South Warwickshire Local Plan

Net Zero Evidence Base

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

December 2025 | Rev P04

Currie & Brown   Bioregional   EDGARS   Etude

Key findings summary

This analysis used a robust energy-prediction modelling approach to assess the energy performance of a range of potential standards across typical building types expected to come forward in South Warwickshire. The building types modelled included a bungalow, a detached house, a semi-detached house, a terrace house, a pair of one-bed flats, a mid-rise block of flats, a school, and an industrial unit.

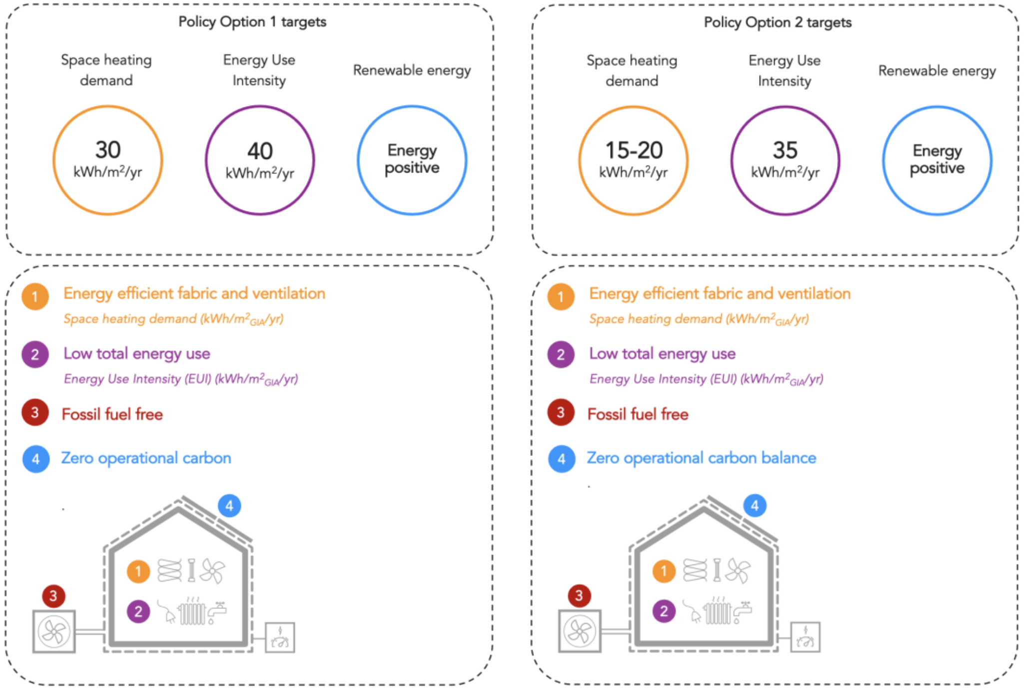
A range of possible performance standards was tested - covering compliance with current and future Building Regulations as well as multiple tiers of improvement beyond these regulations. These standards were designed to reflect different levels of ambition, priorities, and technological pathways. For example, some scenarios rely solely on fabric improvements or renewable energy technologies to exceed incoming regulations, while another incorporates battery storage to achieve a 'zero-bills' outcome. The two highest-ambition scenarios focus on climate outcomes by combining optimal energy-efficiency measures with renewable generation.

Modelling results indicate that both recommended highest-ambition scenarios are technically feasible in the South Warwickshire context. These scenarios significantly outperform the current and future regulatory baselines, as well as all other alternative standards evaluated.

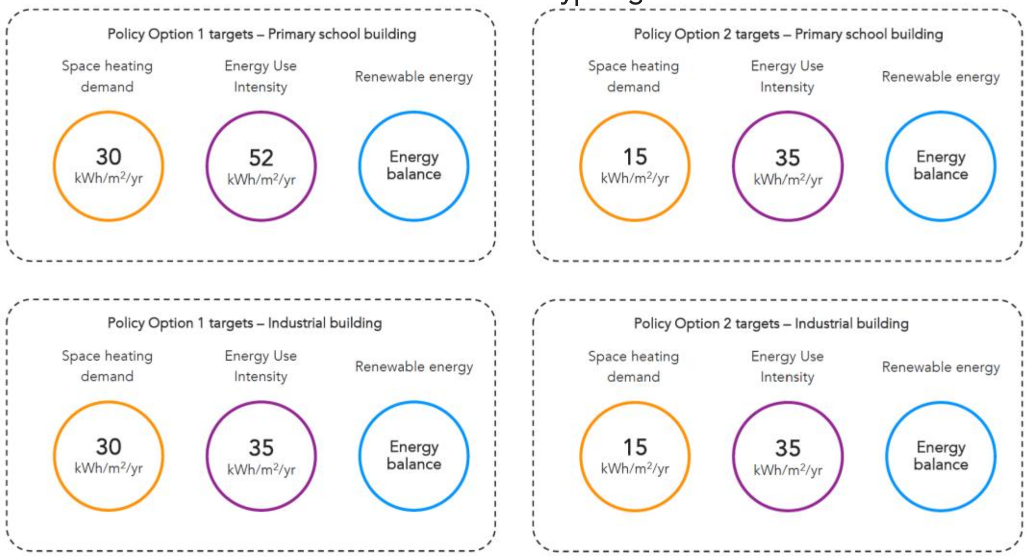
These findings support the development of a policy aligned with the highest-ambition standards (provisionally titled *Net Zero: Low Energy* and *Net Zero: Ultra Low Energy*), as they are feasible within the SWLP area and deliver substantial performance benefits. These benefits would support the local plan's climate-mitigation objectives (refer to the separate Literature Review report) and help safeguard residents against future energy-price volatility.

The estimated additional build costs associated with the recommended standards - reflecting localised cost assumptions - will be incorporated into the SWLP viability study. The modelling results will also inform the separate reports currently in development on local carbon budgets and recommended planning policies.

Residential typologies



Non-Residential typologies



Introduction

The main purpose of this study is to contribute to the development of net zero carbon policies for the South Warwickshire Local Plan (SWLP). In collaboration with Bioregional, Currie & Brown, and Edgars, we have built a robust, locally specific evidence base to underpin ambitious and forward-thinking policies.

Following a review of the local plan area and recent planning applications, eight residential and non-residential archetypes were identified and modeled in agreement with the South Warwickshire Local Plan team.

Two policy options have been proposed for the residential and non-residential typologies, each underpinned by a technical and cost evidence base, illustrating both their deliverability and the costs associated with each approach.

All recommended policy options have been based on the following principles:

- Achieving a positive balance between energy consumption and generation, by producing over 100% of annual energy demand where possible;
- Utilising low carbon heat (i.e. no fossil fuel consumption on-site);
- Addressing carbon emissions from all operational energy uses (both regulated and unregulated energy uses); and
- Reducing energy bills for occupants

In terms of structure, Section 1 of the report provides a contextual overview, including the current definition of net zero buildings and an explanation of relevant energy metrics. Section 2 presents the technical evidence base for residential typologies, while Section 3 addresses the technical evidence base for non-residential typologies. Section 4 details the cost evidence base, and Section 5 provides a glossary of key terms. The appendices contain information on the assumptions applied in the technical and cost modelling for all typologies, as well as details of the cost methodology used.

Residential typologies

Recommended Policy Options		Other Policy Option tested
Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Potential policy option 1 – Spec to meet space heating demand less than 30 kWh/m²/yr, EUI of 40kWh/m²/year and energy positive based on 60% GFA / 4.5 kW renewable generation.	Potential policy option 2 – Spec to meet space heating demand less than 15-20 kWh/m²/yr, EUI of 35kWh/m²/year and energy positive based on 60% GFA / 4.5 kW renewable generation.	Other policy option tested – More PVs and battery leading to zero running costs for the occupants.

** Anticipated Future Homes Standard refers to the Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar*

Non-Residential typologies

Recommended Policy Options	
Net Zero (Low energy)	Net Zero (Ultra Low energy)
Potential policy option 1 – Spec to meet space heating demand less than 30kWh/m²/year, EUI of 52kWh/m²/year (primary school) / 35kWh/m²/year (industrial building) and energy balance.	Potential policy option 2 – Spec to meet space heating demand less than 15kWh/m²/year, EUI of 52kWh/m²/year (primary school) / 35kWh/m²/year (industrial building) and energy balance.

Residential typologies: Policy option 1 I Summary

Net Zero (Low Energy)

This option targets net zero in operation by significantly improving building fabric efficiency and producing more on-site renewable generation than the annual energy use. The specification targets a Space Heating Demand below 30 kWh/m²/yr and an Energy Use Intensity (EUI) of less than 40 kWh/m²/yr.

Technical Feasibility

Using PHPP modelling, all archetypes achieved the net zero energy balance within site boundaries. All house archetypes have sufficient roof area to accommodate the PV required to generate more than 100% of their annual energy demand, except for mid-rise flats with limited roof space. The PV shortfall has been calculated in this case.

Construction Cost Impact

Achieving this specification introduces a cost uplift of 3–8% per dwelling relative to a Part L 2021 compliant baseline. This is driven by improved fabric performance, MVHR installation and the inclusion of ASHPs. While initial costs are higher than baseline, they remain within the viability range for high-quality new build. For developers already working towards Passivhaus or LETI performance levels, the cost difference is negligible. The difference against the anticipated Future Building Standard will also be much less.

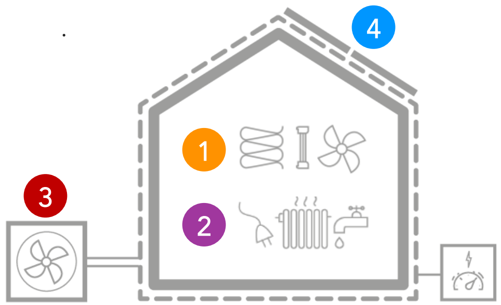
Energy Cost Impact

Homes built to this specification except for the mid-rise block of flats show significantly lower operational energy costs compared with Part L 2021 dwellings, mainly due to the combination of low heating demand and self-generated renewable electricity. In practice, occupants experience close to zero or net negative running costs for most of the year. This approach also offers greater resilience against energy price fluctuations, aligning strongly with South Warwickshire's ambition to reduce fuel poverty and future-proof homes.

Policy Option 1 targets

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

1. **Energy efficient fabric and ventilation**
   Space heating demand (kWh/m^2_{GIA}/yr)
2. **Low total energy use**
   Energy Use Intensity (EUI) (kWh/m^2_{GIA}/yr)
3. **Fossil fuel free**
4. **Zero operational carbon**



Residential typologies: Policy option 2 I Summary

Net Zero (Ultra-Low Energy)

This option models the highest level of performance, targeting ultra-low energy use. It represents a Passivhaus-equivalent specification, designed to minimise space heating demand and maximise on-site renewable generation to achieve or exceed a net zero annual balance. This scenario targets a Space Heating Demand of 15–20 kWh/m²/yr and an Energy Use Intensity (EUI) of less than 35 kWh/m²/yr.

Technical Feasibility

Modelling using PHPP shows that all house typologies can exceed net zero annual energy use. However, feasibility for mid-rise block of flats is limited by available roof area for PV. The PV shortfall has been calculated in this case. Achieving this performance requires specialist detailing and rigorous construction quality control, but has been proven achievable in numerous cases.

Construction Cost Impact

Capital cost uplift is estimated at 4-10% per dwelling relative to Part L 2021, depending on dwelling size and form. Additional costs are triple glazing, deep insulation and airtightness. Costs may reduce over time as ultra-low energy construction scales. For developers already working towards Passivhaus or LETI performance levels, the cost difference is negligible. The difference against the anticipated Future Building Standard will also be much less.

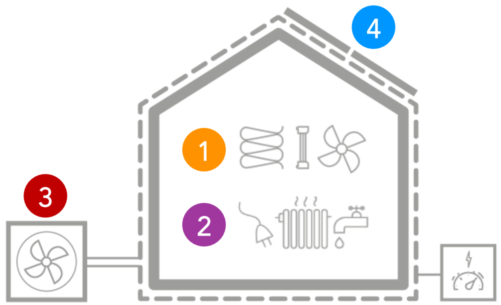
Energy Cost Impact

Operational energy bills under this scenario, except for the mid-rise block of flats are close to zero or net negative, with most homes generating as much or more electricity than they consume annually. The combination of high-efficiency fabric and renewable generation delivers exceptional occupant comfort, air quality, and resilience to future energy price volatility.

Policy Option 2 targets

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

1. **Energy efficient fabric and ventilation**
   Space heating demand (kWh/m²$_{GIA}$/yr)
2. **Low total energy use**
   Energy Use Intensity (EUI) (kWh/m²$_{GIA}$/yr)
3. **Fossil fuel free**
4. **Zero operational carbon**



Residential typologies: Other policy option tested I Summary

Anticipated Future Homes Standard* with Additional PV and Battery

This option represents a near-term, technically ready approach aligned with the upcoming Future Homes Standard (FHS). It retains FHS Option 2 notional fabric standards and introduces solar PVs and battery storage to achieve zero running costs for occupants, guaranteed for 5-10 years. It does not achieve fabric comfort standards.

Technical Feasibility

Modelling using SAP 10.2 and PHPP found that all archetypes meet compliance with the anticipated FHS standard, with additional PV and batteries further reducing energy demand and bills. All archetypes have sufficient roof area to host the required PV arrays; mid-rise flats though have limited space, reducing generation potential but not preventing compliance.

Construction Cost Impact

Compared with a Part L 2021 compliant dwelling, this scenario introduces a moderate capital cost uplift in the range of 7–12% per dwelling, depending on building type. Most of this increase arises from the inclusion of ASHPs, PV and a battery system. Costs are expected to continue falling as heat pump and PV deployment accelerates, suggesting a limited impact on overall scheme viability. This level of intervention is therefore economically practical and can be readily adopted by local developers without requiring major changes to building methodology.

Energy Cost Impact

Energy modelling indicates that dwellings built to this standard could achieve zero annual energy costs guaranteed by the provider. The improved building envelope reduces heating energy, while PV generation and battery storage further cut grid imports. This approach improves energy affordability.

Why is it not currently recommended as a policy option?

The technical feasibility study has shown that the anticipated Future Homes Standard specification is insufficient to reduce space heating demand and energy use intensity to the target levels set for the other two policy options. Additionally, the fact that the methodology and calculations for maximising PV generation is currently operated by only one provider in the UK presents a limitation for the study.

Other policy option - Advantages

- Flexibility to accommodate residents with higher energy use
- If not signed up with the current provider, net bills can be strongly negative at current import/export tariffs

Other policy option - Disadvantages

- Only one provider currently guarantees zero bills for the next 5–10 years in the UK
- An additional allowance for EV charging is needed
- A battery is also required
- Reduced thermal comfort due to relaxed fabric specifications
- Fabric measures are expensive to retrofit, so leaving them until after construction makes them highly unlikely to happen (excluding windows and doors, which can be done more easily)

** Anticipated Future Homes Standard refers to the Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar*

Non-Residential typologies: Policy option 1 I Summary

Zero (Low Energy)

This option targets Net Zero in operation by significantly improving building fabric efficiency and balancing annual energy use with on-site renewable generation. The specification targets a Space Heating Demand of less than 30 kWh/m^2/yr and an Energy Use Intensity (EUI) below 52 kWh/m^2/yr for the primary school and 35 kWh/m^2/yr for the industrial building, respectively.

Technical Feasibility

Using PHPP modelling for the school building and the main energy uses of the industrial building, both archetypes achieved the net zero energy balance within site boundaries. For other industrial building uses, assumptions have been based on data from comparable projects. Both buildings have sufficient roof area to host the PV required for a full energy balance.

Construction Cost Impact

Achieving this specification introduces a cost uplift of approximately 2–4% for the school, relative to an anticipated Future Building Standard–compliant baseline. For the industrial building, the range is –0.1% to 3%. The additional cost is driven by improved fabric performance, MVHR installation, and more efficient heating systems. The negative value is due to the introduction of a VRF system, which replaces a less efficient heat pump assumed for the anticipated Future Building Standard notional building.

Policy Option 1 targets – Primary school building

Space heating demand	Energy Use Intensity	Renewable energy
30 kWh/m^2/yr	52 kWh/m^2/yr	Energy balance

Policy Option 1 targets – Industrial building

Space heating demand	Energy Use Intensity	Renewable energy
30 kWh/m^2/yr	35 kWh/m^2/yr	Energy balance

Non-Residential typologies: Policy option 2 I Summary

Net Zero (Ultra Low Energy)

This option models the highest level of performance, targeting ultra-low energy use. It represents a Passivhaus-equivalent specification, designed to minimise space heating demand and maximise on-site renewable generation to achieve or exceed a net zero annual balance. This scenario targets a Space Heating Demand of 15 kWh/m^2/yr and an Energy Use Intensity (EUI) below 52 kWh/m^2/yr for the primary school and 35 kWh/m^2/yr for the industrial building, respectively.

Technical Feasibility

Modelling using PHPP shows that both non-residential typologies can reach or exceed net zero annual energy use. Reaching this performance standard requires meticulous detailing, thermal bridge avoidance, and high-quality construction management, but is readily achievable.

Construction Cost Impact

Capital cost uplift is estimated at 4-6% and 2-6% for the school and industrial buildings respectively relative to a Future Building Standard–compliant baseline. The main contributors are the improved fabric: triple glazing, deep insulation and airtightness as well as the higher performing heating systems.

Policy Option 2 targets – Primary school building

Space heating demand	Energy Use Intensity	Renewable energy
15 kWh/m^2/yr	52 kWh/m^2/yr	Energy balance

Policy Option 2 targets – Industrial building

Space heating demand	Energy Use Intensity	Renewable energy
15 kWh/m^2/yr	35 kWh/m^2/yr	Energy balance

Contents

1.0

The context and net zero

1.1 The purpose of South Warwickshire's Net Zero Carbon Policy

Developing policies that meaningfully address climate change

UK Building Regulations currently assess energy efficiency using three metrics :

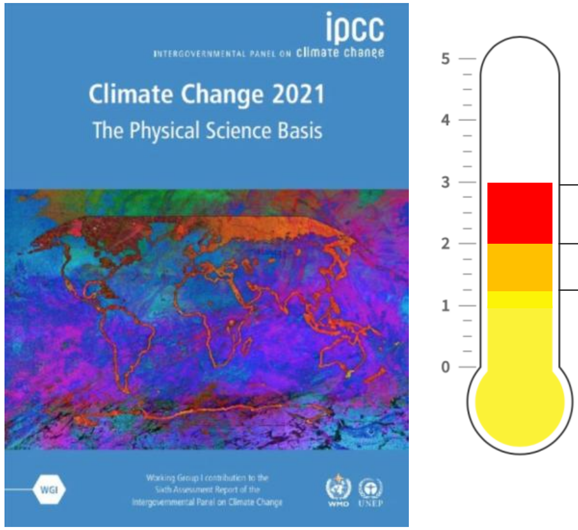
- Fabric Energy Efficiency
- Carbon Emission Rate
- Primary Energy Rate

While new buildings must meet baseline standards, there is no requirement to exceed them in many Local Authorities.

To tackle climate change effectively, policies must push for greater reductions in overall energy demand across the building stock. Complementary policies and alternative metrics could help create a more consistent and impactful approach to energy efficiency across different building typologies.

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

This evidence base provides South Warwickshire with the relevant information to develop new policies to address climate change and improve the energy efficiency of new buildings. Using three new metrics (space heating demand, energy use intensity, and renewable generation), policies can drive new buildings to achieve or even exceed, balance between energy use and renewable energy generation. Although current metrics and those that will be used in the Future Homes Standard can be helpful indicators of building performance, they do not themselves drive better building design.

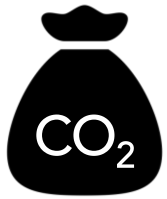


3°C the temperature rise we are likely to see with currently agreed policies and actions

Well below 2°C (and aim for 1.5 °C) - the global warming limits agreed through the Paris Agreement.

1.2°C The temperature rise already created

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.

1.2 Current industry definition of Net Zero buildings

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 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

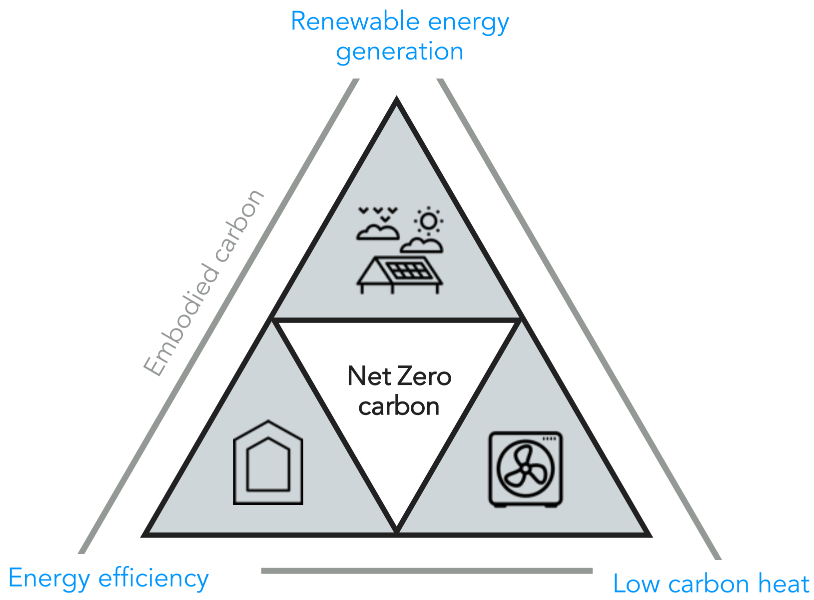
Low carbon heat is an essential feature of Net Zero Carbon buildings. All new buildings should be built with a low carbon heating system and must not connect to the gas network or, more generally, use fossil fuels on-site.

3 - Renewable energy generation

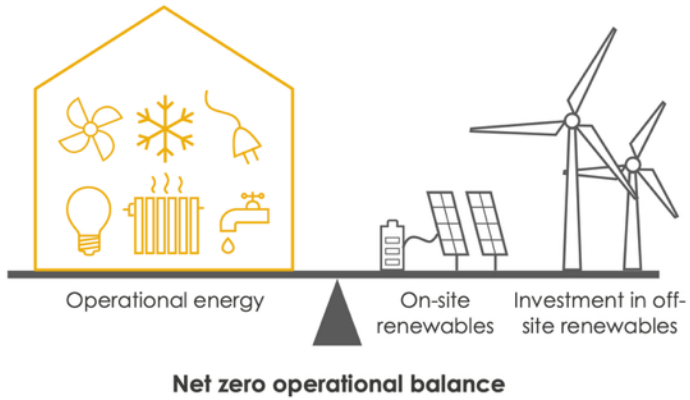
New buildings should seek to add at least as much renewable energy generation to the energy system as the energy they will use on an annual basis. In South Warwickshire, solar photovoltaic (PV) panels will be the renewable energy system to deliver this objective.

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



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

1.3 The metrics explained | Space heating demand and energy use intensity

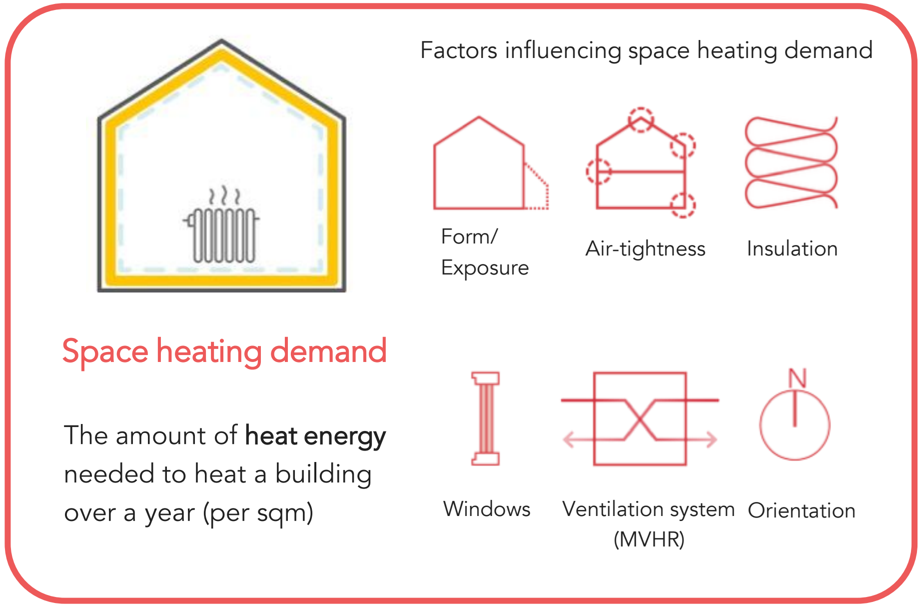
Space heating demand

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 (CCC) recommends a space heating demand of less than 15-20 kWh/m²/yr for new homes.

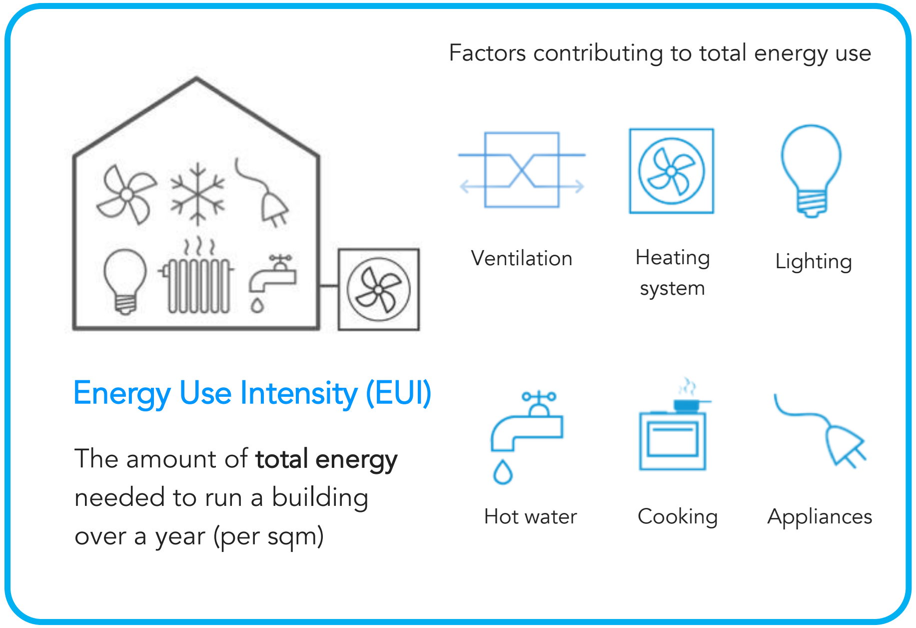
Energy Use Intensity (EUI)

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/m²/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, the building's heat 'at the meter' will need to be converted to heat energy (further information on this is provided later in the report).



The space heating demand metric



The Energy Use Intensity (EUI) metric

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 $kWh/m^2_{GIA}/yr$. 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 be 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.

Buildings can generate renewable electricity through rooftop solar photovoltaic (PV) systems, which can be used to power space heating, hot water, and appliances. This provides three key benefits:

1. **Lower energy bills.** On-site electricity generation reduces the need to purchase energy from the grid. Over time, this can save a lot of money. The electricity generated on-site is free to use.
2. **Protection from rising energy prices.** By relying less on grid energy, households are partially shielded from fluctuations in energy prices.
3. **Potential financial return.** Surplus electricity can, in most cases, be exported back to the grid or credited, lowering the overall running costs.

Although PV systems require upfront investment, the long-term financial benefits for residents can be substantial. More importantly, these benefits have direct implications for fuel poverty. Lower and more predictable bills reduce the risk of households being unable to afford adequate energy, improving affordability, health outcomes, and quality of life.

1.4 Octopus Zero Bills Energy Standard | Background

Octopus Zero Bills Energy Standard

The Octopus Zero Bills Energy Standard* is a housing approach that links energy-efficient design with a specific tariff model designed to deliver no household energy costs for an initial contractual period (commonly 5 or 10 years), subject to eligibility and provider terms and conditions.

Required specifications

For a home to meet the Zero Bills Energy Standard, it must satisfy certain technical requirements, including:

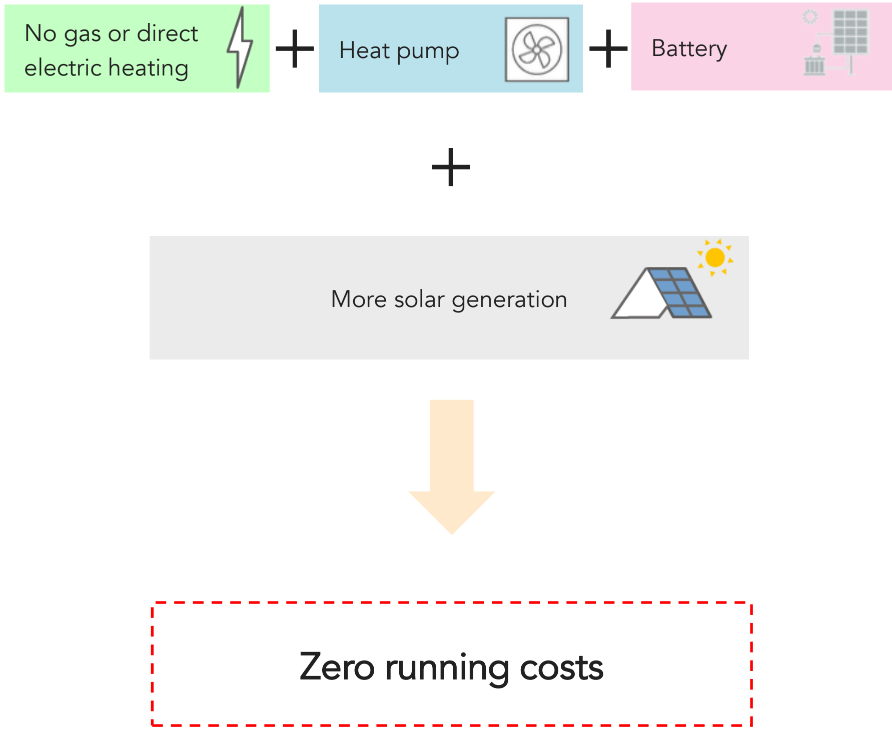
- Heat pump: typically, from approved manufacturers such as Vaillant, Daikin or Cosy (other brands may be eligible if signed off by the provider).
- Battery and inverters: generally, from specified manufacturers such as GivEnergy, Solaredge, Enphase, Tesla PowerWall, Huawei, AlphaESS.
- No gas, solar diversion, or direct electric heating.
- Broadband/fibre connection.

How has the standard been applied to the study?

The Zero Bills Energy Standard has been modelled and is referred to as the 'other policy option' within the technical evidence base. The solar generation needed in order to achieve zero running costs for each house typology has been calculated separately.

Is the standard applicable to blocks of flats?

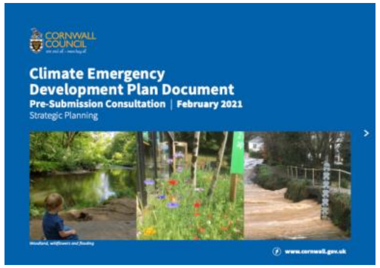
The standard is not easily applicable to blocks of flats taller than three storeys as the available roof space becomes insufficient. Providers are currently exploring solutions, such as installing additional PVs on adjacent land. For the purposes of this study, this scenario has been excluded for the mid-rise blocks of flats.



