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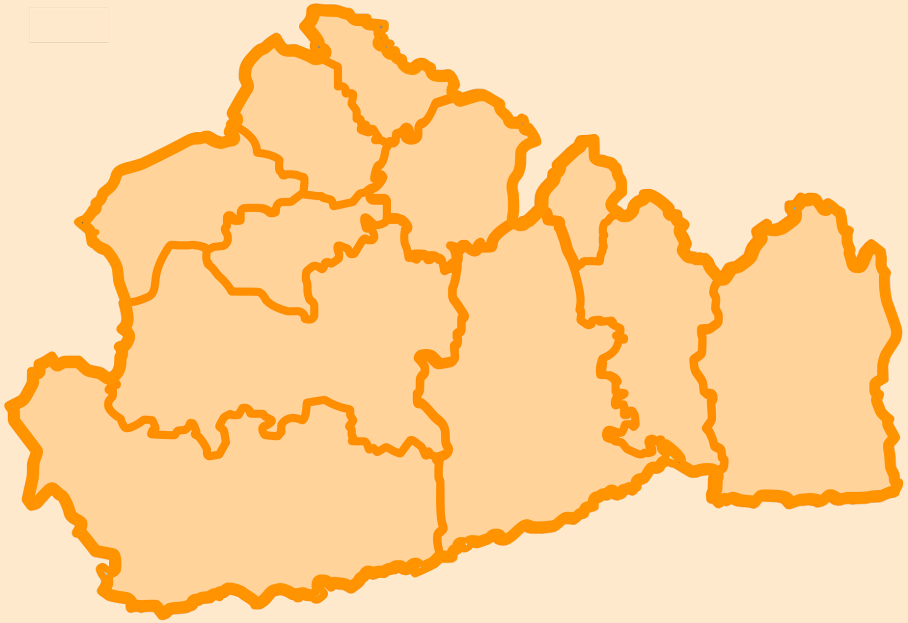


Surrey Viability Toolkit

An evidence study to support planning policies which deliver Net Zero Carbon developments

Part B: Energy modelling and technical feasibility report

May 2024 | Rev C

Bioregional

Three Dragons

Etude

Contents

1.0

Introduction and context

1.1

The purpose of the Toolkit and its structure

1.1.1 The purpose of Surrey's Net Zero Carbon Viability Toolkit

Developing policies that meaningfully address climate change

Surrey County Council and its districts and boroughs wish to develop new buildings policies that deliver buildings which exceed minimum national standards and meaningfully address the climate emergency.

The policies should be developed in order that new buildings are:

- Fully net zero;
- Utilise low carbon heat (i.e. no fossil fuel consumption on-site);
- Address carbon emissions from all operational energy uses (both regulated and unregulated energy uses), and;
- Address embodied carbon.

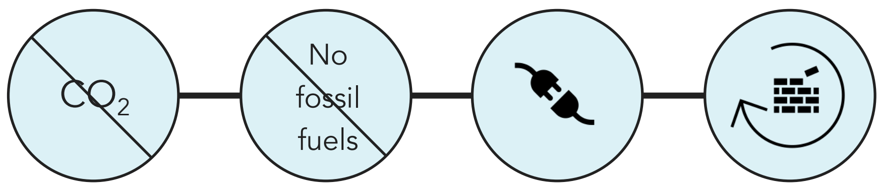
Providing the tools for districts and boroughs to implement net zero carbon new buildings policies

As each district and borough within Surrey updates their local plan, the inclusion of net zero carbon buildings policies will require robust evidence to demonstrate technical deliverability and financial viability. This Net Zero Carbon Viability Toolkit gives the districts and boroughs the tools they need to inform technical feasibility of delivering net zero carbon new buildings across different archetypes. The toolkit also provides costing data and information for districts and boroughs to undertake their own viability assessments for new buildings meeting net zero carbon metrics.

Who is this Toolkit for?

This Toolkit has been designed primarily for planners and policy makers within Surrey's districts and boroughs to give them the data and information needed to develop their own evidence bases.

Surrey's objectives for net zero carbon buildings policies



1.1.2 The Toolkit Structure

The Surrey Net Zero Carbon Viability Toolkit is a suite of **five** separate components illustrated here.

Part A: Summary Report

The summary report captures the main headlines and findings of the energy and cost modelling results. It also provides a summary of recommendations for policy to take forward.

This report

Part B: Energy modelling results

Refer to this section for more detail on:

- The energy modelling process: what was modelled, how and why was it modelled that way.
- The assumptions used behind the energy modelling process.
- The results of the energy modelling for each archetype modelled.
- The design and specifications of the archetypes chosen.
- Running costs modelling assumptions and results.
- Embodied carbon recommendations.

Part C: Energy and costs spreadsheet

Refer to this spreadsheet for more details on:

- A breakdown of costing data and results
- The specifications of the dwellings modelled.
- Costing graphs for each dwelling archetype modelled.
- The assumptions used behind the cost modelling.

Part D: Viability Calculator

This spreadsheet can be used as a quick, one-page viability calculator tool.

It enables the districts and boroughs to plug in their own data and return

Part E: Cost and Viability modelling results

Refer to this section for more detail on:

- The cost modelling process and methodology.
- The assumptions used behind the cost modelling.
- The viability process and methodology.
- The assumptions used behind the viability modelling.
- The viability modelling results.

1.2

The context: net zero planning in 2024

1.2 The context: net zero planning in 2024

Contents

1.2.1 A great urgency to meet global carbon commitments

There is a climate emergency

There is overwhelming scientific consensus that significant climate change is happening. This is evidenced in the latest assessment of the Intergovernmental Panel on Climate Change (IPCC AR6). The IPCC special report published in 2022 on the impacts of global warming of 1.5°C above pre-industrial levels highlights the **urgency for action** and has generated a high level of interest and concern in society.

The Glasgow Agreement (2021)

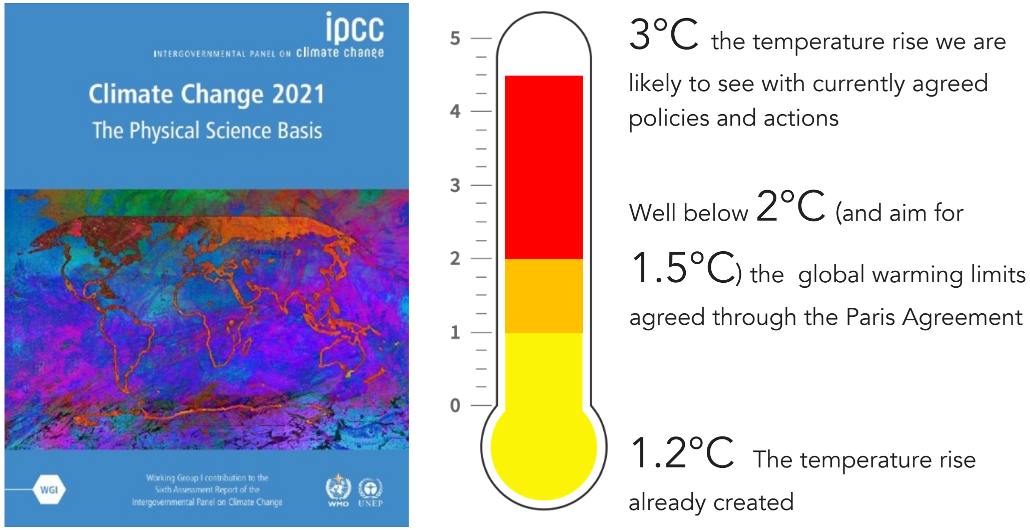
International negotiations on climate change are governed through the United Nations Framework Convention on Climate Change (UNFCCC). The most recent negotiations concluded with the Glasgow Agreement in 2021. Nations collectively agreed to work to reduce the gap between existing emission reduction plans and what is required to reduce emissions, so that the rise in the global average temperature can be limited to 1.5 degrees.

Global carbon budgets

The concept of carbon budgets is absolutely critical to understand; Net Zero is not only about a destination; a very significant and fast required decarbonisation pathway is needed from now on.

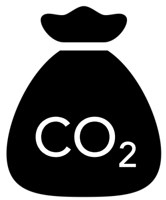
The IPCC Special Report on 1.5°C has estimated the quantity of CO_2 that can be emitted globally and still be consistent with keeping global temperatures well below 2°C, with a chance of stabilising at 1.5°C. The report gives different budgets for different temperature rises and probabilities. At the start of 2020, the global carbon budget for a 66% probability of keeping global warming to below 1.5°C was 400Gt CO_2.

Recent work by Lamboll et al has indicated that at the start of 2023 the global carbon budget for a 50% probability of keeping global warming to below 1.5°C was 250Gt CO_2. This budget will be consumed within under 6 years at current emission rates.



Source: Copernicus Climate Change Service, ECMWF

Latest IPCC report and the associated targeted limit on global warming: 1.5-2°C



250,000 $MtCO_2$

Remaining global carbon budget (from January 2023) for a 50% chance of limiting temperature rises to below 1.5°C (Lamboll et al, 2023). Includes updates to climate models and incorporation of new knowledge on contribution from non-CO_2 emissions

<6 years

The number of years it would take to **consume our entire global carbon budget** at current global emissions rates for a 50% chance of limiting temperature rises to below 1.5°C

The remaining global carbon budget is not significant. We need to reduce annual emissions sharply and quickly if we do not want to spend it in the next 10-14 years.

1.2.2 Meeting national carbon commitments

National commitment

The UK's national commitment is set through the Climate Change Act 2008, which was updated in 2019. It legislates that the UK must be net zero carbon by 2050 and sets a system of carbon budgets to ensure that the UK does not emit more than its allowance in the next 27 years. This legal requirement is underpinned by the Climate Change Committee's report '*Net Zero: The UK's Contribution to Stopping Global Warming*'.

The carbon budget for the UK

The Climate Change Committee have produced a series of five year carbon budgets for the UK. While these are useful and have enabled the Committee to map out a 1.5˚C compliant policy pathway, the budgets are not directly comparable to the IPCC's carbon budgets due to variations in their scope over time.

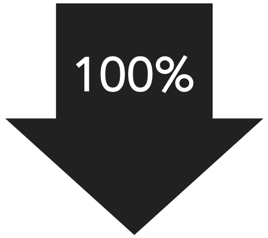
Scaling the global carbon budget to the UK based on population indicates a remaining national carbon budget of 2,080 MtCO_2 as of the start of 2023.

Achieving Net Zero Carbon by 2050

Key measures identified by the Climate Change Committee (CCC) include:

- 100% low carbon electricity by 2050.
- Ultra-efficient new homes and non-domestic buildings.
- Low carbon heat to all but the most difficult to treat buildings.
- Ambitious programme of retrofit of existing buildings.
- Complete electrification of small vehicles.
- Large reduction in waste and zero biodegradable waste to landfill.
- Significant afforestation and restoration of land, including peatland.

The UK Government has committed in June 2019 to Net Zero emissions by 2050



Reduction in CO_2 emissions the UK government is **legally required** to achieve by 2050 over 1990 levels.

250,000 MtCO_2 Global CO_2 budget

2,080 MtCO_2
UK budget (start of 2023)

The UK's remaining carbon budget for limiting warming to under 1.5°C was 2,080 Mt CO2 at the start of 2023, based on scaling the remaining global carbon budget by population. The UK also has a series of five-year carbon budgets set by the CCC, however these are not directly comparable to the figure above as their scope has changed over time.

1.2.3 Current industry definition of Net Zero buildings

Industry definitions of Net Zero Carbon

A significant amount of work has been undertaken since 2019 to define and articulate the requirements of Net Zero carbon buildings. This includes the work undertaken and published by the Climate Change Committee (CCC), the Royal Institute of British Architects (RIBA), the Chartered Institute of Building Services (CIBSE), the UK Green Building Council (UKGBC), the Better Buildings Partnership (BBP), the Passivhaus Trust, the Good Homes Alliance (GHA) and the Low Energy Transformation Initiative (LETI).

Relevant reports and initiatives include:

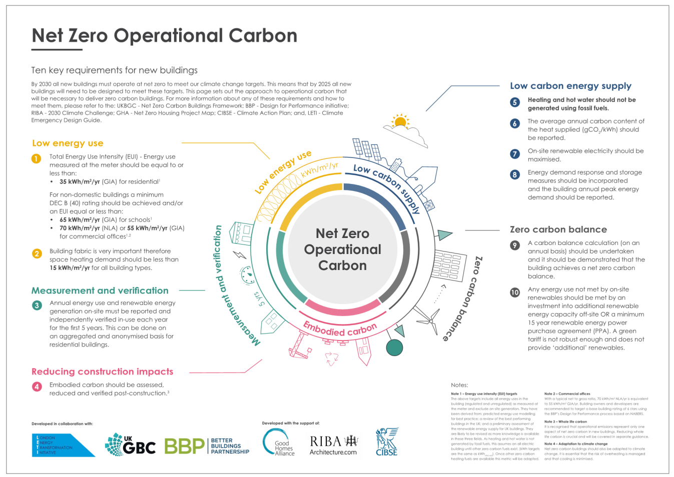
- UKGBC Net Zero Carbon - A framework definition
- LETI Net Zero operational carbon one pager
- LETI Climate Emergency Design Guide
- WLCN - Carbon definitions for the built environment
- RIBA 2030 Climate Challenge.
- NABERS UK
- The Forthcoming UK Net Zero Carbon Buildings Standard

The above documents and guidance are consistent in their approach, and all have similar metrics that include:

- Space Heating Demand (SHD) targets (kWh/m^2/yr)
- Energy Use Intensity (EUI) targets (kWh/m^2/yr)
- Embodied carbon targets kg CO_2/ m^2 either upfront embodied carbon (A1-A5) , lifecycle embodied carbon (A1-C4) or both.

This study uses the current industry definition of Net Zero Carbon (refer to appendix for detailed definition).

Industry publications on Net Zero



Ten key requirements for a Net Zero Operation Carbon - A summary. Developed by UKGBC, LETI and BBP, and supported by the Good Homes Alliance, RIBA and CIBSE.

1.2.4 Net Zero buildings: Breaking it down

A growing evidence base has led to an industry definition

The current definition of a Net Zero Carbon in operation for new buildings has been developed by UKGBC, LETI the UK Net Zero Carbon Buildings Standard and BBP, and supported by the Good Homes Alliance, RIBA and CIBSE. In summary, it needs to achieve a low level of space heating demand and total energy use, cannot use fossil fuels on site and needs to generate renewable energy on-site to match its energy use on an annual basis.

1 - Energy efficiency

Buildings use energy for heating, hot water, ventilation, lighting, cooking, appliances and equipment. All energy use within the building must be considered (not only "regulated" energy use) and need to comply with a maximum value, the Energy Use Intensity (EUI) which varies depending on the building type and represents 'delivered energy' generally.

2 - Low carbon heat

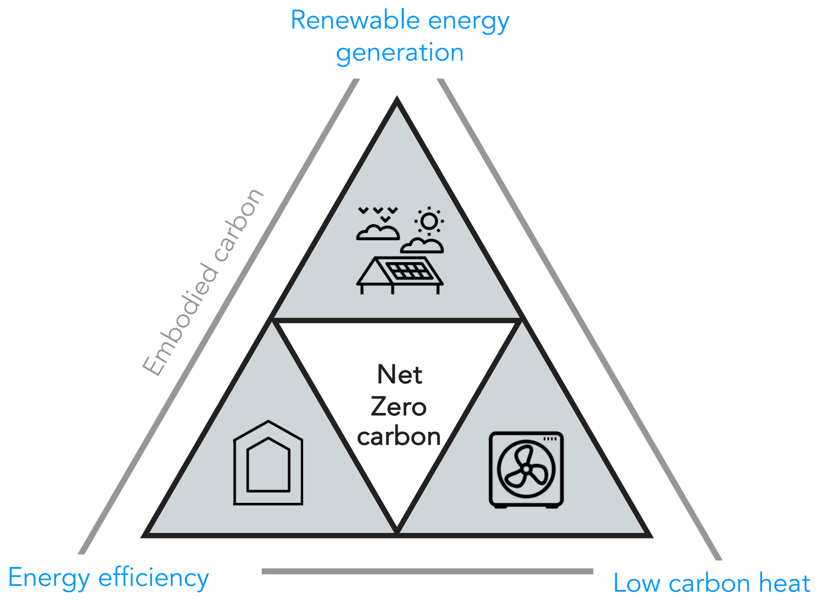
Low carbon heat is an essential feature of Net Zero Carbon buildings. All new buildings should be built with a low carbon heating system and must not connect to the gas network or, more generally, use fossil fuels on-site.

3 - Renewable energy generation

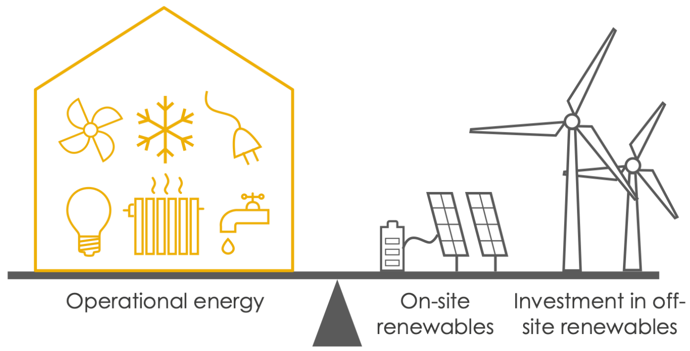
New buildings should seek to add at least as much renewable energy generation to the energy system as the energy they will use in an annual basis. In Surrey, solar photovoltaic (PV) panels will be the renewable energy system to deliver this objective.

4 - Embodied carbon

Operational carbon is only part of the story. Net Zero Carbon buildings should also minimise embodied carbon in materials and their impact throughout their lifecycle, including demolition.



For the Climate Change Committee, energy efficiency and low carbon heat represent two key pillars of future buildings compliant with our climate change commitments



Net zero operational balance

Renewable energy should be provided to achieve an operational "energy balance" – the amount of energy generated in one year should be equal to or more than the energy used in a year. Off-site provision can be considered where it is not possible to provide energy on-site.
© LETI

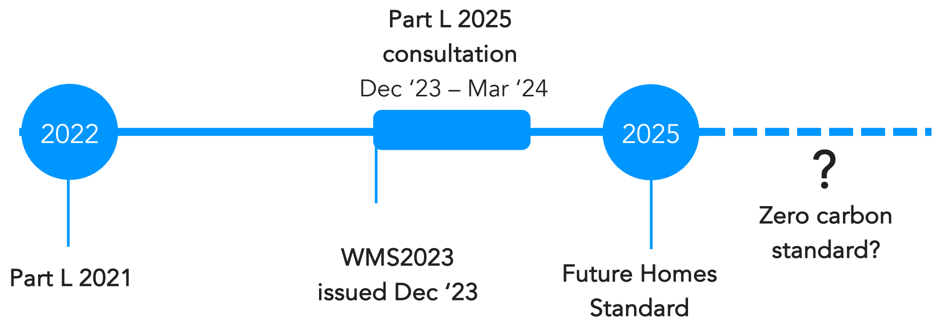
1.2.5 The building regulations landscape

Updates to Part L of the Building Regulations

Part L of the building regulations set the minimum standards for energy and carbon performance of new buildings.

The government is currently consulting on Part L 2025 (commonly known at the Future Homes Standard) and the Home Energy Model (the methodology for determining compliance with it). This is expected to be released in 2025, although no date has been confirmed and it is quite possible that it will be later than this). When the Future Homes Standard comes into operation it will replace Part L 2021, and the Home Energy Model will replace the Standard Assessment Procedure (SAP) – the methodology currently used to determine compliance with Part L of the building regulations for dwellings.

Since we are in a consultation period, we do not know with any certainty the details of the Future Homes Standard, the Future Buildings Standard or the methodologies for determining compliance with them.



Policy changes are moving towards zero carbon, however there is much uncertainty surrounding the details. At the time of producing this Viability Toolkit for Surrey (Jan-March 2024) the consultation for the next version of the building regulations Part L is underway.

1.2.6 The ability of Local Authorities s to set their own energy & carbon requirements 2008-2023

The role of local authorities in mitigating climate change in the UK and what they have been encouraged and allowed to do has changed over the years. Three distinct phases can be noted.

2008-2014: the realisation that the planning system has a key role to play to mitigate climate change

- The **Planning and Compulsory Purchase Act 2004** requires the local plan to ensure that development and use of land contribute to mitigation of climate change.
- The **Climate Change Act 2008** sets a clear direction for the UK. It obliges the government to set policy that will enable the UK to meet its carbon budgets.
- The **Planning and Energy Act 2008** empowers local plans to set "*reasonable requirements*" for new buildings to comply with "*energy efficiency standards that exceed … building regulations*" and "*supply a proportion of their energy from nearby renewable or low carbon sources*".

2015-2019: deregulation and the misguided reliance on ambitious national standards

The **Deregulation Act 2015** was intended to dis-apply s.1(c) of the Planning and Energy Act to dwellings removing the ability of LPAs to impose local requirements above building regulations on energy efficiency standards. However, this has not been brought into force.

On 25th March 2015, a **Written Ministerial Statement (WMS)** sought to limit the freedom of LPAs to set their own standards until the introduction of zero carbon homes policy late in 2016. Until then LPAs were expected not to set conditions with requirements above CfSH level 4 (i.e. 19% improvement over Part L).

However, there has been no adoption of a zero carbon homes policy at a national level.

Since 2019: the turning point of Net Zero

Further to a special report completed by the Climate Change Committee, the **Climate Change Act** was updated in 2019: the overall greenhouse gas reduction was changed from an 80% reduction to a 100% reduction by 2050, i.e. Net Zero.

At the same time, a very large number of local authorities declared a **climate and ecological emergency**.

An updated **NPPF** (National Planning Policy Framework) (2021) now expects the planning system to contribute to a "*radical reduction in greenhouse gas emissions*" (Para 148) and requires LPAs to take a proactive approach (Para 149). Further, the Government has confirmed that the Planning and Energy Act 2008 will not be amended. **The result of all this is that Councils are able to set local energy efficiency standards without falling foul of Government policy.** This has been confirmed by recent Planning Inspector reports (e.g. Dec 2022 for B&NES Council and Jan 2023 for Cornwall Council) which indicate that the WMS of 25 March 2015 is of limited relevance and that it has been superseded by subsequent events.

It should also be noted that in their **response to the Future Homes Standard consultation** in 2021, the Government stated the following:

"All levels of Government have a role to play in meeting the net zero target and local councils have been excellent advocates of the importance of taking action to tackle climate change. Local authorities have a unique combination of powers, assets, access to funding, local knowledge, relationships with key stakeholders and democratic accountability."

December 2023: A new Written Ministerial Statement aiming to constrain local authorities in setting their own standards

On 13th December 2023 a new Written Ministerial Statement (WMS) was issued on the topic of "Planning – Local Energy Efficiency Standards". This new, important WMS is discussed in depth on the following page.

1.2.7 Written Ministerial Statement on Energy Efficiency 2023 (WMS2023)

On 13th December 2023 a new Written Ministerial Statement (WMS) was issued on the topic of "Planning – Local Energy Efficiency Standards".

The new WMS sets out to constrain the ability for local authorities to set their own standards, but it does not remove them. The constraints include:

1) Energy efficiency policies must be expressed as a % reduction on a dwelling's TER (Target Emissions Rate) as defined by the Building Regulations and calculated using a specified version of SAP (Standard Assessment Procedure, the assessment methodology for calculating energy and carbon emissions for Building Regulations).
2) Policies must be applied flexibly "where the applicant can demonstrate that meeting the higher standards is not technically feasible, in relation to the availability of appropriate local energy infrastructure … and access to adequate supply chains."

What does the WMS2023 mean for local plans?

The WMS only relates to *energy efficiency* policies, and **not** policies on renewable energy, embodied carbon or overall carbon emissions.

It seeks to affect how a local plan can exercise its power to require energy efficiency standards beyond those of building regulations (a power granted by the Energy & Planning Act 2008).

However, the weight that should be given to the WMS2023 is under question as illustrated by the open legal advice given to Essex, and the legal challenge to the WMS, both detailed on the right. Local authorities have a legal duty to mitigate climate change (Planning & Compulsory Act 2004) and there is an expectation laid on them to support "radical reductions in greenhouse gas emissions … [taking] a proactive approach … in line with the objectives and provisions of the Climate Change Act 2008" (National Planning Policy Framework).

A barrister's legal interpretation of the WMS2023

Estelle Dehon KC of Cornerstone Barristers has provided advice to Essex County Council and Essex Climate Action Commission on the ability of local authorities to set local plan policies mandating energy efficiency standards that exceed those in the building regulations Part L. This advice has been made available to all in an open document published on Essex County Council's website[1].

Extracts from the conclusions of the advice are reproduced below:

"LPAs have a statutory authority to set energy efficiency targets that exceed the baseline in national Building Regulations, and to mandate that a proportion of energy used in development in their area be from renewable and/or low carbon sources in the locality of the development.

"This position has not been changed by the WMS2023"

"The WMS2023 must be interpreted in a way that:

- Allows for the effective operation of the PEA 2008 powers, and;

- allows LPAs effectively to meet the obligation on them to ensure development plan documents designed to secure that development of land in the local authority's area "*contribute to the mitigation of, and adaptation to, climate change*."

"This means that the 2023 WMS cannot be interpreted to prevent LPAs from putting forward, and planning inspectors from finding sound, policies which are justified and evidenced and which use metrics other than the TER metrics other than the TER metric and/or do not require calculation by SAP."

A legal challenge to the WMS2023

In April 2024 the High Court has recently allowed a judicial review of the WMS 2023 which the claimant, NGO Rights: Community: Action alleges is unlawful. The hearing date has been set for June 2024. This document was written in April 2024 and therefore the results of the judicial review are not yet known.

1https://www.essexdesignguide.co.uk/climate-change/essex-net-zero-evidence/essex-open-legal-advice-energy-policy-and-building-regulations/

1.3

New buildings: strategic planning policy options

1.3 New buildings: strategic planning policy options for London Boroughs

Contents

1.3.1 New buildings: exploring two different strategic options

Adapting the current system or changing it?

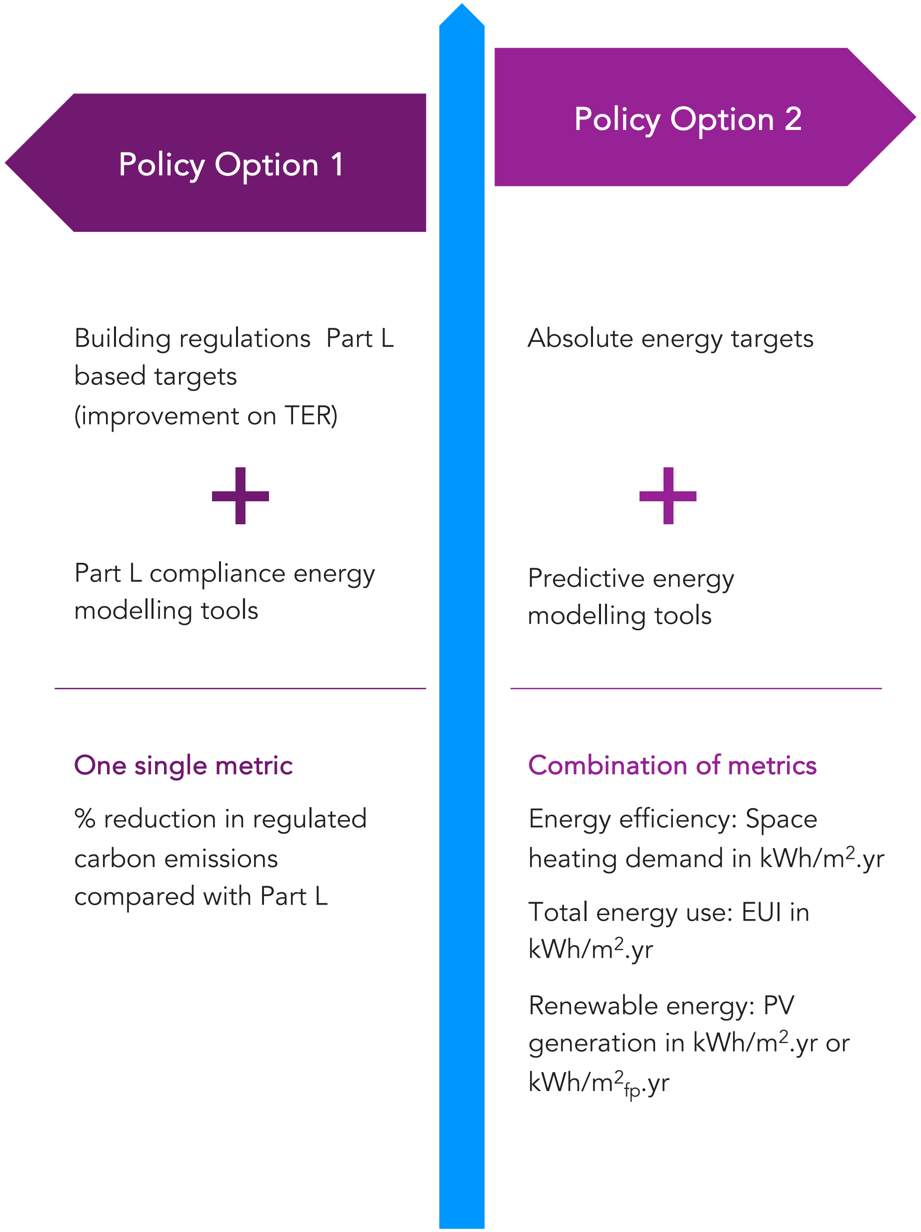
This evidence base study will explore the two broad policy options for local authorities wishing to translate their climate ambitions into requirements for new buildings in the county have the choice between two different strategic directions:

- **Policy Route 1 uses the building regulations framework - setting % improvements over the Target Emissions Rate (TER).** This system requires the applicant to use a Part L energy modelling software, and performance is measured against a single metric (i.e. % reduction in regulated carbon emissions). This metric cannot be measured at a post-occupancy stage.
- **Policy option 2 is a relatively new system focusing on absolute energy-based metrics**. This system requires the applicant to use predictive energy modelling tools and methodologies. Performance is measured against a number of metrics (e.g. space heating demand, Energy Use Intensity), A significant advantage of the Energy Use Intensity (EUI) is that it can be measured post-occupancy as it generally aligns with 'energy at the meter'. Many other local authorities have recently adopted, or are in the process of adopting, policies aligned with this option.

Some recent successfully adopted local plans have taken Policy option 2:

- Cornwall Council
- Bath and North East Somerset Council
- Central Lincolnshire Council.

There are several other local authorities that are intending to follow the same route, including: Greater Cambridge; Bristol City Council; Leeds City Council; Winchester, Uttlesford and South Oxfordshire and Vale.



Two types of approach are possible to go beyond the requirements of Part L 2021

1.3.2 Policy option 1 vs Policy option 2 I At a glance comparison

	Policy Route 1	Policy Route 2
Metrics used	Target Emissions Rate (TER) (CO_2) The TER is a relative metric, it will change from building to building. And for the same building, will change from one revision of Part L to the next. It does not predict actual CO_2 emissions (or energy use).	Absolute energy metrics: • Space Heating Demand (kWh/m^2/yr) • Energy Use Intensity (kWh/m^2/yr) • Renewable Energy generation (kWh/m^2/yr)
Definition of "net zero"	100% reduction on the Target Emissions Rate (TER)	Energy balance (annual energy consumption = annual renewable energy generation).
Regulated energy included?	• space heating - ✓ • hot water ✓ • pumps and fans ✓ • Lighting ✓	• space heating ✓ • hot water ✓ • pumps and fans ✓ • Lighting ✓
Unregulated energy included?	• Cooking ✕ • Appliances ✕ Unregulated energy can account for 50% of energy in low-energy dwellings.	• Cooking ✓ • Appliances ✓
Renewable energy included?	Yes. Renewable energy is accounted for in the calculations. Carbon savings are rolled into one metric so it is not possible to see what contribution renewable energy is making.	Yes. Renewable energy generation has its own metric so it is clear to see what contribution is being made.
Embodied carbon included?	Additional policy mechanism required.	Additional policy mechanism required.
Calculation methodologies	Calculation through compliance tools: • Building regulations Standard Assessment Procedure (SAP) for dwellings. • Building regulations National Calculation Methodology (NCM) for non-dwellings.	Calculation through design tools: • PassivHaus Planning Package (PHPP) for dwellings. • TM54 or Dynamic Simulation for non-dwellings.
Aligned with national policy?	Yes.	Not yet.
Does it promote good building design?	No. The benefits of building design and orientation is not captured in building regulations assessment methodologies.	Yes. The significant impacts that building design and orientation have on energy use are captured through the space heating demand metric and the use of accurate calculation methodologies.
Can it be verified or measured in operation?	No. Abstract metrics and only accounting for regulated energy means that this does not be checked in operation.	Yes. The EUI can be calculated by reading the energy used at the main electricity meter and dividing it by the floor area of the building.

1.3.3 Policy option 2 | Absolute energy performance targets

Policy option 2 for Surrey's districts and boroughs is to introduce a Net Zero Carbon building policy in line with the emerging industry definition of Net Zero Carbon new buildings. This would require the introduction of the following requirements and energy performance metrics.

1. **No fossil fuels on-site**
   This would be consistent with the GLA's Accelerated Green Pathway which relies on banning new gas boilers.
2. **Space heating demand** (e.g. <15-20 kWh/m^2.yr).
   This would be consistent with the CCC's recommendations[1].
3. **Energy use intensity (EUI)** (e.g. <35 kWh/m^2.yr for domestic).
   This would be consistent with the current industry definition of Net Zero carbon new buildings in operation.
4. **Renewable energy generation** (e.g. to match the EUI or >100 kWh/m$^2_{footprint}$.yr). This would incentivise more renewable energy generation on new buildings and a balance with energy use.
5. **Upfront embodied carbon**
   This is not covered by this report but should become a policy.

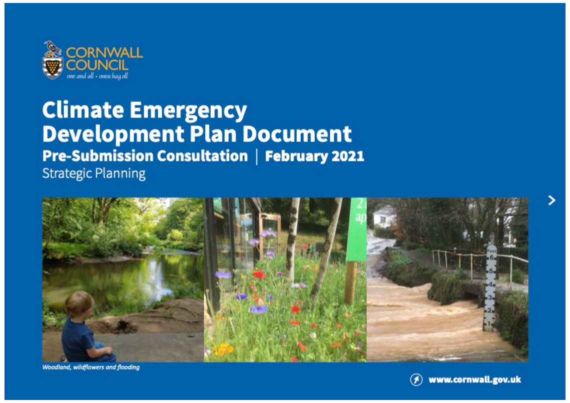
Local authorities using absolute energy performance targets

The list below includes the names of local authorities which have already published proposed policies consistent with option 2 above: Cornwall Council (Climate Emergency DPD), Bath & North East Somerset Council (Local Plan), London Borough of Newham (Local Plan), Greater Cambridge (Local Plan), Central Lincolnshire (Local Plan) London Borough of Merton, from 2025 (Local Plan).

GLA energy guidance (2022) and energy-based metrics

The GLA now requires applicants to report the Energy Use Intensity (EUI) and space heating demand of the development.

Evidence base for the London Borough of Newham's new Local Plan
https://www.newham.gov.uk/planning-development-conservation/newham-local-plan-refresh/4



Left) Cornwall Council Climate Emergency DPD and associated evidence base
https://www.cornwall.gov.uk/planning-and-building-control/planning-policy/adopted-plans/climate-emergency-development-plan-document/

(Right) Greater Cambridge New Local Plan
https://consultations.greatercambridgeplanning.org

[1] *See the report 'The Future of Housing', Climate Change Committee, 2019*

[2] *See 2022 Energy Assessment guidance item 1.7*

1.3.4 Policy option 2 | The metrics explained

Space heating demand

Space heating demand measures the amount of energy needed to heat a home or building. A space heating demand policy mandates a minimum level energy efficiency of the building fabric. It is affected by form, exposure, air-tightness, orientation as well as the insulation and window selection. It is independent of which heating system is used, but the type of ventilation system used will impact it. The Climate Change Committee recommends a space heating demand of less than 15-20 kWh/m^2/yr for new homes.

Energy Use Intensity (EUI)

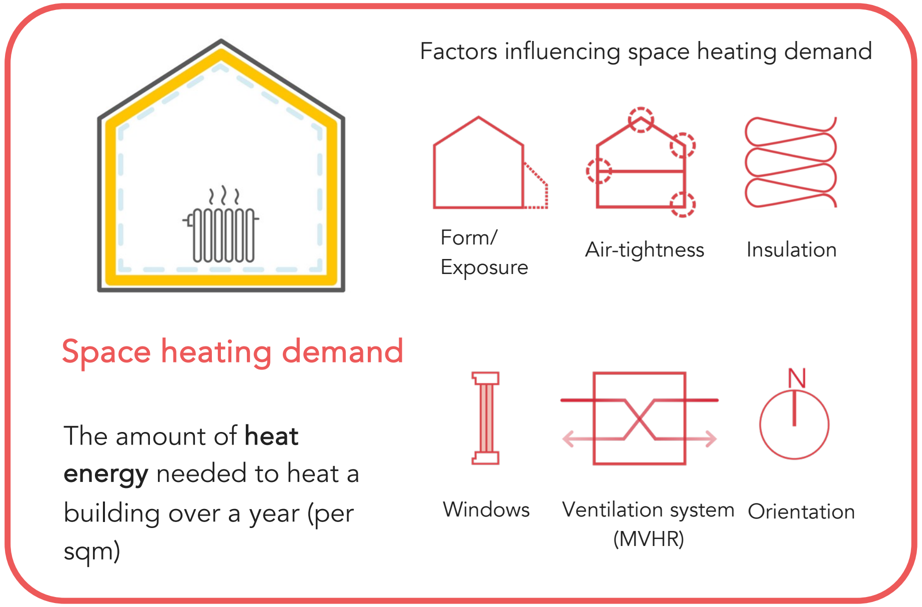
The Energy Use Intensity (EUI) represents the total amount of energy used by a building divided by its floor area (GIA). It is reported in kWh/m^2.year. It is very easy to check in operation: it will be the annual 'energy at the meter' divided by the floor area.

For communally heated dwellings/buildings heat 'at the meter' will need to be converted to heat energy (further information on this is provided later in the report).

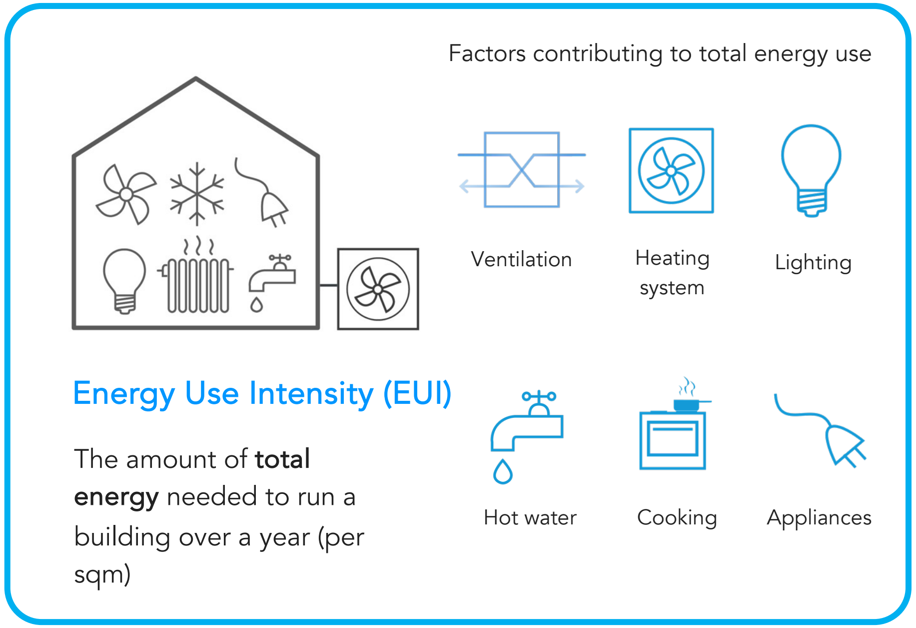
Renewable energy

A renewable energy balance is achieved when a building generates the same amount of renewable energy over the course of a year as it uses in a year. It is reported in kWh/m2(GIA)/yr. This will require a certain amount of installed renewable energy generation (usually photovoltaics). The more energy efficient the building, the less renewable energy is required to achieve an annual energy balance. A renewable energy balance is possible for buildings of 4 or even 5 storeys providing they have been designed efficiently and with maximum renewable energy generation in mind.

In the summer months these buildings will likely net exporters of renewable energy to the national grid. In winter months they will likely be net importers of renewable energy. In this way buildings can become an important part of the continued decarbonization of our electricity grid.



The space heating demand metric



The Energy Use Intensity (EUI) metric

1.3.5 Policy option 1: a TER based approach | How does it work?

The same approach as building regulations (Part L)

Policy option 1 uses the Part L calculation use to demonstrate compliance with building regulations.

To pass building regulations, a dwelling or building must demonstrate at least the same carbon performance to that of the "notional building".

The notional building's carbon performance is expressed as a metric called the Target Emissions Rate (TER). The new dwelling or building's carbon performance is expressed as the Dwelling Emission Rate (DER) or the Building Emissions Rate (BER).

For policy purposes, the difference between the two can be expressed as a % improvement or reduction. 0% improvement = just compliant with building regulations).

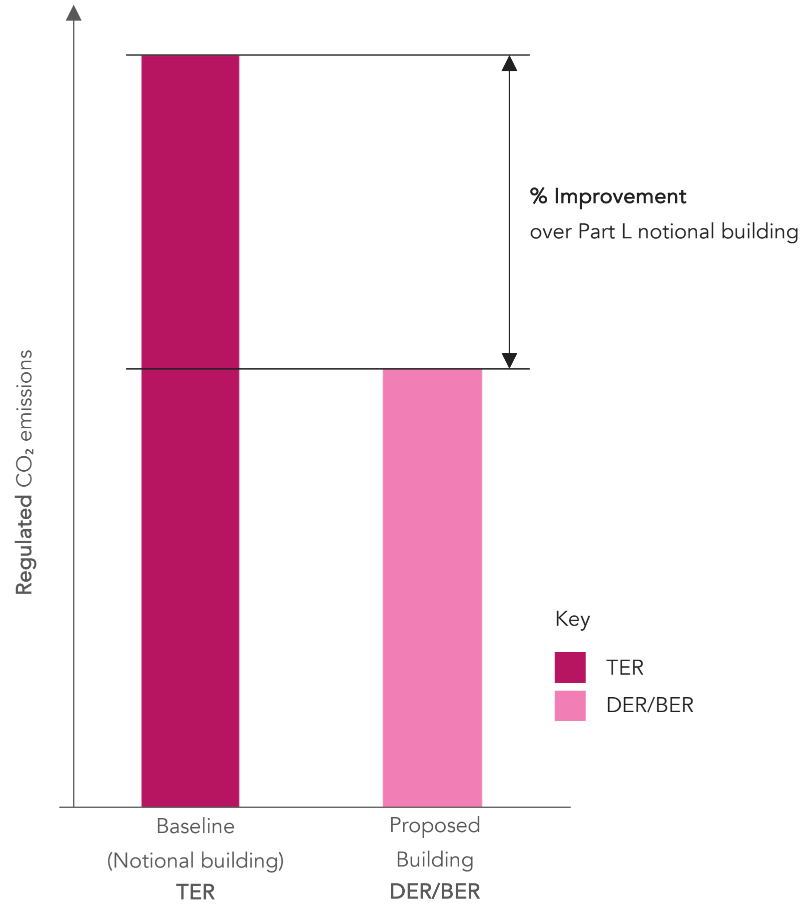
What is the 'notional' building?

The notional building has the same size, shape, orientation and up to a point, glazing proportions as the proposed building. In domestic developments, the notional building's fabric and services specifications are standardised and defined by the Part L notional dwelling specification.

The notional building specification changes from one version of Part L to the next – so the TER (and hence % improvements) cannot be compared between Part L 2013 and Part L 2021. Similarly, the DER and BER cannot be compared from one version of Part L to the next because the calculation methodologies change.

The calculation methodology was formulated primarily for compliance, and not determining accurate energy or CO_2 emissions predictions.

(Note, for non-domestic developments, the fabric specifications are also standardised, however the services specifications change according to the proposed building's services).



The key metric in Policy option 1 is the % reduction in regulated carbon emissions against baseline, represented by the notional building, an 'equivalent building' with the same size and shape but with standardised proportions of windows and specifications.

The percentage improvement is calculated according to the formula below:

$$\frac{(TER) - (DER/BER)}{(TER)} \times 100\%$$

1.3.6 Key difference 1 I A relative target (Policy option 1) or Absolute target (Policy option 2)

Validating performance against the targets

Policy option 1 is based on a required improvement over compliance with building regulations, determined using a baseline: the 'notional building'. The notional building has the same shape, orientation and, up to a point, the same glazing proportions as the actual proposed building design. For clarity, the notional building is fictional and is created by the compliance software only for building regulations purposes. The % improvement over a notional building is an intangible requirement that cannot be measured, whereas an absolute energy use target in kWh/m^2.yr (as per Policy option 2) can be checked against metered energy in the occupied building. This makes post-construction verification and learning from a feedback loop easier with the absolute target.

Incentivising better design

Improving the design of a building by reducing the extent of heat loss areas, the number of junctions, and by optimising elevation design are widely considered as essential components of an energy efficient design. However, comparing a development to its own notional building (Policy option 1) essentially neutralises the benefit of these measures and moreover does not penalise inefficient building designs. With an absolute target (Policy option 2), the benefits (or penalty) of changes to the building form and design are assessed and good design practice is rewarded.

Additional issues with changing carbon and primary energy factors

Policy option 1 relies on carbon emission factors and primary energy factors that introduce additional complexity.

Compliance with energy use metrics (Policy option 2) is only affected by changes in building design, and not by these wider 'system factors'.

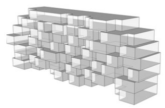
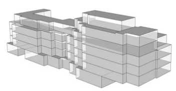
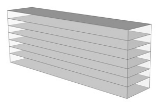
%
improvement over notional building

- ✗ Is not a 'physical' metric
- ✗ Is a concept only experts can understand
- ✗ Cannot be checked during operation
- ✗ Cannot be used to 'close the loop' and improve the system over time
- ✗ Does not reward good design e.g. form

kWh/m^2/yr
at the meter (EUI)

- ✓ Is a 'physical' metric which can be measured
- ✓ Can be understood by all professionals, and most consumers
- ✓ Can be checked against in-use data

The relative metric used by Policy option 1 (i.e. % improvement over Part L) has a number of unintended consequences which hinder the continuous improvement of building design, consumer trust and performance outcomes.

