Central Lincolnshire

Joint Strategic Planning Committee

Energy Efficiency Design Guide 2023

Central Lincolnshire
LOCAL PLAN

Project Information

Project Title: Central Lincolnshire Energy efficiency design guide
Project Number: 20-0095
Document title: Central Lincolnshire Energy Efficiency Design Guide 2023
Current Version: 03
Issue file-name: Central Lincs Design Guide DRAFT4.0 - 24.04.2023

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Document History

Version number	Date	Reason	Approved
01	05.10.2022	First draft issue to client	LK
02	21.10.2022	Second draft following client and partner feedback	LK
03	24.04.2023	Final draft following plan adoption and officer workshop	LK

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Contents

Introduction

- This guidance
- Energy efficiency design hierarchy
- How this guidance relates to local plan policy
- Routes to compliance
- Detailed officer guidance

The Energy Efficiency Design Guide

This document has been developed to provide practical, accessible guidance on how to comply with Central Lincolnshire Local Plan policy relating to energy efficiency in new buildings.

The guidance is aimed at building professionals (such as applicants, architects, and contractors) in designing buildings to meet best practice energy efficiency standards, and for planning officers to refer to when assessing applications for relevant policy compliance.

Which policies does this guide address?

- Policy S6: Design Principles for Efficient Buildings
- Policy S7: Reducing Energy Consumption - Residential Development
- Policy S8: Reducing Energy Consumption - Non-residential Buildings

How is the guide used to comply with policy?

This guide is paired with a Compliance Checklist document, which must be submitted with a planning application to evidence compliance with the policies above.

More detail on this can be found on page 8.

Navigating the guide

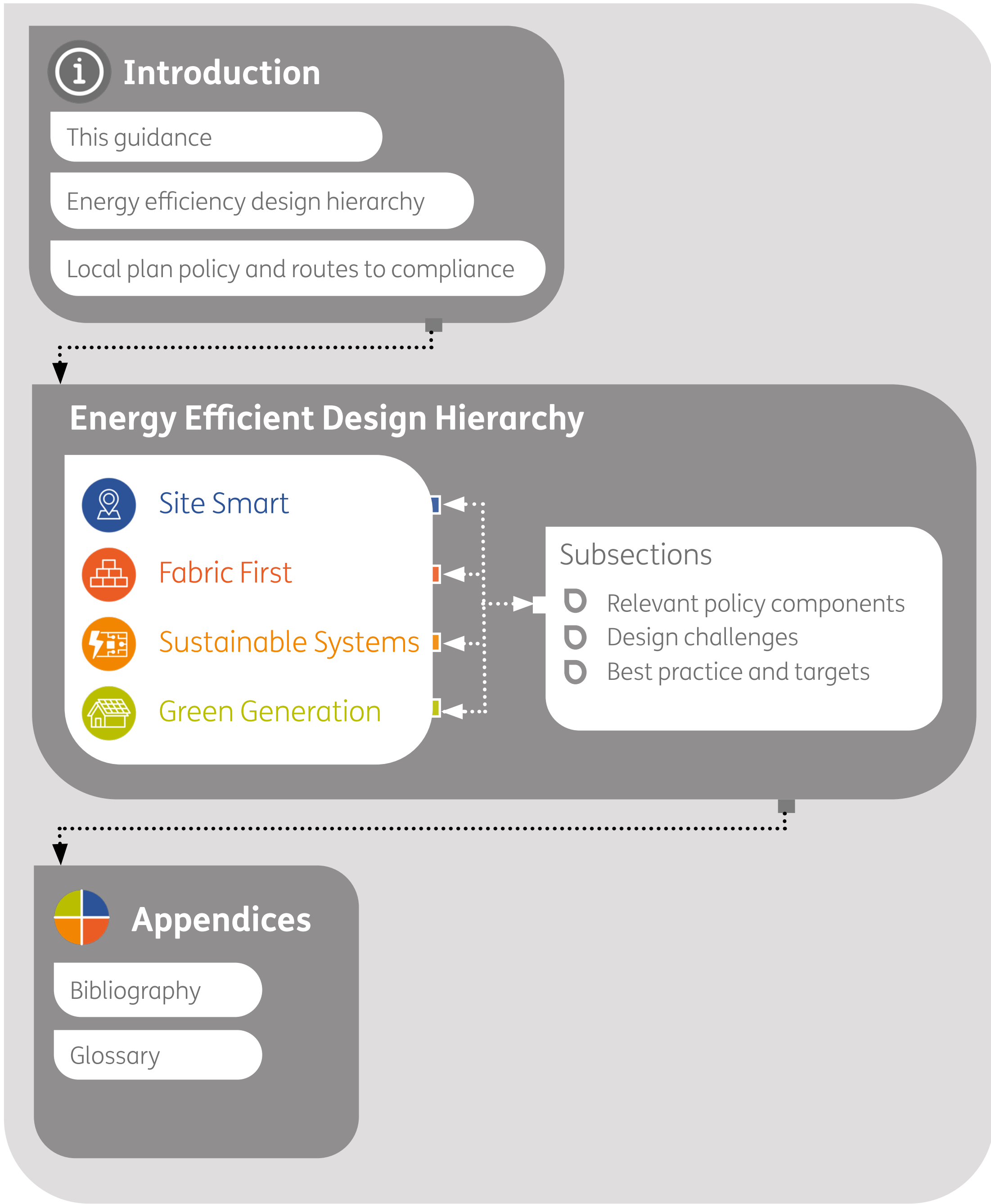
If viewing this guide as a PDF electronically, a series of hyperlinks can be used to navigate the document.

On the header of each page throughout the document, there are a series of icons. Each icon represents a different section within the guide.

Clicking on one of these icons will take you to the opening page of that section. You will know which section is currently being viewed by the colour of the header, which will match the icon.

Each section's opening page contains hyperlinks to four sub-sections (these are the same for each section). Clicking a link will take you to the respective sub-section.

Map of the guide



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Energy Efficiency Design Hierarchy

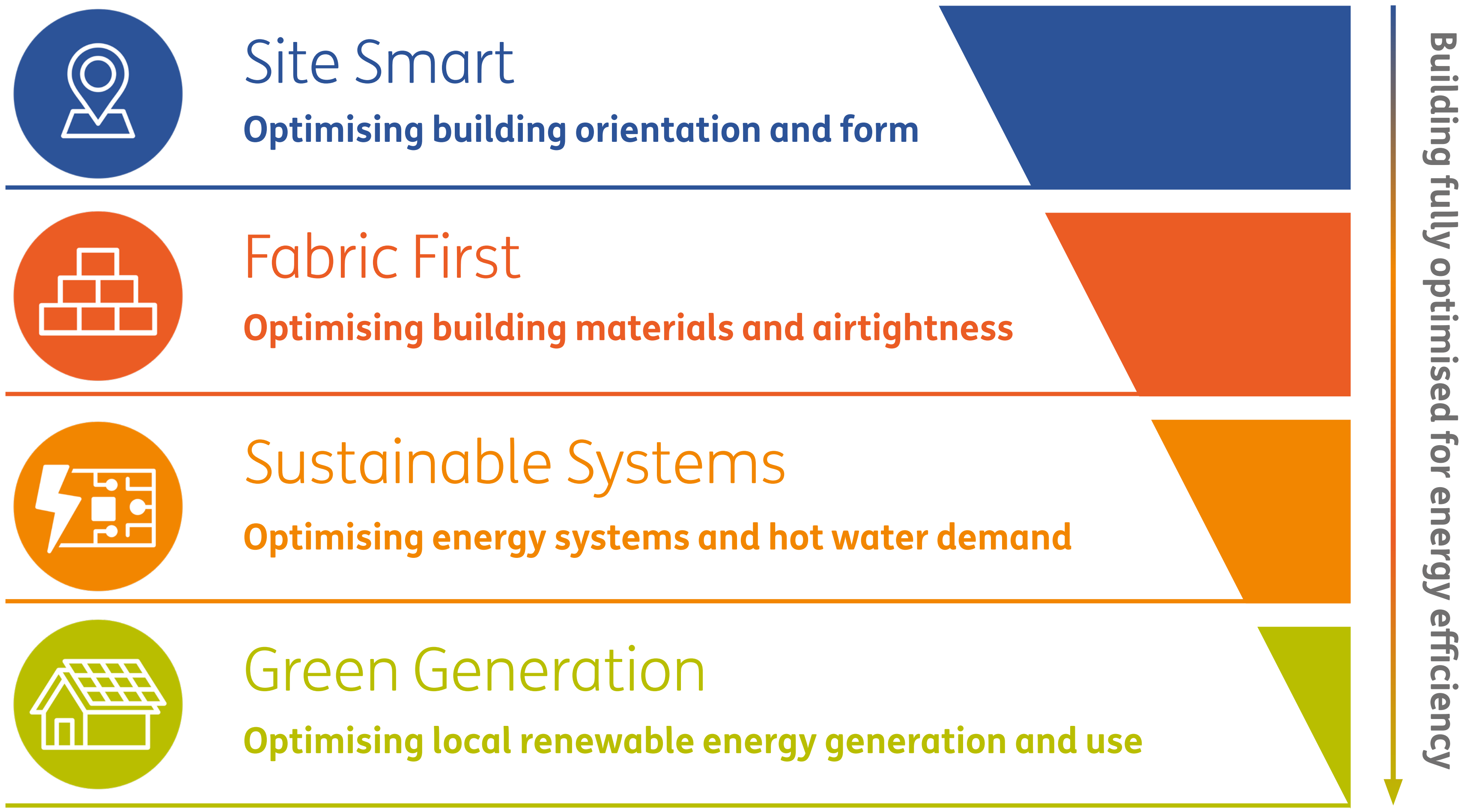
This guide divides energy efficient design into four themes that inform how to optimise energy efficiency within new buildings. Together, these themes form the 'energy efficient design hierarchy'.