*Currently provided only by Octopus, the same technology could, however, be used with other energy suppliers and may result in greater energy savings (see the running costs section), though these savings are not currently guaranteed.

1.5 Policy Precedents | Cornwall Council

Two examples of other councils that have adopted similar policies are provided on this and the next page.



Net Zero policy adopted by Cornwall Council based on energy metrics

Policy SEC1 – Sustainable Energy and Construction

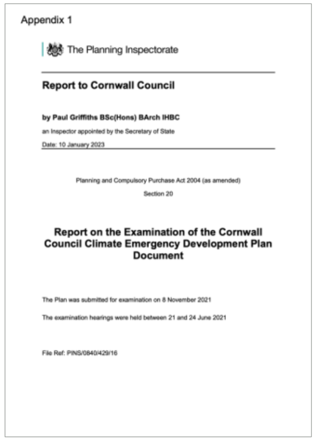
Development proposals will be required to demonstrate how they have implemented the principles and requirements set out in the policy below.

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 is a Net Zero policy which uses energy-based metrics. It has successfully completed the examination process in January 2023.

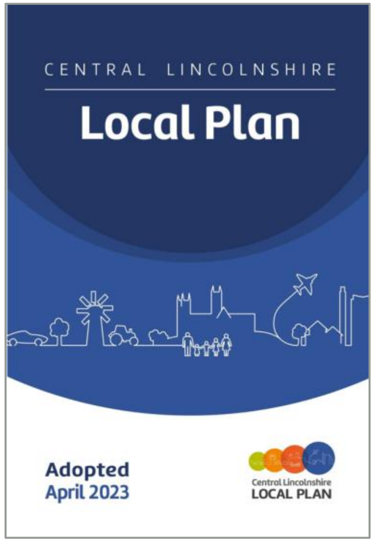
Relevant extracts of the Planning Inspector's report include the following:

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**.*



Central Lincolnshire Local Plan adopted in April 2023

The Council have also prepared an Energy Efficiency Design guide to accompany the policy

Central Lincolnshire have adopted a Net Zero policy using energy-based metrics for both domestic and non-domestic applications.

The Local Plan includes 3 key policies:

Policy S6: Design Principles for Efficient Buildings,

Policy S7: Reducing Energy Consumption - Residential Development

Policy S8: Reducing Energy Consumption - Non-residential Buildings

They have also developed an Energy Efficiency Design Guide to help applicants understand and apply the new requirements. This includes *decision trees are provided illustrating routes to compliance for domestic and non-domestic building types utilising either PHPP or other modelling approach.*

Policy S7: Reducing Energy Consumption – Residential Development

Unless covered by an exceptional basis clause below, all new residential development proposals must include an Energy Statement which confirms in addition to the requirements of Policy S6 that all such residential development proposals:

1. Can generate at least the same amount of renewable electricity on-site (and preferably on-plot) as the electricity they demand over the course of a year, such demand including all energy use (regulated and unregulated), calculated using a methodology proven to accurately predict a building's actual energy performance; and
2. To help achieve point 1 above, target achieving a site average space heating demand of around 15-20kWh/m2/yr and a site average total energy demand of 35 kWh/m2/yr, achieved through a 'fabric first' approach to construction. No single dwelling unit to have a total energy demand in excess of 60 kWh/m2/yr, irrespective of amount of on-site renewable energy production. (For the avoidance of doubt, 'total energy demand' means the amount of energy used as measured by the metering of that home, with no deduction for renewable energy generated on site).

The Energy Statement must include details of assured performance arrangements. As a minimum, this will require:

a) The submission of 'pre-built' estimates of energy performance; and
b) Prior to each dwelling being occupied, the submission of updated, accurate and verified 'as built' calculations of energy performance. Such a submission should also be provided to the first occupier (including a Non-Technical Summary of such estimates).

Weight will be given to proposals which demonstrate a deliverable commitment to on-going monitoring of energy consumption, post-occupation, which has the effect, when applicable, of notifying the occupier that their energy use appears to significantly exceed the expected performance of the building, and explaining to the occupier steps they could take to identify the potential causes of such high energy use.

Policy S6: Design Principles for Efficient Buildings

When formulating development proposals, the following design expectations should be considered and in the following order:

1. Orientation of buildings – such as positioning buildings to maximise opportunities for solar gain, and minimise winter cold wind heat loss;
2. Form of buildings – creating buildings that are more efficient to heat and stay warm in colder conditions and stay cool in warmer conditions because of their shape and design;
3. Fabric of buildings – using materials and building techniques that reduce heat and energy needs. Ideally, this could also consider using materials with a lower embodied carbon content and/or high practical recyclable content;
4. Heat supply – net zero carbon content of heat supply (for example, this means no connection to the gas network or use of oil or bottled gas);
5. Renewable energy generated – generating enough energy from renewable sources on-site (and preferably on plot) to meet reasonable estimates of all regulated and unregulated total annual energy demand across the year.

Energy statements, as required by Policies S7 and S8, must set out the approach to meeting each of the above principles.

2.0

Residential energy modelling

2.1

Residential energy modelling:

Methodology, typologies and specifications

2.1 **Residential energy modelling:** Methodology, typologies and specifications

2.1

Contents

2.1.1 Energy and cost modelling analysis | Our approach

Purpose of energy and cost modelling

The purpose of this evidence base is to assess whether an exceedance of renewable energy generation over energy consumption for buildings in South Warwickshire is both:

a) Feasible from a technical perspective

b) Feasible from a viability perspective

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

1) Low energy specification + net zero carbon operational energy balance
2) Ultra-low energy specification + net zero carbon operational energy balance

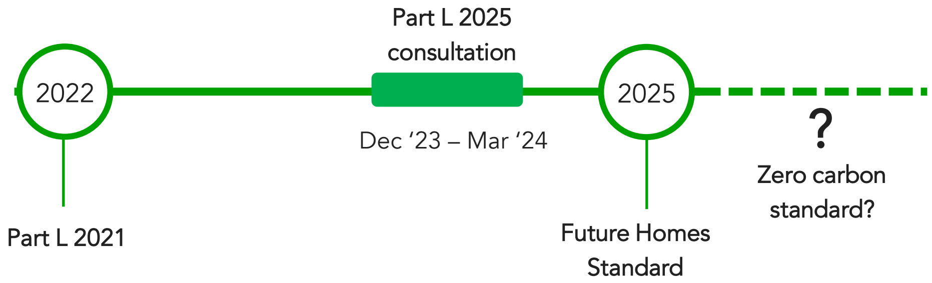
A third policy option has also been tested: the anticipated Future Homes Standard* specification combined with additional PV and battery capacity, which is not among the recommended options at this stage.

Energy and cost modelling forms the core of this technical evidence base. Its role is to assess how different building archetypes perform against the metrics in Part L 2021, the anticipated Future Homes Standard, and the three additional policy options (two recommended and one other) using different specification combinations.

The modelling results will inform target setting by officers and provide evidence that the proposed policies are technically achievable. In addition, the cost modelling will highlight the extra costs associated with these policies compared with minimum compliance under Part L 2021.

Cost baseline

The baseline for cost modeling is a Part L 2021-compliant building – just meeting current energy and carbon regulations. This reflects typical current practice and provides a robust starting point. The Anticipated Future Homes Standard* is also used as a secondary baseline for comparison.



Policy changes are moving towards zero carbon, however there is much uncertainty surrounding the details. At the time of producing this evidence base for South Warwickshire (Sep-Oct 2025) 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 as 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.

** Notional building specification Option 2 from Future Homes Standard consultation document, with the addition of solar PV from Option 1*

2.1.2 Energy and cost modelling analysis | Archetype selection

Archetype selection

To undertake the energy and cost modelling for this technical evidence base, a number of residential archetypes were identified and assessed.

In discussions with the South Warwickshire Local Plan team, we have identified 6 residential building archetypes: bungalow, detached house, semi-detached house, terrace house, pair of 1-bed flats and medium-rise apartment buildings. These have been modelled and costed specifically for South Warwickshire.

For each archetype, we have identified one representative building (see adjacent images). Each is a typical developer-built example of its type. In reality, building design, specification, and site conditions vary considerably, and these factors affect energy, carbon, and cost. However, it is standard practice in technical evidence bases to use representative examples of different building types, as we have done here. The analysis can always be expanded to include additional buildings or building types if required.

Five different combinations of specifications

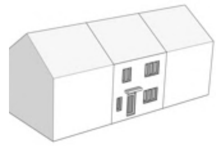
Five different combinations of specifications have been modelled, incorporating variations in fabric and ventilation, heating systems, and solar PVs. Each is explained in detail on the next page.

Residential archetypes selected

Bungalow

109 sqm (GIA)

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



Terrace house

93 sqm (GIA)

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

Detached house

142 sqm (GIA)

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

Two 1-bed flats

112 sqm (GIA - both flats)

This building represents the generic **pair of two 1-bed flats** new build typology

Semi-detached house

93 sqm (GIA)

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

Mid-rise

5 storeys

2,600 sqm (GIA)

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

Graphical representation of the 6 residential buildings chosen as archetypes

2.1.3 Energy and cost modelling analysis | Scenarios modelled

Five scenarios modelled

We have chosen five different scenarios to model for each of the six residential archetypes. Of these, two scenarios form the baseline, and three scenarios represent the policy options tested.

Benchmark / context scenarios

- *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).
- *Anticipated Future Homes Standard*: We modelled the Future Homes Standard Notional Building specification option 2 with the addition of solar panels. This might* represent an alternative future cost baseline.

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

Policy Scenarios

Recommended Policy Options

- *Net Zero Carbon (low energy)* – A fabric specification that achieves a Space Heating Demand of 30 kWh/m^2/yr and an EUI of 40 kWh/m^2/yr. Energy positive using PV.
- *Net Zero Carbon (ultra-low energy)* - A fabric specification that achieves a Space Heating Demand of 15-20 kWh/m^2/yr and an EUI of 35 kWh/m^2/yr. Energy positive using PV.

Other Policy Option

- *Anticipated Future Homes Standard* with additional PV and battery** – Zero running costs for the occupants.

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

	Benchmarks / Context		Recommended Policy Options		Other Policy Option tested
	Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Purpose	Energy, carbon, cost baseline – Notional building spec, tweaked to pass Part L 2021**	Possible future energy, carbon, cost baseline – Anticipated FHS notional building spec*	Potential policy option 1 – Spec to meet space heating demand less than 30 kWh/m^2/yr, EUI of 40kWh/m^2/year and energy positive ***	Potential policy option 2 – Spec to meet space heating demand less than 15-20 kWh/m^2/yr, EUI of 35kWh/m^2/year and energy positive **	Other policy option tested – More PVs and battery leading to zero running costs for the occupants****
SAP 10	Yes	Yes	No	No	Yes
PHPP	Yes	Yes	Yes	Yes	Yes
Cost analysis	Yes	Yes	Yes	Yes	Yes

(See next page for expanded version of modelling scenarios tabulated, with explanation for each scenario of its purpose, how the building specification 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 predictive operational energy modelling tool PHPP (10.6) 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 both the benchmark and the other policy options. This enabled us to establish the cost baseline specification, ensure compliance with the minimum fabric targets set in SAP, and define the additional PV required for the latter

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 <u>not</u> used as part of this policy project.

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

	Benchmarks / Context		Recommended Policy Options		Other Policy Option tested
	Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Purpose	Energy, carbon, cost baseline – Notional building spec, tweaked to pass Part L 2021**	Possible future energy, carbon, cost baseline – Anticipated FHS notional building spec*	Potential policy option 1 – Spec to meet space heating demand less than 30 kWh/m²/yr, EUI of 40kWh/m²/year and energy positive ***	Potential policy option 2 – Spec to meet space heating demand less than 15-20 kWh/m²/yr, EUI of 35kWh/m²/year and energy positive **	Other policy option tested – More PVs and battery leading to zero running costs for the occupants****
SAP 10	Yes	Yes	No	No	Yes
PHPP	Yes	Yes	Yes	Yes	Yes
Cost analysis	Yes	Yes	Yes	Yes	Yes

** Notional building specification Option 2 from Future Homes Standard consultation document, with the addition of solar PV from Option 1*

*** Fabric specifications tweaked slightly where needed so that the Actual Building spec just meets the Notional Building target under Part L 2021*

**** There is a shortfall for the mid-rise block of flats only*

***** Based on calculations provided by the current energy provider, Octopus*

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 (Part L, anticipated Future Homes Standard* options) and more ambitious ones aiming to achieve and exceed energy balance (low-energy and ultra-low energy options). 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 were tested in each option 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 the first 3 scenarios represent the type of specifications expected on developments with no particular focus on energy efficiency, whereas the last 2 scenarios are meant to represent two grades of very energy efficient specifications.

Airtightness

A high level of airtightness (i.e., a low airtightness test result) is crucial for achieving reduced space heating demand. Minimum requirements as per Building Regulations Part L 2021 and anticipated Future Homes Standards*, were chosen in the first 3 scenarios. Values in the low and ultra-low scenarios align with more stringent industry targets, such as Passivhaus performance requirements.

Windows

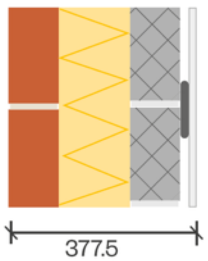
All scenarios were tested using high quality double glazing, except the ultra-low energy one, which considers triple glazed windows. This specification meets existing and proposed Building Regulations.

Specifications | Bungalow

This table summarises the different energy efficiency assumptions modelled based on five different scenarios.

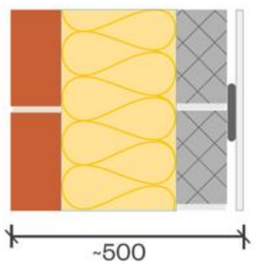
		Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Building fabric and ventilation strategy	Floor (W/m²K, SAP adjusted)	0.12	0.12	0.11	0.10	0.12
	Walls (W/m²K)	0.18	0.18	0.13	0.10	0.18
	Roof (W/m²K)	0.10	0.10	0.10	0.09	0.10
	Windows (W/m²K)	1.2 (double-glazed) g value: 0.63	1.2 (double-glazed) g value: 0.63	1.2 (double-glazed) g value: 0.63	0.8 (triple-glazed) g value: 0.50	1.2 (double-glazed) g value: 0.63
	Doors (W/m²K)	1.0	1.0	1.0	1.0	1.0
	Thermal bridging (W/K)	6.4 (PHPP)	6.4 (PHPP)	8.4(PHPP)	3.6 (PHPP)	6.4 (PHPP)
	Air Permeability (m³/m²/hr)	5	5	1	0.45 (0.6ach)	5
	Ventilation	0% heat recovery Intermittent extract (0.08 Wh/m³)	0% heat recovery Intermittent extract (0.08 Wh/m³)	88% HR. 2m duct 25mm insulation 0.24 Wh/m³	88% HR. 2m duct 25mm insulation 0.24 Wh/m³	0% heat recovery Intermittent extract (0.08 Wh/m3)
Heating, hot water	Space Heating	Gas combi boiler (55°C) 89%	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <35˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp
	Domestic Hot Water	No cylinder WWHR system A 36% efficiency	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss
Renewables	Solar PV	5.85kWp S (module power:450W)	(40% GFA / 4.5 kW) 9.90kWp** S (module power:450W)	(40% GFA / 4.5 kW) 14.52kWp*** S (module power:605W)	(40% GFA / 4.5 kW) 14.52kWp** S (module power:605W)	Octopus Tool 9.68kWp S (module power:605W)
	Battery Storage	-	-	-	-	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

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 in the Appendix.



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.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Option 1*

2.1.6 Thermal bridging

Causes of thermal bridging

Thermal bridging can be a significant source of heat loss from buildings. It often occurs at junctions in the building envelope due to:

1. Structural thermal bridging, which result from additional structural materials required in these locations.
2. Geometrical thermal bridging, which results from the under or over counting of heat loss areas. In SAP, heat loss areas are typically under counted, while in PHPP they are usually over counted.

With careful design, building junctions can be thermally broken, and psi values and heat loss significantly reduced.

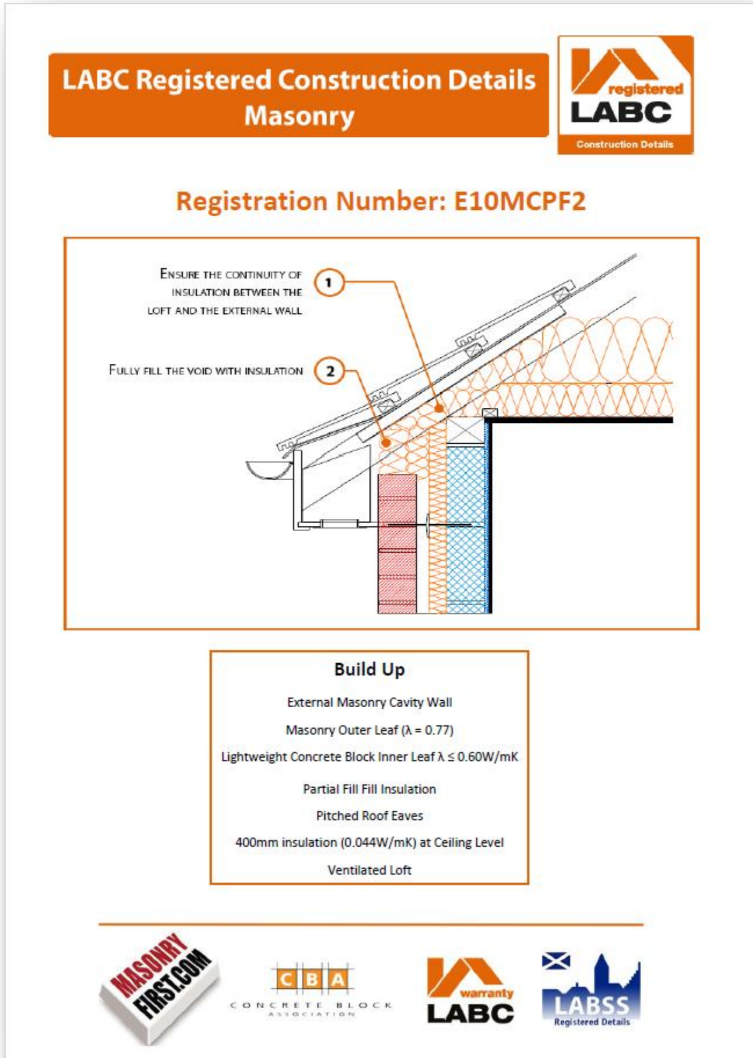
Junction Designs and psi values

Etude have carried out 2D thermal bridge modelling using LABC details to create a full set of psi values that could be used for all the dwellings except the mid-rise block of flats. The details assumed beam and block floors with masonry cavity wall construction and insulation at ceiling level for all scenarios, except the ultra-low energy scenario which assumes the junctions have been broken with foamglas® or an equivalent material.

Since psi values will vary depending on the amount of insulation present in the adjacent building elements, a single set of psi values cannot be applied to the different buildings and scenarios.

Instead, for each junction, two calculations were made using best- and worst-case U-values (Part L 2021 limits). Bespoke psi-values for each scenario were then interpolated between these bounds. Although this assumes a linear relationship that may not hold in practice, it provides sufficient accuracy for this evidence base.

For the mid-rise block of flats, reasonable thermal bridging budgets in kWh/m²/yr heat loss were assumed for each of the scenarios based on previous experience.



Example of an LABC detail that was used for thermal bridge modelling of the eaves junction. Insulation depths were varied according to scenario. © LABC

2.1.7 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 fully 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 achieving an energy balance 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 the Part L scenario which is based in the notional building specification.

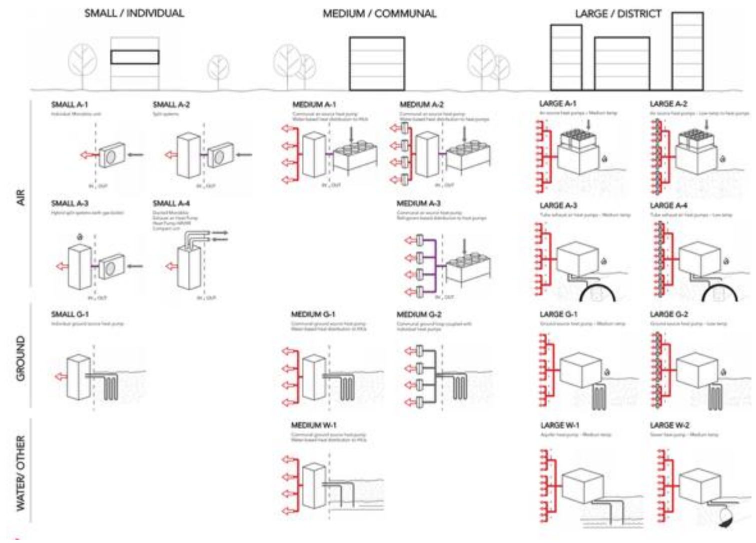
Heating systems modelled

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

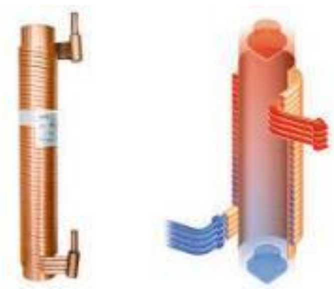
There is however no 'one size fits all' low carbon heating system across all building archetypes. Different types and scales of heating systems were considered and selected as suitable for each archetype:

- Individual air source heat pump: The five house typologies (bungalow, detached, semi-detached, terrace, pair of two 1-bed 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 apartments utilise a communal ambient loop system with ASHP located on the roof to deliver heating and 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 according to the archetype characteristics.

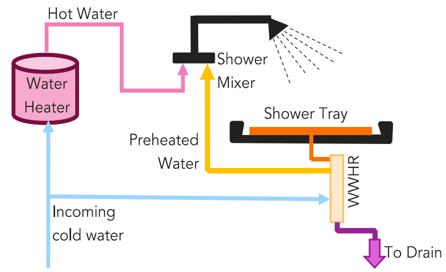
It is recognised that other heating systems not selected in this study may align with the performance metrics or targets suggested as part of the policy recommendations.



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



WWHR vertical pipe installation © Power pipe UK



WWHR example operation schematic

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.

2.1.8 On site renewable energy generation and energy balance

Onsite renewables are a key component of net zero

In order for a building to be net zero, renewable energy must be generated to balance the annual energy use of the building. This balance should ideally happen within the site boundary. This typically means installing solar PVs on the roof of the development.

The amount of energy that can be generated depends on the energy intensity of the building (residential homes use less energy per floor area than offices or hotels), and the number of storeys of the building. For taller buildings there is less roof area available per GIA compared to lower rise buildings.

Installing PVs on the building reduces the energy bill of residents

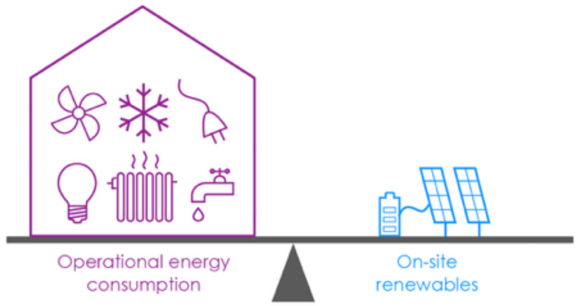
Although the carbon reductions remain the same if the solar PV is installed on the building or on the plot, the cost benefits to the residents only apply to the solar PV that is installed on the building.

The benefits of self consumption

The cost effectiveness of solar PV changes depending on how much of the energy that is being generated is being used by the building at the time that it is generated, and how much is sold back to the grid.

It is much more cost effective to use the electricity than to sell it to the grid, as the price that householders can sell the electricity for is less than the price that they purchase electricity.

Solar PV systems installed on single family homes are a very effective way of reducing energy bill of the residents. On blocks of flats the electricity is often only used for landlord energy consumption due to technical challenges (e.g. wiring, metering). There are however technologies available, such as SolShare, which takes the electricity generated by a single PV array on a block of flats and distributes it equally between the flats. This enables the occupants to use this free electricity with significant impact on operational savings.



Energy balance

The amount of renewable energy generated in a year should match or exceed the EUI

A key component of a net zero carbon building is achieving an energy balance – the amount of renewable energy generated in a year should match the energy used by the building in a year.

2.2

Residential energy modelling:

Analysis & Results

2.2 Residential energy modelling: Analysis & results

2.2

Contents

2.2.1 Technical feasibility | Summary of findings

Energy modelling using PHPP was undertaken to estimate space heating demand and the total energy use (EUI) for each scenario for the different domestic typologies. Results have been provided only for the low- and ultra-low energy scenarios (recommended policy options) as part of this summary page. In the following pages, there is a detailed analysis of all three policy options (including the other policy option tested).

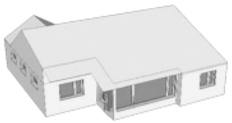
In summary:

- A space heating demand of **30 kWh/m²·yr** can be achieved by all typologies in the low-energy scenario. This performance largely depends on net-zero-level fabric and ventilation specifications.
- Additionally, a space heating demand of **15-20 kWh/m²·yr** can be achieved by all typologies in the ultra-low-energy scenario.
- An energy use intensity (EUI) of less than **40 kWh/m².yr** can be achieved by all typologies in the low energy scenario.
- Additionally, an energy use intensity (EUI) of les than **35 kWh/m².yr** can be achieved by all typologies in the ultra-low energy scenario.
- All typologies use a low-carbon heating system (e.g., a heat pump) and are fossil-fuel-free, which is essential to meeting the EUI targets.
- The scenarios highlighted above are all compliant with Part L 2021.

Building typologies	Building regulations Part L 2021	Scenario	Space heating demand (kWh/m²·yr) Target	Space heating demand Result	Space heating demand Met	Energy use intensity (EUI) (kWh/m².yr) Target	EUI Result	EUI Met	Fossil fuel free	Renewable energy generation
 Bungalow	✓	*Low energy*	≤30	30	✓	≤40	34	✓	✓	Energy positive
	✓	*Ultra-low energy*	15-20	18	✓	≤35	30	✓		
 Detached house	✓	*Low energy*	≤30	27	✓	≤40	31	✓	✓	Energy positive
	✓	*Ultra-low energy*	15-20	17	✓	≤35	26	✓		
 Semi-detached house	✓	*Low energy*	≤30	21	✓	≤40	34	✓	✓	Energy positive
	✓	*Ultra-low energy*	15-20	14	✓	≤35	31	✓		
 Terrace house	✓	*Low energy*	≤30	21	✓	≤40	33	✓	✓	Energy positive
	✓	*Ultra-low energy*	15-20	14	✓	≤35	30	✓		
 2 1-bed flats	✓	*Low energy*	≤30	27	✓	≤40	38	✓	✓	Energy positive
	✓	*Ultra-low energy*	15-20	18	✓	≤35	34	✓		
 Mid-rise apartment building	✓	*Low energy*	≤30	18	✓	≤40	35	✓	✓	No energy balance achieved – shortfall calculated
	✓	*Ultra-low energy*	15-20	15	✓	≤35	34	✓		

Summary of space heating demand, energy use intensity and Part L compliance results

2.2.2 Bungalow I Specification and energy modelling results (1/3)

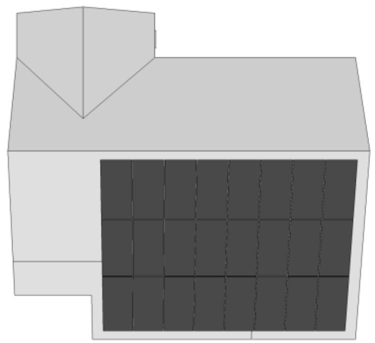


		Low energy
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m²K)	0.11 0.13 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W – 1.2 D – 1
	Airtightness (m³/m²h)	1
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	14.52 kWp
	Battery storage	N/A

Results

Low Energy

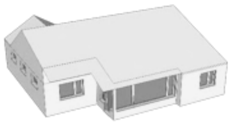
Target KPI		Result	
Space heating demand	<30 kWh/m²/yr	30 kWh/m²/yr	✔
Energy Use Intensity	<40 kWh/m²/yr	34 kWh/m²/yr	✔
Renewable energy balance		Energy positive on-site	✔



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

2.2.2 Bungalow I Specification and energy modelling results (2/3)

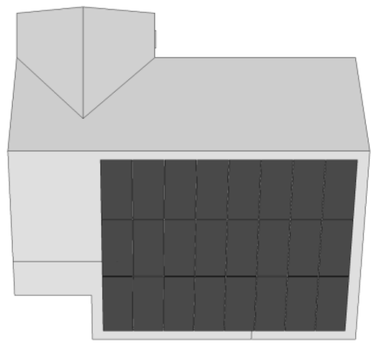


		Ultra-low energy
Building fabric and ventilation strategy		Ultra-low energy fabric
	Floor Walls Roof (W/m²K)	0.10 0.10 0.09
	Windows (W) Doors (D) (W/m²K)	Triple glazing W – 0.8 D – 1
	Airtightness (m^3/m^2h)	0.45 (0.6ach)
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (35°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	14.52 kWp
	Battery storage	N/A

Results

Ultra-Low Energy

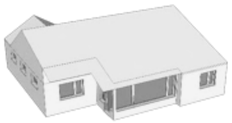
Target KPI	Result	
Space heating demand <15-20 kWh/m²/yr	18 kWh/m²/yr	✓
Energy Use Intensity <35 kWh/m²/yr	30 kWh/m²/yr	✓
Renewable energy balance	Energy positive on-site	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

2.2.2 Bungalow | Specification and energy modelling results (3/3)

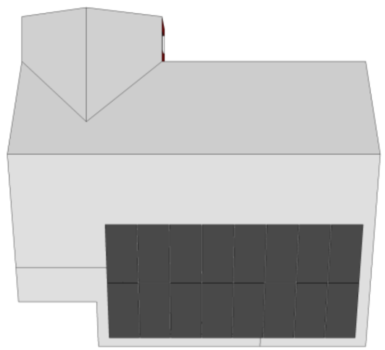


		Anticipated Future Homes Standard - Option 2* with additional PV and battery
Building fabric and ventilation strategy	Floor Walls Roof (W/m²K)	Low energy fabric 0.12 0.18 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W – 1.2 D – 1
	Airtightness (m³/m²h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	9.68 kWp
	Battery storage	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

Results

Anticipated Future Homes Standard - Option 2* with additional PV and battery

Requirements	Met
Air Source Heat Pump	✓
Battery storage	✓
More renewable energy generation to achieve zero bills	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

* Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1

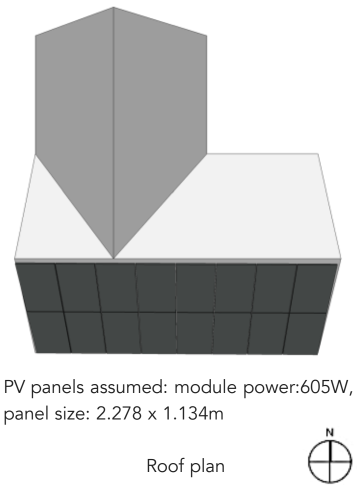
2.2.3 Detached house | Specification and energy modelling results (2/3)

		Low energy
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m²K)	0.11 0.13 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W – 1.2 D – 1
	Airtightness (m^3/m^2h)	1
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	9.68 kWp
	Battery storage	N/A