		Improvement over Part L (%) SAP	Space heating demand (kWh/m^2/yr) SAP	Space heating demand (kWh/m^2/yr) PHPP
High form factor		35%	18	26
Medium form factor		35%	15	20
Low form factor		37%	11	13

A more efficient form is important for low energy buildings, but it is not rewarded by the notional building approach: with similar specifications (e.g. U-values) the performance against Part L (%) calculated by SAP for the three buildings above is broadly similar despite the fact that space heating demand is much smaller with a more efficient design.

1.3.7 Key difference 2 I A single metric (Policy option 1) or a suite of metrics (Policy option 2)

A single metric for policy option 1

Policy option 1 uses a single performance metric: the reduction in regulated carbon emissions over the building regulations Part L limit expressed as a percentage (e.g. 35% better than Part L 2021). This amalgamates into one metric the building's efforts in terms of energy efficiency, low carbon heat and renewable energy generation.

A suite of metrics for policy option 2

Policy option 2 uses a set of metrics to separately measure each of the key attributes needed to achieve Net Zero:

- Space heating demand (kWh/m^2.yr) for energy efficiency
- Gas use (yes/no) for low carbon heat
- EUI (kWh/m^2.yr) for energy efficiency (including system efficiencies)
- Energy balance (kWh/m^2.yr) or total renewable energy generated ((kWh/m$^2_{fp}$.yr) for renewable energy generation.

Why a suite of metrics can be better for Net Zero?

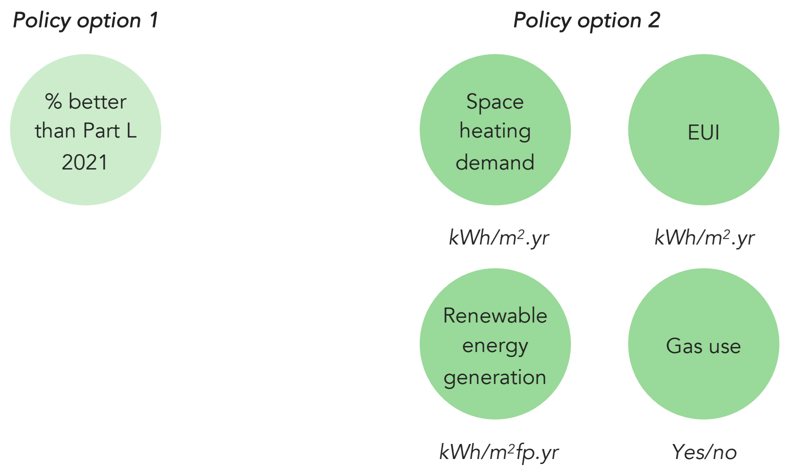
Having a dedicated metric per key objective (e.g. space heating demand for fabric energy efficiency) helps to deliver a minimum or threshold performance for each objective. This avoids 'trading' between the different objectives and recognises each as being essential components of a Net Zero Carbon new building.

Energy, not CO_2, is the best metric

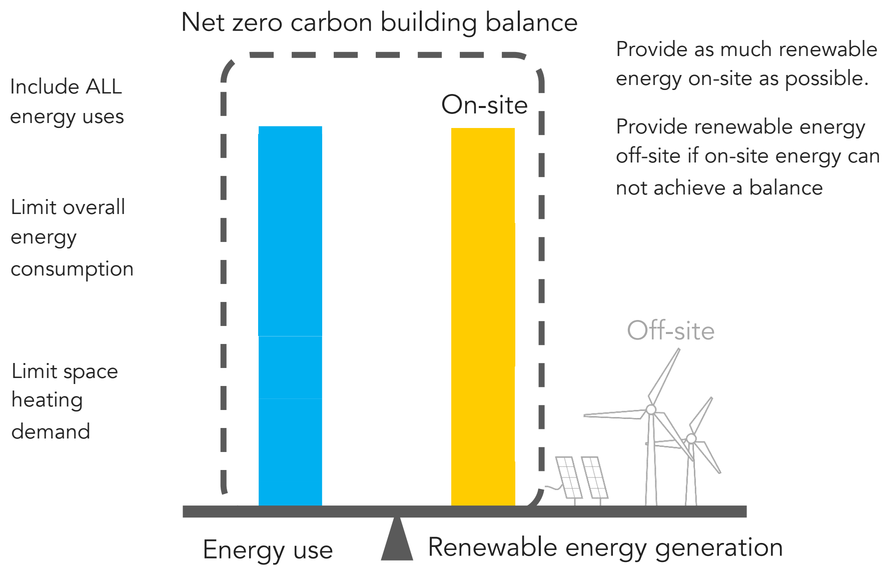
As the grid decarbonises, there is a real risk that looking only at the carbon emissions will dilute the differences between buildings. A move towards energy metrics would ensure the ability to distinguish and support good building design is maintained.

Regulated energy or total energy

Policy option 1 does not include CO_2 emissions from equipment and appliances. This represents approximately 50% of energy use in a low energy home.



Key metrics used in Policy options 1 and 2



How energy metrics help to deliver zero carbon buildings. The goal is simple and tangible – to achieve a balance between energy use and renewable energy generation on-site. The definition also includes the requirement to limit the energy required for space heating and limit overall energy use, which reduces the amount of renewable energy needed on-site.

1.3.8 Key difference 3 | Part L energy modelling (Policy option 1) or Predictive energy modelling (Policy option 2)

Part L modelling for Policy option 1

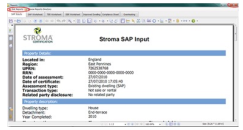
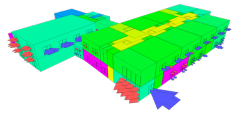
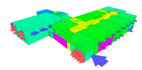
SAP (domestic) and the National Calculation Methodology (NCM) (non domestic) are the calculation methodologies used to demonstrate compliance with Part L of the Building Regulations. SAP (Standard Assessment Procedure) is used through the associated SAP software and the NCM and (National Calculation Methodology) through SBEM and Dynamic Simulation Modelling (DSM) tools. Policy option 1 relies on the same tool.

However, until now, these Part L energy assessment methodologies were developed only to check compliance with Building Regulations. They were never meant to perform key functions that are required to deliver Net Zero carbon buildings, and most importantly they were not meant to predict future energy use accurately. This is a widely accepted fact in the industry which all stakeholders agree with.

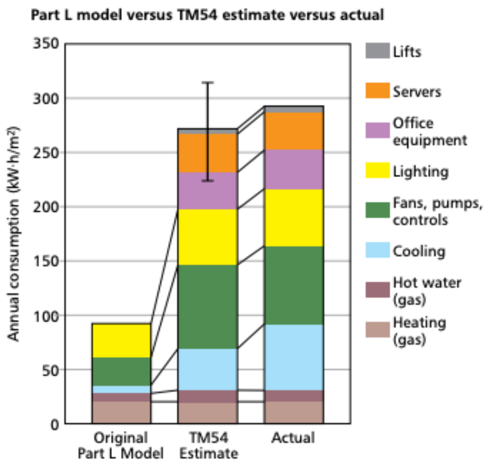
It seems that when these tools were first mandated to be used at planning stage, approximately 15 years ago, it was to minimise the burden on applicants. A different and better type of energy modelling may be required if Net Zero Carbon buildings are to be delivered.

Predictive energy modelling for Policy option 2

The accuracy of energy modelling is important to ensure it provides a reasonable indication of future energy use. While behaviour of the users may vary once a building is occupied, predictive energy modelling can be used to reliably estimate energy use and to drive suitable design and construction decisions. For domestic buildings, the PHPP methodology and excel based tool have been shown to predict energy use much more accurately than the current version of SAP. For non domestic buildings, predictive energy modelling using the methodology set out in CIBSE Technical Memorandum 54 (TM54) allows estimation of the operational energy for all end uses of a building. IESVE, TAS and PHPP are three energy modelling packages that can be used to carry out TM54 assessments.

	Part L modelling	Predicted energy use modelling
Domestic	 SAP (Part L1A)	 PHPP
Non-domestic	 NCM (Part L2A)	  PHPP or DSM (TM54)

There is a significant difference between Part L modelling currently used to demonstrate compliance with planning policy and predicted energy use modelling.



In the UK, energy models are used at the design stage to compare design options and to check compliance with Building Regulations. ***These energy models are not intended as predictions of energy use, but are sometimes mistakenly used as such.***

In some other countries, total energy use at the design stage is estimated through voluntary standards. For example, the Australian NABERS (a building rating system) encourages the estimation of energy use at the design stage and provides guidance for designers/modellers.

Extracts of CIBSE Technical Memorandum 54 (TM54): Evaluating operational energy performance of buildings at the design stage

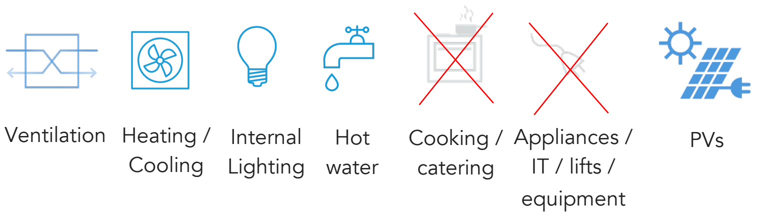
1.3.9 Key difference 3 | Part L energy modelling (Policy option 1) or Predictive energy modelling (Policy option 2)

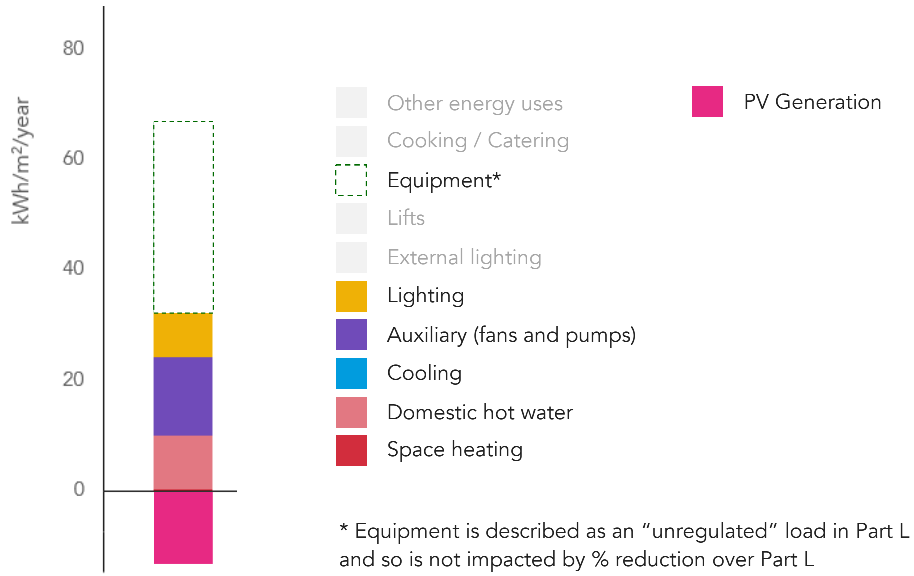
Policy Option 1

Part L compliance energy modelling

Energy use

Renewable generation

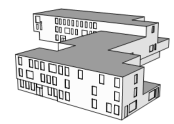




Energy uses assessed by a typical Part L compliance energy model

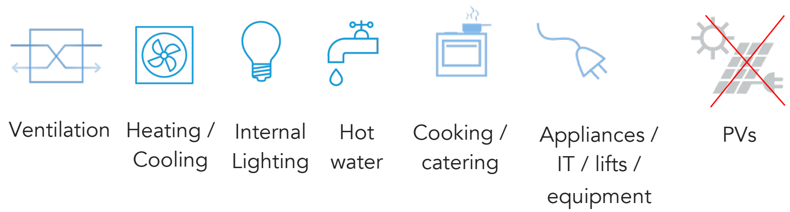
Policy Option 2

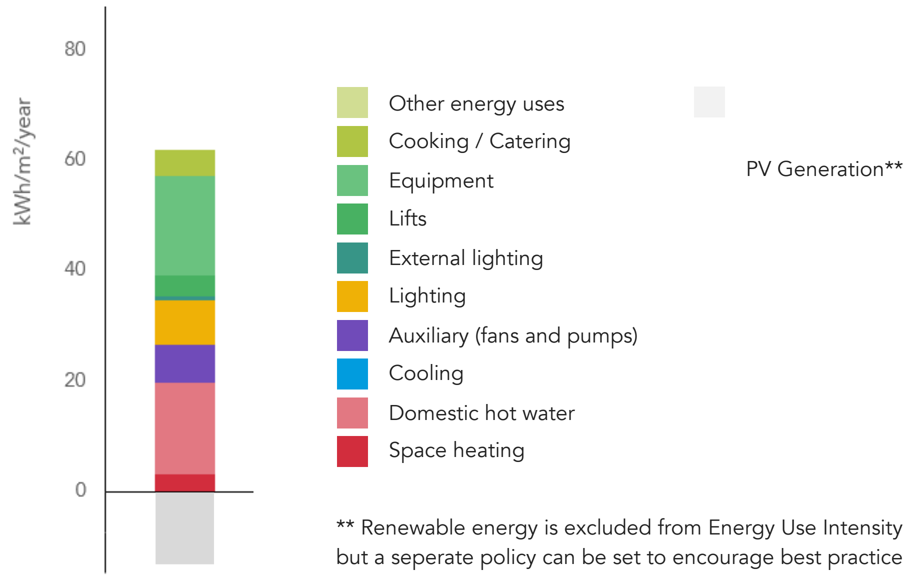
Predictive energy modelling



Energy use

Renewable generation





Energy uses assessed by a typical predictive energy model

Note: *the Part L softwares can assess unregulated energy use and this assessment can be used for 'be seen'. However, this is a standard assessment which does not reflect the actual building. And as it is not taken into account in any Part L / policy / Be seen target there is no incentive to reduce it.*

1.3.10 Case study 2 | Bath & North East Somerset | Policy and extracts of the Planning Inspector's report

Bath and North East Somerset adopted their new policy in January 2023, becoming the first council in England to successfully adopt an energy-based net zero housing policy as part of its commitment to tackling the climate emergency.

"The new housing development policy will ensure the energy use of any proposed development is measured and meets a specified target — setting a limit on the total energy use and demand for space heating. It will also require sufficient on-site renewable energy generation to match the total energy consumption of the buildings — ensuring the development is 100% self-sufficient.

The council will also impose net zero operational carbon standards for new major non-residential development.

The policy is the first new housing policy to be net-zero aligned based on 2030 trajectories of industry-leading organisations such as the London Energy Transformation Initiative (LETI), the Royal Institute of British Architects (RIBA) and the Chartered Institute of Building Services Engineers (CIBSE)."

Source: B&NES Council's website

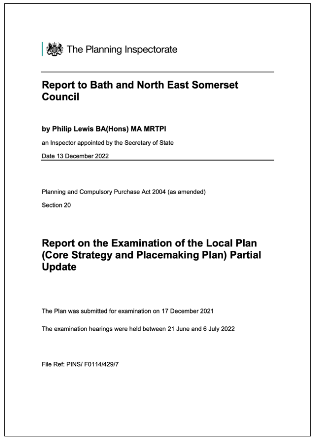
Policy SCR6 - New Build Residential

New build residential development will be required to meet the standards set out below.

New build residential development will aim to achieve zero operational emissions by reducing heat and power demand then supplying all energy demand through onsite renewables. Through the submission of an appropriate energy assessment, having regard to the Sustainable Construction Checklist SPD, proposed new residential development will demonstrate the following:

- **Space heating demand less than 30kWh/m^2/annum;**
- **Total energy use less than 40kWh/m^2/annum; and**
- **On site renewable energy generation to match the total energy use, with a preference for roof mounted solar PV**
- **Connection to a low- or zero-carbon district heating network where available**

Net Zero policy adopted by Bath & North East Somerset Council based on energy metrics



The Planning Inspectorate

Report to Bath and North East Somerset Council

by Philip Lewis BA(Hons) MA MRTPI

an Inspector appointed by the Secretary of State

Date 13 December 2022

Planning and Compulsory Purchase Act 2004 (as amended)

Section 20

Report on the Examination of the Local Plan (Core Strategy and Placemaking Plan) Partial Update

The Plan was submitted for examination on 17 December 2021

The examination hearings were held between 21 June and 6 July 2022

File Ref: PINS/ F0114/429/7

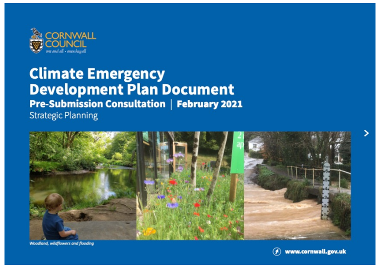
Selected extracts of the Planning Inspector's report on the examination of B&NES's Local Plan partial update (December 2022)

79. Policy SCR6 is concerned with sustainable construction for new residential buildings, aiming to achieve zero operational emissions by reducing heat and power demand and supplying all energy demand through onsite renewables. The Policy includes ***limits on space heating and total energy use****, taking an* ***energy based approach****, rather than being based upon carbon reduction as per the Building Regulations. The approach taken in the Plan to energy usage applies to* ***both regulated and non-regulated energy use****, which is a further difference to that taken in the Building Regulations which are concerned only with regulated energy use.*

85. I therefore consider that the relevance of the WMS 2015 to assessing the soundness of the Policy has been reduced significantly. […] For the reasons set out, that whilst I give the WMS 2015 some weight, any inconsistency with it, given that it has been overtaken by events, does not lead me to conclude that Policy SCR6 is unsound, nor inconsistent with relevant national policies.

86. ***I am satisfied that the energy efficiency standards set out in Policy SCR6 are justified and that they would not threaten deliverability or viability of housing development***

1.3.11 Case study 1 | Cornwall Council | Policies and extracts of the Planning Inspector's report



Net Zero policy adopted by Cornwall Council based on energy metrics

Policy SEC1 – Sustainable Energy and Construction

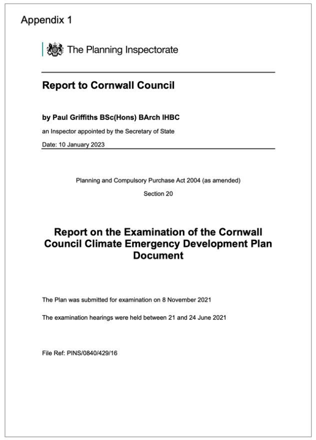
Development proposals will be required to demonstrate how they have implemented the principles and requirements set out in the policy below.

2b. New Development – Residential

Residential development proposals will be required to achieve Net Zero Carbon and submit an 'Energy and Carbon Statement' that demonstrates how the proposal will achieve:

- Space heating demand less than 30kWh/m2/annum;
- Total energy use less than 40kWh/m2/annum; and
- On-site renewable generation to match the total energy use, with a preference for roof mounted solar PV.

Where the use of onsite renewables to match total energy consumption is demonstrated to be not technically feasible (for example with apartments) or economically viable, renewable energy generation should be maximised as much as possible; and/or connection to an existing or proposed district energy network; or where this is not possible the residual carbon offset by a contribution to Cornwall Council's offset fund.



Appendix 1

The Planning Inspectorate

Report to Cornwall Council

by Paul Griffiths BSc(Hons) BArch IHBC

an Inspector appointed by the Secretary of State

Date: 10 January 2023

Planning and Compulsory Purchase Act 2004 (as amended)

Section 20

Report on the Examination of the Cornwall Council Climate Emergency Development Plan Document

The Plan was submitted for examination on 8 November 2021

The examination hearings were held between 21 and 24 June 2021

File Ref: PINS/0840/429/16

Selected extracts of the Planning Inspector's report on the examination of Cornwall Council's Climate Emergency Development Plan Document (January 2023)

Cornwall Council's Climate Emergency DPD has successfully completed the examination process in January 2023.

Relevant extracts of the Planning Inspector's report include the following:

172. […] the Plan requires residential development proposals to achieve net zero carbon with applications to be accompanied by an Energy and Carbon Statement demonstrating how the proposal will achieve: space heating demand of less that 30kWh per square metre per annum; total energy consumption of less than 40kWh per square metre per annum; and on-site renewable energy generation to match the total energy consumption with roof mounted solar PV as a preference. It goes on to say that where meeting onsite energy demands through renewables is not possible on-site technically, or not viable, renewable energy generation on-site should be maximised and/or a connection to an existing or proposed District Heating Network facilitated. If this is not possible, then the residual carbon should be offset through a contribution to Cornwall Council's offset fund.

*174. Broadly, as set out above, **this approach is soundly based and justified**. There is however a need to make some parts of these requirements more transparent given that the policy is aimed at energy use, not carbon emissions. First, given the approach taken the initial part of this policy element needs to say that what is required is an Energy Statement rather than an Energy and Carbon Statement. Second, and linked to that point, it needs to set out that it is the residual energy that must be offset by a contribution rather than the residual carbon. These changes are needed to make the policy effective.*

Conclusion

*182. With these MMs, my view is that **the requirements of Policy SEC1 are acceptable in the light of what the Plan aims to achieve**.*

2.0

Residential energy and cost modelling

2.1

Residential buildings

Energy and cost modelling:

Methodology, typologies and specifications

2.1 Residential buildings Energy and cost modelling: Methodology, typologies and specifications

Contents

2.1.1 Energy and cost modelling analysis I Our approach

Purpose of energy and cost modelling

The purpose of this evidence base toolkit is to determine that net zero carbon buildings in Surrey are both:

a) Feasible from a technical perspective

b) Feasible from a viability perspective

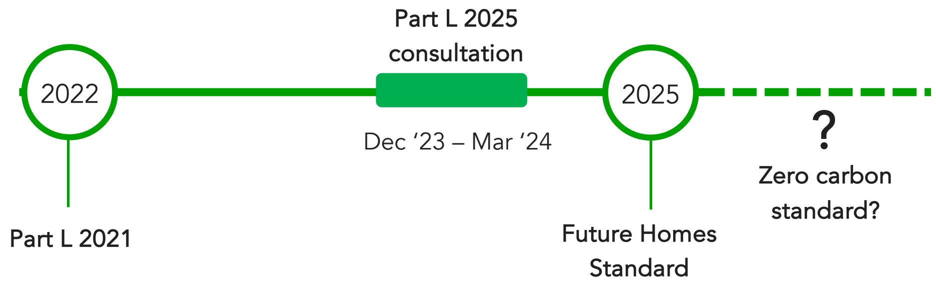
This will be determined from three different policy option stand points:

1) 100% reduction over the Future Homes Standard*
2) Low energy specification + net zero carbon operational energy balance
3) Ultra-low energy specification + net zero carbon operational energy balance

Energy and cost modelling constitutes the core of this technical evidence base. Its purpose is to investigate how different building archetypes would perform against the metrics in Part L 2021, Policy option 1 and Policy option 2, using different combination of specifications. These results can then be used to inform the process of target setting by officers, and constitute the evidence that the associated policies are technically achievable. Finally, the cost modelling can be used to identify the additional cost of these policies above minimum building regulations compliance (Part L 2021).

Cost baseline

The baseline we are using for cost modelling purposes will be a Part L 2021 compliant building – that is a building that would just pass building regulations in terms of energy and carbon performance. It is assumed that this is what developers are building to now, it provides a known starting point and a robust baseline.



Policy changes are moving towards zero carbon, however there is much uncertainty surrounding the details. At the time of producing this Viability Toolkit for Surrey (Jan-March 2024) the consultation for the next version of the building regulations Part L is underway.

***Updates to Part L of the Building Regulations**

Part L of the building regulations set the minimum standards for energy and carbon performance of new buildings.

The government is currently consulting on Part L 2025 (commonly known at the Future Homes Standard) and the Home Energy Model (the methodology for determining compliance with it). This is expected to be released in 2025, although no date has been confirmed and it is quite possible that it will be later than this). When the Future Homes Standard comes into operation it will replace Part L 2021, and the Home Energy Model will replace the Standard Assessment Procedure (SAP) – the methodology currently used to determine compliance with Part L of the building regulations for dwellings.

Since we are in a consultation period, we do not know with any certainty the details of the Future Homes Standard, the Future Buildings Standard or the methodologies for determining compliance with them.

2.1.2 Energy and cost modelling analysis | Archetype selection

Archetype selection

In order to undertake the energy and cost modelling for this technical evidence base, a number of domestic and non-domestic archetypes had to be identified and assessed.

There is obviously a very wide range of building types in Surrey and within each building type an almost infinite variety of buildings. In discussions with districts and boroughs, we have identified 8 building archetypes:

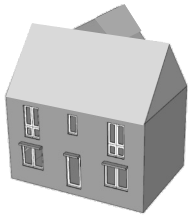
- six domestic: detached house, semi-detached house, terrace house, low-rise, medium-rise and high-rise apartment buildings. These have been modelled and costed specifically for Surrey.
- two non-domestic: office and light industrial/warehouse. We have re-used models and costing produced for the London area, and extrapolate the learnings and evidence for Surrey. Weather and cost data are similar.

We have then identified one building for each of these building types (see adjacent images). Each building is a typical developer-built example of that particular archetype. In reality there is much variation in building designs and specification, and site upon which they sit, and this impacts energy, carbon and cost. However, it is very common for technical evidence bases to use representative examples of different building types, as we are doing here. It can always be expanded with more buildings/building types if required.

6 different scenarios/combinations of specifications

6 different scenarios will be modelled, combining different specifications in terms of fabric and ventilation, heating system and solar PVs.

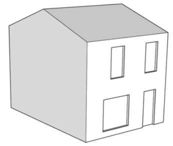
Domestic archetypes selected



Detached house

142 sqm

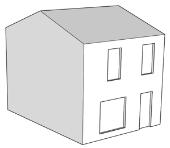
This building represents the generic **detached house** new build typology



Semi-detached house

93 sqm

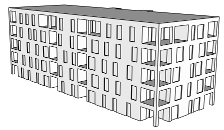
This building represents the generic **semi-detached house** new build typology



Terrace house

93 sqm

This building represents the generic **Terrace house** new build typology

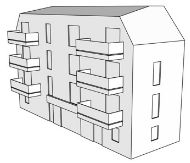


Mid-rise

5 storeys

2,600 sqm

This building represents the generic **Mid-rise apartment building** new build typology

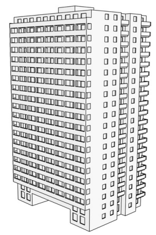


Low-rise

3/4 storeys

470 sqm

This building represents the generic **Low-rise apartment building** new build typology



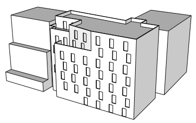
High-rise

19 storeys

16,300 sqm

This building represents the generic **High-rise apartment building** new build typology

Non-domestic archetypes selected

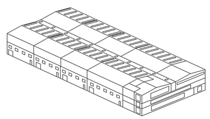


Office

7 storeys

4,000 sqm

This building represents the generic **office building** new build typology



Industrial

2 storeys

9,000 sqm

This building represents the generic **industrial building** new build typology

Graphical representation of the 8 buildings chosen as archetypes

2.1.3 Energy and cost modelling analysis | Scenarios modelled

Six scenarios modelled

We have chosen 6 different scenarios to model for each of the 6 residential archetypes. Of these, 3 scenarios are variations on a cost baseline, and 3 scenarios represent 3 different policy options.

Baseline scenarios

- Scenario 0 - Cost baseline (Part L 2021) – The primary cost baseline used in this study is a Part L 2021 compliant building. This is what is being built by developers now and until the point the Future Homes Standard comes into force in 2025 (or later).
- Scenario 1 - Future Homes Standard – Notional Building Option 1: We modelled the Future Homes Standard Notional Building specification option 1. This might* represent an alternative future cost baseline.
- Scenario 2 - Future Homes Standard – Notional Building Option 2: We modelled the Future Homes Standard Notional Building specification option 2. This might* represent an alternative future cost baseline.

*Note: There is no certainty whether this Notional Building specification will be retained or adapted after the consultation period.

Policy Option Scenarios

- Scenario 3 - Future Homes Standard,100% reduction on the Target Emissions Rate (TER). The same fabric specification as Scenario 2 but with additional PV to i) achieve a 100% reduction on a Part L 2021 TER and ii) achieve an energy balance using PHPP.
- Scenario 4 - Net Zero Carbon (low energy) – A fabric specification that achieves a Space Heating Demand of 30 kWh/m²/yr. An energy balance for PV.
- Scenario 5 - Net Zero Carbon (ultra-low energy) - A fabric specification that achieves a Space Heating Demand of 15-20 kWh/m²/yr. An energy balance for PV.

				Policy Route 1	Policy Route 2	
	Scenario 0: Part L 2021	Scenario 1: Future Homes Standard - Option 1	Scenario 2: Future Homes Standard - Option 2	Scenario 3: 100% better than FHS - Option 2 TER	Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Purpose	Baseline Energy, carbon, cost.	Possible future cost/energy/carbon baseline.	Possible future cost/energy/carbon baseline.	Potential policy option 1 - based on minimum FHS fabric and more PVs Comparison with Part L 2021	Potential policy option 2 - space heating demand less than 30 kWh/m²/yr	Potential policy option 3 - space heating demand of 15-20 kWh/m²/yr
Spec	Notional building spec, tweaked to pass Part L 2021	FHS Notional building spec* option 1	FHS Notional building spec* option 2	FHS Notional building spec option 2 + PVs to bring TER to 0	Spec to achieve SHD of 30, EUI of 35 and energy balance.	Spec to achieve SHD of 15-20, EUI of 35 and energy balance.
SAP 10	Yes	No	No	Yes	No	No
PHPP	Yes	Yes	Yes	Yes	Yes	Yes
iHEM	No	Semi-detached only	Semi-detached only	Semi-detached only	No	No
Cost analysis	Yes	Yes	No	Yes	Yes	Yes

(See next page for expanded version of modelling scenarios tabulated, with explanation for each scenario of its purpose, how the building specificaton was derived, what methodologies were used for modelling and whether or not it was costed.)

Predictive energy modelling outputs

The dwellings were modelled for every scenario using a predictive operational energy modelling tool PHPP (10) to calculate the space heating demand (SHD) and Energy Use Intensity (EUI). PHPP was used in each case due to its ability to accurately predict real world performance in use.

Part L 2021 compliance modelling outputs

The dwellings were modelled using Part L 2021 accredited software based on SAP 10.2 (i.e. Elmhurst Design SAP 1.7.25) for Scenario 0 and Scenario 3 only. This enabled us to set the cost baseline specification, and understand the amount of renewable energy needed for a 100% reduction on the TER.

Home Energy model

The Home Energy Model (the methodology that will be used to demonstrate compliance with the Future Homes Standard) is in beta version and under consultation. It was only used for the semi-detached house to compare results with the established methodology for Part L 2021.

2.1.4 Energy and cost modelling analysis | Our approach to scenarios modelling

				Policy Route 1	Policy Route 2	
	Scenario 0: Part L 2021	Scenario 1: Future Homes Standard - Option 1	Scenario 2: Future Homes Standard - Option 2	Scenario 3: 100% better than FHS - Option 2 TER	Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Purpose	Baseline Energy, carbon, cost.	Possible future cost/energy/carbon baseline.	Possible future cost/energy/carbon baseline.	Potential policy option 1 - based on minimum FHS fabric and more PVs Comparison with Part L 2021	Potential policy option 2 - space heating demand less than 30 kWh/m²/yr	Potential policy option 3 - space heating demand of 15-20 kWh/m²/yr
Spec	Notional building spec, tweaked to pass Part L 2021	FHS Notional building spec* option 1	FHS Notional building spec* option 2	FHS Notional building spec option 2 + PVs to bring TER to 0	Spec to achieve SHD of 30, EUI of 40 and energy balance.	Spec to achieve SHD of 15-20, EUI of 35 and energy balance.
SAP 10	Yes	No	No	Yes	No	No
PHPP	Yes	Yes	Yes	Yes	Yes	Yes
iHEM	No	Semi-detached only	Semi-detached only	Semi-detached only	No	No
Cost analysis	Yes	Yes	Yes	Yes	Yes	Yes

*wall and u-value specs improved slightly to reflect our experience that the Notional Building spec doesn't meet the TER when using Part L 2021 or HEM.

2.1.5 Fabric energy efficiency

Specification modelled

Five different 'levels' or 'scenarios' of fabric and airtightness efficiency were modelled. Although the same 'scenarios' are considered for each archetype, the detailed fabric specification for each of these scenarios are specific to each one. Meeting different target levels is essential, including current and proposed Building Regulations (Scenarios 0, 1, 2 and 3) and more ambitious ones aiming to achieve net zero carbon (Scenarios 4 and 5). The balance considered between u-values, airtightness and thermal bridging seek to represent a wide range of performance and to be practical to build.

U-Values

Different combinations of U-values we tested in each scenario for all elements of the building's envelope to ensure set targets were achieved. We used predictive energy modelling tools (PHPP) to establish the NZC KPI's were met and SAP 10.2 to ensure compliance with Building Regulations.

Fabric in scenarios 0, 2 and 3 represent the type of specifications expected on developments with no particular focus on energy efficiency, whereas scenarios 4 and 5 are meant to represent two grades of very energy efficient specifications.

Airtightness

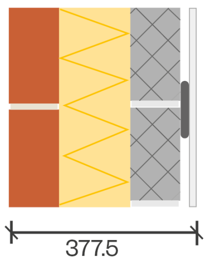
A low airtightness is critical to achieving a low space heating demand. Minimum requirements as per Building Regulations Part L 2021 and Future Homes Standards – Options 1 and 2, were chosen for scenarios 0, 1, 2 and 3 respectively. Low and ultra-low scenarios values align with more stringent industry targets, such as Passivhaus performance requirements.

Windows

All scenarios were tested using high quality double glazing, except Scenario 5, which considers triple glazing windows. This specification meets existing and proposed Building Regulations.

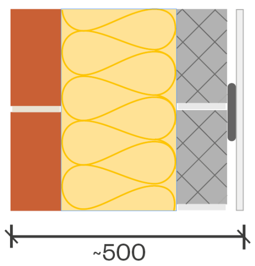
		Scenario 0: Part L 2021	Scenario 1: Future Homes Standard - Option 1	Scenario 2: Future Homes Standard - Option 2	Scenario 3: 100% better than FHS - Option 2 TER	Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Building fabric	Building fabric strategy	Part L 2021 compliant fabric, developer spec	FHS Option 1 compliant fabric, developer specs	FHS Option 2 compliant fabric, developer specs	To achieve DER=0 for FHS Option 2 compliant fabric, developer specs	To achieve space heat demand of 30 kWh/m²/yr	To achieve space heat demand of 15-20 kWh/m²/yr
	Floor (W/m²K)	0.11 (SAP)	0.13 (SAP)	0.13 (SAP)	0.13 (SAP)	0.11 (SAP)	0.09 (SAP)
		0.133 (PHPP)	0.163 (PHPP)	0.163 (PHPP)	0.163 (PHPP)	0.148 (PHPP)	0.105 (PHPP)
	Walls (W/m²K)	0.16	0.16	0.16	0.16	0.20	0.12
	Roof (W/m²K)	0.10	0.10	0.10	0.10	0.13	0.10
	Windows (W/m²K)	1.2	1.2	1.2	1.2	1.2	0.8
		(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(triple-glazed)
	Thermal bridging* (W/K)	10.26 (SAP)	10.29 (SAP)	10.29 (SAP)	10.29 (SAP)	10.41 (SAP)	10.15 (SAP)
		3.6 (PHPP)	3.3 (PHPP)	3.3 (PHPP)	3.3 (PHPP)	3.0 (PHPP)	4.5 (PHPP)
	Air Permeability (m³/m²/hr)	5	4	5	5	1	0.6

Table 1.1 - Example of the five different levels of fabric efficiency considered. Although the same 'levels' are considered for each typology, the detailed fabric specifications for each of these levels are specific to each typology. A full size list of assumptions for each typology can be found at the end of this chapter.



Current wall build-up for Woodford Independent Living Development. A traditional cavity wall with combustible full fill insulation – 0.16 U-value

The Levitt Bernstein and Etude [Easi Guide to Passivhaus Design] provides indicative construction thicknesses and u-values for achieving net zero.



Example non-combustible full fill cavity wall build-up capable of achieving 0.12-0.13 U-value depending on the conductivity of the wall ties selected.

2.1.6 Heating systems

Choosing the heating systems to assess

It is widely recognised that the industry is currently going through a paradigm shift, moving away from fossil fuel-based heating systems to all electric systems (e.g heat pumps).

Apart from the Part L 2021 baseline (considered 'business as usual'), the scenarios modelled aim to be compatible with a net zero carbon future and each include a different low carbon heating system. The heating systems chosen are fuelled by electricity, drawn either from the grid or on-site photovoltaics. Waste water heat recovery (WWHR) has been included only in scenarios based in the notional building specification (Scenario 0 and Scenario 1).

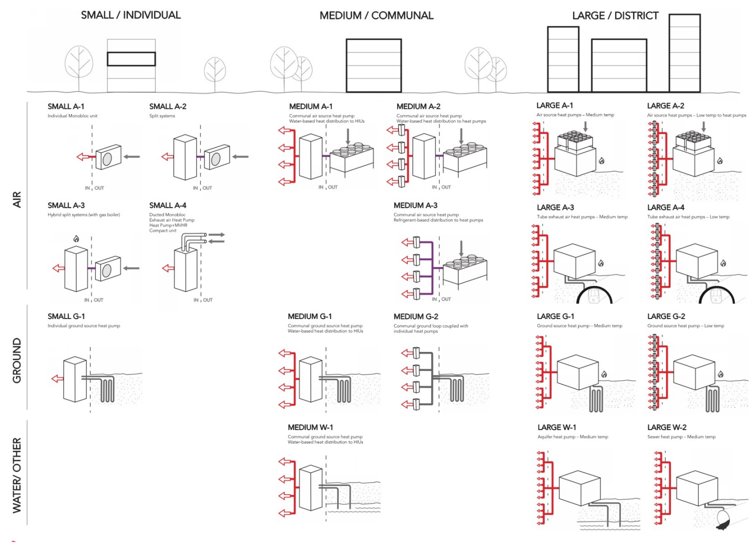
Heating systems modelled

Air source heat pumps (ASHPs) are currently the most viable technology and efficient to achieve widespread electrification of heat at scale while limiting overall demand on the electricity network..

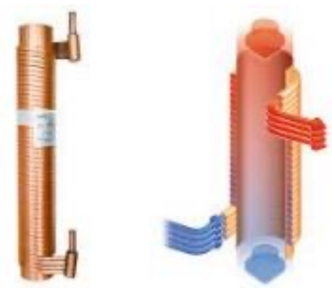
There is however no 'one size fits all' low carbon heating system across all building archetypes. Different types and scales of heat pumps were considered and selected as suitable for each archetype:

- **Individual air source heat pump**: The three house typologies (detached, semi-detached and terraced), as well as the low-rise flats utilise individual monobloc air source heat pumps (ASHPs) to provide an autonomous, efficient, low carbon heat source to each unit. The air source heat pumps are located externally, generally on a roof, terrace or balcony.
- **Communal heat pumps**: Mid-rise and High-rise apartments utilise a communal ambient loop system with ASHP located on the roof to deliver hot water to each individual apartment, connected directly to a heating source and a hot water tank. Unit size, distribution pipe length, diameters, etc were assessed accordingly to the archetype characteristics.

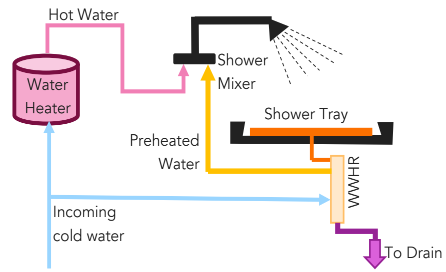
It is recognised that other heating systems not selected in this study may align with the performance metrics or targets suggested as part of the policy recommendations.



Heat pumps are available in many different types and scales, from individual systems to large scale heat pumps (© Etude for the Greater London Authority)



WWHR vertical pipe installation © Power pipe UK



WWHR example operation schematic

Figure 6.4 - What is WWHR and what is its impact?
A WWHR system is a heat recovery device that recycles the heat energy from waste water. 'Be Lean' calculations required by London Plan policy are based on the notional building specification (TER) set out in Part L 2021. As WWHR has a significant effect on the calculations, a development could provide calculations that pass the 'Be Lean' requirement through including WWHR systems without improving the building fabric much beyond 'Business as Usual'. Furthermore, proposals with high-performance fabric and ventilation could be penalised for not including WWHR.

2.1.7 Renewable energy: determining a feasible amount of generation (1/2)

Potential for Solar PV

Etude looked at solar photovoltaic as the most feasible technology to use in dwellings. In our assessment, for each typology, we determined the amount of PV that can allocated in the roof, as well as the requirements to meet the proposed policy targets.

The ratio of suitable area for solar PV panels relative to internal floor area varies across different types of buildings. Larger houses typically have large roofs suitable for solar PV installation, that can balance their internal floor area. Medium rise blocks of flats might have internal floor areas that are six times higher than their roof area. This means there is less roof space available to install solar PV for each individual dwelling, relative to a larger house.

In all cases best practice solar technology is assumed: 420W high efficiency monocrystalline silicone panels with microinverters or DC optimisers.

The schematics on the right illustrate the maximum roof capacity of each archetype. In the case of multiresidential archetypes, a conservative space allowance has been made to locate the building's plant room. It is important to note that aspects like shading and orientation will impact and change this predictions:

Detached house

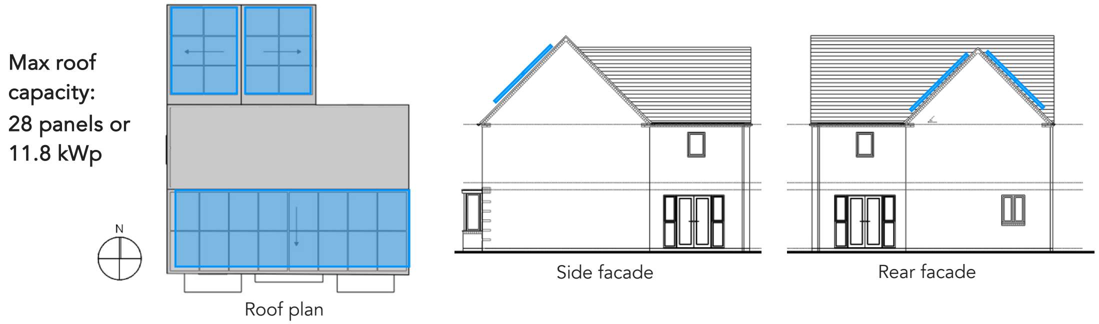
- Sufficient space for c.28 panels with the main roof facing South.
- Facing East or West, the number of panels on the main roof could increase whilst the ones in the smaller section of it will reduce.

Semi-detached house

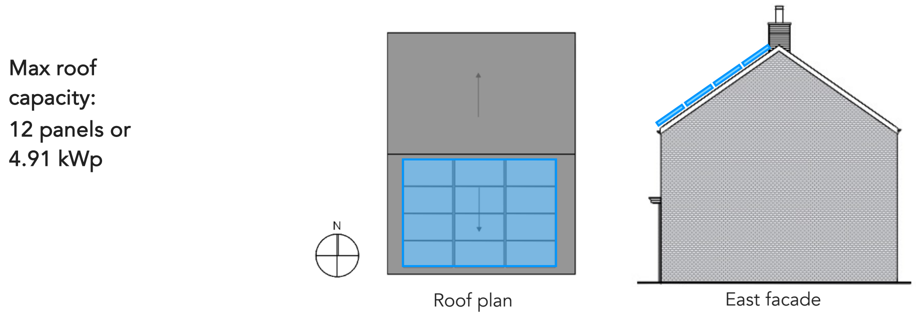
- Sufficient space for c.10 panels with the main roof facing South.
- Facing East or West the number of panel will increase to 24.

Terraced house

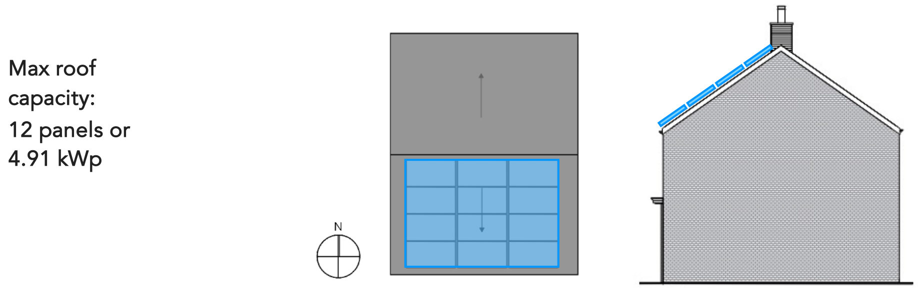
- Sufficient space for c.10 panels with the main roof facing South.
- Facing East or West the number of panel will increase to 24.



Mark-up of roof showing the maximum PV capacity for the detached house



Mark-up of roof showing the maximum PV capacity for the semi-detached house



Mark-up of roof showing the maximum PV capacity for the terraced house

2.1.8 Renewable energy: determining a feasible amount of generation (2/2)

Low-rise flats

- Sufficient space for c.55 panels with the main roof facing East and a 'monopitched' solar array.
- Facing Nort or South, and on a flat roof, the number of panels could increase slightly.

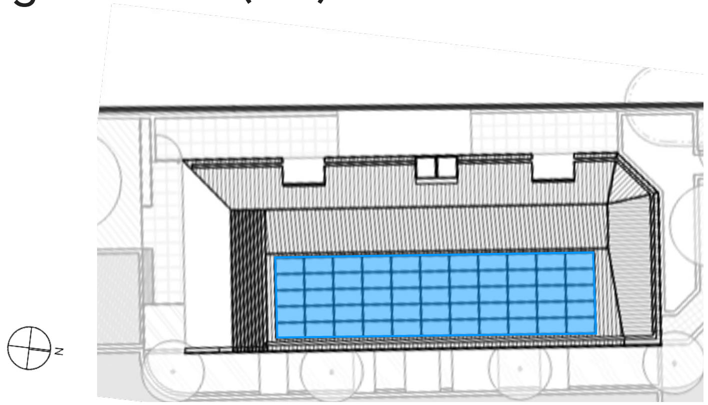
Mid-rise flats

- Sufficient space for c.128 panels with an East-West orientation and a 'concertina' type installation.
- Facing Nort or South, the number of panels will reduce.

High rise flats

- Sufficient space for c.248 panels with an East-West orientation and a 'concertina' type installation.
- Facing Nort or South, the number of panels will reduce.