The hierarchy broadly demonstrates the order in which design decisions should be made in order to effectively optimise the subsequent theme.

For example, a poor implementation of 'Site Smart', which involves optimising the orientation and form of a building for energy efficiency, will fundamentally limit how effective the material choices within 'Fabric First' can be, and so on.

Each of the themes forms a section within this guide, comprising of three sub-sections:

1. **'Relevant policy components** introduces how the section of the guide contributes to maximising energy efficiency, and which policies the section relates to
2. **'Design challenges'** builds upon the theme and explains the potential complications that may arise during the design process
3. **'Best practice'** provides examples of existing best practice relating to the section theme, and provides suggested targets to aid policy compliance. This section also sign-posts to the most relevant industry guidance



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How this guidance relates to local plan policy

The themes presented in this guide relate to the components of Local Plan Policy S6: Design Principles for Efficient Buildings.

Policy S6 acts as an overarching policy. The principles set out in Policy S6, when followed, help to achieve the overall building performance targets set out in Policies S7 and S8.

There are two routes to policy compliance, depending on the methodology chosen to model building performance - SAP or PHPP. These models are explained on page 6.

The decision trees on pages 7 & 8 further explain the routes for compliance, and outline the process of how to comply via either route.

Policy S6: Design Principles for Efficient Buildings

- **S6.1** Orientation of buildings
- **S6.2** Form of buildings
- **S6.3** Fabric of buildings
- **S6.4** Heat supply
- **S6.5** Renewable energy generated

Policy S7: Reducing Energy Consumption - Residential Development

S7.2 Space heating and total energy demand

Target space heating demand of ~15-20 kWh/m^2/yr, and total energy demand of 35 kWh/m^2/yr

No unit to have a total energy demand in excess of 60 kWh/m^2/yr

Policy S8: Reducing Energy Consumption - Non-residential

S8.2 Space heating and total energy demand

Target space heating demand of ~15-20 kWh/m^2/yr, and total energy demand of 70 kWh/m^2/yr

No unit to have a total energy demand in excess of 90 kWh/m^2/yr

S7.1 and S8.1 Renewable generation matching total energy demand

On-site renewable electricity generation meets the development's total energy demand

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SAP/RdSAP vs PHPP - A non-technical explanation

SAP Standard Assessment Procedure

What is SAP/RdSAP?

SAP (Standard Assessment Procedure) is the UK government's methodology for calculating the energy performance of homes. It is used to demonstrate compliance with Part L (Conservation of Fuel and Power) of the building regulations, and it is also used to generate Energy Performance Certificates (EPCs).

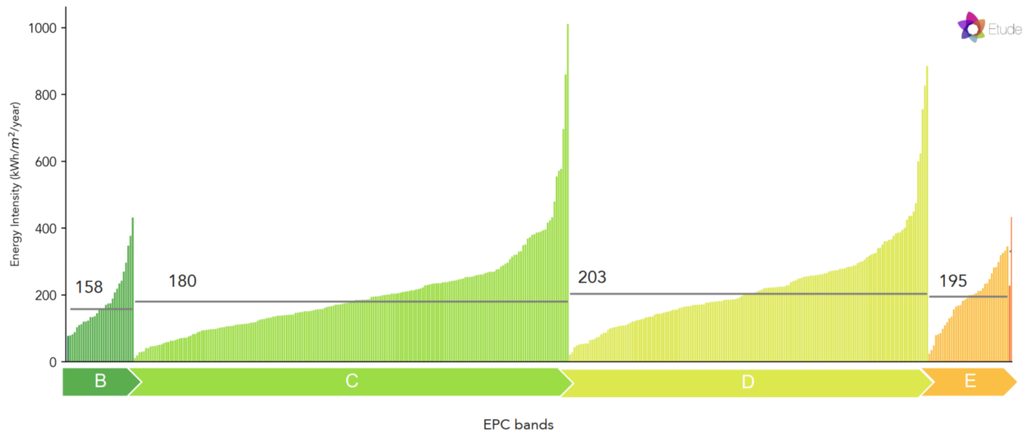
Reduced data SAP (RdSAP) was introduced as a lower cost method of assessing the energy performance of existing dwellings.

Benefits

- Quick and simple methodology which is well known across the industry
- Many inputs are simplified and utilise standard assumptions for consistency and speed
- SAP and RdSAP are compliance tools used to demonstrate building regulatory compliance
- Compares performance against an equivalent notional building, allowing comparison of some specific system values and building characteristics

Limitations of SAP/RdSAP in delivering net-zero carbon homes

- SAP/RdSAP does not accurately predict future energy use - Studies have shown that the relationship between EPC ratings and metered energy use is loose. A study carried out by Etude on 420 dwellings in London showed that there was only a 22% reduction in total average energy use from D to B ratings – much less than that predicted by SAP. (See figure below)
- SAP uses many standard assumptions - SAP is primarily a compliance tool, and as such relies on a lot of standard assumptions (e.g. a fixed geographical location). It cannot fully reflect the energy performance of the building.
- SAP does not reward energy efficient building forms - Outputs are based on a relative performance compared to the "notional building" of identical shape instead of an absolute performance level.
- SAP central outputs are out of date - The carbon intensity and unit cost of grid energy are changing year-on-year. Hence, the energy cost and carbon emission metrics of SAP are a poor reflection of reality. Using energy metrics and a zero-carbon definition based on energy balance, as proposed in Policy S7/S8 addresses this.



Credit: Central Lincolnshire Climate Change Evidence Base: Task G - Feasibility

PHPP Passive House Planning Package

What is PHPP?

PHPP (Passive House Planning Package) is the building energy modelling software used for designing low-energy Passive House buildings and to show compliance with the Passive House standard. It is a valuable design tool for all low-energy buildings, regardless of whether the Passive House standard is being pursued.

PHPP is created by the Passive House Institute who refine and update it regularly. PHPP is a series of interlinked spreadsheets, which can be run in Microsoft Excel or OpenOffice Calc. The outputs are based on energy – including total annual energy use, space heating demand, as well as peak heating and cooling loads.

Benefits

- Built around building physics principles and accurately predicts in-use energy performance (validated)
- Simple to use, with clear inputs offering flexibility and detail
- Can be used as a design tool from the earliest design stages
- Simpler route to policy compliance

Drawbacks

- Lengthier and necessarily more detailed process, requiring deeper engagement with the energy using building systems

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Routes to compliance decision tree - residential buildings

Applicant submits compliance checklist to officers for review → Has the applicant performed PHPP modelling?

Yes → PHPP route to compliance

No → SAP route to compliance

PHPP route to compliance

S7.2 Space heating

Is there an average space heating demand of 15-20kWh/m²/yr?

- Yes → **Compliant** with S6.1, S6.2 & S6.3
- No → Review site smart and passive design approach

S7.2 Total energy demand

Is there an average total energy demand of < 35 kWh/m²/yr?

- Yes → **Compliant** with S6.4 & S7.2
- No → Review heating system and system design approach

S7.1 Net-zero balance

Is the on-site renewable energy generation equal to/greater than the total energy demand?

- Yes → **Compliant** with Policy S6.5 & S7.1
- No → Review renewable energy system approach

Compliance demonstrated by applicant

Automatic compliance can't be granted, detailed officer review required

SAP route to compliance

Are the following design recommendations met?

Theme	Design element	Recommended specification
	Airtightness (m³/h/m²)	<1
	Ventilation system	MVHR, >=90% efficiency
	Walls (w/m².K)	<0.13
	Ground floor (w/m².K)	<=0.1
	Roof (w/m².K)	<=0.1
	Windows and doors (w/m².K)	0.8
	Heat supply system	Heat pump, < 45C flow temperature for space heating
	PV installed - 1 storey building	25% roof area
	PV installed - 2 storey building	50% roof area
	PV installed - 3 storey building	75% roof area
	PV installed - 4 storey building	Roof area for PV generation maximised

- Yes → **Automatic Compliance with Policy S6 & S7**
- No → **Automatic compliance can't be granted, detailed officer review required**

Routes to compliance decision tree - non-residential buildings

Design for performance (DfP) - refers to a package of industry standard modelling approaches which attempt to model actual building energy use. Compliant example methodologies includes:

- CIBSE TM54 (2022) - Evaluating operational energy use at the design stage
- NABERS - Design for Performance
- PHPP
- [Possibly upcoming] BEIS national performance-based framework

Applicant submits compliance checklist to officers for review

Has the applicant performed modelling using an established "design-for-performance" methodology?

Yes → **Design for Performance route to compliance**

S8.2 Space heating
Is there an average space heating demand of 15-20kWh/m²/yr?
- Yes → **Compliant** with S6.1, S6.2 & S6.3
- No → Review site smart and passive design approach

S8.2 Total energy demand
Is there an average total energy demand of < 70 kWh/m²/yr?
- Yes → **Compliant** with S6.4 & S8.2
- No → Review heating system and system design approach

S8.1 Net-zero balance
Is the on-site renewable energy generation equal to/greater than the total energy demand?
- Yes → **Compliant** with Policy S6.5 & S8.1
- No → Review renewable energy system approach

Automatic compliance can't be granted, detailed officer review required

Compliance demonstrated by applicant

No → **SAP route to compliance**

Are the following design recommendations met?

Theme	Design element	Recommended specification
Fabric	Airtightness (m³/h/m²)	<1
	Ventilation system	Mechanical ventilation with at least 85% heat recovery.
	Walls (w/m².K)	<0.15
	Ground floor (w/m².K)	<=0.1
	Roof (w/m².K)	<=0.1
	Windows and doors (w/m².K)	0.8
Heat supply	Heat supply system	Heat pump, < 45C flow temperature for space heating.
Renewables	PV installed - 1 storey building	50% roof area
	PV installed - 2 storey building	80% roof area
	PV installed - 3 storey + building	Roof area for PV generation maximised

- Yes → **Automatic Compliance with Policy S6 & S7**
- No → **Automatic compliance can't be granted, detailed officer review required**

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How proposals will be considered

This guidance document presents a clear approach to appraising the compliance of planning applications to Policies S6, S7 and S8, for applicants and officers.