Results

Low Energy

Target KPI	Result	
Space heating demand <30 kWh/m²/yr	27 kWh/m²/yr	✓
Energy Use Intensity <40 kWh/m²/yr	31 kWh/m²/yr	✓
Renewable energy balance	Energy positive on-site	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

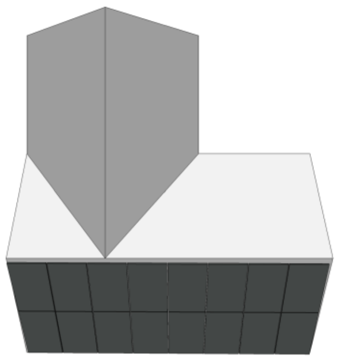
2.2.3 Detached house | Specification and energy modelling results (3/3)

		Ultra-low energy
Building fabric and ventilation strategy		Ultra-low energy fabric
	Floor Walls Roof (W/m²K)	0.10 0.10 0.09
	Windows (W) Doors (D) (W/m²K)	Triple glazing W – 0.8 D – 1
	Airtightness (m^3/m^2h)	0.6 (0.6ach)
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (35°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	9.68 kWp
	Battery storage	N/A

Results

Ultra- Low Energy

Target KPI	Result	
Space heating demand <15-20 kWh/m²/yr	17 kWh/m²/yr	✔
Energy Use Intensity <35 kWh/m²/yr	26 kWh/m²/yr	✔
Renewable energy balance	Energy positive on-site	✔



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

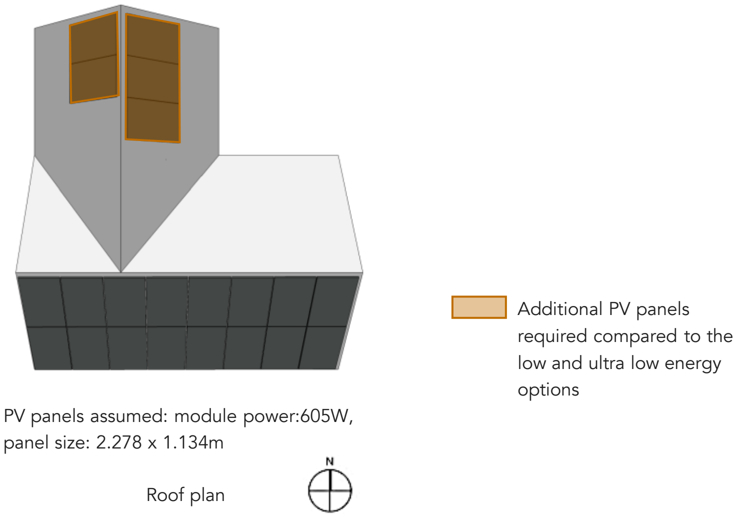
2.2.3 Detached house | Specification and energy modelling results (3/3)

		Anticipated Future Homes Standard - Option 2* with additional PV and battery
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m²K)	0.12 0.16 0.10
	Windows (W) Doors (D) (W/m²K)	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 (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	12.71 kWp 9.68kWp (S), 1.82kWp (E) 1.21kWp (W)
	Battery storage	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

Results

Anticipated Future Homes Standard - Option 2* with additional PV and battery

Requirements	Met
Air Source Heat Pump	✓
Battery storage	✓
More renewable energy generation to achieve zero bills	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

* *Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

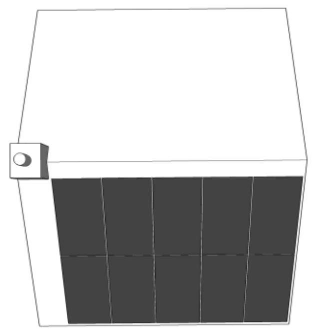
2.2.4 Semi-detached house | Specification and energy modelling results (1/3)

		Low energy
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m²K)	0.11 0.13 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W – 1.2 D – 1
	Airtightness (m^3/m^2h)	1
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	6.05 kWp
	Battery storage	N/A

Results

Low Energy

Target KPI	Result
Space heating demand <30 kWh/m²/yr	21 kWh/m²/yr ✓
Energy Use Intensity <40 kWh/m²/yr	34 kWh/m²/yr ✓
Renewable energy balance	Energy positive on-site ✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

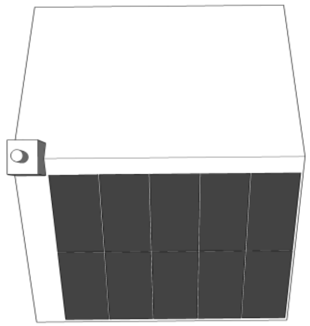
2.2.4 Semi-detached house | Specification and energy modelling results (2/3)

		Ultra-low energy
Building fabric and ventilation strategy		Ultra-low energy fabric
	Floor Walls Roof (W/m²K)	0.10 0.10 0.10
	Windows (W) Doors (D) (W/m²K)	Triple glazing W – 0.8 D – 1
	Airtightness (m³/m²h)	0.7 (0.6ach)
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (35°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	6.05 kWp
	Battery storage	N/A

Results

Ultra-Low Energy

Target KPI	Result	
Space heating demand 15-20 kWh/m²/yr	14 kWh/m²/yr	✓
Energy Use Intensity <35 kWh/m²/yr	31 kWh/m²/yr	✓
Renewable energy balance	Energy positive on-site	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

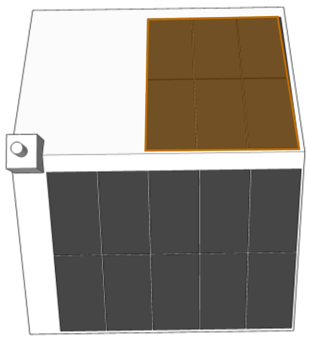
2.2.4 Semi-detached house | Specification and energy modelling results (3/3)

Category	Element	Anticipated Future Homes Standard - Option 2* with additional PV and battery
Building fabric and ventilation strategy	Floor Walls Roof (W/m²K)	Low energy fabric 0.12 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	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	9.68 kWp 6.05kWp (SW), 3.63kWp (NE)
	Battery storage	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

Results

Anticipated Future Homes Standard - Option 2* with additional PV and battery

Requirements	Met
Air Source Heat Pump	✓
Battery storage	✓
More renewable energy generation to achieve zero bills	✓



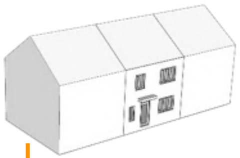
Additional PV panels required compared to the low and ultra low energy options

PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

* *Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

2.2.5 Terrace house | Specification and energy modelling results (1/3)

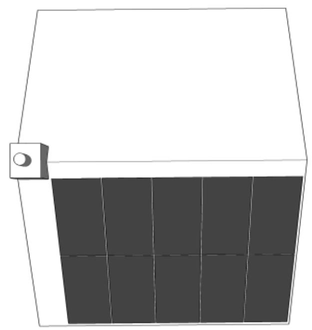


		Low energy
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m²K)	0.11 0.15 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W – 1.2 D – 1
	Airtightness (m³/m²h)	3
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	6.05 kWp
	Battery storage	N/A

Results

Low Energy

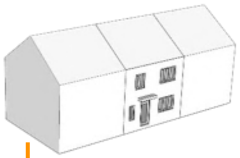
Target KPI	Result	
Space heating demand <30 kWh/m²/yr	21 kWh/m²/yr	✓
Energy Use Intensity <40 kWh/m²/yr	33 kWh/m²/yr	✓
Renewable energy balance	Energy positive on-site	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

2.2.5 Terrace house | Specification and energy modelling results (2/3)

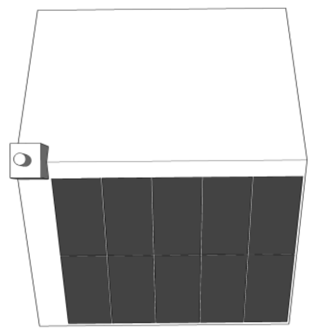


		Ultra-low energy
Building fabric and ventilation strategy		Ultra-low energy fabric
	Floor Walls Roof (W/m²K)	0.13 0.15 0.11
	Windows (W) Doors (D) (W/m²K)	Triple glazing W – 0.8 D – 1
	Airtightness (m³/m²h)	2
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (35°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	6.05 kWp
	Battery storage	N/A

Results

Ultra-Low Energy

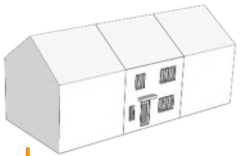
Target KPI	Result	
Space heating demand 15-20 kWh/m²/yr	14 kWh/m²/yr	✓
Energy Use Intensity <35 kWh/m²/yr	30 kWh/m²/yr	✓
Renewable energy balance	Energy positive on-site	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

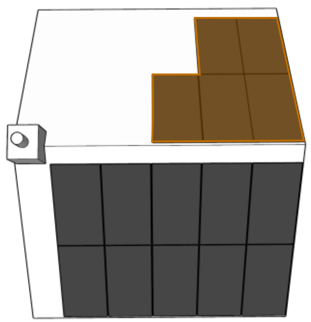
2.2.5 Terrace house | Specification and energy modelling results (3/3)



		Anticipated Future Homes Standard - Option 2* with additional PV and battery
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m²K)	0.12 0.18 0.10
		Double glazing
	Windows (W) Doors (D) (W/m²K)	W – 1.2 D – 1
	Airtightness (m³/m²h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	9.08 kWp 6.05kWp (SW), 3.03kWp (NE)
	Battery storage	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

Results

Anticipated Future Homes Standard - Option 2* with additional PV and battery	
Requirements	Met
Air Source Heat Pump	✓
Battery storage	✓
More renewable energy generation to achieve zero bills	✓



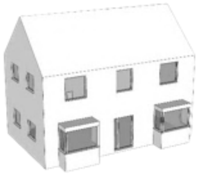
Additional PV panels required compared to the low and ultra low energy options

PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

* *Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

2.2.6 Two 1-bed flats house | Specification and energy modelling results (1/3)

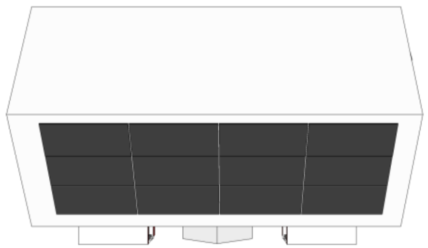


		Low energy
Building fabric and ventilation strategy		Low energy fabric
	Floor Walls Roof (W/m²K)	0.11 0.13 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W – 1.2 D – 1
	Airtightness (m³/m²h)	1
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	7.26 kWp
	Battery storage	N/A

Results

Low Energy

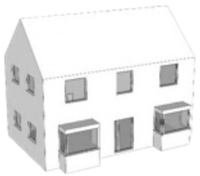
Target KPI	Result	
Space heating demand <30 kWh/m²/yr	27 kWh/m²/yr	✓
Energy Use Intensity <40 kWh/m²/yr	38 kWh/m²/yr	✓
Renewable energy balance	Energy positive on-site	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

2.2.6 Two 1-bed flats house | Specification and energy modelling results (2/3)

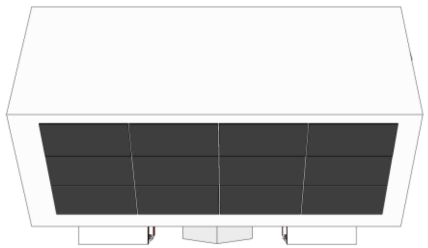


		Ultra-low energy
Building fabric and ventilation strategy		Ultra-low energy fabric
	Floor Walls Roof (W/m²K)	0.10 0.10 0.09
	Windows (W) Doors (D) (W/m²K)	Triple glazing W – 0.8 D – 1
	Airtightness (m³/m²h)	0.85 (0.6ach)
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	5kW ASHP (35°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	7.26 kWp
	Battery storage	N/A

Results

Low Energy

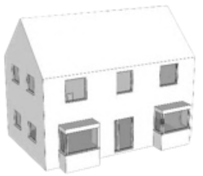
Target KPI	Result	
Space heating demand 15-20 kWh/m²/yr	18 kWh/m²/yr	✓
Energy Use Intensity <35 kWh/m²/yr	34 kWh/m²/yr	✓
Renewable energy balance	Energy positive on-site	✓



PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

2.2.6 Two 1-bed flats house | Specification and energy modelling results (3/3)

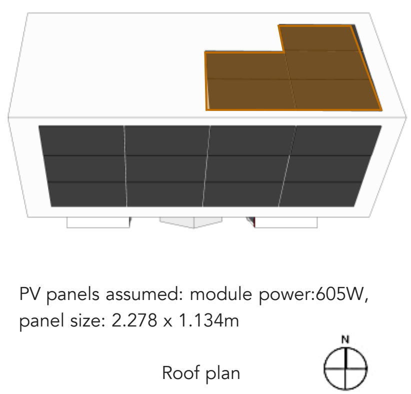


		Anticipated Future Homes Standard - Option 2* with additional PV and battery
Building fabric and ventilation strategy	Floor Walls Roof (W/m²K)	Low energy fabric 0.12 0.17 0.10
	Windows (W) Doors (D) (W/m²K)	Double glazing W – 1.2 D – 1
	Airtightness (m³/m²h)	5
	Ventilation strategy	Natural ventilation with intermittent extract fans
Heating, hot water	Heating system	5kW ASHP (45°C)
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	10.29 kWp 7.26kWp (SW), 3.03kWp (NE)
	Battery storage	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

Results

Anticipated Future Homes Standard - Option 2* with additional PV and battery

Requirements	Met
Air Source Heat Pump	✓
Battery storage	✓
More renewable energy generation to achieve zero bills	✓



Additional PV panels required compared to the low and ultra low energy options

PV panels assumed: module power:605W, panel size: 2.278 x 1.134m

Roof plan

* Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1

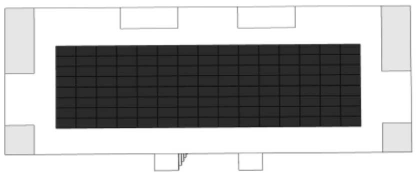
2.2.7 Mid-rise block of flats | Specification and energy modelling results (1/2)

		Low energy
Building fabric and ventilation strategy	Floor Walls Roof (W/m²K)	Low energy fabric 0.13 0.13 0.11
	Windows (W) Doors (D) (W/m²K)	Double glazing W – 1.2 D – 1
	Airtightness (m³/m²h)	3
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	Communal ASHP
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	72.6 kWp
	Battery storage	N/A

Results

Low Energy

Target KPI	Result	
Space heating demand <30 kWh/m²/yr	18 kWh/m²/yr	✔
Energy Use Intensity <40 kWh/m²/yr	35 kWh/m²/yr	✔
Renewable energy balance	Energy positive on-site	✘



PV panels fitting: module power:605W, panel size: 2.278 x 1.134m

Roof plan

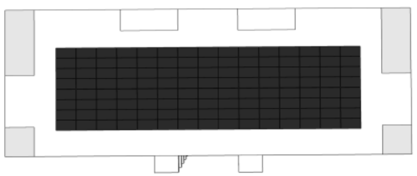
2.2.7 Mid-rise block of flats | Specification and energy modelling results (2/2)

		Ultra-low energy
Building fabric and ventilation strategy		Ultra-low energy fabric
	Floor Walls Roof (W/m²K)	0.10 0.17 0.11
	Windows (W) Doors (D) (W/m²K)	Triple glazing W – 0.8 D – 1
	Airtightness (m³/m²h)	1.25 (0.6ach)
	Ventilation strategy	High Efficiency MVHR
Heating, hot water	Heating system	Communal ASHP
	Hot water heating system	200l cylinder
	Waste water heat recovery (WWHR)	No
Renewables	PV required	72.6 kWp
	Battery storage	N/A

Results

Ultra-Low Energy

Target KPI	Result	
Space heating demand <15-20 kWh/m²/yr	15 kWh/m²/yr	✓
Energy Use Intensity <35 kWh/m²/yr	34 kWh/m²/yr	✓
Renewable energy balance	Energy positive on-site	✗



PV panels fitting: module power:605W, panel size: 2.278 x 1.134m

Roof plan

2.3

Residential energy modelling: PV analysis

2.3

Contents

2.3.1 Renewable energy | Determining a feasible amount of generation (1/2)

Potential for solar PV – Low and ultra-low energy scenarios

Etude examined solar photovoltaics (PV) as the most feasible technology for use in dwellings. In our assessment, we calculated for each typology the amount of PV that can be accommodated on roofs, as well as the requirements needed to meet the proposed policy targets.

The ratio of roof area suitable for PV panels relative to internal floor area varies across different building types. Larger houses typically have more roof space available for PV installation, which can balance their internal floor area. In contrast, medium-rise blocks of flats may have internal floor areas up to six times larger than their roof area. This means that, compared to larger houses, there is less roof space available per dwelling for PV installation.

For the low and ultra low energy scenarios, best-practice solar technology is assumed: 605W high-efficiency monocrystalline silicon panels with microinverters or DC optimisers.

The schematics on the right show the roof capacity needed for each archetype in order to meet the policy requirements set out in the low and ultra-low energy scenarios (60% GFA / 4.5kWp). For the multi-residential archetype, a conservative allowance has been made for the building's plant room. It is important to note that factors such as shading and orientation will affect and potentially alter these predictions.

Bungalow

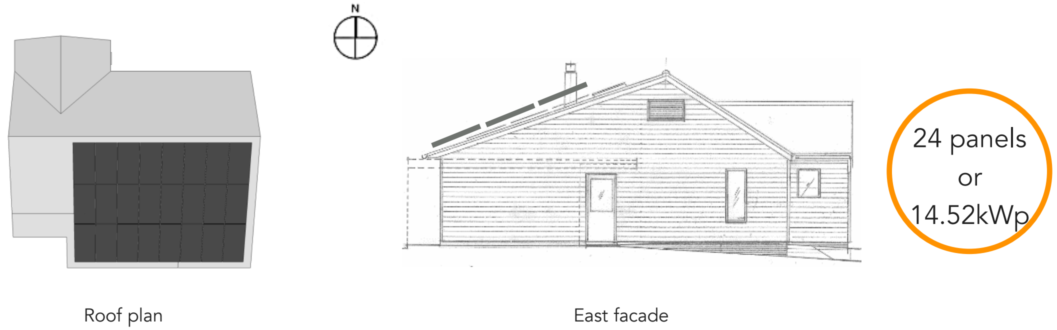
- Sufficient space for c.24 panels with the main roof facing south

Detached house

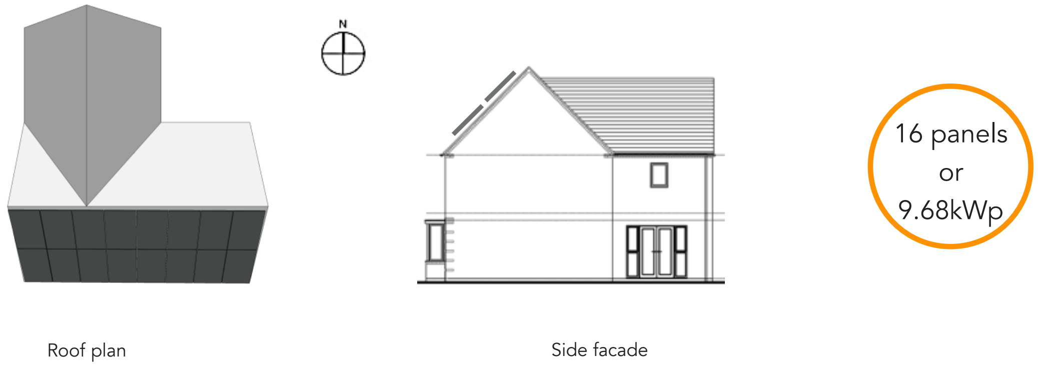
- Sufficient space for c.16 panels with the main roof facing south

Semi-detached house

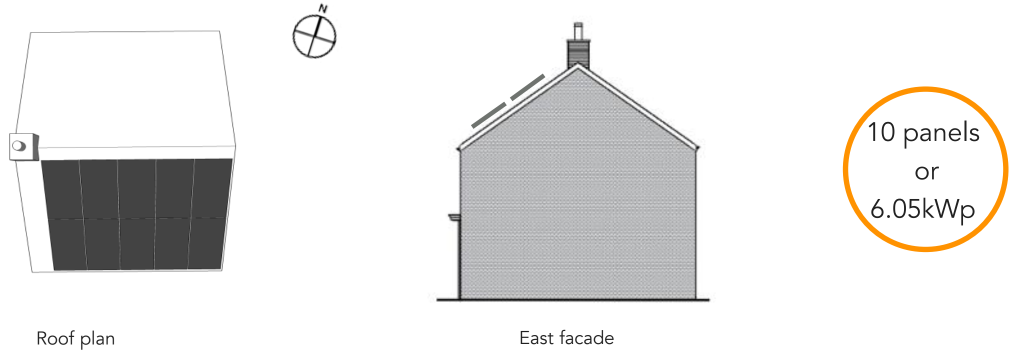
- Sufficient space for c.10 panels with the main roof facing south-west



Mark-up of roof showing assumed PV capacity for the bungalow.



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



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

2.3.1 Renewable energy | Determining a feasible amount of generation (2/2)

Mid-terrace house

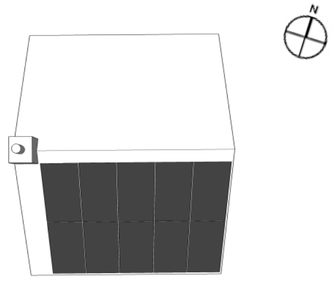
- Sufficient space for c.10 panels with the main roof facing south-west

Two 1-bed flats

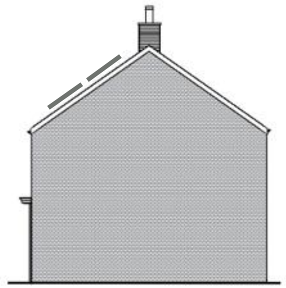
- Sufficient space for c.12 panels with the main roof facing south-west

Mid-rise flats

- Sufficient space for c.120 panels with an east-west orientation and a ‘concertina’ type installation. In this case the panels have been maximised as much as practicable and a shortfall of 45.98 kWp and 42.35 kWp has been calculated for the low and ultra-low energy scenarios accordingly.



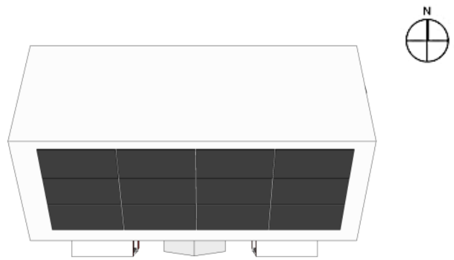
Roof plan



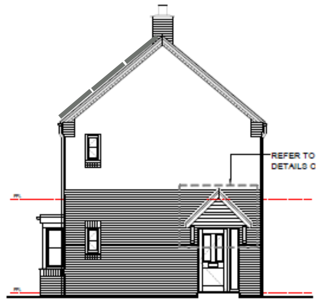
East facade

10 panels or 6.05kWp

Mark-up of roof showing the assumed PV capacity for the mid-terrace house.



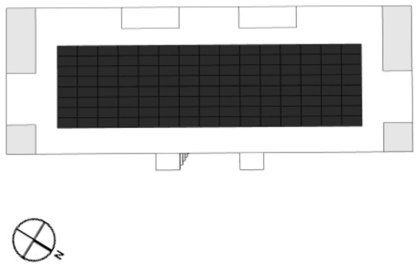
Roof plan



East facade

12 panels or 7.26kWp

Mark-up of roof showing the assumed PV capacity for two 1-bed flats.



Roof plan

120 panels or 72.6kWp

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

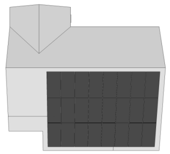
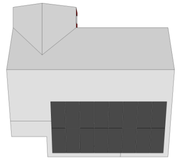
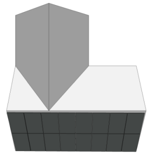
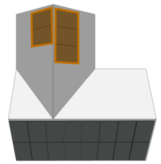
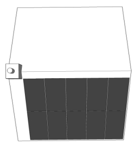
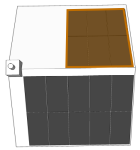
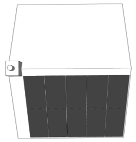
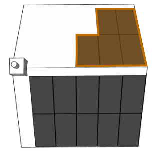
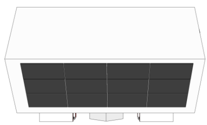
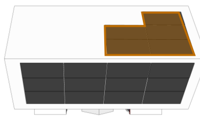
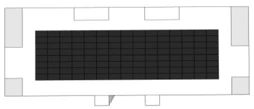
More solar PV – Other policy scenario tested

The additional number of PV panels needed to meet the other policy scenario tested has been also calculated.

Similarly to the low and ultra-low energy scenarios, best-practice solar technology is assumed: 605W high-efficiency monocrystalline silicon panels with microinverters or DC optimisers.

It needs to be noted that a battery would be required in this scenario too.

In most cases, a couple of additional PV panels are needed to meet the requirements, except for the bungalow. In that instance, the floor area is quite large, resulting in less generation being required in the other policy option.

Building typologies	Renewable energy generation for low and ultra-low energy scenarios	Additional generation needed to meet the requirements of the other policy option tested		
 Bungalow		Less amount of PV panels is needed		16 panels or 9.68kWp
 Detached house		10 additional panels needed		21 panels or 12.71kWp
 Semi-detached house		9 additional panels needed		16 panels or 9.68kWp
 Terrace house		9 additional panels needed		15 panels or 9.08kWp
 2 1-bed flats		9 additional panels needed		17 panels or 10.29kWp
 Mid-rise apartment building		N/A		

2.3.3 Renewable energy | Power output of solar photovoltaic panels

Basis for the government's proposed solar requirements

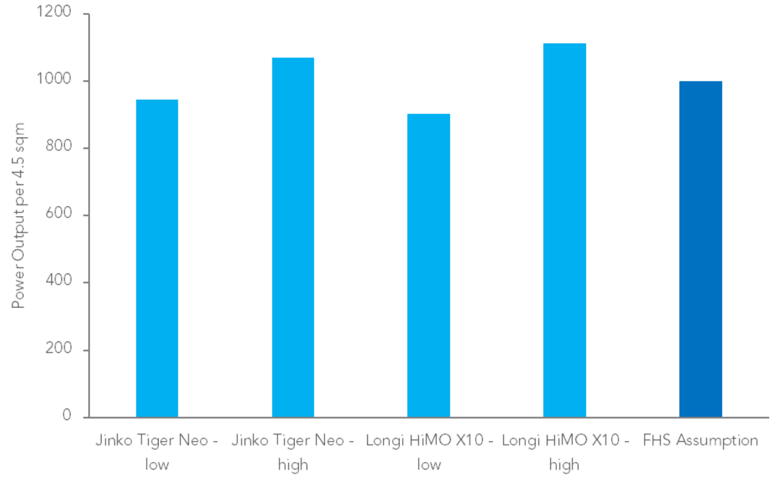
The formula for calculating the nominal DC capacity of solar required for the anticipated Future Homes Standard option proposed by the government was 40% x ground floor area / 4.5. As mentioned previously, this has been retained and upgraded to a requirement of 60% x ground floor area / 4.5 for the two recommended policies.

The divisor of 4.5 is based on an assumption that commercially available solar panels can generate 1kW per 4.5sqm of panel area under standard test conditions that are used to measure the nominal power output of solar modules.

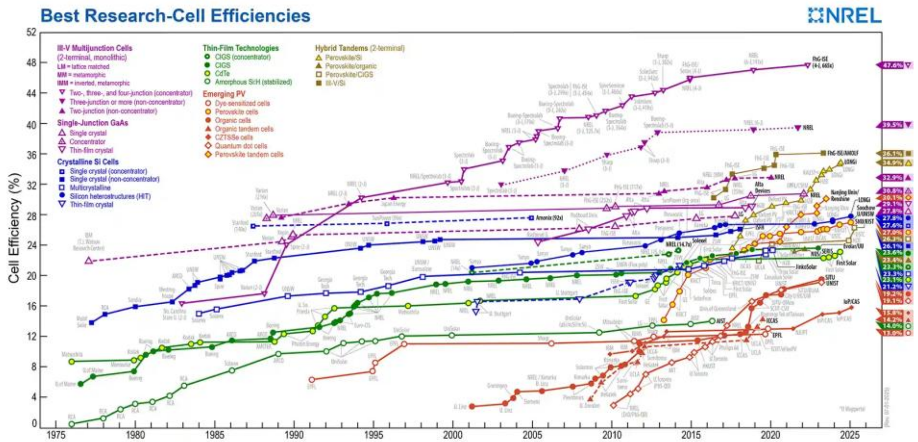
Power output of commercially available panels

Etude checked the power outputs of commercially available solar panels from two of the world's largest manufacturers, Jinko and Longi. This confirmed availability of modules that met, and exceeded, the power output assumed by the FHS formula, which has been used as the basis for the proposed policy. See the adjacent upper image.

Solar cell efficiencies have continually improved since the technology's inception, as shown in the lower adjacent image. These improvements tend to feed into commercially available solar modules, meaning the amount of roof space required to comply with the proposed policy requirements is therefore likely to fall over time.



Upper and lower power output per 4.5 sqm for commercially available module ranges from two of the world's largest solar photovoltaic module manufacturers, compared to the power output assumed in the FHS formula.

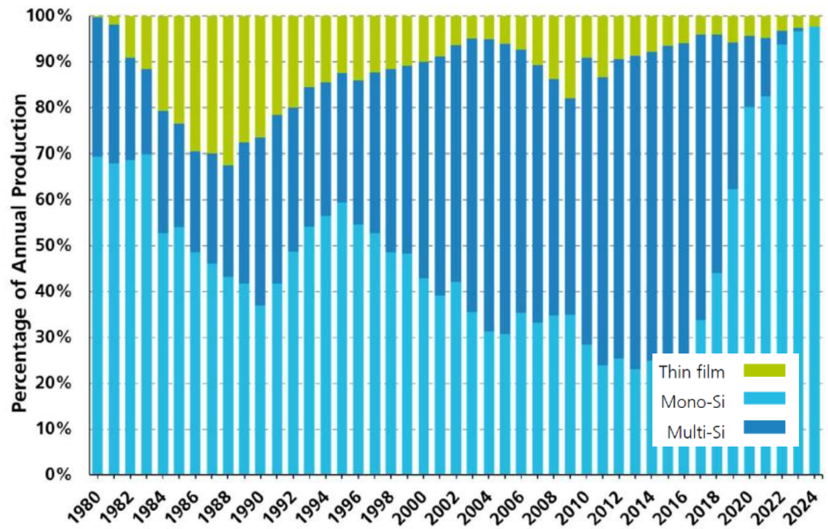


NREL's Best Research Cell Efficiencies chart shows ongoing improvements to the efficiency of monocrystalline silicone cells (blue line). These improvements have led to regular improvements to the efficiency of commercially available solar panels.

