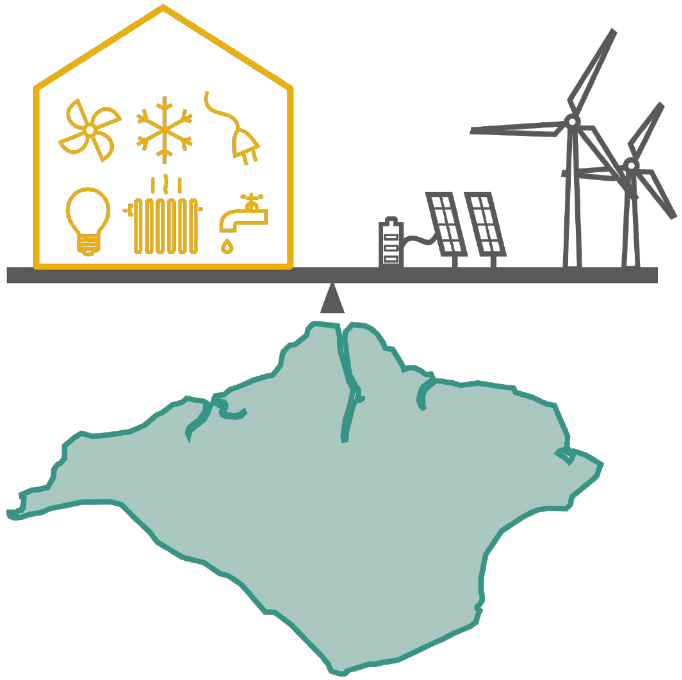

THE ISLE OF WIGHT GUIDE
TO DELIVER NET ZERO CARBON HOMES

January 2022 I Rev J

Levitt Bernstein People.Design | Etude | Currie & Brown | elementa Member of Integral Group

Contents

10-minute summary

This section explains why Net Zero carbon homes are required now and provides a succinct overview of our analysis, conclusions and recommendations.

The Mission Zero: Climate and Environment Strategy 2021-2040 sets out the status quo carbon emissions and proposed decarbonisation strategy for the Isle of Wight. The key overarching target is to achieve Net Zero carbon across the Island by 2040.

Isle of Wight Council have commissioned this work with support from the LGA to understand the technical and cost implications of delivering Net Zero new homes in the Island, understand the implications for owners and occupiers and to inform emerging planning policy. The analysis covers five different locally relevant housing typologies. For each typology, we have analysed the impact of five different specifications:

- Building Regulations (Part L 2021)
- Future Homes Standard

And, three different options which achieve an on-site Net Zero energy balance:

- **Technology first** (low energy, heat pump and PVs)
- **Fabric first** (ultra-low energy, direct electric* and PVs)
- **Comprehensive** ((ultra-low energy, heat pumps) – the only one to comply with all KPIs of the LETI/UKGBC Net Zero definition.

The key differences between these three specifications are illustrated on the right. Their performance is analysed for each typology in the report. Currie and Brown have costed the specifications and measures in order that cost uplifts against a Part L 2021 baseline are evident.

** This focuses on direct electric panel heaters but energy and carbon conclusions are likely to apply to other forms of electric heating, including storage heaters*

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The Isle of Wight Council declared a climate emergency in 2019. This report considers how the Island's future new homes should form part of response to this challenge.

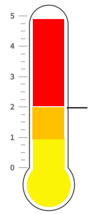
Technology First	Fabric First	Comprehensive
30 kWh/m²/yr	15 kWh/m²/yr	15 kWh/m²/yr
Double glazing	Triple glazing	Triple glazing
< 3	< 0.6	< 0.6
Heat Pump	Direct Electric	Heat Pump
PV panels	PV panels	PV panels

Five different "specifications" were modelled for each housing typology: Part L 2021, Future Homes Standard and three different approaches to energy efficiency and net zero energy balance.

10-minute summary | **Why?**

What are we trying to achieve?

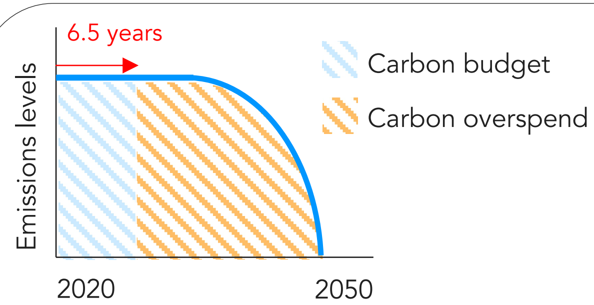
Paris agreement



To limit global temperature rises to 1.5-2°C above pre-industrial levels (as per IPCC recommendations).

What does this really mean?

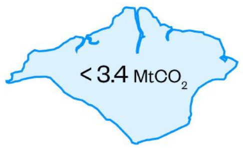
We need to limit cumulative carbon in the atmosphere to be Paris compliant.



Zero carbon by 2030/40/50 isn't necessarily Paris compliant - it's how much carbon we emit that matters.

Carbon budgets

The Isle of Wight's carbon budget



6.5 years left at current emissions rates

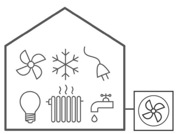
So we need to decarbonise the economy fast

New buildings need to be zero carbon asap

Net zero carbon buildings

Energy efficiency

Space heating demand



Energy Use Intensity (EUI)

- Less energy to run = reduced energy bills
- Energy flexibility - reduces overall and peak demands on the electricity grid = assists the grid and other sectors to decarbonise.
- Technology flexibility = ultra efficient fabric can accommodate different heating systems allowing occupants more choice

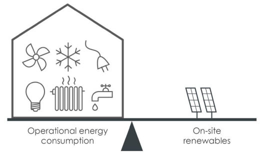
Low carbon heat

No more gas

Electrification of heat

- The carbon intensity of gas has limited potential to reduce.
- The carbon intensity of grid electricity is reducing fast.
- Full electrification of new homes is the answer now (we don't have time to wait for other technologies)
- Heat pumps use less energy, therefore lower energy bills for occupants to run and reduce overall and peak demands on the electricity grid.

Renewable energy generation



Energy balance

- Contributes to grid decarbonisation
- Running cost benefits to occupant
- Resilience to energy supply issues
- Zero carbon on-site.

+ **Embodied carbon**

Five typologies have been chosen to represent a range of potential developments on the Isle of Wight. These have been developed through conversations with the Isle of Wight Council and Southern Housing Group and reviewing some of the current major planning applications for the Isle of Wight. They include:

- **a small 3-bed semi-detached house**
- **a small 3-bed terrace house**
- **a small 2-bed bungalow**
- **a fairly large 4-bed detached house**
- **a medium rise block of apartments.**

The different typologies have different form factors (i.e. ratio between the external envelope losing heat and floor area). The form factor is an interesting concept which helps to understand how inherently energy efficient some typologies are (or not), and the likely impact of additional fabric costs. A low form factor is more energy efficient than a high form factor.

Energy and cost modelling was undertaken on five different sets of specification:

S1 – Part L 2021

S2 – Future Homes Standard (Part L 2025)

S3 – Technology first, with a heat pump

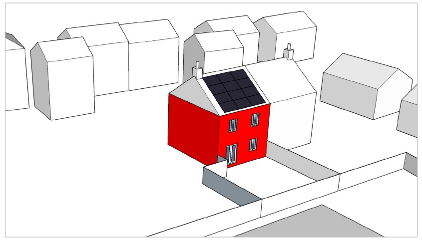
S4 – Fabric first, with ultra-low energy specs and direct electric