Applicants are strongly encouraged to produce a PHPP model (or equivalent level design-for-performance model for non-residential buildings), as this provides a more robust approach to predicting the in-use energy performance of buildings (see following page for a detailed explanation).

This methodology encourages applicants to take a “design for performance” approach, prioritising technologies and interventions which deliver real-world environmental benefits, over a minimum compliance led design approach.

To make the process easier for applications for those taking this approach, the guidance has outlined two “rapid” routes for demonstrating compliance. If the requirements stipulated for these routes are met, then compliance with the policy is automatic. These routes (shown in the previous pages) are as follows:

1. **PHPP/Design-for-performance Compliance route** - If the applicant has undertaken PHPP (resi)/ “design-for-performance” (non-resi) design analysis, and shown a space heating demand around 15 - 20 kWh/m²/yr (both resi and non-resi), a total energy demand of < 35 kWh/m²/yr (resi) or <70 KwH/m²/yr (non-resi) and an equivalent annual generation from on-site renewable systems then automatic compliance is granted.
2. **SAP Compliance route** - If the applicant hasn’t undertaken PHPP/ “design-for-performance” modelling, it is more challenging for the officers to assess the likely real-world energy performance of a building. In this case, a recommended specification is provided. If the applicant designs and builds the systems to this specification it is reasonable to predict that the building will be highly energy efficient, and hence automatic policy compliance is granted.

If the applicant doesn’t meet automatic compliance, the officer needs to review in detail the applicants compliance checklist, and provide a judgement on whether the intentions of Policy S6, S7 and S8 have reasonably been met. This section provides additional guidance to officers in appraising these applications.

Residential application review guidance

Residential applications might not achieve automatic compliance for three reasons. In these cases, officers have some discretion in considering the level of policy compliance. The following approach is advised:

1. Space heating demand target exceeded - Excedence of the demand target suggests that either Site Smart or Fabric First measures suggested in the guide haven’t been implemented. However, it may be that for some units on the site, constraints mean that applicants struggle to achieve the efficient forms and orientation which can help limit demands.

   In the case of space heating demand exceeding 20 kWh/m2/yr, officers are advised that a degree of latitude is acceptable, as long as robust mitigating circumstances have been provided, and the total energy demand remains beneath the 35 kWh/m2/yr target.
2. Total energy demand target exceeded - If the total energy demand target is exceeded, officers should first check if the space heating demand is within target, as often high energy demand is due to insufficient passive design measures.

   In the case of good passive design, the energy demand excedence may be due to poor system efficiency, or a high assumption for the energy using behaviour of the occupants. We would note here that compliance with the target total energy demand of 35 kWh/m²/yr is very challenging with a direct electric heating system. Heat pumps offer significant benefits both to energy intensity and future resident bills.
3. Net-zero energy balance not achieved - The net-zero balance is most challenging to achieve if the total-energy-demand exceeds the target value.

   However, in certain locations, renewable energy generation may be severely curtailed due to overshadowing. This could be from other buildings, or from existing site features such as trees. In cases where the applicant can demonstrate curtailment of renewable generation potential from such features, providing the total energy demand target is met officers are advised to grant compliance according to the Clause 1 exemption.

Non-residential application review guidance

Non-residential applications cover a significantly wider variety of building types, end-uses and technologies. As such, both the space heating demand and the total energy demand targets are more likely to be exceeded. Officers are advised to approach an applicant’s submission according to the hierarchy developed in this guidance. Specific points to focus on could be:

- If space heating demand is significantly higher than the target level, check if the use type and hence space heating temperature set-point or ventilation requirements are significantly different from a typical building. In these cases, space heating demand excedence may be unavoidable
- If the total energy demand is significantly greater than the target of 70 kWh/m²/yr this could be due to specific high-energy uses on site. For example, some office buildings contain significant server room energy uses, or lifts. Where these exceptional energy uses are unavoidable, officers could explore what the total energy demand would be if these were discounted from the calculation. Focussing on the heating, cooling, ventilation and lighting energy uses should be the focus for advising applicants
- Commercial buildings are often taller with higher energy intensities than residential buildings. As such, achieving an energy balance on site can be challenging. Officers should ensure that renewable generation potential has been maximised within the constraints before moving down the Clause 1 exemption route.

Site Smart

Optimising building orientation and form

- Relevant policy components
- Design challenges
- Best practice and targets

Site Smart - getting it right from the start

Informed early decisions on site planning are low cost measures which can make achieving high levels of energy performance significantly easier.

Dwellings should aim to orient the main living areas to the south, delivering passive solar gains during winter. Non-domestic buildings should avoid long facades oriented directly east or west.

Buildings should be kept compact and simple in form, minimising the surface area from which heat loss occurs.

The section explains the policy components encouraging good early design decisions, the design challenges developers face and some guiding best practice and targets.

Relevant policy components

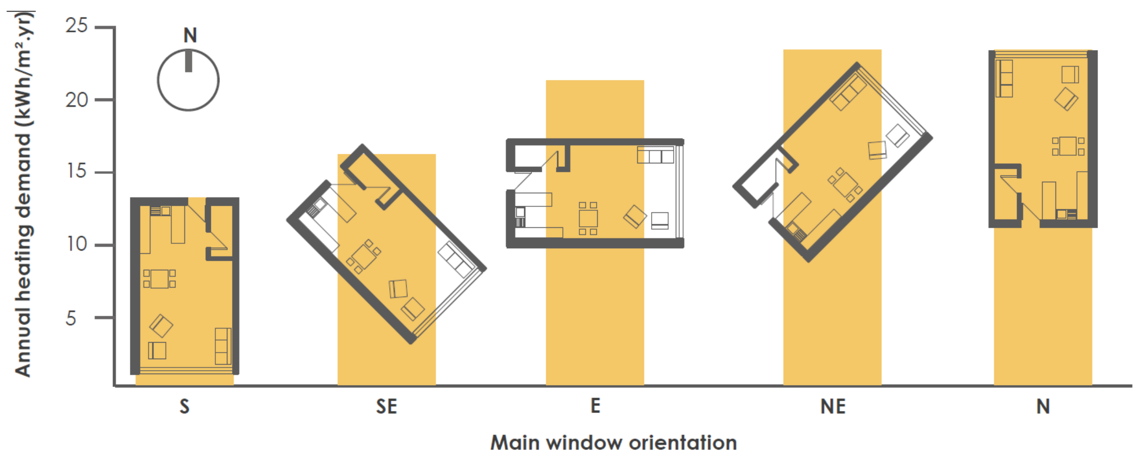
S6.1 Orientation of buildings

Policy text

Positioning buildings to maximise opportunities for solar gain, and minimise winter cold wind heat loss.

Contribution to energy efficiency

A building's orientation can contribute to reducing the space heating energy demand. In the UK over an annual period, north facing windows lead to a net heat loss, whereas south facing windows can normally be designed to achieve a net heat gain.



Credit: LETI

S6.2 Form of buildings

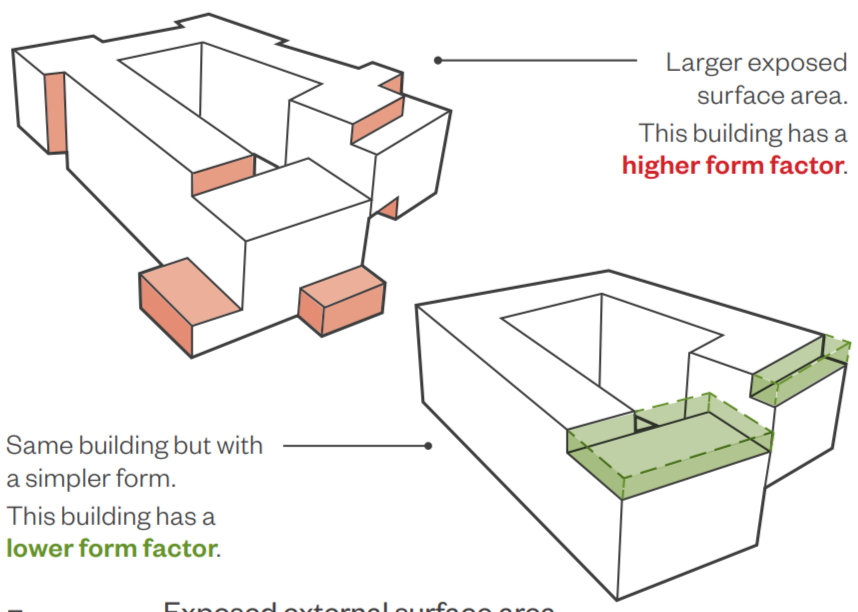
Policy text

Creating buildings that are more efficient to heat and stay warm in colder conditions and stay cool in warmer conditions because of their shape and design.

Contribution to energy efficiency

Simple compact building shapes are more energy efficient due to having less exposed external surface area per square meter of internal floor area, or a lower form factor.

For example, with the same internal floor area, a detached house has more exposed external surface area than a mid-terraced house, and therefore a less thermally efficient form factor .