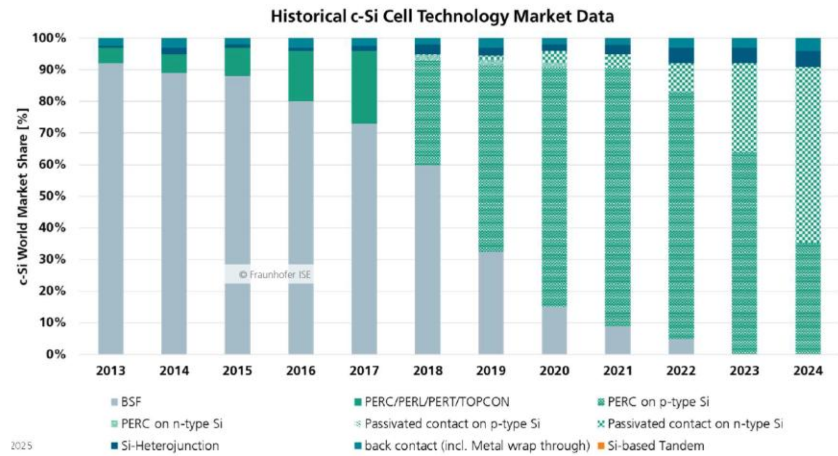
Market adoption of high efficiency technology

The adjacent upper graph shows how the proliferation of higher efficiency monocrystalline silicon led to the phase-out of lower efficiency polycrystalline silicon based solar modules, while the lower graph shows that there have been several other waves of improvement within crystalline silicon technology, which have led to older technology being retired.

This means by the time the panels are being procured for projects approved under the proposed policy, module efficiencies are likely to exceed even further the levels required for most homes to have sufficient roof space to achieve policy compliance.



Fraunhofer ISI's annual photovoltaics report shows that less efficient polycrystalline technology has been phased out in favour of monocrystalline silicon.



Even within crystalline silicon modules, the introduction of more efficient sub-types typically leads to retirement of less efficient older technology over time. Image from Fraunhofer ISI 's 2024 Photovoltaics Report.

2.4

Residential energy modelling: Comparison results

2.4 Residential energy modelling: Comparison results

2.4

Contents

2.4.1 Space heating demand | Comparison results

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 the Future Homes Standard specifications recently in consultation.
- Energy efficiency shows a marked improvement between the benchmark / other policy tested and the low and ultra-low energy scenarios.
- The improvement between the anticipated Future Homes Standard scenario + maximized solar + battery and the low energy scenario has been achieved primarily through enhanced air-tightness standards, as well as improvements in the building fabric.
- The improvement between the low and ultra low energy scenarios has been achieved primarily through the transition from double glazing to triple glazing.
- Overall, 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.

This graph illustrates the predicted annual Space Heating Demand for all scenarios and housing archetypes.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

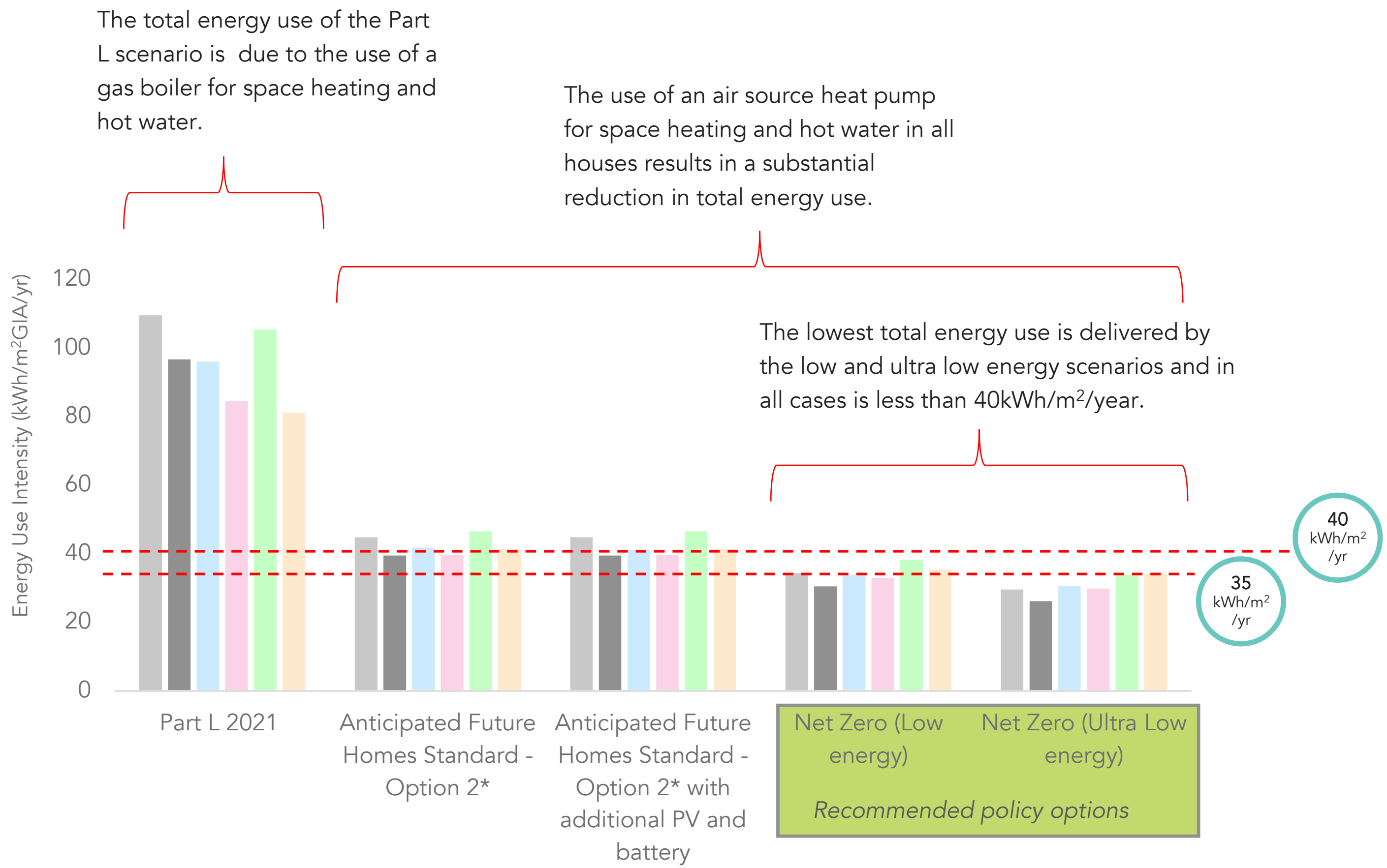
2.4.2 Energy Use Intensity | Comparison results

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 scenario has a much larger EUI than the other scenarios primarily due to the use of a gas boiler. All other scenarios and house typologies 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.



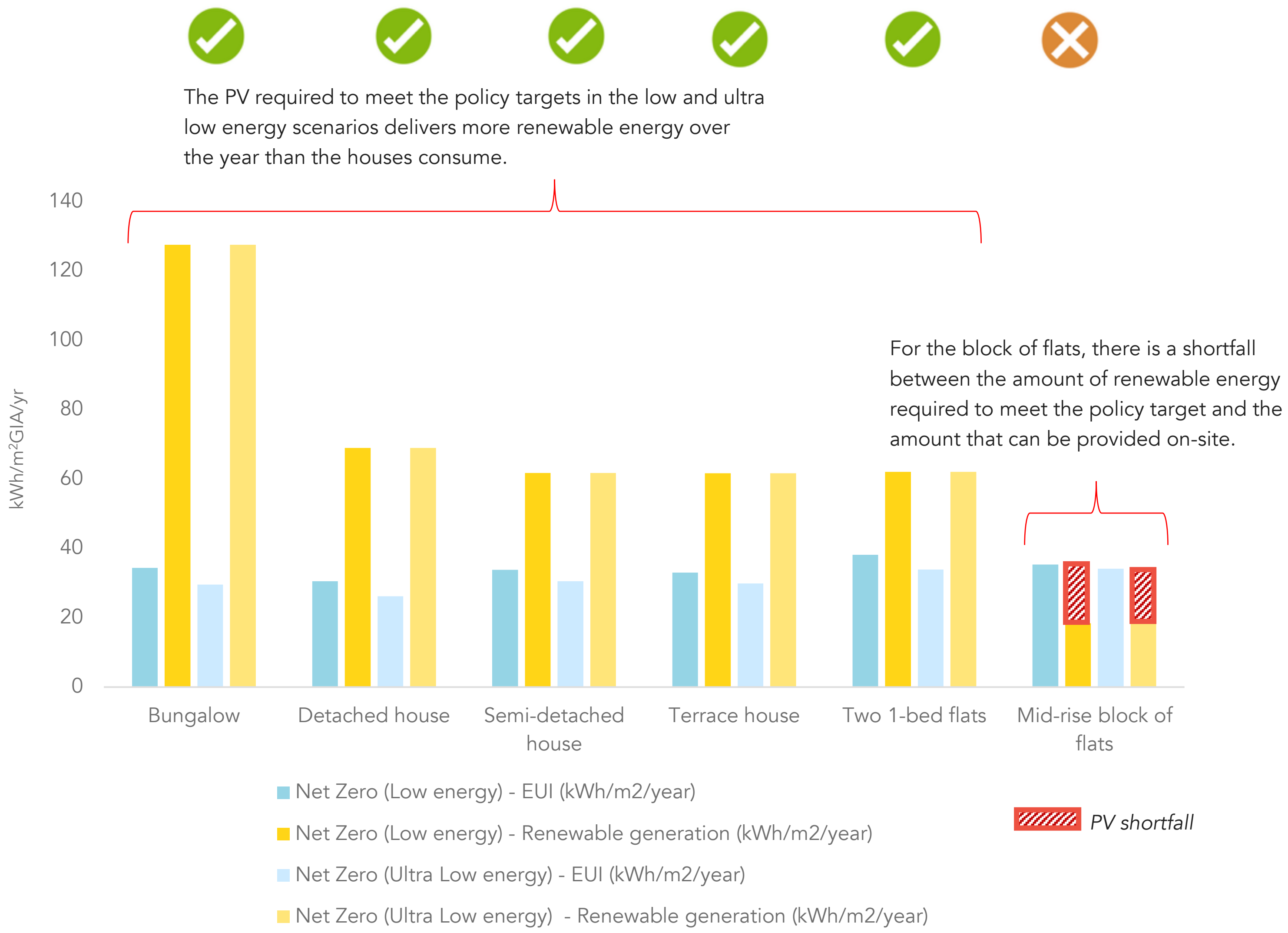
This graph illustrates the predicted annual Energy Use Intensity (EUI) for all scenarios and housing archetypes.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

The amount of PV based on a 60% GFA / 4.5 kWp proposed generation has been calculated for the low- and ultra-low-energy scenarios, with consideration given to potential mechanical plant located on the roof

Observations:

- For all house typologies, in both scenarios, it is technically feasible to accommodate the required number of PV panels.
- However, it is not possible to meet the policy requirements for either scenario of the mid-rise block of flats, mainly due to limited roof space. South Warwickshire Council will need to consider implementing an energy or carbon offset policy for applicants in cases where sufficient PV cannot be accommodated on site to achieve compliance. The shortfall has been calculated to be an additional 76 panels for the low and 70 panels for the ultra low option.



This graph illustrates the predicted annual Energy Use Intensity (EUI) compared with the predicted annual renewable energy generation required to meet the policy targets for the low and ultra low energy scenarios, for each housing archetype.

3.0

Non-residential energy modelling

3.1

Non-Residential energy modelling: Methodology, typologies and specifications

3.1 Non-residential buildings Energy modelling: Methodology, typologies and specifications

3.1

Contents

3.1.1 Energy and cost modelling analysis | Our approach

Purpose of energy and cost modelling

As with the residential typologies, the purpose of this evidence base is to determine that net zero carbon non-residential buildings in South Warwickshire are both:

a) Feasible from a technical perspective

b) Feasible from a viability perspective

For this work we have referred to:

- Analysis of industry guidance and standards.
- Previous energy modelling work for development of evidence bases to support policy elsewhere in the UK.
- Bespoke energy modelling work to account for the difference in climate compared to previous modelling work and updated assumptions on building use.

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

1) Low energy specification + net zero carbon operational energy balance
2) Ultra-low energy specification + net zero carbon operational energy balance

Energy and cost modelling forms the core of this technical evidence base. Its role is to assess how different building archetypes perform against the metrics **expected to become part of Future Buildings Standard**, and the two additional policy options, using different specification combinations.

The modelling results will inform target setting by officers and provide evidence that the proposed policies are technically achievable. In addition, the cost modelling will highlight the extra costs associated with these policies compared with minimum compliance **expected to become part of Future Buildings Standard**.

.

Cost baseline

The baseline we are using for cost modelling purposes will be a building that would **expected to become part of Future Buildings Standard**. It is assumed that this is what developers are building to now, it provides a known starting point and a robust baseline.

3.1.2 Energy and cost modelling analysis | Archetype selection

Archetype selection

Similarly to the residential typologies, to undertake the energy and cost modelling for this technical evidence base, two non-residential archetypes were identified and assessed following discussions with the South Warwickshire Local Plan team: a primary school and an industrial building. These have been modelled and costed for South Warwickshire.

For each archetype, we have identified one representative building (see adjacent images). Each is a typical developer or local authority built example of its type. In reality, building design, specification, and site conditions vary considerably, and these factors affect energy, carbon, and cost. However, it is standard practice in technical evidence bases to use representative examples of different building types, as we have done here. The analysis can always be expanded to include additional buildings or building types if required.

Three different combinations of specifications

Three different combinations of specifications have been modelled, incorporating variations in fabric and ventilation, heating systems, and solar PVs. Each is explained in detail on the next page.

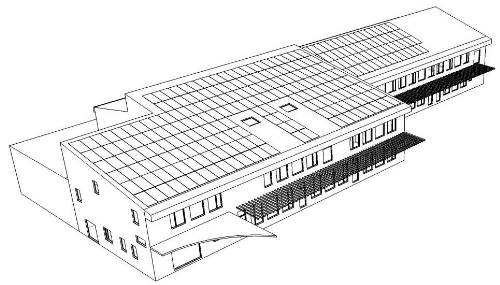
Primary school

The primary school has been modelled based on a representative school building elsewhere in the country.

Industrial building with integrated office

The industrial building analysis is based on updated information on heat loss areas relevant to planning applications received in the local area. The space heating energy has been calculated for this building, and this has been supplemented by other energy uses calculated per metre squared for a similar industrial building.

Non-domestic archetypes selected

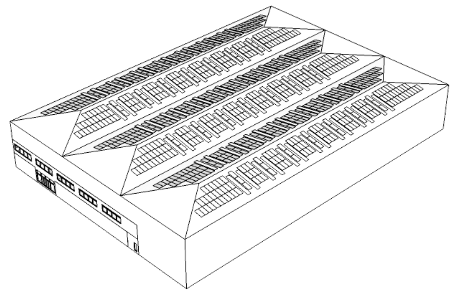


Primary School

2 storeys

2,537 sqm (GIA)

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



Industrial building

2 storeys

6,300 sqm (GIA)

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

3.1.3 Energy and cost modelling analysis | Scenarios modelled

Three scenarios modelled

We have chosen three different scenarios to model for each of the two non-residential archetypes. Of these, one scenario forms the baseline, and two scenarios represent the policy options tested.

Benchmark / context scenario

*Anticipated Future Building Standard**: We modelled the Future Building Standard Notional specification. This could represent an alternative future cost baseline.**

**The anticipated future building standard notional building specification was used with a direct electric baseline. An alternative baseline is also shown with heat pump heating in the office, direct electric heating in the warehouse and direct electric hot water (industrial building) / heat pump heating and direct electric point-of-use for hot water (school building).*

***It is not yet certain whether this Notional Building specification will be retained or adapted after the consultation period.*

Policy Scenarios

- *Net Zero Carbon (low energy)* – A fabric specification that achieves a Space Heating Demand of 30 kWh/m^2/yr, an EUI of 52 kWh/m^2/yr for the primary school building and an EUI of 35 kWh/m^2/yr for the industrial building. An energy balance for PV.
- *Net Zero Carbon (ultra-low energy)* - A fabric specification that achieves a Space Heating Demand of 15 kWh/m^2/yr, an EUI of 52 kWh/m^2/yr for the primary school building and an EUI of 35 kWh/m^2/yr for the industrial building An energy balance for PV.

Each of the 2 policy scenarios has been tested with 2 different heating and hot water systems.

	Benchmark / Context	Policy Options	
	Anticipated Future Building Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)
Purpose	Possible future energy, carbon, cost baseline – Anticipated FBS notional building spec.	Potential policy option 1 – Spec to meet space heating demand less than 30kWh/m^2/year, EUI of 52kWh/m^2/year (primary school) / 35kWh/m^2/year (industrial building) and energy balance.	Potential policy option 2 – Spec to meet space heating demand less than 15kWh/m^2/year, EUI of 52kWh/m^2/year (primary school) / 35kWh/m^2/year (industrial building) and energy balance.
PHPP	Yes	Yes	Yes
Cost analysis	Yes	Yes	Yes

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

Predictive energy modelling outputs

The primary school building was modelled for every scenario using predictive operational energy modelling tool PHPP (10.6) to calculate the space heating demand (SHD) and Energy Use Intensity (EUI). PHPP was used due to its ability to accurately predict real world performance in use.

The industrial building also used PHPP but only for the main energy uses (heating and hot water). The assumptions for the rest of the uses have been derived from models developed for other projects.

Part L 2021 compliance modelling outputs

The non-residential typologies were not modelled using Part L 2021 accredited software as part of this study; however, this could be undertaken in an additional study if deemed necessary.

3.1.4 Energy and cost modelling analysis I Our approach to scenarios modelled

	Benchmark / Context	Policy Options	
	Anticipated Future Building Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)
Purpose	Possible future energy, carbon, cost baseline – Anticipated FBS notional building spec.	Potential policy option 1 – Spec to meet space heating demand less than 30kWh/m²/year, EUI of 52kWh/m²/year (primary school) / 35kWh/m²/year (industrial building) and energy balance.	Potential policy option 2 – Spec to meet space heating demand less than 15kWh/m²/year, EUI of 52kWh/m²/year (primary school) / 35kWh/m²/year (industrial building) and energy balance.
PHPP	Yes	Yes	Yes
Cost analysis	Yes	Yes	Yes

Each policy option was tested with the following heating and hot water systems:

1. Heat pump to provide heating in the office and direct electric in the warehouse, direct electric hot water provision.
2. Central heat pump for heating and hot water.

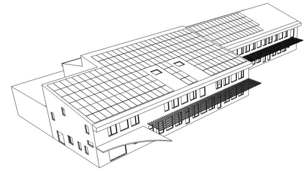
Each policy option was tested with the following renewable energy strategy:

1. PV provision to meet the expected Future Building Standard.

Additionally, the PV provision to make maximum use of the roof space has been calculated. There is significant opportunity to require a more ambitious PV provision, especially for the industrial building.

** With heat pump heating in the office, direct electric heating in the warehouse and direct electric hot water (industrial building) / heat pump heating and direct electric point-of-use for hot water (school building)*

3.1.5 Technical viability context | Primary schools EUI



This page explains the various EUI levels defined for schools by industry standards and benchmarks and set by various local authorities as part of adopted and emerging local plans.

Current regulations and benchmarks

The **Department for Education's Output Specification (OS)** for schools in England defines an EUI requirement of 52 kWh/m²/yr and sets elemental limits for U-values and airtightness.

Industry standards and frameworks

UK NZCBS standard EUI limits are 45 and 35 kWh/m²/yr for 2025 and 2040 derived from stakeholder engagement at the time of development. **The RIBA targets** are 70 and 60 kWh/m²/yr for 2025 and 2030, and the **LETI target** is 65 kWh/m²/yr. The CIBSE benchmarks for Primary school "Good practice electricity" and "Typical practice electricity" are much lower, at 34 and 41 kWh/m²/yr.

Adopted and emerging local plans

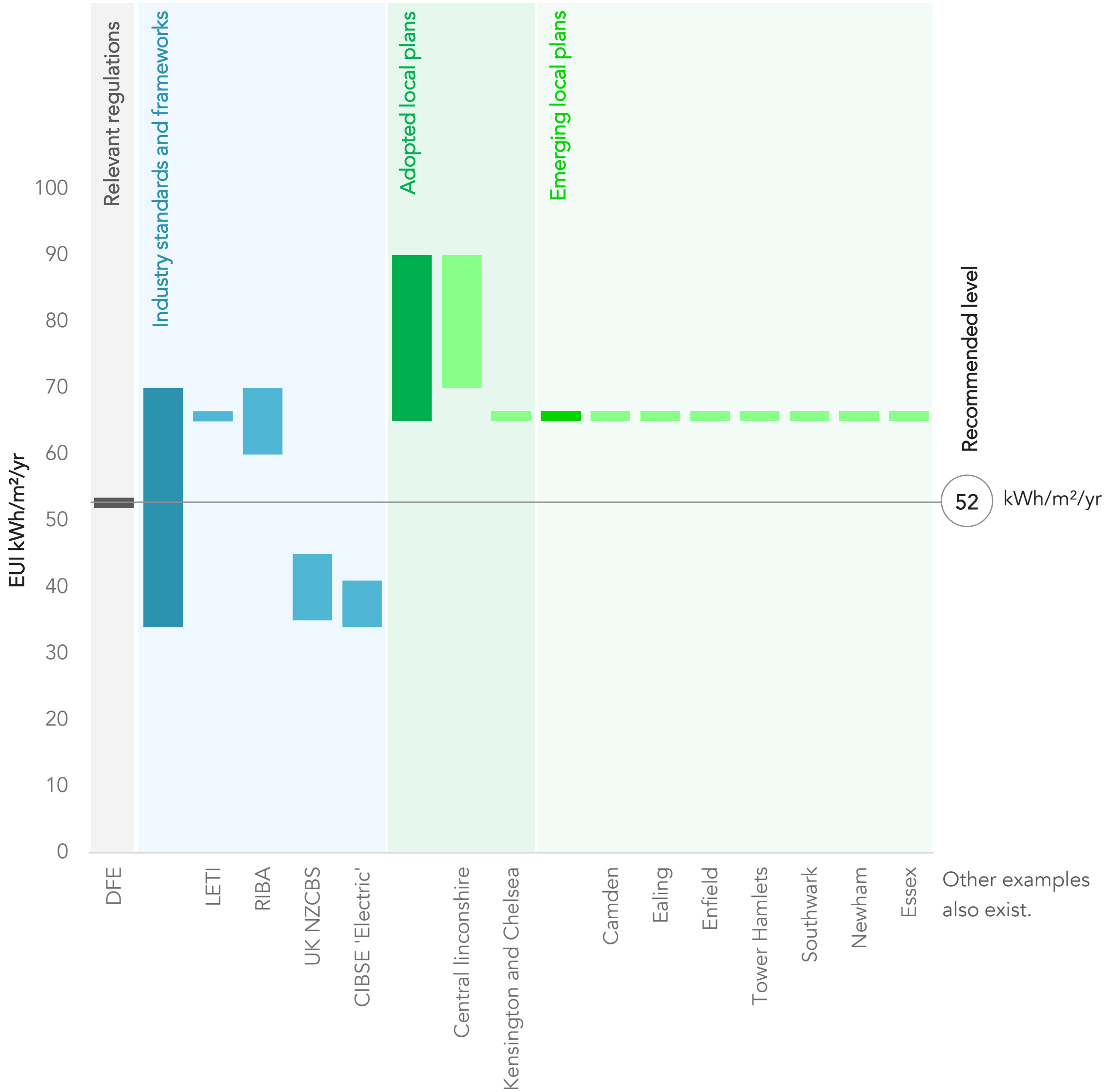
Central Lincolnshire has adopted EUI limits of 70 & 90 kWh/m²/yr, and Kensington and Chelsea have adopted a limit of 65 kWh/m²/yr. At least seven emerging local policies also propose a limit of 65 kWh/m²/yr.

Summary of local evidence base

Based on the modelling we have carried out, we have found out that 52 kWh/m²/yr is an achievable target.

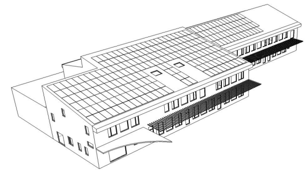
Recommended level: 52 kWh/m²/yr

This level aligns with the DfE Output Specification EUI limit as well as being achievable according to the UK NZCBS limits, which were set from industry engagement.



More detail on the existing evidence of technical feasibility for schools. The CIBSE 'Electric' benchmark range relates to: 'Good practice electricity' level for Primary schools (34), 'Typical practice electricity' level for Primary schools (41).

3.1.5 Technical viability context | Primary schools Space heating demand



This page explains the various space heating demand levels defined for schools by industry standards and benchmarks and set by various local authorities as part of adopted and emerging local plans.

Industry standards and frameworks

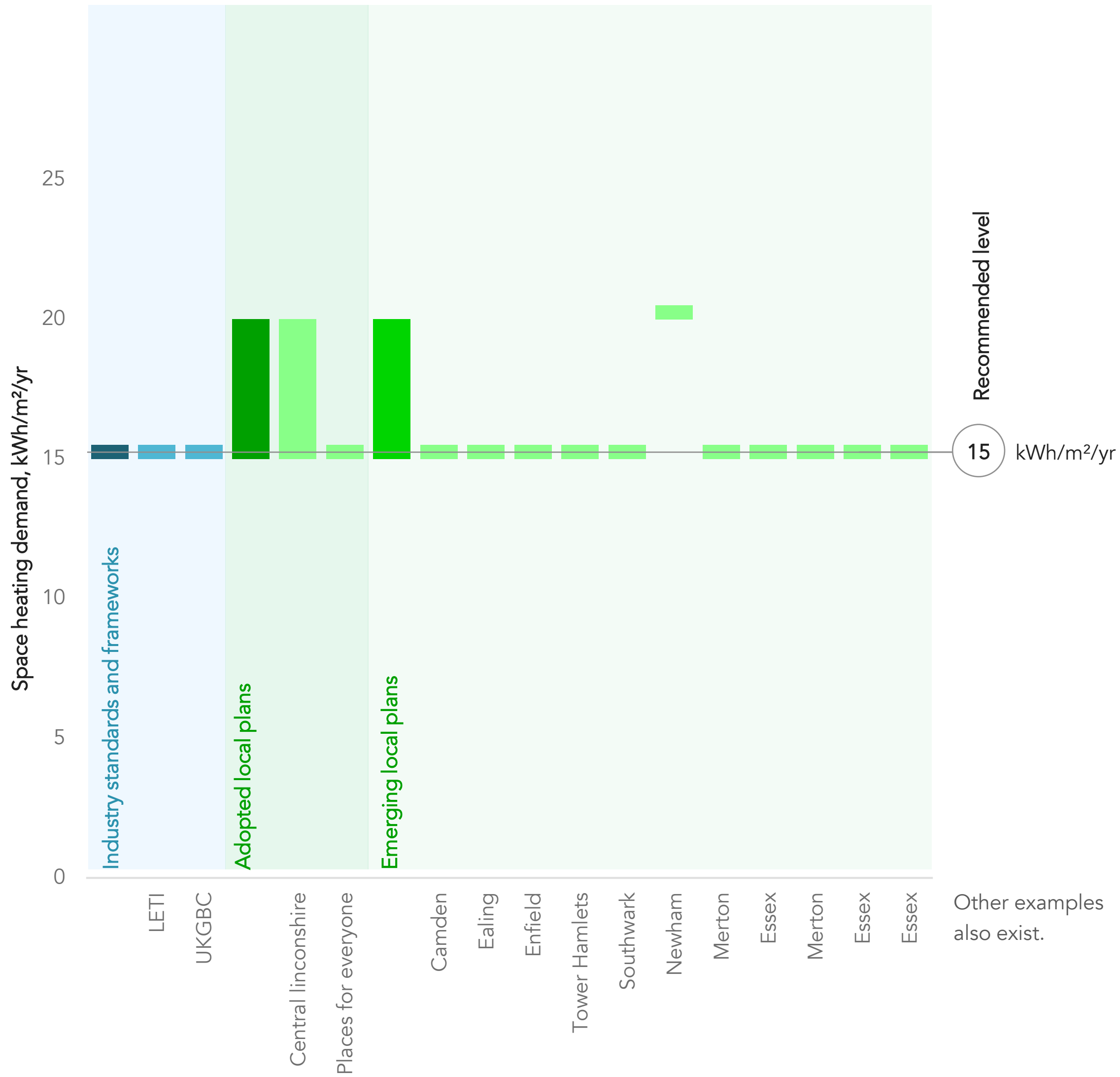
UKGBC and LETI space heating demand limits are 15 kWh/m²/yr.

Adopted and emerging local plans

Central Lincolnshire has adopted limits of 20 kWh/m²/yr. At least eleven emerging local policies also propose a limit of 15 kWh/m²/yr.

Summary of local evidence base

Based on the modelling we have carried out, we have found out that 15 kWh/m²/yr is an achievable target.



More detail on the existing evidence of technical feasibility for schools.

Recommended level: 15 kWh/m²/yr

This level aligns with most other local authorities adopted and emerging local plans and is readily achievable.

3.1.6 School case studies

Ultra-low energy buildings have been delivered for a while now. The educational case studies below meet or perform better than SHD Level 3 (15 kWh/m²GIA). Where SHD is reported per TFA it is overestimated and in reality if their SHD was reported per GIA, it would be even lower. Some approximate EUI data has been shown for the case studies below.

Image source: Architype

Hackbridge, Sutton

Building typology: 2-storey primary school
Architect: Architype
Completion: 2020

Fabric and energy performance:
Exterior wall U-value: 0.13 W/m²K
Ground floor U-value: 0.14 W/m²K
Roof U-value: 0.09 W/m²K
Window U-value: 0.92 W/m²K
Window g-value: 0.52
Airtightness (n50): 0.54 ac/h
Ventilation: MVHR
Heating and hot water: ground source heat pump with bore holes and gas fired hot water storage heater.

SHD: 15 kWh/m²TFA/yr
EUI: c.40 kWh/m²GIA/yr
Certified Passivhaus

Image source: : Rivington Street Studio

Stebon, Tower Hamlets

Building typology: 2-storey primary school
Architect: Rivington Street Studio
Completion: 2015

Fabric and energy performance:
Exterior wall U-value: 0.13 W/m²K
Ground floor U-value: 0.13 W/m²K
Roof U-value: 0.13 W/m²K
Window U-value: 0.6 W/m²K
Airtightness (n50): 0.60 ac/h

SHD: 15 kWh/m²TFA/yr
Certified Passivhaus

Image source: ARch8itype

Mulberry academy, Shoreditch

Building typology: 4-5 storeys secondary school
Architect: Architype
Completion: 2024

Fabric and energy performance:
Form factor: 1.53
Exterior wall U-value: 0.15 W/m²K
Ground floor U-value: 0.09 W/m²K
Roof U-value: 0.15 W/m²K
Window U-value: 0.87 W/m²K
Window g-value: 0.46
Airtightness (n50): 0.20 ac/h
Ventilation: Centralised MVHR
Heating and hot water: Air-sourced heat pumps

SHD: 12 kWh/m²TFA/yr
EUI: c.40 kWh/m²GIA/yr
Certified Passivhaus

Image source: Levitt Bernstein

Plashet Road Nursery, Newham

Building typology: 1 storey nursery
Architect: Levitt Benrstein
Completion: 2024

Fabric and energy performance:
Form factor: 1.53
Exterior wall U-value: 0.15 W/m2K
Ground floor U-value: 0.11 W/m2K
Roof U-value: 0.10 W/m2K
Window U-value: 1.16 W/m2K
Window g-value: 0.53
Airtightness (n50): 0.60 ac/h
Ventilation: MVHR
Heating and hot water: communal air-sourced heat pumps, supplemented by direct electric heating system in each home as a back-up.