S5 – Comprehensive, with both ultra-low energy specs and a heat pump

3-bed Semi Detached

GIA: 93m²

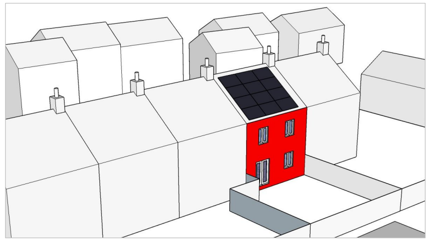
Form heat loss factor: 2.76



3-bed Mid terrace

GIA: 93m²

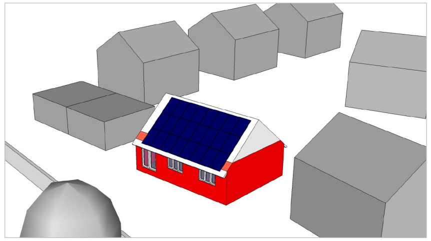
Form heat loss factor: 2.20



2-bed Bungalow

GIA: 74m²

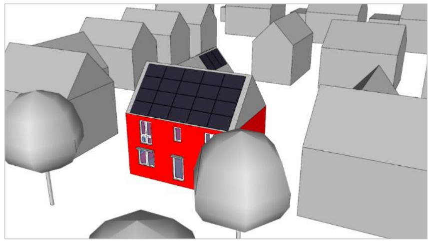
Form heat loss factor: 4.04



4-bed Detached House

GIA: 142m²

Form heat loss factor: 2.95

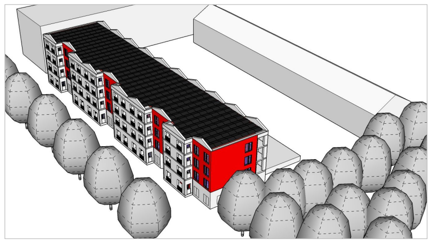


Medium rise block

40-units

GIA: 2,362m²

Form heat loss factor: 2.04



The 'Comprehensive' scenario is recommended

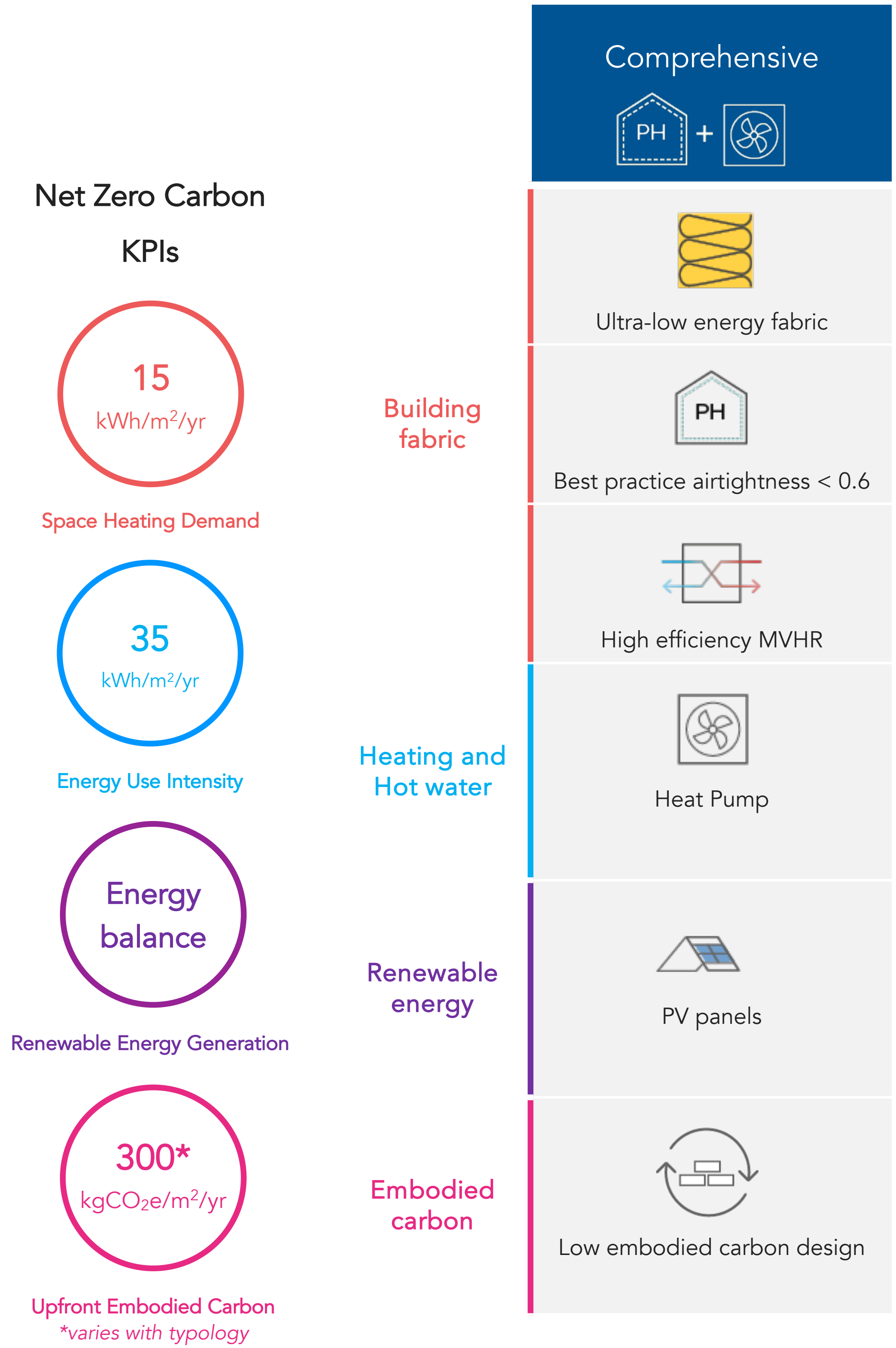
Our conclusion from the energy and cost analysis highlighted the 'comprehensive' specification as our recommended approach for delivering Net Zero carbon. The 'comprehensive' specification requires a ultra-low energy-fabric, heat pump and PV panels to achieve an energy balance i.e. a balance between the total energy the building uses with the amount of renewable energy generated each year.

This scenario brings a number of benefits for a relatively limited additional cost against Part L 2021 and 2025 (i.e. 5-8%):

- An ultra-low level of space heating demand in line with the recommendations of the Climate Change Committee, i.e. 15-20 kWh/m²/yr, except in the case of the bungalow.
- A fossil fuel free and efficient heating system (i.e. heat pump).
- A total energy use compliant with the LETI/UKGBC definition of Net Zero carbon in operation and the RIBA Climate Challenge, i.e. less than 35 kWh/m²/yr, except in the case of the bungalow.
- An energy balance with roof-mounted PVs for all typologies.
- The lowest energy bills for the residents.

Key Performance Indicator

We have provided a set of Key Performance Indicators (KPIs) to target best practice and signify if a building is truly achieving Net Zero Carbon. These targets are recommended over carbon reductions targets.



Methodology

The costs have been calculated for each of the typologies modelled using the dimensions for each typology, as well as the fabric standards and technologies assumed for each scenario. Costs are based on the expert view of Currie & Brown's cost management team who maintain a live database of costs associated with energy and carbon saving measures in construction and these have been used for the basis of this analysis with adjustment for the local circumstances for Isle of Wight. Baseline construction costs are based on the data held and expertise of our cost management teams including those based in Southampton with experience of the local market.

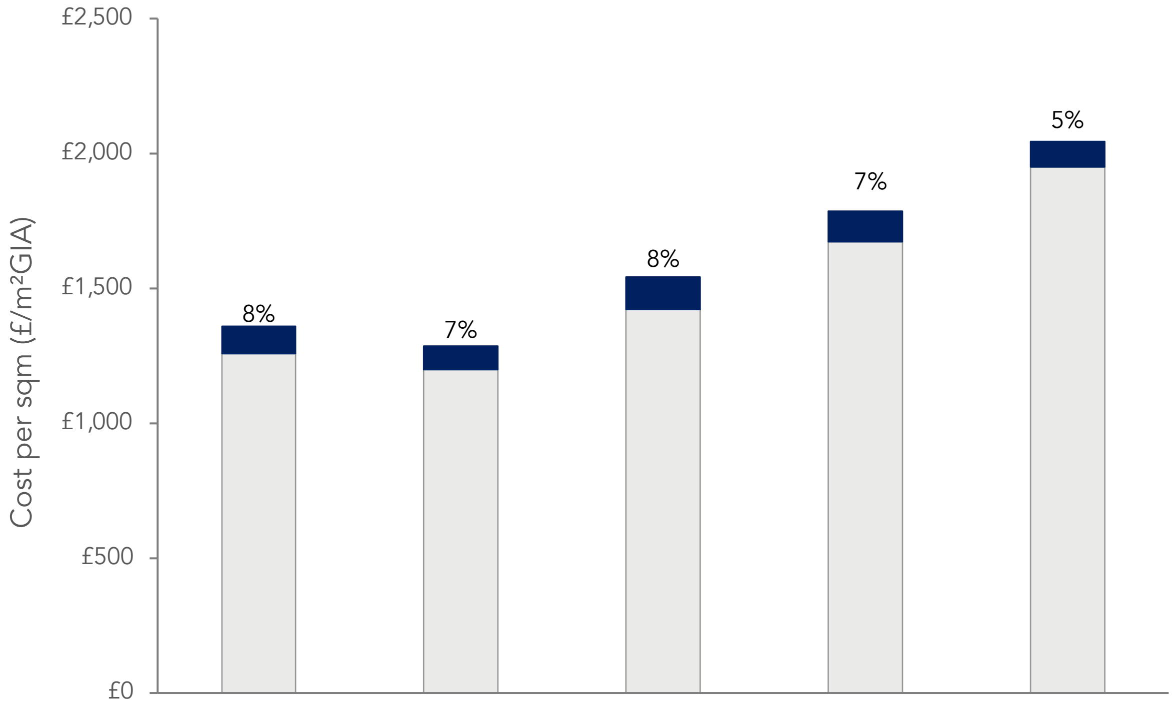
Main conclusion

This page summarises our findings for the comprehensive scenario only. The uplift in construction costs of Net Zero carbon (in operation) homes compared with Part L 2021 (and Part L 2025) is estimated to be between 5 and 8% depending on the typologies. This 'Net Zero' premium is considered acceptable particularly in comparison with other cost increases affecting the housing market. It is also important to see it as a premium that can only be reduced over the next 30 years as Net Zero becomes the norm.

