs to be considered and for these reasons biomass is rarely considered appropriate on sites where space is limited.

Best Practice Recommendations

- No onsite combustion of fossil fuel for new development.
- All development shall assess the viability of onsite renewable generation and design a strategy to maximise storage.
- Major development shall match total energy demand through a combination of renewable energy generation capacity, energy storage and smart controls.

Further Information

- Energy Saving Trust

In addition, while biomass itself is considered renewable, the fuel is often transported long distances on lorries that emit carbon and burning t he fuel itself also emits carbon so is it is unclear if this will remain to be considered as a low carbon heating option. The availability of heat pumps and prioritising an electricity led heat source that benefits from grid de-carbonisation has also lead to biomass being a less viable option.

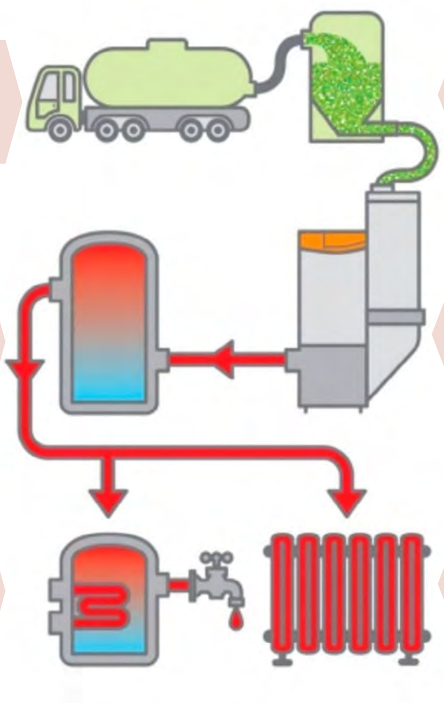


Image 45:
45 https://www.treco.co.uk/news/article/systems-approach-installing-biomass-bo

District approach to energy provision

A district heating scheme provides heat from a central source and distributes it to multiple buildings. Combined Heat and Power (CHP) is a technology that produces electricity close to the point of use and captures the waste heat that is normally lost to provide heating, hot water and sometimes cooling.

There are a number of options when considering a centralised approach to heating along with pros and cons for having a central energy centre or using an individual building strategy. Ultimately the suitability needs to be decided on a site by site basis, with the distance from the energy source and subsequent distribution losses a key driver. Design of these networks should achieve best practice standards of the ADE and CIBSE Code of Practice for Heat Networks.

Large scale renewable energy installations adjacent to new development could also be considered, for example solar arrays linked to battery storage and electric vehicle charging provision to create a smart grid to energy infrastructure.

Further Information

- ADE and CIBSE Code of Practice for Heat Networks

Energy Targets

In 2019 the UK Government passed a law to require the UK to end its contribution to global warming by 2050 by bringing all greenhouse gas emissions to net zero. With the built environment contributing significantly to these emissions it is important that industry targets are set to ensure that the net zero is met and in advance of this regulation.

UK bodies RIBA (Royal Institute of British Architects), the UKGBC (UK Green Building Council) and LETI (London's Energy Transformation Initiative) have issued voluntary performance targets that cover a number of areas such as operational energy use, water use, low carbon energy and embodied carbon aiming to achieve the significant reductions necessary by 2030 in order to have a realistic prospect of achieving net zero carbon for all UK buildings by 2050.

A review of these has led to a set of Best Practice targets for development to be included within this document. To understand these targets requires an understanding of the terminology used and how this equates to the building performance.

Operational energy is the energy consumed by a building associated with heating, hot water, cooling, ventilation, and lighting systems, as well as equipment such as fridges, washing machines, TVs, computers, lifts, and cooking.