SHD: 10 kWh/m²TFA/yr
EUI: 45 kWh/m²GIA/yr
Certified Passivhaus
Renewables: 36 kWh/m²TFA/yr

3.1.6 School case studies

Ultra-low energy buildings have been delivered for a while now. The educational case studies below meet or perform better than SHD Level 3 (15 kWh/m^{2}GIA). Where SHD is reported per TFA it is overestimated and in reality if their SHD was reported per GIA, it would be even lower. Some approximate EUI data has been shown for the case studies below.

Image source: Architype

Oak Meadow Primary School, Wolverhampton

Building typology: 2-storey primary school
Architect: Architype
Completion: 2011

Fabric and energy performance:
Exterior wall U-value: 0.127 W/m2K
Ground floor U-value: 0.127 W/m2K
Roof U-value: 0.107 W/m2K
Window U-value: 0.67 W/m2K
Window g-value: 0.46
Airtightness (n50): 0.48 ac/h
Ventilation: MVHR

SHD: 15 kWh/m^{2}TFA/yr

Certified Passivhaus

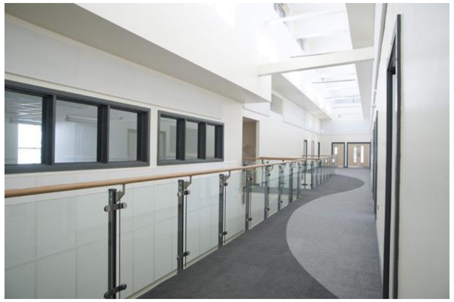


Image source: Space Architecture

Richmond Hill Primary School, Leeds

Building typology: 2-storey primary school
Architect: Space Architecture
Completion: 2012

Fabric and energy performance:
Exterior wall U-value: 0.085 W/m2K
Ground floor U-value: 0.065 W/m2K
Roof U-value: 0.071 W/m2K
Window U-value: 0.6 W/m2K
Window g-value: 0.64
Airtightness (n50): 0.25 ac/h
Ventilation: MVHR

SHD: 11 kWh/m^{2}TFA/yr

Certified Passivhaus

Image source: The Barn Studio

Centre for Renewable Energy and Sustainable Technologies at South West College in Enniskillen, Northern Ireland

Building typology: 1-2 college
Architect: The Barn Studio
Completion: 2014

Fabric and energy performance:
Exterior wall U-value: 0.121 W/m2K
Ground floor U-value: 0.086 W/m2K
Roof U-value: 0.16 W/m2K
Window U-value: 0.57 W/m2K
Window g-value: 0.61
Airtightness (n50): 0.6 ac/h
Ventilation: Centralised MVHR
Heating and hot water: Air to water Heat Pump and direct electric water heater

SHD: 13 kWh/m^{2}TFA/yr

Certified Passivhaus

Image source: : Stride Treglown

Gilbert Ward Academy, Northumberland

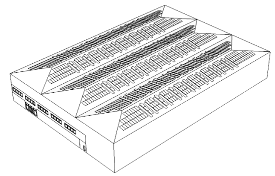
Building typology: 2-storey primary school
Architect: Stride Treglown
Completion: 2024

Fabric and energy performance:
Exterior wall U-value: 0.118 W/m^{2}K
Ground floor U-value: 0.16 W/m^{2}K
Roof U-value: 0.137 W/m^{2}K
Window U-value: 0.55 W/m^{2}K
Airtightness (n50): 0.60 ac/h
Heating and hot water: Air-sourced heat pumps

SHD: 19 kWh/m^{2}TFA/yr

Certified Passivhaus

3.1.7 Technical viability context | Industrial buildings EUI



This page explains the various EUI levels defined for industrial buildings by industry standards and benchmarks and set by various local authorities as part of adopted and emerging local plans.

Industry standards and frameworks

UK NZCBS standard EUI limits are 80 and 40 kWh/m²/yr for 2025 and 2040 derived from stakeholder engagement at the time of development. **There are no other specific EUI limits from industry standards and frameworks.** UK Government are consulting on a performance-based energy rating framework, which will eventually affect large industrial buildings.

Adopted and emerging local plans

Central Lincolnshire has adopted limits of 70 & 90 kWh/m²/yr, and Kensington and Chelsea has adopted a limit of 35 kWh/m²/yr. At least six emerging local policies for other local authorities also propose a limit of 35 kWh/m²/yr.[1]

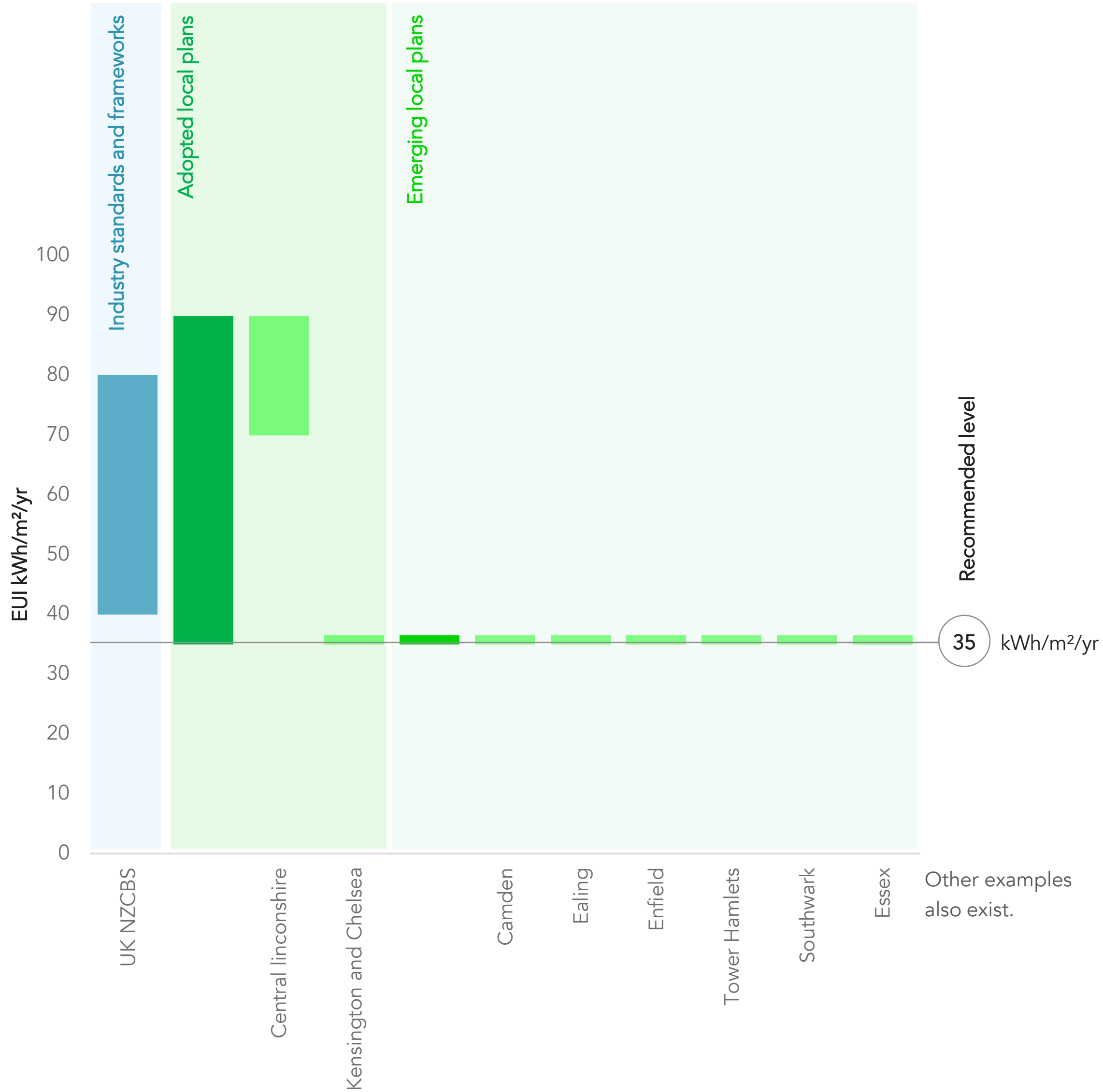
Summary of local evidence base

Based on the modelling we have carried out, we have found out that 35 kWh/m²/yr is an achievable target if either heat pump heating or ultra low energy fabric is used.

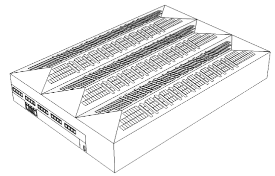
Recommended level: 35 kWh/m²/yr

This aligns with current adopted and emerging local plans.

[1] *The London Borough of Newham proposes a limit of 100 - 120 kWh/m²/yr for industrial buildings, this has been removed from the graph, as these are for more intensive industrial buildings than assumed in this evidence base.*



More detail on the existing evidence of technical feasibility for industrial buildings.



This page explains the various space heating demand levels defined for industrial buildings by industry standards and benchmarks and set by various local authorities as part of adopted and emerging local plans.

Industry standards and frameworks

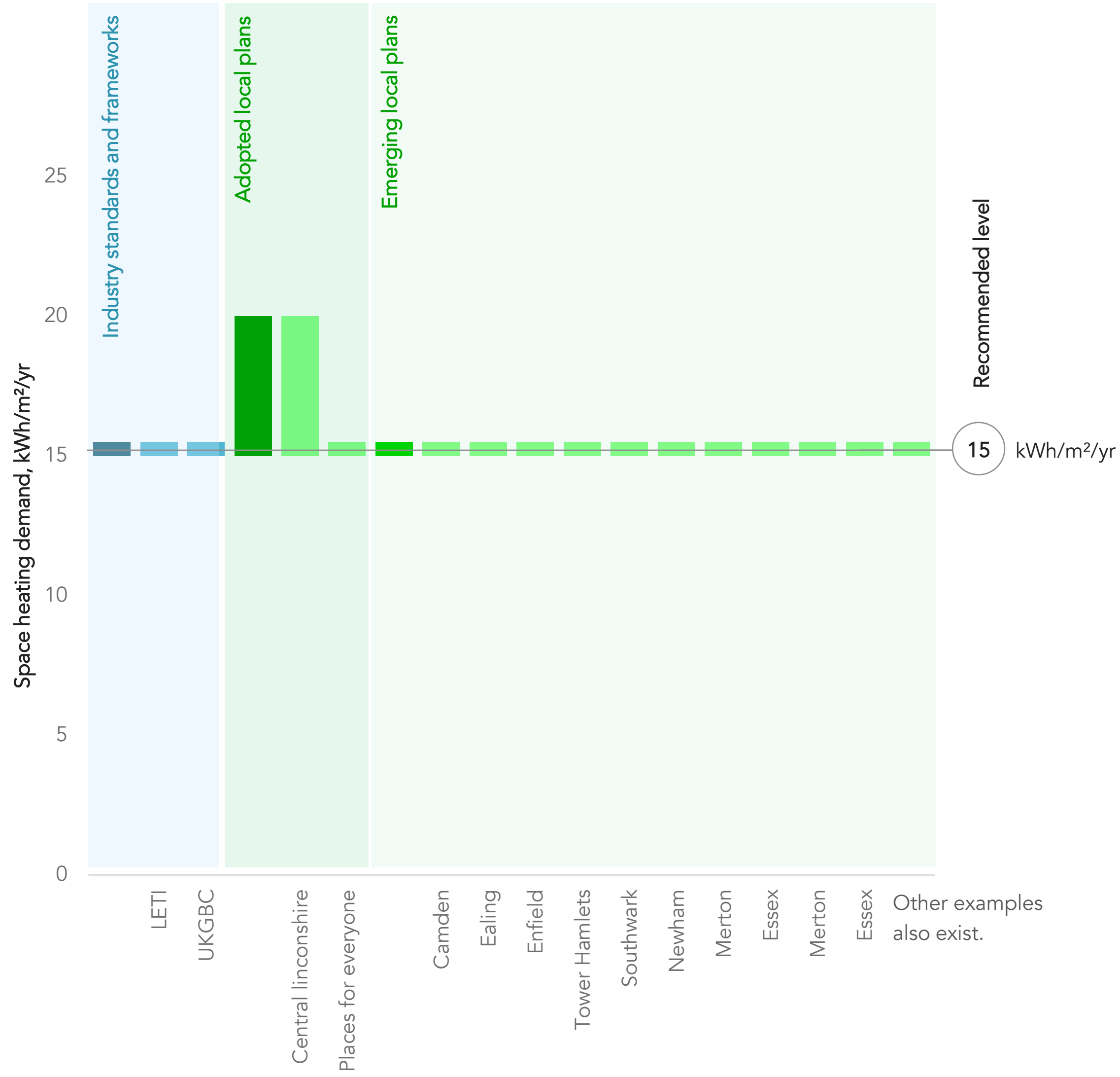
UKGBC and LETI space heating demand limits are 15 kWh/m²/yr.

Adopted and emerging local plans

Central Lincolnshire has adopted limits of 20 kWh/m²/yr. At least eleven emerging local policies also propose a limit of 15 kWh/m²/yr.

Summary of local evidence base

Based on the modelling we have carried out, we have found out that 15 kWh/m²/yr is an achievable target.



More detail on the existing evidence of technical feasibility for industrial buildings.

Recommended level: 15 kWh/m²/yr

This level aligns with most other local authorities adopted and emerging local plans and is readily achievable.

3.2

Non-Residential energy modelling: Analysis and Results

3.2 Non-residential buildings Energy modelling: Analysis and results

3.2

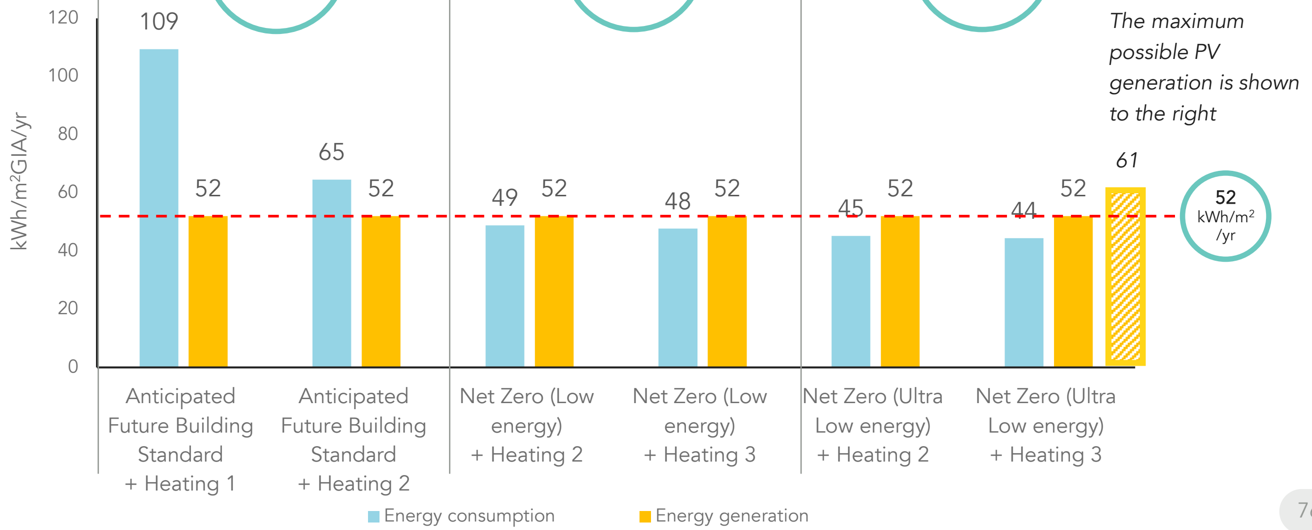
Contents

3.2.1 Primary school building I Energy modelling results

Observations:

- The space heating demand target of 30kWh/m²/year is achieved in both the low and ultra low energy scenarios.
- The most stringent space heating demand target of 15kWh/m²/year is met in the ultra low energy scenario and that's achieved primarily through enhanced air-tightness standards, as well as improvements in the building fabric.
- The Energy Use Intensity (EUI) target of 52 kWh/m²·year is achieved across all policy scenarios, indicating that overall building energy performance aligns with the target threshold.
- An annual energy balance is achieved in all policy scenarios through the proposed photovoltaic (PV) generation capacity, ensuring that on-site renewable energy production offsets the total annual energy demand.

	Benchmark / Context	Policy Options	
	Anticipated Future Building Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)
Space heating demand <15 kWh/m²/yr	✗	✗	✓
Space heating demand <30 kWh/m²/yr	✗	✓	✓
Energy Use Intensity <52 kWh/m²/yr	✗	✓	✓
Renewable energy balance	✗	✓	✓
Space heating demand results kWh/m²/yr	68 kWh/m²/yr	25 kWh/m²/yr	15 kWh/m²/yr

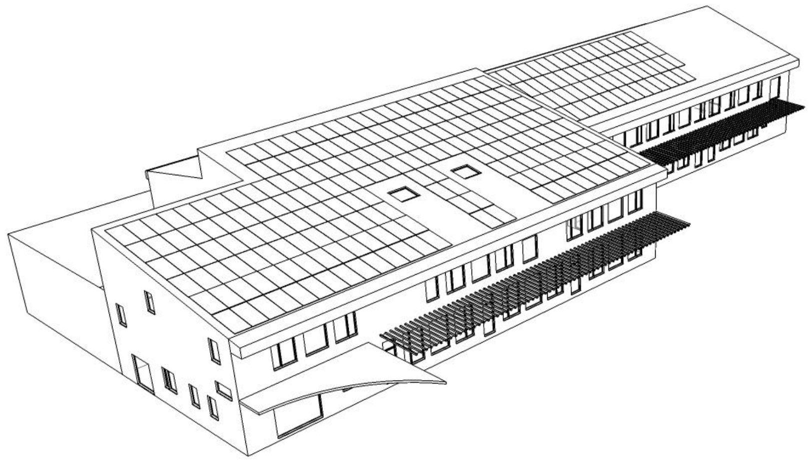


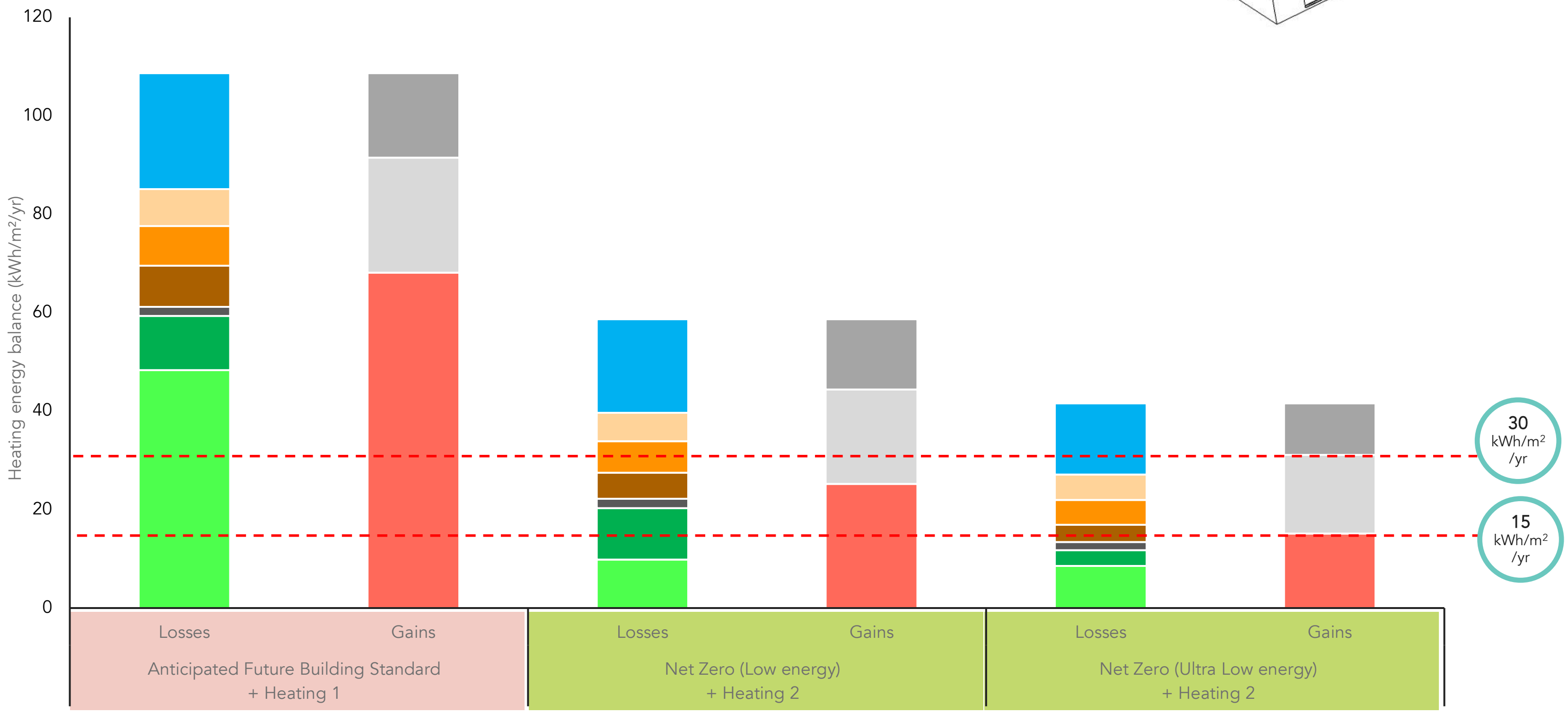
3.2.2 Primary school building | Modelling summary and results breakdown

The graph below illustrates the breakdown of the space heating energy balance for the primary school building, highlighting the contributions of heat gains and losses from various components.

The impact of the mechanical ventilation with heat recovery system in the two policy options significantly reduces the heat losses and, consequently, the space heating demand.

The detailed specifications of all scenarios are presented in Appendix 6.





Detailed energy use breakdown (kWh/m².yr)	
Solar Gains	
Internal Gains	
Heating	
Windows	
Roof	
Wall	
Floor	
Thermal bridges	
Infiltration	
Ventilation	

This graph illustrates the breakdown of the space heating energy balance for all scenarios of the primary school building.

3.2.2 Primary school building | Modelling summary and results breakdown

The graph below presents the breakdown of total energy use for the primary school building and compares it with the on-site renewable energy generation.

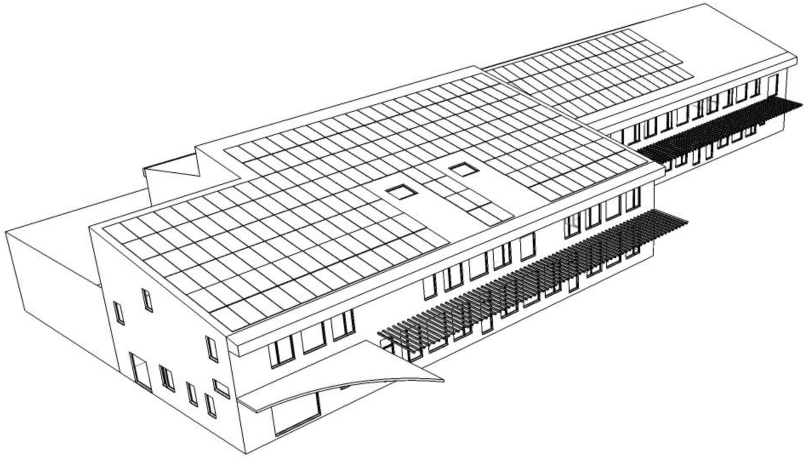
The following combinations of heating systems have been modelled:

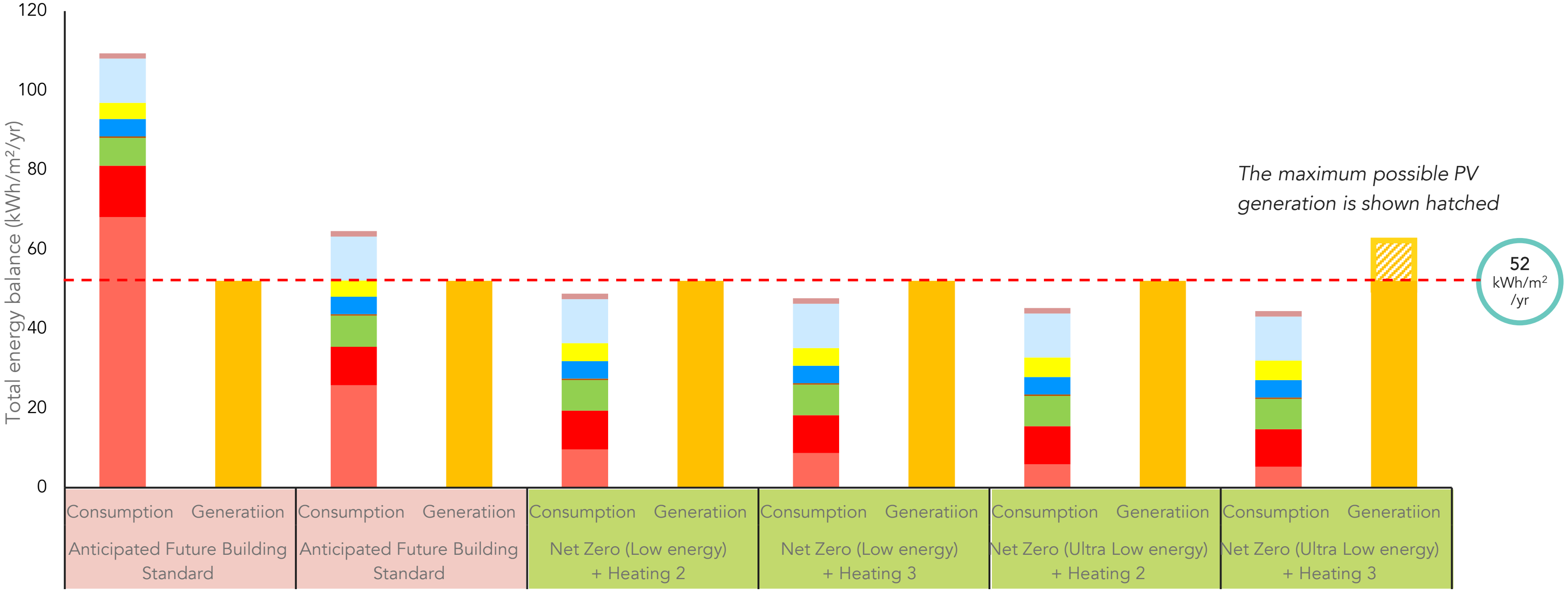
Heating 1: A low-efficiency heat pump serves the school spaces, while hot water is provided by direct electric points of use.

Heating 2: A communal heat pump serves the school spaces. Hot water for the bathrooms is provided by direct electric points of use, while hot water for the kitchen spaces is supplied via the heat pump system.

Heating 3: The same system as Heating 2 is assumed, but with a more efficient heat pump.

The heat pump, when paired with good practice fabric specifications, significantly reduces energy consumption.





Detailed energy use breakdown (kWh/m².yr)	
Generation	
Other	
Catering	
External lighting	
Internal lighting	
Equipment & appliances	
Lifts	
Fans & pumps	
Cooling	
Hot water	
Space heating	

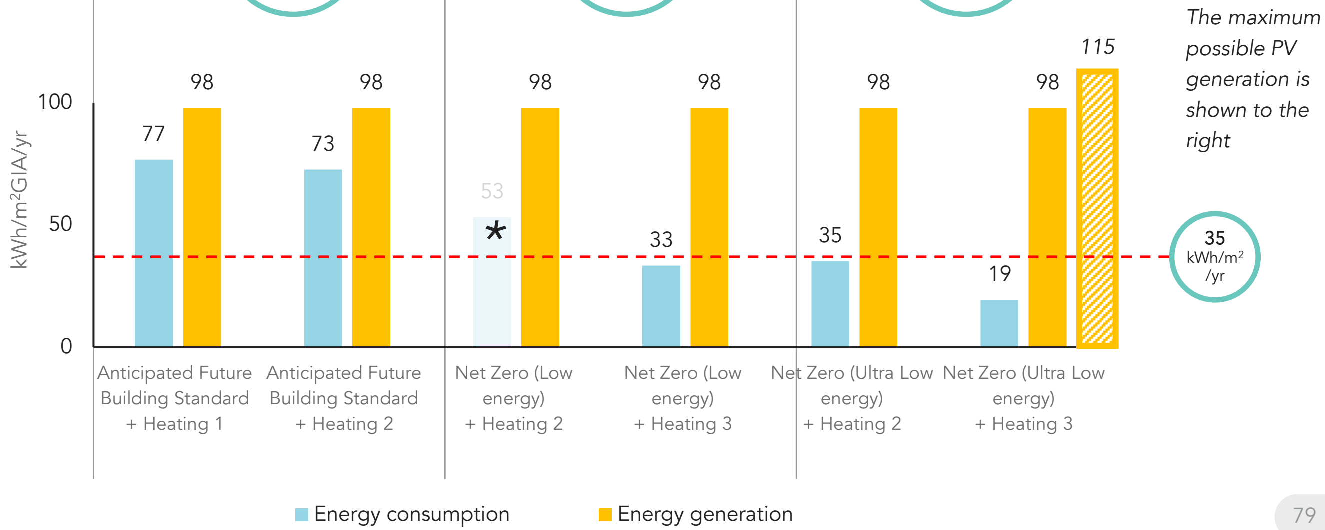
This graph illustrates the breakdown of total energy use for all scenarios of the primary school building.

3.2.3 Industrial building | Energy modelling results

Observations:

- The space heating demand target of 30kWh/m²/year is achieved in both the low and ultra low energy scenarios.
- The most stringent space heating demand target of 15kWh/m²/year is met in the ultra low energy scenario and that's achieved primarily through enhanced air-tightness standards, as well as improvements in the building fabric.
- The Energy Use Intensity (EUI) target of 35 kWh/m²·year is achieved across all policy scenarios, **which have either a centralised heat pump for heating or ultra low building fabric**, where both are used, the target is comfortably exceeded.
- An annual energy balance is achieved in all policy scenarios through the proposed photovoltaic (PV) generation capacity, with generation significantly exceeding the requirement.

	Benchmark / Context	Policy Options	
	Anticipated Future Building Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)
Space heating demand <15 kWh/m²/yr	✗	✗	✓
Space heating demand <30 kWh/m²/yr	✗	✓	✓
Energy Use Intensity <35 kWh/m²/yr	✗	✗ ✓	✓
Renewable energy balance	✗	✓	✓
Space heating demand results kWh/m²/yr	51 kWh/m²/yr	30 kWh/m²/yr	12 kWh/m²/yr



Not met for electric heating without ultra low energy building fabric.

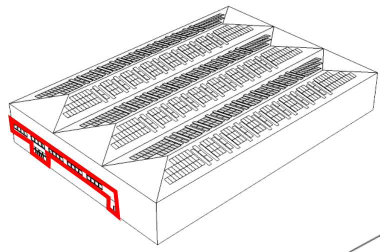
3.2.4 Industrial building | Modelling summary and results breakdown

The graph below illustrates the breakdown of the space heating energy balance for the industrial building, highlighting the contributions of heat gains and losses from various components.