Alignment to the IoW's viability work

In general the floor area of the house types modelled in this study are consistent with those considered in the LP viability study, albeit the 4 bed house is larger.

Our baseline cost information is more granular than that used in the viability study which uses a fixed rate for housing (£1,288/m²) and for flats (£1,385/m²). Our figures range from £1,200/m² to £1,680/m² for houses and are £2,120/m² for 6-8 storey blocks of flats.



Cost uplifts /m²GIA	Semi detached	Mid terrace	Bungalow	Detached	Med Rise Flat
Fabric	£74	£63	£101	£83	£53
System (heating & hot water)	£27	£25	£29	£33	£27
PV	£1	£1	-£12	-£4	£8

*Costs per sqm for the **comprehensive scenario** of all typologies. The percentage uplifts are shown in the bar chart and the uplift costs per sqm are shown in the table below.*

Note: The % increase is relative to Part L 2021.

10-minute summary | **How to do it?**

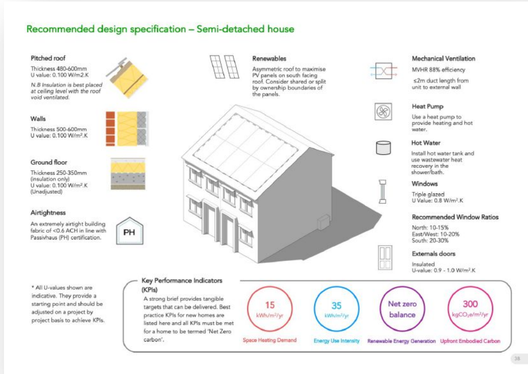
Recommended design specification pages

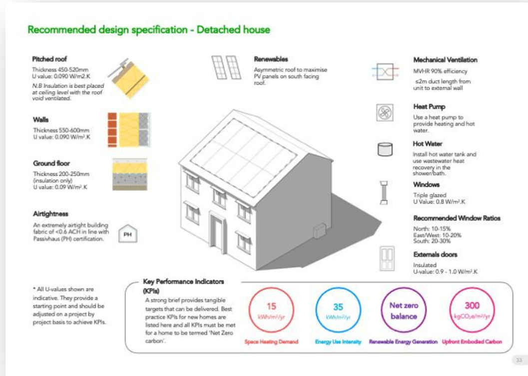
A series of recommended design specifications have been compiled for each typology in order to demonstrate a good starting point for meeting the KPIs outlined in this guide.

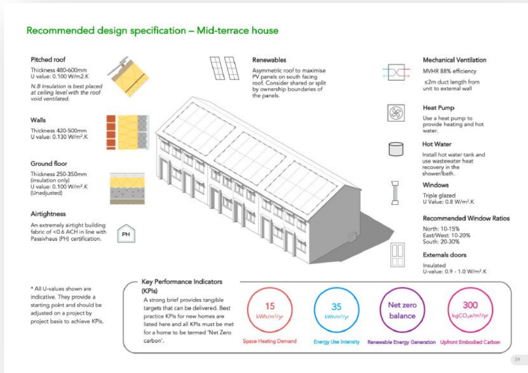
Please note the U-values provided for each typology are indicative and provide a good starting point. A bespoke methodology and specifications will be required for every project to ensure that all KPI targets are met in practice.

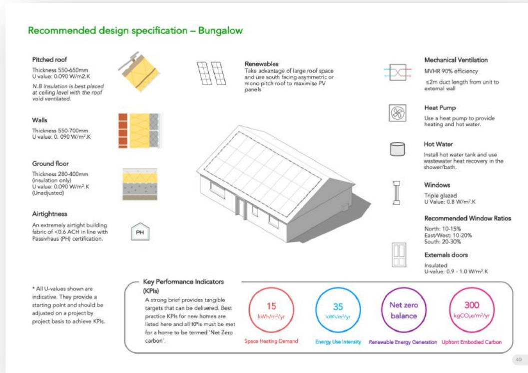
Each site will have its unique set of opportunities and constraints when it comes to obtaining net zero carbon, which must be investigated. For example, a site may only allow for a suboptimal orientation, meaning that considerable solar gain cannot be attained and that other measures must be strengthened to compensate. The focus point pages can serve as a starting point of best practice design.

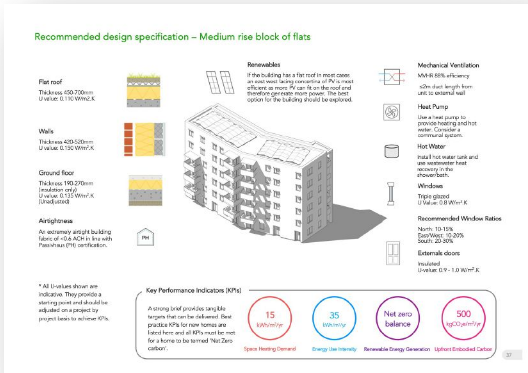
We would generally recommend avoiding bungalow typologies where possible since as it is simply more challenging to achieve net zero carbon without incurring costs in providing a high performing fabric.











1.0

Zero Carbon on the Isle of Wight

This section summarises the Isle of Wight's Zero Carbon strategy and considers the local context.

It also covers (at a high level) key energy infrastructure questions.

Mission Zero: the Isle of Wight's Climate and Environment Strategy 2021-2040

The **Mission Zero: Climate and Environment Strategy 2021-2040** documents published in September 2021 set out the status quo carbon emissions and proposed decarbonisation strategy for the Isle of Wight. The two overarching targets are:

- Net Zero for council operations by 2030; and
- **Net Zero across the Island by 2040.**

The document sets out the current performance for emissions across the Island, the carbon budgets that fit into these timescales, and the short-term sectoral targets that need to be achieved to hit them.

The domestic pathway

As with most areas in the UK, the majority of emissions are attributable to **housing, transport and commercial/industry**, with homes emitting around a third of the Island's emissions in total.

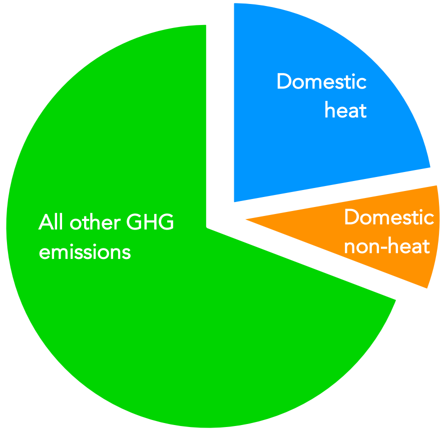
As part of the net zero strategy on the Island the following incentives have either been developed or are proposed:

- Draft planning policy produced in 2019 outlines the promotion of renewable energy schemes on domestic properties.
- Major residential development to implement the highest possible standards of energy efficiency.
- New housing to use renewable heating and energy sources wherever possible by 2021.

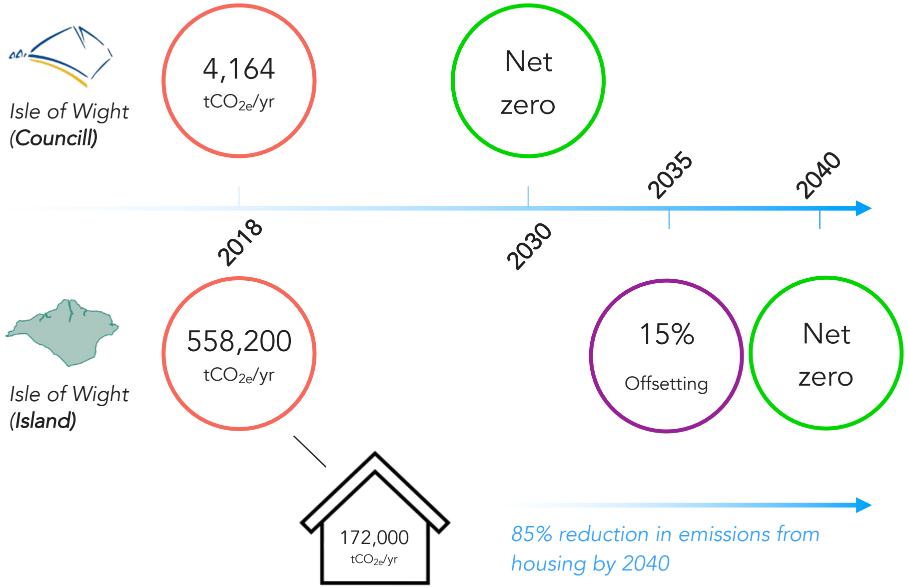
Energy supply

The production of low carbon energy is a key pillar of the net zero aspirations for the Island. Two main targets of the Mission Zero report around energy generation and supply are:

- For the island to become self sufficient in renewable energy generation; and
- Fully decarbonise all existing energy and heating systems.