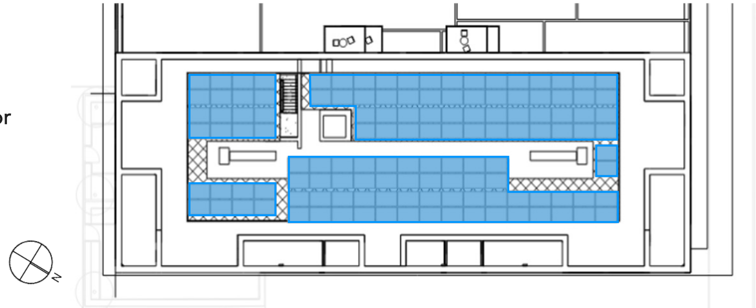
Max roof capacity:
55 panels or 23.1 kWp



Roof plan

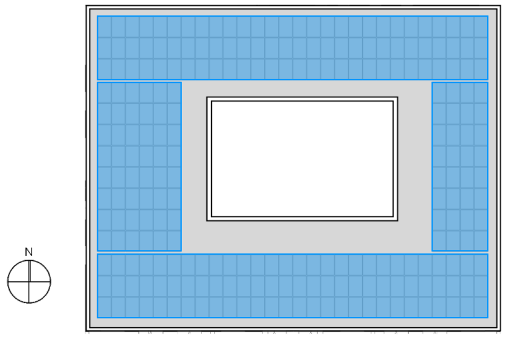
Mark-up of roof showing the maximum PV capacity for the low-rise block

Max roof capacity:
128 panels or 57.6 kWp



Mark-up of roof showing the maximum PV capacity for the mid-rise block

Max roof capacity:
248 panels or 111.6 kWp



Mark-up of roof showing the maximum PV capacity for the high-rise block

2.1.9 The performance gap

What is it?

The actual energy performance of buildings often fails to meet the design standard. This difference is commonly referred to as 'the Performance Gap'. The Zero Carbon Hub concluded in their Evidence Review Report in 2014 that a compliance process focused on design rather than as built performance is a key contributor to the Performance gap[09] . Closing the Performance Gap requires action at various stages through the design, construction and post occupancy phases of development

Reducing the gap through policy

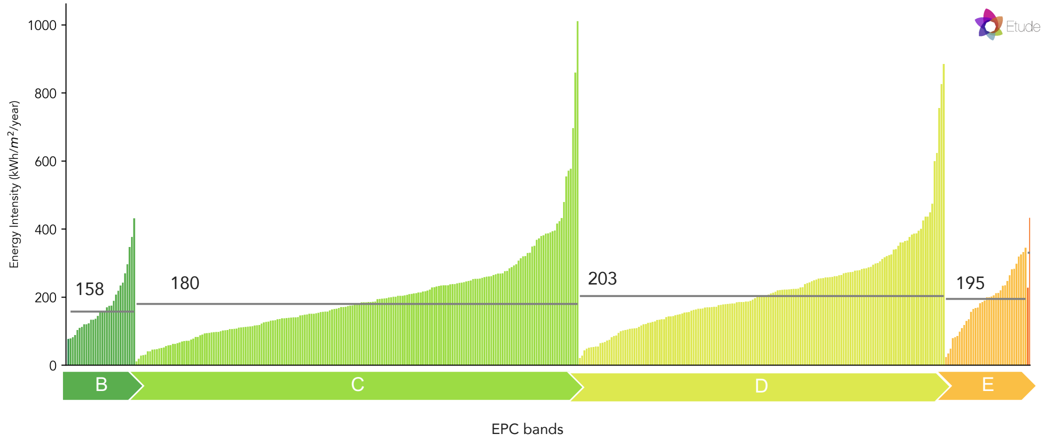
Implementing a policy option approach based on predictive energy modelling will help to reduce this performance gap. However, quality standards set at planning stage are often not carried forward into the actual built design as specifications may be 'downgraded' at a later stage through the 'value-engineering' process. Poor construction quality is another reason that energy performance may not perform as expected in 'as-built' development.

A good way for Local Plans to avoid these problems and support successful policy implementation would be to require proposals to meet an independently certified quality assurance standard (e.g. Passivhaus certification). Local Authorities could also consider supporting minor applications through providing a bespoke, simplified energy statement template for minor schemes to reduce the burden on applicants.

What assumptions have been used in the running costs modelling?

Considering the above, the modelling strategy applied two different levels of performance gap:

- 40% to those scenarios where predictive energy modelling has not been used and assume a lack of quality assurance policy (scenarios 0, 1, 2 and 3)
- 10% to those scenarios using predictive energy modelling and assume a quality assurance policy in place (scenarios 4 and 5).



EPC data compared with measured energy consumption of 420 homes. There is little correlation and only marginal improvement on average energy consumption per EPC rating which demonstrates the existence of a performance gap between intended and actual energy performance.

2.2

Residential buildings
Energy modelling analysis for Policy Route 1:
A TER based approach

2.2 Residential buildings energy modelling analysis for Policy Route 1 (a TER based approach)

Contents

2.2.1 Determining compliance with Policy Route 1

Policy Route 1: a building regulations aligned KPI

The target Key Performance Indicator (KPI) for compliance with the Policy Option 1 is a 100% reduction over the Target Emissions Rate (TER).

The strategy for determining the route to compliance was to use the most likely route chosen by a developer – the one with least capital cost. This consisted of:

1) Use of the minimum building fabric specification to pass the potential* Future Homes Standard notional building specification option 2 , with an Air Source Heat Pump system.

PLUS

2) Add photovoltaic panels to the roof to achieve a 100% reduction in carbon emissions using SAP 10.

SAP 10 or iHEM

To calculate how much renewable energy is required to achieve a 100% reduction on the Target Emissions Rate the building regulations calculation methodologies needs to be used. SAP 10 is the current methodology (designed for use with Part L 2021) and will be replaced by the Home Energy Model in 2025 with the introduction of the Future Homes Standard. Both options for the purposes of this evidence base are imperfect.

SAP 10, while it will go out of date when the Home Energy Model is released, will be the methodology that applicants will need to use until that point. Therefore SAP 10 was to determine compliance with Policy Option 1 for all archetypes.

We used the semi-detached house to test iHEM, the beta version of the Home Energy Model. Because it is relatively untested and in beta version it was felt it was not robust enough to use to test all archetypes for compliance with the policy.

Target KPI

100% reduction on TER

Policy Option 1 uses a single KPI aligned with building regulations: a 100% reduction in CO2 emissions over the Target Emissions Rate set by SAP 10 or the Home Energy Model.

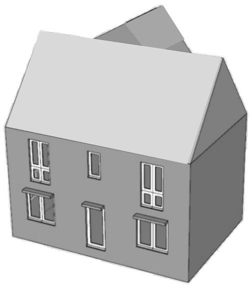
***Notes of caution**

1) The fabric specification selected for determining compliance with this route (Notional building Option 2 in the Future Homes Standard Consultation 2023) is highly subject to change until the Future Homes Standard is finalised.

2) Creating a policy that uses a % reduction on the TER approach will not provide consistency to developers over time.

Initially, applicants will need to demonstrate compliance using the established SAP 10 methodology. The level of measures required to achieve a 100% reduction in CO_2 emissions will likely be vary significantly depending on whether SAP 10 or the Home Energy Model is used.

2.2.2 Policy Route 1: Energy modelling results using SAP 10 – Detached House



		Scenario 3: 100% better than FHS - Option 2 TER
Building fabric and ventilation strategy	Floor Walls Roof (W/m^2K)	Low energy fabric 0.10 0.15 0.14
	Windows (W) Doors (D) (W/m^2K)	Double glazing W - 1.2 D – 1
	Airtightness (m^3/m^2h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	5kW ASHP (<55 °C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	Yes
Renewables	PV panels	9.8 kW

Results

Target KPI	Target KPI met on-site?
100% reduction on TER	✔

The results have been calculated using SAP 10.

9.8 kWp of PV is required to achieve a 100% reduction over the Target Emissions rate using the Future Homes Standard Option 2 specification.

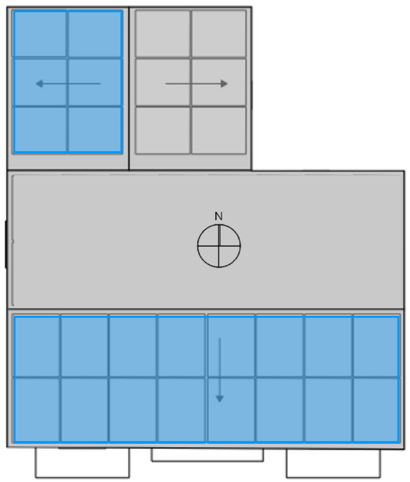
The available roof space is sufficient to accommodate this amount of PV.

PV on roof

9.8 kWp

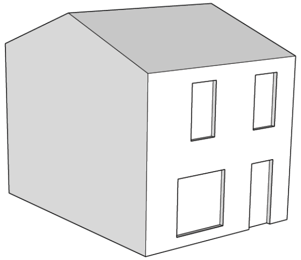
PV shortfall

0 kWp



Roof plan

2.2.3 Policy Route 1: Energy modelling results using SAP 10 – Semi-detached House



		Scenario 3: 100% better than FHS - Option 2 TER
Building fabric and ventilation strategy	Floor Walls Roof (W/m²K)	Low energy fabric 0.13 0.16 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W - 1.2 D – 1
	Airtightness (m³/m²h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	5kW ASHP (<55 °C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	Yes
Renewables	PV panels required for policy target	6.5 kW

Results

Target KPI	Target KPI met on-site?
100% reduction on TER	✗

The results have been calculated using SAP 10.

6.5 kWp of PV is required to achieve a 100% reduction over the Target Emissions rate using the Future Homes Standard Option 2 specification. However, on this particular dwelling only 4.9 kWp can be accommodated on the roof.

This will require the applicant to either improve the fabric specification or provide additional renewable energy off-site in order to meet the policy target.

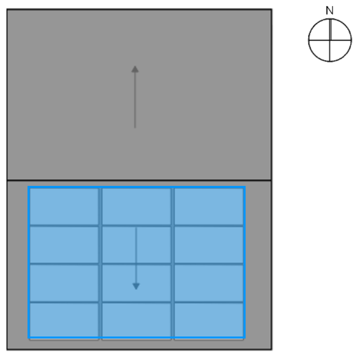
PV on roof

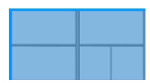
4.9 kWp max

+

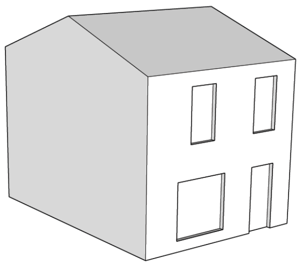
PV shortfall

1.6 kWp





2.2.4 Policy Route 1: Energy modelling results using SAP 10 – Terrace House



		Scenario 3: 100% better than FHS - Option 2 TER
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m^{2}K)	0.13 0.16 0.10
		Double glazing
	Windows (W) Doors (D) (W/m^{2}K)	W - 1.2 D – 1
	Airtightness (m^3/m^{2}h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	5kW ASHP (<55 °C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	Yes
Renewables	PV panels required for policy target	6.3 kW

Results

Target KPI	Target KPI met on-site?
100% reduction on TER	✗

The results have been calculated using SAP 10.

6.3 kWp of PV is required to achieve a 100% reduction over the Target Emissions rate using the Future Homes Standard Option 2 specification. However, on this particular dwelling only 4.9 kWp can be accommodated on the roof.

This will require the applicant to either improve the fabric specification or provide additional renewable energy off-site in order to meet the policy target.

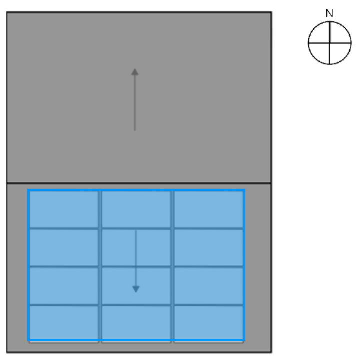
PV on roof

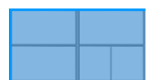
4.9 kWp max

+

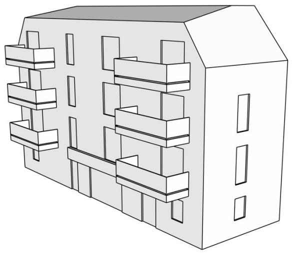
PV shortfall

1.4 kWp





2.2.5 Policy Route 1: Energy modelling results using SAP 10 – Low rise flats



		Scenario 3: 100% better than FHS - Option 2 TER
Building fabric and ventilation strategy	Floor Walls Roof (W/m²K)	Low energy fabric 0.13 0.15 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W - 1.2 D – 1
	Airtightness (m³/m²h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	Individual 5kW ASHP (<55 °C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	Yes
Renewables	PV panels required for policy target	6.3 kW

Results

Target KPI	Target KPI met on-site?
100% reduction on TER	✗

The results have been calculated using SAP 10.

23.1 kWp of PV is required to achieve a 100% reduction over the Target Emissions rate using the Future Homes Standard Option 2 specification. However, on this particular block only 23.1 kWp can be accommodated on the roof.

This will require the applicant to either improve the fabric specification or provide additional renewable energy off-site in order to meet the policy target.

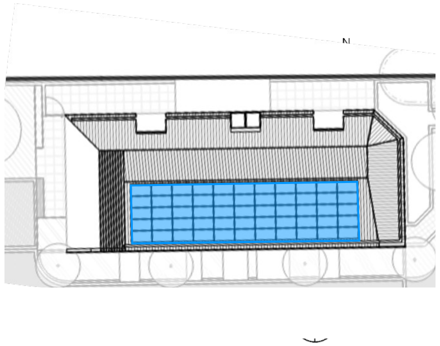
PV on roof

23.1 kWp max

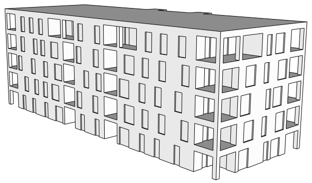
+

PV shortfall

4.2 kWp



2.2.6 Policy Route 1: Energy modelling results using SAP 10 – Mid rise flats



		Scenario 3: 100% better than FHS - Option 2 TER
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m^2K)	0.13 0.15 0.14
		Double glazing
	Windows (W) Doors (D) (W/m^2K)	W - 1.2 D – 1
	Airtightness (m^3/m^2h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	Ambient loop ASHP (<55 °C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	Yes
Renewables	PV panels required for policy target	156.1 kW

Results

Target KPI: 100% reduction on TER

Target KPI met on-site? ✗

The results have been calculated using SAP 10.

156.1 kWp of PV is required to achieve a 100% reduction over the Target Emissions rate using the Future Homes Standard Option 2 specification. However, on this particular block only 57.6 kWp can be accommodated on the roof.

This will require the applicant to either improve the fabric specification or provide additional renewable energy off-site in order to meet the policy target.

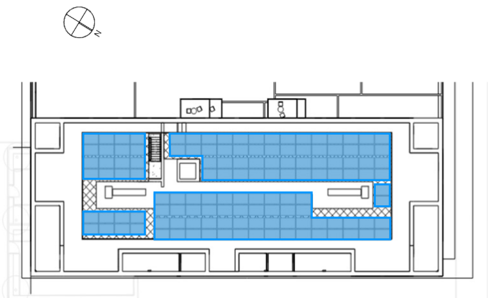
PV on roof

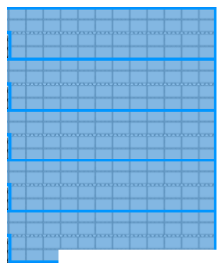
57.6 kWp max

+

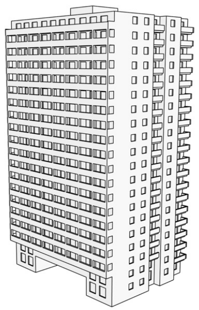
PV shortfall

98.4 kWp





2.2.7 Policy Route 1: Energy modelling results using SAP 10 – High rise flats



		Scenario 3: 100% better than FHS - Option 2 TER
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m²K)	0.13 0.16 0.10
		Double glazing
	Windows (W) Doors (D) (W/m²K)	W - 1.2 D – 1
	Airtightness (m^3/m^2h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	Ambient loop ASHP (<55 °C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	Yes
Renewables	PV panels required for policy target	156.1 kW

Results

Target KPI	Target KPI met on-site?
100% reduction on TER	✗

The results have been calculated using SAP 10.

156.1 kWp of PV is required to achieve a 100% reduction over the Target Emissions rate using the Future Homes Standard Option 2 specification. However, on this particular block only 57.6 kWp can be accommodated on the roof.

This will require the applicant to either improve the fabric specification or provide additional renewable energy off-site in order to meet the policy target.

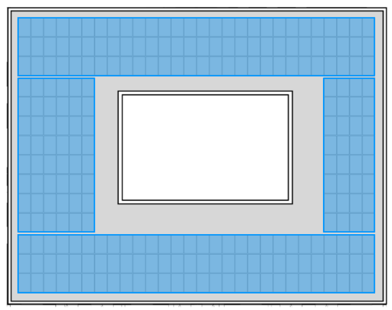
PV on roof

111 kWp max

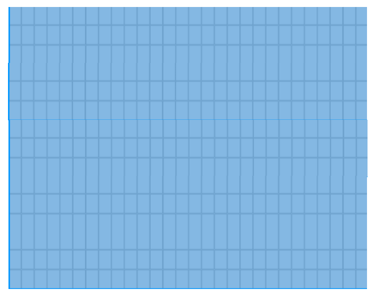
+

PV shortfall

759 kWp



Roof plan



X 4.5

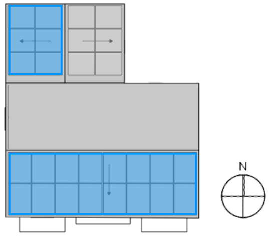
2.2.8 Policy Route 1: Energy modelling results using SAP 10 – PV provision required

Detached house

9.8 kWp of photovoltaics would be required on the detached house to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

On roof - 9.8 kWp



Roof plan

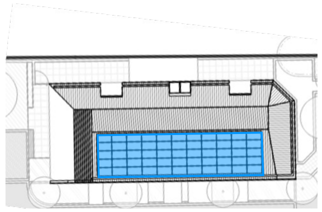
Shortfall – 0 kWp

Low-rise flats

27.3 kWp of photovoltaics would be required on the low-rise flats to achieve this policy option with the chosen fabric strategy.

The block can accommodate a maximum of 23.1 kWp therefore there would be a 4.3 kWp shortfall.

On roof -23.1 kWp



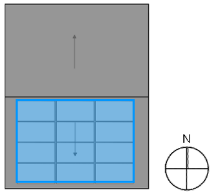
Shortfall – 4.2 kWp

Semi-detached house

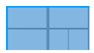
6.5 kWp of photovoltaics would be required on the semi-detached house to achieve this policy option with the chosen fabric strategy.

The house can accommodate a maximum of 4.9 kWp therefore there would be a 1.6kWp shortfall.

On roof – 4.9 kWp + Shortfall – 1.6 kWp



Roof plan

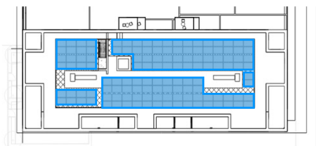


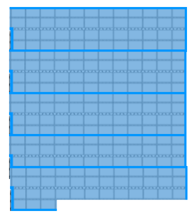
Mid-rise flats

156 kWp of photovoltaics would be required on the mid-rise flats to achieve this policy option with the chosen fabric strategy.

The block can accommodate a maximum of 57.6 kWp therefore there would be a 98.4kWp shortfall.

On roof – 57.6 kWp + Shortfall – 98.4 kWp



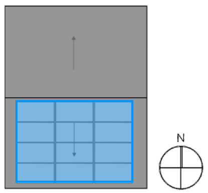


Terrace house

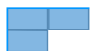
6.3 kWp of photovoltaics would be required on the semi-detached house to achieve this policy option with the chosen fabric strategy.

The house can accommodate a maximum of 4.9 kWp therefore there would be a 1.4kWp shortfall.

On roof – 4.9 kWp + Shortfall – 1.4 kWp



Roof plan

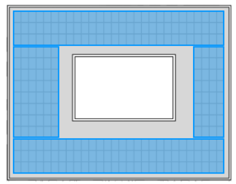


High-rise flats

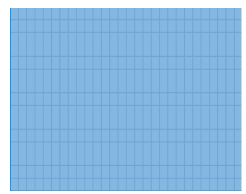
870 kWp of photovoltaics would be required on the high-rise flats to achieve this policy option with the chosen fabric strategy.

The house can accommodate a maximum of 111.6 kWp therefore there would be a 758.4 kWp shortfall.

On roof – 111 kWp + Shortfall – 759 kWp



Roof plan



X 4.5

2.2.9 Policy Option 1: Looking at predicted energy performance

A consistent and accurate methodology for comparing energy consumption

It is important to understand how a dwelling delivered under this policy option might perform in terms of operational energy use. This will allow us to compare energy performance and running costs across the different policy options.

SAP 10 is a building regulations compliance tool and as such the simplified inputs and assumptions within it do not make it suitable for predicting actual energy use in operation. Therefore, the predictive energy modelling tool Passivhaus Planning Package (PHPP) has been used.

Space heating demand: this policy option may not drive improvements in building fabric

Predictive energy use modelling was used to assess the likely space heating demand of each archetype.

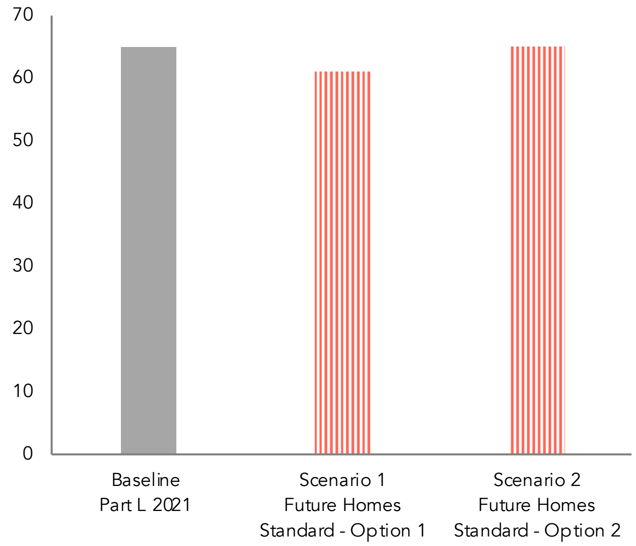
The adjacent graph compares the space heating demand of the detached house for three scenarios: i) the baseline (Part L 2021), ii) the Future Homes Standard consultation option 1 (notional building) and ii) the Future Homes Standard consultation option 2 (notional building).

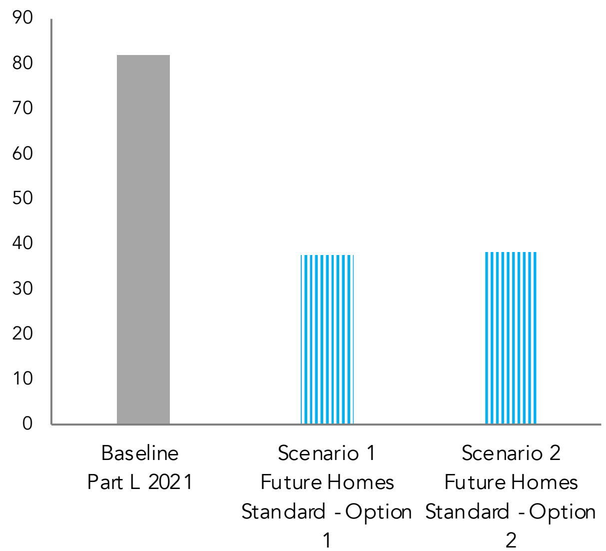
The graph clearly illustrates the very minimal improvement in fabric energy efficiency that the Future Homes Standard will likely bring.

Similar patterns were found for the semi-detached and terrace house.

Total energy use

Predictive energy use modelling was used to assess the likely total energy use of each archetype. The significant reduction in total energy use is due to the use of an Air Source Heat Pump to provide space heating and hot water for Scenarios 1, 2 and 3, as opposed to a gas boiler in the baseline scenario.





2.2.10 Policy Option 1: Predicted energy consumption and renewable energy generation

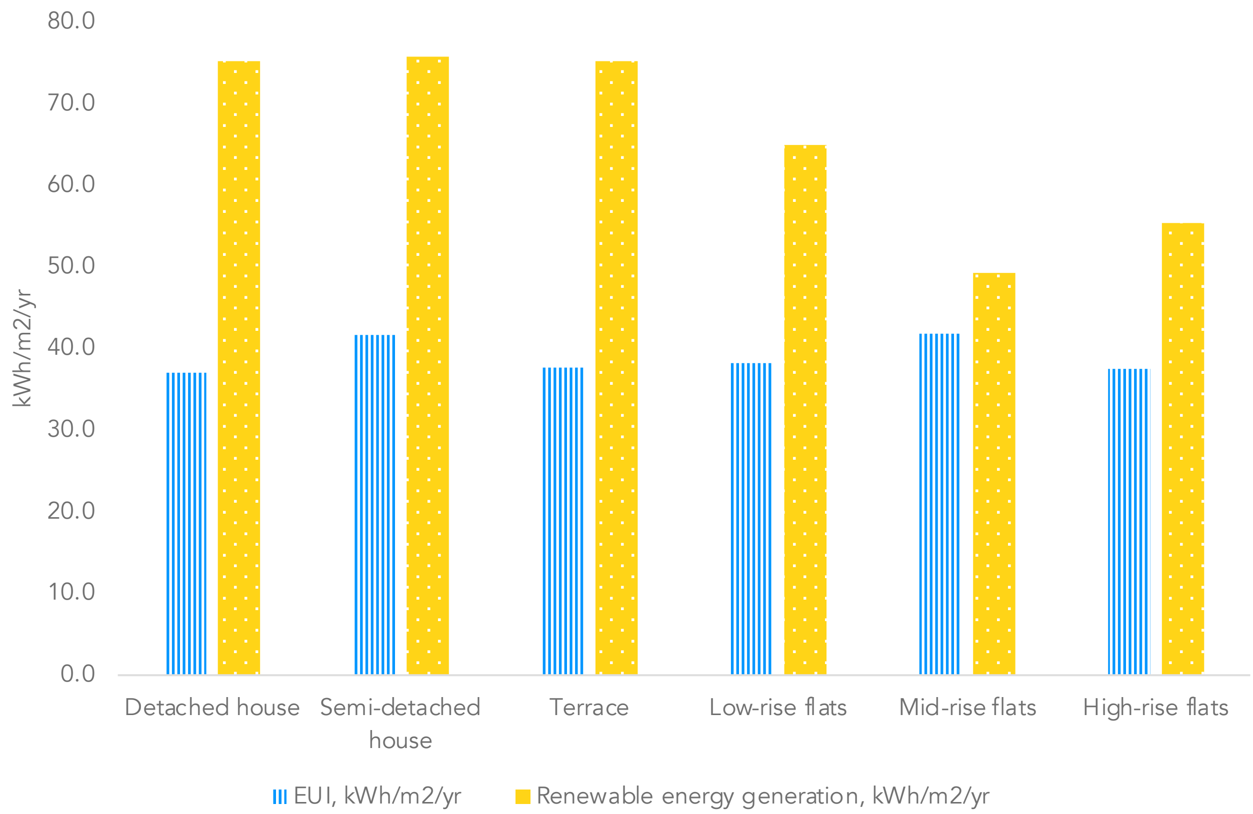
Using the modelled specifications for this policy option (see Section 6 Appendices), we explored what energy consumption and renewable energy generation might look like using the predictive energy modelling tool PassivHaus Planning Package (PHPP). The results are illustrated in the graph below.

The adjacent graph illustrates the annual energy consumption of each archetype (blue column) compared with the annual energy generation of each archetype (yellow column).

In all cases, if using SAP 10 to determine policy compliance and the amount of renewable energy required, all buildings would likely be net energy producers (on an annual basis) in operation.

The issue is that in most cases this cannot be provided on site (see section 2.2.8) and applicants would need to provide an energy offset to comply (if the council decide to operate an offset policy). This compliance route requires applicants to provide more than an energy balance.

The very large amounts of photovoltaics required are due to the carbon factors set within SAP.



This graph illustrates the predicted annual Energy Use Intensty (EUI) compared with the predicted annual renewable energy generation for the specifications used to achieve Policy Option 1 for each archetype. In all cases, the dwellings would produce more renewable energy in a year than the total amount of energy consumed in a year.

2.2.11 Determining compliance with the policy using iHEM

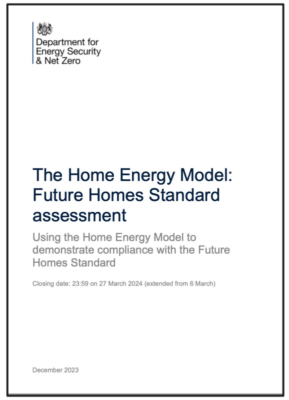
The Home Energy Model is in development at the time of writing this evidence base. It is due to be released in 2025 and will replace SAP 10 as the domestic building regulations calculation methodology.

A beta version of the Home Energy Model (iHEM) is available to use (as part of the public consultation). This was used with caution for this evidence base for the semi-detached house only, as it is highly subject to change between now and the final version being released.

The significant change that we see using iHEM is the very different amount of installed photovoltaic capacity required to achieve a 100% reduction on the Target Emissions Rate.

The implications of this are:

- that if policy option 1 is selected, the goal posts for applicants may change significantly when the Future Homes Standard and the Home Energy Model is released.
- upon release, a new evidence base may be needed to support the policy.
- results from SAP 10 dos not provide a robust or sensible basis upon which to build the evidence base.


Department for Energy Security & Net Zero

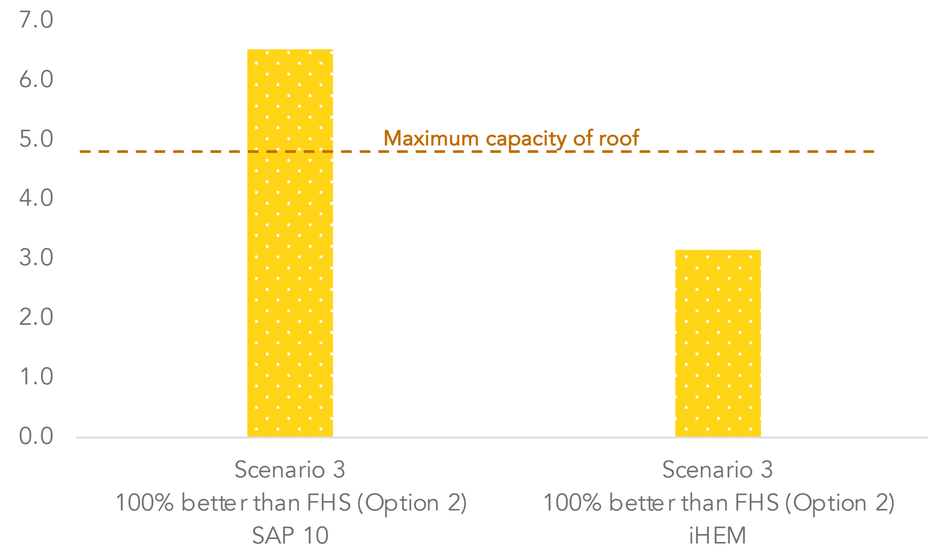
The Home Energy Model: Future Homes Standard assessment

Using the Home Energy Model to demonstrate compliance with the Future Homes Standard

Closing date: 23:59 on 27 March 2024 (extended from 6 March)

December 2023

A beta version of the Home Energy Model was out for Consultation from December 2023-March 2024 at the time of writing this evidence base study.



Depending on whether SAP 10 (left column) or iHEM (right column) is used you get two very different amounts of installed photovoltaic capacity to achieve a 100% reduction over the Target Emissions Rate. In the case of this semi-detached house, the amount of PV required is greater than the roof can feasibly accommodate on the south facing pitch. An energy offset would therefore be required. Note: the iHEM results are subject to change when it is finally released in 2025.

2.2.12 Policy Option 1: Conclusion and recommendations

Demonstrating compliance

Applicants would in the first instance need to demonstrate compliance with this policy using SAP 10 until the Home Energy Model is released (2025 at the earliest). The amount of renewable energy required to achieve the policy target using SAP 10 is very large and in all bar one of the archetypes not possible to achieve on-site.

The results for the semi-detached house using the beta version of the Home Energy Model returned a very different result (around half the amount of installed photovoltaics required). Since the final version of the Home Energy Model is not available it is not possible to say what the results will be when it is released.

Alternative specifications to meet the target

A target that is defined by an improvement over the building regulations Target Emissions Rate (TER) can be achieved through a combination of energy efficiency, heating system and renewable energy.

Therefore, if the energy efficiency of the archetype is improved over the specification selected for Scenario 3 in this study, then the amount of renewable energy required to achieve a 100% reduction in CO_2 emissions would reduce. This would make it easier to provide enough renewable energy on-site to achieve the policy target.

Alternative orientations and building design may also make the target easier to achieve on site.

For most flats it is likely that it will never be possible to achieve on-site and therefore alternative routes to compliance would need to be sought.

Energy or carbon off-setting

The very large amounts of photovoltaics that are potentially required to achieve this policy route may only be feasible to deliver on certain 2-storey house designs (those optimised to provide suitable roof space for photovoltaics). Any dwelling 3 storeys or higher is not likely to be able to meet the policy requirements on-site.

In cases where it's not possible to achieve the policy target on site, Surrey's districts and boroughs may want to consider and energy or carbon offsetting policy. This is discussed in more depth in section 4.1.

A policy for low carbon heat

Unless a specific policy for low carbon heat is included it may be possible to applicants to pass the requirements of this Policy Option using a gas boiler and energy offsetting – this is particularly the case in the period before the Future Homes Standard and the Home Energy Model come into force. Therefore, a standalone low carbon heat policy is recommended to ensure Surrey's net zero carbon objectives are met.

2.3

Residential buildings

Energy modelling analysis for Policy Route 2: An absolute energy targets approach (EUI and SHD)

2.3 Residential buildings energy modelling analysis for Policy Route 2 (absolute energy targets)

Contents

2.3.1 Determining compliance with Policy Route 2

Policy Route 2: absolute energy targets KPIs

The Target Key Performance Indicators (KPIs) for compliance with the Policy Option 2 are based on absolute energy targets, as discussed on sections 1.2.4 and 1.3. Separate targets are set for:

- Space heating demand (energy efficiency of the building fabric)
- Energy Use Intensity (overall energy use)
- Renewable energy generation.

The building fabric specifications were set at a level to meet the space heating demand at the lowest cost, most pragmatic level.

Air-tightness and Mechanical Ventilation with heat recovery have a large impact on space heating demand and are included as standard, allowing some of the u-values to be relaxed compared with previous scenarios.

Using predictive energy modelling

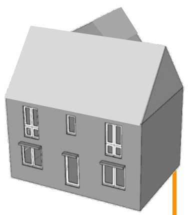
Predictive energy modelling tools are required for this approach. Building regulations calculations are not predictive and do not correlate with actual energy and carbon emissions in use and therefore are not appropriate. It is not yet known how well the Home Energy Model will perform in this respect when it is released in 2025.

Therefore for dwellings we have used the PassivHaus Planning Package (PHPP) a proven predictive energy modelling software that can be used for any project.

To comply with this policy option applicants will need to submit calculations from predictive energy modelling tools. Alternatively the councils could look at using a SAP conversion tool.

	Scenario 4 – Low Energy SHD 30 kWh/m^2/yr Target KPIs	Scenario 5 – Ultra-low energy SHD 15-20 kWh/m^2/yr Target KPIs
Space heating demand	30 kWh/m^2/yr	15-20 kWh/m^2/yr
Energy Use Intensity	35 kWh/m^2/yr	35 kWh/m^2/yr
Renewable energy	Energy balance	Energy balance

2.3.2 Detached house: Specification and energy modelling results

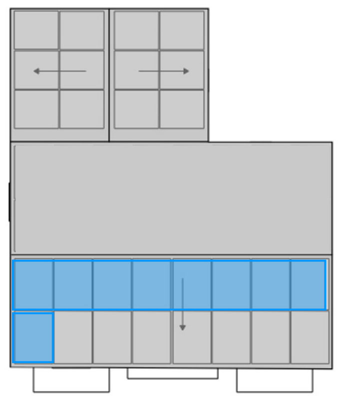


		Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Building fabric and ventilation strategy	Floor Walls Roof (W/m^2K)	Low energy fabric 0.13 0.15 0.11	Ultra-low energy fabric 0.10 0.12 0.11
	Windows (W) Doors (D) (W/m^2K)	Double glazing W – 1.2 D – 1	Triple glazing W – 0.8 D – 1
	Airtightness (m^3/m^2h)	1	0.6
	Ventilation strategy	High Efficiency MVHR	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (35°C)	5kW ASHP (35°C)
	Hot water heating system	200l cylinder	200l cylinder
	Waste water heat recovery (WWHR)	Yes	Yes
Renewables	PV required to meet policy target	3.8 kWp	3.4 kWp

Results

Scenario 4 – Low Energy

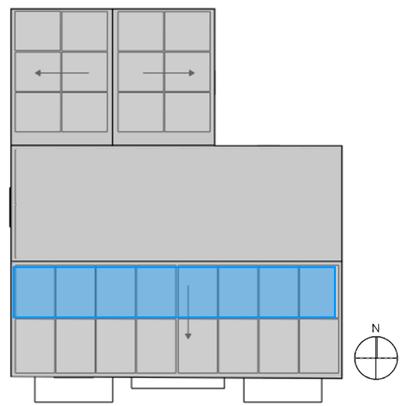
Target KPI	Result	
Space heating demand <30 $kWh/m^2/yr$	27 $kWh/m^2/yr$	✓
Energy Use Intensity <35 $kWh/m^2/yr$	29 $kWh/m^2/yr$	✓
Renewable energy balance	Energy balance achieved on-site	✓



Roof plan

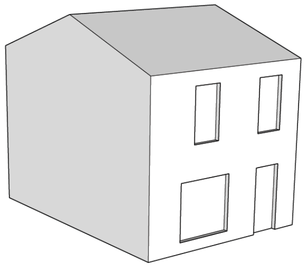
Scenario 5 – Ultra-Low Energy

Target KPI	Result	
Space heating demand 15-20 $kWh/m^2/yr$	19 $kWh/m^2/yr$	✓
Energy Use Intensity <35 $kWh/m^2/yr$	26 $kWh/m^2/yr$	✓
Renewable energy balance	Energy balance achieved on-site	✓



Roof plan

2.3.3 Semi-detached house: Energy modelling results



Semi-detached house
GIA = 93 m^2
Storeys = 2

Space heating demand

The space heat demand targets for both scenarios are met with deliverable fabric specifications.

The key difference between the two specifications is triple glazing and slightly improved air-tightness for Scenario 5.

Energy Use Intensity

The Energy Use Intensity targets for both scenarios are met through the use of an Air Source Heat Pump.

Direct Electric heating or gas boilers would not achieve this target.

Renewable energy

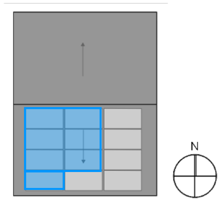
An energy balance is possible for both scenarios. The required amount of photovoltaic panels comfortably fits on the roof of this south facing semi-detached house. There is additional room to spare for more photovoltaic panels should occupants desire to be net energy positive in the future.

If the house was orientated east-west instead of north-south there would be even greater potential solar capacity.

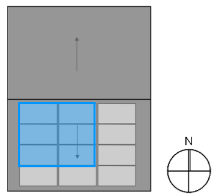
Specifications

More detailed specifications and energy results used in this model can be found in the Appendix.

	Scenario 4 – Low Energy	Scenario 5 – Ultra-Low Energy
	Required performance, space heating demand: 30 kWh/m²/yr	Required performance, space heating demand: 15-20 kWh/m²/yr
Space heating demand	27 kWh/m²/yr	17 kWh/m²/yr
Energy Use Intensity	34 kWh/m²/yr	30 kWh/m²/yr
Renewable energy	Energy balance achieved on-site	Energy balance achieved on-site
Floor U-value	0.11 W/m²K	0.09 W/m²K
Wall U-value	0.2 W/m²K	0.12 W/m²K
Roof U-value	0.13 W/m²K	0.10 W/m²K
Window U-value	1.2 W/m²K	0.8 W/m²K
Thermal bridging	3 W/K	4.5 W/K
Ventilation	Centralised MVHR	Centralised MVHR
Airtightness	1m³/m²h	<0.60m³/m²h
Heating system	Air Source Heat Pump	Air Source Heat Pump
Photovoltaics	3.0 kWp	2.6 kWp

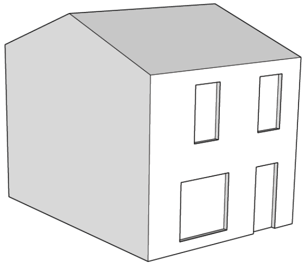


Roof plan



Roof plan

2.3.4 Terraced house: Energy modelling results



Terraced house
GIA = 93 m^2
Storeys = 2

Space heating demand

The space heat demand targets for both scenarios are met with deliverable fabric specifications.

The key difference between the two specifications is triple glazing and slightly improved air-tightness for Scenario 5.

Energy Use Intensity

The Energy Use Intensity targets for both scenarios are met through the use of an Air Source Heat Pump.

Direct Electric heating or gas boilers would not achieve this target.

Renewable energy

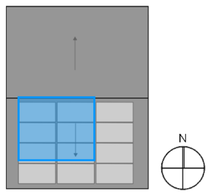
An energy balance is possible for both scenarios. The required amount of photovoltaic panels comfortably fits on the roof of this south facing terraced house. There is additional room to spare for more photovoltaic panels should occupants desire to be net energy positive in the future.

If the house was orientated east-west instead of north-south there would be even greater potential solar capacity.

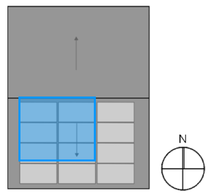
Specifications

More detailed specifications and energy results used in this model can be found in the Appendix.

	Scenario 4 – Low Energy	Scenario 5 – Ultra-Low Energy
	Required performance, space heating demand: 30 kWh/m^2/yr	Required performance, space heating demand: 15-20 kWh/m^2/yr
Space heating demand	17 kWh/m^2/yr	13 kWh/m^2/yr
Energy Use Intensity	31 kWh/m^2/yr	29 kWh/m^2/yr
Renewable energy	Energy balance achieved on-site	Energy balance achieved on-site
Floor U-value Wall U-value Roof U-value	0.18 W/m^2K 0.19 W/m^2K 0.11 W/m^2K	0.18 W/m^2K 0.19 W/m^2K 0.11 W/m^2K
Window U-value	1.2 W/m^2K	0.8 W/m^2K
Thermal bridging	2.8 W/K	2.8 W/K
Ventilation	Centralised MVHR	Centralised MVHR
Airtightness	1m^3/m^2h	<0.60m^3/m^2h
Heating system	Air Source Heat Pump	Air Source Heat Pump
Photovoltaics	2.7 kWp	2.5 kWp

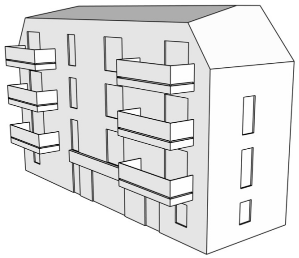


Roof plan



Roof plan

2.3.5 Low-rise flats: Energy modelling results



Low-rise flats
GIA = 3,900 m^2
Storeys = 4
Units = 41

Space heating demand

The space heat demand targets for both scenarios are met with deliverable fabric specifications.

The key difference between the two specifications is triple glazing and slightly improved air-tightness for Scenario 5.

Energy Use Intensity

The Energy Use Intensity targets for both scenarios are met through the use of an Air Source Heat Pump.

Direct Electric heating or gas boilers would not achieve this target

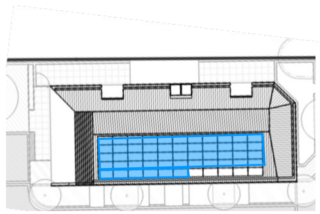
Renewable energy

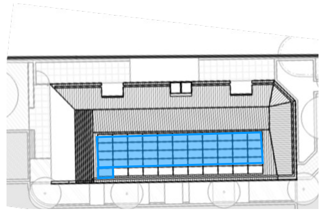
An energy balance is possible for both scenarios. The required amount of photovoltaic panels fits on the roof with some room to spare for mechanical plant.

Specifications

More detailed specifications and energy results used in this model can be found in the Appendix.

	Scenario 4 – Low Energy	Scenario 5 – Ultra-Low Energy
	Required performance, space heating demand: 30 kWh/m²/yr	Required performance, space heating demand: 15-20 kWh/m²/yr
Space heating demand	27 kWh/m²/yr	16 kWh/m²/yr
Energy Use Intensity	29 kWh/m²/yr	26 kWh/m²/yr
Renewable energy	Energy balance achieved on-site	Energy balance achieved on-site
Floor U-value Wall U-value Roof U-value	0.13 W/m²K 0.15 W/m²K 0.10 W/m²K	0.10 W/m²K 0.11 W/m²K 0.10 W/m²K
Window U-value	1.2 W/m²K	0.8 W/m²K
Thermal bridging	4.5 W/K	3.5 W/K
Ventilation	Centralised MVHR	Centralised MVHR
Airtightness	1m³/m²h	<0.60m³/m²h
Heating system	Air Source Heat Pump	Air Source Heat Pump
Photovoltaics	21 kWp	19 kWp





2.3.6 Mid-rise flats: Energy modelling results

Mid-rise flats
GIA = 3,900 m^2
Storeys = 4
Units = 41

Space heating demand

The space heat demand targets for both scenarios are met with deliverable fabric specifications.

The key difference between the two specifications is triple glazing and slightly improved air-tightness for Scenario 5.

Energy Use Intensity

The Energy Use Intensity targets for both scenarios are met through the use of an Air Source Heat Pump.

Direct Electric heating or gas boilers would not achieve this target

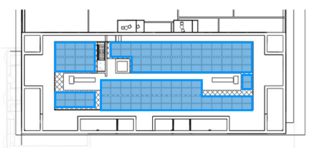
Renewable energy

An energy balance on-site is not possible for either scenario. In order to be policy compliant additional photovoltaic panels should be provided off-site or some other alternative offsetting arrangement made.

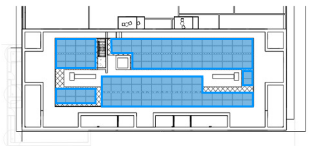
Specifications

More detailed specifications and energy results used in this model can be found in the Appendix.