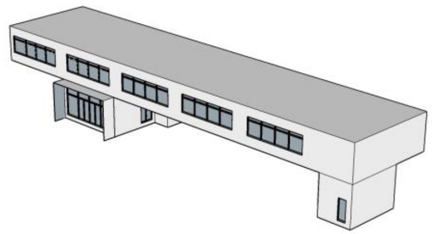
The office and warehouse sections were modelled as separate zones in PHPP to determine the space heating demand specific to this building. Other energy uses, apart from heating and hot water were based on data from a comparable industrial building model.

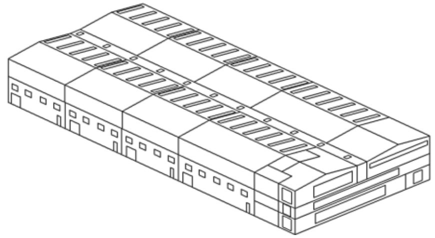
The detailed specifications of all scenarios are presented in Appendix 6.

Office space & warehouse

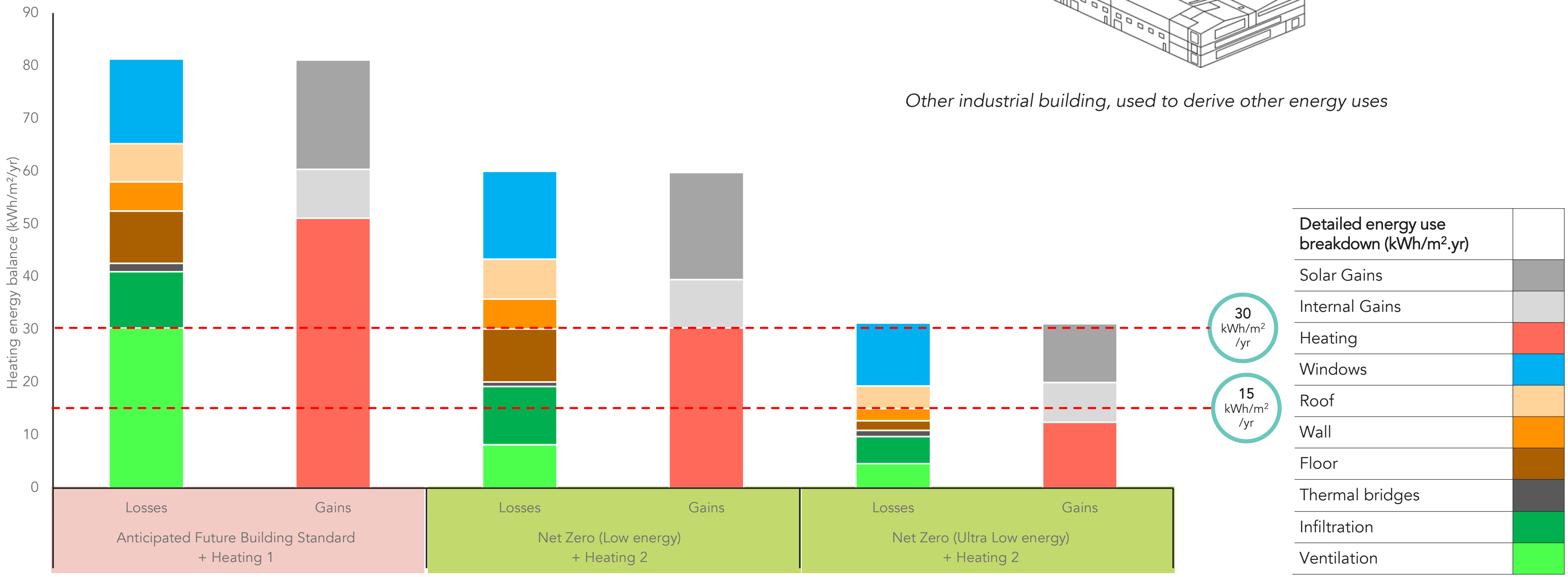


Office space





Other industrial building, used to derive other energy uses



This graph illustrates the breakdown of the space heating energy balance for all scenarios of the industrial building.

3.2.4 Industrial building | Modelling summary and results breakdown

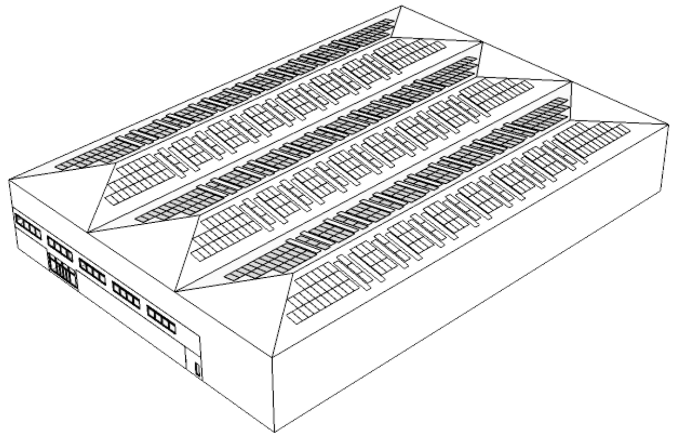
The graph below presents the breakdown of total energy use for the industrial building and compares it with the on-site renewable energy generation.

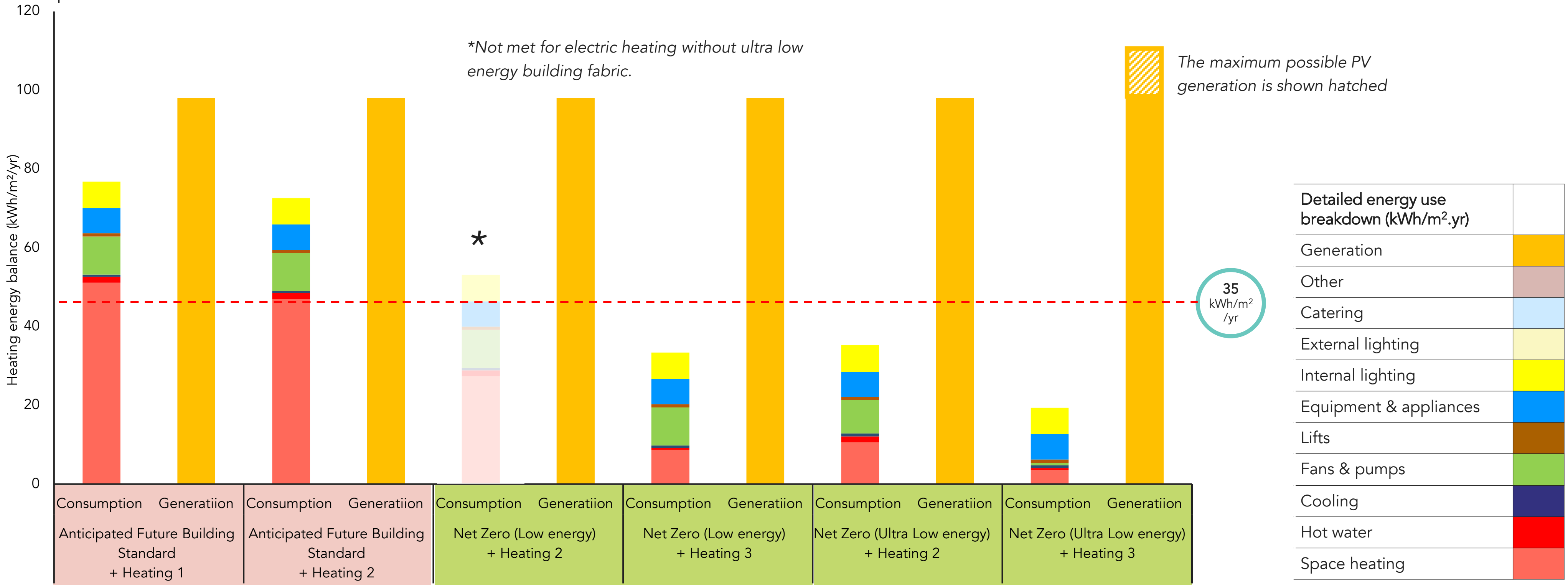
The following combinations of heating systems have been modelled:

Heating 1: A low-efficiency heat pump serves the office spaces, while direct electric heating serves the warehouse spaces. Hot water is provided by direct electric.

Heating 2: A VRF system serves the office spaces, while direct electric heating serves the warehouse spaces. Hot water is provided by direct electric.

Heating 3: A central heat pump provides both heating and hot water to all spaces.





This graph illustrates the breakdown of total energy use for all scenarios of the industrial building.

3.3

Non-Residential energy modelling:
PV Analysis

3.3 Non-Residential Energy modelling: PV Analysis

3.3

Contents

3.3.1 Renewable energy | Determining a feasible amount of generation

For each of the non-residential buildings modelled, we have calculated the expected PV generation required to meet the anticipated Future Building Standard, as well as a maximum scenario using the full available roof capacity.

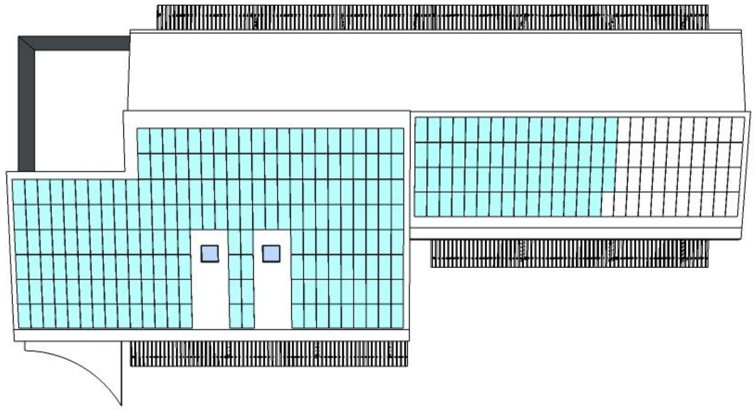
PV likely to be required by the Anticipated Future Building Standard

A 50% footprint coverage has been assumed for the primary school building, in line with the anticipated Future Building Standard requirement, which ranges from 40% to 75% depending on the zone type.

For the industrial building, the requirement is set at 75% PV coverage of the footprint for top-lit spaces. A 70% coverage has been assumed to account for the 40% requirement in the office areas.

Maximum PV possible

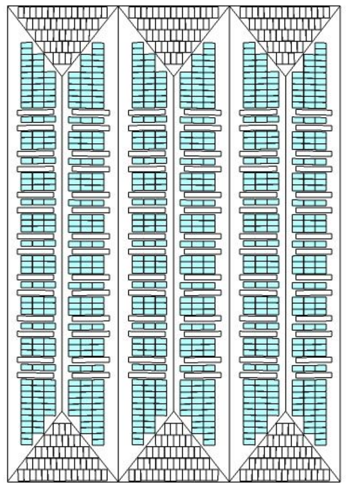
Under the maximum PV scenario, the number of panels that can be technically installed on the roof has been calculated. The roof plans on the right illustrate these layouts. This option has been also costed for reference.



265 panels or 160kWp

Anticipated FBS requirement

Graphical representation of PV panels on the roof of the primary school building, showing the number assumed required for the anticipated Future Building Standard requirement (in blue). Illustration is based on 605Wp panels. The maximum possible is 308 panels or 186kWp (shown in outline).



1514 panels or 916kWp

Anticipated FBS requirement

Graphical representation of PV panels on the roof of the industrial building, showing the number assumed required for the anticipated Future Building Standard requirement (in blue). Illustration is based on 605Wp panels. The maximum possible is 1780 panels or 1077kWp (shown in outline).

4.0

Cost evidence base

4.1

Cost evidence base:

Running costs

4.1 Running Costs

4.1

Contents

4.1.1 Energy running costs | Analysis summary

The energy running costs analysis was carried out to provide visibility on subsequent occupant bills in relation to the different residential scenarios.

A summary of the running cost analysis is shown to the right.

The energy costs are shown per home, assuming a medium occupancy amount of self-consumption from PV generated electricity (following the guidance in the MCS solar PV self-consumption data tables). The results subtract the self-consumption and solar export income from the overall energy costs which results in negative bills in several cases. For simplicity, the proportions of solar are not itemised within the following graphs.

The analysis uses current average 2025 pricing data from OFGEM and average 2025 dynamic tariff pricing data from Octopus Energy. All figures shown relate to the price cap tariff, but the dynamic tariff data is shown alongside for direct comparison in the graphs. Conservative estimates based on zero peak avoidance have been used in this cost analysis for the dynamic tariffs, but the potential for greater savings is significant if households utilise technologies such as battery storage or timers to avoid peak use. These strategies enable occupants to only pay for electricity at the lower unit rates and can result in significant savings.

In most typologies, the optimised saving on energy running costs is with the additional PV and battery. In the low and ultra low energy options, the running costs are also reduced quite significantly. This is enabled by generating more energy than is used by the household, improving the rate of self-consumption and then exporting a significant amount to the grid. The amount of PV in all these cases meets or exceeds the anticipated FHS* requirement for solar on at least 40% of the building footprint. The two net-zero options have been assessed based on 60% of the building footprint being covered by renewable generation.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

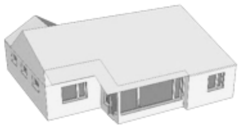
	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Bungalow	↓ £653	↓ £1006	↓ £1603	↓ £1719
Detached house	↓ £370	↓ £1717	↓ £1167	↓ £1299
Semi-detached house	↓ £284	↓ £1275	↓ £763	↓ £829
Mid-terrace house	↓ £313	↓ £1153	↓ £708	↓ £770
Two 1-bed flats (per flat)	↓ £131	↓ £619	↓ £405	↓ £452
Mid-rise block of flats (per flat)	↑ £166	N/A	↓ £192	↓ £211

Summary of difference in annual energy running costs compared to Part L 2021

Assumption	Data
Gas – *price cap tariff 2025 (Q1, Q2, Q3) average*	
Standing charge	£115 per yr
Unit price	0.0655 £/kWh
Electricity – *price cap tariff 2025 (Q1, Q2, Q3) average*	
Standing charge	£202 per yr
Unit price	0.2587 £/kWh
Electricity – *dynamic tariff 2025 (Q1, Q2) average*	
Standing charge	£209 per yr
Unit price	0.2264 £/kWh
Electricity – *export tariff 2025 (Octopus flat rate)*	0.15 £/kWh

List of key data used to calculate energy costs

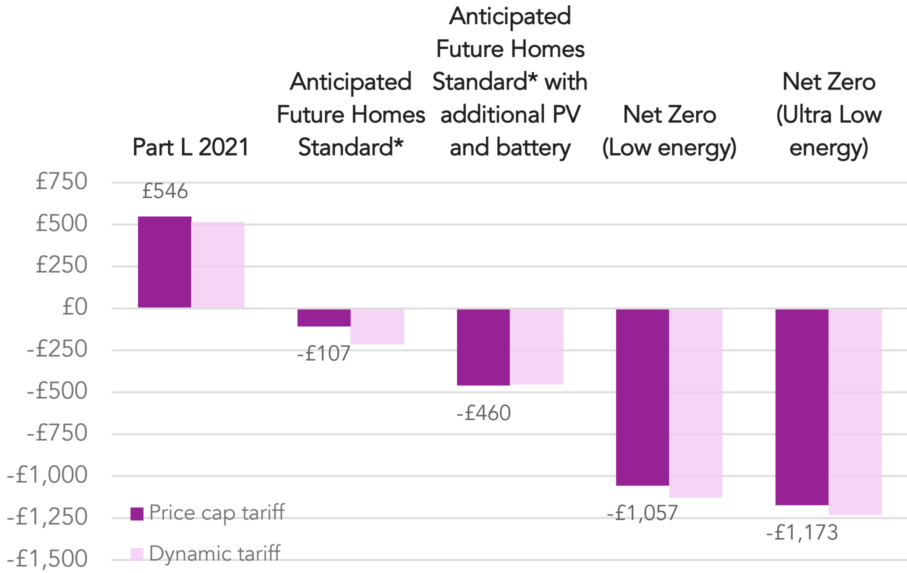
4.1.2 Bungalow | Energy costs modelling



The adjacent graph provides a summary of the annual energy costs for a bungalow built to five different energy performance levels.

- To comply with the anticipated Future Homes Standard* installing a **PV system covering at least 40% of the building's footprint**, results in levels of solar generation far exceeding the household energy use in this scenario. The self-consumption together with the export income result in the household receiving a **net gain**.
- The Part L 2021 scenario is the only case which includes gas as an energy source for space heating and DHW. As the other building scenarios are fully electric, they **avoid the gas standing charge** (£115 per year).
- The scenario with **additional PV and battery storage results in significant savings** as the battery storage enables a much higher self-consumption percentage. Since the electricity unit rate for import is higher than export, there is greater value to the household if they can maximise their solar self-consumption. The battery storage may also enable the user to take further advantage of the lower dynamic tariffs rates by avoiding peak use when they need to import electricity.
- The Net Zero (low-energy and ultra-low energy) scenarios shows notably lower running costs compared with the FHS* scenario with additional PV and battery in the bungalow typology.
- The higher performing fabric of the Net Zero options enables approximately **~£950 – £1000 annual savings** compared to the anticipated FHS* and over £1600 compared to Part L 2021.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*



Estimated annual energy costs for a 109 m² bungalow in South Warwickshire across 5 different energy performance levels

Assumption		Data
South Warwickshire bungalow size		109 m² GIFA
Part L 2021	– annual energy use	11,895 kWh/yr
	– annual energy generation	5,593 kWh/yr
Anticipated Future Homes Standard*	– annual energy use	4,857 kWh/yr
	– annual energy generation	9,475 kWh/yr
Anticipated Future Homes Standard* with additional PV and battery	– annual energy use	4,857 kWh/yr
	– annual energy generation	9,264 kWh/yr
Net Zero (Low Energy)	– annual energy use	3,723 kWh/yr
	– annual energy generation	13,850 kWh/yr
Net Zero (Ultra Low Energy)	– annual energy use	3,198 kWh/yr
	– annual energy generation	13,850 kWh/yr

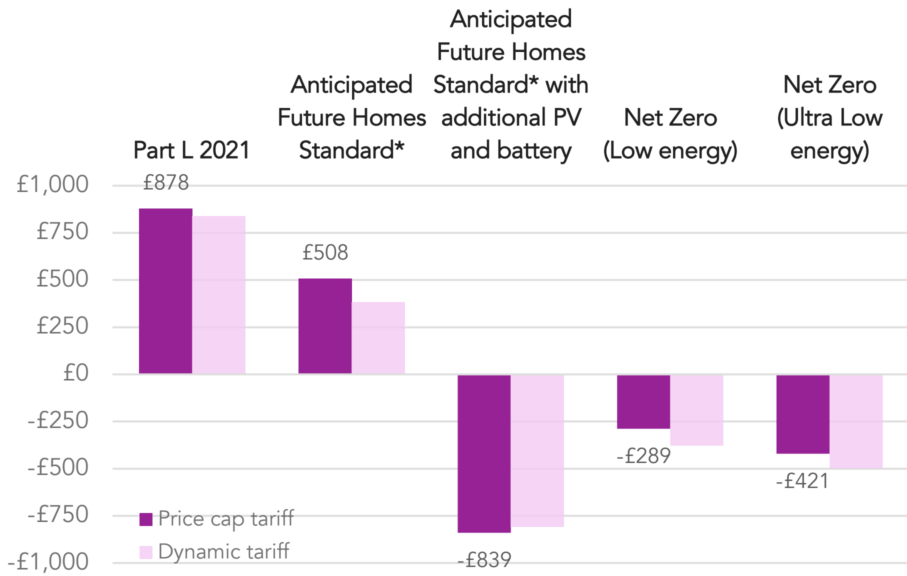
List of key modelling assumptions used to calculate energy costs

4.1.3 Detached house | Energy costs modelling

The adjacent graph provides a summary of the annual energy costs for a detached house built to five different energy performance levels.

- To comply with the anticipated Future Homes Standard* installing a **PV system covering at least 40% of the building's footprint**, results in levels of solar generation which exceed the household energy use in this scenario. The self-consumption together with the export income result in the household receiving a **net gain** in the case where there is additional PV and battery storage or both the Net Zero (Low energy and Ultra low energy) improved fabric options.
- The Part L 2021 scenario is the only case which includes gas as an energy source for space heating and DHW. As the other building scenarios are fully electric, they **avoid the gas standing charge** (£115 per year).
- The scenario with **additional PV and battery storage results in significant savings** as the battery storage enables a much higher self-consumption percentage. Since the electricity unit rate for import is higher than export, there is greater value to the household if they can maximise their solar self-consumption. The battery storage may also enable the user to take further advantage of the lower dynamic tariffs rates by avoiding peak use when they need to import electricity.
- The higher performing fabric of the Net Zero options enables approximately **~£795 – £930 annual savings** compared to the anticipated FHS* and over £1100 compared to Part L 2021.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

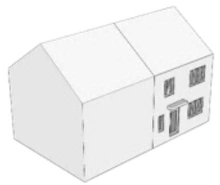


Estimated annual energy costs for a 142 m² detached house in South Warwickshire across 5 different energy performance levels

Assumption		Data
South Warwickshire detached house size		142 m² GIFA
Part L 2021	– annual energy use	13,708 kWh/yr
	– annual energy generation	4,510 kWh/yr
Anticipated Future Homes Standard*	– annual energy use	5,589 kWh/yr
	– annual energy generation	6,514 kWh/yr
Anticipated Future Homes Standard* with additional PV and battery	– annual energy use	5,589 kWh/yr
	– annual energy generation	12,010 kWh/yr
Net Zero (Low Energy)	– annual energy use	4,322 kWh/yr
	– annual energy generation	9,771 kWh/yr
Net Zero (Ultra Low Energy)	– annual energy use	3,709 kWh/yr
	– annual energy generation	9,771 kWh/yr

List of key modelling assumptions used to calculate energy costs

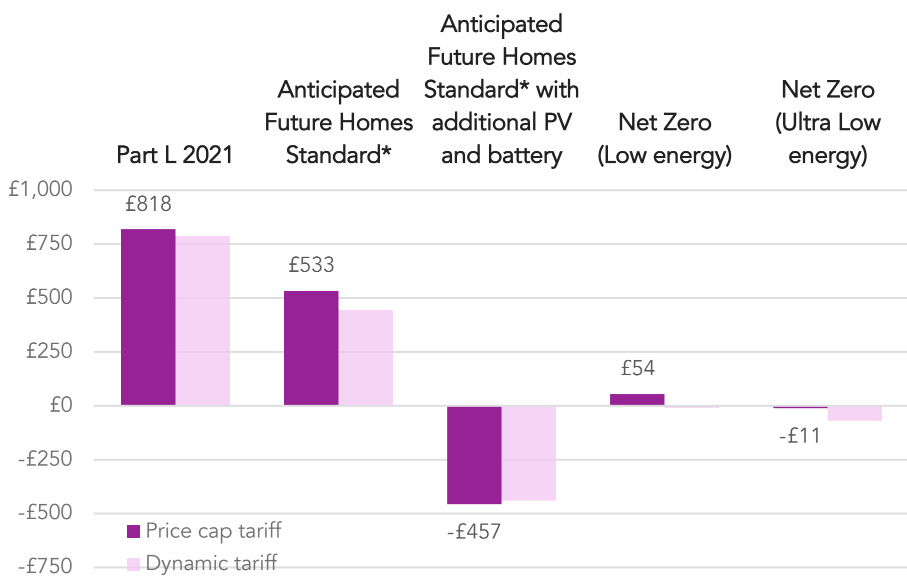
4.1.4 Semi-Detached house | Energy costs modelling



The adjacent graph provides a summary of the annual energy costs for a semi-detached house built to five different energy performance levels.

- To comply with the anticipated Future Homes Standard* installing a **PV system covering at least 40% of the building's footprint**, results in levels of solar generation which are comparable with the household energy use in this scenario. The self-consumption together with the export income result in the household receiving a **net gain** only in the case where there is additional PV and battery storage.
- The Part L 2021 scenario is the only case which includes gas as an energy source for space heating and DHW. As the other building scenarios are fully electric, they **avoid the gas standing charge** (£115 per year).
- The scenario with **additional PV and battery storage results in significant savings** as the battery storage enables a much higher self-consumption percentage. Since the electricity unit rate for import is higher than export, there is greater value to the household if they can maximise their solar self-consumption. The battery storage may also enable the user to take further advantage of the lower dynamic tariffs rates by avoiding peak use when they need to import electricity.
- The higher performing fabric of the Net Zero options enables approximately **~£480 – £545 annual savings** compared to the anticipated FHS* and over £760 compared to Part L 2021.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

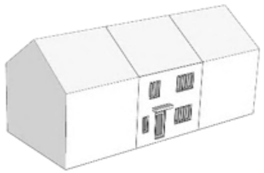


Estimated annual energy costs for a 93 m² semi-detached house in South Warwickshire across 5 different energy performance levels

Assumption		Data
South Warwickshire semi-detached house size		93 m² GIFA
Part L 2021	– annual energy use	8,938 kWh/yr
	– annual energy generation	2,322 kWh/yr
Anticipated Future Homes Standard*	– annual energy use	3,891 kWh/yr
	– annual energy generation	3,833 kWh/yr
Anticipated Future Homes Standard* with additional PV and battery	– annual energy use	3,833 kWh/yr
	– annual energy generation	7,974 kWh/yr
Net Zero (Low Energy)	– annual energy use	3,151 kWh/yr
	– annual energy generation	5,749 kWh/yr
Net Zero (Ultra Low Energy)	– annual energy use	2,845 kWh/yr
	– annual energy generation	5,749 kWh/yr

List of key modelling assumptions used to calculate energy costs

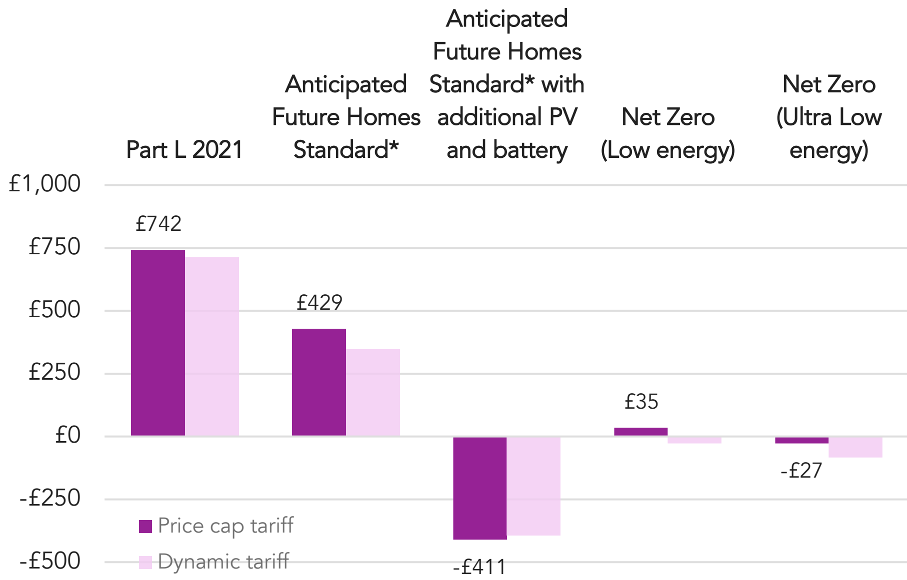
4.1.5 Terrace house | Energy costs modelling



The adjacent graph provides a summary of the annual energy costs for a mid-terrace house built to five different energy performance levels.

- To comply with the anticipated Future Homes Standard* installing a **PV system covering at least 40% of the building's footprint**, results in levels of solar generation which exceed the household energy use in this scenario. The self-consumption together with the export income result in the household receiving a **net gain** only in the case where there is additional PV and battery storage.
- The Part L 2021 scenario is the only case which includes gas as an energy source for space heating and DHW. As the other building scenarios are fully electric, they **avoid the gas standing charge** (£115 per year).
- The scenario with **additional PV and battery storage results in significant savings** as the battery storage enables a much higher self-consumption percentage. Since the electricity unit rate for import is higher than export, there is greater value to the household if they can maximise their solar self-consumption. The battery storage may also enable the user to take further advantage of the lower dynamic tariffs rates by avoiding peak use when they need to import electricity.
- The higher performing fabric of the Net Zero options enables approximately **~£390– £455 annual savings** compared to the anticipated FHS* and over £700 compared to Part L 2021.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

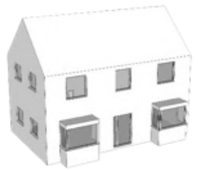


Estimated annual energy costs for a 93 m² mid-terrace house in South Warwickshire across 5 different energy performance levels

Assumption		Data
South Warwickshire mid-terrace house size		93 m² GIFA
Part L 2021	– annual energy use	7,869 kWh/yr
	– annual energy generation	2,320 kWh/yr
Anticipated Future Homes Standard*	– annual energy use	3,694 kWh/yr
	– annual energy generation	4,164 kWh/yr
Anticipated Future Homes Standard* with additional PV and battery	– annual energy use	3,694 kWh/yr
	– annual energy generation	7,577 kWh/yr
Net Zero (Low Energy)	– annual energy use	3,072 kWh/yr
	– annual energy generation	5,744 kWh/yr
Net Zero (Ultra Low Energy)	– annual energy use	2,781 kWh/yr
	– annual energy generation	5,744 kWh/yr

List of key modelling assumptions used to calculate energy costs

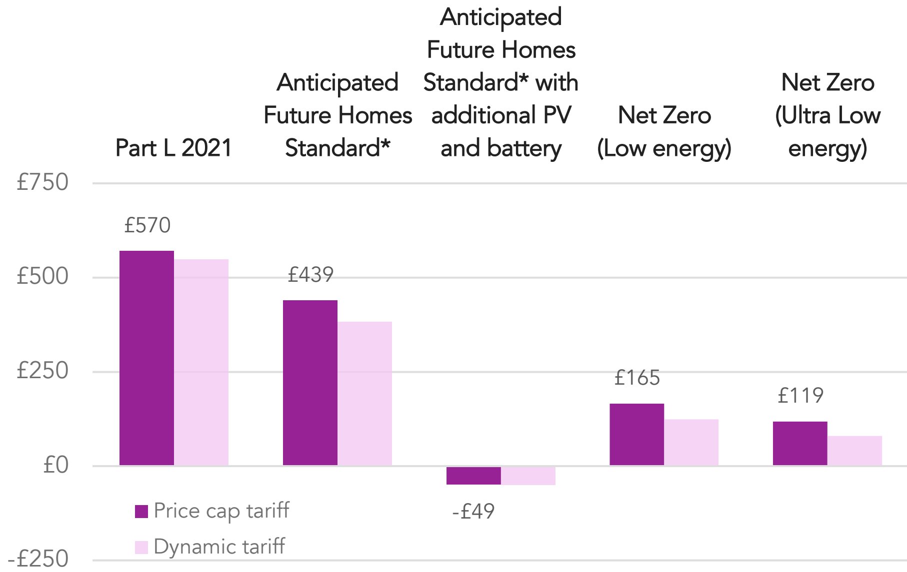
4.1.6 Two 1-bed flats | Energy costs modelling



The adjacent graph provides a summary of the annual energy costs for a one-bed flat built to five different energy performance levels.