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

Credit: Levitt Bernstein

Type		Form factor	Efficiency
	Bungalow house	3.0	Least efficient
	Detached house	2.5	
	Semi-detached house	2.1	
	Mid-terrace house	1.7	
	End mid-floor apartment	0.8	Most efficient

Credit: LETI

Design challenges

1 Site geography

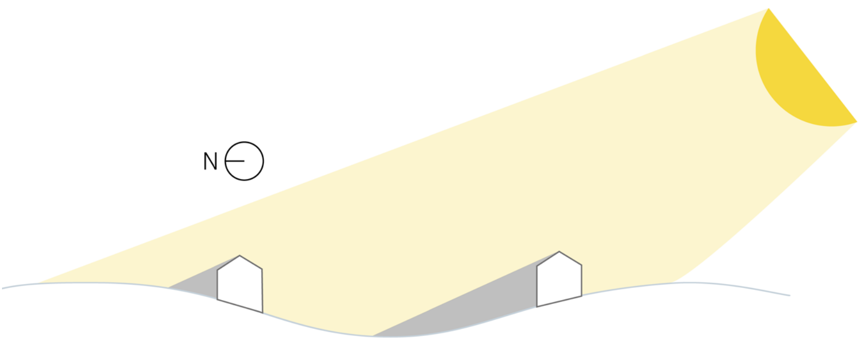
External landscape

Landscape features such as trees can block or limit incidental sunlight. Building orientation, form and site layout should be designed in a way that allows for direct solar incidence while working with existing nature, reducing the need to remove trees.

Neighbouring buildings must also be considered in building placement, as they can cause significant overshadowing, limiting daylight access and solar heat gains, especially in winter.

Topography

The topography of a site can dictate certain building orientations and limit development scope for orienting buildings in an optimum aspect for solar access. Planners should be sensitive to these limitations, and also encourage applicants to utilise existing slopes to maximises solar access.



Prevailing winds

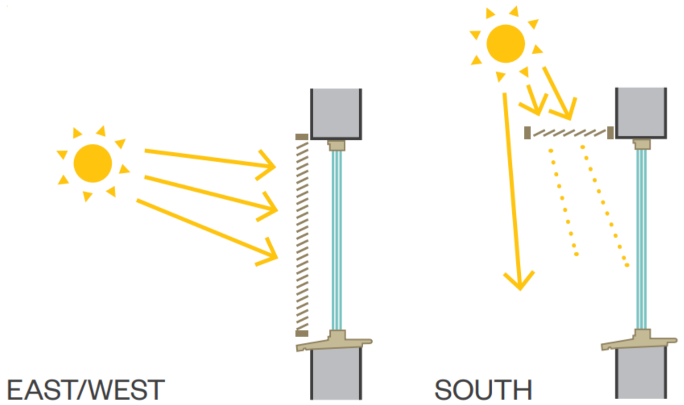
Prevailing winds can be utilised through a natural ventilation strategy, allowing for purge ventilation to limit the risk of summer overheating. Consideration of this in the selection of over-heating purge ventilation strategy is recommended.

2 The "wrong" solar gains

One of the key aims of this policy is to encourage designers to orient buildings to increase solar incidence and heat gains. Though this will reduce and limit winter heating loads, it can also increase the likelihood of elevated summer solar gains - potentially leading to overheating.

Good building orientations also require designers to consider strategies to limit summer solar gains. Control of solar gain can be achieved through external shading (such as vertical fins, and Brise Soleil), deeper window reveals and attention to window aspect.

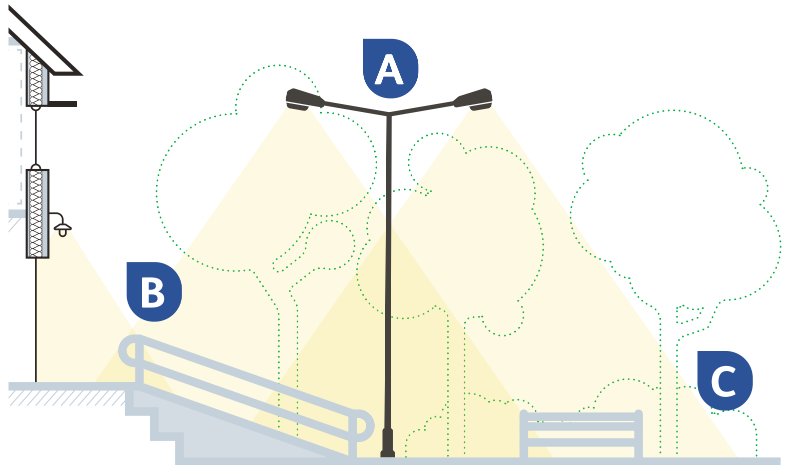
Providing external shutters further allows occupants to reduce solar gains to almost zero on the hottest days, keeping internal spaces cool and negating the need for energy hungry air conditioning.



Credit: Levitt Bernstein

3 Placemaking

Building orientation and form must consider good design principles beyond maximising energy efficiency. Considerations include:



A **Safety and connection:** For a site layout to be effective, people need to be comfortable using and navigating the space. A lack of perceived safety is known to limit mobility through an area, and prevents the community from engaging and interacting with each other. To combat this, sites and buildings must make effective use of design features such as effective external/street lighting, and maximising 'natural surveillance' and 'active frontages'. To complement this, the site layout should have well defined routes, spaces, and entrances that provide for convenient movement without compromising security.

B **Accessibility:** This centres around equitable place-making for all. This includes access in terms of mobility, such as considerations for disabled people throughout the masterplan.

C **Community space:** To facilitate engagement and interaction within the community, outdoor space should be dedicated for public use wherever possible. Design strategies that improve access to shared, public spaces can facilitate social cohesion, build trust within a community, and build social capital. This space should be adaptable and flexible, and suited to a diverse range of community uses to maximise its potential utility.

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Best practice and targets

S6.1 Orientation of buildings

S6.2 Form of buildings

Form factor - typical targets

Typology	Form factor
Small scale housing (terraced/ semi detached)	1.7 - 2.5
Med/large scale housing (four or more storeys)	<0.8 - 1.5
Commercial offices	1 - 2
School	1 - 3

Source: LETI Climate Emergency Design Guide

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

Window ratio - typical residential targets

External wall orientation	Window ratio*
North-facing	20 - 30%
East-facing	20 - 40%
South-facing	30 - 40%
West-facing	20 - 40%

*Ratio's are rules of thumb Bioregional and Etude have found from project experience

The ratio of windows to external elevation should broadly be within the percentage range shown.

Best practice example

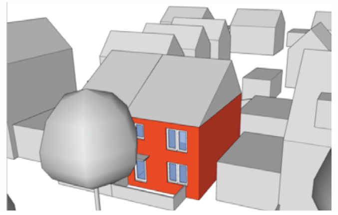
Benefits of optimising form factor

Optimising orientation and built form can mean that policy objectives and targets are met at a reduced construction cost compared with a design that isn't optimised for energy efficiency.

In the example below, an exercise to optimise built form showed that less stringent u-values can be utilised to achieve the same space heating demand.

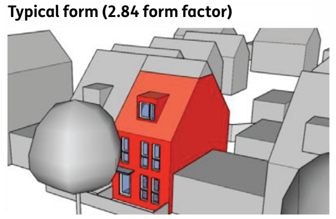
These simple design changes realised a 2% reduction in construction cost compared with the baseline design (taken from an actual planning application in Central Lincolnshire).

Optimised form (2.56 form factor)



Space heating demand kWh/m²/yr	Fabric and ventilation specification	
15	Floor U-value	0.11 W/m²K
	Wall U-value	0.13 W/m²K
	Roof U-value	0.11 W/m²K
	Window U-value	0.9 W/m²K
	Thermal bridging	2 kWh/m²/yr
	Ventilation	MVHR 88%
	Airtightness	<0.6m³/m²h

Typical form (2.84 form factor)



Space heating demand kWh/m²/yr	Fabric and ventilation specification	
15	Floor U-value	0.09 W/m²K
	Wall U-value	0.09 W/m²K
	Roof U-value	0.09 W/m²K
	Window U-value	0.9 W/m²K
	Thermal bridging	2 kWh/m²/yr
	Ventilation	MVHR 88%
	Airtightness	<0.6m³/m²h

Credit: Central Lincolnshire Climate Change Evidence Base: Task G - Feasibility

Fabric First

Optimising building materials and airtightness

- Relevant policy components
- Design challenges
- Best practice and targets

Fabric first - the cheapest energy is the energy you don't need to use

The easiest and cheapest way to save energy is to not use it. However, in many of our homes, maintaining a comfortable internal temperature requires significant heat energy use.

The fabric first approach to building design challenges architects and designers to prioritise minimising energy demands throught passive design measures. Insulated walls, carefully wrapped and sealed junctions and fixings, thermally broken windows and an air-tight thermal line should all be designed into buildigns from the ground up. The fabric first approach saves building users on their energy bills and reduces the demands on the electrical grid.

This section details the relevant policy components encouraging this approach, the design challenges and best practice performance targets.