	Scenario 4 – Low Energy	Scenario 5 – Ultra-Low Energy
	Required performance, space heating demand: 30 kWh/m²/yr	Required performance, space heating demand: 15-20 kWh/m²/yr
Space heating demand	22 kWh/m²/yr	15 kWh/m²/yr
Energy Use Intensity	32 kWh/m²/yr	30 kWh/m²/yr
Renewable energy	Energy balance not achieved on-site	Energy balance not achieved on-site
Floor U-value Wall U-value Roof U-value	0.20 W/m²K 0.20 W/m²K 0.15 W/m²K	0.20 W/m²K 0.18 W/m²K 0.15 W/m²K
Window U-value	1.2 W/m²K	0.8 W/m²K
Thermal bridging	4.0 W/K	4.0 W/K
Ventilation	Centralised MVHR	Centralised MVHR
Airtightness	1m³/m²h	<0.60m³/m²h
Heating system	Air Source Heat Pump (ambient loop)	Air Source Heat Pump (ambient loop)
Photovoltaics	58 kWp	58 kWp

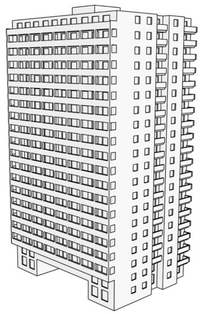


+ 44 kWp offsite



+ 38 kWp offsite

2.3.7 High-rise flats: Energy modelling results



High-rise flats
GIA = 16,00 m^2
Storeys = 19
Units = 171

Space heating demand

The space heat demand targets for both scenarios are met with deliverable fabric specifications.

The key difference between the two specifications is triple glazing and slightly improved air-tightness for Scenario 5.

Energy Use Intensity

The Energy Use Intensity targets for both scenarios are met through the use of an Air Source Heat Pump.

Direct Electric heating or gas boilers would not achieve this target.

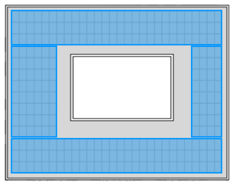
Renewable energy

An energy balance on-site is not possible for either scenario. In order to be policy compliant additional photovoltaic panels should be provided off-site or some other alternative offsetting arrangement made.

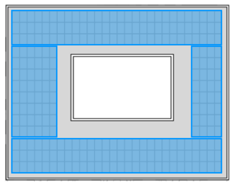
Specifications

More detailed specifications and energy results used in this model can be found in the Appendix.

	Scenario 4 – Low Energy	Scenario 5 – Ultra-Low Energy
	Required performance, space heating demand: 30 kWh/m²/yr	Required performance, space heating demand: 15-20 kWh/m²/yr
Space heating demand	18 kWh/m²/yr	12 kWh/m²/yr
Energy Use Intensity	29 kWh/m²/yr	27 kWh/m²/yr
Renewable energy	Energy balance not achieved on-site	Energy balance not achieved on-site
Floor U-value Wall U-value Roof U-value	0.15 W/m²K 0.12 W/m²K 0.18 W/m²K	0.15 W/m²K 0.12 W/m²K 0.18 W/m²K
Window U-value	1.2 W/m²K	0.8 W/m²K
Thermal bridging	5.5 W/K	5.5 W/K
Ventilation	Centralised MVHR	Centralised MVHR
Airtightness	1m³/m²h	<0.60m³/m²h
Heating system	Air Source Heat Pump (ambient loop)	Air Source Heat Pump (ambient loop)
Photovoltaics	111 kWp	111 kWp



+ 450 kWp offsite



+ 388 kWp offsite

2.3.8 Policy Route 2: Energy modelling results – renewable energy (houses)

Scenario 4 – Low-energy (SHD = 30 kWh/m²/yr)

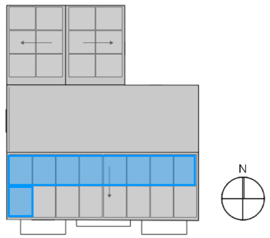
Detached house

3.8 kWp of photovoltaics would be required on the detached house to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

On roof - 3.8 kWp

Shortfall – 0 kWp



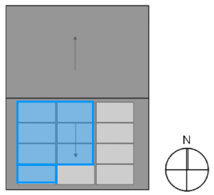
Roof plan

Semi-detached house

3.0 kWp of photovoltaics would be required on the semi-detached house to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

On roof – 3.0 kWp + Shortfall – 0 kWp



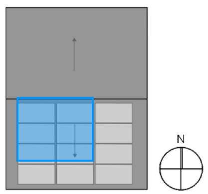
Roof plan

Terrace house

2.7 kWp of photovoltaics would be required on the semi-detached house to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

On roof – 2.7 kWp + Shortfall – 0 kWp



Roof plan

Scenario 5 – Low-energy (SHD = 15-20 kWh/m²/yr)

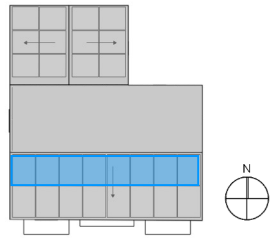
Detached house

3.4 kWp of photovoltaics would be required on the detached house to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

On roof - 3.4 kWp

Shortfall – 0 kWp



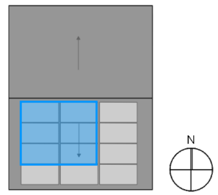
Roof plan

Semi-detached house

2.6 kWp of photovoltaics would be required on the semi-detached house to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

On roof – 2.6 kWp + Shortfall – 0 kWp



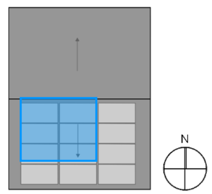
Roof plan

Terrace house

2.5 kWp of photovoltaics would be required on the semi-detached house to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

On roof – 2.5 kWp + Shortfall – 0 kWp



Roof plan

2.3.9 Policy Route 2: Energy modelling results – renewable energy (flats)

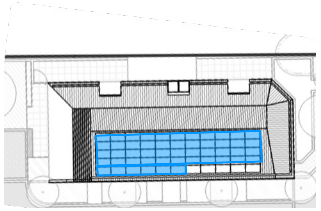
Low-rise flats

On roof - 21 kWp

Shortfall – 0 kWp

21 kWp of photovoltaics would be required on the low-rise flats to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

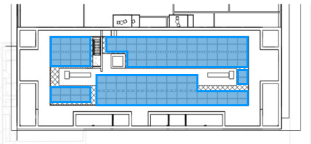


Mid-rise flats

101 kWp of photovoltaics would be required on the mid-rise flats to achieve this policy option with the chosen fabric strategy.

The block can accommodate a maximum of 57.6 kWp therefore there would be a 43.3kWp shortfall.

On roof – 57.6 kWp + Shortfall – 43.4 kWp

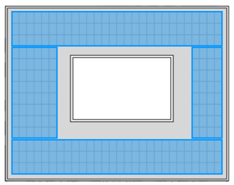


High-rise flats

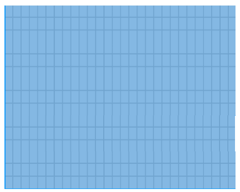
562 kWp of photovoltaics would be required on the high-rise flats to achieve this policy option with the chosen fabric strategy.

The block can accommodate a maximum of 111 kWp therefore there would be a 450 kWp shortfall.

On roof – 111 kWp + Shortfall – 450 kWp



Roof plan



X 2.7

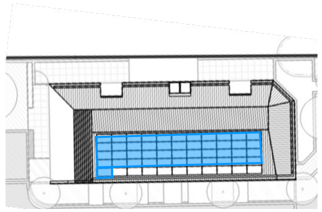
Low-rise flats

On roof - 19 kWp

Shortfall – 0 kWp

19 kWp of photovoltaics would be required on the low-rise flats to achieve this policy option with the chosen fabric strategy.

There would be no shortfall.

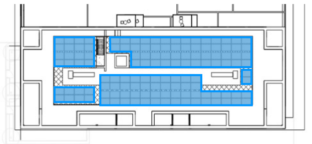


Mid-rise flats

95 kWp of photovoltaics would be required on the mid-rise flats to achieve this policy option with the chosen fabric strategy.

The block can accommodate a maximum of 111 kWp therefore there would be a 37.4 kWp shortfall.

On roof – 57.6 kWp + Shortfall – 37.4 kWp

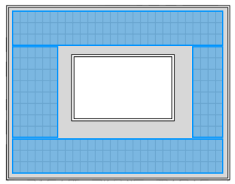


High-rise flats

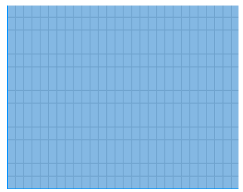
500 kWp of photovoltaics would be required on the high-rise flats to achieve this policy option with the chosen fabric strategy.

The block can accommodate a maximum of 111 kWp therefore there would be a 388 kWp shortfall.

On roof – 111 kWp + Shortfall – 388 kWp



Roof plan



X 2.3

2.3.10 Policy Option 2: Conclusion and recommendations

Demonstrating compliance

To demonstrate compliance with Policy Route 2 applicants will need to submit predicted energy use calculations. Building regulations calculation methodologies do no currently predict energy use in consumption to an accurate level and do not include regulated energy, and therefore cannot be used to demonstrate compliance with absolute energy based policies, such as those proposed here.

PassivHaus Planning Package (PHPP) is becoming an increasingly popular tool for predicting energy use of buildings – it is particularly well suited to dwellings.

The EUI target drives the use of low carbon heat

All archetypes achieved the Energy Use Intensity target in a way that is technically feasible and deliverable.

Achieving an EUI of 35 kWh/m^2/yr is only possible through the use of heat pumps (Air Source or Ground Source Heat Pumps).

Renewable energy provision is reduced

Policy Route 2 mandates greater levels of energy efficiency than building regulations Part L 2021 or proposed Future Homes Standards. Lower Energy Use Intensity translate to smaller amounts of renewable energy needed on-site. Therefore, it is easier to meet these policy targets on site compared with Policy Route 1, and there will likely be less instances of energy offsetting being required.

Energy or carbon off-setting

The very large amounts of photovoltaics that are potentially required to achieve this policy route may only be feasible to deliver on certain 2-storey house designs (those optimised to provide suitable roof space for photovoltaics). Any dwelling 3 storeys or higher is not likely to be able to meet the policy requirements on-site.

In cases where it's not possible to achieve the policy target on site, Surrey's districts and boroughs may want to consider and energy or carbon offsetting policy. This is discussed in more depth in section 4.1.

2.4

Comparison between modelling results for Policy Routes 1 and 2

2.4 Residential buildings: Comparison between modelling results for Policy Routes 1 and 2

Contents

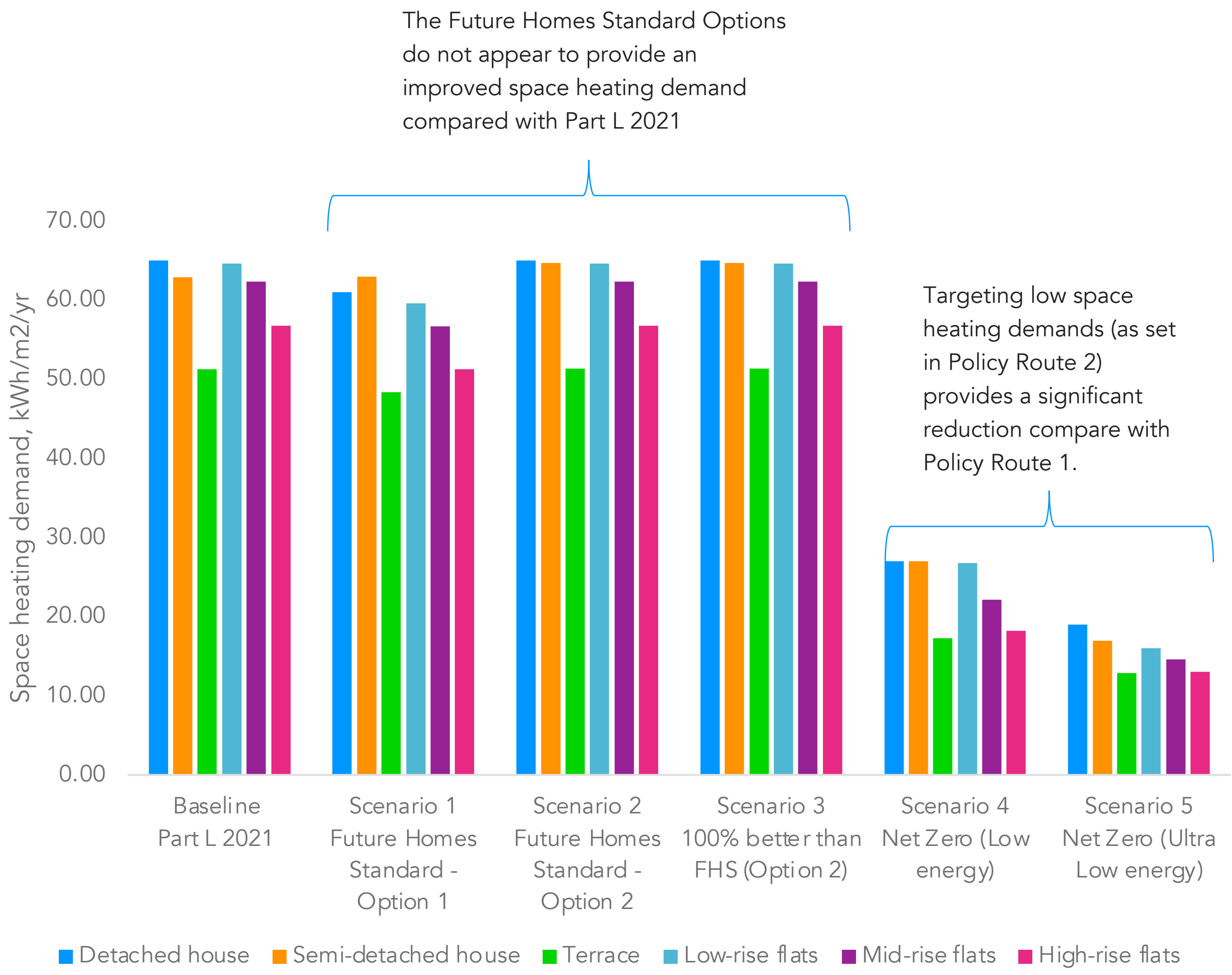
2.4.1 Space heating demand

Space heating demand is a measure of how much energy is required to maintain comfortable living temperatures for each dwelling.

A lower space heat demand correlates with a more energy efficient building fabric.

Observations:

- There is minimal difference in the space heat demand between Part L 2021, and either of the Future Homes Standard specifications recently in consultation.
- There is a marked improvement in energy efficiency between Scenarios 0-3 and Scenarios 4 and 5.
- The improvement between Scenario 3 and 4 has been achieved primarily through improved air-tightness standards.
- The improvement between Scenario 4 and 5 has been achieved primarily through a move from double glazing to triple glazing.
- Achieving the most stringent space heat demands of 15-20 kWh/m²/yr is feasible across all typologies using realistic, buildable u-values and levels of air-tightness.



The space heating demand remains fairly similar between Part L 2021 and the potential Future Homes Standard specifications. Large reductions can be seen when specifically targeting low space heating demands of 30 kWh/m2/yr (Scenario 4) and 15-20 kWh/m2/yr (Scenario 5).

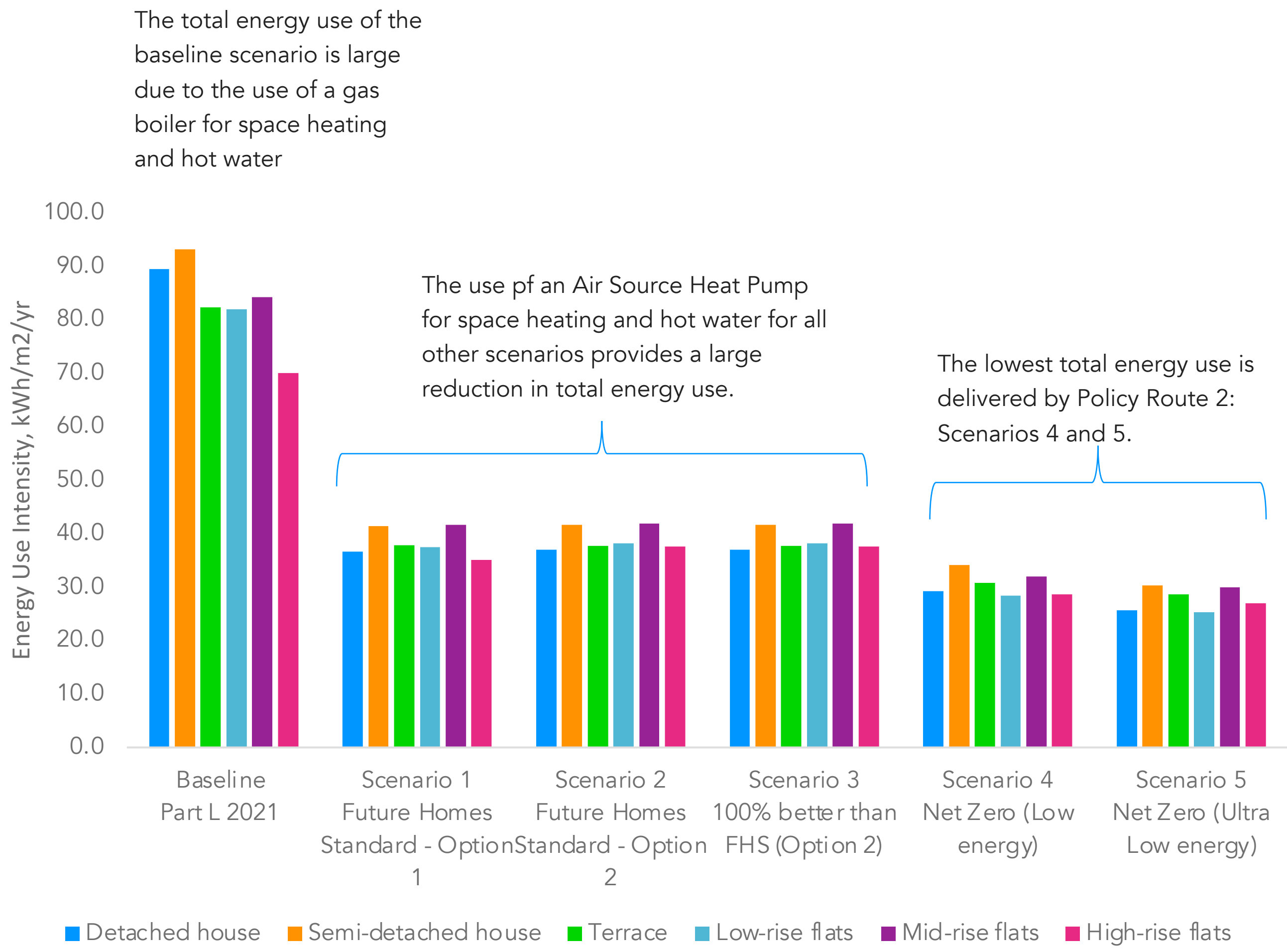
2.4.2 Energy Use Intensity

Energy use intensity (EUI) is a measure of how much energy a building uses overall. It includes all energy used by a building (space heating, hot water, lighting, pumps, fans, cooking and plug-in appliances).

The EUI multiplied by the floor area should correlate with energy measured at the meter. Therefore, the lower the EUI, the lower the occupants' energy bills.

Observations:

- The Part L 2021 (baseline) scenario has a much larger EUI than the other scenarios primarily due to the use of a gas boiler. All other scenarios use heat pumps to deliver space heating and hot water. Heat pumps are more than 350% efficient at turning energy into heat (as opposed to a gas boiler with 85% efficiency). This has the effect of dramatically reducing a dwelling's overall energy use.
- Despite the difference looking minimal on this graph, the difference in EUI between Scenario 4 and 5 ranges between 7-12%.



2.4.3 Renewable energy generation: houses

Renewable energy generation is best provided by solar photovoltaics on roofs in the case of most buildings. All renewable energy modelled in this evidence base comes of solar photovoltaics.

In this graph, the renewable energy generated is expressed in terms of the amount of energy generated over a year, per m^2 ofbuilding. This enables us to make a comparison between different dwellings of different sizes.

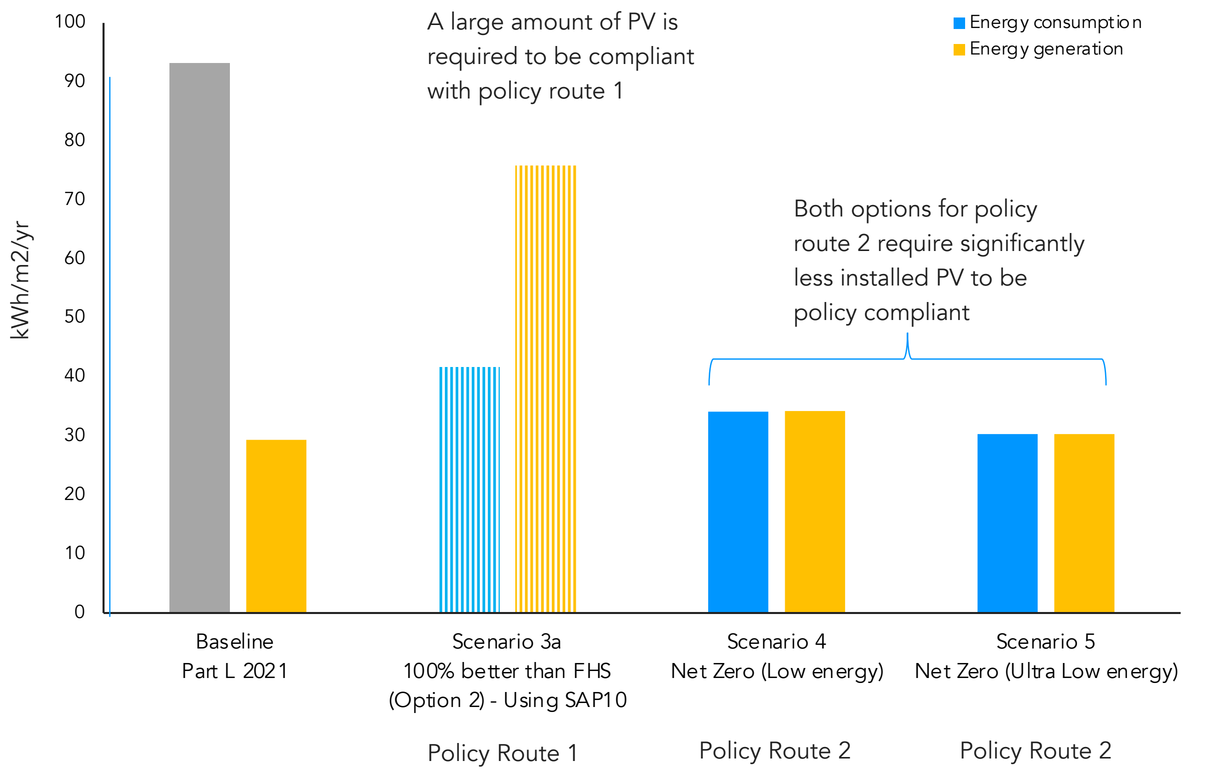
Solar photovoltaics are discussed more here:

- sections 2.1.7-8.

- drawings showing the solar PV on the roof of each archetype can be found in sections 2.2.8, 2.3.8, 2.3.9.

Observations:

- Policy option 1 requires a large amount of PV to be policy compliant and is only technically feasible to provide on site on the detached house.
- Policy option 2 requires less PV and is technically feasible to deliver on all house archetypes.
- The lower the EUI the less PV is needed to achieve an energy balance.
- Determining the amount of PV required to achieve Policy option 1 (scenario 3) is not possible to do in a robust manner at this point in time. We get a very different result if we use SAP 10 (which will be superceded) or iHEM (which is in beta and is not finalised).



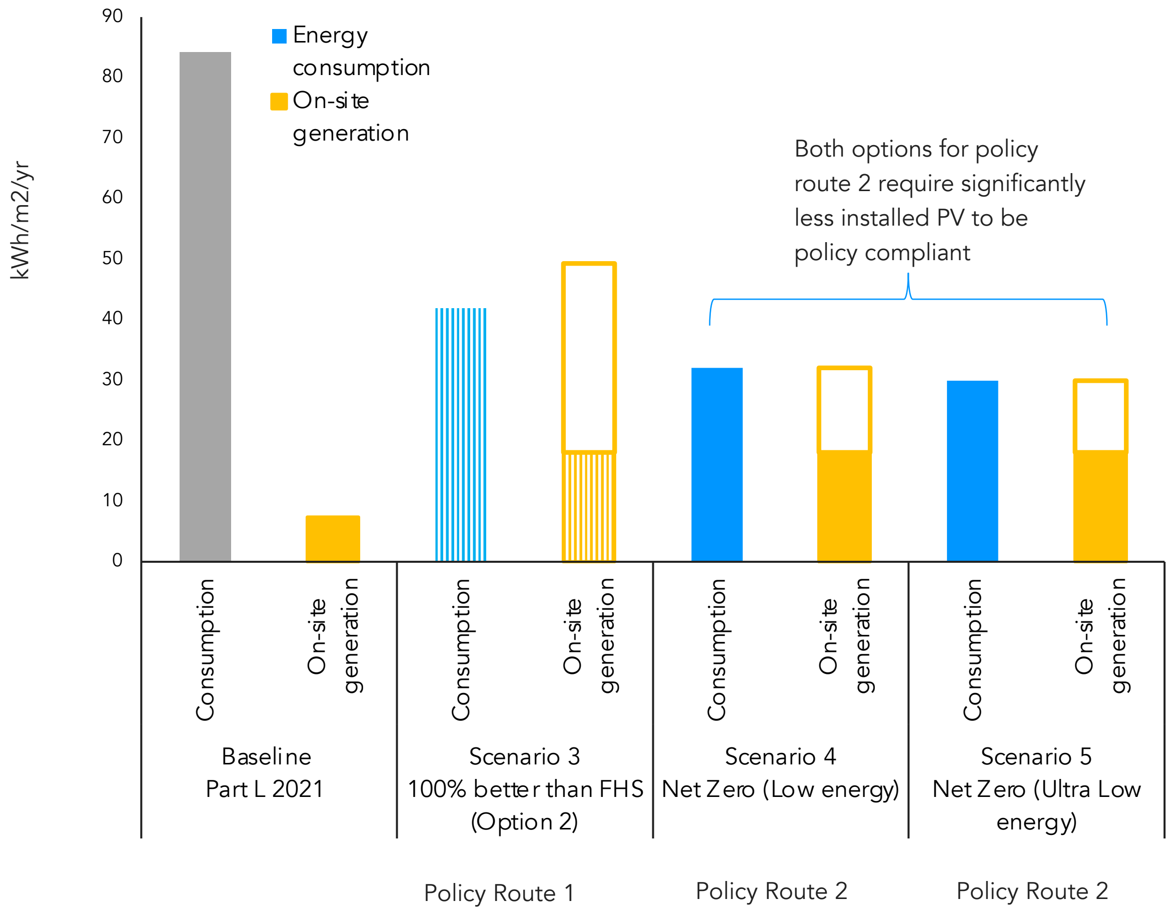
Policy route 1 and policy route 2 require different methodologies for determining compliance. The building regulations methodology required for Policy Route 1 (currently SAP 10) requires a large amount of PV if the minimum building fabric efficiency is used. The roof of the semi-detached house could not accommodate this much PV. However, the calculation methodology will change in 2025. It is not yet known what difference this will make.

2.4.4 Renewable energy generation: flats

The amount of PV that can be physically accommodated on the roofs of the archetypes modelled has been calculated, with consideration given to potential mechanical plant located on the roof. Detailed design has not been undertaken so the layouts illustrated on sections 2.2.8 and 2.3.9 are indicative only.

Observations:

- Policy option 1 requires the largest amount of PV to be policy compliant. The roof space of all flats are not large enough to accommodate the required amount of PV.
- Policy option 2 requires less PV, and it is technically feasible to accommodate the required amount of PV on the low-rise block to achieve the policy targets. however the roof space is still not large enough to accommodate the required amount of PV. However the deficit in PV is much less than Scenario 3.
- However it is not possible to meet the policy requirements of either policy route 2 option for the mid-rise or high-rise flats.
- Surrey's district's and boroughs will need to consider whether to operate an energy or carbon offset policy for applicants to adhere to where sufficient PV to be policy compliant cannot be accommodated on site.



The graph above (mid-rise flats) shows the amount of renewable energy required to meet the potential policy options (yellow bars) compared with the predicted total energy use (blue bars).
The building regulations methodology required for Policy Route 1 (currently SAP 10) requires a large amount of PV if the minimum building fabric efficiency is used. The roof of the mid-rise and high-rise flats could not accommodate this much PV. However, the calculation methodology will change in 2025. It is not yet known what difference this will make.

2.4.5 Policy Route 1: Predicted energy consumption and renewable energy generation

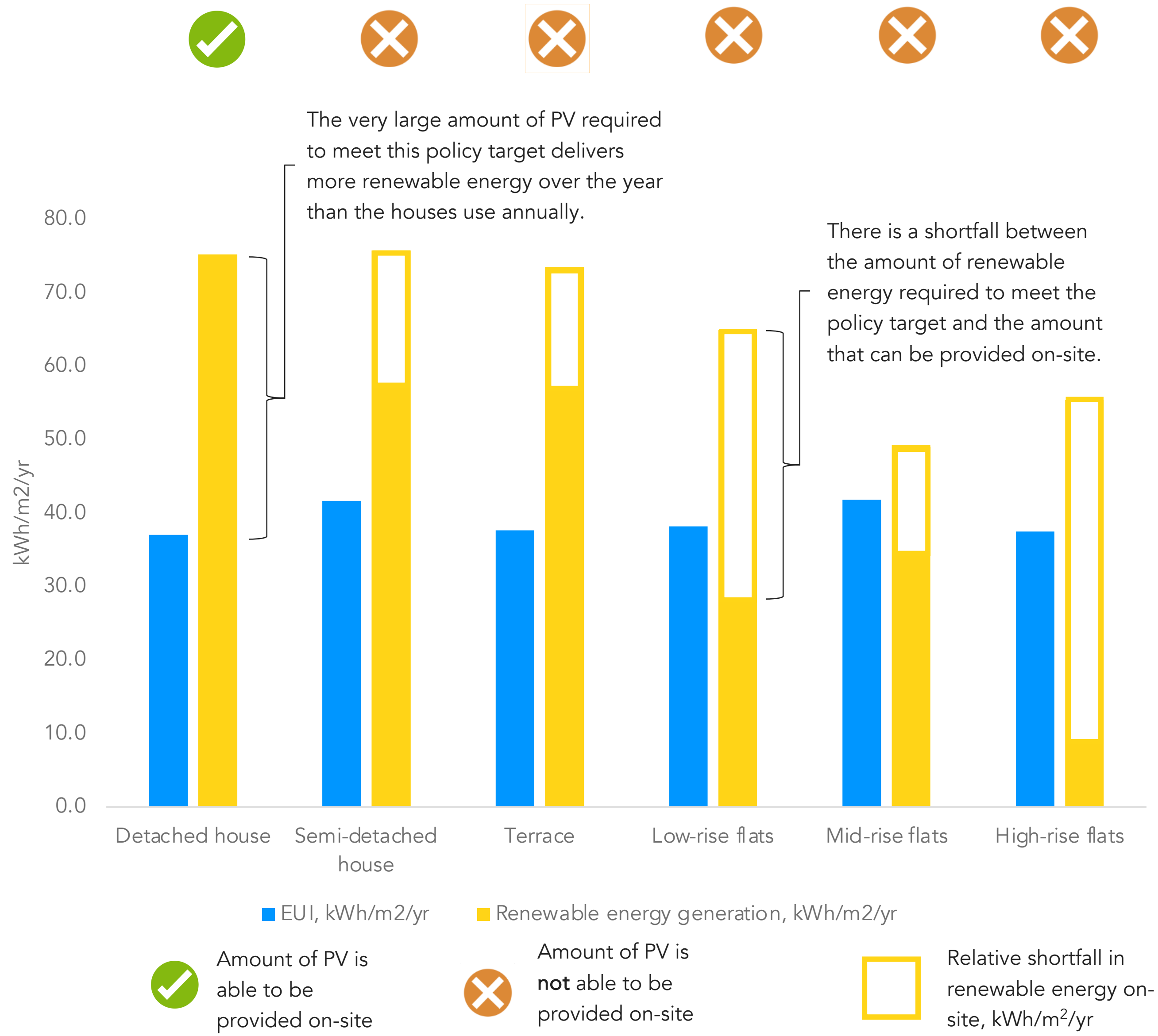
For Policy Route 1 the photovoltaic (PV) arrays were sized to achieve a 100% reduction on the Target Emissions Rate (TER) using SAP 10.

100% reduction on TER

The adjacent graph illustrates the predicted annual energy consumption of each archetype (blue column) compared with the annual energy generation of each archetype (yellow column). These predicted consumption and generation figures were calculated using PassivHaus Planning package so we could compare actual likely energy performance of the different policy options.

- To achieve this policy target (100% reduction in TER) results in very large requirement for PV – so much that there is likely to be more annual energy generation than energy consumption.
- In most cases, the area of PV required to meet this policy target cannot feasibly be installed on-site. Therefore, applicants would need to provide an energy offset to comply (if the council decide to operate an offset policy).
- There is likely to be a significant change in the calculation methodology between SAP 10 the Home Energy Model is released (due in 2025). Therefore developers will need to change how they respond to this policy at that point.

The very large amounts of photovoltaics required are due to the carbon factors set within SAP 10.



This graph illustrates the predicted annual Energy Use Intensity (EUI) compared with the predicted annual renewable energy generation required for the specifications used to achieve Policy Option 1 for each archetype. Figures generated using predictive energy modelling (PHPP) to enable comparison between the different policy options.

2.4.6 Policy Route 2 ultra-low energy: Predicted energy consumption and renewable energy generation

For Policy Route 2 (ultra-low energy) fabric and services specifications were selected to meet the space heating demand and energy use intensity targets. Solar photovoltaic was added to meet the energy balance target.

Space heating demand	Energy Use Intensity	Renewable energy
15-20 kWh/m²/yr	35 kWh/m²/yr	Energy balance

The adjacent graph illustrates the annual energy consumption of each archetype (blue column) compared with the annual energy generation of each archetype (yellow column).

- Overall energy consumption of the archetypes following Policy Route 2 is lower than Policy Route 1. This is because the space heating demand and energy use intensity targets set minimum standards for energy efficiency.
- The amount of solar PV required is lower too, as the target only requires an energy balance. This can be achieved on-site for all archetypes except the mid-rise and high-rise flats.
- Energy offsetting will likely only be required for mid and high rise flats. Councils should consider an energy offsetting policy in order to enable applicants to comply with net zero policies where they cannot be achieved on-site.

This graph illustrates the predicted annual Energy Use Intensity (EUI) compared with the predicted annual renewable energy generation required for the specifications used to achieve Policy Route 2 for each archetype. Only for the mid-rise and high-rise would it not be possible to achieve the renewable energy balance KPI on-site. Therefore an energy offsetting policy and mechanism would be required to achieve compliance with policy objectives.

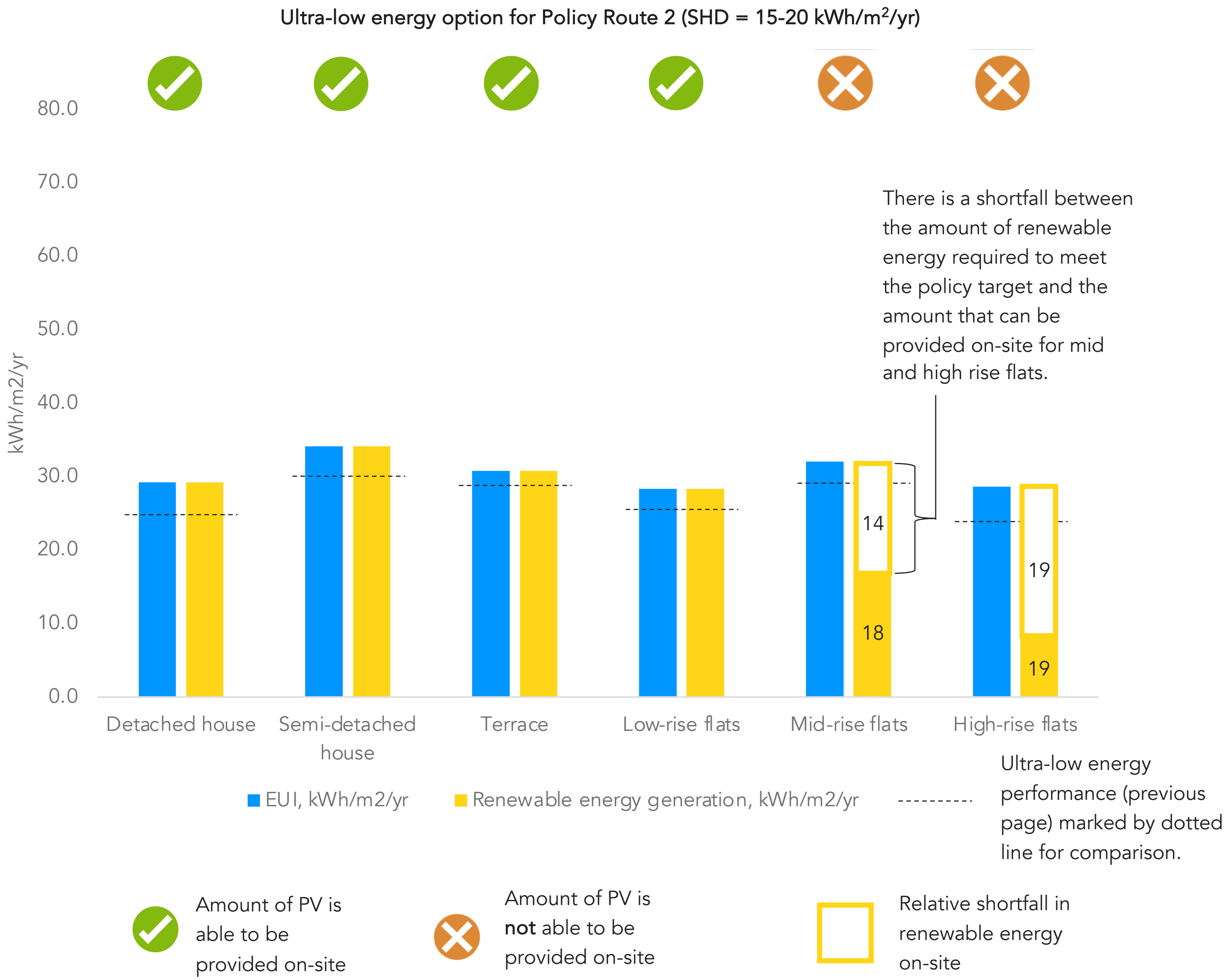
2.4.7 Policy Route 2 low energy: Predicted energy consumption and renewable energy generation

For Policy Route 2 (low energy) fabric and services specifications were selected to meet the space heating demand and energy use intensity targets. Solar photovoltaic was added to meet the energy balance target.

Space heating demand	Energy Use Intensity	Renewable energy
<30 kWh/m²/yr	40 kWh/m²/yr	Energy balance

The adjacent graph illustrates the annual energy consumption of each archetype (blue column) compared with the annual energy generation of each archetype (yellow column).

- Results are very similar to the Ultra-low energy targets option for Policy Route 2 (see previous page). Energy Use Intensities are 6-14% greater for the low-energy targets compared with the ultra-low energy targets illustrated on the previous page (see dotted lines on this chart).



This graph illustrates the predicted annual Energy Use Intensity (EUI) compared with the predicted annual renewable energy generation required for the specifications used to achieve Policy Route 2 for each archetype. This shows the results for Scenario 4 (Policy Route 2 – low energy).

2.5

Cost Modelling:

Running Costs and Capital Costs

2.5 Residential buildings energy modelling analysis for Policy Route 2 (absolute energy targets)

Contents

2.5.1 Running costs for residents

Running costs for residents are affected by many different variables, it is therefore not possible to be precise about potential future running costs.

To establish indicative comparative running costs of each scenario we have made some assumptions where are detailed on the right.

Each variable acts independently of each other and therefore the combination of variables used in calculations can have a big impact on the overall results.

To understand how each policy option performs in terms of potential future running costs for residents, we have taken a look at the three main factors that affect running costs:

1. Potential energy costs before solar export:
   - Design and energy efficiency using different energy costs: low, mid and high.
   - Solar self consumption – the use of renewable energy generated by solar panels directly in the home. Using this energy directly offsets electricity that needs to be imported from the grid.
2. The revenue from solar energy exported to the grid (after self consumption), using different export tariffs (low, mid, high).
3. Potential net energy costs after solar export, and including for the Performance Gap (see section 2.1.9). The Performance Gap can have on expected running costs. The Performance Gap is the difference between how a building is designed and specified (its theoretical energy use as determined by energy modelling) and how it is actually constructed. Variations in construction quality from one building or site to another can have a big impact on the actual energy efficiency of a building.

	Assumptions		
Variables	Low cost	Mid	High cost
Energy consumption	Energy modelling outputs from PHPP are used as the basis for establishing running costs for all scenarios. All energy uses are accounted for (space heating, hot water, lights, ventilation pumps, fans, cooking and appliances). EV charging is excluded.		
Performance gap	40% (baseline and FHS) 10% (net zero)		
Electricity cost[1], £/kWh	0.21	0.25	0.34
Gas cost[1], £/kWh	0.04	0.06	0.1
Standing charges[2], £/yr	£114 (gas) + £219 (elec)		
Solar export revenue[3], £/kWh	0.20	0.15	0.02
Solar self consumption[4]	20% / 30% / 27%		
Battery storage and smart controls	None assumed		
Construction quality (fabric and heating)	Accounted for in the performance gap		
Occupant preferences and habits	Not accounted for		

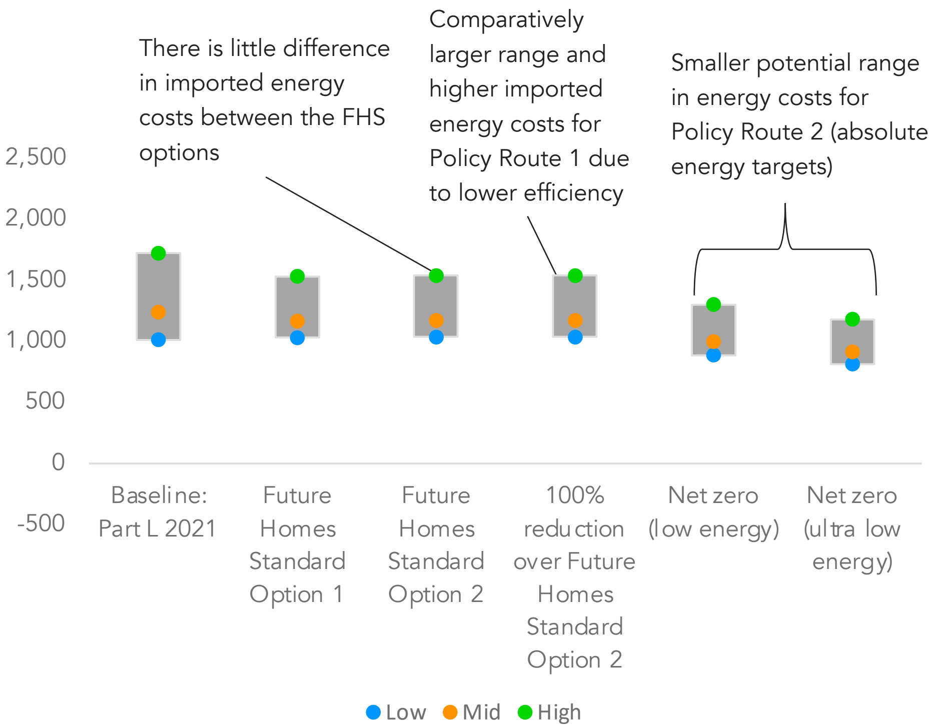
Table of variables and assumptions used in the running cost modelling.
1. Energy costs: Mid = current energy prices as at April 2024. High = average price cap Mar-Oct 2023.
2. Standing charges. Current at April 2024.
3. Solar export: Current and historical low, mid, high.
4. Solar self consumption: from MCS Guidance Note 'Determining the electrical self-consumption of domestics solar PV installations"

2.5.2 Running costs (houses): exploring the impact of energy efficiency

The resultant Energy Use Intensity for each scenario is directly related to how much energy the dwelling will likely consume (not accounting for any performance gap or variations in occupant behaviour).

The results below show us:

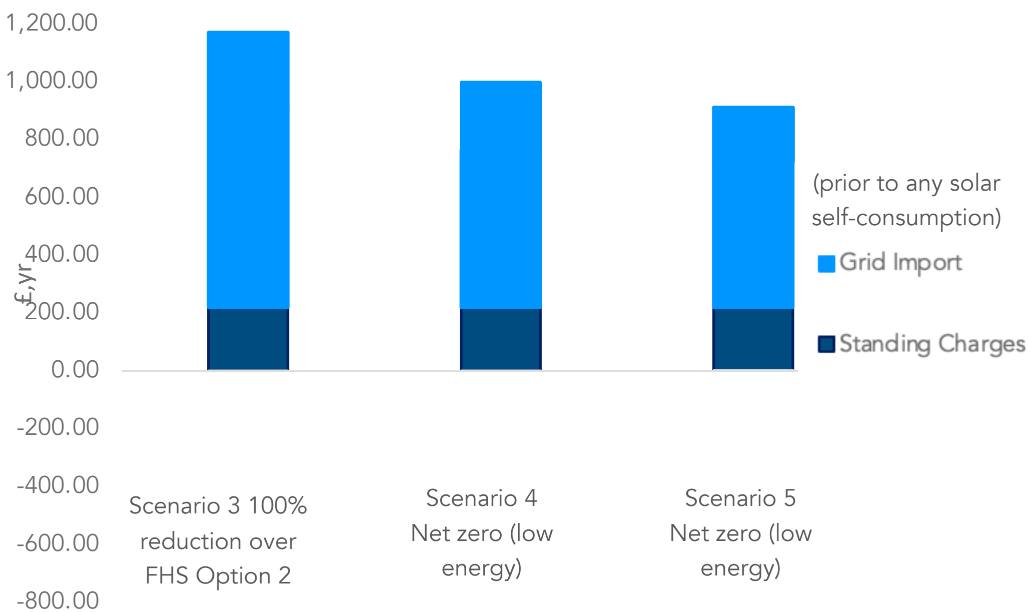
- The increased energy efficiency standards for both the net zero scenarios (Policy Route 2) result in these scenarios having the lowest costs for imported energy.
- In addition these scenarios have the least variation between high and low costs – occupants in these properties will be more insulated from energy price increases.