- To comply with the anticipated Future Homes Standard* installing a **PV system covering at least 40% of the building's footprint**, results in levels of solar generation which is comparable with the household energy use in this scenario. The self-consumption together with the export income result in the household receiving a **net gain** only in the case where there is additional PV and battery storage.
- The Part L 2021 scenario is the only case which includes gas as an energy source for space heating and DHW. As the other building scenarios are fully electric, they **avoid the gas standing charge** (£115 per year).
- The scenario with **additional PV and battery storage results in significant savings** as the battery storage enables a much higher self-consumption percentage. Since the electricity unit rate for import is higher than export, there is greater value to the household if they can maximise their solar self-consumption. The battery storage may also enable the user to take further advantage of the lower dynamic tariffs rates by avoiding peak use when they need to import electricity.
- The higher performing fabric of the Net Zero options enables approximately **~£270 – £320 annual savings** compared to the anticipated FHS* and over £400 compared to Part L 2021.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*



Estimated annual energy costs for a 56 m² 1-bed flat in South Warwickshire across 5 different energy performance levels

Assumption		Data
South Warwickshire 1-bed flat size		56 m² GIFA
Part L 2021	– annual energy use	5,900 kWh/yr
	– annual energy generation	2,228 kWh/yr
Anticipated Future Homes Standard*	– annual energy use	2,605 kWh/yr
	– annual energy generation	2,451 kWh/yr
Anticipated Future Homes Standard* with additional PV and battery	– annual energy use	2,605 kWh/yr
	– annual energy generation	4,467 kWh/yr
Net Zero (Low Energy)	– annual energy use	2,136 kWh/yr
	– annual energy generation	3,475 kWh/yr
Net Zero (Ultra Low Energy)	– annual energy use	1,896 kWh/yr
	– annual energy generation	3,475 kWh/yr

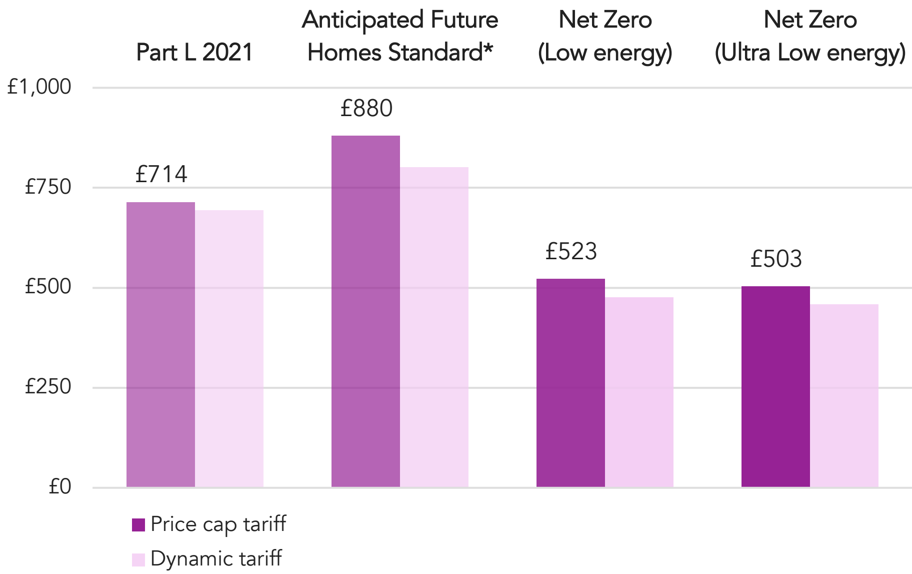
List of key modelling assumptions used to calculate energy costs

4.1.7 Mid-rise block of flats | Energy costs modelling

The adjacent graph provides a summary of the annual energy costs for a mid-rise flat built to five different energy performance levels.

- To comply with the anticipated Future Homes Standard*, there is a **lower relative PV requirement for blocks of flats** as the footprint used is divided by the number of storeys to calculate how much PV is required. This results in much lower levels of solar generation than the household energy use of the flats in this scenario where net gain is not possible. A r amount of PV must be included for the Part L 2021 option to compensate for the inclusion of a gas boiler in the SAP calculations. The difference in calculations means that there is less PV included in the FHS* option than Part L 2021, which creates an anomaly resulting in higher running costs for the FHS* scenario than for Part L 2021.
- The Part L 2021 scenario is the only case which includes gas as an energy source for space heating and DHW. As the other building scenarios are fully electric, they **avoid the gas standing charge** (£115 per year).
- Due to the complexity of building services and penetrations using roof space, the additional PV and battery storage scenario has not been considered for this typology.
- The higher performing fabric of the Net Zero options enables approximately **~£355 – £375 annual savings** per flat compared to the anticipated FHS* and over £190 compared to Part L 2021.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*



Estimated annual energy costs for a 65 m² mid-rise flat in South Warwickshire across 5 different energy performance levels

Assumption		Data
South Warwickshire mid-rise flat size		65 m² GIFA
Part L 2021	– annual energy use	5,519 kWh/yr
	– annual energy generation	1,171 kWh/yr
Anticipated Future Homes Standard*	– annual energy use	2,818 kWh/yr
	– annual energy generation	229 kWh/yr
Anticipated Future Homes Standard with additional PV and battery*	*– annual energy use*	*Not included*
	– annual energy generation	*Not included*
Net Zero (Low Energy)	– annual energy use	2,406 kWh/yr
	– annual energy generation	1,474 kWh/yr
Net Zero (Ultra Low Energy)	– annual energy use	2,329 kWh/yr
	– annual energy generation	1,474 kWh/yr

List of key modelling assumptions used to calculate energy costs

4.2

Cost evidence base:

Capital costs: Residential modelling

4.2 Capital Costs: Residential modelling

4.2

Contents

4.2.1 Capital costs Residential | Analysis summary

The cost analysis was carried out to inform the viability assessment that will be carried out.

A summary of the cost analysis is shown to the right.

The table opposite summarises the estimated capital cost uplifts for each residential typology under the different policy scenarios, relative to both the Part L 2021 baseline and the anticipated Future Homes Standard (FHS).

Across all dwelling types, uplifts to achieve the FHS + PV and battery scenario typically range between +7.0 % and +11.6 % over Part L 2021, reflecting the introduction of heat pumps, enhanced ventilation, and, most significantly, the battery storage system.

For the Net Zero (Low Energy) and Net Zero (Ultra-Low Energy) pathways, uplifts are generally 5.5 – 8.5% above the Part L baseline for most typologies with the bungalows being on the top end with 7.6% – 10.2% uplifts due to greater exposed external envelope and mid-rise flats being on the bottom end with 2.6 – 4.2% uplift due to lower external envelope.

When compared against the anticipated FHS baseline, additional costs reduce to around 1.9 – 7.2 %, indicating that much of the Net Zero cost premium is already captured through the transition to FHS-level standards.

As always with costs, it is important to understand how these assessments were undertaken as well as their limitations. In particular, the costs models are based on the buildings modelled. Although the trends and scale are expected to be similar for other buildings within the same archetype, variations are possible. This is particularly the case for housing where different developer sizes, specifications and delivery models will influence costs.

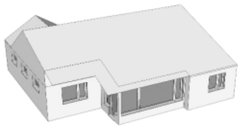
	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Bungalow	+7.0%	+7.6%	+10.2%
Detached house	+7.6%	+5.9%	+8.3%
Semi-detached house	+10.6%	+6.7%	+8.5%
Mid-terrace house	+11.6%	+7.3%	+7.8%
Two 1-bed flats	+7.5%	+5.5%	+7.7%
Mid-rise block of flats	N/A	+2.6%	+4.2%

Summary of uplift in total capital costs compared to Part L 2021

	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Bungalow	+3.4%	+4.0%	+6.5%
Detached house	+4.9%	+3.3%	+5.6%
Semi-detached house	+6.7%	+2.9%	+4.6%
Mid-terrace house	+7.2%	+3.0%	+3.5%
Two 1-bed flats	+5.1%	+3.1%	+5.3%
Mid-rise block of flats	N/A	+1.9%	+3.4%

Summary of uplift in total capital costs compared to anticipated FHS

4.2.2 Bungalow | Capital costs modelling



Combined impact on construction cost of recommended net zero policy options compared to Part L 2021

+7.5-10.2%

Combined impact on construction cost of recommended net zero policy options compared to Anticipated Future Homes Standard*

+3.4-6.5%

The table summarises the results of the cost analysis for a bungalow under different policy scenarios.

The Future Homes Standard (FHS) with additional PV and battery scenario shows a total uplift of £145/m² (+7.0%) compared to Part L 2021. The main cost driver is the battery storage system, with additional contribution from the increased PV capacity.

The Net Zero (Low Energy) scenario results in a total uplift of £156/m² (+7.6%), reflecting improved insulation and enhanced airtightness. The larger PV system required contributes to the additional cost.

The Net Zero (Ultra-Low Energy) scenario represents the most advanced specification, with a total uplift of £209/m² (+10.2%). This includes triple glazing, deeper roof and wall insulation, and enhanced thermal bridging treatment, alongside very low air permeability. The extensive fabric upgrades dominate the cost increase. PV capacity remains similar to the Low Energy case.

Overall, the additional capital cost of the modelled scenarios compared with the Future Homes Standard ranges from 3.4 % – 6.5 %, depending on specification.

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Fabric & ventilation	Part L 2021	FHS option 2	FHS option 2	Achieve SHD 30kWh/m2 /year	Achieve SHD 15-20kWh/m2 /year
Heating	Gas boiler and waste-water heat recovery	Heat pump	Heat pump	Heat pump	Heat pump
Renewable energy	Part L baseline	FHS Baseline	More solar + battery (13.5kWh)	To meet / exceed energy balance	To meet / exceed energy balance
	5.85 kWp	9.90 kWp	9.68 kWp	14.52 kWp	14.52 kWp

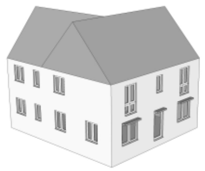
	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Fabric & ventilation	£0/m²	£0/m²	£0/m²	£55/m²	£108/m²
Heating	£0/m²	£45/m²	£45/m²	£45/m²	£45/m²
Renewable energy	£0/m²	£26/m²	£99/m² (Including battery storage)	£56/m²	£56/m²
Total uplift	£0/m²	£71/m²	£145/m²	£156/m²	£209/m²
Total capital costs	£2,055/m²	£2,126/m²	£2,200/m²	£2,211/m²	£2,264/m²
% uplift in capital cost	-	3.5%	7.0%	7.6%	10.2%
% uplift in capital cost	-3.5%	-	3.4%	4.0%	6.5%

Over Part L (current day)

Over FHS (current day)

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

4.2.3 Detached house | Capital costs modelling



Combined impact on construction cost of recommended net zero policy options compared to Part L 2021

+5.9-8.3%

Combined impact on construction cost of recommended net zero policy options compared to Anticipated Future Homes Standard*

+3.3-5.6%

The table summarises the results of the cost analysis for a detached home under different policy scenarios.

The Future Homes Standard (FHS) with additional PV and battery scenario shows a total uplift of £130/m² (+7.6%) compared to Part L 2021. The main cost driver is the battery storage system, at c£8,000 a 13.5kWh battery, with further contribution from the increased PV capacity.

The Net Zero (Low Energy) scenario delivers a lower total uplift of £101/m² (+5.9%). This option achieves energy balance through a combination of improved fabric (U-values reduced for walls and air permeability) and an optimised PV array.

The Net Zero (Ultra-Low Energy) scenario records the highest fabric improvement, with a total uplift of £142/m² (+8.3%). This scenario achieves very low heat loss through triple glazing, enhanced roof, wall, and floor insulation, and a further reduced air permeability. The deeper insulation and higher specification junctions significantly increase construction costs, despite requiring a similar renewable capacity to the Low Energy case.

Overall, the additional capital cost of the modelled scenarios compared to the Future Homes Standard is between 3. 3% – 5.6%, depending on specification.

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

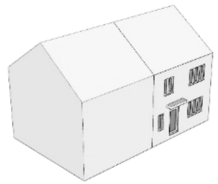
	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Fabric & ventilation	Part L 2021	FHS option 2	FHS option 2	Achieve SHD 30kWh/m2 /year	Achieve SHD 15-20kWh/m2 /year
Heating	Gas boiler and waste-water heat recovery	Heat pump	Heat pump	Heat pump	Heat pump
Renewable energy	Part L baseline	FHS Baseline	More solar + battery (13.5kWh)	To meet / exceed energy balance	To meet / exceed energy balance
	4.50 kWp	6.75 kWp	12.71 kWp	9.68 kWp	9.68 kWp

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Fabric & ventilation	£0/m²	£0/m²	£0/m²	£43/m²	£84/m²
Heating	£0/m²	£35/m²	£35/m²	£35/m²	£35/m²
Renewable energy	£0/m²	£9/m²	£96/m² (Including battery storage)	£24/m²	£24/m²
Total uplift	£0/m²	£44/m²	£130/m²	£101/m²	£142/m²
Total capital costs	£1,711/m²	£1,755/m²	£1,841/m²	£1,812/m²	£1,853/m²
% uplift in capital cost	-	2.6%	7.6%	5.9%	8.3%
% uplift in capital cost	-2.6%	-	4.9%	3.3%	5.6%

Over Part L (current day)

Over FHS (current day)

4.2.4 Semi-Detached house | Capital costs modelling



Combined impact on construction cost of recommended net zero policy options compared to Part L 2021

+6.7-8.5%

Combined impact on construction cost of recommended net zero policy options compared to Anticipated Future Homes Standard*

+2.9-4.6%

The table summarises the results of the cost analysis for a semi-detached home under different policy scenarios.

The Future Homes Standard (FHS) with additional PV and battery scenario shows a total uplift of £192/m^2 (+10.6%) compared with Part L 2021. The largest cost increase comes from the battery system and then the expanded PV array..

The Net Zero (Low Energy) scenario results in a lower uplift of £122/m^2 (+6.7%), achieved through better fabric performance (reduced U-values and improved airtightness) and a smaller renewable requirement than the FHS + battery case.

The Net Zero (Ultra-Low Energy) scenario reaches a total uplift of £154/m^2 (+8.5%), reflecting further enhancement of insulation levels, higher-performing glazing, and tighter air-permeability targets. As in other typologies, these deeper fabric upgrades add capital cost despite similar renewable capacities to the Low Energy case.

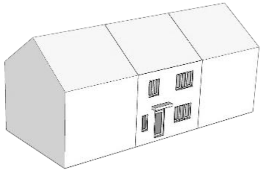
Overall, the additional capital cost of the modelled scenarios compared with the Future Homes Standard ranges from 2.9 % – 6.7%, depending on specification.

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Fabric & ventilation	Part L 2021	FHS option 2	FHS option 2	Achieve SHD 30kWh/m2 /year	Achieve SHD 15-20kWh/m2 /year
Heating	Gas boiler and waste-water heat recovery	Heat pump	Heat pump	Heat pump	Heat pump
Renewable energy	Part L baseline	FHS Baseline	More solar + battery (13.5kWh)	To meet / exceed energy balance	To meet / exceed energy balance
	2.70 kWp	4.50 kWp	9.68 kWp	6.05 kWp	6.05 kWp

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)	
Fabric & ventilation	£0/m^2	£0/m^2	£0/m^2	£44/m^2	£76/m^2	
Heating	£0/m^2	£53/m^2	£53/m^2	£53/m^2	£53/m^2	
Renewable energy	£0/m^2	£14/m^2	£140/m^2 (Including battery storage)	£25/m^2	£25/m^2	
Total uplift	£0/m^2	£67/m^2	£192/m^2	£122/m^2	£154/m^2	
Total capital costs	£1,817/m^2	£1,884/m^2	£2,009/m^2	£1,939/m^2	£1,971/m^2	
% uplift in capital cost	-	3.7%	10.6%	6.7%	8.5%	Over Part L (current day)
% uplift in capital cost	-3.7%	-	6.7%	2.9%	4.6%	Over FHS (current day)

* *Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

4.2.5 Terrace house | Capital costs modelling



Combined impact on construction cost of recommended net zero policy options compared to Part L 2021

+7.3-7.8%

Combined impact on construction cost of recommended net zero policy options compared to Anticipated Future Homes Standard*

+3.0-3.5%

The table summarises the results of the cost analysis for a terrace home under different policy scenarios.

The Future Homes Standard (FHS) with additional PV and battery scenario shows a total uplift of £188/m^2 (+11.6%) compared with Part L 2021. The majority of this increase arises from the battery storage system and expanded PV array.

The Net Zero (Low Energy) scenario results in a lower total uplift of £117/m^2 (+7.3%), driven by improved fabric performance (walls, floors, and airtightness) and a reduced renewable capacity needed to meet energy balance.

The Net Zero (Ultra-Low Energy) scenario reaches a total uplift of £126/m^2 (+7.8%), incorporating higher insulation standards and improved detailing, but without a large change in renewable system size. The tighter building fabric is the main cost contributor in this case.

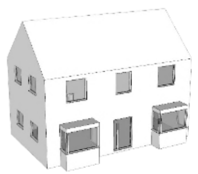
Overall, the additional capital cost of the modelled scenarios compared with the Future Homes Standard ranges from 3.0 % – 7.2 %, depending on specification.

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Fabric & ventilation	Part L 2021	FHS option 2*	FHS option 2*	Achieve SHD 30kWh/m2 /year	Achieve SHD 15-20kWh/m2 /year
Heating	Gas boiler and waste-water heat recovery	Heat pump	Heat pump	Heat pump	Heat pump
Renewable energy	Part L baseline	FHS Baseline	More solar + battery (13.5kWh)	To meet / exceed energy balance	To meet / exceed energy balance
	2.70 kWp	4.50 kWp	9.08 kWp	6.05 kWp	6.05 kWp

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)	
Fabric & ventilation	£0/m^2	£0/m^2	£0/m^2	£39/m^2	£48/m^2	
Heating	£0/m^2	£53/m^2	£53/m^2	£53/m^2	£53/m^2	
Renewable energy	£0/m^2	£14/m^2	£135/m^2 (Including battery storage)	£25/m^2	£25/m^2	
Total uplift	£0/m^2	£67/m^2	£188/m^2	£117/m^2	£126/m^2	
Total capital costs	£1,615/m^2	£1,682/m^2	£1,803/m^2	£1,732/m^2	£1,741/m^2	
% uplift in capital cost	-	4.1%	11.6%	7.3%	7.8%	Over Part L (current day)
% uplift in capital cost	-4.1%	-	7.2%	3.0%	3.5%	Over FHS (current day)

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

4.2.6 Two 1-bed flats | Capital costs modelling



Combined impact on construction cost of recommended net zero policy options compared to Part L 2021

+5.5-7.7%

Combined impact on construction cost of recommended net zero policy options compared to Anticipated Future Homes Standard*

+3.1-5.3%

The table summarises the results of the cost analysis for the two 2-bed flats under different policy scenarios.

The Future Homes Standard (FHS) with additional PV and battery scenario shows a total uplift of £153/m^2 (+7.5%) compared with Part L 2021. This increase is primarily driven by the inclusion of battery storage and the expansion of the PV system.

The Net Zero (Low Energy) scenario delivers a total uplift of £112/m^2 (+5.5%), reflecting improvements in insulation and airtightness alongside a smaller renewable capacity needed to achieve energy balance. The modest increase in fabric specification keeps costs relatively contained.

The Net Zero (Ultra-Low Energy) scenario reaches a total uplift of £157/m^2 (+7.7%), driven by deeper insulation, higher-performing glazing, and enhanced thermal bridging detailing. Although renewable capacity remains similar to the Low Energy case, the fabric improvements are the main cost contributor.

Overall, the additional capital cost of the modelled scenarios compared with the Future Homes Standard ranges from 3.1 % – 5.3 %, depending on specification

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Fabric & ventilation	Part L 2021	FHS option 2*	FHS option 2*	Achieve SHD 30kWh/m2 /year	Achieve SHD 15-20kWh/m2 /year
Heating	Gas boiler and waste-water heat recovery	Heat pump	Heat pump	Heat pump	Heat pump
Renewable energy	Part L baseline	FHS Baseline	More solar + battery (13.5kWh)	To meet energy balance	To meet energy balance
	4.5 kWp	4.95 kWp	10.29 kWp	7.26 kWp	7.26 kWp

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)	
Fabric & ventilation	£0/m^2	£0/m^2	£0/m^2	£50/m^2	£95/m^2	
Heating	£0/m^2	£44/m^2	£44/m^2	£44/m^2	£44/m^2	
Renewable energy	£0/m^2	£3/m^2	£109/m^2 (Including battery storage)	£17/m^2	£17/m^2	
Total uplift	£0/m^2	£47/m^2	£153/m^2	£112/m^2	£157/m^2	
Total capital costs	£2,076/m^2	£2,123/m^2	£2,195/m^2	£2,141/m^2	£2,186/m^2	
% uplift in capital cost	-	2.3%	7.5%	5.5%	7.7%	Over Part L (current day)
% uplift in capital cost	-2.3%	-	5.1%	3.1%	5.3%	Over FHS (current day)

* *Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

4.2.7 Mid-rise block of flats | Capital costs modelling

Combined impact on construction cost of recommended net zero policy options compared to Part L 2021

+2.6-4.2%

Combined impact on construction cost of recommended net zero policy options compared to Anticipated Future Homes Standard*

+1.9-3.4%

The table summarises the results of the cost analysis for a mid-rise block of flats under different policy scenarios.

A scenario with additional PV and battery storage has not been modelled for flats, as large-scale battery storage is not a typical or practical inclusion at the dwelling level for multi-residential developments.

The Net Zero (Low Energy) scenario results in a total uplift of £53/m^2 (+2.6%), primarily due to enhanced insulation, improved airtightness, and a moderate increase in shared PV capacity to achieve energy balance across the block.

The Net Zero (Ultra-Low Energy) scenario records a total uplift of £86/m^2 (+4.2%), driven by further improvements in building fabric; lower U-values, triple glazing, and better thermal bridging treatment. These measures increase construction costs but deliver significantly reduced operational demand.

Overall, the additional capital cost of the proposed Net Zero policy compared with the Future Homes Standard ranges from 1.9 % – 3.4 %, depending on specification.

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Fabric & ventilation	Part L 2021	FHS option 2*		Achieve SHD 30kWh/m2 /year	Achieve SHD 15-20kWh/m2 /year
Heating	Gas boiler and waste-water heat recovery	Heat pump	N/A	Heat pump	Heat pump
Renewable energy	Part L (to meet regs)	FHS Baseline		Maximum on roof	Maximum on roof
	58.95 kWp	45.50 kWp		72.6 kWp	72.6 kWp

	Part L 2021	Anticipated Future Homes Standard*	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)	
Fabric & ventilation	£0/m^2	£0/m^2		£35/m^2	£67/m^2	
Heating	£0/m^2	£15/m^2		£15/m^2	£15/m^2	
Renewable energy	£0/m^2	-£3/m^2		£3/m^2	£3/m^2	
Total uplift	£0/m^2	£12/m^2		£53/m^2	£86/m^2	
Total capital costs	£1,817/m^2	£1,829/m^2	N/A	£2,084/m^2	£2,117/m^2	
% uplift in capital cost	-	0.7%		2.6%	4.2%	Over Part L (current day)
% uplift in capital cost	-0. 7%	-		1.9%	3.4%	Over FHS (current day)

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

4.2.8 Capital costs Residential | Conclusion

Observations:

- The low energy fabric is the least cost-route, except for the bungalow, where FHS + PV + battery is less expensive than Net zero Low Energy due to the smaller PV requirement.
- Low-rise homes (detached, bungalow, semi, terrace) show the highest absolute uplifts. The uplifts for the pair of 1 –bed flats and mid-rise flats are lower due to compact form and shared envelope.
- Ultra-low fabric raises costs mainly through deeper insulation, tighter airtightness and junction detailing.
- Adding domestic storage materially increases uplifts and offers limited value for smaller/compact dwellings (same unit cost spread over less floor area).
- The Part L 2021 baseline is the right baseline 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.
- Potential capital costs must be balanced with potential running costs and energy performance.

4.3

Cost evidence base:

Capital costs: Non-Residential modelling

4.3 Capital Costs: Non-residential modelling

4.3

Contents

4.3.1 Capital costs Non-Residential | Analysis summary

The cost analysis for the school and industrial typologies was undertaken to inform the viability assessment.

The table opposite summarises the estimated capital cost uplifts for each non-residential typology under the different policy scenarios, relative to a Future Building Standard baseline.

Across both typologies, cost uplifts remain relatively modest, ranging from –0.1% to +5.9%, depending on the balance between fabric, heating system, and renewable energy specification.

For the primary school, uplifts range between +2.3% and +5.9%, reflecting progressive improvements in fabric performance, heating efficiency, and the scale of PV deployment. The upper-end results correspond to the ultra-low-energy specification with a high-efficiency heat pump and maximum PV array, while lower-end outcomes capture standard heat pump systems with moderate fabric enhancements.

For the industrial building, uplifts range between –0.1% and +5.9%. Variations are mainly driven by the shift from VRF and direct-electric systems to centralised heat-pump solutions, and by the increase in PV capacity. Once efficient fabric and systems are in place, further capital cost increases are largely associated with higher renewable installation capacity.

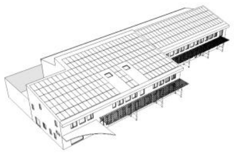
As with the residential results, these uplifts are based on modelled case studies, and actual costs may vary depending on project scale, detailed design, specification, and delivery method.

	Anticipated Future Building Standard + Heating 1	Net Zero (Low energy) + Heating 2	Net Zero (Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 2	Net Zero (Ultra Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 3 + PV2
School	-	+2.3%	+4.0%	+4.3%	+5.5%	+5.9%
Industrial	-	*	+3.4%	+1.8%	+4.0%	+5.9%

Summary of percentage uplift in total capital costs compared to a FBS building.

**EUI not met for electric heating without ultra low energy building fabric.*

4.3.2 School building | Capital costs modelling



Combined impact on construction cost of proposed policy options compared to expected Future Building Standard notional building specifications

+2.3%-5.9%

The table summarises the results of the cost analysis for a primary school under different policy scenarios.

The Net Zero, Low Energy scenario shows a total uplift of £41/m^2 (+2.3%) compared with the FBS baseline. This option assumes improved fabric efficiency and a standard heat pump system providing space heating, with a direct electric point of use for hand wash and a heat pump for the main kitchen hot water generation.

The Net Zero, Low Energy (better heat pump) option achieves further efficiency gains through a higher-performing heat pump system, resulting in a higher total uplift of £70/m^2 (+4.0%).

The Net Zero, Ultra-Low Energy scenario introduces deeper insulation, improved airtightness, and enhanced thermal bridging performance, paired with the standard heat pump. This configuration yields a total uplift of £77/m^2 (+4.3%), as the improved envelope performance is partially offset by reductions in heating demand and plant size.

The Net Zero, Ultra-Low Energy (better heat pump) option increases the uplift to £97/m^2 (+5.5%), reflecting the combined impact of deeper fabric and higher-efficiency heating systems.

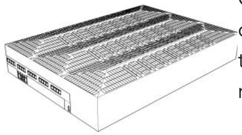
Finally, the Ultra-Low Energy + PV max scenario delivers the largest uplift at £130/m^2 (+5.9%), driven by the additional PV capacity.

Overall, the additional capital cost of the proposed Net Zero options compared with the anticipated Future Homes Standard equivalent ranges from +2.3% to +5.9%.

	Anticipated Future Building Standard + Heating 1	Net Zero (Low energy) + Heating 2	Net Zero (Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 2	Net Zero (Ultra Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 3 + PV2
Fabric & ventilation	Fabric 1	Fabric 2	Fabric 2	Fabric 3	Fabric 3	Fabric 3
Heating	Heating 1	Heating 2	Heating 3	Heating 2	Heating 3	Heating 3
Renewable energy	PV1	PV1	PV1	PV1	PV1	PV2

	Anticipated Future Building Standard + Heating 1	Net Zero (Low energy) + Heating 2	Net Zero (Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 2	Net Zero (Ultra Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 3 + PV2
Fabric & ventilation	£0/m^2	£40/m^2	£40/m^2	£82/m^2	£82/m^2	£82/m^2
Heating	£0/m^2	£1/m^2	£30/m^2	-£5/m^2	£15/m^2	£15/m^2
Renewable energy	£0/m^2	£0/m^2	£0/m^2	£0/m^2	£0/m^2	£8/m^2
Total uplift	£0/m^2	£41/m^2	£70/m^2	£77/m^2	£97/m^2	£130/m^2
Total capital costs	£1,774/m^2	£1,814/m^2	£1,844/m^2	£1,851/m^2	£1,871/m^2	£1,878/m^2
% uplift in capital cost (current day)	-	2.3%	4.0%	4.3%	5.5%	5.9%

4.3.3 Industrial building | Capital costs modelling



Combined impact on construction cost of proposed policy options compared to expected Future Building Standard notional building specifications

-0.1%- 5.9%

The table summarises the results of the cost analysis for an industrial building under different policy scenarios.

The Net Zero, Low Energy (VRF + PV) scenario shows a marginal reduction in cost of –£1/m² (–0.1%) compared with the FBS baseline.

The Net Zero, Low Energy (better heat pump) scenario introduces a centralised heat pump system with improved efficiency, increasing the total uplift to £32/m² (+3.4%).

The Net Zero, Ultra-Low Energy (VRF + PV) scenario includes a deeper insulation standard and enhanced airtightness, resulting in a total uplift of £17/m² (+1.8%). The higher envelope performance partly offsets the cost of mechanical system upgrades.

The Net Zero, Ultra-Low Energy (better heat pump) option combines the improved fabric with a higher-performing heat pump system, yielding a total uplift of £37/m² (+4.0%).

Finally, the Ultra-Low Energy + PV max configuration delivers the highest renewable contribution, with PV capacity increased to 1,077 kWp, raising the total uplift to £55/m² (+5.9%). The additional cost is primarily driven by the larger PV array rather than further changes to the building fabric or systems.

Overall, the additional capital cost of the proposed Net Zero policy options compared with the anticipated Future Homes Standard equivalent ranges from –0.1% to +5.9%.

	Anticipated Future Building Standard + Heating 1	Net Zero (Low energy) + Heating 2 *	Net Zero (Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 2	Net Zero (Ultra Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 3 + PV2
Fabric & ventilation	Fabric 1	Fabric 2	Fabric 2	Fabric 3	Fabric 3	Fabric 3
Heating	Heating 1	Heating 2	Heating 3	Heating 2	Heating 3	Heating 3
Renewable energy	PV1	PV1	PV1	PV1	PV1	PV2

*EUI not met for electric heating without ultra low energy building fabric.

	Anticipated Future Building Standard + Heating 1	Net Zero (Low energy) + Heating 2 *	Net Zero (Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 2	Net Zero (Ultra Low energy) + Heating 3	Net Zero (Ultra Low energy) + Heating 3 + PV2
Fabric & ventilation	£0/m²	£15/m²	£15/m²	£36/m²	£36/m²	£36/m²
Heating	£0/m²	-£16/m²	£17/m²	-£19/m²	£2/m²	£2/m²
Renewable energy	£0/m²	£0/m²	£0/m²	£0/m²	£0/m²	£18/m²
Total uplift	£0/m²	-£1/m²	£32/m²	£17/m²	£37/m²	£55/m²
Total capital costs	£943/m²	£942/m²	£975/m²	£960/m²	£980/m²	998/m²
% uplift in capital cost (current day)	-	-0.1%	3.4%	1.8%	4.0%	5.9%

4.3.4 Capital costs Non-Residential | Conclusion

Observations:

- Cost uplifts across non-residential typologies remain modest, typically between -0.1% and 5.9%, reflecting the fact that the baseline already includes heat pumps.
- Ultra-low energy fabric measures contribute the most to overall cost increases, followed by the mechanical systems.
- The Part L 2021 baseline remains the most appropriate reference point for assessing cost uplifts, as the final specification and costs for a compliant Future Building Standard are not yet defined.
- While overall uplifts are limited, operational energy savings and improved system efficiencies may provide meaningful lifecycle benefits, particularly in buildings with longer daily operating hours such as schools and industrial units.