The operation of domestic buildings currently contributes around one of third of the Isle of Wight's carbon emissions.



A timeline showing the pathway to net zero for council operations and the Island as a whole.

Renewable energy generation on the Isle of Wight

Current renewable energy capacity on the Isle of Wight

The Isle of Wight currently generates approximately 25% of its electrical energy demand from renewable energy (20% from solar and 5% from anaerobic digestion and landfill gas plants).

In total, the Isle of Wight produces approximately 135 GWh of renewable energy per year.

The Isle of Wight should seek to triple its renewable energy output

The UK government plans to fully decarbonise UK electricity by 2035, and the Isle of Wight has an even bigger ambition of becoming self sufficient in renewable energy by 2030.

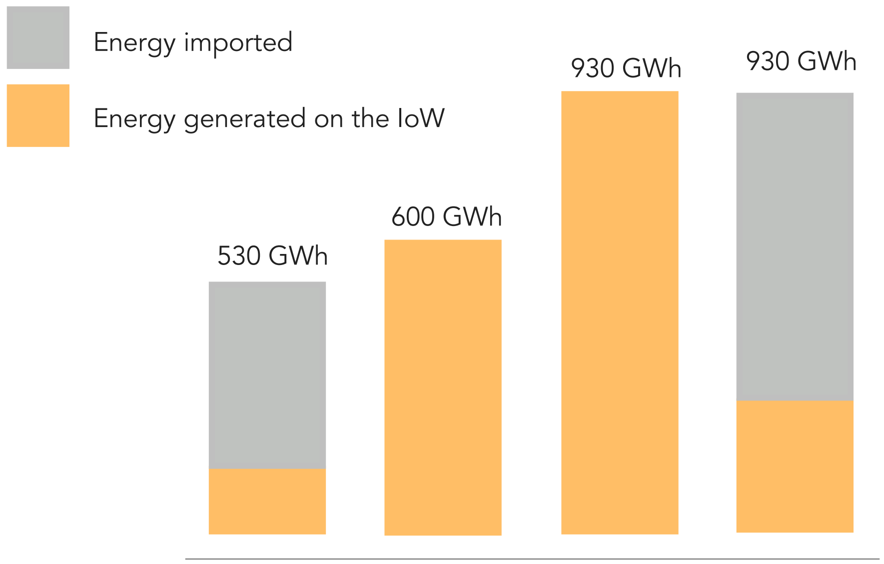
Forecasts from the National Grid's Future Energy Scenario's (FES) Consumer Transformation (CT) scenario estimates that demand for electricity is expected to grow 75% to 930 GWh by 2050. At a national level, approximately 30% of this energy will be generated from land-based renewables such as solar photovoltaics and onshore wind farms. Approximately 50% will be generated through off-shore wind farms.

If the Island were to generate enough renewable energy to contribute its fair share of renewable energy to the national mix, renewable energy output should triple – mostly through on-shore wind but there is scope to alter the balance.

If the island were to be sufficient in 2050 the Island should increase renewable energy output six-fold.

PV on new homes can help the Island generate renewable energy

Buildings represent an ideal opportunity to expand renewable energy generation on the Island. Photovoltaics on buildings contribute to the Island's (and the UK's) renewable energy targets, and provide occupants with a source of energy they can consume directly (reducing energy bills), or sell back to the grid. Photovoltaics on buildings also reduce the need for photovoltaic farms in open fields.



	2019	2030	2050	2050
Scenario	**Current**	**Self sufficient**	**Self sufficient**	**FES CT**
Demand	530 GWh	600 GWh	930 GWh	930 GWh
Self sufficiency (electricity)	25%	100%	100%	30%
Solar PV arrays	110 MW	400 MW	600 MW	100 MW
Onshore wind turbines	0 MW	100 MW	140 MW	70 MW

Indicative future renewable energy capacity required on the Isle of Wight, for self sufficiency, or for a fair contribution to the National renewable energy mix.

Grid Infrastructure

As our economy becomes increasingly electrified, the demands on grid infrastructure increase and local and national grid infrastructure will need to be upgraded and capacity increased.

Capacity is currently limited and although capacity is increasing demand should not outstrip supply. Therefore new buildings should reduce the electrical demands they place on the grid as far as possible. This will also help existing buildings, and other sectors, make the switch to electrification by freeing up capacity.

Peak electrical demands are impacted when there is a call for energy at the same time, for example a cold winter's day. Currently, gas fired power stations are turned on to meet peak demands. Therefore a policy that reduces peak heating demands helps the electricity grid decarbonise. Ultra energy efficient homes can be flexible about when they are heated and load shifting is possible – evening out demand.

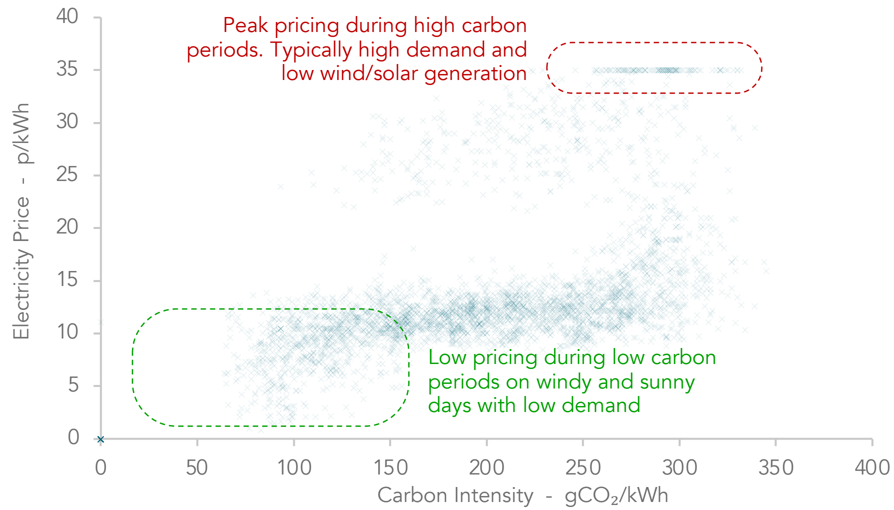
It's important for Local Authorities to liaise with local District Network Operators (DNOs) to understand capacity at a local level. If DNOs are warned in advance of electrical requirements of new developments, they are better able to respond and provide any necessary upgrades.

Energy Storage + Interconnectors

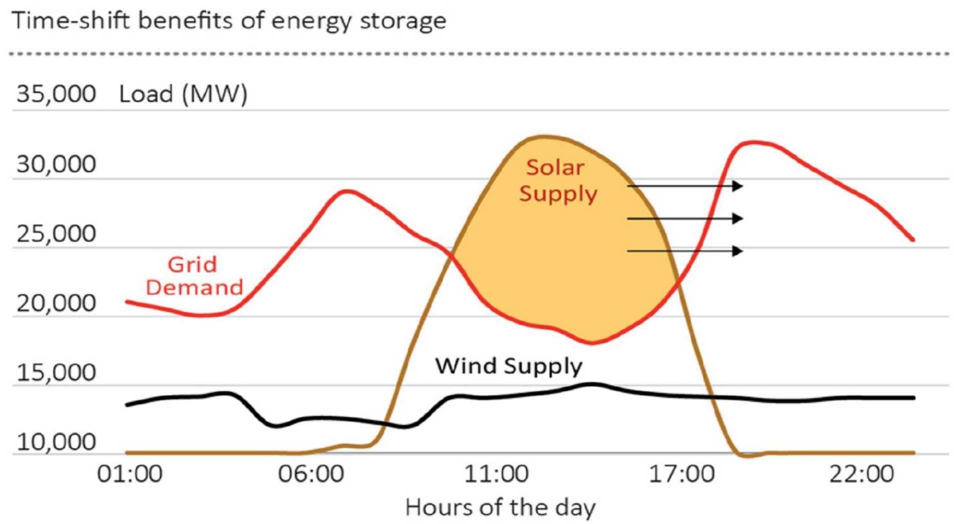
As wind and solar energy are intermittent, and demand for electricity constantly varies, it is necessary to have mechanisms to balance power in the electricity network. The main options are: demand side management; battery or mechanical storage and importing/exporting power through interconnectors with other countries.