Potential range in imported energy costs for different scenarios, based on low, mid and high energy prices. Semi-detached house. No performance gap included.

Variables	Assumptions		
	Low cost	Mid	High cost
Performance gap	None assumed		
Electricity cost, £/kWh	0.21	0.25	0.34
Gas cost, £/kWh	0.04	0.06	0.1
Standing charges, £/yr	£114 (gas) + £219 (elec)		
Solar export revenue, £/kWh	0	0	0
Solar self-consumption	0%		

Key assumptions used for the calculations presented on this page.
Solar export revenue and solar self-consumption set to 0 to explore impact of energy efficiency.



Example of potential energy costs for the "Mid" range for a semi-detached house. The mid-range reflects current energy prices as at April 2024. Key assumptions detailed in the table above.

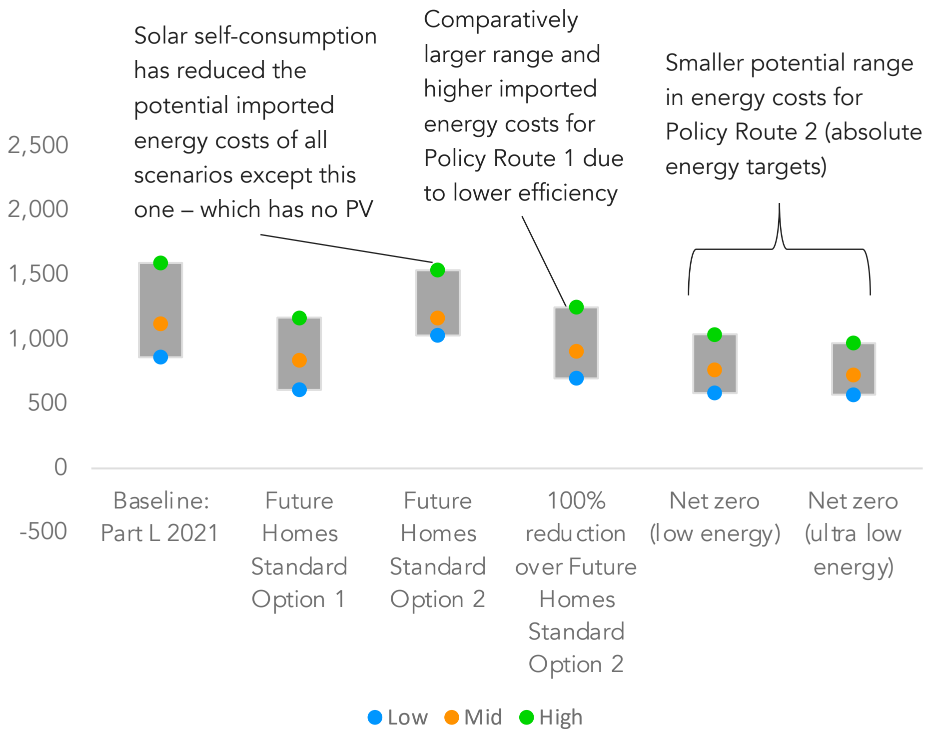
2.5.3 Running costs (houses): exploring the impact of solar self-consumption

Solar self-consumption is where occupants use generated solar energy directly in the home at the time it is generated, instead of importing the energy from the electricity grid. For example, when solar panels are generating electricity, that electricity can be used to power a television or anything else if it is on at the time. By using solar energy directly this way the occupant can effectively save the cost of the energy that would have been imported from the grid to the the same job.

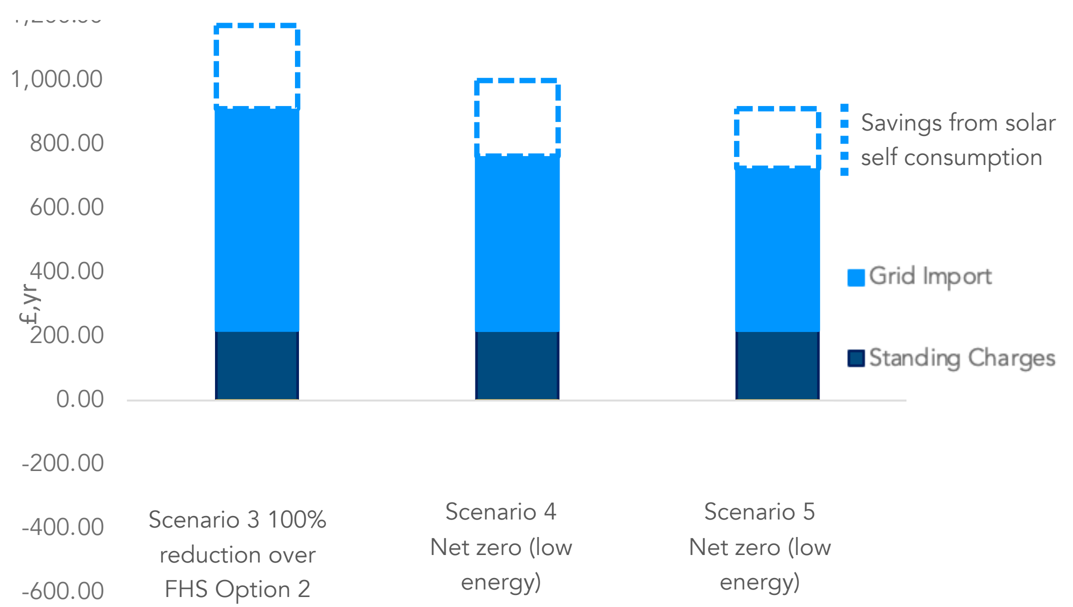
This is the most effective way of saving money from solar photovoltaics installed on the home. The more an occupant can maximise their solar self-consumption, the more money can be saved.

	Assumptions		
Variables	**Low cost**	**Mid**	**High cost**
Performance gap	None assumed		
Electricity cost, £/kWh	0.21	0.25	0.34
Gas cost, £/kWh	0.04	0.06	0.1
Standing charges, £/yr	£114 (gas) + £219 (elec)		
Solar export revenue, £/kWh	0	0	0
Solar self-consumption	20% / 30% / 27%		

Key assumptions used for the calculations presented on this page.
Solar export tariffs set to zero to explore only energy efficiency + solar self consumption.



Potential range in imported energy costs for different scenarios, based on low, mid and high energy prices. Semi-detached house. No performance gap included or solar self-consumption included.



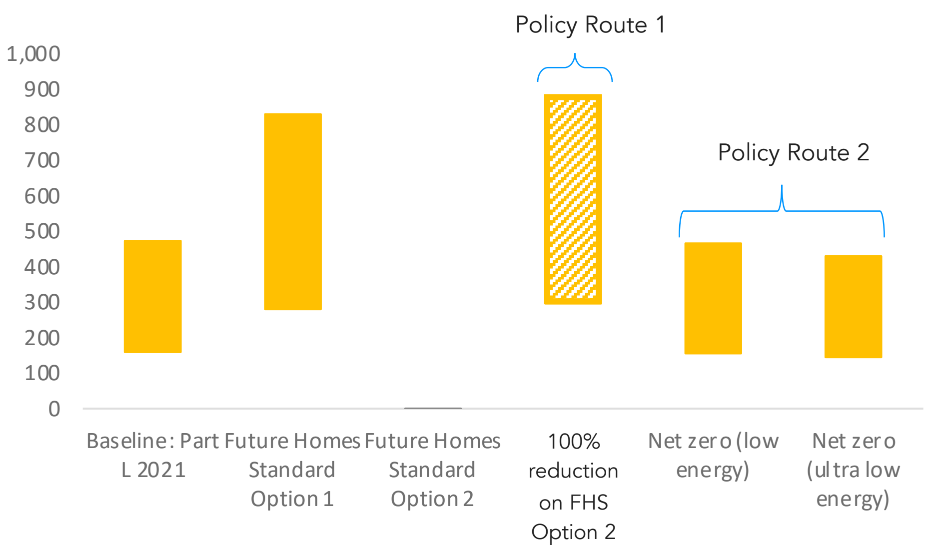
Example of potential energy costs for the "Mid" range for a semi-detached house. The mid-range reflects current energy prices as at April 2024. Key assumptions detailed in the table above.

2.5.4 Running costs (houses): exploring the impact of exporting solar energy

The amount of solar PV installed on a dwelling is proportional to how much revenue the dwelling will likely gain from exporting solar energy to the electricity grid.

The results below show us:

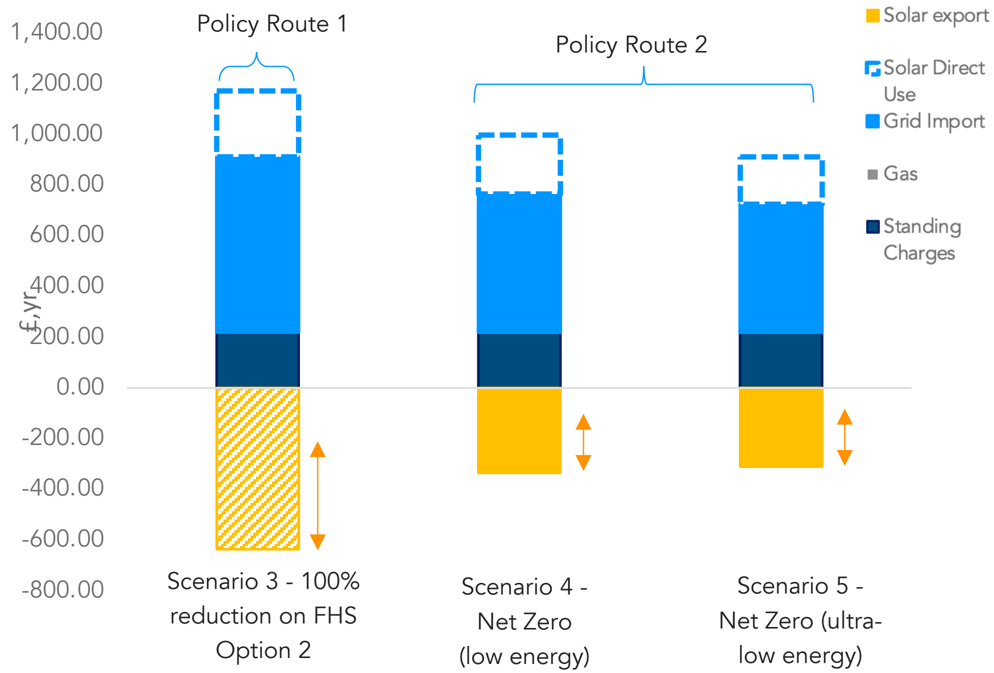
- Export tariffs have a large impact on potential savings – but is highly subject to change. Historically they have been very variable and do not necessarily rise with with rising energy prices.
- The "Net Zero" options (policy route 2) have smaller PV arrays hence lower modelled savings. But occupants, or the developer, could choose to add more solar PV for greater savings
- The potential revenue from solar seen in Policy Route 1 is highly subject to change. This result is due to the current SAP calculation methodology that will be superceded in 2025 (see section 1.2.5). Therefore it should not be relied upon when making a choice between Policy Route 1 and 2.
- The amount of solar determined through Policy Route 2 is based on absolute energy figures and therefore not subject to change.



Potential range of solar export revenue for different scenarios (semi-detached). The revenue is directly proportional to the size of the PV array required. Th

	Assumptions		
Variables	Low cost	Mid	High cost
Performance gap	None assumed.		
Electricity cost, £/kWh	0.21	0.25	0.34
Gas cost, £/kWh	0.04	0.06	0.1
Standing charges, £/yr	£114 (gas) + £219 (elec)		
Solar export revenue, £/kWh	0.20	0.15	0.02
Solar self-consumption	20% / 30% / 27%		

Key assumptions used for the calculations presented on this page.

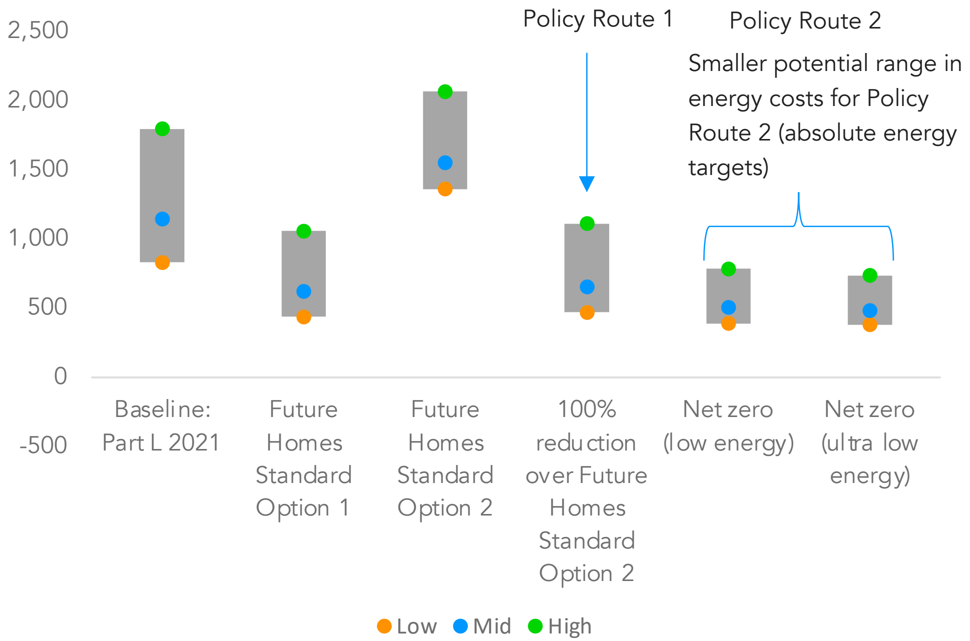


Revenue from solar export is highly subject to changes in solar export tariffs. Example of potential energy costs for the "Mid" range for a semi-detached house. The mid-range reflects current energy prices as at April 2024. Key assumptions detailed in the table above.

2.5.5 Running costs (houses): exploring potential net costs including a performance gap

If we combine the different variables of energy price, solar self-consumption and performance gap we can see large differences in potential net energy costs to occupants.

- Policy Route 2 (absolute energy targets) delivers homes with the least variance in imported energy costs.
- A Performance Gap factor has been added to the energy consumption estimates for all scenarios. A smaller variance for performance gap has been assumed for the net zero (Policy Route 2) dwellings as it assumes an Assured Performance policy is in place.
- The large PV array in Policy Route 1 has the potential to produce significant export revenue. When export prices are high, running costs could be similar or even less than higher efficiency dwellings with smaller PV arrays. But this should not be relied upon.



Potential range of energy costs (excluding the benefit of solar export revenue) for the different scenarios modelled.

	Assumptions		
Variables	Low cost	Mid	High cost
Performance gap	40% (baseline and FHS) 10% (net zero)		
Electricity cost, £/kWh	0.21	0.25	0.34
Gas cost, £/kWh	0.04	0.06	0.1
Standing charges, £/yr	£114 (gas) + £219 (elec)		
Solar export revenue, £/kWh	0.07	0.07	0.07
Solar self consumption	20% / 30% / 27%		

Key assumptions used for the calculations presented on this page.
Wholesale price of electricity has been used as the export tariff across all scenarios since there is not a robust way to pair varying energy costs and solar export costs.

	Policy Route 1	Policy Route 2	
Semi-detached house, today	100% Reduction over FHS Option 2	Net Zero (Low energy)	Net zero (ultra-low energy)
Imported energy cost (average)	£656	£508	£485
Potential PV export revenue (range)	£85 - £850	£45-£450	£41-£410
Potential net annual costs	£-194 - £571	£58 - £463	£75 - £444

Potential net costs of the semi-detached house using today's (April 2024) average energy prices with today's (April 2024) range of solar export prices. A huge range of solar export prices are currently available but this is unusual and cannot be relied upon for the future.

2.5.6 Running Costs: Flats

It is much harder for flats to benefit from renewable energy

The running costs analysis illustrated on the previous pages has been done using a semi-detached house as the basis. The patterns will be replicated between any house type.

However, it is logistically and organisationally difficult for flats to benefit from solar PV (either from self-consumption or from exporting renewable energy to the grid). This is because a number of flats will share one roof and one PV array.

When considering the impact of selected policies on running costs for the occupants of flats, the only factor that will reliably impact running costs is energy efficiency.

A policy which encourages energy efficiency is recommended

The graph on the right illustrates how the potential range of energy costs is smaller in Policy Route 2, and overall imported energy costs are likely to be smaller. The same pattern is seen when any impact of the performance gas is removed.

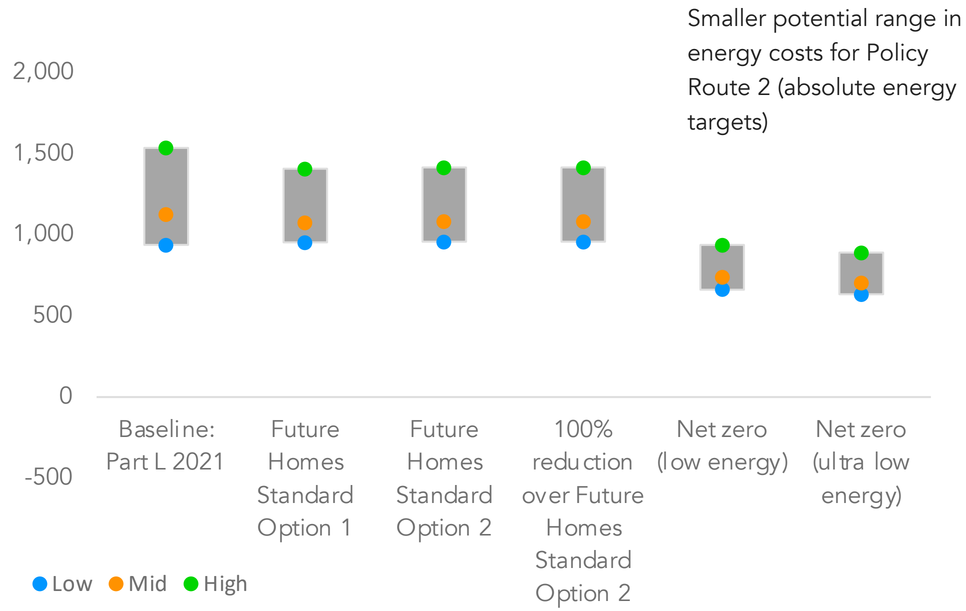
Solutions for sharing solar energy tend to increase costs and add complexity

There are potential avenues for enabling occupants of flats to benefit from shared PV arrays. Examples of these include:

- Energy from solar PV array is fed directly to "landlord" energy loads and savings are passed to occupants through reduced service charges or reduced energy bills (depending on billing and metering arrangements).
- Proprietary systems such as "Solshare" which distributes renewable energy generation to each flat as and when the demand arises, directly reducing their imported energy costs.
- Multiple individual solar arrays linked to each flat.

There are advantages and disadvantages to each of the above options - and the most beneficial for occupants tend to the most costly and expensive to implement.

	Assumptions		
Variables	Low cost	Mid	High cost
Performance gap	40% (baseline and FHS) 10% (net zero)		
Electricity cost, £/kWh	0.21	0.25	0.34
Gas cost, £/kWh	0.04	0.06	0.1
Standing charges, £/yr	£114 (gas) + £219 (elec)		
Solar export revenue, £/kWh	n/a	n/a	n/a
Solar self consumption	n/a		



Potential range of imported energy costs a 60m² mid-rise flat for the different scenarios modelled. This excludes the effect of the Performance Gap – the addition of which is illustrated in the adjacent graph.

2.5.7 Running Costs: Summary and recommendations

Energy efficiency

- Occupants are more insulated from rising energy prices in more energy efficient dwellings. Policies that encourage energy efficiency (Policy Route 2) are therefore recommended.
- With Policy Route 2, we see a reduction of 12-24% (SHD* < 30) and 20-31% (SHD* 15-20) in energy demand compared with Part L 2021 – and only a 6% reduction in energy demand for Policy Route 1.
- For flats, the only reliable way to deliver reduced running costs is through implementation of energy efficiency targets – e.g through absolute energy targets in Policy Route 2.
- The higher the energy efficiency the more occupants are able to take advantage of solar self-consumption, and the more they stand to save.

Solar self-consumption

- The presence of solar PV benefits occupants and reduces running costs significantly by using some of the generated renewable energy on-site. Running costs are reduced by 20-40% in the scenarios modelled through solar self-consumption alone (without the use of battery storage). This means that occupants can make reliable and significant savings on their running costs whether or not any revenue is made from exporting renewable energy to the grid. Savvy occupants may be able to increase these savings even further through managing when their appliances run (peak demand shifting).

Performance gap

- An Assured Performance policy can have a big impact on running costs. Dwellings will be delivered that are more likely to perform as designed.

*SHD = Space heat demand, kWh/m^2/yr. See all glossary of terms, section 5.

Revenue from solar export

- The benefit of exporting surplus solar energy generation has the further benefit of generating revenue. The amount of potential revenue will vary and will be proportional to the export tariff from the occupants' energy supplier.
- Net energy costs will depend on the balance between import tariffs and export tariffs, which change between energy supplier and market conditions. With the current (April 2024) ratio of potential export tariffs to import tariffs, energy efficient homes with large solar PV array may have minimal, or even negative levels.
- There is a clear benefit to larger solar PV arrays and these should be encouraged.
- Where an energy balance can be met on site without maximising the amount of solar on the roof, solar panels should be positioned in a way that occupants can add more a later date should they wish.

Recommendations for policy creation

- Energy efficiency has clear benefits for running costs for both houses and flats leading to more stable energy costs. Policy Route 2 is recommended.
- In practice, occupants of flats will find it more difficult to benefit from reduced running costs from solar PV even if it is present on the building. Policies that require high levels of energy efficiency are even more important for flats.
- An assured performance policy helps to make energy performance and therefore running costs more certain.
- Solar PV on homes make a big difference to running costs. Policies should include a requirement for solar PV to assist in occupants' running costs.
- The larger the PV array, the bigger the benefit. Ensure applicants are meeting the policy targets through good use of roof space, and any additional roof space can be used by occupants for more PV.

2.5.8 Capital costs

How we approached modelling

Each of the resultant specifications for the dwelling archetypes modelled (Section 6.0 Appendices) were costed by the cost consultant. The cost consultant's methodology can be found at (Section 6.0 Appendices). Detailed cost breakdowns can be found in the Energy and Costs spreadsheet (Part C of the Toolkit).

The "current" baseline has been used to assess costs against

The "current" baseline can be considered to be a dwelling that meets current (as at April 2024) building regulations standards (Part L 2021). This was used as the baseline for cost uplifts.

Potential future baseline

There is much uncertainty around the future baseline since the details of the Future Homes Standard are not known. The consultation documents released in December 2023 sought to get feedback on two levels of potential performance but our analysis shows that costs for delivering these vary fairly widely. See graph below right.

It would be reasonable to speculate that when the Future Homes Standard is released, the specifications and hence costs could sit somewhere between these two options - where exactly is unknown.

Therefore, we are not able to forecast a potential future cost baseline.

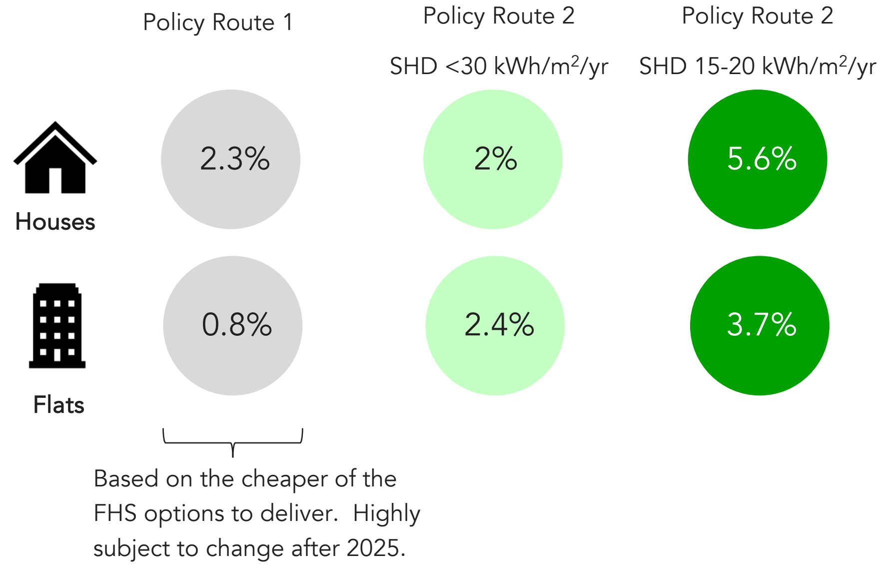
Cost uplifts to achieve all policy options are relatively modest

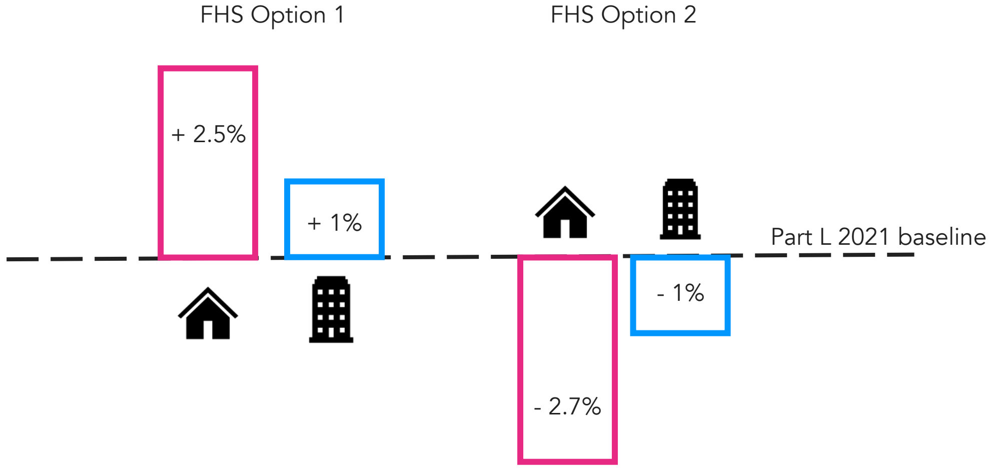
The graphic on the top right shows the relatively modest cost uplifts to achieve all policy options.

The % cost uplifts are less for flats than houses.

Note: the relatively low % uplifts for delivering Policy Route 1 are only relevant until the Future Homes Standard is released in 2025. Our modelling was based on the cheaper of the FHS consultation options to deliver (Option 2), however, as we have seen above the actual cost of delivering FHS compliant spec is likely to be higher than this.

Average cost uplift compared with a Part L 2021 baseline.





% cost uplifts compared to Part L 2021 baseline of FHS consultation options 1 and 2. This shows us how variable the cost of delivering FHS compliant dwellings could be. The average of the cost uplifts is consistent with the baseline costs.

2.5.9 Capital costs

- Future Homes Standard consultation options 1 and 2 vary in cost to deliver – Option 1 being more expensive, and option 2 being less expensive to deliver than Part L 2021.
- It is highly uncertain what the Future Homes Standard will look like
- The majority of the cost uplifts between Scenario 4 and 5 (Policy Route 2) are related to the inclusion of triple instead of double glazing in Scenario 5.
- The Future Homes Standard (FHS) Option 2 turns out to be cheaper than the current Part L 2021 baseline because it does not require any provision of solar PV. If this option is the preferred option after the consultation occupants will not reap the benefits of solar PV and will have higher running costs compared with the other scenarios.

Recommendations:

- The Part L 2021 baseline is the right one against which to consider cost uplifts. The cost of delivering a FHS compliant home will not be known until the Future Homes Standard is released.
- It would be reasonable to speculate that when the Future Homes Standard is released, the specifications and hence costs could sit somewhere between these two options - where is unknown.
- % cost uplifts for delivering both Policy Route 2 options (Scenarios 4 & 5) are relatively modest.
- Potential capital costs must be balanced with potential running costs and energy performance.

3.0

Non-domestic buildings:

Energy and cost analysis from Delivering Net Zero for 18 London Boroughs

3.1

Non-domestic buildings
‘Delivering Net Zero’
Methodology of energy modelling analysis

3.1 Non-domestic buildings: 'Delivering Net Zero' methodology of energy modelling analysis

Contents

3.1.1 Energy and cost modelling analysis for non-domestic buildings (Delivering Net Zero)

Providing an evidence base for non-domestic buildings

Etude was part of a consortium of consultants who developed the energy and cost modelling for a net zero carbon evidence base for 18 London Boroughs – Delivering Net Zero. The Delivering Net Zero reports are available to download from Haringey and Merton Council websites.

https://www.merton.gov.uk/planning-and-buildings/sustainability-and-climate-change/buildings-and-energy

This evidence base refers to back to Delivering Net Zero

We have not created a new set of non-domestic energy or cost models for Surrey's districts and boroughs. Non-domestic building characteristics are subject to a great deal more variation than domestic buildings. Similarly, non-domestic buildings can be used and operated in very different ways, with a wide variety of processes and functions being contained in them. For these reasons, energy modelling results can vary greatly depending on the building type, design and assumptions chosen. Therefore, remodelling for the Surrey context will yield significantly useful or more robust results than referring to the results from the Delivering Net Zero report. This is especially the case given that London is geographically close to Surrey and differences in weather will be minimal.

Non-domestic archetypes looked at

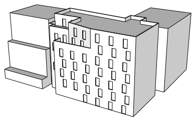
Four non-domestic archetypes were modelled in the Delivering Net Zero Study: office; industrial warehouse; school; hotel. These are illustrated on the right.

Approach to cost and viability for non-domestic buildings

[explain]

The Delivering Net Zero evidence base has been used as the source of modelling and cost data for the Surrey Net Zero Viability Toolkit.

Non-domestic archetypes selected

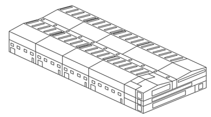


Office

7 storeys

4,000 sqm

This building represents the generic **office building** new build typology

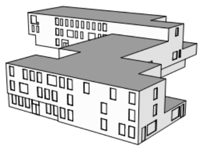


Industrial

2 storeys

9,000 sqm

This building represents the generic **industrial building** new build typology

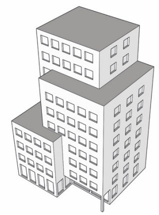


School

3/4 storeys

6,000 sqm

This building represents the generic **school building** new build typology



Hotel

11 storeys

3,900 sqm

This building represents the generic **hotel building** new build typology

Graphical representation of the 4 buildings chosen as archetypes

3.1.2 Energy and cost modelling analysis for non-domestic buildings I Specifications modelled

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude

Specification scenarios modelled

The Delivering Net Zero study utilised a fair and balanced set of specifications which considered various levels of performance for fabric and ventilation, heating systems and renewable energy provision were modelled.

Three specific sets of building fabric, ventilation and renewable energy specifications selected are illustrated on the right.

The detailed specifications can be found in the appendix.

Part L 2021 compliance modelling outputs

The different scenarios were modelled for 4 different archetypes using the NCM methodology for non-domestic buildings (i.e. EDSL's Tas and IES's VE).

Part L modelling outputs for Policy option 1

Results were analysed to investigate how the different cases would perform against the requirements of Policy option 1 in terms of:

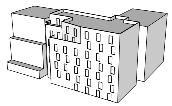
- Regulated carbon emissions - % improvement over Part L 2021

Predictive energy modelling outputs for Policy option 2

The buildings were also modelled using a predictive operational energy modelling tool: EDSL's Tas and IES's VE using CIBSE TM54 methodology for non-domestic buildings. They were used to calculate the space heating demand (SHD) and Energy Use Intensity (EUI) for each scenario and each building.

Fabric and Ventilation	Heating system	Solar PVs
Business as usual*	Gas boiler	No
Good practice	Direct electric	High provision of PVs
Ultra-low energy	Less efficient heat pump	
	More efficient heat pump	

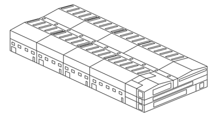
*Many different scenarios were modelled for the Delivering Net Zero study for each archetype, combining different levels of fabric specification, heating system and renewable energy provision. The scenarios most applicable to the aims of Surrey's evidence base are shown above. * The 'Business as usual' scenarios is meant to represent the type of fabric and ventilation specifications that most applicants in London would consider 'standard' in the last 5-10 years.*



Office

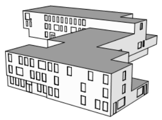
54.8 kWp
432 m² of PV panels
70% of roof area

Max PV option



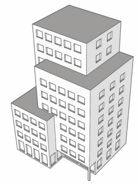
Industrial building

76.7 kWp
666 m² of PV panels
25% of roof area



School

135.5 kWp
608 m² of PV panels
25% of roof area



Hotel

45 kWp
202 m² of PV panels
50% of roof area

Summary of PV assumptions confirming total PV panel area and kWp output

3.1.3 Energy and cost modelling analysis for non-domestic buildings I Aligning with Surrey

Alignment with Surrey's policy objectives and policy options

No bespoke modelling on *non-domestic buildings* has been done for this Surrey Viability Toolkit. Therefore we refer to modelling done for the Delivering Net Zero (DNZ) study for 18 London Boroughs.

Although similar policy objectives and aims, the modelling and the study for DNZ was structured in a different way to how the bespoke residential modelling for this Surrey Net Zero Viability Toolkit.

On the right, we indicate which of the combination of scenarios modelled for the non-domestic buildings in the DNZ study align with the scenarios modelled for Surrey's residential study.

Policy Route 1 – TER based approach

Like Surrey, a TER based approach to policy targets was explored for the Delivering Net Zero study.

A Part L 2021 compliant scenario was used as a baseline. Results are presented in terms of a % reduction against a Part L 2021 baseline.

Policy Route 2 – absolute energy targets

Again, like Surrey, an absolute energy targets approach was explored for the Delivering Net Zero Study.

Results are presented in terms of space heating demand and energy use intensity. Renewable energy generation and energy balance results were not considered in the DNZ study.

Policy Route 1 – TER based approach

Fabric and Ventilation	Heating system	Solar PVs
Business as usual*	~~Gas boiler~~	~~No~~
Good practice	~~Direct electric~~	High provision of PVs
Ultra-low energy	~~Less efficient heat pump~~	
	More efficient heat pump	

Policy Route 2a (low energy) – Absolute energy targets approach

Fabric and Ventilation	Heating system	Solar PVs
Business as usual*	~~Gas boiler~~	~~No~~
Good practice	~~Direct electric~~	High provision of PVs
Ultra-low energy	~~Less efficient heat pump~~	
	More efficient heat pump	

Policy Route 2b (ultra-low energy) – Absolute energy targets approach

Fabric and Ventilation	Heating system	Solar PVs
Business as usual*	~~Gas boiler~~	~~No~~
Good practice	~~Direct electric~~	High provision of PVs
Ultra-low energy	~~Less efficient heat pump~~	
	More efficient heat pump	

3.2

Non-domestic buildings: 'Delivering Net Zero' Energy modelling analysis for Policy Route 1

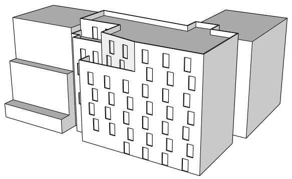
3.2 Non-domestic buildings: 'Delivering Net Zero' Energy modelling analysis for Policy Route 1

Contents

3.2.1 Office building I Policy option 1 I Improvement over Part L 2021

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude



This page duplicates the results from the Delivering Net Zero for 18 London Boroughs study

A Business as Usual approach to the building fabric, with PVs added to cover the roof would not achieve the policy target on-site for this building type.

Better % reductions are achieved as the building fabric improves. However a 100% reduction was not achieved in any scenario.

Therefore an energy offsetting policy would be required to make up for the shortfall.

The gas boiler results from DNZ are not relevant to the Surrey study.

Reduction in CO_2 - NCM - SAP 10.2 GLA (reg)		With PV			
		Gas boiler	VRF	Heat pump less efficient	Heat pump more efficient
Fabric & ventilation	Business as usual	-1%	37%	30%	38%
	Good practice	28%	53%	49%	54%
	Ultra-low energy	47%	57%	55%	57%

Results above are from Delivering Net Zero study for 18 London Boroughs.

PV area covering 70% of the building footprint area

Performance of each case in terms of CO_2 against the Part L 2021 baseline

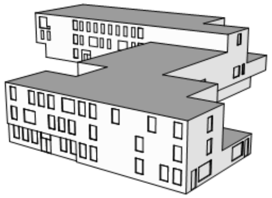
Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

< 0%	< 35%	< 60%	60-80%	> 80%

3.2.2 Primary School building | Policy option 1 | Improvement over Part L 2021

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude



This page duplicates the results from the Delivering Net Zero for 18 London Boroughs study

A Business as Usual approach to the building fabric, with PVs added to cover the roof would not achieve the policy target on-site for this building type.

Better % reductions are achieved with the ultra-low building fabric. However a 100% reduction was not achieved in any scenario.

Therefore an energy offsetting policy would be required to make up for the shortfall.

The gas boiler results from DNZ are not relevant to the Surrey study.

Reduction in CO_2 - NCM - SAP 10.2 GLA (reg)		With PV			
		Gas boiler	Direct electric	Heat pump less efficient	Heat pump more efficient
Fabric & ventilation	Business as usual	27%	11%	75%	77%
	Good practice	26%	3%	40%	40%
	Ultra-low energy	63%	73%	83%	83%

Results above are from Delivering Net Zero study for 18 London Boroughs.

PV area covering 25% of the building footprint area

Performance of each case in terms of CO_2 against the Part L 2021 baseline

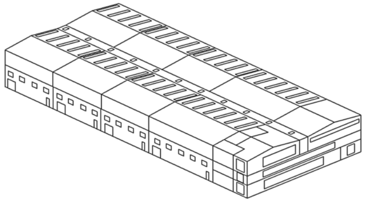
Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

< 0% | < 35% | < 60% | 60-80% | > 80%

3.2.3 Industrial building | Policy option 1 | Improvement over Part L 2021

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude



This page duplicates the results from the Delivering Net Zero for 18 London Boroughs study

A Business as Usual approach to the building fabric, with PVs added to cover the roof would not achieve the policy target on-site for this building type.

Better % reductions are achieved with the ultra-low building fabric. However a 100% reduction was not achieved in any scenario. Therefore an energy offsetting policy would be required to make up for the shortfall.

The gas boiler results from DNZ are not relevant to the Surrey study.

Reduction in CO_2 - NCM - SAP 10.2 GLA (reg)		With PV			
		Gas boiler	VRF	Four pipe chiller	Heat pump more efficient
Fabric & ventilation	Business as usual	0%	41%	40%	53%
	Good practice	6%	41%	40%	53%
	Ultra-low energy	21%	48%	46%	61%

Results above are from Delivering Net Zero study for 18 London Boroughs.

PV area covering 25% of the building footprint area

Performance of each case in terms of CO_2 against the Part L 2021 baseline

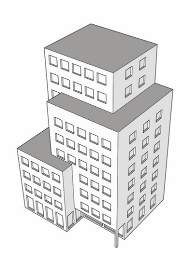
Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

< 0%	< 35%	< 60%	60-80%	> 80%

3.2.4 Hotel building I Policy option 1 I Improvement over Part L 2021

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude



This page duplicates the results from the Delivering Net Zero for 18 London Boroughs study

A Business as Usual approach to the building fabric, with PVs added to cover the roof would not achieve the policy target on-site for this building type.

Better % reductions are achieved with the ultra-low building fabric. However a 100% reduction was not achieved in any scenario.

Therefore an energy offsetting policy would be required to make up for the shortfall.

The gas boiler results from DNZ are not relevant to the Surrey study.

	Reduction in CO_2 - NCM - SAP 10.2 GLA (reg)	With PV			
		Gas boiler	Heat pump (220)	Heat pump (400/300)	Heat pump (450/300)
Fabric & ventilation	Business as usual	-2%	-18%	7%	8%
	Good practice	2%	-13%	10%	11%
	Ultra-low energy	4%	-7%	16%	16%

Results above are from Delivering Net Zero study for 18 London Boroughs.

PV area covering 50% of the building footprint area

Performance of each case in terms of CO_2 against the Part L 2021 baseline

Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

< 0%	< 35%	< 60%	60-80%	> 80%

3.2.5 Part L energy modelling for Policy option 1 I Non-domestic buildings I Summary of findings

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude

Policy option 1 assumes that the Part L framework continues to be used to go beyond the minimum requirements of Building Regulations Part L 2021.

Part L 2021 methodology for non-domestic buildings is assessed using a new government-approved NCM modelling methodology. This methodology is expected to change in 2025 with the introduction of the Future Buildings Standard.

In summary, non-domestic Part L modelling undertaken indicates the following

- The results indicate a large range of CO_2 emissions reductions depending on the building typology.
- The results of the modelling suggest that a 100% reduction beyond Part L 2021 cannot be achieve on-site for any of the archetypes and an energy offsetting policy would be required to make up for the shortfall. Setting different policy targets across building types could be an appropriate solution.
- Better on-site % reductions are achieved where building fabric energy efficiency is improved.
- Improvements in % reduction are relatively minimal suggesting an applicant may prefer to opt for energy offsetting as opposed to improving the building fabric to achieve better CO_2 reductions on site.
- All results are highly reactive to the amount of PV provision, partially due to the fact that heating energy use tends to be significant underestimated.

Would not pass both metrics of Building Regulations Part L 2021

< 0% | < 35% | < 60% | 60-80% | > 80%

Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

Reduction in CO_2 - NCM - SAP 10.2 GLA(reg)	School: Direct electric	School: Heat pump less efficient	School: Heat Pump more efficient	Office: VRF	Office: Heat pump less efficient	Office: Heat pump more efficient	Industrial: VRF	Industrial: Four pipe chiller	Industrial: Heat pump more efficient	Hotel: Heat pump (400/300)	Hotel: Heat pump (450/300)
Fabric & ventilation: Business as usual	11%	75%	77%	37%	30%	38%	41%	40%	53%	7%	8%
Fabric & ventilation: Good practice	3%	40%	40%	53%	49%	54%	41%	40%	53%	10%	11%
Fabric & ventilation: Ultra-low energy	73%	83%	83%	57%	55%	57%	48%	46%	61%	16%	16%

Performance of each case in terms of CO_2 against the Part L 2021 baseline

3.3

Non-domestic buildings: ‘Delivering Net Zero’ Energy modelling analysis for Policy Route 2

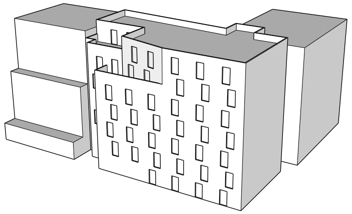
3.3 Non-domestic buildings: 'Delivering Net Zero' Energy modelling analysis for Policy Route 2

Contents

3.3.1 Office building | Policy option 2 | Predictive energy modelling

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude



Space heating demand varies from 23 (worst) down to 4 kWh/m²/yr (best). The benefit of better fabric and MVHR is clearly showing.

The estimated EUIs range from 104 (worst) down to 66 kWh/m²/yr (best).

Space heating demand

Worst | Best

Fabric & ventilation	Space heating demand - Predictive (kWh/m²/yr)
Business as usual	23
Good practice	12
Ultra-low energy	4

Performance of each case in terms of space heating demand

Energy use intensity

Worst | Best

Fabric & ventilation — EUI - Predictive (kWh/m²/yr)	Gas boiler	VRF	Heat pump less efficient	Heat pump more efficient
Business as usual	104	82	87	81
Good practice	83	72	74	72
Ultra-low energy	71	66	67	66

Performance of each case in terms of energy use intensity (EUI)

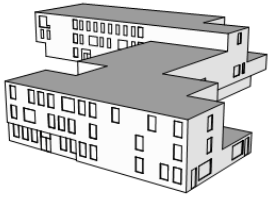
Note: the above four heating options are not exhaustive. Other options (e.g. low carbon heat networks with low distribution losses) may perform well.

Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

3.3.2 Primary school building | Policy option 2 | Predictive energy modelling

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude



Space heating demand varies from 37 (worst) down to 4 kWh/m²/yr (best). The benefit of better fabric and MVHR is clearly showing.

The estimated EUIs range from 96 (worst) down to 57 kWh/m²/yr (best).

Space heating demand

Worst	Best

Fabric & ventilation	Space heating demand - Predictive (kWh/m²/yr)
Business as usual	37
Good practice	12
Ultra-low energy	4

Performance of each case in terms of space heating demand

Energy use intensity

Worst	Best

Fabric & ventilation / EUI - Predictive (kWh/m2/yr)	Gas boiler	Direct electric	Heat pump less efficient	Heat pump more efficient
Business as usual	96	92	65	64
Good practice	72	71	62	62
Ultra-low energy	60	60	57	57

Performance of each case in terms of energy use intensity (EUI)

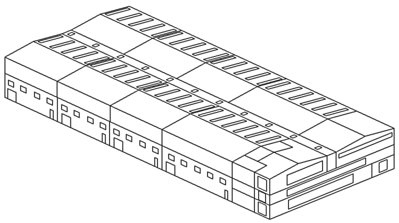
Note: the above four heating options are not exhaustive. Other options (e.g. low carbon heat networks with low distribution losses) may perform well.

Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

3.3.3 Industrial building | Policy option 2 | Predictive energy modelling (Space heating demand and EUI)

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude



Space heating demand varies from 17 (worst) down to 10 kWh/m²/yr (best). The benefit of better fabric and MVHR is clearly shown as you move towards better fabric performance.

The estimated EUIs range from 50 (worst) down to 27 kWh/m²/yr (best). EUI results are very similar for VRF, Four pipe chiller and heat pump scenarios.

Space heating demand

Worst	Best

Fabric & ventilation	Space heating demand - Predictive (kWh/m²/yr)
Business as usual	17
Good practice	12
Ultra-low energy	10

Performance of each case in terms of space heating demand

Energy use intensity

Worst	Best

EUI - Predictive (kWh/m²/yr)	Gas boiler	VRF	Four pipe chiller	Heat pump more efficient
Business as usual	50	34	34	32
Good practice	41	30	31	29
Ultra-low energy	36	28	28	27

Performance of each case in terms of energy use intensity (EUI)

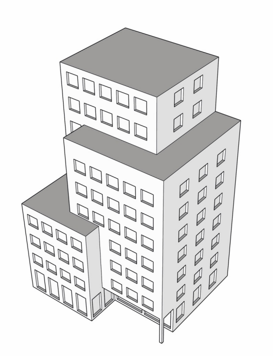
Note: the above four heating options are not exhaustive. Other options (e.g. low carbon heat networks with low distribution losses) may perform well.

Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

3.3.4 Hotel building | Policy option 2 | Predictive energy modelling (Space heating demand and EUI)

Delivering Net Zero evidence base (for 18 London boroughs)

Prepared by Levitt Bernstein, Introba, Inkling, Currie & Brown and Etude



Space heating demand

Worst	Best

Space heating demand - Predictive (kWh/m²/yr)		
Fabric & ventilation	Business as usual	30
	Good practice	24
	Ultra-low energy	15

Performance of each case in terms of space heating demand

Space heating demand varies from 30 (worst) down to 15 kWh/m²/yr (best). The benefit of better fabric and ventilation is clearly showing

The estimated EUIs range from 233 (worst) down to 142 kWh/m²/yr (best).

Energy use intensity

Worst	Best

EUI - Predictive (kWh/m²/yr)		Gas boiler	Heat pump (220)	Heat pump (400/300)	Heat pump (450/300)
Fabric & ventilation	Business as usual	233	174	159	158
	Good practice	222	166	152	152
	Ultra-low energy	206	154	143	142

Performance of each case in terms of energy use intensity (EUI)

Note: the above four heating options are not exhaustive. Other options (e.g. low carbon heat networks with low distribution losses) may perform well.

Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

3.3.5 Predictive energy modelling analysis for Policy option 2 I Non-domestic buildings I Summary of findings

Energy modelling using TAS and IES software in conjunction with CIBSE TM54 was undertaken to estimate space heating demand and the total energy use (EUI) for the different non-domestic typologies.

- **Space heating demand seeks to improve energy efficiency.** As it can be seen from the adjacent table, the results are fairly consistent and would enable to use a particular level for policy (e.g. 15 or 20 kWh/m².yr). The school and office typologies have the widest range of space heating demand per floor area (GIA) relative to the other typologies.
- **Energy Use Intensity (EUI) seeks to reduce total energy use.** As it can be seen from the table below, the range of results is very wide and would require specific EUI targets for the different typologies. The benefit of introducing a more efficient heat pump is clearest for the hotel which has the highest EUI.

Space heating demand – Predictive (kWh/m²/yr)

Fabric & ventilation	School	Office	Industrial	Hotel
Business as usual	37	23	17	30
Good practice	12	12	12	24
Ultra-low energy	4	4	10	15

Summary of space heating demand results ranges for each non-domestic typology and each different level of fabric and ventilation specifications

Space heating demand: Worst / Best

Energy use intensity: Worst / Best

Indicates which combination of scenarios aligns best with the approach to the residential specification for Policy Route 1 for Surrey.

EUI - Predictive (kWh/m²/yr)

Fabric & ventilation	School: Direct electric	School: Heat pump less efficient	School: Heat Pump more efficient	Office: VRF	Office: Heat pump less efficient	Office: Heat pump more efficient	Industrial: VRF	Industrial: Four pipe chiller	Industrial: Heat pump more efficient	Hotel: Heat pump (220)	Hotel: Heat pump (400/300)	Hotel: Heat pump (450/300)
Business as usual	92	65	64	82	87	81	34	34	32	159		158
Good practice	71	62	62	72	74	72	30	31	29	152		152
Ultra-low energy	60	57	57	66	67	66	28	28	27	143		142

Energy use intensity result ranges for each case of each non-domestic typology

3.4

Non-domestic buildings:

‘Delivering Net Zero’ Cost modelling

3.4 Non-domestic buildings: 'Delivering Net Zero' Cost modelling

Contents

3.4 1 Summary costs per m² of construction | Non-domestic*

*Costs reproduced from the **Delivering Net Zero** study for 18 London Boroughs. These have not been made applicable to Surrey.

The tables below show the summary results for the non-domestic archetypes in comparison to the 'zero additional cost' Part L 2021 compliant option.

Office building (~ £4,050/m² baseline construction cost)

% uplift in cost per m² of construction		With PV			
		Gas boiler	VRF	Heat pump less efficient	Heat pump more efficient
Fabric & ventilation	Business as usual	~~-0.9%~~	-2.9%	-0.2%	3.0%
	Good practice	0.0%	-1.6%	0.4%	2.7%
	Ultra-low energy	1.8%	0.6%	2.0%	3.7%

Industrial building (~ £1,300/m² baseline construction cost)

% uplift in cost per m² of construction		With PV			
		Gas boiler	VRF	Four pipe chiller	Heat pump more efficient
Fabric & ventilation	Business as usual	~~-6.5%~~	3.8%	5.2%	7.1%
	Good practice	~~-2.2%~~	3.8%	4.7%	5.8%
	Ultra-low energy	0.0%	5.5%	6.2%	7.3%

Primary school (~ £3,400/m² baseline construction cost)

% uplift in cost per m² of construction		With PV			
		Gas boiler	Direct electric	Heat pump less efficient	Heat pump more efficient
Fabric & ventilation	Business as usual	-1.1%	-3.1%	0.0%	3.3%
	Good practice	0.6%	-1.0%	1.1%	2.9%
	Ultra-low energy	2.9%	-1.4%	2.9%	3.6%

Hotel (~ £4,250/m² baseline construction cost)

% uplift in cost per m² of construction		With PV			
		Gas boiler	Heat pump (220)	Heat pump (400/300)	Heat pump (450/300)
Fabric & ventilation	Business as usual	~~-0.8%~~	~~-2.2%~~	-0.3%	0.8%
	Good practice	0.0%	~~-1.3%~~	0.5%	1.6%
	Ultra-low energy	1.4%	~~-0.8%~~	1.9%	2.8%

Would not pass both metrics of Building Regulations Part L 2021

Summary of all non-domestic relative costs (£/m²) compared to the '0' baseline, overlaid with compliance with all Part L 2021 criteria

3.4.2 Making costs applicable to Surrey | Non-domestic

Additional costs of meeting the net zero scenarios (non-residential)

The costs of higher building standards on non-residential development depends on the combination of fabric and ventilation specifications, heating systems and renewable energy specifications. Including PV but without gas boilers, the cost increase over base construction costs varied between -3.1% to +7.3% of base build cost. Ultra-low energy building fabric with improved heating/ventilation had increased costs of approximately 2%, except for industrial buildings where the costs increases were higher.

3.5

Viability Summary

3.4 Viability Summary

Contents

3.5.1 Economic Viability Modelling: Background and typologies

Background to the economic viability modelling

To understand the potential for delivering net zero solutions on both residential and non-residential development across Surrey, a set of costings and economic viability tests have been undertaken. This will help address the central question of whether net zero development policies are generally achievable across Surrey and within individual districts & boroughs or if some trade-offs with other policy objectives may need to be considered.

The viability analysis has been undertaken in accordance with national policy and guidance - including the December 2023 National Planning Policy Framework and latest Planning Practice Guidance. This includes consultation with the development industry active in Surrey and the eleven district and borough councils.

It is important to emphasise that, as this is a Surrey-wide study, the typologies and base assumptions employed in the modelling are necessarily high-level. In practice when they reach plan making stage, councils will need to undertake their own viability assessment of their policies. but they can make reference to the specific net zero costs contained in the full report to this study and the toolkit.

An individual development can be said to be viable if, after taking account of all costs, including central and local government policy and regulatory costs and the cost and availability of development finance, the scheme provides a competitive return to the developer to ensure that development takes place and generates a land value sufficient for the landowner to sell the land for the development proposed. If these conditions are not met, a scheme will not be viable.

Typologies – residential testing

Typology reference	Number units	Development type	Land use	Density (dwellings per hectare)
Res 1a	6	Houses (tested with and without affordable housing)	Greenfield	30dph
Res 1b	6	Houses (tested with and without affordable housing)	Brownfield	30dph
Res 2a	35	Mixed (houses and flats)	Greenfield	35 dph
Res 2b	35	Mixed (houses and flats)	Brownfield	35 dph
Res 3	60	Flats - 4 storey	Brownfield	120 dph
Res 4	260	Mixed (houses and flats)	Greenfield	40 dph
Res 5	240	Flats - 15 storey	Brownfield	343 dph

Typologies used in the residential testing

The analysis is based on a series of development typologies, typical of the types of development found across Surrey. Typologies were tested on greenfield and brownfield land and in three overarching value areas, identified using Land Registry sales data. The value areas are labelled 1-3 in the study (see image on the following page). Sales values are highest in value area 3 and lowest in value area 1 but construction costs are largely constant throughout.

From other local studies in Surrey we have also identified a range of benchmark land values (BMLV) applicable to the different land uses. To capture the full potential range we have also modelled each typology at BMLV1 and BMLV 2, with BMLV1 being lower than BMLV2.

3.5.2 Economic Viability Modelling: Testing assumptions and value areas

Testing assumptions information sources

The viability analysis follows national guidance and good practice and has drawn on:

- Published data: the Building Cost Information Service (BCIS) (for build costs), Land Registry values and House Price Index (HPI) (for residential market values) , Energy Performance Certificates (EPCs) for dwelling size;
- Published viability studies for the Surrey local authorities;
- Discussion with district council officers;
- A workshop with developers;
- Industry norms and standard practice
- Government impact assessments.

Surrey has been divided into three broad value areas as shown on the right.

Testing assumptions included - for residential development

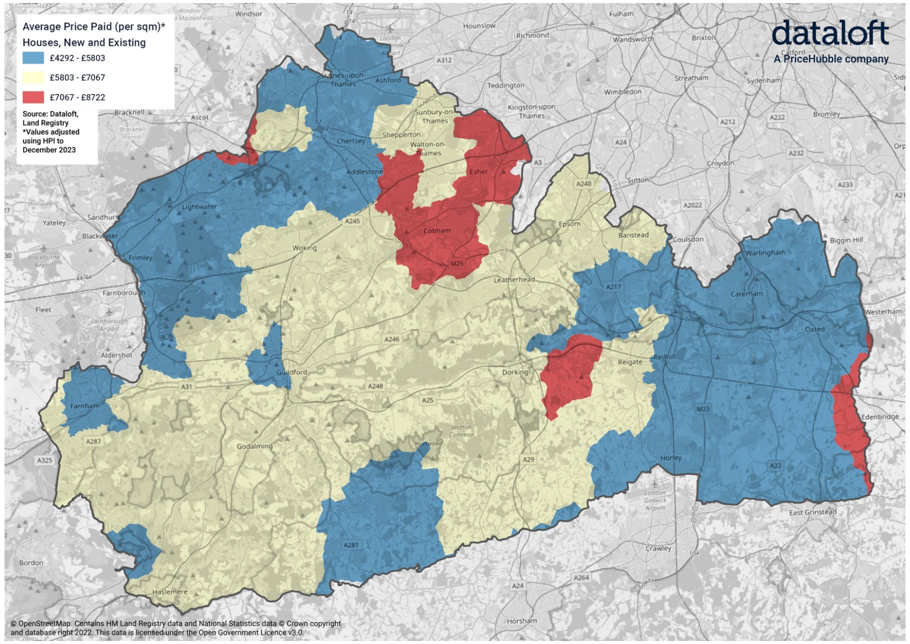
The modelling has taken account of the costs of meeting Building Regulations 2021 Parts L, F, O and S as well as biodiversity net gain and First Homes.

For sites of 10 or more dwellings, an affordable housing requirement of 40% has been modelled with a tenure mix of 35% social rent / 35% affordable rent / 25% first homes / 5% shared ownership. Sites of 6 to 9 dwellings have been modelled with and without affordable housing – to reflect differences in approach across Surrey.

An allowance of £5,000 a unit has been made for habitat mitigation measures and between £2,500 and £10,000 a unit for s106, depending on site size.

All dwellings are assumed to meet Building Regulations Part M4(2) and 5% Part M4(3)(a) for accessibility. 5% of dwellings on non-flatted schemes are reserved for self build and custom housebuilding.

CIL varies significantly across Surrey and, as a working assumption, a levy of £200 per sqm has been used in the modelling.



Map showing the 3 value areas tested across Surrey

Average value of semi-detached house of 102 sqm in each value area (VA)

VA1 = £540,600

VA2 = £673,200

VA3 = £724,200

3.5.3 Economic Viability Modelling: Additional costs of meeting net zero scenarios

Additional costs of meeting the net zero scenarios (residential)

With a base case of Building Regulations 2021 (including Part L), the additional costs for achieving the net zero scenarios outlined earlier in this report were obtained, including the cost of the Future Homes Standard using options 1 and 2, as identified by the government in its 2023 consultation.

Each of the residential typologies has been modelled at the base position and the five scenarios shown on the right and for development in each of the three value areas.

It is noted that The Future Homes Standard option 2 represents a cost saving against the base position for houses and high rise flats and that scenario 4, low energy, is cheaper than the cost of meeting The Future Homes Standard option 1 (which is the higher of the two standards presented in the government consultation).

Additional costs of meeting the net zero scenarios (non-residential)

The costs of higher building standards on non-residential development depends on the combination of fabric and ventilation specifications, heating systems and renewable energy specifications. Including PV but without gas boilers, the cost increase over base construction costs varied between -3.1% to +7.3% of base build cost. Ultra-low energy building fabric with improved heating/ventilation had increased costs of approximately 2%, except for industrial buildings where the costs increases were higher.

Average Additional Cost for each Scenario	Base	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
		Future Homes Standard – option1	Future Homes Standard – option2	Future Homes Standard – scaled to 100%	Net Zero – low energy	Net Zero – ultra low energy
Total additional cost per house (rounded)	£0	£5,600	-£6,400	£6,300	£4,600	£13,500
Additional cost sqm – house of 110 sqm	£0	£51	-£58	£57	£42	£122
Additional cost per sqm low-mid rise flats	£0	£14	£152	£192	£214	£237
Additional cost sqm high rise flats	£0	£4	-£ 20	-£11	£17	£44

3.5.4 Economic Viability Modelling: Results

Results of the residential modelling

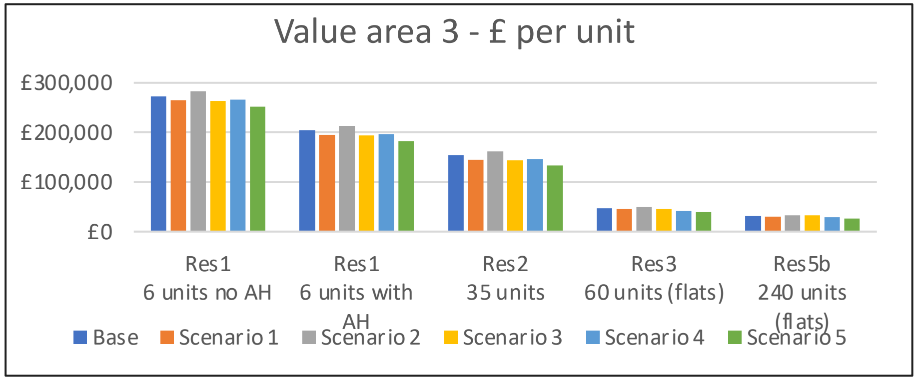
The results of the viability modelling demonstrates good general viability and that most development can absorb the additional costs of achieving net zero. However there are exceptions, particularly in lower value areas and on brownfield sites This is explored in more detail below.

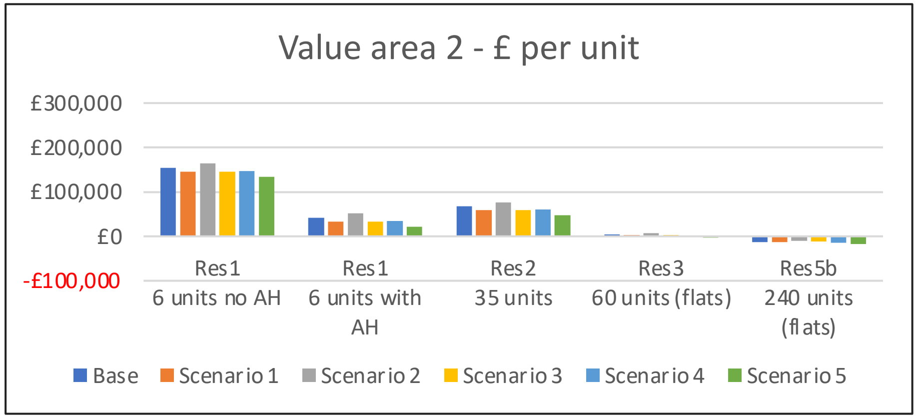
The results on **greenfield sites**, with an average CIL, show development consistently able to meet the policy costs associated with all net zero scenarios.

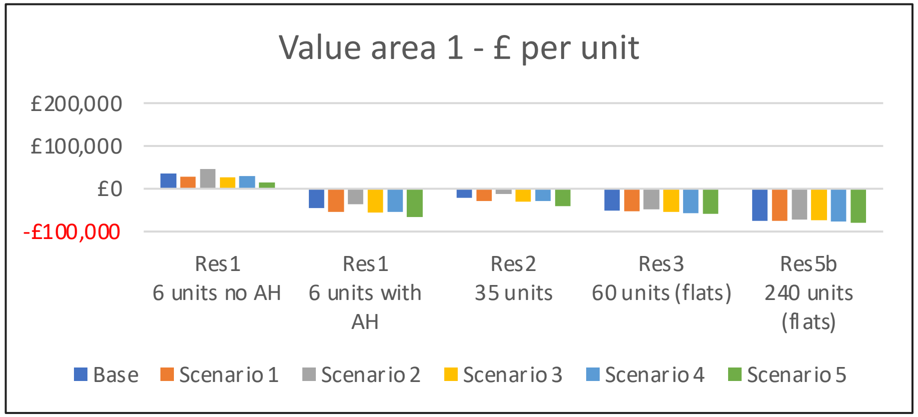
On **brownfield sites** the outcome is more varied and a sample of results are shown to demonstrate this on the right (£/unit).

- In the highest value area, **value area 3,** all brownfield development is viable and able to meet the costs of all net zero scenarios.
- In **value area 2** house-led development is viable on brownfield sites and able to meet the costs of the net zero scenarios but mid-rise and high-rise flatted development is not. Blocks of flats were already marginal or not viable at the base position and the additional costs of meeting net zero exacerbates the poor outcome.
- In **value area 1**, the lowest value area, only the 6-unit typology without affordable housing is able to meet the additional net zero policy costs on a brownfield site at BMLV2. (Not shown here but at BMLV1, the house-led typologies, Res 1 & Res 2, would be viable and able to meet the additional costs, although not the flatted typologies.) Consistently, flatted schemes are least viable but this is so with or without the additional costs of achieving net zero development.

To adopt net zero policies local authorities will need to carry out their own district-wide viability assessment taking into account specific local costs, land values and variances in house prices. Where development is marginal or not viable policy trade off may be required unless flexibilities can be found within land values or other development costs.







The results above show the residual value on brownfield sites, with all costs deducted including BMLV2 and CIL of 200 sqm. The results are per unit.

3.5.5 Economic Viability Modelling: Future scenario sensitivity modelling

Future scenario – residential sensitivity modelling

Further modelling was undertaken to explore whether potential changes in costs and values over the next five years would improve or worsen viability and the ability of development in Surrey to meet the highest net zero standards. It is recognised that forecasts do not necessarily become reality but they are a useful way of taking a longer term view of development viability. Using the best available evidence it has been assumed that over the next 5 years, house prices increase by 18% and build costs by 16.5%.

Two of the development typologies have been taken to illustrate the impact of the 5 year forecasts on development viability – one with housing and the other, a flatted scheme. The results are much more encouraging especially for the house led typology of 35 units, but still show relatively poor viability in value zone 1 with its implications for policy trade-offs and/or land values if net zero is to be adopted at the local level. This will be particularly so should councils wish to encourage flatted development in the lower value areas.

5-year forecast – results per unit at BMLV2

RES2 35 units B/Field	Value area 1	Value area 2	Value area 3
Base	£7,255	£107,399	£207,930
Scenario 1	-£2,542	£97,764	£198,311
Scenario 2	£17,892	£117,861	£218,362
Scenario 3	-£3,673	£96,651	£197,200
Scenario 4	-£1,468	£98,820	£199,396
Scenario 5	-£16,442	£88,038	£184,696

5-year forecast – results per unit at BMLV2

RES3 60 flats B/Field	Value area 1	Value area 2	Value area 3
Base	-£46,998	£14,897	£64,589
Scenario 1	-£48,960	£12,967	£62,676
Scenario 2	-£43,419	£18,417	£68,078
Scenario 3	-£49,191	£12,740	£62,451
Scenario 4	-£52,430	£9,561	£59,299
Scenario 5	-£55,717	£10,389	£56,148

4.0

Associated policies to support net zero buildings

4.1

Offsetting

4.1 Offsetting

Contents

4.1 1 Offsetting and Policy option 2 | How energy offsetting could work

Moving towards energy offsetting

Policy option 2 is based on energy metrics, most importantly the buildings' predicted energy use (Energy Use Intensity - EUI) but also the balance between annual energy use and annual renewable energy generation on-site.

In order for the role of energy offsetting to be clearly defined, we would recommend the following:

1. Option A - Policy option 2 should seek to minimise the building' predicted energy and maximise PV generation on site.
2. Option A - Once officers are satisfied that the building complies with these policy requirements, energy offsetting could be used to deal with the residual difference between energy use and renewable energy generation.

Case study: *if we take the example of a residential development of 5,000m² GIA with an Energy Use Intensity of 27 kWh/m²$_{GIA}$/yr and a PV generation of 15 kWh/m²$_{GIA}$/yr. There is a shortfall between annual energy use and renewable energy generation of 12 kWh/m²$_{GIA}$/yr, which equates to 60,000 kWh/yr. The applicant should pay into the Council's offset fund a sum of £79,200 (i.e £1.32/kWh x 60,000 kWh) to enable the Council to install a renewable energy system elsewhere which would generate 60,000 kWh/yr.*

Another option is possible (Option B) in case the Surrey's boroughs and districts decide to set a specific renewable energy generation target. In this case, the energy offset will not seek to address the gap between the predicted EUI and renewable energy generation on-site, but the gap between the policy requirement for PV generation (e.g. 100 kWh/m²$_{footprint}$) and renewable energy generation on-site. The targets provided on this page are only indicative. If a London borough wishes to proceed with Option B, it is recommended to undertake a technical evidence base to establish which targets would be technically feasible based on a variety of typologies and buildings.

1

Option A

Set the EUI requirement at the right level to minimise energy use and require PVs to match the EUI

These levels could be specific to each typology, e.g:

- 35 kWh/m²$_{GIA}$ for domestic
- 70 kWh/m²$_{GIA}$ for offices
- 70 kWh/m²$_{GIA}$ for schools
- 35 kWh/m²$_{GIA}$ for industrial buildings
- 160 kWh/m²$_{GIA}$ for hotels

Option B

Set a renewable energy generation requirement at the right level to maximise renewable energy generation

These levels could be specific to each typology, e.g:

- 100 kWh/m²$_{fp}$ for domestic
- 50 kWh/m²$_{fp}$ for offices
- 80 kWh/m²$_{fp}$ for schools
- 150 kWh/m²$_{fp}$ for industrial buildings
- 50 kWh/m²$_{fp}$ for hotels

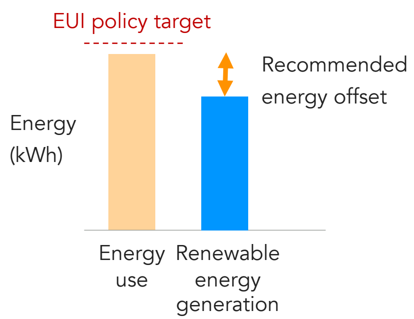
2

Work out the difference between the energy used by the development and how much renewable energy it will generate

Any shortfall of renewable energy generation will lead to an energy offset payment

Work out the difference between the target and the actual renewable energy generation

Any shortfall of renewable energy generation will lead to an energy offset payment



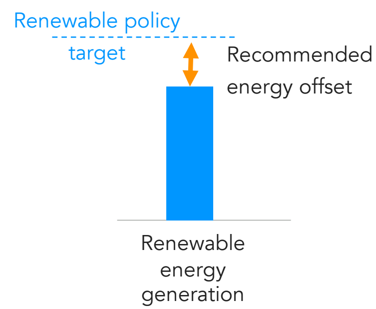


Figure 10.5 – Two alternative options for the energy offset

A fair energy offset price for applicants

As the source of the energy offset is the gap between energy use and renewable energy generation (or the gap between the required and actual renewable energy generation on site), its price should be set on the basis of the cost of PVs.

Using a reasonable cost rate for a high output PV system with micro-inverters (i.e. £1,370/kWp*) and applying a 10% additional rate for administering and managing the PV funding process, would give an energy offset price of £1.32/kWh/yr**.

Funding PVs, retrofit and other climate mitigation projects

It is up to boroughs to decide what most appropriate offset mechanism is. They can develop separate SPDs to determine locally appropriate use of offset funds.

** Median cost of 10-50kWp PV installations for 2022/23 from MCS (Source: DESNZ)*

*** This is assuming a conservative electricity generation rate for the PV system of 850 kWh/kWp.*

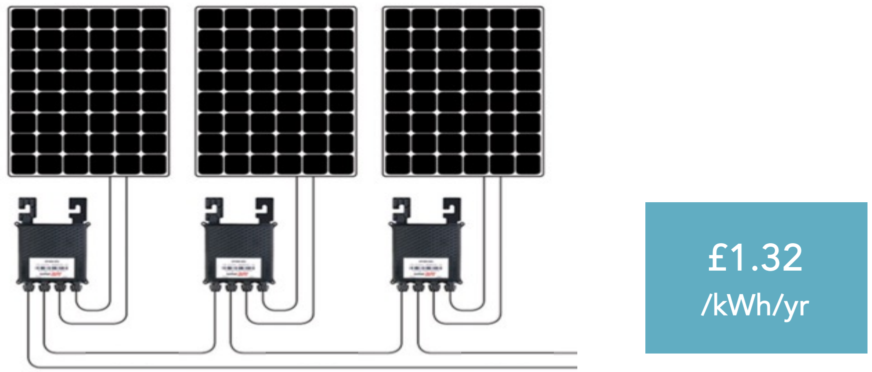


Figure 10.6 - If the energy offset price is to incentive more PVs on-site, it should be set at ***more than £1.77/kWh****.*

4.2.3 Assessing the impact of offsetting on costs

Although the main objective of policy options 1 and 2 is to maximise performance on-site, offsetting may still be required. The move away from fossil fuels and the decarbonisation of the grid are generally reducing offset costs for developers, but any future increase in scope for offsetting or carbon offset price may counter-balance this effect. Assessing its impact on capital costs depends on a number of parameters:

1. **Which policy option will be used?**

   With policy option 1, carbon emissions assessed with Part L energy modelling will need to be offset. With policy option 2 it is the shortfall of renewable energy generation which needs to be 'offset'.

2. **Which targets will be used?**

   The report provides some indicative targets for each policy option but London boroughs may decide to use different ones.

3. **What will be offset?**

   For policy option 1, Surrey's districts and boroughs should decide whether to follow this report's recommendation and offset unregulated emissions as well, or just regulated emissions.

   For policy option 2, Surrey's districts and boroughs should decide whether to offset the shortfall between the EUI and the on-site renewable energy generation (option A) or to offset the shortfall between the target and the actual renewable energy generation on-site (option B). They may also decide not to use offsetting.

4. **Which price will be used?**

   Finally, Surrey's districts and boroughs should confirm which carbon offset price they will want to use.

Step 1 - Decide which policy will be used

↓

Step 2 – Confirm which targets will be set in policy

↓

Step 3 – Confirm extent of offsetting required

↓

Step 4 – Validate offsetting price

↓

Step 5 – Test the impact of offsetting on capital costs

Figure 10.7 - The above process is recommended to estimate the additional cost of offsetting.

4.2

Embodied carbon

4.2 Embodied Carbon

Contents

4.2.1 Embodied carbon in new buildings is important to address

Construction industry emissions

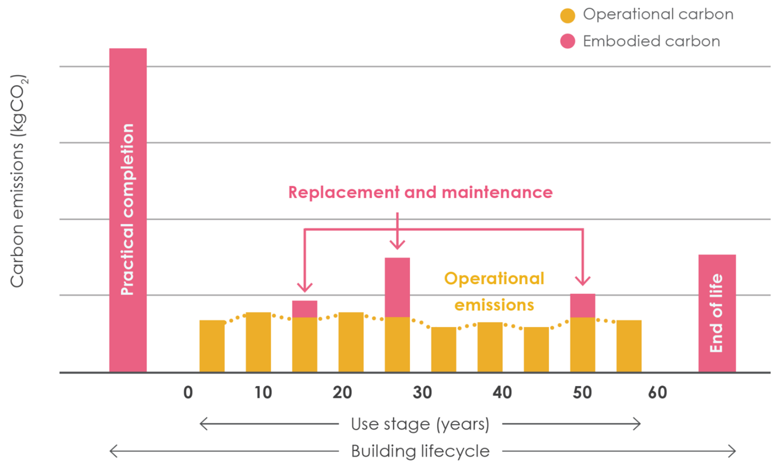
According to the LETI Climate Emergency Design Guide the UK building construction industry is responsible for approximately 49% of total UK carbon emissions. Building associated carbon consists of emissions resulting from the operational energy consumption in the day to day running of the building (heating, hot water, lighting, ventilation and equipment) and emissions resulting from life cycle embodied carbon (construction process, maintenance and demolition of the building).

The importance of embodied carbon emissions

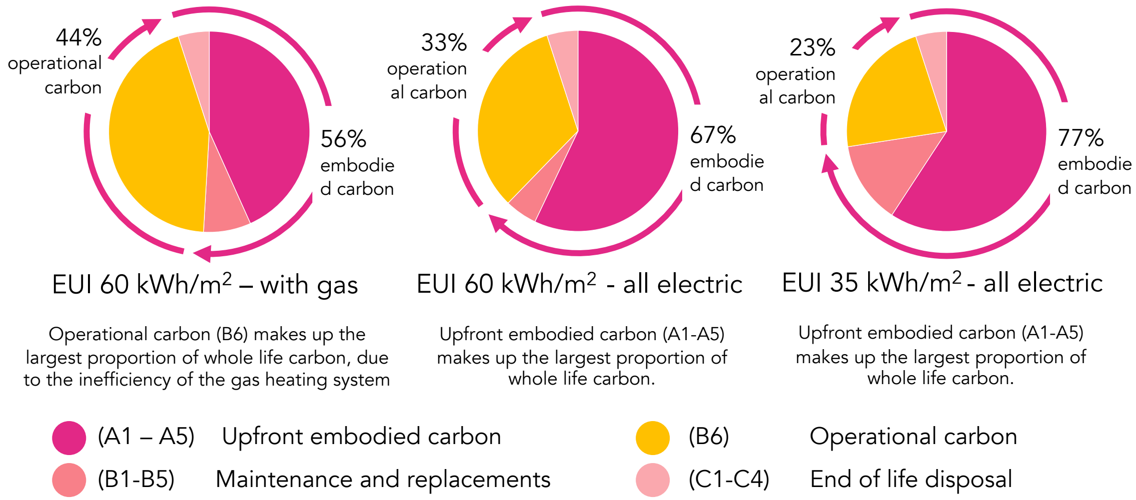
Addressing the national emission targets for the building sector has traditionally focused on reducing operational carbon emissions through building regulation and planning policy. However, as a building becomes lower carbon in operation, the operational carbon emissions of new buildings are significantly reduced. This results in embodied carbon emissions representing 40-80% of the whole life carbon (WLC) emissions of the building.

According to Net Zero Whole Life Carbon Roadmap technical report published by the UK Green Building Council in 2021 ''*Embodied carbon emissions contribute to some 40-50 million tonnes of CO_2 annually, more than emissions from aviation and shipping combined*''.

Therefore, addressing embodied carbon through policy is crucial to meet local and national climate targets. As embodied carbon relates to materials, it is also important to develop policies that help to transition to a circular economy, in which the resource intensive linear process of use and disposal is stopped.



Interaction between operational and embodied carbon throughout the lifetime of a building (Source: LETI)



Whole life carbon emissions breakdown for three residential buildings, with different energy use intensities (EUIs) for operational carbon, showing that as operational carbon reduces, embodied carbon represents a higher proportion of whole life carbon.

4.2.2 Current and emerging guidance on embodied carbon and whole life carbon

RICS - Whole Life Carbon Assessment for the Built Environment

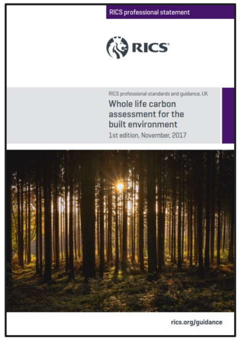
The Royal Institute of Chartered Surveyors (RICS) first published the '*Professional Statement: Whole Life Carbon (WLC) assessment for the built environment*' in 2017. It is the industry standard methodology for WLC assessments and provides supporting guidance in line with BS EN 15978 principles. The document outlines the minimum scope required for a WLC assessment, including demolition, facilitating works, substructure, superstructure (structural element, building envelope, internal elements), finishes, fittings, furnishing and equipment (FF&E), services (MEP) and external works within the building's boundary. RICS accounts for sequestered carbon in materials separately but does not account for biogenic carbon losses from the existing site (existing plants, habitats, etc.). A second edition of RICS Professional Statement was published in 2023 and is due to take effect in July 2024. Key changes include:

- the separate reporting of buildings within a site
- the introduction of new life-cycle stages, some of which are mandatory to report (e.g. A5.1, demolition)
- the alignment of carbon data with the cost plan of the projects
- the separate reporting of carbon offsets and biogenic carbon
- the rating of quality of data for carbon emissions.

Other useful guidance and targets

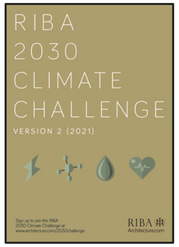
Additional useful embodied carbon and circular economy guidance and information is available from the Royal Institute of British Architects (RIBA), Low Energy Transformation Initiative (LETI), Chartered Institution of Building Services Engineers (CIBSE), Building Research Establishment's BREEAM, the UK Green Building Council (UKGBC), the Institution of Structural Engineers (IStructE) , the Centre for Windows and Cladding Technology (CWCT) , the Concrete Centre, industry proposed Building regulations Part Z, Buildings as Material Banks (BAMB), and the UK Net Zero Carbon Building Standard (NZCBS) - currently under development.

Professional standard for assessment:

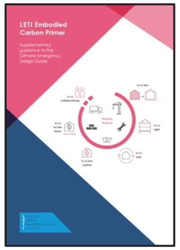


RICS 2017 (left) and 2023 (right) professional statements: Whole Life Carbon assessment for the built environment.

Industry guidance and targets:

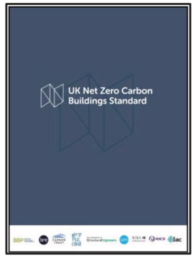


RIBA 2030 climate challenge

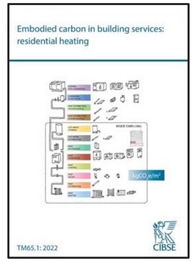


LETI embodied carbon primer

UKGBC – Net zero whole life carbon roadmap

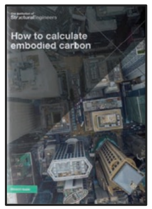


UK Net Zero Carbon Building Standard

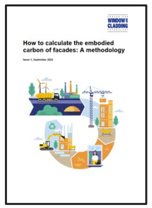


TM 65 – Embodied carbon in building services

Other useful guidance:

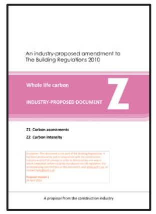


IStructE – How to calculate embodied carbon



CWCT– How to calculate embodied carbon of facades

The concrete centre– Sustainable concrete



Part Z proposed amendment to building regulations

BAMB –Material passports

4.2.3 Industry targets and benchmarks for embodied carbon

LETI

In 2021, LETI reviewed how targets from different organisations could be reconciled with each other. To do so they consulted other industry groups including CIBSE, RIBA, IStructE, the GLA, and the Whole Life Carbon Network. The Whole Life Carbon Alignment paper set targets for upfront and life cycle embodied carbon and provided a set of reporting templates to help with consistency.

RIBA

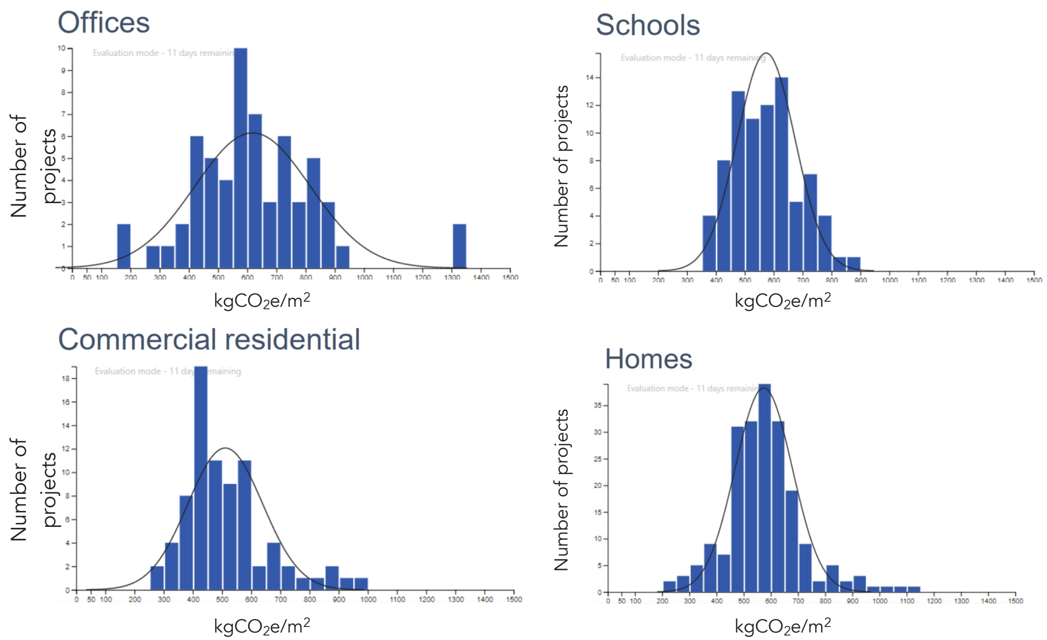
RIBA developed voluntary performance targets for embodied carbon which form the basis of the RIBA 2030 Climate Challenge published in 2021. The targets were set after consultations with experts across the industry. The targets are based on a growing database of projects submitted by signatories who have committed to participate the data collection for the initiative.

Further work in the industry - NZCBS

The UK Net Zero Carbon Building Standard (NZCBS) is a science-based research project aimed at developing a unified methodology for achieving net zero carbon buildings in the UK. The standard is in development and is in the process of reviewing upfront embodied carbon targets. In a technical study (June 2023) focused on assessing the upfront embodied carbon of new builds, performance levels of recent schemes were reviewed. The performance levels opposite give an indication of how projects compare for their predicted upfront embodied carbon. The number of schemes submitted was significant across many building typologies. While this evidence base is useful, it also has some limitations in that the quality of the data submitted by design teams could not be verified.

Upfront embodied carbon, kgCO$_2$e/m^2 (modules A1-A5, excluding upfront biogenic carbon)				
Band	Office	Residential (6+ storeys)	Education	Retail
A++	<100	<100	<100	<100
A+	<225	<200	<200	<200
A (LETI 2030)	<350	<300	<300	<300
B	<475	<400	<400	<425
C (LETI 2020)	<600	<500	<500	<550
D	<775	<675	<625	<700
E	<950	<850	<750	<850
F	<1100	<1000	<875	<1000
G	<1300	<1200	<1100	<1200

Upfront embodied carbon targets for various building typologies. The residential targets have been set based on data from 6+ storey developments, therefore the applicability to low-rise housing is unknown (Source: LETI)

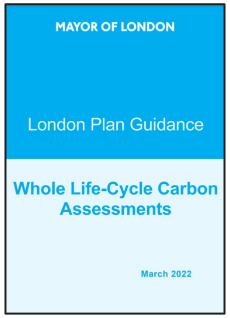
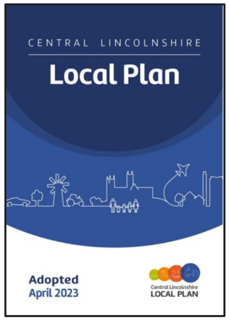
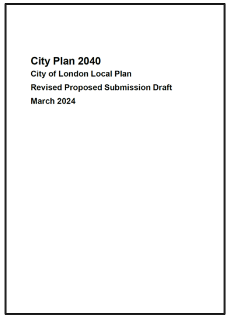
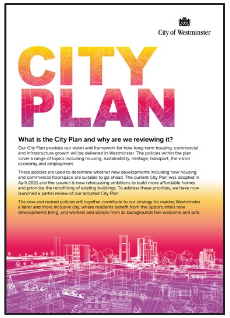
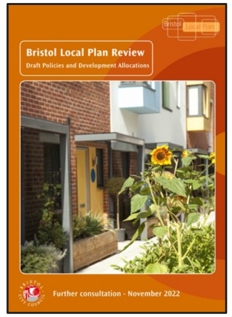


Upfront embodied carbon case study analysis (Source: Net Zero Carbon NZCBS)

4.2.4 Planning policy precedents | Summary of existing embodied carbon policies and approaches in the UK

Summary

This page summarises some of the existing embodied carbon approaches to policy in the UK.

						
	Greater London Authority	Central Lincolnshire Council	City of London Council	City of Westminster Council	Bath and North East Somerset Council (B&NS)	Bristol City Council
Presumption against demolition	✗	✓	✓	✓	✗	✗
Embodied carbon assessment + reporting	✓ (whole life carbon assessment)	✗ (Seek to reduce only)	✓ (whole life carbon assessment)	✓ (whole life carbon assessment)	✓ (upfront embodied carbon)	✓ (upfront embodied carbon)
Meet embodied carbon target/limit/benchmark	✓ (benchmarks)	✗ (no targets/limits/ benchmarks)	✓ (benchmarks)	✓ (either upfront of life cycle embodied carbon)	✓ (for substructure, superstructure and finishes only)	✓ (upfront embodied carbon targets)
Applies to	Referrable schemes	All developments	Major developments must submit a whole life-cycle carbon assessment	Major developments	Large scale new- build developments	Major developments
Other requirements	Demonstrate actions taken to reduce life-cycle carbon emissions	Take opportunities to reduce the development's embodied carbon	Development proposals should minimise whole life-cycle carbon emissions.	Demonstrate the maximum embodied carbon reductions deliverable without affecting the delivery of affordable housing	If the development is not compliant with the policy, a valid justification must be provided with the appropriate reasons and evidences.	Demonstrate actions taken to reduce life-cycle carbon emissions

4.2.5 Planning policy precedents | Focus on Bath and North East Somerset (B&NS) and Bristol

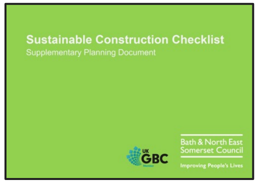
Bath and North East Somerset Council (B&NS)

The UK's first Net Zero Carbon policy was introduced in January 2023 and covers both operational and embodied carbon. Policy SCR8 on embodied carbon states that all major developments must submit an upfront embodied carbon assessment, demonstrating that less than 900 $kgCO_{2e}/m^2$ can be achieved. No offsetting is permitted and if the development is not compliant with the policy, a valid justification must be provided with appropriate reasons and evidence.

Bristol City Council

The draft Bristol Local Plan sets an embodied carbon, materials and waste policy. Major developments will be required to undertake an upfront embodied carbon assessment and are expected to achieve a set of minimum targets. Where policy is not met, carbon offsetting is used. It also provides general principles and guidance for reducing embodied carbon.

This policy has been based on the findings of the West of England Embodied Carbon Evidence Base.



Sustainable Construction checklist SPD – B&NES

B&NES - SCR8 - Embodied Carbon

"Large scale new-build developments (a minimum of 50 dwellings or a minimum of 5,000m^2 of commercial floor space) are required to submit an Embodied Carbon Assessment that demonstrates a score of less than 900$kgCO_2e/m^2$ can be achieved within the development for the substructure, superstructure and finishes."

Bristol City Council draft Local Plan

Bristol City Council – Draft policy

"Embodied carbon – major applications

Major development will be required to undertake an embodied carbon assessment, submitted as part of the Sustainability Statement using a nationally recognised embodied carbon assessment methodology, and demonstrate actions taken to reduce life-cycle carbon emissions. New development will be expected to achieve the following targets as a minimum:

- Residential (4 storeys or fewer) - <625 $kgCO_2e/m^2$
- Residential (5 storeys or greater) - <800 $kgCO_2e/m^2$
- Major non-residential schemes - <970 $kgCO_2e/m^2$

Where these targets for embodied carbon cannot feasibly be met, a full justification will be required as part of the embodied carbon assessment.

Any shortfall against the embodied carbon targets will be offset through a financial contribution towards council approved renewable energy, low-carbon energy and energy efficiency schemes elsewhere in the Bristol area. The value of a tonne of CO2e is tied to the high scenario in the Valuation of Energy Use and Greenhouse Gas supplementary guidance to the Treasury's Green Book (currently £373)."

4.2.6 Summary of proposed policy recommendations

Proposed policy recommendations have been set across four main areas:

1. Retrofit first and promoting circular economy
2. Lean building design and good material efficiency for lower embodied carbon
3. Reducing upfront embodied carbon
4. Reporting whole life carbon

For each of the suggested policy requirements we have set out:

- The types/scale of development the requirement would apply to
- The policy objective
- Suggested submission requirements
- A proposed requirement wording

1 Retrofit first and promoting circular economy

This policy recommendation seeks to prevent unnecessary partial or total demolition of existing buildings by requiring justification, additional requirements and potentially Whole Life Carbon optioneering studies.

2 Lean building design and good material efficiency for lower embodied carbon

This policy recommendation seeks to reduce resource use by encouraging all applications to be efficient in their material use and design.

3 Reducing upfront embodied carbon

This policy recommendation sets limits on upfront embodied carbon emissions for major applications and requires calculations and reporting to demonstrate compliance.

4 Reporting whole life Carbon (WLC)

This policy recommendation requires reporting on WLC emissions.

4.2 7 Retrofit first and promotion of circular economy

Applies to

All development scales and building types.

1

Policy objective

Developments should prioritise retrofit over re-build, thoroughly exploring the potential for retaining and retrofitting existing buildings. Where partial or total demolition is proposed, full justification and potentially an optioneering study is carried out comparing whole life carbon scenarios for retrofit vs rebuild.