Relevant policy components

S6.3 Fabric of buildings

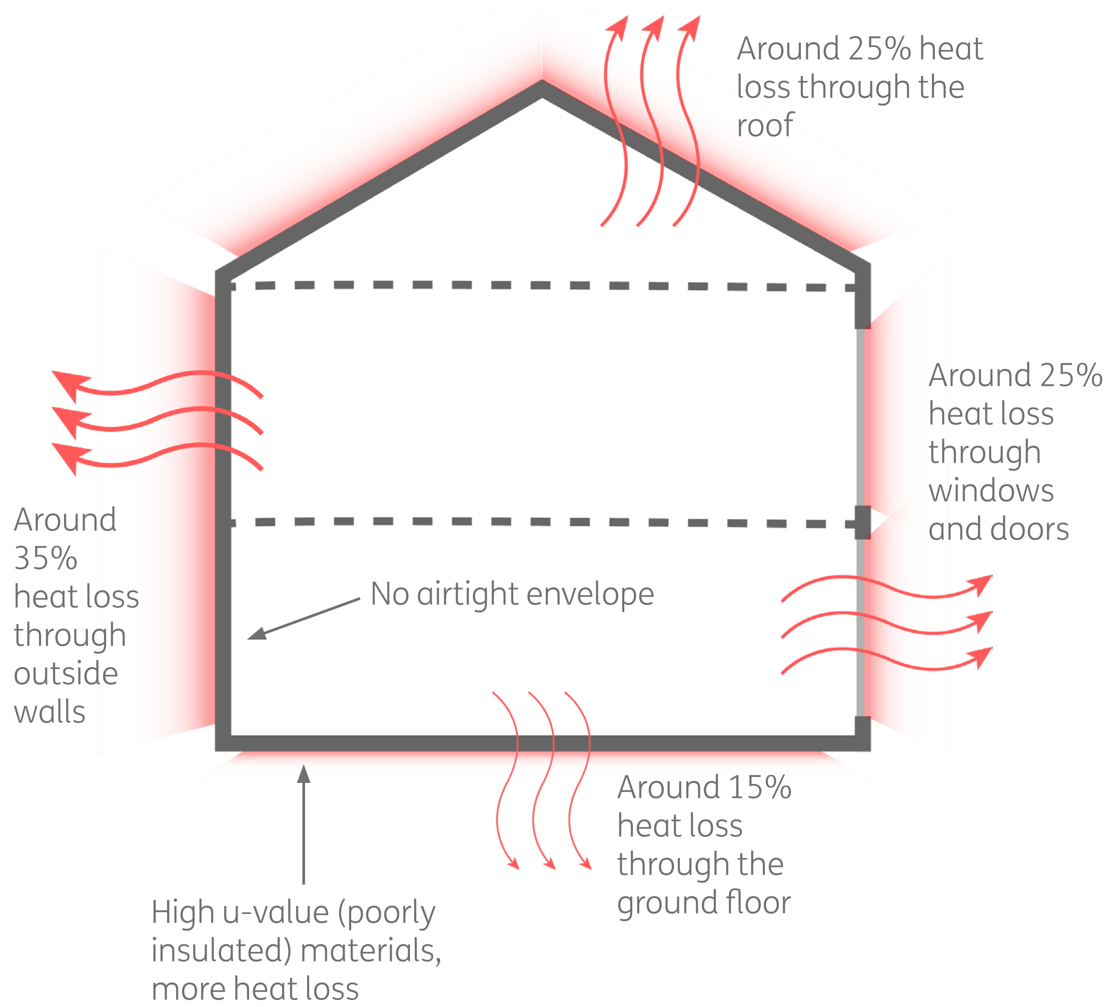
Policy text

Using materials and building techniques that reduce heat and energy needs. Ideally, this could also consider using materials with a lower embodied carbon content and/or high practical recyclable content.

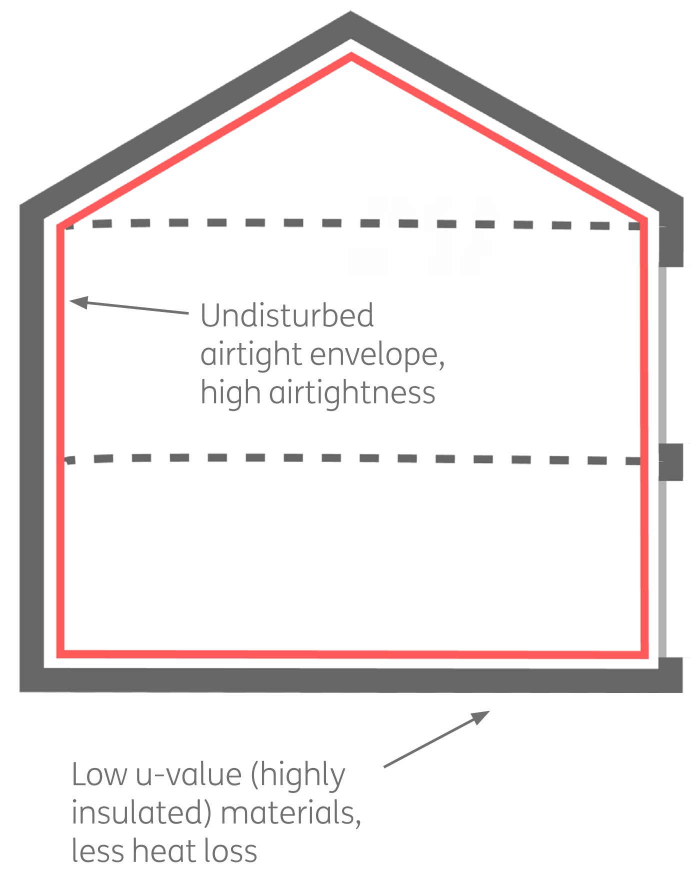
Contribution to energy efficiency

To maintain comfortable, consistent indoor temperatures with minimal energy demand, buildings must isolate the internal from the external environment. This is achieved through the use of highly insulated building materials (measured via u-values), constructed in a way that minimises 'leaky' heat loss (measured via airtightness). Optimising these elements enables control of internal temperatures with a minimum of energy use. Passive measures are also key to minimising resident heating bills.

Location of heat losses in a typical home



A home with high fabric efficiency



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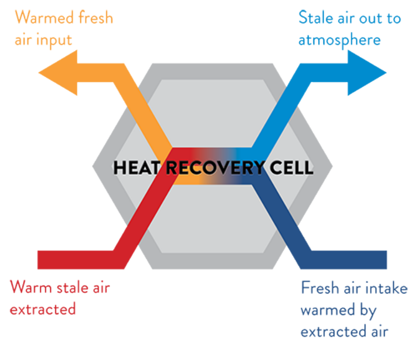
Design challenges

1 Ventilation - Fresh air provision

As high building air-tightness is essential to limit heat losses and maximise building energy efficiency, controlled ventilation is required to deliver the fresh air to meet ventilation requirements and prevent moisture or carbon dioxide build-up.

Where external air quality allows, a “mixed mode” system which uses natural ventilation during summer and shoulder seasons would deliver energy savings through reduced fan energy usage.



For residential buildings, utilising a Mechanical Ventilation with Heat Recovery (MVHR) system provides the greatest energy benefit by reducing winter heat loads. However, there are alternative ventilation systems which do provide some demand control over air infiltration. These should only be considered where MVHR systems are shown by the applicant to be beyond the viability of the project.

For commercial developments, a central air-handling unit with heat recovery ventilation is a standard approach. Planners should interrogate how the applicant plans to provide demand control to reduce ventilation and fan energy use at periods of lower building occupancy.

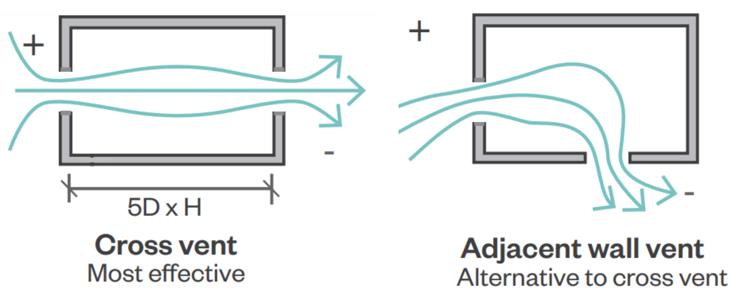
2 Ventilation - Hot air purging

Having a highly insulated fabric reduces heat loss and minimises heating loads on the coldest winter days. However, during warmer periods, or when there are unusually high internal heat gains, it is important buildings are designed with the capacity to purge hot air and limit over-heating risk.

Purge ventilation can be provided in two ways:

1. Active ventilation purge - in domestic properties this is delivered through a “boost” mode on the MVHR unit which temporarily increases air-flow. However, this comes at a fan power energy cost. Further, this is often not that effective given the air-flow limits.
2. Natural ventilation purging - A window opening strategy is the most effective at purging hot air due to the significantly greater air-flows. Cross ventilation - where windows open on opposite sides of the building, delivers the greatest flow-rate potential.

Applicants should demonstrate over-heating compliance within Policy S20, preferably through compliance with an industry accepted standard such as CIBSE TM59 and CIBSE TM52.



Credit: Levitt Bernstein

3 Embodied carbon

Embodied carbon emissions of buildings include all the emissions associated with the extraction, manufacture, transportation, and assembly of the materials used to construct a building. Minimising embodied carbon must not be neglected when designing energy efficient buildings. As the operational energy efficiency of the building improves, and therefore emissions resultant of energy use fall, embodied carbon comes to dominate the whole life cycle carbon emissions of a building.

	Embodied carbon proportion of whole life carbon	
Typology	**Building Reg compliant**	**Highly energy efficient**
Office	34%	72%
Mid-scale housing	33%	77%

Credit: LETI

A majority of these carbon emissions are embodied in the building structure - advice on which is beyond the scope of this guide (see Policies S10 & S11 for more detail). However, a portion of these emissions are embodied in the fabric insulation - which becomes increasingly significant in energy efficient buildings. Designers should be encouraged to select low embodied carbon insulation materials.

	Material of wall	Embodied carbon (kgCO_2 e/m²) to achieve 0.15 W/m².K U-Value
Suggested	Low-density Rockwool (23 kg/m³)	7
Suggested	Wood-fibre	5 (-70 inc. carbon sequestration)
Avoid	High-density Rockwool (200 kg/m³)	40
Avoid	Expanded Polyurethane	160

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Best practice to meet policy aims - residential

S6.3 Fabric of residential buildings

Indicative specification to comply with Policy S7.2

	Unlikely to comply	Caution needed	Reccomended*
Airtightness ($m^3/h/m^2$)	5+	2-5	<=1
Ventilation system	Natural vent/ extract vent only	MVHR, 75% efficiency	MVHR, 90% efficiency
Walls ($W/m^2.K$)	0.16+	0.14 - 0.15	<=0.13
Ground floor ($W/m^2.K$)	0.13	0.12+	<=0.1
Roof ($W/m^2.K$)	0.13	0.12+	<=0.1
Windows and doors ($W/m^2.K$)	1.1+	0.9+	<=0.8

* The values in this column are Compliant with Policy S7 SAP route

Recommended MVHR specification

Distance from external wall	<2m
Specific fan power	<0.85 W/l/s
Heat recovery	>90%
Thickness of duct insulation mm	>25mm

Recommended solar control

Glazing g-value	<0.5
Shading	External shading where appropriate, internal blinds are insufficient

Optimising a building's orientation and form (Policy S6.1 and S6.2) may allow for more forgiving fabric efficiencies while still achieving a low thermal energy demand.