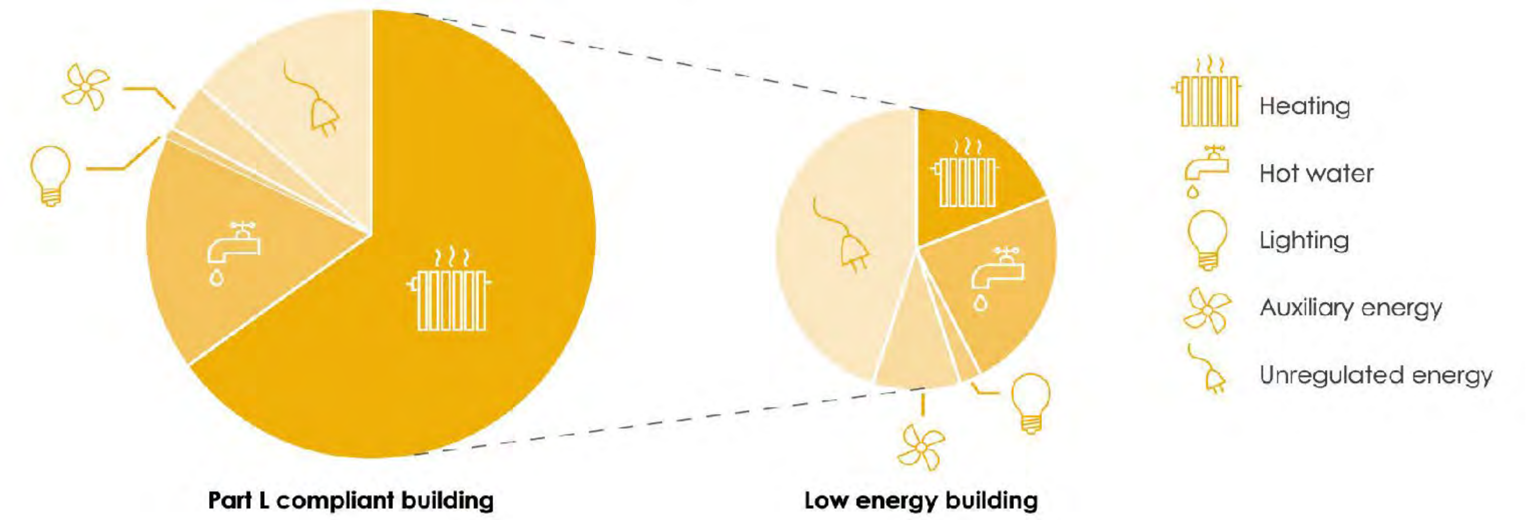


Image 46:
46 LETI Best Practice Residential Energy Breakdown

	Office	Residential	Education
2025 RIBA Target	< 75 kWh/ m²/year	< 60 kWh/ m²/year	< 70 kWh/ m²/year
2030 RIBA Target	< 55 kWh/ m²/year	< 35 kWh/ m²/year	< 60 kWh/ m²/year

47 **Image 47**: RIBA 2030 climate challenge operational energy targets (Targets based on GIA. Figures include regulated & unregulated energy consumption irrespective of source (grid/ renewables)).

Operational carbon is the carbon dioxide and greenhouse gases which are emitted as a result o f the above factors. It has a direct and consistent environmental impact throughout the life of a building and can account for between 40% and 65% of the total life cycle emissions.

How to reduce energy use: The simplest and most effective way to reduce carbon in operation is to lower the amount of energy required in the building. Passivhaus is a design approach that e nables this. Using a fabric first approach and a focus on efficient servicing it is possible to reduce the energy loading and in turn the carbon emissions of a building by around 80%.

The RIBA 2030 climate challenge operational energy targets listed above and the Passivhaus and LETI target of under 15 kWh/m²/year for heating demand only provide achievable goals for lower energy use and lower operational emissions. It is important to commit to these targets from the outset and ensure that design decisions reflect them.

LETI have also published indicative design measures for building typologies which if applied should help achieve these energy targets.

Creating a low energy or Passivhaus building changes the energy breakdown of a building. Where traditional buildings have a large portion of the energy use attributed to the heating and cooling of the space, energy efficient buildings have a more even distribution of energy loading in an overall smaller total use figure. The diagram on the previous page shows LETI's best practice outcomes and distribution of energy use across the building.