The National Grid's "Consumer Transformation" scenario shows a steep rise in the need for electricity storage capacity.

It is not yet clear how much storage capacity will be deployed at a utility scale, versus smaller systems within buildings, however larger systems can achieve significant economies of scale and their growth may render the need for building-level storage less important.



The carbon intensity and price of electricity vary depending on the balance between supply and demand. *The above chart shows price vs carbon intensity in London, at half hour intervals over 3 years from 2018 to 2021. (Source www.energy-stats.uk/download-historical-pricing-data)*



Notional graph of renewable energy supply vs energy demand

Heat networks should not remain the go-to of heat policy

For the last 15 years heat networks have been a favourite of policy makers to decarbonise heat. This was largely driven by the fact that with their larger scale and the aggregation of smaller heat demands they enabled different heat generation technologies to be considered, mainly gas-fired Combined Heat and Power (CHP) but also large biomass boilers.

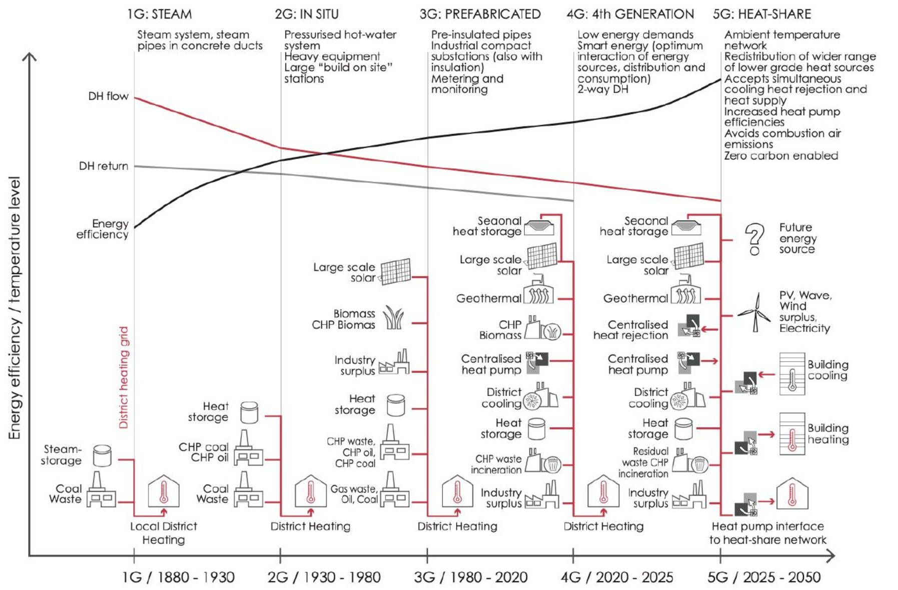
Unfortunately with the decarbonisation of the electricity system, gas-fired CHP does not save carbon anymore and biomass heating systems generally come with questions around their impact on local air quality and the long term sustainability of their wood fuel supply. Low carbon heat networks now rely on heat pumps which can be integrated at a smaller scale (house, block of flats): one of the key drivers behind heat networks (low carbon generation) is therefore no longer there.

Generation mix: no fossil fuels

Most heat networks in the UK have heat generated by fossil fuels. Similarly to individual gas boilers, this approach is not suitable for Net Zero carbon homes. Heat networks with central heat pumps are now being developed and can be a suitable solution. They should be compared objectively to communal and individual heating systems as they may not have a clear advantage over them.

An accurate assessment of distribution losses is necessary

Over the last 20 years, the industry has had to deal with heat networks with very high distribution losses, sometimes greater than the energy required by the residential units. With distribution at medium-high temperatures, this issue is likely to be even more significant for low energy housing developments as the proportion of losses will go up. Distributing at a low temperature (e.g. 25°C) has the potential to reduce these losses.



Summary of evolution of heat networks towards lower temperatures and lower carbon sources (Source: LETI's Climate Emergency Design Guide)

A growing consensus

Our team analysed recent publications relevant to the potential role of hydrogen in heating homes in the future and discussed it with several experts in energy and buildings. The growing consensus is that hydrogen is unlikely to play a significant role in the short to medium term (if at all) for this purpose.

Costs will be (very) high

Re-using the existing gas grid network and turning it into a 100% hydrogen network is not possible without major upgrades. The costs of this combined with hydrogen generation costs and the replacement of all gas appliances into hydrogen-ready ones will be very significant. It is unclear why investors or the Government would finance this major undertaking when renewable electricity distribution appears comparatively much more attractive and less risky.

The Climate Change Committee view

The Committee on Climate Change sees a limited role for hydrogen where 'electrification reaches the limits of feasibility and cost-effectiveness'.

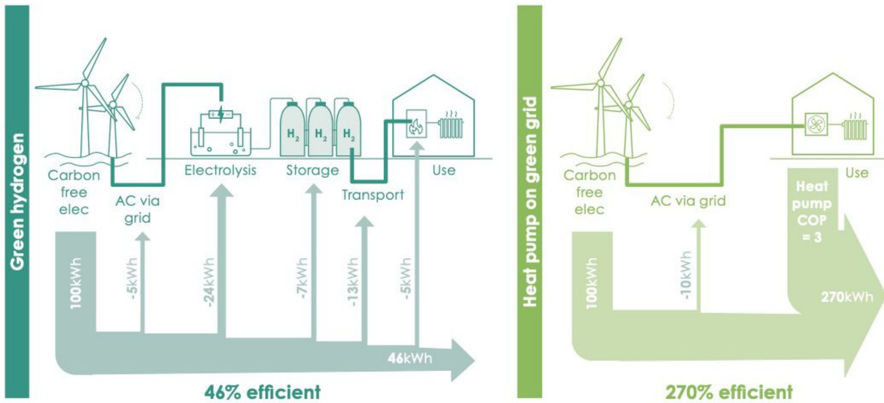
'Blue hydrogen' is unproven and not carbon neutral

Hydrogen is currently produced via four methods, three of which require a fossil fuel feedstock to create 'blue hydrogen' with inherently high emissions. Carbon capture and storage (CCS) is therefore required to reduce emissions but economically viable CCS at scale for this purpose is unproven.

Using 'green hydrogen' is not as efficient as heat pumps

Burning 'Green hydrogen' (produced via electrolysis powered by very low carbon sources of electricity such as renewables and nuclear) in boilers is much less efficient than using electricity directly to power heat pumps.

A number of independent reports suggest that hydrogen is likely to have a very limited role (if any at all) to heat our homes (the above examples are from the Fraunhofer Institute, the International Energy Agency and LETI)



Heating with a heat pump is a 5 times more efficient use of electricity generated by renewables than 'green hydrogen' (Source: LETI)

Local supply chain on the Isle of Wight

The recently withdrawn Green Homes Grant national voucher scheme showed that there is a national skills shortage in the home energy efficiency sector. Upskilling across the construction sector will be a necessary undertaking if we are, as a country, to shift towards truly net zero homes. However, as projects like Cameron Close on the Isle of Wight demonstrate, simple construction methods and non-specialist contractors can achieve ultra low energy buildings with thoughtful design, a considered programme and support.

On-site supervision and programming

The disparity between how buildings are designed and how they are constructed has been major contributor to creating the performance gap. To rectify this construction sites need to evolve and site managers must lead the change. Constructing low energy buildings does not rely on a substantial change in our current approach but simply better management and monitoring, more consideration for sequencing, and comprehensive post-construction commissioning and checks.

Investing fully in technology

All the technology required to meet net zero buildings is in existence and well understood. There are existing companies located on the Isle of Wight that supply these systems. Design teams must allow for these systems from project inception and aim for optimum performance. Installers should then take responsibility for implementing these plans and testing that the technology meets the designed performance.

Simple upskilling options are out there

Training courses for both building designers and contractors are available that take their existing knowledge and adapt it to help construct low energy buildings. Raising awareness of these courses will help to build the future net zero workforce.

A significant part of reducing energy demand in buildings is minimising heat losses and air leakage and paying attention to detail. Site supervision and empowering construction teams to take responsibility for these performance items is a crucial part of this. The images above show techniques for reducing air leakage around windows, ventilation ducting and electrical services by using off the shelf products and considering construction sequence from an early stage.

Technology that drives down energy consumption is easily available. Designers and contractors must however allow for these systems early-on in scheme conception and pay close attention to their installation, commissioning and maintenance. Allowing space on floor plans from an early point in design is crucial. The above images show the integration of (from left to right) an individual heat pump, a mechanical ventilation system with heat recovery, and roof mounted photovoltaics.

2.0

What is a Net Zero Carbon new home?

This section provides an overview of why the Isle of Wight needs Net Zero Carbon new homes, and what they are

Net Zero and new homes - Overview of evidence

Our buildings produce a lot of carbon – and are expensive to run

The emissions from our buildings account for 26% of the UK's total emissions. 18% of this total is from our homes. This is not only bad for the planet, it is bad for the occupants. It is therefore important for new homes to be designed and built to use significantly less energy which also means they would cost a lot less to run.