If the PHPP route to compliance is taken, it may be possible to achieve the space heating demand targets of Policy S7 with the u-values in the 'caution needed' range above.

Best practice example

Goldsmith Street, Norwich

Completed in 2019, the Stirling Prize winning Goldsmith Street in Norwich is a 100% social housing scheme comprising of 93 Passivhaus certified homes. The scheme cost £14.7 million total to build, equivalent to £1,825 per m^2.

Performance	
Airtightness ($m^3/h/m^2$)	0.56
Space heating demand ($kWh/m^2.yr$)	12.3

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Best practice to meet policy aims - non-residential

S6.3 Fabric of non-residential buildings

Indicative specification to comply with Policy S8.2

	Unlikely to comply	Caution needed	Reccomended*
Airtightness ($m^3/h/m^2$)	5+	2-5	<=1
Ventilation system	Natural vent/ extract vent only	MVHR, 75% efficiency	Mechanical ventilation, with over 85% efficient heat recovery
Walls ($W/m^2.K$)	0.16+	0.14 - 0.15	<=0.13
Ground floor ($W/m^2.K$)	0.13	0.12+	<=0.1
Roof ($W/m^2.K$)	0.13	0.12+	<=0.1
Windows and doors ($W/m^2.K$)	1.1+	0.9+	<=0.8

* The values in this column are Compliant with Policy S8 NCM route

Recommended MVHR specification (if used)

Distance from external wall	<2m
Specific fan power	<0.85 W/l/s
Heat recovery	>90%
Thickness of duct insulation mm	>25mm

Recommended solar control

Glazing g-value	<0.4
Visual light transmittance	>0.6
Facde shading strategy	External shading often needed, internal blinds are required for glare control

Optimising a building's orientation and form (Policy S6.1 and S6.2) may allow for more forgiving fabric efficiencies while still achieving a low thermal energy demand.

If the Design for Performance route to compliance is taken, it may be possible to acheive the space heating demand targets of Policy S8 with the u-values in the 'caution needed' range above.

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Sustainable Systems

Optimising energy systems and hot water demand

- Relevant policy components
- Design challenges
- Best practice and targets

Sustainable systems - decarbonising heat provision

The UK's buildings are predominantly heated through natural gas - in total contributing to 17% of the UK's carbon footprint.

New building system design must be encouraged through policy to move away from fossil fuel based heating systems to electric systems which can deliver heat efficiently and at low cost to building users.

Heat pumps are currently the most efficient technology for this building heating. Available in many technological varieties, heat pumps are currently cost competitive to gas boilers in terms of annual running costs.

This section details the policy component relating to building heating systems, the core design challenges faced and some best practice recommendations and targets.

Relevant policy components

S6.4 Heat supply

Policy text

Net zero carbon content of heat supply (for example, this means no connection to the gas network or use of oil or bottled gas)

Contribution to energy efficiency

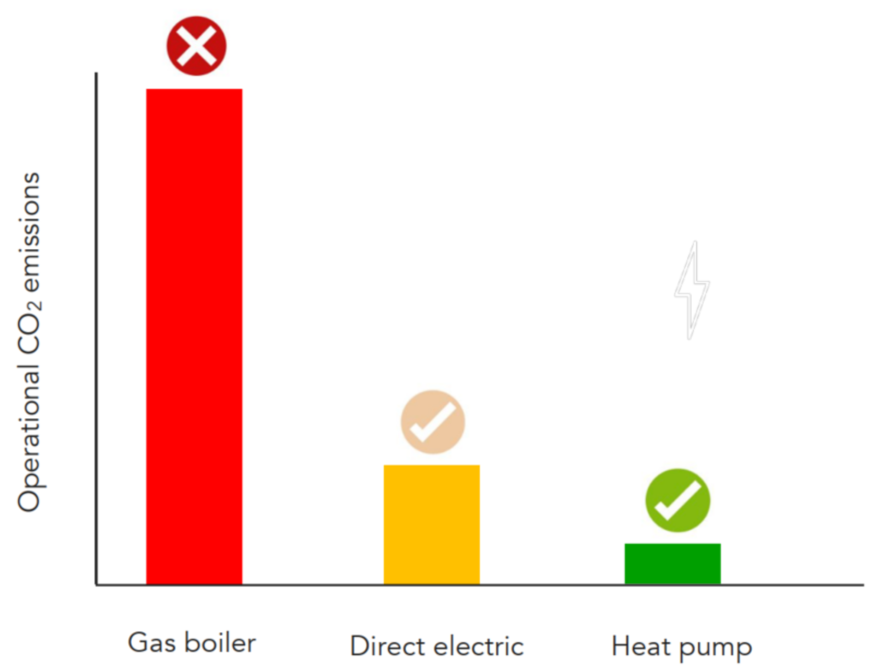
Supplying fossil fuel free energy is key to minimising carbon emissions. For new builds, heat pumps are the most efficient* means of heating a building without reliance on fossil fuels.

Heat pumps come in a variety of forms, can provide both space heating and domestic hot water, and can serve individual buildings or act as communal heating systems.

To ensure energy efficiency is maximised, and to minimise energy demand, the choice of system must be informed by the building and site's context and use case.

*'Direct electric' heating systems are another zero-emissions compatible source of heat, however typically require 3x the amount of electricity than heat pumps to provide the same amount of heat

Why are heat pumps so important?



Heating system technology	Indicative comparison of annual average energy bill (£/annum)[1][2]
Gas Boilers (91% efficiency)	£1,050
Direct electric	£1,553
Heat pump (seasonal heating COP of 3.6)	£907

[1] Typical 2-Bed policy compliant home has 1,500 kWh/annum base electrical energy demand, 2,500 kWh/annum heating and hot-water energy demand (Central Lincolnshire Climate Change Evidence Base: Task G - Feasibility)

[2] Calculations based upon average October 2022 government price cap energy costs. Electricity - unit price 35.8p/kWh + 33.15p/day standing charge. Gas - unit price 10.5p/kWh + 28.48p/day standing charge

Key Points:

- New buildings need to be low carbon now, and direct electric and air source heat pump systems can deliver now.
- Heat pumps would use significantly less energy than a direct electric heating system to heat the same home (hence cheaper to run, less peak load).
- A zero carbon balance is easier to achieve with a building that uses a Heat pump because total energy use (EUI) is smaller (i.e. less PVs are needed). Hence compliance with Policy S7/S8 is more easily achieved.

Design challenges

1 Feasibility of low-carbon heat systems

Low-carbon heating system design requires a sensitivity to site conditions and whole-system design considerations which are not as critical to traditional fossil fuel based heating systems. Here, some critical considerations are provided which will help guide applicants and advise planners on whether an optimal system selection has been made:

- **Air-source heat pump** -
  - Requires appropriately positioned external units, accoustically baffled if necessary
  - Appropriately sized hot-water/thermal stores to buffer demands and allow for optimum operation
  - Deliver a space heating system optimised for low flow temperatures to deliver maximum heating efficiency for the heat pump
- **Closed-loop Ground source heat pump** -
  - Requires array sizing to allow for recharge of ground temperature over annual period. Applicants should demonstrate long-term temperature stability achieved. This can be either through a balanced load, or by ensuring sufficient boreholes are within the array to achieve geothermal recharge
  - Preferably a study on ground conditions with assessment of conductivity performed
- **Open-loop ground source heat pump** -
  - Requires assessment of aquifer potential, preferably with a British Geological Survey issued report
  - Sufficient distance between extract and re-injection wells within the site boundary

Best practice guidance is available from CIBSE, and heat pump associations such as the Ground Source Heat Pump Association (GSHPA).

2 Efficient fixtures and fittings

Electrification of hot water generation is necessary for decarbonisation. However, hot water demand is very concentrated at specific points in the day, putting potentially large peak demands on the electrical grid. Absolute demand reduction technologies - such a low flow fixtures and tank insulation should be prioritised.

The AECB Good Practice Fittings Standard (below) provides recommended specifications. See the full guide for more information.

Appliance/ fitting	AECB Good Practice Fittings Standard
Showers	6 to 8 l/min measured at installation
Basin taps	4 to 6 l/min measured at installation (per pillar tap or per mixer outlet)
Kitchen sink taps	6 to 8 l/min measured at installation
WCs	≤ 6 l full flush when flushed with the water supply connected.
Baths	≤ 180 litres measured to the centre line of overflow

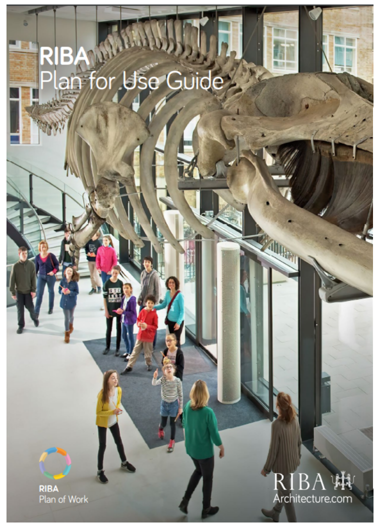
3 Soft landings

Occupant control

Occupants must be able to use the energy systems effectively in order to maximise their performance. This is key within low-carbon energy systems such as heat pumps as the technology is unfamiliar to most. It is recommended that a non-technical, plain english guide to operating and maintaining energy systems is provided to building users and operators.

Monitoring

Through the design phases, modellers will rely on a series of assumptions regarding occupant behaviour to inform the systems design and optimisation of the building. However, in practice, energy use intensity is heavily connected to occupant behaviour, which can only be understood through monitoring of the energy systems within the building. Post-occupancy monitoring can inform building operators on where certain systems are consuming more energy than expected, and provide guidance on where to focus to achieve reductions in practice.