Achieving net zero in operation requires not only a reduction in energy demand, but relies on the decarbonisation of the grid and a form of onsite renewables to balance the remaining carbon emissions. Though challenging, this is achievable with close monitoring of the buildings energy and carbon emission from the outset of the design.

The following LETI performance standards set the Best Practice targets for renewable PV energy generation on-site:

- Small scale residential: Generate 100% of annual energy requirement on-site
- Medium and large scale residential: Cover 70% of roof area
- Offices: Generate the annual energy requirement for at least two floors of the development on-site
- Schools: Cover 70% of the roof area

Along with this, attention should be given to reducing the embodied carbon, which was discussed at the end of the previous chapter along with the Best Practice targets.

In summary to achieve Net Zero targets for development the following actions are required:

- A Reduction in Operation Emissions
- Decarbonisation of the Grid
- On-site Renewables
- Reduced Embodied Emissions

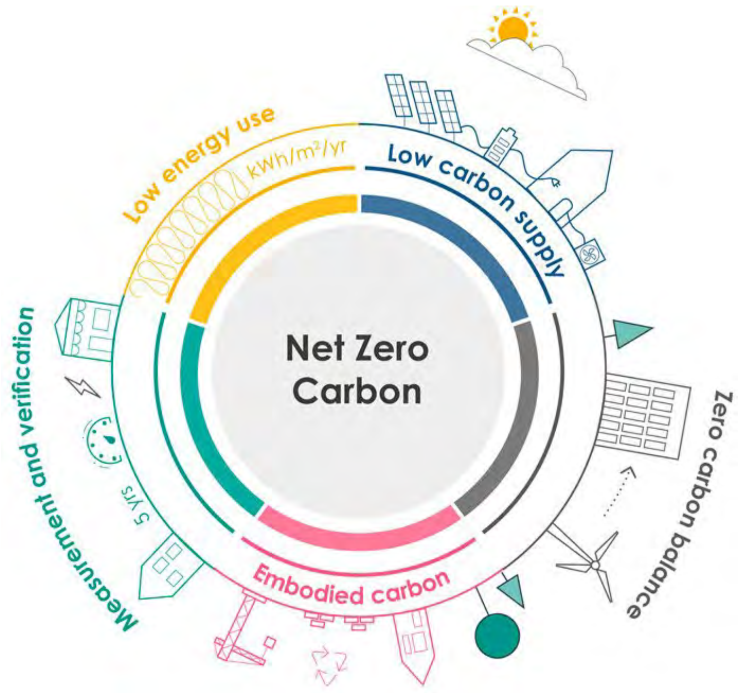


Image 48:
48 LETI: Key Requirements for New Buildings to achieve Net Zero Carbon

Further Information

- LETI Climate Emergency Design Guide: How new buildings can meet UK climate change targets
- LETI Net Zero 1-Pager

Best Practice Recommendations

- Compliance of the evaluation of operational energy shall be demonstrated through performance methods such as the Passivhaus Planning Package (PHPP), CIBSE TM54 or Better Buildings Partnership Design for Performance (2019).
- Offset remaining carbon emissions by contributing to renewable energy projects that will help facilitate decarbonising the national and/or local grid. Alternatively, offset through investment in a retrofit programme, requiring certification to Passivhaus EnerPHit or another agreed target.

Robust targets are a key tool in delivering a true net zero building.

The Royal Institute of British Architects (RIBA) has developed a set of voluntary targets for operational energy, water use and embodied carbon. A set of core health and wellbeing metrics are also included and can be seen on page 44 of this SPD. These targets form the basis of the 2030 Climate Challenge and provide a stepped approach towards reaching net zero.

These targets have been developed in consultation with other UK construction bodies and provide an approach that will realise the significant reductions necessary by 2030 in order to achieve the Government target of net zero carbon for the whole UK building stock by 2050.

The RIBA Climate Challenge does not provide accreditation, instead performance targets to aim towards, many of which are included as best practice recommendations within this SPD. Ultimately the purpose of setting these targets as with those set out by LETI is to encourage us to take action now and not lock in poor performing buildings that will require expensive interventions later on.