Submission requirements

- Description of retrofit measures and level of building retention on-site. Full justification for total or partial demolition.
- Report findings of WLC optioneering study

Proposed requirement wording

The Council promotes a 'Retrofit first' approach and the re-use of existing buildings wherever possible unless a full justification for demolition is provided. Justification where partial or total demolition and re-build is sought must include:

(a) The purpose of the new building and whether this is a change of use.

(b) How much demolition is proposed:

- *Percentage of envelope and structure to be retained*
- *Percentage of internal materials to be retained*
- *Justification of partial or total demolition by building layer (skin/shell, structure/frame, building services, and space plan/interior).*

(c) Explanation as to why the existing building cannot be retained, providing evidence to this effect. This should go beyond saying a building is 'low quality' or 'not fit for purpose' and include an assessment of:

- *Structural condition - by means of a structural engineers report*
- *Contamination (e.g. asbestos)*
- *Visual/importance of the architecture in streetscape/location*
- *Meeting needs of users – Is there bespoke operational requirements which could not be provided through the repurposing, adaptation and/or extension of the existing building(s)?*
- *Service life/maintenance of fabric and systems – by means of an architectural and building services report.*

(d) a Whole Life Carbon (WLC) assessment optioneering for different genuine retrofit and new build scenarios may be required by the Council.

(e) If the existing building on-site is considered for demolition,

- *A pre-demolition audit of the existing building(s) should be carried out.*
- *A material analysis of the existing building should be carried out and include recommendations for re-use of building materials.*
- *The percentage of materials (by volume) that will be re-used on and off-site, how much will be recycled on or off-site, and how much will be disposed of elsewhere should be reported. Proposed materials considered for re-use should not be not downgraded or be processed further.*

4.2.8 Lean building design, good material efficiency for lower embodied carbon and circular economy

Applies to

All development scales and building types.

2

Policy objective

The applicant should seek to reduce the use of resources, by designing a building that is efficient in its use of materials, its building form and design.

Designs should be improved to reduce upfront embodied carbon, e.g. sub- and super-structure should be optimised, building form should not result in excess structure and material use, material choices should represent lowest upfront carbon options.

Submission requirements

- List of design improvements.
- Description of efforts made on the building design, material efficiency and material selection, with form factor of buildings declared, three wall type sand two sub- and super-structure types analysed and compared with a declaration of which one was chosen and why.

Proposed requirement wording

All new buildings and developments should demonstrate that upfront embodied carbon has been considered and reduced where possible through good design and material efficiency. As part of the planning process applicants should submit a summary of the efforts made to reduce upfront embodied carbon. This should include:

- *A summary of the efforts made to design a lean, low carbon structure and building design. This should take into account efficiency of material use, as well as types of material used.*
- *A justification where large volumes of material are proposed to be used due to specific design features (such as basements, podiums, large cantilevers).*
- *A calculation of the building form factor (exposed external surface area/gross internal floor area).*
- *An elemental analysis of the upfront embodied carbon ($kgCO_2e/m^2$) associated with three external wall options and two superstructure options, including justification for the selected wall and structure type.*
- *A summary of any steps taken to design for and drive a circular economy.*

4.2.9 Limiting upfront embodied carbon

Applies to

Major developments of all building types.

Also applies to major retrofit.

3

Policy objective

Placing quantitative limits to reduce upfront embodied carbon emissions from major applications (both new build and refurbishment) and reducing these limits over time.

A review of policy limits is recommended every 3-5 years as the level of knowledge and understanding of upfront embodied carbon and the associated impact on the definition of poor, good and best practice is expected to increase rapidly, enabling a reduction in upfront embodied carbon. Limits will therefore have to be strengthen to be effective.

Submission requirements

- Upfront embodied carbon calculation results carried out in line with RICS WLCA PS v2 2023 demonstrating limits are met for all major building types.
- Reporting of top five highest emitting materials by weight and upfront embodied carbon, together with circular economy metrics.

Proposed requirement wording

New major developments, major retrofits and rebuild developments should achieve the following set limits for upfront embodied carbon (A1-A5):

- *Low rise residential (up to 11m):*

  500 kgCO_2e/m^2 initially reducing to 400 kgCO_2e/m^2 from 2030
- *Mid and high rise residential (over 11m)*

  600 kgCO_2e/m^2 initially reducing to 500 kgCO_2e/m^2 from 2030
- *Non-domestic buildings*

  NZCBS limits

New major developments should also report on the following:

- *List the top five materials (e.g. brick, concrete) by weight and by upfront embodied carbon emissions (A1-A5).*
- *For the top five highest upfront embodied carbon materials reported: how they will be treated at the end of life and circular economy metrics (% recycled content/ designed for re-use/ recycling/ disassembly).*

4.2.10 Reporting whole life carbon

Applies to

Major developments of all building types.
Also applies to major retrofit.

4

Intention

Gathering this data will help to inform the development of potential future policy requirements on Whole Life Carbon.

Submission requirements

- WLC calculation results carried out in line with RICS WLCA PS v2 2023.
- Reporting of top five highest emitting materials by weight and lifecycle embodied carbon, together with circular economy metrics.

Proposed requirement wording

All new major developments should:

- *Have met policy requirement 3 – 'Limiting upfront embodied carbon (A1-A5)'*
- *Calculate and report against life cycle stages B-C (including B6/B7).*

New major developments should also report on the following:

- *List the top five materials (i.e. brick, concrete, tile) by weight and by lifecycle embodied carbon emissions (A-C, excluding B6-B7).*
- *List the expected replacement cycle lengths for the top five highest embodied carbon materials.*
- *To consider how the highest embodied carbon materials will be treated at the end of life, provide circular economy metrics for the top five highest lifecycle embodied carbon materials reported (% recycled content/ designed for re-use/ recycling/ disassembly).*

4.2.11 Impact on capital cost

Reducing the upfront and life cycle embodied carbon of a building does not necessarily mean higher capital costs. Contrary to this, adopting strategies such us lean and circular economy design can reduce capital costs. This is due to reducing the volume of materials needed in a building and the frequency of maintenance, or allowing the building to be used for multiple purposes.

Structural lean design

The sub and super-structure often represents >50% of upfront embodied carbon emissions in a building. Designing leaner structure can reduce the volume of overall material used in the building, including less foundations where the building becomes lighter. Considerations for reduction include: grid spacing, location of the core, structural depth, amount of cantilevers. These can all be capital cost saving design exercises.

Architectural lean design

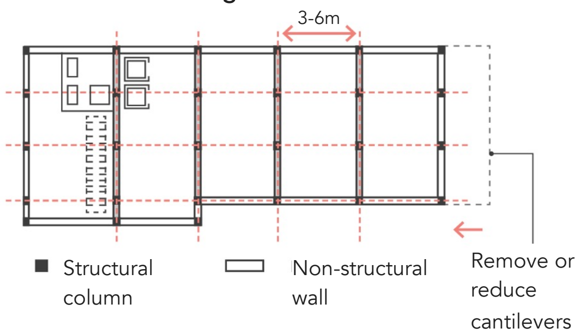
Façades often represent 15-20% of the upfront embodied carbon emissions in a building. Considerations for leaner façade designs include: amount of metal components, glazing-to-wall ratio, multi-purpose façade components. Capital cost savings can be made though the reduction of window area, conversely upfront embodied carbon will likely increase. This is an area for considering the balance of wall to window ratios.

Building services lean design

Building services have the least known overall impact on upfront embodied carbon but are made from high carbon materials (metals, plastics, refrigerants) which are replaced multiple times during a building's lifetime. Considerations to reduce these high carbon materials include: passive measures, ducts design, refrigerant specifications. Reductions in the capacity of building services will likely bring capital cost and space savings.

If embodied carbon targets are set in planning policy, this has the ability to restrict material selection and therefore increase costs. Please refer to following page.

Structural lean design



- Optimisation of column grid to decrease slab thickness and beam depths, e.g. 3-6m column grid is a good starting point.
- Rules of thumbs and unnecessary tolerances on loading assumptions should be avoided.
- Design of structure for 100% utilisation.
- Reduction of spans and overhangs which require more materials, e.g. encouragement of columns to support balconies and walkways externally.

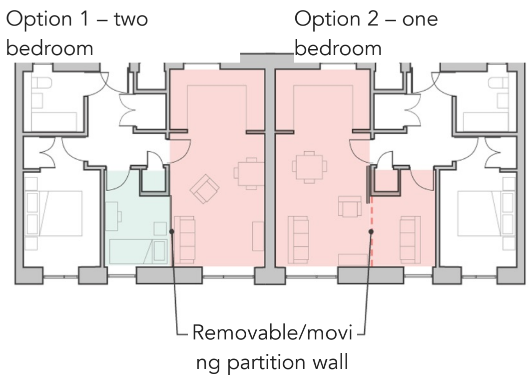
Architectural lean design

- Selection of elements with multiple benefits, e.g. embellishments of the façade also used as shading elements.
- Reduction of quantity of metal components: shelf angles, metal studs and frames.
- Balance between glazing-to-wall ration, between upfront embodied carbon and operational carbon.

Building services lean design

- Prioritisation of passive measures to reduce the need for building services equipment, e.g. optimised glazing ratios, natural ventilation and shading devices.
- Reduction of the need for long pipes and duct runs.
- Specification of low global warming potential refrigerants and reduction of leakage rate.

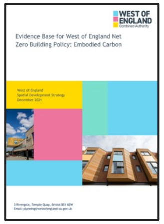
Circular economy design



- Designing for disassembly and adaptability for easy change of use of the building and re-use or sell materials at the end of its as an alternative to non-profitable, wasteful demolition.
- Selection of durable and easily-maintain materials to reduce maintenance cost and replacement cycles.
- Exploration of modularity and pre-assembly methods for faster and error-reduced construction time.

Key lean and circular economy design considerations for the reduction of upfront and life-cycle embodied carbon.

4.2.12 Impact on capital cost | The West of England's evidence base



West of England evidence base

Prepared by WSP and Gardiner & Theobald.

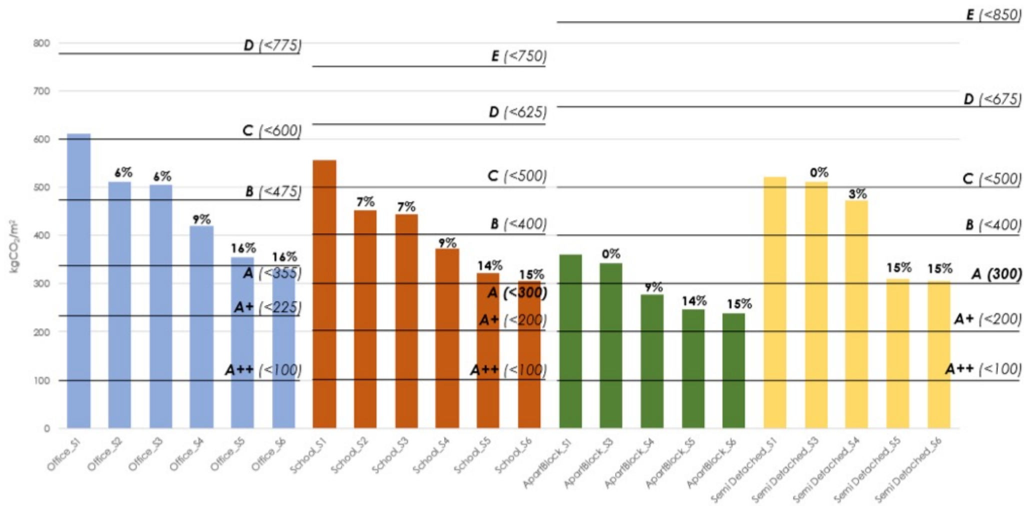
This document was commissioned by four local authorities in the West of England (i.e. Bath and North East Somerset Council, Bristol City Council, North Somerset Council and South Gloucestershire Council), and the Combined Authority.

The document reviews a series of embodied carbon targets across different building types (office, school, apartment block and semi detached house) and considers the cost uplift of different scenarios. This supports policy makers to explore options for setting embodied carbon targets.

The evidence base shows, in table and bar chart formats, which LETI upfront embodied carbon banding and which RIBA whole life embodied carbon banding these designs can lead to, and at which extra costs. This can be seen for upfront embodied carbon on the adjacent bar chart.

	S1 - BASELINE	S2 – HYBRID TIMBER	S3 – LOW CARBON CONCRETE	S4 – TIMBER FRAME	S5 – LOW CARBON FACADES	S6 – LOW CARBON INT. FINISHES
SEMI DETACHED HOUSE	Load bearing masonry walls, timber floors and roof	-	40% cement replacement (foundation, GF slab)	Timber studs, floor and roof (Sawn timber)	Timber cladding on timber wall assembly; Wood frame windows; Glass wool insulation (replacing rockwool)	Linoleum floors (replacing vinyl)
APARTMENT BLOCK	Concrete frame and hollowcore slabs	-	40% cement replacement (foundation, GF slab, frame, staircase)	Glulam frame, CLT walls CLT floors)	Timber cladding on timber wall assembly; Wood frame windows	Internal timber wall assembly; Linoleum floors (replacing vinyl)
OFFICE / SCHOOL	Steel frame and composite concrete-steel deck floor slabs	Steel frame and CLT floors/roof	40% cement replacement (foundation, GF slab, staircase)	Glulam frame – CLT floor	Timber cladding on timber wall assembly; Wood frame windows	Internal timber wall assembly; Linoleum floors (replacing vinyl); Exposed soffits

Summary of the different scenarios modelled in terms of embodied carbon (upfront and whole life) and costed by WSP and G&T



Cost uplift (%) from baseline for each scenario and comparison with letter banding targets (upfront embodied carbon-stage A only)

4.3

Recommendations for planning policies

4.3 Recommendations for planning policies

Contents

4.3.1 Policy Route 1 (a TER approach): the conclusions and recommendations

We do not think that Policy Route 1 is a suitable option for local authorities in Surrey to meet their climate change targets and objectives: a TER based approach will not deliver fully net zero buildings, does not include all energy uses and may allow fossil fuels.

Demonstrating compliance

- Applicants will need to use SAP 10 until the Home Energy Model is release in 2025 (or later).
- If Policy Route 1 is selected, the goal posts for applicants may change significantly when the Future Homes Standard and the Home Energy Model is released.

Using building regulations calculations methodologies

- Building regulations calculation methodologies discount unregulated energy (anything that is a plug-in appliance) – this can represent 50% of a dwelling's energy consumption.
- Using SAP 10 we saw that a very large amount of solar PV is required to achieve the 100% reduction on the TER. This will be challenging to achieve on site for almost all dwelling types.
- Using the beta version of the Home Energy Model the amount of solar PV required to achieve this reduction was greatly reduced. Although the Home Energy Model is also under consultation and is highly subject to change. Upon release, a new evidence base may be needed to support the policy.
- SAP 10 is not predictive. Although it is intended that the Home Energy Model improves how it calculates predicted energy consumption, we do not know how well it will achieve this.

Energy

- Policy Route 1 is likely to deliver greater energy consumption compared with Policy Route 2.
- Energy consumption is **22-31%** larger than Scenario 4 (low energy) and **31-44%** larger than Scenario 5 (ultra-low energy).

(Calculated using PHPP to give estimate of actual energy use)

Energy offsetting

Due to the very large amounts of solar PV required to meet Policy Route 1, a high number of applicants will not be able achieve this on-site. Councils will need to decide whether to implement a carbon or energy offset policy to mitigate this non-compliance.

Running costs

Running costs are highly dependant on a number of factors, including energy prices, solar export prices and occupant behaviour and habits.

1) Energy efficiency - The relatively lower energy efficiency likely to be delivered by developers using Policy Route 1 will disadvantage occupants and make them more vulnerable to the effects of increasing energy prices.

2) Solar self-consumption – Occupants will be able to take advantage of solar self-consumption but to a lesser extent than with Policy Route 2.

3) Solar export - For houses in particular, the very large solar PV array is a clear advantage, especially when solar export prices are high.

4) Performance gap – Part of the Performance Gap issue is due to energy modelling that is not predictive (e.g. SAP 10). We do not know how well SAP 10's successor (the Home Energy Model) will address this.

Capital costs

It is cheaper to build than Policy Route 2. However our analysis is based on the cheaper of the two FHS Options and in reality is highly subject to change.

A policy for low carbon heat

Unless a specific policy for low carbon heat is included it may be possible for applicants to pass the requirements of Policy Route 1 using a gas boiler and energy offsetting – this is particularly the case in the period before the Future Homes Standard and the Home Energy Model come into force. Therefore, a standalone low carbon heat policy is recommended to ensure Surrey's net zero carbon objectives are met.

4.3.2 Policy Route 2 (Absolute Energy Targets): the conclusions and recommendations

Policy Route 2 – setting absolute energy targets for new buildings in policy - is a suitable option for the districts and boroughs of Surrey. It will help achieve Surrey's climate change objectives, and is the more reliable route for keeping energy bills low for occupants.

Demonstrating compliance

Applicants will need to demonstrate compliance through either predictive modelling outputs (such as PHPP or CIBSE TM54 paired with Passivhaus Planning Package or IES-VE).

An alternative option for dwellings would be to use the SAP Conversion Tool (adapted for Surrey) to convert SAP outputs to predicted energy outputs until the Home Energy Model is released.

Absolute energy targets are tangible and directly related to building energy consumption and therefore industry should easily be able to become more comfortable with them over time.

Energy

Policy Route 2 enables the council to mandate minimum energy efficiency standards through setting Space Heat Demand and Energy Use Intensity Targets.

Modelling showed consistently lower energy consumption with both the low energy (Scenario 4) and the ultra-low energy (Scenario 5) option compared with all other scenarios (including Scenario 3 – Policy Route 1).

- Policy Route 2 is likely to deliver homes with lower energy consumption compared with Policy Route 1.
- Energy consumption (EUI) is **18-23%** lower in Scenario 4 (low energy) and **24-30%** lower than Scenario 5 (ultra-low energy) compared with Policy Route 1.

Running costs

Running costs are highly dependant on a number of factors, including energy prices, solar export prices and occupant behaviour and habits.

1) Energy efficiency - Occupants are more insulated from rising energy prices in more energy efficient dwellings. Policies that encourage energy efficiency (Policy Route 2) are therefore recommended.

For flats, which the only reliable way to deliver reduced running costs is through implementation of energy efficiency targets – e.g through absolute energy targets in Policy Route 2 (which does not rely on revenue from solar export to lower net running costs).

2) Solar self-consumption – Occupants are more able to take advantage of solar self-consumption through smart heating controls in more energy efficient dwellings (Policy Route 2 recommended).

3) Solar export – The larger the PV array, the more occupants can benefit from solar export. For dwellings delivered to Policy Route 2 standards it is likely that there will be space to spare on the roof. Developers should design and install PV in a way that enables occupants to add more PV at a later date should they wish.

4) Performance Gap – An Assured Performance policy is recommended to ensure good quality construction that delivers energy performance intent.

Capital costs

	Policy Route 2 SHD <30 kWh/m^2/yr	Policy Route 2 SHD 15-20 kWh/m^2/yr
Houses	2%	5.6%
Flats	2.4%	3.7%

4.3.3 Policy option 1 vs Policy option 2 | At a glance comparison

	Policy Route 1	Recommended Policy Route 2
Metrics used	Target Emissions Rate (TER) (CO_2) The TER is a relative metric, it will change from building to building. And for the same building, will change from one revision of Part L to the next. It does not predict actual CO_2 emissions (or energy use).	Absolute energy metrics: • Space Heating Demand (kWh/m^2/yr) • Energy Use Intensity (kWh/m^2/yr) • Renewable Energy generation (kWh/m^2/yr)
Definition of "net zero"	100% reduction on the Target Emissions Rate (TER)	Energy balance (annual energy consumption = annual renewable energy generation).
Regulated energy included?	• space heating - ✓ • hot water ✓ • pumps and fans ✓ • Lighting ✓	• space heating ✓ • hot water ✓ • pumps and fans ✓ • Lighting ✓
Unregulated energy included?	• Cooking ✕ • Appliances ✕ Unregulated energy can account for 50% of energy in low-energy dwellings.	• Cooking ✓ • Appliances ✓
Renewable energy included?	Yes. Renewable energy is accounted for in the calculations. Carbon savings are rolled into one metric so it is not possible to see what contribution renewable energy is making.	Yes. Renewable energy generation has its own metric so it is clear to see what contribution is being made.
Embodied carbon included?	Additional policy mechanism required.	Additional policy mechanism required.
Calculation methodologies	Calculation through compliance tools: • Building regulations Standard Assessment Procedure (SAP) for dwellings. • Building regulations National Calculation Methodology (NCM) for non-dwellings.	Calculation through design tools: • PassivHaus Planning Package (PHPP) for dwellings. • TM54 or Dynamic Simulation for non-dwellings.
Aligned with national policy?	Yes.	Not yet.
Does it promote good building design?	No. The benefits of building design and orientation is not captured in building regulations assessment methodologies.	Yes. The significant impacts that building design and orientation have on energy use are captured through the space heating demand metric and the use of accurate calculation methodologies.
Can it be verified or measured in operation?	No. Abstract metrics and only accounting for regulated energy means that this does not be checked in operation.	Yes. The EUI can be calculated by reading the energy used at the main electricity meter and dividing it by the floor area of the building.

4.3.4 Choosing policy targets

Local Authorities and Boroughs in Surrey have a choice over the standards set within their new net zero carbon buildings policies.

We recommend that Policy Route 2 (absolute energy targets) is the most suitable for the delivery of climate change objectives and to deliver homes with reliably low energy costs. The five main policies recommended, together with the recommended targets (and alternatives) are illustrated below.

Space heating demand	Energy Use Intensity Resi	PV generation	Offsetting	Performance gap
Ensures that space heating is reduced and that inefficiency is not ‘masked’ by the heat pump, helping to reduce the risk of high heating costs.	Covers all energy uses, reduces the risk of high energy heating system. It also provides the ‘energy use’ number for Net Zero and a simple metric for users post completion.	Addresses the need for greater PV deployment in an obvious location for them: the roof of new buildings.	When policy requirements cannot be met on-site due to constraints on roof space, applicants are required to pay into an offset fund.	Helps to ensure that the estimated energy/carbon performance is not only theoretical and that it is delivered, which is what matters.
No requirement	No requirement	No requirement	No requirement	No requirement
30 kWh/m^2/yr	40 kWh/m^2/yr	Maximise PV on roof	Carbon offset	Uplift to SAP / SBEM requirements
15 - 20 kWh/m^2/yr	35 kWh/m^2/yr	Enough to match EUI	Energy offset	Bespoke Surrey process
				Passivhaus or other requirement

4.3.5 Recommendations for planning policy: Policy wording and clauses

Policy wording

Wording of policies must be formulated so it is clear whether a policy component is required or encouraged.

- For requirements (i.e. policy compliance must be demonstrated), phrases such as 'required to' and 'must' are to be used.
- For other policy components that cannot strictly be required by policy or are nice-to-haves, phrases such as 'are encouraged to' and 'should' are to be used.
- The phrase 'policy target' implies that the component is not mandatory.

It is important to make clear distinctions and be explicit on policy requirements to avoid any confusion at planning application stage, which can cause delays and ineffectiveness.

Additional wording in support of the policy requirements (either as supporting text in local plans or in supplementary guidance) should be produced to state what information is required for each application type. This is important to consider as the level of detail required for policy compliance will vary between Outline, Reserved Matters and Full applications. A position should be formed by the LPA on requirements for Hybrid applications and mixed-use developments. For example, full energy performance modelling is unlikely to be available at Outline stage but sufficient information to demonstrate principles required to achieve true net zero on-site are in place should be given.

If links to other policies are evident and/or a hierarchy in place of what requirements must be achieved, this should be made clear with individual components clearly laid out. For example, LPAs may decide that an EUI and space heating demand requirement must be complied with no scope for offsetting. Offsetting may only be a last resort option for a shortfall of on-site renewable energy generation. It should therefore be explicit that non-compliance with the EUI and space heating demand requirements is unacceptable.

Policy clauses

Whilst it is important to be clear where strict policy requirement are in place, some flexibility is inherently required to accommodate exceptional circumstances. Exceptional circumstances should be assessed on a case-by-case basis by someone with sufficient expertise to make such a judgement. However, it can be useful to provide examples alongside policy requirements, such as:

- *"Exceptional circumstances where an on-site net zero energy balance is not achieved may only be found acceptable in some cases, for example with taller flatted buildings (4 storeys or above) or where overshadowing significantly impacts solar PV output."*

In the case of operational energy, exceptional circumstances are typically only likely to be justified in the case of tall buildings with a small relative roof area for PV or non-residential buildings with high energy demand such as data centres.

Although an exhaustive list of potential exceptional circumstances should not be published, as this could encourage developers to avoid policy compliance through pursuing a design with an exceptional circumstance, sample scenarios should be provided to Development Management officers, so they are able to assess the legitimacy of any non-compliance in the first instance.

4.3.6 Recommendations for planning policy

Implementation considerations

Adoption of policies is a crucial first step to achieving intended outcomes, yet the implementation of policy is where any tangible outcomes will be determined.

It is essential that a dedicated officer, either within the policy or Development Management team, is trained up or hired to govern implementation of net zero policies. Net zero energy policy is a highly nuanced area that requires careful assessment and Development Management officers have a swathe of topics to assess when determining applications. Therefore, allocating net zero policy compliance assessments to a dedicated officer, or externally, is important to ensure sufficient attention is given. Policy reputation and efficacy could be undermined unless sufficient attention is given to assessments of compliance.

However, it is still important for training sessions to be delivered to Development Management officers on technical processes involved with net zero carbon development. This will strengthen broad internal capabilities to assess and scrutinise applications that may have submitted overly-optimistic building performance values for the sake of policy compliance. These may include:

- Understanding of modelling techniques and tools (e.g. PHPP)
- Building elements energy performance values (e.g. U-values)
- Low- and zero-carbon heating and ventilation systems/technologies
- Orientation, form factor and design features for solar PV generation

Application assessment

To ensure the development industry are clear on what is required for detailed compliance with new policies, supplementary guidance should be provided. Such guidance should go beyond surface-level policy wording and state what information and documentation is required.

To ensure that policies on net zero operational energy, embodied carbon and overheating are delivered as intended, two key stages of assessing compliance are necessary:

- Planning application/design stage
- Post-completion/pre-occupation stage

Submission of data throughout design stages is what will determine policy compliance for the full planning application, yet this must be verified with as-built data to confirm true policy compliance. Pre-commencement and pre-occupation conditions must therefore be set at the planning application stage, which could include:

- Photographic evidence of building fabric, heating systems and ventilation technologies
- Air tightness tests whilst the air barrier remains accessible (to allow improvements to be made if required standards are missed)
- As-built reports for building energy performance, embodied carbon assessments and overheating measures

In cases where standards fall below required levels at the post-completion stage, it is important to have enforcement mechanisms in place to penalise non-compliant applications. This is a difficult issue to deal with as buildings cannot be deconstructed but the council should explore options with the Enforcement team on how to mitigate as-built risks.

4.3.7 Recommendations for planning policy: Mitigating the Performance Gap

Mitigating the performance gap

In the UK, buildings consistently experience a gap between their intended energy efficiency at the design phase and their actual performance during operation. Achieving truly net zero buildings necessitates implementing rigorous systems to bridge this performance divide. There are two root causes at the heart of the Performance Gap:

i) inaccurate modelling, primarily driven by flawed compliance tools such as Building Regulations' SAP and SBEM.

ii) A lack of construction quality on-site, leading to poorly installed insulation, air-tightness or heating systems.

Seeking better quality modelling and energy prediction

To effectively move towards genuinely net zero buildings, local policies must transition from reliance on SAP, which inadequately forecasts space heating demand and overlooks unregulated energy calculations.

To reliably achieve net zero buildings, alternative methodologies for assessing energy performance during the design phase are essential. Proven alternatives exist for both residential and non-residential buildings:

- **Residential**: Passivhaus Planning Package
- **Non-residential**: CIBSE TM54 paired with Passivhaus Planning Package or IES-VE

An alternative to requiring applicants to undertake predictive energy modelling which Cornwall Council & Bath and NE Somerset Council use is a SAP Conversion Tool. The tool recalculates inaccuracies of SAP to better align with outputs from more sophisticated modelling tools.

Raising construction quality through Assured Performance

Assured Performance Policies are recommended as a crucial step in mitigating the performance gap. Local Building Control authorities may lack jurisdiction over all development sites, and even where they do, regular on-site inspections may not always be conducted. Therefore, management systems ensuring high construction quality are imperative to meet predicted energy performance standards.

For instance, factors like air tightness and thermal bridging are pivotal in achieving the operational energy goals outlined for net zero buildings. Monitoring these aspects throughout construction phases is essential, as a mere confirmation of insulation thickness does not suffice to gauge construction quality.

Several reputable schemes are available and proven effective, including:

- Passivhaus Certification (residential and non-residential)
- AECB Building Standard (residential and non-residential)
- NABERS UK (non-residential)
- Assured Performance Process (residential)
- National Energy Foundation (residential)

Further recommendations

- Any modelling tool is only as accurate as the modeller using the tool. Request that all calculations are done with qualified assessors.
- The introduction of the Home Energy Model could also solve many of the issues above, if it is able to produce accurate modelling outputs whilst providing consistency as the selected Building Regulations modelling tool. However, it is not yet known how well this will perform.

4.3.8 Implementing net zero carbon policies: lessons learned from others

The structure of the policies recommended for Surrey (Policy Route 2, absolute energy targets) is consistent with other local authorities such as Cornwall Council and Bath & NE Somerset, who have implemented policies for new build homes using space heat demand (SHD), total energy use (EUI) and renewable energy targets.

The specific targets chosen within that framework should be considered to balance the impacts on the different parties involved in development with the needs to progress rapidly on reducing carbon emissions from buildings.

The table to the right is a qualitative summary of those impacts at different performance target levels.

Understanding how policies work in operation assist the future development of improved policies and informs other local authorities on what is deliverable. The council should develop a reliable monitoring system that enables the collation of policy performance data both for compliance at application stages and once the building is in use. This should be made available in a standardised format for ease of data input for developers and subsequent sharing of data. Surrey County Council could look to distribute this standardised reporting form to LPAs throughout Surrey to form a regional understanding of policy implementation.

Concerns \ Targets	SHD = 30 EUI = 40 PV = EUI	SHD = 15 – 20 EUI – 35 PV = EUI
Policy makers	Used by Cornwall and B&NES so has passed inspection process	SHD matches CCC recommendation so is evidenced.
Planning officers	There may be some groups of exceptions, where some projects cannot comply with targets. Specific exemptions and guidance should be identified.	There may be significant numbers of projects that can't comply, and officers will need to be able to judge which are genuine and should have derogations.
Designers	Low energy design principles will need to be applied and energy assessments carried out pre-planning	Ultra-low energy design principles will need to be understood and designs will have to conform to best practice principles
Contractors	Best practice required for airtightness and thermal insulation continuity	Specific products may be required and reduced flexibility in construction methodology
Developers	Preplanning (at risk) costs will include energy modelling and energy statements	Preplanning (at risk) costs will include thermal bridge calculations, energy modelling and energy statements
Community	Higher running costs for residents, higher peak demand on the electricity network	Lowest running costs and peak demand within what the CCC estimated the UK infrastructure could support. best flexibility to operate as 'smart' buildings with the grid

SHD = Space heating demand

EUI – Energy Use Intensity

PV – Solar Photovoltaics

4.3.9 The Future Homes Standard: Local Authorities and Boroughs should strive to go beyond it

At the time of writing this evidence base (Jan to April 2024) the Future Homes Standard was undergoing a round of consultation (December 2023 to March 2024) on the standards it should mandate and the methodology of how to assess it (the Home Energy Model).

The Future Homes Standard is due to come into effect in 2025 – although it could be later than this.

The final standards and methodologies are highly uncertain and subject to change from the consultation documents.

The two potential minimum performance standards – as illustrated by the notional buildings options 1 and 2 were assessed in our modelling.

Energy efficiency

- In terms of fabric efficiency, there is **minimal improvement between the different options and the current Part L 2021 standards.**

Solar PV

- While we don't know what the final FHS standards will be when it is released, the consultation documents show us that **it's possible that a home will be able to pass the FHS standard with lower levels of energy efficiency and no solar PV** (as demonstrated by Option 2 in the FHS consultation).

Running costs

- The potential lack of PV being required for the Future Homes Standard has the biggest impact on running costs through:
  - i) greater overall energy consumption compared with alternatives;
  - ii) no ability to offset imported energy through self-consumption and
  - iii) no renewable energy generation to export and create revenue from.
- Taken together, this means **imported energy increases 40-100% for the FHS Option 2 home compared with the FHS Option 1 home.**
- The two FHS options have **very different potential running cost profiles** due mainly to the presence or not of solar PV:
  - A home built to FHS Option 1 standards is likely to be cheaper to run than a Part L 2021 compliant dwelling.
  - A home built to FHS Option 2 standards is likely to be more expensive to run than a Part L 2021 compliant dwelling.

Capital costs

- Our analysis showed that FHS Option 1 is more expensive to build than the Part L 2021 scenario and FHS Option 2 was cheaper to build than the Part L 2021 scenario. We therefore have no basis on which to predict a potential future cost baseline.

In summary

- Local authorities should not rely on the Future Homes Standard to deliver homes consistent with climate change objectives.
- We don't know what the FHS will look like when it is released.
- Improving energy efficiency does not appear to be a priority for the standard. Resultant space heating demands are likely to be in the region of 50-60 kWh/m^2/yr (for comparison the Climate Change Committee recommends 15-20 kWh/m^2/yr recommended for new homes and LETI (Low Energy Transformation Initiative) recommends 15 kWh/m^2/yr to meet our climate objectives.
- It's possible that solar PV will not be required – for this reason it's possible that running costs will be increased compared with Part L 2021.
- For an LPA to fulfil its duty and relative responsibility to comply with the Climate Change Act 2008, it should require policy that all new buildings are net zero by 2025 as per Balanced Pathway to Net Zero by the CCC. FHS does not anticipate to achieve this by 2035 at the earliest.

5.0

Glossary

Glossary 1/2

Absolute Energy Targets – Energy targets based on predicted actual energy use (e.g. space heating demand, Energy Use Intensity and renewable energy balance).

Air Source Heat Pumps (ASHP) – an electric heating system that gathers ambient heat from surroundings to efficiently heat a dwelling.

Air-tightness – A measure of how much air naturally leaks out of or into a building, through gaps around doors, windows, keyholes etc. Usually measured in $m^3/m^2/hr$ @ 50Pa.

Archetype – A building type used for energy and cost modelling purposes. Selected to reflect common building types in Surrey.

Baseline – The starting point from which energy performance and cost uplifts are compared.

Building fabric – a term used to describe collectively the walls, roof, floor, windows and doors of a building.

Carbon offsets – a way of balancing emissions in one area by reducing emissions in another or by sequestration of carbon*.

CO_2 – carbon dioxide, a greenhouse gas.

Coefficient of Performance (CoP) - a measure of efficiency usually used when describing heat pumps. The CoP is the amount of useful heat (or coolth) produces from every kilowatt of electricity used. E.g. a heat pump with a CoP of 3 produces 3 kW heat for every 1 kW of electricity it uses.

Communal heating system – a multi dwelling heating system.

Energy balance – where the amount of renewable energy generated by a building is the same as the amount of energy the building uses over the course of a year.

Energy efficiency – the relative amount of energy a building or system uses to achieve a certain aim (e.g. maintain a specific internal temperature)

Energy offset – The amount of renewable energy that is needed off-site to make up for the shortfall of renewable energy that can be provided on-site to meet policy targets.

Energy Use Intensity (EUI) – The total energy consumption of a building, divided by its gross internal area. Expressed in $kWh/m^2/yr$.

Fabric Efficiency – a measure of how effective a building's fabric is at retaining heat or staying cool.

Future Homes Standard (Part L 2025) – The proposed successor to the building regulations Part L 2021.

Home Energy Model – The proposed methodology which will assess whether new dwellings demonstrate compliance with the Future Homes Standard (to replace SAP)

$ktCO_2$ – kiloton of CO_2, a measure of the amount of carbon dioxide emitted or offset.

kWh – kilowatt hour, a measure of the amount of energy used or generated in one hour.

Mechanical Ventilation with Heat Recovery (MVHR) – a form of building ventilation that recovers heat from stale air before it is vented outside the building and uses it to warm incoming fresh air.

Net Zero Carbon – where the amount greenhouse gases emitted by an organisation are equivalent to the emissions either: i) sequestered or offset , ii) displaced by production of renewable energy.

Notional Building – part of the building regulations calculation methodology. It is a dwelling or building based on the same geometry and orientation as the proposed building, but with the building specification (U-values, window area, heating system and efficiency etc.) made up of a set of reference values.

PassivHaus Planning Package (PHPP) – predictive energy modelling and design tool.

Glossary 2/2

Performance Gap – The difference between the amount of energy a building actually consumes compared with what it is predicted to consume through energy modelling.

Policy Route 1 – Policy target aligned with building regulations Target Emissions Rate (TER) indicator.

Policy Route 2 – Policy target aligned with absolute energy targets, the Climate Change Committee and LETI.

Renewable energy – energy from a renewable source e.g. wind or solar.

Renewable Energy Balance – Where the amount of renewable energy generated by a building is equal to the amount of energy it consumes over the course of a year.

SAP – Standard Assessment Procedure (SAP) is the calculation methodology currently used to demonstrate compliance with Building Regulations.

Scenarios for energy modelling - The six different standards or specifications each archetype was modelled to. See page 12.

Scenario 0 – Baseline, Part L 2021.

Scenario 1 – Future Homes Standard Consultation 2023, Notional Building Option 1

Scenario 2 - Future Homes Standard Consultation 2023, Notional Building Option 2

Scenario 3 – 100% reduction on TER, using FHS Option 2 specification (Policy Route 1)

Scenario 4 – Net Zero Carbon, Low-energy (SHD < 30 kWh/m^2/yr)

Scenario 5 – Net Zero Carbon, Ultra-low energy (SHD 15-20 kWh/m^2/yr)

Space heat demand (SHD) – the amount of heat energy required to heat a space. SHD is a reflection of building fabric efficiency and is usually expressed in kWh/m^2/yr.

Solar photovoltaic (PV) – a form of renewable electricity generation from solar energy well suited to buildings and urban environments. Can be stated in installed capacity (kW), annual generation (kWh/yr) or annual generation per m^2 of building footprint (kWh/m^2/yr)

Solar self-consumption – The amount of solar energy used directly by the building at the point of generation. Expressed as a % of the total annual energy demand of the building.

Solar Export – Solar energy generated by the building and exported directly to the electricity grid.

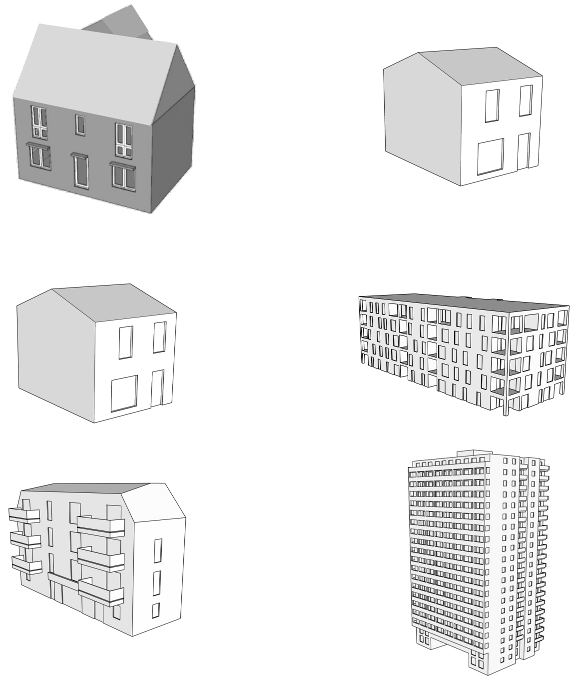
TER (Target Emissions Rate) - The target CO_2 emission rate (TER) sets a minimum allowable standard for the energy performance of a building and is defined by the annual CO_2 emissions of a notional building of same type, size and shape to the proposed building. TER is expressed in annual kgCO_2/m^2.

Waste Water Heat Recovery (WWHR) – A proprietary system fitted to the outlets from sinks, showers and baths, which collects heat from the waste water and transfers it to the cold water feeding a hot water store.

6.0

Appendices

Energy and cost modelling assumptions for dwellings



Range of building fabric and building services performance | Detached house

This table summarises the different energy efficiency assumptions modelled based on five different scenarios.

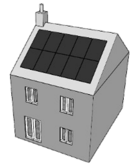
		Scenario 0: Part L 2021	Scenario 1: Future Homes Standard - Option 1	Scenario 2: Future Homes Standard - Option 2	Scenario 3: 100% better than FHS - Option 2 TER	Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Building fabric	Building fabric strategy	Part L 2021 compliant fabric, developer spec	FHS Option 1 compliant fabric, developer specs	FHS Option 2 compliant fabric, developer specs	To achieve DER=0 for FHS Option 2 compliant fabric, developer specs	To achieve space heat demand of 30 $kWh/m^2/yr$	To achieve space heat demand of 15-20 $kWh/m^2/yr$
	Floor (W/m^2K)	0.12 (SAP)	0.12 (SAP)	0.12 (SAP)	0.12 (SAP)	0.12 (SAP)	0.09 (SAP)
		0.13 (PHPP)	0.13 (PHPP)	0.13 (PHPP)	0.13 (PHPP)	0.13 (PHPP)	0.10 (PHPP)
	Walls (W/m^2K)	0.15	0.15	0.15	0.15	0.15	0.12
	Roof (W/m^2K)	0.11	0.11	0.11	0.11	0.11	0.10
	Windows (W/m^2K)	1.2	1.2	1.2	1.2	1.2	0.8
		(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(triple-glazed)
	Thermal bridging* (W/K)	15.07 (SAP)	15.07 (SAP)	15.07 (SAP)	105.07 (SAP)	15.07 (SAP)	15.15 (SAP)
		2.3 (PHPP)	2.3 (PHPP)	2.3 (PHPP)	2.3 (PHPP)	2.3 (PHPP)	3.2 (PHPP)
	Air Permeability ($m^3/m^2/hr$)	5	4	5	5	1	0.6
Building services	Ventilation	Centralised mechanical ventilation - 0% heat recovery	Decentralised mechanical ventilation (dMEV) system	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	Centralised MVHR 88% HR. 2m duct 25mm insulation	Centralised MVHR 88% HR. 2m duct 25mm insulation
	Space Heating	Gas combi boiler Radiators at <60˚C Programmer and room thermostat	5kW individual ASHP Radiators at <45˚C Programmer and room thermostat	5kW individual ASHP Radiators at <45˚C Programmer and room thermostat	5kW individual ASHP Radiators at <45˚C Programmer and room thermostat	5kW individual ASHP Radiators at <35˚C Programmer and room thermostat	5kW individual ASHP Radiators at <35˚C Programmer and room thermostat
	Domestic Hot Water	No additional tank	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 55˚C	200l hot water storage cylinder, 120mm insulation at 55˚C
		WWHR 36%	WWHR 50%	No WWHR	No WWHR	No WWHR	No WWHR
Renewables	Solar PV	4.5 kW	7.5 kW	0 kW	9.8 kW	3.8 kW	3.4 kW
	Assumed performance gap *(Increase in space heating demand)*	50%	40%	40%	40%	10%	5%

Range of building fabric and building services performance | Semi-detached house

This table summarises the different energy efficiency assumptions modelled based on five different scenarios.

		Scenario 0: Part L 2021	Scenario 1: Future Homes Standard - Option 1	Scenario 2: Future Homes Standard - Option 2	Scenario 3: 100% better than FHS - Option 2 TER	Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Building fabric	Building fabric strategy	Part L 2021 compliant fabric, developer spec	FHS Option 1 compliant fabric, developer specs	FHS Option 2 compliant fabric, developer specs	To achieve DER=0 for FHS Option 2 compliant fabric, developer specs	To achieve space heat demand of 30 kWh/m²/yr	To achieve space heat demand of 15-20 kWh/m²/yr
	Floor (W/m^{2}K)	0.11 (SAP)	0.13 (SAP)	0.13 (SAP)	0.13 (SAP)	0.11 (SAP)	0.09 (SAP)
		0.133 (PHPP)	0.163 (PHPP)	0.163 (PHPP)	0.163 (PHPP)	0.148 (PHPP)	0.105 (PHPP)
	Walls (W/m^{2}K)	0.16	0.16	0.16	0.16	0.20	0.12
	Roof (W/m^{2}K)	0.10	0.10	0.10	0.10	0.13	0.10
	Windows (W/m^{2}K)	1.2	1.2	1.2	1.2	1.2	0.8
		(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(triple-glazed)
	Thermal bridging* (W/K)	10.26 (SAP)	10.29 (SAP)	10.29 (SAP)	10.29 (SAP)	10.41 (SAP)	10.15 (SAP)
		3.6 (PHPP)	3.3 (PHPP)	3.3 (PHPP)	3.3 (PHPP)	3.0 (PHPP)	4.5 (PHPP)
	Air Permeability (m^3/m^2/hr)	5	4	5	5	1	0.6
Building services	Ventilation	Centralised mechanical ventilation - 0% heat recovery	Decentralised mechanical ventilation (dMEV) system	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	Centralised MVHR 88% HR. 2m duct 25mm insulation	Centralised MVHR 88% HR. 2m duct 25mm insulation
	Space Heating	Gas combi boiler Radiators at <60˚C Programmer and room thermostat	5kW individual ASHP Radiators at <45˚C Programmer and room thermostat	5kW individual ASHP Radiators at <45˚C Programmer and room thermostat	5kW individual ASHP Radiators at <45˚C Programmer and room thermostat	5kW individual ASHP Radiators at <35˚C Programmer and room thermostat	5kW individual ASHP Radiators at <35˚C Programmer and room thermostat
	Domestic Hot Water	No additional tank	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 55˚C	200l hot water storage cylinder, 120mm insulation at 55˚C
		WWHR 36%	WWHR 50%	No WWHR	No WWHR	No WWHR	No WWHR
Renewables	Solar PV	2.4 kW	4.9 kW	0 kW	6.5 kW	3.0 kW	2.6 kW
	Assumed performance gap *(Increase in space heating demand)*	50%	40%	40%	40%	10%	5%

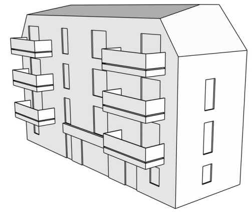
Range of building fabric and building services performance | Terraced house



This table summarises the different energy efficiency assumptions modelled based on five different scenarios.