The RIBA Plan for Use Guide provides key information on how to effectively enact soft landings, and provides valuable case studies of best practice.

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Best practice to meet policy aims

S6.4 Heat supply

Indicative heating system to comply with policy S7.2/8.2

	Unlikely to comply	Caution needed	Recommended*
Heat supply system	Direct electric	Heat pump, above 45°C flow temperature for space heating	Heat pump, below 45°C flow temperature for space heating

*Compliant with Policy S7/8 SAP route

Heat pumps will perform more efficiently in a building with low u-value building materials and high airtightness .

Recommendations to maximise system efficiency

Reduce flow rates	The AECB water standards (prior page) provide clear guidance on sensible flow rates for showers and taps in low energy buildings.
Reduce distribution losses	All pipework must be insulated and designed to ensure there are no 'dead legs' containing more than 1 litre. Tapping points (e.g. taps, shower connections) should be clustered near the hot water source. Small bore pipework should be careful sized based on peak demands, minimising the diameter where possible.
Insulate to 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. Target a hot water tank heat loss of less than 1 kWh/day equivalent to 0.75 W/K.
Install waste water heat recovery systems in shower drains	A simple technology that recovers heat from hot water as it is drained. Vertical systems can recover up to 60% more heat than common horizontal ones recovering 25-40%.

Examples of best practice

Springfield Meadows

Springfield Meadows, completed in 2021, is a residential development of 25 homes located on the outskirts of Southmoor, Oxfordshire.

The scheme was designed using Passivhaus principles, and features heat pumps serving underfloor heating and domestic hot water, and MVHR ventilation systems. The low thermal energy demand is complimented by highly efficient building fabric, such as triple glazed timber windows, and a closed-panel timber structure insulated with wood fibre.

Performance	
Heating and ventilation system	ASHP and MVHR
Thermal energy demand ($kWh/m^3.yr$)	<15
Site-wide solar PV provision (kW)	114

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Green Generation

Optimising local renewable energy generation and use

- Relevant policy components
- Design challenges
- Best practice and targets

Green generation - contributing to energy system decarbonisation

Buildings present a significant opportunity for the mounting of renewable energy generation systems - predominantly in the form of either solar thermal or solar photovoltaics.

In the UK, it is generally possible to build up to 6 residential stories and generate enough photovoltaic energy from the roof area to offset the annual electrical energy demands of the building.

Local photovoltaic generation saves building users money, and provides zero carbon power for home appliance use and heating generation.

This section details the policy component relating to renewable generation, the core design challenges faced and some best practice recommendations and targets.

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Relevant policy components

S6.5 Renewable energy generated

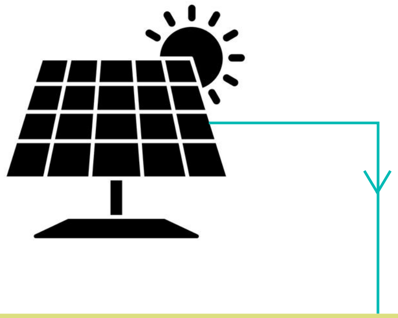
Policy text

Generating enough energy from renewable sources on-site (and preferably on plot) to meet reasonable estimates of all regulated and unregulated total annual energy demand across the year.

Contribution to energy efficiency

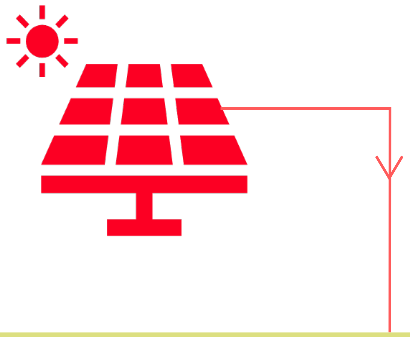
Local energy generation can provide an important contribution to building energy use, while reducing the demands on grid infrastructure. Most common at the building scale is the integration of photovoltaic panels of various forms, but solar thermal installations can also be cost effective where sufficient and well controlled hot water storage is utilised. On-site consumption of local generation should be maximised to provide greatest value and minimise impact on grid constraints.

Solar photovoltaics



- Principle technology for policy compliance
- Panels can currently achieve over 20% efficiency and are capable of generating up to 400W each
- BEIS small scale solar statistics estimate a cost of around £1000/kWp for a residential scale array

Solar thermal systems



- Evacuated tube solar thermal systems can achieve efficiencies of around 60%
- Need to ensure there is sufficient demand to absorb hot water generation in summer months
- Can be more expensive upfront than equivalent area of Solar PV

Wind turbines

- Rarely seen within developments due to noise and visual pollution concerns
- A single well sited 0.5 MW turbine can generate around 1,400 MW.h / annum. Enough to power 350 low-energy homes
- Rural developments could explore nearby location options

Design challenges

1 Feasibility of renewable generation

Site layout & context

Solar renewable energy generation, whether photovoltaic or solar thermal, requires unobstructed access to direct sunlight for optimum operation. Overshadowing can lead to poor system efficiency, limited annual generation potential or even system damage. Planners should ensure that the impacts of overshadowing have been considered, and solar generation positioned accordingly. As a rule of thumb, annual solar irradiation of >700 kWh/m^2 is considered sufficient for economic solar generation.

Optimising roof utilisation

To maximise solar generation, roofs should be oriented to the south, or along a shallow east-west axis. Achieving maximum generation potential requires careful utilisation of space and consideration of panel angles. The following general advice should guide planners in reviewing this:

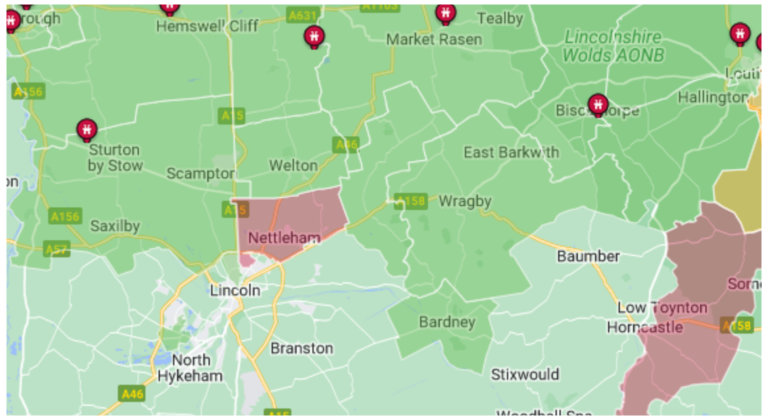
- Solar photovoltaic - Generally maximising roof area utilisation is more important than optimising panel angle and orientation. The optimal panel angle for a single panel is 32° oriented directly south, but panels at a shallower angle (always > 15° to prevent settlement) typically only lose 5 - 10% off this optimum, but enable a larger roof area to be utilised.
- Solar thermal - Solar thermal is often oriented at steeper angles than solar PV to deliver an optimum of winter heat generation, where it can provide the greatest benefit to building users.

2 Grid export limitations

Central Lincolnshire lies on the boundary of the district networks of the national grid and northern power grids.

District networks manage the high and medium voltage lines and substations which deliver power from the main grids transmission network. These substations have limited bounds of voltage for normal operation, and hence only have capacity for a limited amount of "embedded" generation within each sub-station area. Some areas of the grid are at capacity and further renewable generation can only be provided if 100% of it is utilised on site. Applicants should approach the DNO on this issue, as often grid upgrades can be made to support deeper renewables integration.

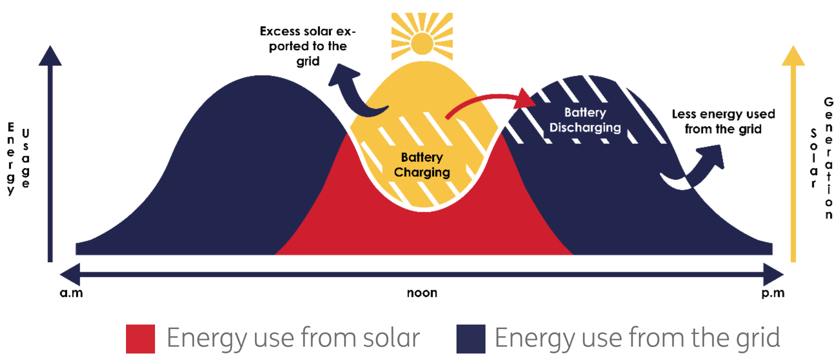
Northern power grid constraints map example:



3 Ensuring on-site consumption

Generation of solar energy follows a typical daily curve with peak generation around midday, and very limited generation in the early morning and evenings. For commercial buildings, particularly offices, this means the generation typically coincides with peak energy usage, and minimal demand shifting is required.

However, for residential uses, electrical energy demands follow an inverse profile, with peak demands typically occurring in the early morning between 7am and 10am, and in the evening from 5 - 9pm. Hence, to maximise on-site consumption either demand shift technologies or some form of storage needs to be utilised. One option for this is to utilise a SMART domestic hot water cylinder which can absorb solar energy throughout the day to provide hot water for the evening. Applicants should be encouraged to explore such systems and technologies.



Credit: National Energy Action (NEA)

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Best practice to meet policy aims

S6.5 Renewable generation guidelines

Solar PV provision compliant with Policy S7 and S8 SAP/ NCM route

Height of building	Target PV roof area fraction - residential	Target PV roof area fraction - non-resi
1 storey	25%	50%
2 storey	50%	80%
3 storey	75%	Maximise roof PV area
4 storey	Maximise roof PV area	

The above area proportions reflect the typical roof fraction required to achieve an energy balance on different building heights. Buildings above the height of four stories may struggle to achieve an energy balance using rooftop solar, and hence maximum roof utilisation is considered sufficient to demonstrate compliance.

Applicants are encouraged to exceed these percentages where possible. These calculations are based on the space heating demand and energy use intensity targets in policy S7.2 and S8.2 being met through using the design guidance in sections S6.1-S6.4. If the guidance isn't followed, larger areas of PV will be required to comply with S7.1 and S8.1.