The UK's commitment to net zero carbon

The UK has binding targets to reduce CO_2 emissions through the Paris Agreement. This is legislated in the UK by The Climate Change Act 2008 (amended in 2019) – which requires that the UK carbon account for 2050 must be 100% lower than 1990 levels – i.e. the UK must be net zero carbon by 2050.

Climate Change Committee (CCC)

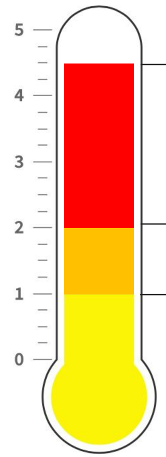
The Climate Change Committee (CCC) is an independent, statutory body whose purpose it is to advise the UK government on emissions reductions targets and report on progress made.

The CCC advises on required emissions reductions from all sectors, including housing. A key recommendation of "UK Housing: Fit for the Future?" is that new homes should be ultra-low energy (space heating < 15-20 $kWh/m^2/yr$), not connected to the gas grid and equipped with a low carbon heating system.

LETI

The London Energy Transformation Initiative (LETI) undertook research culminating in the Climate Emergency Design Guide, which outlines the KPIs of new buildings to ensure our emissions reductions targets are met. In summary,

- New homes must be designed to be net zero carbon.
- New homes must be ultra-low energy (extremely energy efficient)
- New homes must be heated by low-carbon heat – e.g. heat pumps. There should be no gas boilers installed in new homes.

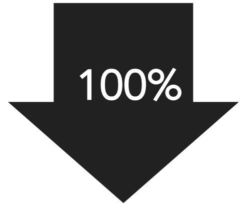


4-5 C the temperature rise we are likely to see if we continue on a **business as usual** path

1.5-2C The maximum temperature rise above pre-industrial levels the IPCC recommends.

1C The temperature rise already created

1990



2050

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

Key publications informing the required performance of new homes to meet global and UK climate change targets: LETI Climate Emergency Design Guide, Climate Change Committee's 'UK Housing: Fit for the Future?' and 'Net Zero: The UK's contribution to stopping global warming'.

Why action is required now (carbon budgets)

Cumulative carbon is more important than a zero carbon target date

Cumulative carbon is directly proportional to global temperature rises. Informed by the latest climate science, the IPCC has developed global carbon budgets for limiting global temperature rises to 1.5-2C.

We will exceed our carbon budget in 7 years unless action is taken

Tyndall Carbon Budget Reports derive carbon budgets for each UK local authority from the IPCC's global carbon budget. They are powerful in their simplicity, since they are directly related to actual CO_2 missions from energy (representing 80% of the UK's greenhouse gas emissions). A local authority can monitor their own local CO_2 emissions from energy (using BEIS datasets) and plan to reduce them in line with the recommended trajectory.

In summary, the report recommends:

- The Isle of Wight stays within a maximum cumulative CO_2 emissions budget of 3.4 million tonnes ($MtCO_2$) for the period 2020-2100.
- If emissions continue at 2017 levels, the entire carbon budget for the area would be used within 7 years (from 2020), i.e. by 2027.
- Emissions cuts must average -12.3% per year to deliver a Paris aligned carbon budget.
- Reach net zero no later than 2041, at which point 5% of the budget remains.
- Meeting the budget must not rely on carbon offsets.

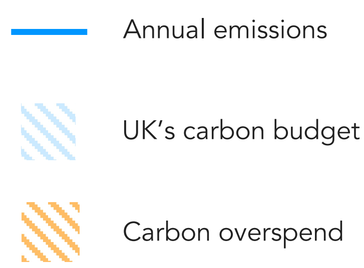
A zero carbon target date is not enough

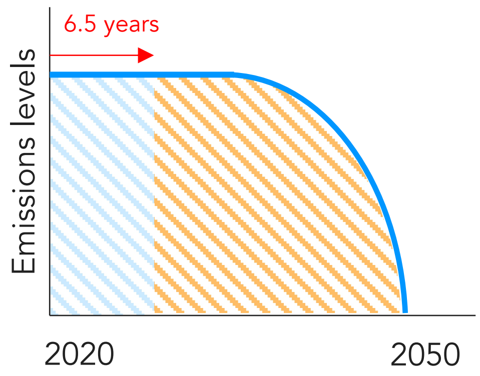
The UK government's zero carbon by 2050 target is not enough without also taking a carbon budgets approach. The two graphs on the right illustrate different emissions trajectories – both of which get to zero carbon by 2050. However, trajectory A emits three times as much carbon as trajectory B, and would put us on a path to much higher global temperature rises than the target 1.5-2 C.

Isle of Wight's carbon budget = 3.4 $MtCO_2$/yr

Current emissions rate = 0.5 $MtCO_2$/yr

Years left of budget at current emissions rate:
6.5 years

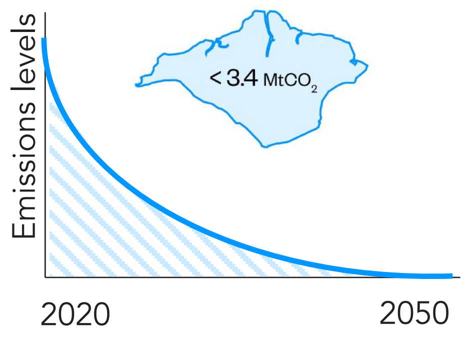




Trajectory type **A**

This trajectory continues at current emissions rates until the 2030s at which point it drops off steeply.

It is zero carbon by 2050 but the carbon budget is far exceeded.



Trajectory type B

This trajectory sees a 12.5% reduction in emissions year on year. Cumulative emissions stays within the carbon budget.

Other trajectories are possible – but it's imperative that we do not overspend on carbon, otherwise we will not be on a Paris compliant trajectory.

New homes need to be ahead of the curve

New homes are easy to make zero carbon

New homes and buildings are relatively easy to build to zero carbon standards. The technology is there and the cost increases have been shown to be minimal.

New homes built today should not be fitted with gas boilers – these gas boilers could continue emitting CO_2 emissions for another 15-20 years.

New buildings should not add to the retrofit burden

The retrofit of existing homes to low carbon heat sources (and any energy efficiency measures that will enable the transition) is a huge challenge.

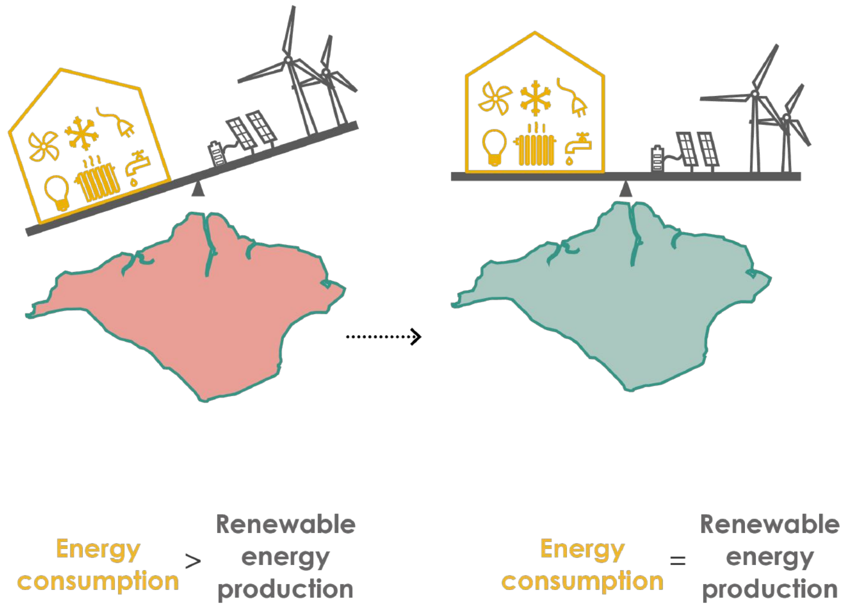
The vast majority of the Isle of Wight's 71,000 homes are heated by gas and oil boilers. To meet carbon budgets we estimate that these would need to be replaced by the early 2030s, with the rate of replacement peaking at 10,000/yr in the mid 2020s.

There is little logic in contributing to the future retrofit burden of the Isle of Wight by continuing to build new homes with gas boilers and mediocre levels of energy efficiency.

Buildings should decarbonise more quickly than other sectors

As we have seen on the previous page, it is imperative to take a carbon budgets approach if we are to meet Paris Agreement targets and limit global warming to 1.5-2°C.