The targets are set out to allow progression to the 2030 targets, with buildings today built to the 2025 targets as a minimum, with the aspiration that all should be designed to achieve the 2030 targets. A checklist has also been developed to aid the design process.

As highlighted in this SPD these targets should form the basis of any design and consequently are included as best practice recommendations throughout.

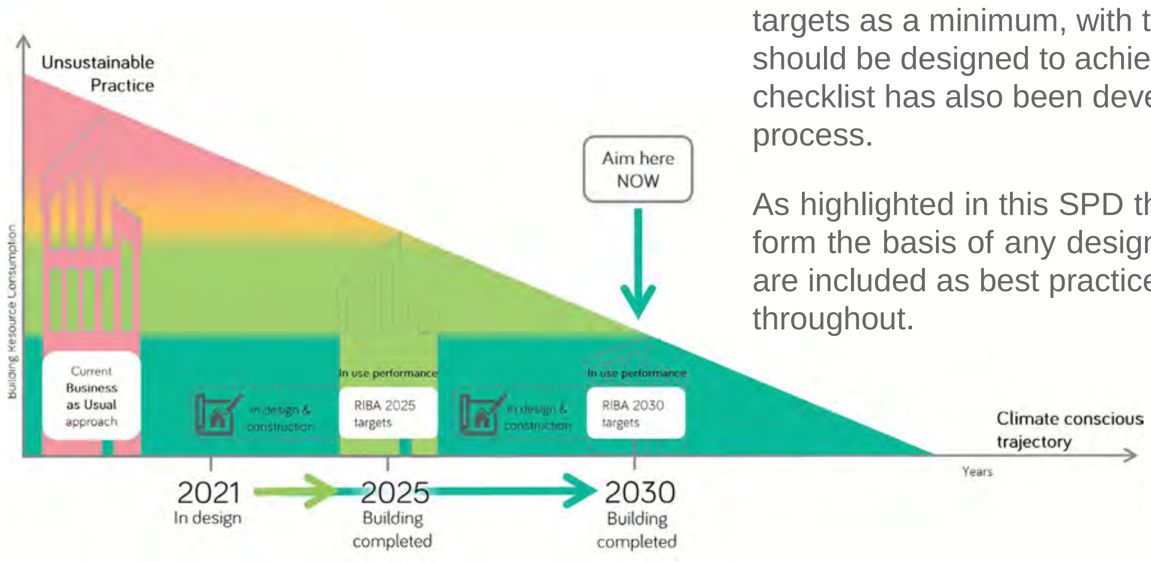


Image 49:
49 RIBA 2030 Climate Challenge as built target trajectories

Further Information

- RIBA 2030 Climate Challenge

Whole Life Cycle Carbon and Cost Assessments

Life Cycle Carbon Assessments look at the carbon emissions of a development and include an assessment of embodied carbon and operational carbon.

Life Cycle Cost Assessments look at the costs associated with the development and include the construction costs, through to maintenance and replacement costs as well as energy costs.

These studies particularly if completed at early design stages allow comparisons to be made between different construction approaches and standards, understanding the carbon and cost implications long term, allowing these to inform the design.

Assessing both upfront costs and those required for future maintenance, replacement etc often provides a convincing argument for the upfront investment in quality materials and achieving a higher energy performance.

Whole life carbon and cost assessments are recommended by leading advocates within

the sector including the RIBA and LETI, and are increasingly being written in as a policy requirement.

ECCOLAB

Image 50: 50 ECCOLAB by Architype

There are a number of assessment tools now available such as ECCOLAB, which may be used to assist this process.

Further Information

- ECCOLAB, web based decision support tool for design of low impact buildings

Best Practice Recommendations

EU1 No onsite combustion of fossil fuel for new development.

EU2 All development shall assess the viability of onsite renewable generation and design a strategy to maximise storage.

EU3 Major development shall match total energy demand through a combination of renewable energy generation capacity, energy storage and smart controls.

EU4 Compliance of the evaluation of operational energy shall be demonstrated through performance methods such as the Passivhaus Planning Package (PHPP), CIBSE TM54 or Better Buildings Partnership Design for Performance (2019).

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