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

Alternate Policy Option – Anticipated Future Homes Standard* with additional PV and battery

Anticipated Future Homes Standard – Benchmark - Possible future energy, carbon, cost baseline – Anticipated FHS notional building spec*

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

Glossary 1/2

Part L 2021 - Energy, carbon, cost baseline – Notional building spec, tweaked to pass Part L 2021**

PassivHaus Planning Package (PHPP) – predictive energy modelling and design tool

Policy Option 1 – Net Zero (Low energy)

Policy Option 2 – Net Zero (Ultra-Low energy)

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 five different specifications each archetype was modelled to. See page 22

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 Export – Solar energy generated by the building and exported directly to the electricity grid

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

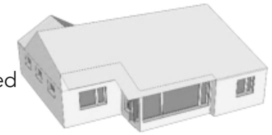
This final section includes:

- Energy & cost modelling assumptions for residential typologies
- Energy & cost modelling assumptions for non-residential typologies
- Cost Sensitivity Analysis of Heat Pumps
- Cost modelling methodology
- Reduced renewable generation option

Energy and cost modelling assumptions for residential typologies

Specifications | Bungalow

This table summarises the different energy efficiency assumptions modelled based on five different scenarios.



Category	Element	Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Building fabric and ventilation strategy	Floor (W/m^2K, SAP adjusted)	0.12	0.12	0.11	0.10	0.12
	Walls (W/m^2K)	0.18	0.18	0.13	0.10	0.18
	Roof (W/m^2K)	0.10	0.10	0.10	0.09	0.10
	Windows (W/m^2K)	1.2 (double-glazed) g value: 0.63	1.2 (double-glazed) g value: 0.63	1.2 (double-glazed) g value: 0.63	0.8 (triple-glazed) g value: 0.50	1.2 (double-glazed) g value: 0.63
	Doors (W/m^2K)	1.0	1.0	1.0	1.0	1.0
	Thermal bridging (W/K)	6.4 (PHPP)	6.4 (PHPP)	8.4(PHPP)	3.6 (PHPP)	6.4 (PHPP)
	Air Permeability ($m^3/m^2/hr$)	5	5	1	0.45 (0.6ach)	5
	Ventilation	0% heat recovery Intermittent extract (0.08 Wh/m^3)	0% heat recovery Intermittent extract (0.08 Wh/m^3)	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	0% heat recovery Intermittent extract (0.08 Wh/m3)
Heating, hot water	Space Heating	Gas combi boiler (55°C) 89%	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <35˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp
	Domestic Hot Water	No cylinder WWHR system A 36% efficiency	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss
Renewables	Solar PV	5.85kWp S (module power:450W)	(40% GFA / 4.5 kW) 9.90kWp** S (module power:450W)	(60% GFA / 4.5 kW) 14.52kWp** S (module power:605W)	(60% GFA / 4.5 kW) 14.52kWp** S (module power:605W)	Octopus Tool 9.68kWp S (module power:605W)
	Battery Storage	-	-	-	-	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

*** The minor discrepancy in the generation figures is due to the different modules. In all 3 cases the minimum Anticipated FHS generation is met.*

Specifications | Detached house

This table summarises the different energy efficiency assumptions modelled based on five different scenarios.

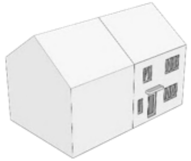
		Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Building fabric and ventilation strategy	Floor (W/m^2K, SAP adjusted)	0.12	0.12	0.11	0.10	0.12
	Walls (W/m^2K)	0.16	0.16	0.13	0.10	0.16
	Roof (W/m^2K)	0.10	0.10	0.10	0.09	0.10
	Windows (W/m^2K)	1.2 (double-glazed) g value: 0.63	1.2 (double-glazed) g value: 0.63	1.2 (double-glazed) g value: 0.63	0.8 (triple-glazed) g value: 0.50	1.2 (double-glazed) g value: 0.63
	Doors (W/m^2K)	1.0	1.0	1.0	1.0	1.0
	Thermal bridging (W/K)	7.1 (PHPP)	7.1 (PHPP)	8.4 (PHPP)	5.3 (PHPP)	7.1 (PHPP)
	Air Permeability ($m^3/m^2/hr$)	5	5	1	0.60 (0.6ach)	5
	Ventilation	0% heat recovery Intermittent extract (0.08 Wh/m^3)	0% heat recovery Intermittent extract (0.08 Wh/m^3)	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	0% heat recovery Intermittent extract (0.08 Wh/m^3)
Heating, hot water	Space Heating	Gas combi boiler (55°C) 89%	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <35˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp
	Domestic Hot Water	No cylinder WWHR system A 36% efficiency	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss
Renewables	Solar PV	4.95kWp S (module power:450W)	(40% GFA / 4.5 kW) 6.75kWp** S (module power:450W)	(60% GFA / 4.5 kW) 9.68kWp** S (module power:605W)	(60% GFA / 4.5 kW) 9.68kWp** S (module power:605W)	Octopus Tool 12.71kWp (total) 9.68kWp (S) 1.82kWp (E) 1.21kWp (W) (module power:605W)
	Battery Storage	-	-	-	-	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

*** The minor discrepancy in the generation figures is due to the different modules. In all 3 cases the minimum Anticipated FHS generation is met.*

Specifications | Semi-detached house

This table summarises the different energy efficiency assumptions modelled based on five different scenarios.



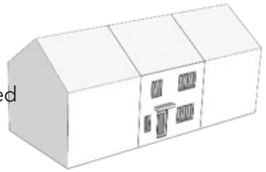
Category		Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Building fabric and ventilation strategy	Floor (W/m^{2}K, SAP adjusted)	0.12	0.12	0.11	0.10	0.12
	Walls (W/m^{2}K)	0.15	0.15	0.13	0.10	0.15
	Roof (W/m^{2}K)	0.10	0.10	0.10	0.10	0.10
	Windows (W/m^{2}K)	1.2 (double-glazed)	1.2 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	1.2 (double-glazed)
	Doors (W/m^{2}K)	1.0	1.0	1.0	1.0	1.0
	Thermal bridging (W/K)	6.5 (PHPP)	6.5 (PHPP)	7.0 (PHPP)	4.1 (PHPP)	6.5 (PHPP)
	Air Permeability (m^3/m^2/hr)	5	5	1	0.7 (0.6ach)	5
	Ventilation	0% heat recovery Intermittent extract (0.08 Wh/m^3)	0% heat recovery Intermittent extract (0.08 Wh/m^3)	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	0% heat recovery Intermittent extract (0.08 Wh/m^3)
Heating, hot water	Space Heating	Gas combi boiler (55ºC) 89%	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <35˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp
	Domestic Hot Water	No cylinder WWHR system A 36% efficiency	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss
Renewables	Solar PV	2.70 kWp SW (module power:450W)	(40% GFA / 4.5 kW) 4.50 kWp** SW (module power:450W)	(60% GFA / 4.5 kW) 6.05 kWp** SW (module power:605W)	(60% GFA / 4.5 kW) 6.05 kWp** SW (module power:605W)	Octopus tool 9.68 kWp (total) 6.05 kWp (SW) 3.63 kWp (NE) (module power:605W)
	Battery Storage	-	-	-	-	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

*** The minor discrepancy in the generation figures is due to the different modules. In all 3 cases the minimum Anticipated FHS generation is met.*

Specifications | Terrace house

This table summarises the different energy efficiency assumptions modelled based on five different scenarios.



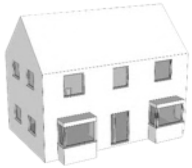
		Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Building fabric and ventilation strategy	Floor (W/m^2K, SAP adjusted)	0.12	0.12	0.11	0.13	0.12
	Walls (W/m^2K)	0.18	0.18	0.15	0.15	0.18
	Roof (W/m^2K)	0.10	0.10	0.10	0.11	0.10
	Windows (W/m^2K)	1.2 (double-glazed) g-value: 0.6	1.2 (double-glazed) g-value: 0.6	1.2 (double-glazed) g-value: 0.6	0.8 (triple-glazed) g-value: 0.5	1.2 (double-glazed) g-value: 0.6
	Doors (W/m^2K)	1.0	1.0	1.0	1.0	1.0
	Thermal bridging (W/K)	5.8 (PHPP)	5.8 (PHPP)	6.4 (PHPP)	2.5 (PHPP)	5.8 (PHPP)
	Air Permeability ($m^3/m^2/hr$)	5	5	3	2	5
	Ventilation	0% heat recovery Intermittent extract (0.08 Wh/m^3)	0% heat recovery Intermittent extract (0.08 Wh/m^3)	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	88% HR. 2m duct 40mm insulation 0.24 Wh/m^3	0% heat recovery Intermittent extract (0.08 Wh/m^3)
Heating, hot water	Space Heating	Gas combi boiler (55°C) 89%	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <35˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp
	Domestic Hot Water	No cylinder WWHR system A 36% efficiency	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss
Renewables	Solar PV	2.70 kWp SW (module power:450W)	40% GFA / 4.5 4.50 kWp** SW (module power:450W)	(60% GFA / 4.5 kW) 6.05 kWp** SW (module power:605W)	(60% GFA / 4.5 kW) 6.05 kWp** SW (module power:605W)	Octopus Tool 9.08 kWp (Total) 6.05 kWp (SW) 3.03 kWp (NE) (module power:605W)
	Battery Storage	-		-	-	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

*** The minor discrepancy in the generation figures is due to the different modules. In all 3 cases the minimum Anticipated FHS generation is met.*

Specifications | Two 1-bed flats

This table summarises the different energy efficiency assumptions modelled based on five different scenarios.



		Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Building fabric and ventilation strategy	Floor (W/m^2K, SAP adjusted)	0.12	0.12	0.11	0.10	0.12
	Walls (W/m^2K)	0.17	0.17	0.13	0.10	0.17
	Roof (W/m^2K)	0.10	0.10	0.10	0.09	0.10
	Windows (W/m^2K)	1.2 (double-glazed)	1.2 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	1.2 (double-glazed)
	Doors (W/m^2K)	1.0	1.0	1.0	1.0	1.0
	Thermal bridging (W/K)	3.5 (PHPP)	3.5 (PHPP)	4.5 (PHPP)	2.4 (PHPP)	3.5 (PHPP)
	Air Permeability ($m^3/m^2/hr$)	5	5	1	0.85 (0.6ach)	5
	Ventilation	0% heat recovery Intermittent extract (0.08 Wh/m^3)	0% heat recovery Intermittent extract (0.08 Wh/m^3)	88% HR. 2m duct 40mm insulation 0.24 Wh/m^3	88% HR. 2m duct 40mm insulation 0.24 Wh/m^3	0% heat recovery Intermittent extract (0.08 Wh/m^3)
Heating, hot water	Space Heating	Gas combi boiler (55°C) 89%	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp	5kW ASHP Radiators at <35˚C Weather comp	5kW ASHP Radiators at <45˚C Weather comp
	Domestic Hot Water	No cylinder WWHR system A 36% efficiency	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss	200l heat pump tank at 55˚C 1.4kWh/day loss
Renewables	Solar PV	4.5kWp S (module power:450W)	(40% GFA / 4.5 kW) 4.95kWp** S (module power:450W)	(60% GFA / 4.5 kW) 7.26 kWp** S (module power:605W)	(60% GFA / 4.5 kW) 7.26 kWp** S (module power:605W)	Octopus Tool 10.29 kWp (Total) 7.26 kWp (S) 3.03 kWp (N) (module power:605W)
	Battery Storage	-	-	-	-	Tesla Powerwall 3 (includes 13.5kWh battery, 11kW inverter and DC isolator)

** Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

*** The minor discrepancy in the generation figures is due to the different modules. In all 3 cases the minimum Anticipated FHS generation is met.*

Specifications | Mid-rise block of flats

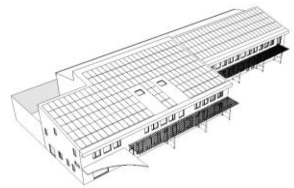
This table summarises the different energy efficiency assumptions modelled based on five different scenarios.

		Part L 2021	Anticipated Future Homes Standard*	Net Zero (Low energy)	Net Zero (Ultra Low energy)	Anticipated Future Homes Standard* with additional PV and battery
Building fabric and ventilation strategy	Floor (W/m^2K, SAP adjusted)	0.13	0.13	0.13	0.10	N/A
	Walls (W/m^2K)	0.13	0.18	0.13	0.17	
	Roof (W/m^2K)	0.11	0.11	0.11	0.11	
	Windows (W/m^2K)	1.2 (double-glazed)	1.2 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	
	Doors (W/m^2K)	1.0	1.0	1.0	1.0	
	Thermal bridging (W/K)	246 (PHPP)	246 (PHPP)	246 (PHPP)	359 (PHPP)	
	Air Permeability ($m^3/m^2/hr$)	5	5	3	1.25 (0.6ach)	
	Ventilation	0% heat recovery Intermittent extract (0.08 Wh/m^3)	0% heat recovery Intermittent extract (0.08 Wh/m^3)	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	88% HR. 2m duct 25mm insulation 0.24 Wh/m^3	
Heating, hot water	Space Heating	Communal gas boiler 93%	Communal ASHP at <65˚C with HIUs	Communal ASHP at <65˚C with HIUs	Communal ASHP at <65˚C with HIUs	
	Domestic Hot Water	No cylinder WWHR system B 36% efficiency	Hot Water Heat Pump 200l cylinder 1.4kW/day loss	Hot Water Heat Pump 200l cylinder 1.4kW/day loss	Hot Water Heat Pump 200l cylinder 1.4kW/day loss	
Renewables	Solar PV	58.95 kWp East (module power:450W)	(40% GFA / 4.5 / no. storeys kW) 45.50 kWp East (module power:450W)	72.6 kWp East (module power:605W)	72.6 kWp East (module power:605W)	
	Battery Storage	N/A	N/A	N/A	N/A	

* *Notional building specification option 2 from Future Homes Standard consultation document, with the addition of solar PV from Notional building specification option 1*

Energy and cost modelling assumptions for non-residential typologies

Specifications | Primary School building



These tables summarise the different efficiency assumptions for fabric and ventilation, heating and water and renewable energy.

Building fabric and ventilation strategy

	Fabric 1 Anticipated Future Building Standard	Fabric 2 Net Zero (Low energy)	Fabric 3 Net Zero (Ultra Low energy)
Description	Energy efficiency performance most applicants are used to deliver. *1	Energy efficiency performance expected to achieve DFE minimum standards.*4	Feasible and proven best practice level of performance
Floor U-Value (W/m^2K)	0.15 90mm of insulation @ 0.035W/mK	0.12 150mm of insulation @ 0.035W/mK	0.10 200mm of insulation @ 0.035W/mK
External wall U-Value (W/m^2K)	0.18	0.15	0.13
Roof U-Value (W/m^2K)	0.15	0.12	0.10
Thermal bridge performance*	Fixed values (3% of losses)	Fixed values (5% of losses)	Fixed values (5% of losses)
Windows U-value (W/m^2K)* Windows g-value	1.40 0.42	1.20 0.50	0.90 0.50
External doors (W/m^2K)	1.9	1.20	1.20
Air Permeability ($m^3/m^2/hr$)	3	3	1
Ventilation system and design	MEV²	Good quality MVHR	Good quality MVHR
AHU heat recovery efficiency	0% *2 (I think we can assume MEV)	80%*5	80%
AHU specific fan power	1.6 W/l/s	1.6 W/l/s	1.2 W/l/s
Demand Control Ventilation	Yes - CO2 sensors with speed control	Yes - CO2 sensors with speed control	Yes - CO2 sensors with speed control
Internal Lighting (lm/W)	115 *3	115	115

Heating, hot water

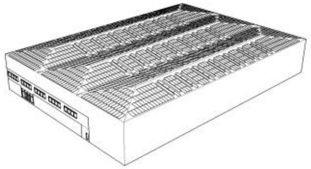
	Heating 1 Low efficiency heat pump	Heating 2 Less efficient Heat Pump System *Communal heat pump*	Heating 3 More Efficient Heat Pump System *Communal heat pump*
Description	Heat pumps serving a heating system with flow temperature 65°C	High temperature heat pumps serving a heating system with flow temperature 65°C	Low temperature heat pumps serving a heating system with low flow temperature 45°C
Heating emitters	LTHW radiators fed by heat pump	LTHW radiators fed by heat pump	LTHW radiators fed by heat pump
Heating seasonal efficiency	264%	270%	300%
Hot water system	Direct electric point-of-use hot water	Direct electric point-of-use hand washing / Heat pump for kitchen	Direct electric point-of-use hand washing / Heat pump for kitchen
Hot water seasonal efficiency	100%	100% / 225%	100% / 300%
Waste Water Heat Recovery (WWHR)	No WWHR assumed	No WWHR assumed	No WWHR assumed
Cooling seasonal efficiency	No cooling assumed	No cooling assumed	No cooling assumed

Renewable energy

	PV 1 eFBS compliant 50% of footprint assumed (req. 40-75% of footprint depending on zone).	PV 2 *Maximum* Maximum technically possible on roof.
Wp	450	605
Number of modules	357	308
Total capacity, kWp	161	186

**1 These match the minimum standards noted in the NCM modelling guide, 2025 consultation on the Future Building Standard edition except where noted. *2 NCM requires MVHR with 80% HR efficiency to be used for the notional building if MVHR is assumed in Actual. Otherwise fan assisted with 0% HR efficiency. *3 Lighting efficiency updated to 170/150 (side / top-lit) in the consultation, but these will not be tested and kept consistent instead. *4 Add note on DFE requirements. *5 DFE requirement is 70%, using 80% to match NCM.*

Specifications | Industrial building



These tables summarise the different efficiency assumptions for fabric and ventilation, heating and water and renewable energy.

Building fabric and ventilation strategy

	Fabric 1 Anticipated Future Building Standard	Fabric 2 Net Zero (Low energy)	Fabric 3 Net Zero (Ultra Low energy)
Description	Energy efficiency performance most applicants are used to deliver. *[1]	Better than business as usual but not as good as ultra low energy.	Feasible and proven best practice level of performance
Floor U-Value (W/m^2K)	3.00 (uninsulated) *[2]	3.00 (uninsulated) *[2]	0.188 (150mm insulation) *[2]
External wall U-Value (W/m^2K)	0.18 / 0.26 (office/warehouse)	0.18 / 0.26 (office/warehouse)	0.15
Roof U-Value (W/m^2K)	0.15 / 0.18 (office/warehouse)	0.15 / 0.18 (office/warehouse)	0.11
Windows/Rooflights U-value (W/m^2K)* Windows g-value	 1.40 / 2.10 0.42 / 0.50 TBC	 1.40 / 2.10 0.40 / 0.50	 1.10 / 1.40 0.40 / 0.50
External doors – Pedestrian / Vehicle (W/m^2K)	1.9 / 1.3	1.9 / 1.3	1.2 / 1.3
Thermal bridging (W/m^2K)	Good practice (5% of losses)	Better practice (3% of losses)	Best practice (1% of losses)
Air Permeability ($m^3/m^2/hr$)	3	3	1.5
Ventilation system and design	MEV*[3]	office: AHU with HR warehouses: AHU with HR	office: AHU with HR warehouses: AHU with HR
AHU heat recovery efficiency	0% *[3] (I think we can assume MEV)	office: 80% warehouse: 75%	office: 85% warehouse: 85%
AHU specific fan power	Industrial offices: 1.4*[4] Industrial warehouses: 1.4	Industrial offices: 1.4* Industrial warehouses: 1.4	Industrial offices: 1.2* Industrial warehouses: 1.2
Demand Control Ventilation*	CO_2 sensors with speed control in offices	CO_2 sensors with speed control in offices	CO_2 sensors with speed control in offices
Internal Lighting (lm/W)*	115*[5]	115	115

Heating, hot water

	Heating 1 Low efficiency heat pump + Direct electric	Heating 2 VRF + Direct electric *VRF space heating in office. Direct electric in warehouse Direct electric hot water*	Heating 3 More Efficient Heat Pump System *Central heat pump*
Description	Low efficiency heat pump system for the office spaces and DE heating serving the warehouse spaces	VRF system for the office spaces and DE heating serving the warehouse spaces.	Heat pumps serving a wet system, low flow / return temperatures 45°C/40°C fed from ambient loop.
Heating emitters (office/warehouse)	FCU / Radiant panels	FCU / Radiant panels	FCU / Radiant panels
Heating seasonal efficiency (office/warehouse)	264% / 100%	450% / 100%	350% / 350%
Hot water system	Direct electric	Direct electric	Heat pump
Hot water seasonal efficiency	100%	100%	300%
Cooling seasonal efficiency (Office)	3.5 EER 5.0 SEER	3.5 EER 5.0 SEER	3.5 EER 5.0 SEER

Renewable energy

	PV 1 eFBS compliant 70% of footprint assumed (req. 75% of footprint for top-lit, 40% in office).	PV 2 *Maximum*
Wp	605	605
Number of modules	1514	1780
Total capacity	916	1077

*[1] *These match the minimum standards noted in the NCM modelling guide, 2025 consultation on the Future Building Standard edition except where noted.* *[2] *Uncorrected value shown, as corrected value ends up very low.* *[3] *NCM requires MVHR with 80% HR efficiency to be used for the notional building if MVHR is assumed in Actual Otherwise fan assisted with 0% HR efficiency.* *[4] *0.2 for terminal units* *[5] *Lighting efficiency updated to 170/150 (side / top-lit) in the consultation, but these will not be tested and kept consistent instead.*

Cost Sensitivity Analysis of Heat Pumps

Capital Cost Results | Cost Sensitivity Analysis

Results sensitivity Analysis ASHP learning curve:

Over the longer-term, it is estimated that the costs associated with both heat pumps will fall, as supply chains mature and become more integrated, and learning rates take effect. By 2030, it is assumed that the cost of a heat pump will be around 75% of the initial cost. This difference in price would bring the total and percentage uplifts down when compared to Part L 2021 baseline.

The tables opposite show the total and percentage uplifts with the learning rate applied.

	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Bungalow	£129/m²	£140/m²	£194/m²
Detached house	£118/m²	£89/m²	£130/m²
Semi-detached house	£174/m²	£103/m²	£135/m²
Mid-terrace house	£169/m²	£99/m²	£107/m²
Two 1-bed flats	£137/m²	£96/m²	£141/m²
Mid-rise block of flats	N/A	£34/m²	£67/m²

Summary of uplift in total capital costs compared to Part L 2021 with ASHP learning rate of 75% applied.

	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Bungalow	+6.3%	+6.8%	+9.4%
Detached house	+6.9%	+5.2%	+7.6%
Semi-detached house	+9.6%	+5.7%	+7.4%
Mid-terrace house	+10.5%	+6.1%	+6.6%
Two 1-bed flats	+6.8%	+4.7%	+7.0%
Mid-rise block of flats	N/A	+1.7%	+3.3%

Summary of percentage uplift in total capital costs compared to Part L 2021 with ASHP learning rate of 75% applied.

Cost modelling methodology

Cost modelling methodology

Elemental cost data

The uplift costs associated with each specification were estimated based on Currie & Brown's cost datasets for energy efficient and low carbon technologies. These incorporate information from market prices, specific market testing and first principles cost planning by specialist quantity surveyors.

The costs are based on current Q3 2025 prices and reflect a South Warwickshire cost base (Location Index: 101%).

Costs were developed for each building element linked to energy efficiency or carbon emissions, principally external envelope and building services. Those elements that are not materially affected by the energy efficiency / low carbon technology options. E.g., substructure, roof coverings, kitchen and bathrooms, etc, were not costed in detail. Instead, these costs were incorporated within a 'balance of construction' cost estimated using a typical baseline whole building construction cost per m² for the building type in question.

Calculation of the baseline build costs

The baseline build cost for this study was taken as being for a building constructed to meet minimum regulations only. Reference baseline build costs were derived using BCIS average mean rate for houses and flats for the period of the last 5 years rebased to Q3 2025 and South Warwickshire location.

Reference build costs are as follows:

- Bungalows (single storey) - £2,055 per m^2
- Detached houses (two storey) - £1,711 per m^2
- Semi-detached houses (two storey) - £1,817 per m^2
- Mid-terrace houses (two storey) - £1,615 per m^2
- Two 1-bed flats (two-storey) - £2,029 per m^2
- Mid-rise apartment block - £2,031 per m^2
- Primary School - £1,774 per m^2
- Industrial - £943 per m^2

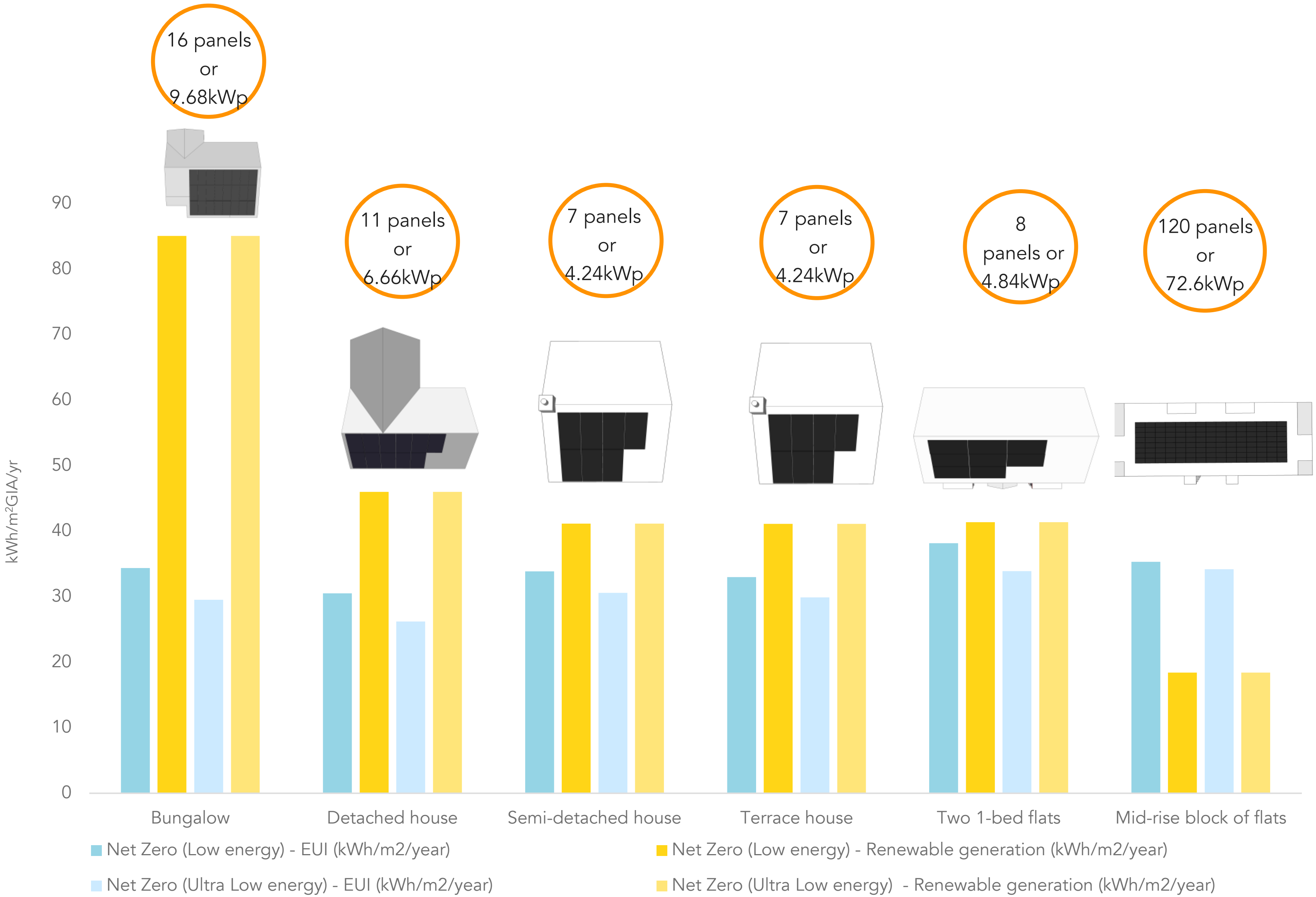
The benchmark £/m² cost was estimated for each building type based on Currie & Brown's experience of helping deliver developments across the UK with costs adjusted to reflect the South Warwickshire location.

It should be noted, that total build costs can vary significantly dependent on design and specification choices to reflect target market requirements.

Reduced renewable generation option

Predicted energy consumption and renewable energy generation | PVs covering 40% of the building footprint

A reduced renewable generation scenario has been tested following the proposed formula in the consultation Future Homes Standard document (Option 1: 40% GFA / 4.5 kW). If this formula were applied to the low- and ultra-low-energy scenarios, the results would be as summarized in the graph below. However, we have been recommending going beyond what is currently outlined in the anticipated Future Homes Standard consultation document, as this would offer significant benefits for occupants and aligns with the two net-zero policy options in the main report.



Cost analysis summary | PVs covering 40% of the building footprint

The cost analysis was also carried out for a lower PV scenario that is covering 40% of the building footprint as per the graph above.

A summary of the cost analysis is shown to the right.

The table opposite summarises the estimated capital cost uplifts for each residential typology under the different policy scenarios, relative to both the Part L 2021 baseline and the anticipated Future Homes Standard (FHS).

Across all dwelling types, uplifts to achieve the FHS + PV and battery scenario typically range between +7.0 % and +11.6 % over Part L 2021, reflecting the introduction of heat pumps, enhanced ventilation, and, most significantly, the battery storage system.

For the Net Zero (Low Energy) and Net Zero (Ultra-Low Energy) pathways, uplifts are generally 5.0 – 7.7% above the Part L baseline for most typologies with the bungalows being on the top end with 6.1% – 8.7% uplifts due to greater exposed external envelope and mid-rise flats being on the bottom end with 2.6 – 4.2% uplift due to lower external envelope.

When compared against the anticipated FHS baseline, additional costs reduce to around 1.9 – 7.2 %, indicating that much of the Net Zero cost premium is already captured through the transition to FHS-level standards.

	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Bungalow	+7.0%	+6.1%	+8.7%
Detached house	+7.6%	+5.0%	+7.4%
Semi-detached house	+10.6%	+5.9%	+7.7%
Mid-terrace house	+11.6%	+6.4%	+6.9%
Two 1-bed flats	+7.5%	+4.7%	+7.0%
Mid-rise block of flats	N/A	+2.6%	+4.2%

Summary of uplift in total capital costs compared to Part L 2021 with PVs covering 40% of the building footprint

	Anticipated Future Homes Standard* with additional PV and battery	Net Zero (Low energy)	Net Zero (Ultra-Low energy)
Bungalow	+3.4%	+2.5%	+5.0%
Detached house	+4.9%	+2.4%	+4.7%
Semi-detached house	+6.7%	+2.2%	+3.9%
Mid-terrace house	+7.2%	+2.2%	+2.7%
Two 1-bed flats	+5.1%	+2.4%	+4.6%
Mid-rise block of flats	N/A	+1.9%	+3.4%

Summary of uplift in total capital costs compared to anticipated FHS with PVs covering 40% of the building footprint