Each sector could effectively be given a carbon budget. Those sectors that have the means to decarbonise sooner (e.g. buildings) should arguably have a smaller share of the budget than those sectors which do not yet have all the technological means of decarbonising quickly (e.g. industry and transport). This will mean buildings will need to decarbonise faster than other sectors, and gives more urgency to policy that mandates zero carbon homes.



For the Isle of Wight to reach Net Zero, it needs to produce as much renewable energy as it is consuming. This requires improving the energy efficiency of homes on the island in tandem to increasing the energy consumption through renewable sources e.g. solar panels.

Core principles of net zero carbon buildings in operation

Net Zero carbon buildings in operation are supported by four core principles: energy efficiency, low carbon heat, renewable energy and embodied carbon.

1 - Energy efficiency

Buildings use energy for heating, hot water, ventilation, lighting, cooking and appliances. The efficient use of energy reduces running costs and carbon emissions. It also reduces a building's impact on the wider energy supply network, which is also an important consideration.

2 - Low carbon heating

Low carbon sources of heat are 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.

3 - Renewable energy generation

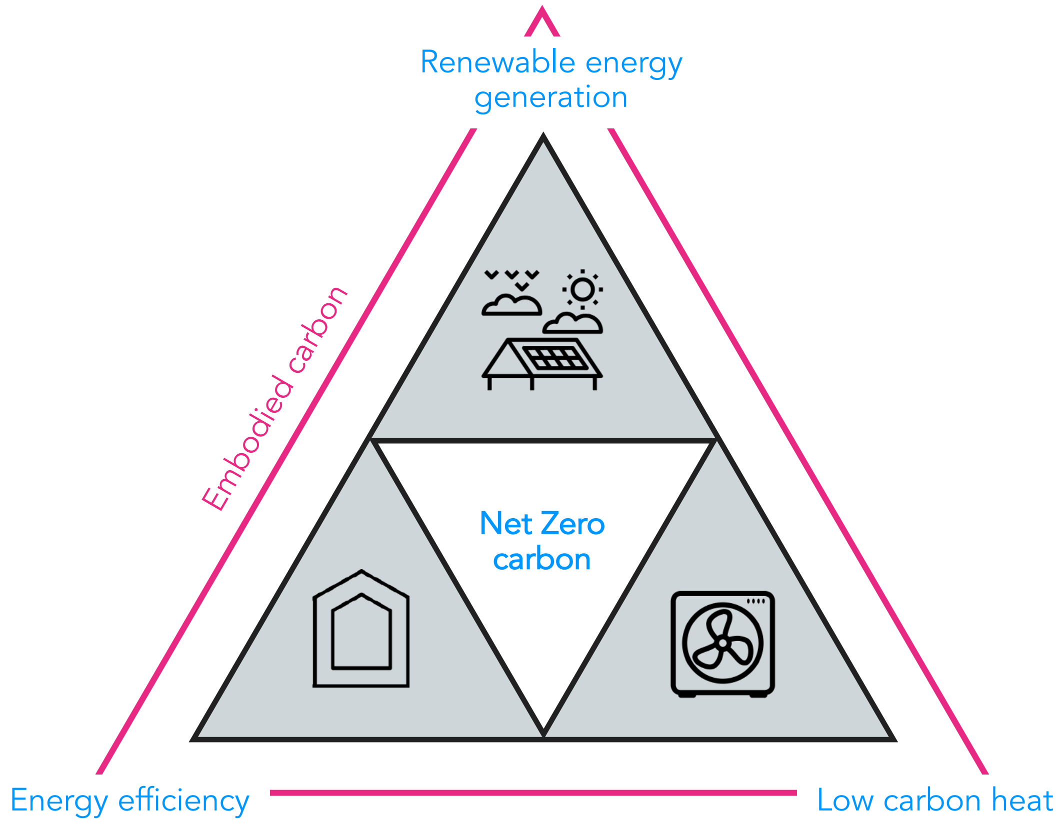
In new buildings, renewable energy generation should be at least equal to the energy use of the building on an annual basis for it to qualify as Net Zero carbon in operation. This is straightforward to achieve on site for most new homes through the use of solar photovoltaic (PV) panels.

4 - Embodied carbon

Operational carbon is only part of the story. Net Zero buildings should also minimise embodied carbon in materials.

Inter-relationships

The core components of a zero carbon building are all interrelated, and all three impact each other. They also affect a building's impact on the local electricity grid, and smart electrical systems play an important role too.



The four core principles of a "net zero" building: energy efficiency, low carbon heat, renewable energy generation and embodied carbon.

1 - Energy efficiency

Why is energy efficiency important?

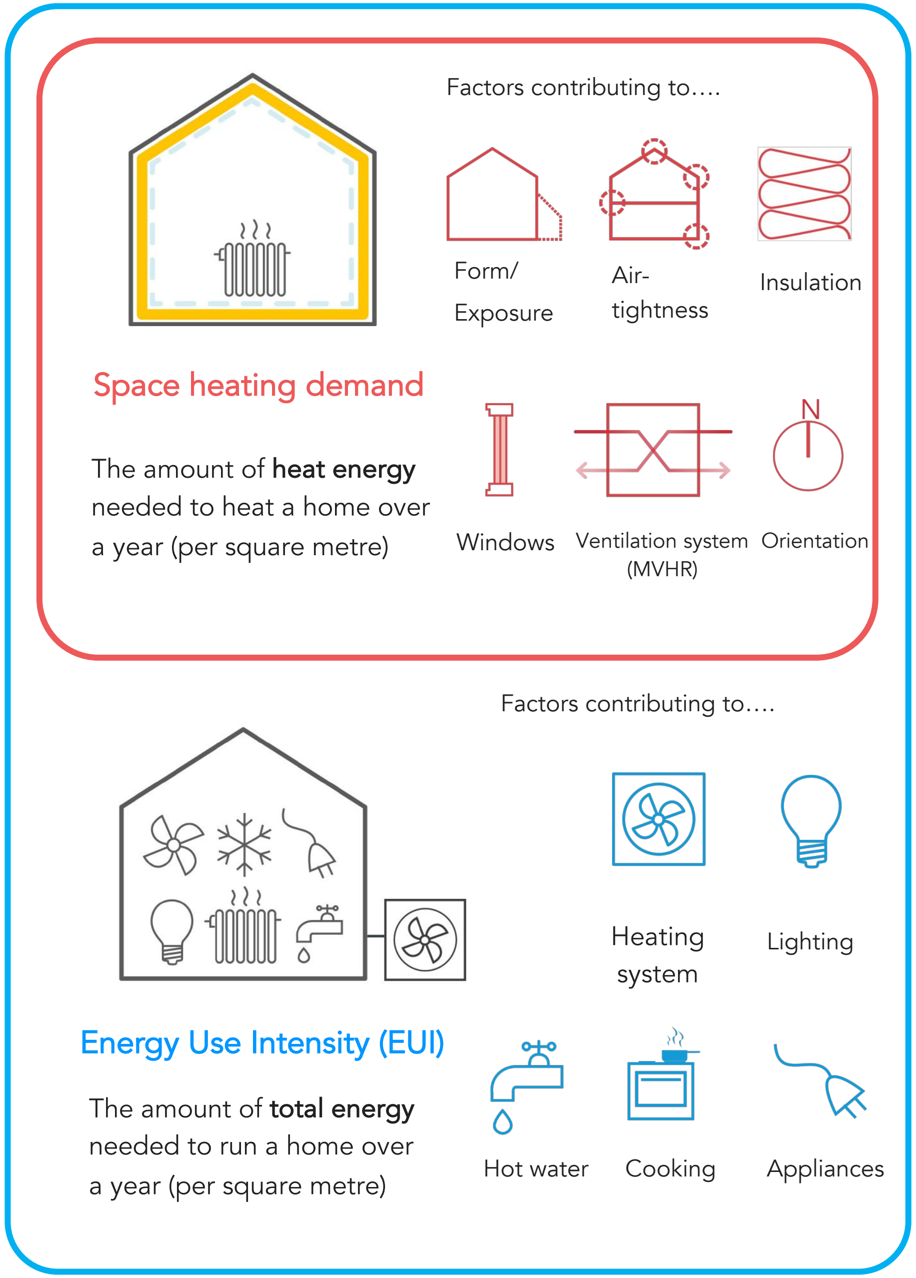
Energy efficiency is important for a number of reasons. An energy efficient home:

- Reduces energy costs to residents
- Is more flexible in terms of the heating system it can use – both direct electric systems and air source heat pumps can be used (although the latter is preferred – see the Low Carbon Heat page).
- Loses heat very slowly, and is therefore more flexible about when heat is delivered. This means that it can be heated when energy is cheap.
- Requires less heat at peak times and therefore reduces demand on grid electricity.