Examples of best practice

Typical development

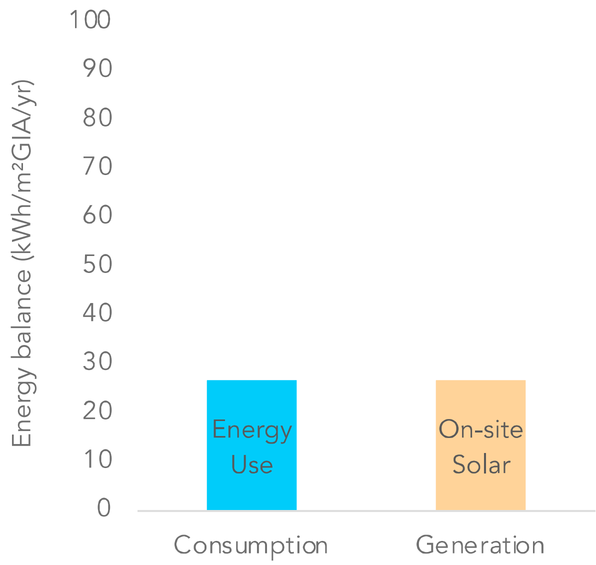
Space heating demand: 15 kWh/m²/yr

Orientation: south-southwest

2.7 kWp — Nominal array power

62 kWh/m²fp — Specific energy generation

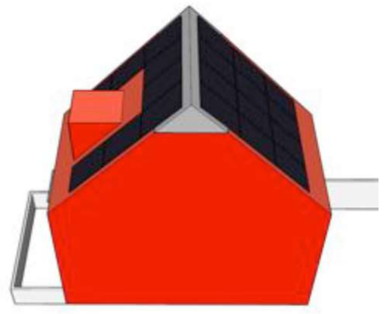
Minimum solar generation potential on typology. With a single roof aspect available, 8x340W PV panels would be sufficient to generate 27 kWh/m²/yr and therefore potentially achieve zero carbon performance if a very low energy building is specified.



Typical development

Space heating demand: 15 kWh/m²/yr

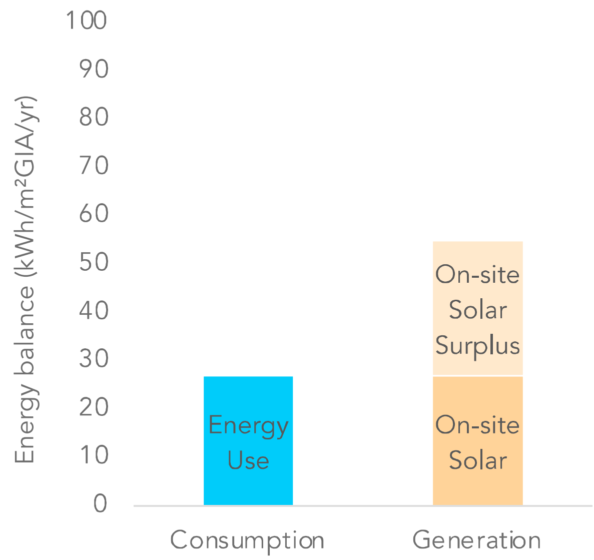
Orientation: west



6.8 kWp — Nominal array power

154 kWh/m²fp — Specific energy generation

Through a more optimum roof orientation, panels can be placed on both the east and west oriented roofs, delivering 20x340W panels and around 50kWh/m²/annum energy generation. Possible to be energy positive if a low energy building is specified.



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Appendices

- Key resources/ further reading
- Glossary

Key resources and further reading

LETI Climate Emergency Design Guide	
RIBA Plan for Use Guide	
Passivhaus Easi Guide	
Cotswold Net Zero Carbon Toolkit	
Passivhaus Trust Good Practice Guide to Airtightness	
National Model Design Code Guidance Notes	
AECB Good Practice Fittings Standard	
Central Lincolnshire Climate Change Evidence Base: Task G - Feasibility	
HVDH Domestic heating design guide (2021)	

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Glossary

Absolute zero carbon – Refers to a development that has zero carbon embodied or operational emissions, and zero offsetting is required.

Active frontages - Refers to the frontage of buildings where there is an active visual engagement between those in the street and those on the ground and upper floors of buildings – for example through large windows, shop-fronts, and building entrances.

Auxiliary energy use– Auxiliary energy is the energy used by equipment (pumps and fans) and is part of the regulated emissions that are calculated for a building.

BREEAM– The Building Research Establishment is an internally recognised sustainability assessment scheme. Non-residential buildings are assessed at the design and post construction stage and certificates awarded based on meeting criteria surrounding sustainable design, construction and operation. The New Construction scheme is used to assess all non-residential spaces and the Community scheme is used for masterplan community developments.

Brise soleil- An architectural feature of a building designed to reduce heat gain and deflect sunlight. Examples of this include 'fins' on a building façade.

Building Regulations– Produced by the government, these national technical guidance documents confirm how building regulations must be complied with during construction. Example approved documents include: Part B Fire Safety, Part F Ventilation and Part L Conservation of Fuel and Power.

CIBSE TM54 - Is a methodology developed by the Chartered Institute of Building Services Engineers used to calculate a building's predicted in-operation energy use.

CO2e- Is a common unit that refers to the CO2 equivalent (e) of greenhouse gasses. Many gasses contribute to climate change, though as CO2 is the most prevalent and widely known, other greenhouse gasses are converted to their equivalent global-warming potential of CO2 to provide a simple number.

Demand response- Refers to a change in the power consumption of a building to better match the demand for power with the supply. A simple example of this would be running a washing machine when energy demand is lower.

Design for Performance - A modelling approach which attempts to predict the energy use of a building using realistic assumptions about building use and performance. This differs to compliance approaches which use standardised assumptions. For non-residential buildings, methodologies such as CIBSE TM54, NABERS and PHPP are well established within industry.

Energy Use Intensity (EUI)– Measures the building's energy efficiency and is the annual measure of energy consumed by the building. EUI can be estimated at Design Stage and then the kWh from energy bills when the building is in use can be compared to the target.

EPC - Energy performance certificate. The certificate presents a score, ranging from 0 - 100, which provides a reflection of the buildings normative energy performance. Required for all domestic dwellings on the market either for sale or rental.

Fabric first approach – Refers to prioritising and maximising the energy efficiency of building components and materials when designing a scheme, before considering the use of energy systems.

G-value– G-values are the solar transmittance that passes through a piece of glazing. The lower the g-value, the lower the amount of solar heat that is passed through the material. Glazing can be treated to reduce the g-value and reduce the solar gains. G-values usually range between 0.2 and 0.7, with high performance solar control glazing <0.4.

HVAC– Heating, ventilation and air conditioning are the building services designed to provide a good indoor environment.

LETI- The London Energy Transformation Initiative is a volunteer network of over 1000 built environment professionals working to ensure London transitions to become net zero carbon. They have written and published a series of guides including their Embodied Carbon Primer, Climate Emergency Design Guide and Climate Emergency Retrofit Guide.

Life cycle analysis (LCA) – Refers to a method of assessing the environmental impacts associated with all stages of a development's life cycle.

Local generation- Refers to energy that is generated on-site

Low flow fixtures- Refers to appliances within a building that are designed to use less water than their traditional counterparts. An example of this is an aerated tap, or low-flow toilet.

MEP systems– Mechanical, electrical and plumbing engineering are the essential systems required to make a building comfortable for people to use. This includes heating, cooling, ventilation, lighting, power, freshwater and wastewater.

NABERS - The National Australian Built Environment Rating System is an assessment scheme measuring a building's energy efficiency and carbon emissions based on annual operational performance (and updated every year).

Natural surveillance – Refers to the ability to see in and out of an area. It involves designing a site's physical features in a way that maximises the visibility of a given space, as to deter crime and optimise potential to see suspicious activity if it occurs.

Net zero carbon - Refers to a 'net' balance of zero carbon emissions from a development. If a development is emitting carbon emissions, either embodied or operational, these emissions must be 'offset' elsewhere to achieve net zero carbon emissions. There are many ways to offset emissions, though a simplified example would be funding tree planting which would sequester the amount of carbon emissions as the development would produce.

Photovoltaics (PV)– Panels which capture the suns energy and convert it into electrical energy. Layers of semi-conductive silicon create a flow of electricity when sun hits them. Panels are generally 15-20% efficient and should be installed to capture the sun for the longest period of the day (south or west-east). Typically, domestic appliances use AC power so an inverter is required to convert the energy from DC to AC electricity.

PHPP - Passive House Planning Package. The modelling approach developed by the Passivhaus Institute as a building physics based realistic model for low energy domestic building modelling.

Purge ventilation - Ventilation operating at significantly higher flow rates than the minimum background rates recommended in Part F. Used for removing excess heat build-up from a dwelling and reducing risk of dangerous overheating.

RIBA– The Royal Institute of British Architects is an internationally recognised professional body for architects aiming to building knowledge and support architects.

SAP - Standard Assessment Procedure. The methodology used to demonstrate compliance with UK building regulations approved document Part L. Provides the basis for EPC scores.

Thermal transmittance (U-values)– Thermal transmittance is the rate of heat transfer through a material. U-values are the total of the thermal resistance of the layers of a building element and the lower the U-value, the more slowly heat passes through the building element, meaning less heat loss. U-values are measured in watts per square meter per kelvin (W/m2K). For example, an external wall (made up of layers of brick cladding, mineral wool insulation, studs and plasterboard) may have a u-value of 0.18 W/m2K.

Whole life carbon – Is the total of embodied carbon and operational carbon across the lifespan of a building.

This guide was produced by Bioregional and Etude for the Central Lincolnshire Joint Strategic Planning Committee.

Bioregional champions a better, more sustainable way to live.

We work with partners to create places which enable people to live, work and do business within the natural limits of the planet. We call this One Planet Living.

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