		Scenario 0: Part L 2021	Scenario 1: Future Homes Standard - Option 1	Scenario 2: Future Homes Standard - Option 2	Scenario 3: 100% better than FHS - Option 2 TER	Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Building fabric	Building fabric strategy	Part L 2021 compliant fabric, developer spec	FHS Option 1 compliant fabric, developer specs	FHS Option 2 compliant fabric, developer specs	To achieve DER=0 for FHS Option 2 compliant fabric, developer specs	To achieve space heat demand of 30 kWh/m²/yr	To achieve space heat demand of 15-20 kWh/m²/yr
	Floor (W/m^2K)	0.10 (SAP) 0.13 (PHPP)	0.10 (SAP) 0.13 (PHPP)	0.10 (SAP) 0.13 (PHPP)	0.13 (SAP) 0.13 (PHPP)	0.13 (SAP) 0.185 (PHPP)	0.13 (SAP) 0.185 (PHPP)
	Walls (W/m^2K)	0.16	0.16	0.16	0.16	0.19	0.19
	Roof (W/m^2K)	0.10	0.10	0.10	0.10	0.11	0.11
	Windows (W/m^2K)	1.2 (double-glazed)	1.2 (double-glazed)	1.2 (double-glazed)	1.2 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)
	Thermal bridging* (W/K)	9.58 (SAP) 3.6 (PHPP)	9.58 (SAP) 3.6 (PHPP)	9.58 (SAP) 3.6 (PHPP)	9.58 (SAP) 3.6 (PHPP)	10.40 (SAP) 2.8 (PHPP)	10.10 (SAP) 2.8 (PHPP)
	Air Permeability ($m^3/m^2/hr$)	5	4	5	5	1	0.6
Building services	Ventilation	Centralised mechanical ventilation - 0% heat recovery	Decentralised mechanical ventilation (dMEV) system	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	Centralised MVHR 88% HR. 2m duct 25mm insulation	Centralised MVHR 88% HR. 2m duct 25mm insulation
	Space Heating	Gas combi boiler Radiators at <60°C Programmer and room thermostat	5kW individual ASHP Radiators at <45°C Programmer and room thermostat	5kW individual ASHP Radiators at <45°C Programmer and room thermostat	5kW individual ASHP Radiators at <45°C Programmer and room thermostat	5kW individual ASHP Radiators at <35°C Programmer and room thermostat	5kW individual ASHP Radiators at <35°C Programmer and room thermostat
	Domestic Hot Water	No additional tank WWHR 36%	200l hot water storage cylinder, 120mm insulation at 60°C WWHR 50%	200l hot water storage cylinder, 120mm insulation at 60°C No WWHR	200l hot water storage cylinder, 120mm insulation at 60°C No WWHR	200l hot water storage cylinder, 120mm insulation at 55°C No WWHR	200l hot water storage cylinder, 120mm insulation at 55°C No WWHR
Renewables	Solar PV	2.3 kW	4.9 kW	0 kW	6.3 kW	2.7 kW	2.5 kW
	Assumed performance gap *(Increase in space heating demand)*	50%	40%	40%	40%	10%	5%

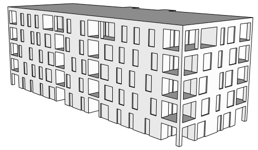
Range of building fabric and building services performance | Low-rise flats



This table summarises the different energy efficiency assumptions modelled based on five different scenarios.

		Scenario 0: Part L 2021	Scenario 1: Future Homes Standard - Option 1	Scenario 2: Future Homes Standard - Option 2	Scenario 3: 100% better than FHS - Option 2 TER	Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Building fabric	Building fabric strategy	Part L 2021 compliant fabric, developer spec	FHS Option 1 compliant fabric, developer specs	FHS Option 2 compliant fabric, developer specs	To achieve DER=0 for FHS Option 2 compliant fabric, developer specs	To achieve space heat demand of 30 kWh/m²/yr	To achieve space heat demand of 15-20 kWh/m²/yr
	Floor (W/m^{2}K)	0.10 (SAP)	0.10 (SAP)	0.10 (SAP)	0.13 (SAP)	0.10 (SAP)	0.09 (SAP)
		0.13 (PHPP)	0.13 (PHPP)	0.13 (PHPP)	0.13 (PHPP)	0.13 (PHPP)	0.10 (PHPP)
	Walls (W/m^{2}K)	0.15	0.15	0.15	0.15	0.15	0.11
	Roof (W/m^{2}K)	0.10	0.10	0.10	0.10	0.10	0.10
	Windows (W/m^{2}K)	1.2	1.2	1.2	1.2	1.2	0.8
		(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(triple-glazed)
	Thermal bridging* (W/K)	7.77 (SAP)	7.77 (SAP)	7.77 (SAP)	7.77 (SAP)	7.77 (SAP)	8.00 (SAP)
		5.5 (PHPP)	5.5 (PHPP)	5.5 (PHPP)	5.5 (PHPP)	4.5 (PHPP)	3.5 (PHPP)
	Air Permeability (m^3/m^2/hr)	5	4	5	5	1	0.6
Building services	Ventilation	Centralised mechanical ventilation - 0% heat recovery	Decentralised mechanical ventilation (dMEV) system	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	Centralised MVHR 88% HR. 2m duct 25mm insulation	Centralised MVHR 88% HR. 2m duct 25mm insulation
	Space Heating	Gas combi boiler Radiators at <60˚C Programmer and room thermostat	5kW individual ASHP Radiators at <55˚C Programmer and room thermostat	5kW individual ASHP Radiators at <55˚C Programmer and room thermostat	5kW individual ASHP Radiators at <55˚C Programmer and room thermostat	5kW individual ASHP Radiators at <45˚C Programmer and room thermostat	5kW individual ASHP Radiators at <35˚C Programmer and room thermostat
	Domestic Hot Water	No additional tank	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 55˚C	200l hot water storage cylinder, 120mm insulation at 55˚C
		WWHR 36%	WWHR 50%	No WWHR	No WWHR	No WWHR	No WWHR
Renewables	Solar PV	4.9 kW	11.5 kW	0 kW	27.3 kW	21.0 kW	18.7 kW
	Assumed performance gap *(Increase in space heating demand)*	50%	40%	40%	40%	10%	5%

Range of building fabric and building services performance | Mid-rise flats



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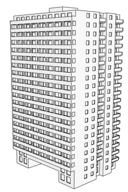
Building fabric	Building fabric strategy	Part L 2021 compliant fabric, developer spec	FHS Option 1 compliant fabric, developer specs	FHS Option 2 compliant fabric, developer specs	To achieve DER=0 for FHS Option 2 compliant fabric, developer specs	To achieve space heat demand of 30 kWh/m²/yr	To achieve space heat demand of 15-20 kWh/m²/yr
	Floor (W/m^{2}K)	0.10 (SAP)	0.10 (SAP)	0.10 (SAP)	0.13 (SAP)	0.13 (SAP)	0.13 (SAP)
		0.14 (PHPP)	0.14 (PHPP)	0.14 (PHPP)	0.14 (PHPP)	0.20 (PHPP)	0.20 (PHPP)
	Walls (W/m^{2}K)	0.15	0.15	0.15	0.15	0.20	0.18
	Roof (W/m^{2}K)	0.14	0.14	0.14	0.14	0.15	0.15
	Windows (W/m^{2}K)	1.2	1.2	1.2	1.2	1.2	0.8
		(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(triple-glazed)
	Thermal bridging* (W/K)	5.8 (SAP)	5.8 (SAP)	5.8 (SAP)	5.8 (SAP)	5.8 (SAP)	6.0 (SAP)
		6.0 (PHPP)	6.0 (PHPP)	6.0 (PHPP)	6.0 (PHPP)	4.0 (PHPP)	4.0 (PHPP)
	Air Permeability (m^3/m^2/hr)	5	4	5	5	1	0.6
Building services	Ventilation	Centralised mechanical ventilation - 0% heat recovery	Decentralised mechanical ventilation (dMEV) system	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	Centralised MVHR 88% HR. 2m duct 25mm insulation	Centralised MVHR 88% HR. 2m duct 25mm insulation
	Space Heating	Gas communal boiler Radiators at <60˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <55˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <55˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <55˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <45˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <35˚C Programmer and room thermostat
	Domestic Hot Water	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 55˚C	200l hot water storage cylinder, 120mm insulation at 55˚C
		WWHR 36%	WWHR 50%	No WWHR	No WWHR	No WWHR	No WWHR
Renewables	Solar PV	23.4 kW	44.3 kW	0 kW	156.1 kW	101.4 kW	94.8 kW
	Assumed performance gap *(Increase in space heating demand)*	50%	40%	40%	40%	10%	5%

Range of building fabric and building services performance | High-rise flats



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		Scenario 0: Part L 2021	Scenario 1: Future Homes Standard - Option 1	Scenario 2: Future Homes Standard - Option 2	Scenario 3: 100% better than FHS - Option 2 TER	Scenario 4: Net Zero (Low energy)	Scenario 5: Net Zero (Ultra Low energy)
Building fabric	Building fabric strategy	Part L 2021 compliant fabric, developer spec	FHS Option 1 compliant fabric, developer specs	FHS Option 2 compliant fabric, developer specs	To achieve DER=0 for FHS Option 2 compliant fabric, developer specs	To achieve space heat demand of 30 kWh/m²/yr	To achieve space heat demand of 15-20 kWh/m²/yr
	Floor (W/m^{2}K)	0.11 (SAP)	0.11 (SAP)	0.11 (SAP)	0.11 (SAP)	0.15 (SAP)	0.15 (SAP)
		0.13 (PHPP)	0.13 (PHPP)	0.13 (PHPP)	0.13 (PHPP)	0.15 (PHPP)	0.15 (PHPP)
	Walls (W/m^{2}K)	0.16	0.16	0.16	0.16	0.20	0.20
	Roof (W/m^{2}K)	0.10	0.10	0.10	0.10	0.18	0.18
	Windows (W/m^{2}K)	1.2	1.2	1.2	1.2	1.2	0.8
		(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(double-glazed)	(triple-glazed)
	Thermal bridging* (W/K)	5.8 (SAP)	5.8 (SAP)	5.8 (SAP)	5.8 (SAP)	5.8 (SAP)	6.0 (SAP)
		6.0 (PHPP)	6.0 (PHPP)	6.0 (PHPP)	6.0 (PHPP)	4.0 (PHPP)	4.0 (PHPP)
	Air Permeability (m^3/m^2/hr)	5	4	5	5	1	0.6
Building services	Ventilation	Centralised mechanical ventilation - 0% heat recovery	Decentralised mechanical ventilation (dMEV) system	Natural ventilation with intermittent extract fans	Natural ventilation with intermittent extract fans	Centralised MVHR 88% HR. 2m duct 25mm insulation	Centralised MVHR 88% HR. 2m duct 25mm insulation
	Space Heating	Gas communal boiler Radiators at <60˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <55˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <55˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <55˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <45˚C Programmer and room thermostat	ASHP – Ambient loop system Radiators at <35˚C Programmer and room thermostat
	Domestic Hot Water	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 60˚C	200l hot water storage cylinder, 120mm insulation at 55˚C	200l hot water storage cylinder, 120mm insulation at 55˚C
		WWHR 36%	WWHR 50%	No WWHR	No WWHR	No WWHR	No WWHR
Renewables	Solar PV	87.6 kW	64.0 kW	0 kW	870.3 kW	562.0 kW	500.0 kW
	Assumed performance gap *(Increase in space heating demand)*	50%	40%	40%	40%	10%	5%

Methodology for costing archetypes

Method Statement for Cost Calculations

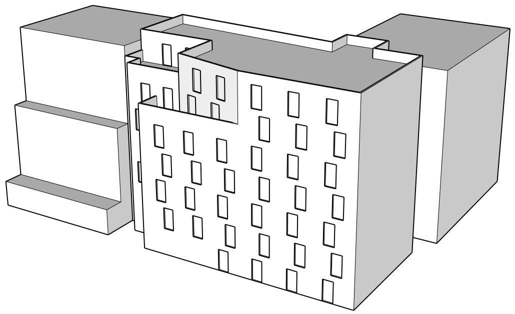
The full method statement can be found in the Appendix of Part E Cost and Viability Modelling Results

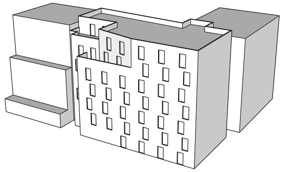
	Houses	Flats
Notes:	The BCIS average cost is based on the median published on 18th March 2024, rebased for Surrey. The detached units are based on the median rate for 2-storey dwellings on a development of 3 units or less. In calculating the costs for a terraced house, a mid-terraced plot has been used, on the basis that an end of terrace is similar to a semi- The 'GIFA' is the Gross Internal Floor Area of the archetype, as measured in accordance with RICS Guidance. The 'Average Blended Rate' is the total of the three archetypes divided by three.	The BCIS average cost is based on the median published on 18th March 2024, rebased for Surrey. The low and mid-rise rate is based on the BCIS published rate on 18th March 2024 for 3-5 storey apartments rebased to Surrey. The high rise rate is based on recent tenders received by QSetc for 15 – 22 storey buildings and rebased for Surrey. The 'GIFA' is the Gross Internal Floor Area of the archetype, as measured from the drawings provided, in accordance with RICS The number of units is based on the units included within each archetype, based on the drawings provided and the relevant block where indicated. The mix of unit sizes has not been reviewed, and the rates assume a mixture of studios through to 3-bedroom apartments.
Preliminaries	Preliminaries – an additional 13% on all of the above.	Preliminaries – an additional 15% on all of the above.
Overheads & Profit	Overheads & Profit – on the basis the development is not a self-build, an additional allowance of 8% should be added to all of the above, after the preliminaries percentage add-on.	Overheads & Profit – on the basis the development is not a self-build, an additional allowance of 8% should be added to all of the above, after the preliminaries percentage add-on.
Design Fees	Design Fees – these are excluded.	Design Fees – these are excluded.
External Works	External Works – these are excluded.	External Works – these are excluded.
Site specific abnormals	Site specific abnormals – these are excluded.	Site specific abnormals – these are excluded.
Floors	The costs reflect the difference in the thickness of insulation applied to the ground floor slab, based on the area required to meet the necessary 'U- Value' to achieve the Standard.	The costs reflect the difference in the thickness of insulation applied to the ground floor slab, based on the area required to meet the necessary 'U- Value' to achieve the Standard.
Walls	The costs reflect the difference in the thickness of the insulation fitted within the external wall build-up, based on the area of the external walls (excluding windows and doors) required to meet the U-Value to achieve	The costs reflect the difference in the thickness of the insulation fitted within the external wall build-up, based on the area of the external walls (excluding windows and doors) required to meet the U-Value to achieve

Roof	The costs reflect the difference in the thickness of the insulation laid to the roof (based on the pitched roof area), assuming a 'warm roof' required to meet the U-Value to achieve the Standard.	The costs reflect the difference in the thickness of the insulation laid to the roof (measured on the roof plan area), required to meet the U-Value to achieve the Standard.
Windows & Doors	Double glazed windows and doors have been priced on the basis of UPVC windows and doors to the measured areas. Triple glazed windows are based on composite aluminium/timber windows and doors, on the basis that the weight increase of the glazing is not suitable for UPVC installations. This has been witnessed on several projects which QSetc has been involved with, where the specification of	Double glazed windows and doors have been priced on the basis of composite aluminium and timber windows and doors to the measured Triple glazed windows are based on composite aluminium/timber windows and doors
Thermal Bridging	An allowance has been included based on the area of external walls to meet the thermal bridging requirements for each Scenario.	An allowance has been included based on the area of external walls to meet the thermal bridging requirements for each Scenario.
Airtightness	This is more difficult to apply a cost to. Arguably, it relies on the quality of workmanship on site, and in order to achieve 4 or 5m3/m2/hr there should be no cost associated with this, provided robust architectural detailing is followed. However, in order to achieve the lower number of air changes to meet the two 'Net-Zero' Scenarios, additional work will be required, and this has been costed by applying a rate to the total external	This is more difficult to apply a cost to. Arguably, it relies on the quality of workmanship on site, and in order to achieve 4 or 5m3/m2/hr there should be no cost associated with this, provided robust architectural detailing is followed. However, in order to achieve the lower number of air changes to meet the two 'Net-Zero' Scenarios, additional work will be required, and this has been costed by applying a rate to the total external
Ventilation Systems	Costed based on market data received for current projects for the installation of the ventilation systems specified by Etude. The costs in this instance have been priced on a per plot basis, rather than being area	Costed based on market data received for current projects for the installation of the ventilation systems specified by Etude. The costs in this instance have been priced on a per unit basis, rather than being area
Space Heating (including provision domestic hot water)	Heating and hot water systems are intrinsically linked and difficult to separate within the cost data received. The installation of a heating system, includes the provision of a hot water tank, and associated The systems have been priced based on the specification prepared by QSetc has been requested to breakdown the costs between labour and materials. This is difficult, as it varies slightly on a project specific basis, and can change depending on the location of the heat source relative to the tank. QSetc has received supply costs for a Daikin system on a recent project, along with the installed cost. As a 'rule of thumb', the split between the labour and materials element is generally 30–35% for the The costs in this instance have been priced on a per plot basis, rather than being area generated. In the instance of a gas fired boiler, an allowance of £1,000 per plot has also been included for the connection charge as advised by British Gas.	Heating and hot water systems are intrinsically linked and difficult to separate, within the cost data received. The installation of a heating system, includes the provision of a hot water tank, and associated The systems have been priced based on the specification prepared by QSetc has been requested to breakdown the costs between labour and materials. This is difficult, as it varies slightly on a project specific basis, and can change depending on the location of the heat source relative to the tank. QSetc has received supply costs for a Daikin system on a recent project, along with the installed cost. As a 'rule of thumb', the split between the labour and materials element is generally 30–35% for the The costs in this instance have been priced on a per unit basis, rather than being area generated. In the instance of a gas fired boiler, an allowance of £1,000 per unit has also been included for the connection charge as advised by British Gas.

	Wastewater Heat Recovery is priced on the basis of three points per dwelling, effectively capturing the bath, shower and kitchen wastes.	Wastewater Heat Recovery is priced on the basis of three points per dwelling, effectively capturing the bath, shower, and kitchen wastes.
Solar Photovoltaics	Costs are based on the installed capacity in kWs for each Archetype. Generally, a domestic array generating circa 3.5kW, and occupying an area of circa 25m2, will cost in the order of £7,000 (i.e. £2,000/kW). However, photovoltaics do benefit from significant economies of scale for larger installations. For example, for arrays generating 10–50kW, the	Costs are based on the installed capacity in kWs for each Archetype. Generally, a domestic array generating circa 3.5kW, and occupying an area of circa 25m2, will cost in the order of £7,000 (i.e. £2,000/kW). However, photovoltaics do benefit from significant economies of scale for larger installations. For example, for arrays generating 10 – 50kW, the
Preliminaries	As preliminaries are time related, QSetc would argue that the adoption of any of the Scenarios should not increase the preliminaries' costs for any specific development. However, in respect of early estimates, a programme is not known, and Quantity Surveyors apply a percentage addition for preliminaries. The base rates within BCIS include an allowance for preliminaries, and it is generally accepted this is between QSetc would recommend a preliminaries percentage of 13% is added to any additional costs for achieving the various scenarios outlined above.	As preliminaries are time related, QSetc would argue that the adoption of any of the Scenarios should not increase the preliminaries' costs for any specific development. However, in respect of early estimates, a programme is not known, and Quantity Surveyors apply a percentage addition for preliminaries. The base rates within BCIS include an allowance for preliminaries, and it is generally accepted this is between QSetc would recommend a preliminaries percentage of 15% is added to any additional costs for achieving the various scenarios outlined above.
Overheads & Profit	Overheads and profit will be added to all projects where a third party contractor is involved. However, for a self-build, these are often excluded, with contractors' profit obtained from the sale of the units. Each scheme needs reviewing depending on the type of development. For developments where a third party contractor is appointed, the level of overheads and profit is generally 7.5–10%, with the higher level	Overheads and profit will be added to all projects where a third party contractor is involved. However, for a self-build, these are often excluded, with contractors' profit obtained from the sale of the units. Each scheme needs reviewing depending on the type of development. For developments where a third-party contractor is appointed, the level of overheads and profit is generally 7.5–10%, with the higher level
Design Fees	These are excluded from all Scenarios.	These are excluded from all Scenarios.
External Works	These are excluded from all Scenarios, as these are site specific. BCIS also exclude external works from their published average prices. These should be dealt with on a site-by-site basis.	These are excluded from all Scenarios, as these are site specific. BCIS also exclude external works from their published average prices. These should be dealt with on a site-by-site basis.
Site Specific Abnormals	These are excluded from all Scenarios, as these are site specific. BCIS also exclude site specific abnormals from their published prices. Such abnormals may include demolition costs, removal of asbestos, dealing with unusual ground conditions or the presence and removal of	These are excluded from all Scenarios, as these are site specific. BCIS also exclude site specific abnormals from their published prices. Such abnormals may include demolition costs, removal of asbestos, dealing with unusual ground conditions or the presence and removal of

Energy and cost modelling assumptions for office building





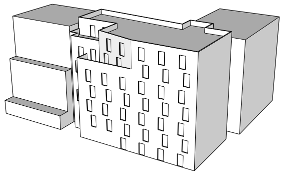
Office building | Fabric & Ventilation

This table summarises the different energy efficiency assumptions modelled based on the three different fabric and ventilation scenarios. Modelling was carried out for a 7-storey office of 4000m² GIA.

New input for Part L 2021

	1 Business as Usual	2 Good Practice	3 Ultra Low Energy
Description	This scenario represents the type of energy efficiency performance most applicants are used to deliver.	This scenario represents an intermediate level of performance: better than business as usual but not as good as ultra low energy.	This scenario represents a feasible best practice level of performance, approximately equivalent to Passivhaus.
Floor U-Value (W/m^{2}K)	0.15	0.12	0.09
External wall U-Value (W/m^{2}K)	0.25	0.18	0.13
Roof U-Value (W/m^{2}K)	0.15	0.13	0.10
Windows U-value (W/m^{2}K)* Windows g-value	 1.60 0.40	 1.40 0.40	 0.80 0.40
External doors (W/m^{2}K)	2.0	1.5	1.5
Thermal bridging (W/m^{2}K)	Good practice (5% of losses)	Better practice (3% of losses)	Best practice (1% of losses)
Air Permeability (m^3/m^2/hr)	5	3	1
Ventilation system and design	Standard quality AHU	Good quality AHU	Best practice AHU
AHU heat recovery efficiency	75%	80%	90%
AHU specific fan power	1.8 W/l/s 0.3 W/l/s (FCU terminal units)	1.6 W/l/s 0.3 W/l/s (FCU terminal units)	1.2 W/l/s 0.3 W/l/s (FCU terminal units)
Demand Control Ventilation	No	Yes - CO_2 sensors with speed control	Yes - CO_2 sensors with speed control
Internal Lighting (lm/W)	95	105	115
Lighting Control	PIR Presence Detection + Daylight Dimming in Offices only	PIR Presence Detection + Daylight Dimming in Offices only	PIR Presence Detection + Daylight Dimming in Offices only

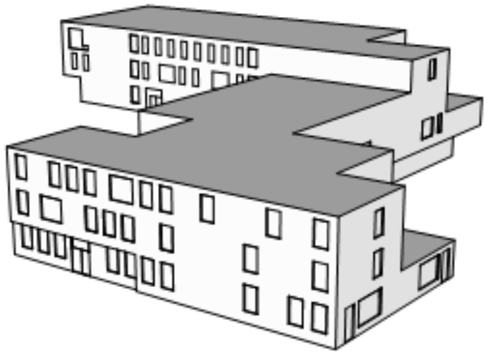
The term 'Business as Usual' Business as usual' scenarios is meant to represent the type of fabric and ventilation specifications that most applicants in London would consider 'standard' for a mid-rise apartment building. For consistency it has not been changed compared with the initial 2019 study. We think that this approach is acceptable as 'Business as usual' has not changed significantly in terms of fabric and ventilation specifications

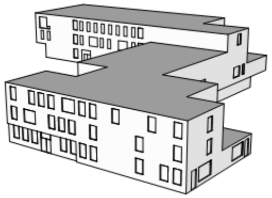


This table summarises the different heating system assumptions modelled based on the four different scenarios.

	A Gas boiler	B VRF	C Less efficient Heat Pump System *Communal heat pump*	D More Efficient Heat Pump System *Communal heat pump*
Description	Gas boiler serving a heating system with flow and return temperature 70°C/50°C	VRF unit	Heat pumps serving a heating system with flow and return temperature 65°C/50°C	Heat pumps serving a heating system with low flow and return temperatures 45°C/40°C fed from ambient loop.
Heating emitters	LTHW Fan Coil Unit fed by Gas Boiler	Fan Coil Unit fed by VRF	LTHW Fan Coil Unit fed by Heat Pump	LTHW Fan Coil Unit fed by Heat Pump
Hot water system	Direct electric hot water to toilets A 400L hot water store for the showers fed by gas boiler	Direct electric hot water to toilets A 400L hot water store for the showers fed by heat pump	Direct electric hot water to toilets A 400L hot water store for the showers fed by heat pump	Direct electric hot water to toilets A 400L hot water store for the showers fed by heat pump
Heating and hot water seasonal efficiency	95% for heating and hot water	350% for heating 300% for hot water	220% for heating and hot water	400% for heating 300% for hot water
Waste Water Heat Recovery (WWHR)	No WWHR assumed	No WWHR assumed	No WWHR assumed	No WWHR assumed
Cooling seasonal efficiency	3.5 EER 5.0 SEER	3.5 EER 5.0 SEER	3.5 EER 5.0 SEER	3.5 EER 5.0 SEER

Energy and cost modelling assumptions for primary school





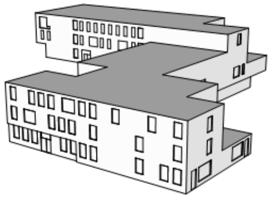
Primary school building | Fabric & Ventilation

This table summarises the different energy efficiency assumptions modelled based on the three different fabric and ventilation scenarios. Modelling was carried out for a 3/4-storey primary school of 6000m² GIA.

NEW New input for Part L 2021

	1 Business as Usual	2 Good Practice	3 Ultra Low Energy
Description	This scenario represents the type of energy efficiency performance most applicants are used to deliver.	This scenario represents an intermediate level of performance: better than business as usual but not as good as ultra low energy.	This scenario represents a feasible best practice level of performance, approximately equivalent to Passivhaus.
Floor U-Value (W/m^{2}K)	0.15	0.12	0.09
External wall U-Value (W/m^{2}K)	0.20	0.18	0.13
Roof U-Value (W/m^{2}K)	0.15	0.13	0.11
Thermal bridge performance*	25% added to the U-values	25% added to the U-values	25% added to the U-values
Windows U-value (W/m^{2}K)* Windows g-value	 1.40 0.50	 1.20 0.50	 0.80 0.50
External doors (W/m^{2}K)	1.6	1.6	1.6
Air Permeability (m^3/m^2/hr)	5	3	1
Ventilation system and design	Fan assisted ventilation	Good quality MVHR	Best practice MVHR
AHU heat recovery efficiency	0%	70%	80%
AHU specific fan power	0.5 W/l/s	1.6 W/l/s	1.2 W/l/s
Demand Control Ventilation NEW	No	No	Yes - CO_2 sensors with speed control
Internal Lighting (lm/W) NEW	95	105	115
Lighting Control	PIR Absence Detection + Daylight Dimming in Teaching and Offices only PIR Presence Detection in Circulation, Toilets, Stores, Kitchen, Dining, Server and Changing	PIR Absence Detection + Daylight Dimming in Teaching and Offices only PIR Presence Detection in Circulation, Toilets, Stores, Kitchen, Dining, Server and Changing	PIR Absence Detection + Daylight Dimming in Teaching and Offices only PIR Presence Detection in Circulation, Toilets, Stores, Kitchen, Dining, Server and Changing

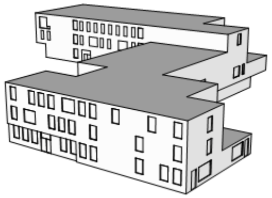
The term 'Business as Usual' is meant to represent the type of fabric and ventilation specifications that most applicants in London would consider 'standard' for a school.
For consistency it has not been changed compared with the initial 2019 study. We think that this approach is acceptable as 'Business as usual' has not changed significantly in terms of fabric and ventilation specifications
**Variations in thermal bridging have not been modelled as the software doesn't support modelling psi values so adds a default 25% uplift to all U-values in actual building in accordance with NCM.*



This table summarises the different heating system assumptions modelled based on the four different scenarios.

	A Gas boiler	B Direct electric	C Less efficient Heat Pump System *Communal heat pump*	D More Efficient Heat Pump System *Communal heat pump*
Description	Gas boiler serving a heating system with flow and return temperature 70°C/50°C	Direct electric panel radiators providing heating	Heat pumps serving a heating system with flow temperature 65°C	Heat pumps serving a heating system with low flow temperature 45°C fed from ambient loop
Heating emitters	LTHW radiators fed by gas boiler	Direct electric panel radiators	LTHW radiators fed by heat pump	LTHW radiators fed by heat pump
Hot water system	A 2500L hot water store	Direct electric point-of-use hot water to bathrooms	Direct electric point-of-use hot water to bathrooms	Direct electric point-of-use hot water to bathrooms
Heating and hot water seasonal efficiency	95% for heating and hot water	100% for heating and hot water	400% for heating* 100% for hot water	450% for heating* 100% for hot water
Waste Water Heat Recovery (WWHR)	No WWHR assumed	No WWHR assumed	No WWHR assumed	No WWHR assumed
Cooling seasonal efficiency	No cooling assumed	No cooling assumed	No cooling assumed	No cooling assumed
Distribution efficiency (heating, cooling and DHW)	95%	95%	95%	95%

**Heat pumps in Systems C and D have been improved from the initial 2019 study to more closely align with the other typologies and take account of the minimum permissible performance levels set by Part L.*



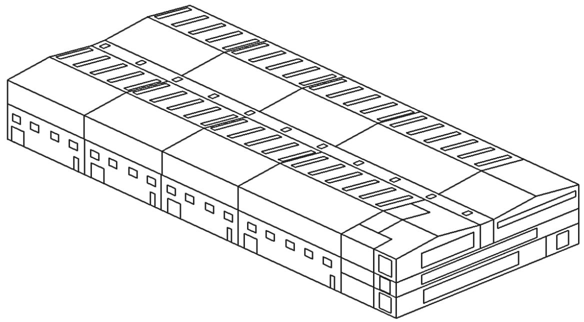
Primary school building | Photovoltaics (PVs)

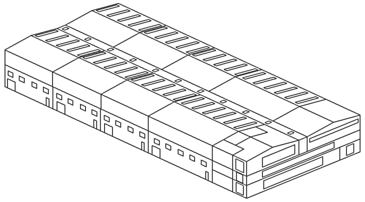
This table summarises the different sizes of PV system assumed.

New input for Part L 2021

	No PV	PV
Description	This assumed no PVs at all on the roof or any of the elevation	This assumes a standard practice for PVs. No particular effort has been made to design the roof in order to accommodate PVs.
Photovoltaic Panels (kWp)	0	135.5
Module Efficiency (%)	N/A	TBC%
Assumed area (Panel area)	N/A	607.8m^2 (25% of footprint)
Tilt	N/A	10° (Horizontal)
Shading	N/A	Average/unknown
Battery capacity (kWh)	N/A	N/A
Predicted Annual Yield	N/A	114,657 kWh

Energy and cost modelling assumptions for industrial building



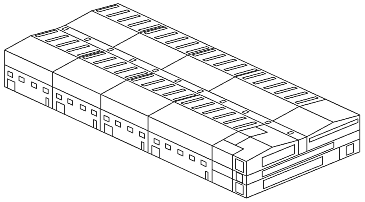


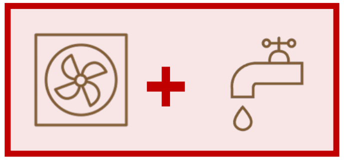
Industrial building | Fabric & Ventilation

This table summarises the different energy efficiency assumptions modelled based on the three different fabric and ventilation scenarios. Modelling was carried out for a 2-storey industrial building of 9000m² GIA.

NEW New input for Part L 2021

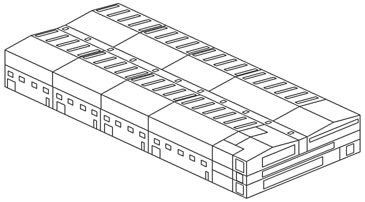
	1 Business as Usual	2 Good Practice	3 Ultra Low Energy
Description	This scenario represents the type of energy efficiency performance most applicants are used to deliver.	This scenario represents an intermediate level of performance: better than business as usual but not as good as ultra low energy.	This scenario represents a feasible best practice level of performance, approximately equivalent to Passivhaus.
Floor U-Value (W/m^{2}K)	0.18	0.15	0.13
External wall U-Value (W/m^{2}K)	0.26	0.18	0.14
Roof U-Value (W/m^{2}K)	0.16	0.13	0.11
Windows/Rooflights U-value (W/m^{2}K)* Windows g-value	 1.60 / 2.00 0.40 / 0.50	 1.40 / 1.60 0.40 / 0.50	 1.20 / 1.40 0.40 / 0.50
External doors – Pedestrian / Vehicle (W/m^{2}K)	2.0 / 1.3	1.5 / 1.3	1.5 / 1.3
Thermal bridging (W/m^{2}K)	Good practice (5% of losses)	Better practice (3% of losses)	Best practice (1% of losses)
Air Permeability (m^3/m^2/hr)	5	3	2
Ventilation system and design	Industrial offices: AHU with HR Industrial warehouses: Exhaust only	Industrial offices: AHU with HR Industrial warehouses: AHU with HR	Industrial offices: AHU with HR Industrial warehouses: AHU with HR
AHU heat recovery efficiency	Industrial offices: 75% Industrial warehouses: NA	Industrial offices: 80% Industrial warehouses: 80%	Industrial offices: 80% Industrial warehouses: 80%
AHU specific fan power	Industrial offices: 1.6 (0.2 for terminal units) Industrial warehouses: 0.5	Industrial offices: 1.4 (0.2 for terminal units) Industrial warehouses: 1.4	Industrial offices: 1.2 (0.15 terminal units) Industrial warehouses: 1.2
Demand Control Ventilation NEW	No	No	Yes - CO_2 sensors with speed control only in offices
Internal Lighting (lm/W) NEW	100	110	115
Lighting Control	PIR Presence Detection + Daylight Dimming in offices only	PIR Presence Detection + Daylight Dimming in offices only	PIR Presence Detection + Daylight Dimming in offices only





This table summarises the different heating system assumptions modelled based on the four different scenarios.

	A Gas boiler	B VRF	C Less efficient Heat Pump System *Four pipe chiller*	D More Efficient Heat Pump System *Central heat pump*
Description	Gas boiler serving a heating system with flow and return temperature 70°C/50°C	ASHP serving the warehouse spaces and VRF system for the office spaces.	Four pipe chiller which does simultaneous heating and cooling	Heat pumps serving a heating system with low flow and return temperatures 45°C/40°C fed from ambient loop.
Heating emitters (Workshop)	Radiant panels	Radiant panels	Radiant panels	Radiant panels
Heating seasonal efficiency (Workshop)	95%	300%	300%	350%
Heating emitters (Office)	FCU	FCU	FCU	FCU
Heating seasonal efficiency (Office)	95%	450%	300%	350%
Hot water system	Direct electric	Direct electric	Direct electric	Heat pump
Hot water seasonal efficiency	100%	100%	100%	300%
Cooling seasonal efficiency (Office spaces)	3.5 EER 5.0 SEER	3.5 EER 5.0 SEER	3.0 EER 4.0 SEER	3.5 EER 5.0 SEER



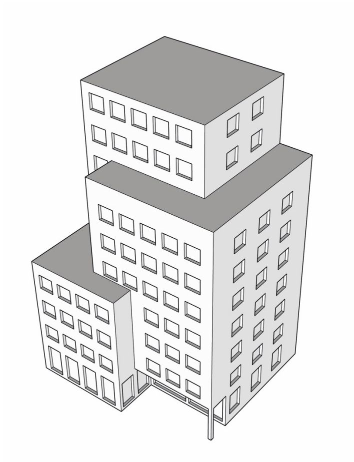
Industrial building | Photovoltaics (PVs)

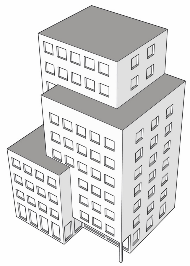
This table summarises the different sizes of PV system assumed.

New input for Part L 2021

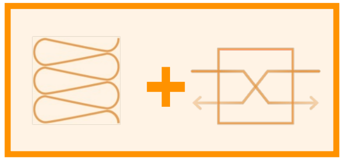
	No PV	PV
Description	This assumed no PVs at all on the roof or any of the elevation	This assumes a standard practice for PVs. No particular effort has been made to design the roof in order to accommodate PVs.
Photovoltaic Panels (kWh/year)	0	122,160
Module Efficiency (%)	N/A	20%
Assumed area (Panel area)	N/A	666 m^2 (20% of building footprint area)
Tilt	N/A	30° (Horizontal)
Shading	N/A	Average/unknown
Battery capacity (kWh)	N/A	N/A

Energy and cost modelling assumptions for hotel





Hotel building | Fabric & Ventilation

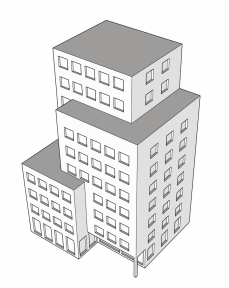


This table summarises the different energy efficiency assumptions modelled based on the three different fabric and ventilation scenarios. Modelling was carried out for a 11 storey hotel with 100 bedrooms, ground floor restaurant and 3900m² GIA.

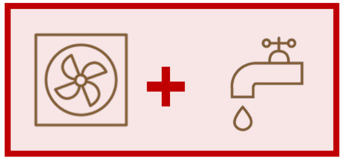
NEW New input for Part L 2021

	1 Business as Usual	2 Good Practice	3 Ultra Low Energy
Description	This scenario represents the type of energy efficiency performance most applicants are used to deliver.	This scenario represents an intermediate level of performance: better than business as usual but not as good as ultra low energy.	This scenario represents a feasible best practice level of performance, approximately equivalent to Passivhaus.
Floor U-Value (W/m^{2}K)	0.15	0.12	0.09
External wall U-Value (W/m^{2}K)	0.25	0.18	0.13
Roof U-Value (W/m^{2}K)	0.15	0.13	0.10
Thermal bridge performance*	25% added to the U-values	25% added to the U-values	25% added to the U-values
Windows U-value (W/m^{2}K) Windows g-value	 1.40 0.4	 1.20 0.4	 0.80 0.4
Air Permeability (m^3/m^2/hr)	5	3	1
Ventilation system and design	AHU	AHU	AHU
AHU heat recovery efficiency	75%	80%	80%
AHU specific fan power	1.6 W/l/s	1.4 W/l/s	1.2 W/l/s
Demand Control Ventilation NEW	No	No	Yes - CO_2 sensors with speed control
Internal Lighting (lm/W) NEW	95	105	115
Lighting Control	Manual on/off and daylight controls are assumed for all bedrooms. PIR presence detection + daylight dimming in restaurant and reception, PIR to circulation and all back of house spaces	Manual on/off and daylight controls are assumed for all bedrooms. PIR presence detection + daylight dimming in restaurant and reception, PIR to circulation and all back of house spaces	Manual on/off and daylight controls are assumed for all bedrooms. PIR presence detection + daylight dimming in restaurant and reception, PIR to circulation and all back of house spaces

The term 'Business as Usual' Business as usual' scenarios is meant to represent the type of fabric and ventilation specifications that most applicants in London would consider 'standard' for a hotel.
For consistency it has not been changed compared with the initial 2019 study. We think that this approach is acceptable as 'Business as usual' has not changed significantly in terms of fabric and ventilation specifications
**Variations in thermal bridging have not been modelled as the software doesn't support modelling psi values so adds a default 25% uplift to all U-values in actual building in accordance with NCM.*



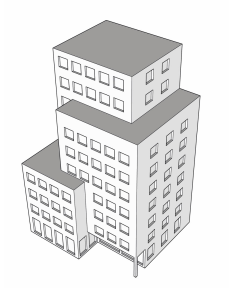
Hotel building | Building services



This table summarises the different heating system assumptions modelled based on the four different scenarios.

	A Gas boiler	B Less efficient Heat Pump System *Central heat pump*	B VRF	D More Efficient Heat Pump System *Central heat pump*
Description	Gas boiler serving a heating system with flow and return temperature 70°C/50°C	Heat pumps serving a heating system with flow temperature 65°C	VRF units	Heat pumps serving a heating system with low flow temperatures 45°C fed from ground source array
Heating emitters	LTHW Fan Coil Unit fed by gas boiler	LTHW Fan Coil Unit fed by reversible chiller/heat pump	LTHW Fan Coil Unit fed by VRF	LTHW Fan Coil Unit fed by heat pump
Hot water system	A 3500L hot water store	A 3500L hot water store	A 3500L hot water store	A 3500L hot water store
Heating and hot water seasonal efficiency	95% for heating and hot water	220% for heating and hot water*	400% for heating 300% for hot water	450% for heating 300% for hot water
Waste Water Heat Recovery (WWHR)	No WWHR assumed	No WWHR assumed	No WWHR assumed	No WWHR assumed
Cooling seasonal efficiency	5.0	5.0	5.0	5.0
Distribution efficiency (heating, cooling and DHW)	95%	95%	95%	95%

**The system C heat pump efficiency of 220% was used to be consistent with the CoC1 study. The minimum efficiency allowed under Part L is 250%.*



Hotel building | Photovoltaics (PVs)

This table summarises the different sizes of PV system assumed.

New input for Part L 2021

	No PV	PV
Description	This assumed no PVs at all on the roof or any of the elevation	This assumes a standard practice for PVs. No particular effort has been made to design the roof in order to accommodate PVs.
Photovoltaic Panels (kWp)	0	45.02
Module Efficiency (%)	N/A	TBC%
Assumed area (Panel area)	N/A	202m² (50% of footprint)
Tilt	N/A	30° (Horizontal)
Shading	N/A	Average/unknown
Battery capacity (kWh)	N/A	N/A
Predicted Annual Yield	N/A	38,120 kWh

How on-site renewable energy can benefit occupants

A new paradigm, a new opportunity

PV systems on blocks of flats used to be (very) small and and were therefore only able to supply landlord's areas (e.g. lights, lifts) with small amounts of excess energy sold to the grid at a low price (e.g. 5p/kWh).

As maximising renewable energy generation on-site is critical for Net Zero Carbon new housing, PV arrays on blocks of flats will become much more significant. This creates a significant opportunity for the 'free' electricity generated by the PV system to benefit residents. Direct use of solar electricity by residents can avoid the need to import grid electricity at full retail prices (i.e. 15-30p/kWh).

Standard solutions

The two most standard solutions for PV integration are:

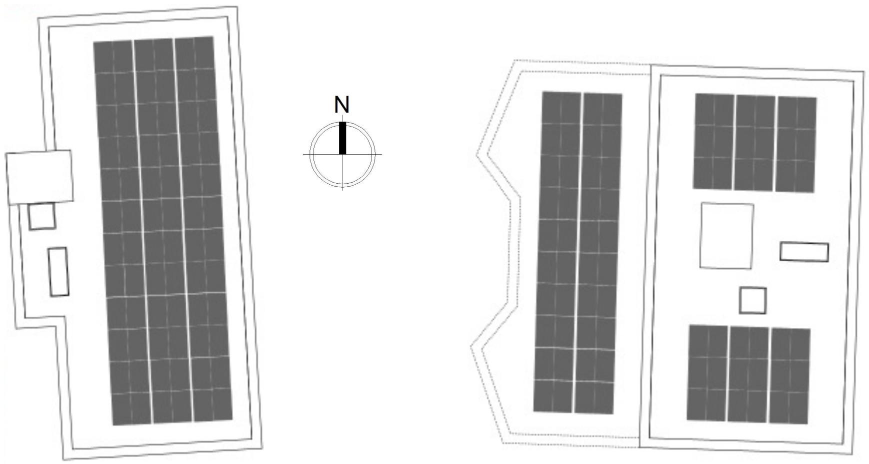
- Connection to the landlords's electricity supply only (i.e. lights, lifts, communal heating if present).
- Separate direct connections between a number of PV panels and each flat (on the 'flat-side' of each individual electricity meter).

New solutions

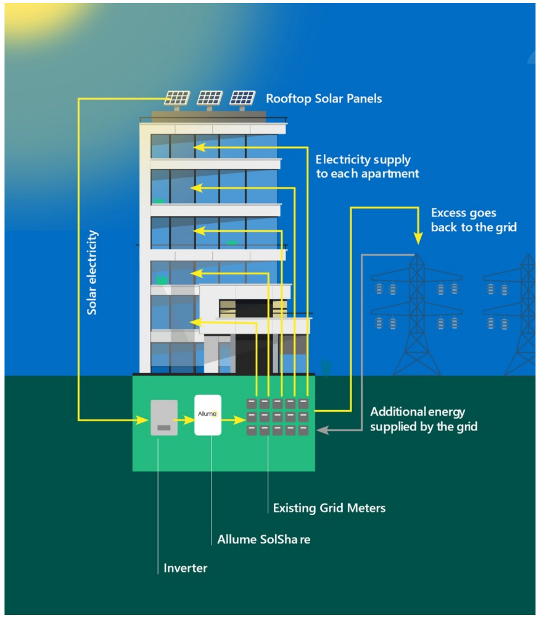
New systems are becoming available which effectively still use the PV array as a single array but distribute its output to each flat. An example of such a system is Allume's Solshare. It is likely that similar solutions will develop further in the future.

Storing solar energy

Energy storage can be most effective when the PV array is feeding individual homes, which typically have a higher total energy demand than communal areas. We currently recommend favouring thermal storage (e.g. hot water cylinder, smart thermostat) over chemical storage (e.g. batteries) for embodied carbon reasons. Solar charging of electric vehicles can also be an effective strategy, where parking is available adjacent to building mounted solar PV.



Net Zero Carbon new housing projects seek to maximise renewable energy generation on-site with large solar PV arrays. This represents an opportunity for residents to benefit from this 'free' electricity



New systems are becoming available which enable the distribution and optimisation of PV electricity generation for use in blocks of flats (e.g. adjacent example with the Solshare system from Allume)