How we measure energy efficiency

Energy efficiency can be measured using two key metrics:

- **Space heating demand**, which is the amount of **heat energy** needed to heat a home over a year (per square metre). It is a measure of the thermal efficiency of the building (kWh/m^2/yr). Various design and specification decisions affect space heating demand including building form and orientation, insulation, air-tightness, windows and doors and the type of ventilation system.
- **Energy Use Intensity (EUI)**, or metered energy use, is the **total energy** needed to run a home over a year (per square metre). It is a measure of the total energy consumption of the building (kWh/m^2/yr). The EUI of a building covers all energy uses: space heating, domestic hot water, ventilation, lighting, cooking and appliances.



2 - Low carbon heat

Low carbon heat is an essential component of a zero carbon building

Net Zero carbon buildings should not burn fossil fuels for energy. Low carbon alternatives that are available now (sustainable green hydrogen is not currently an option) include Air Source Heat Pumps and Direct Electric heating. Electricity can be met through on-site renewables and through grid electricity, which is becoming increasingly decarbonised.

Heat pumps are the most energy efficient means of heating

Heat pumps use refrigerant to efficiently move heat from one place (outside the building) to another (inside the building). Heat sources can include outside air, the ground or a local water source. Heat pumps can provide both space heating and domestic hot water and can serve individual homes or communal heating systems.

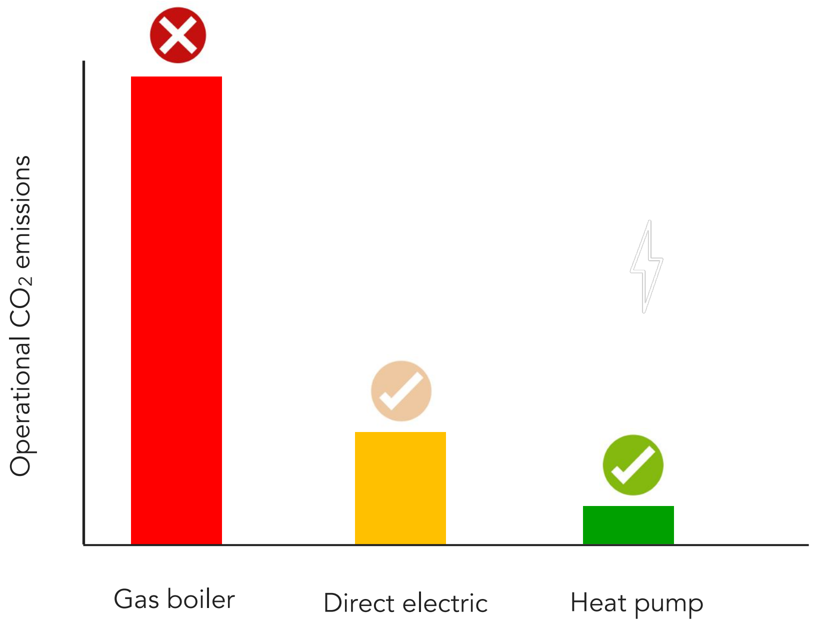
They key benefit of heat pumps is their efficiency. Efficiencies vary, but are typically around 250-300% for an Air Source Heat Pump.

Direct electric heating

Direct electric heating systems convert electricity directly into heat through resistive heating. It is typically 100% efficient. The price of electricity can make this a relatively expensive means of heating buildings and providing hot water, unless cheaper off-peak electricity is used.

Impact of heating system on energy use

The choice of heating system significantly affects how much energy a building uses for space heating and hot water provision – the higher the efficiency of the heating system, the less energy is required to meet the space heating demand. Heat pumps require significantly less energy than direct electric heating to provide the same amount of heat. Therefore heat pumps reduce a home's overall electricity use, reduce the amount of renewable energy required to make a building net zero carbon and reduce peak electrical demands on the grid.



The choice of heating system will affect operational CO_2 emissions over a long time. Electric forms of heating (direct electric and heat pumps will emit a fraction of a gas boiler carbon emissions (average over 2022-2050)

Key points

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

3 - Renewable energy generation

Solar photovoltaics (PV) are ideally suited to buildings

Solar photovoltaic (PV) panels generate electricity when exposed to sunlight. They are usually the most appropriate form of renewable energy generation for a building as they are simple, mature and durable technology and can be installed on both roofs and suitable facades.

Aim for at least an energy balance

A net zero energy balance is achieved when the amount of renewable energy generated in a year matches the energy used in a year (the EUI).

In the UK it is generally possible for blocks of flats up to six storeys in height to achieve a net zero energy balance on site through the use of rooftop solar PV arrays, heat pumps and efficient building fabric.

A key challenge for solar panels on multi-residential buildings is figuring out how to maximise the financial benefit to occupants.

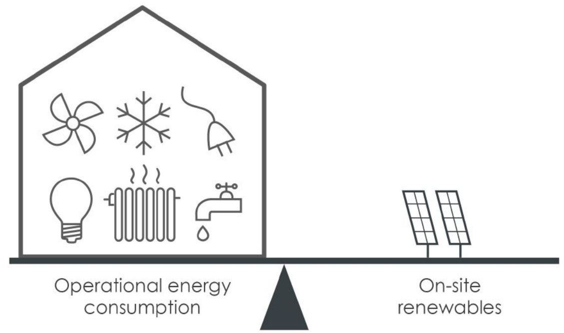
Roof design maximises solar photovoltaic energy generation

By considering solar photovoltaics at the very earliest of design stages, it's possible to optimise roof shape and orientation to maximise solar photovoltaic output – in turn maximising returns for occupants. How well a roof space is designed and utilised can be expressed in kWh of energy generated per m^2 of building footprint.

Renewable energy generation offers many benefits

Generating electricity at the point of use offers several advantages, including:

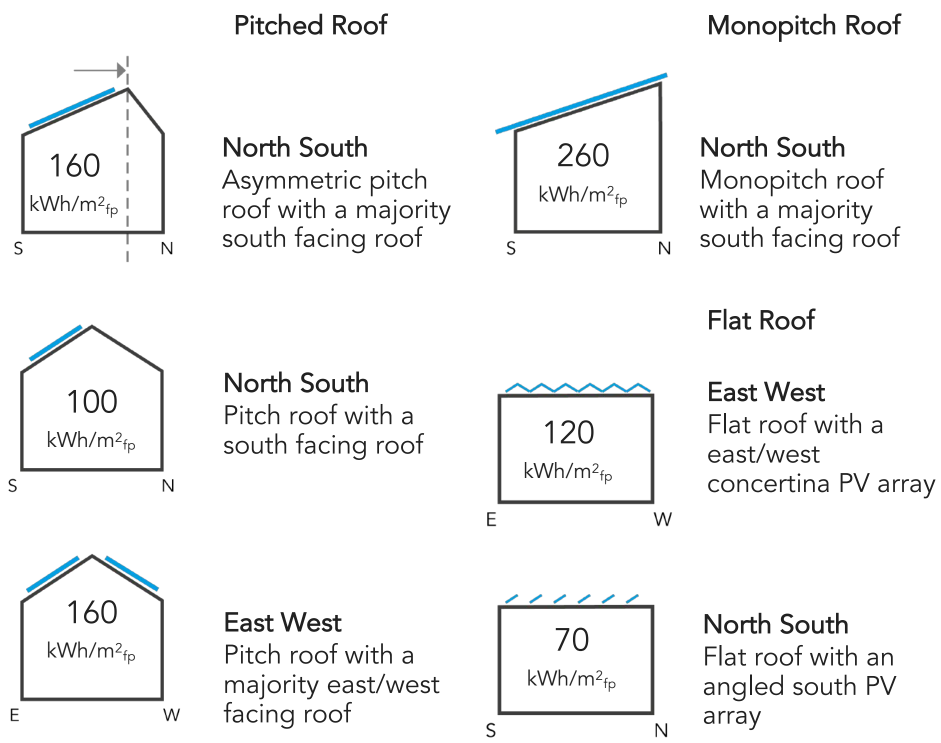
- provision of cheap electricity close to demand that can offset electricity consumption at full retail price,
- the ability to directly power building systems or charge electric vehicles from rooftop solar energy, and
- immediate decarbonisation of electricity supplies (rather than having to wait for the UK grid to decarbonise)..



Energy balance

The amount of renewable energy generated in a year matches 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 matches the energy used by the building in a year.



Roof design can be optimised to maximise energy output from photovoltaics. How well the roof space is utilised can be expressed in kWh generated per m^2 of building footprint (kWh/m$^2_{fp}$)

4 - Embodied carbon

Embodied carbon reductions

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

Embodied carbon must be drastically curtailed throughout the building life cycle. Identify big ticket items early and target reductions during the design stage for largest impact.

Emerging guidance

Guidance on embodied carbon and calculation methodologies are still in development. This page sets out the core design principles to be followed at the outset in order to reduce embodied carbon through the design and specification of materials.

Engage structural engineer

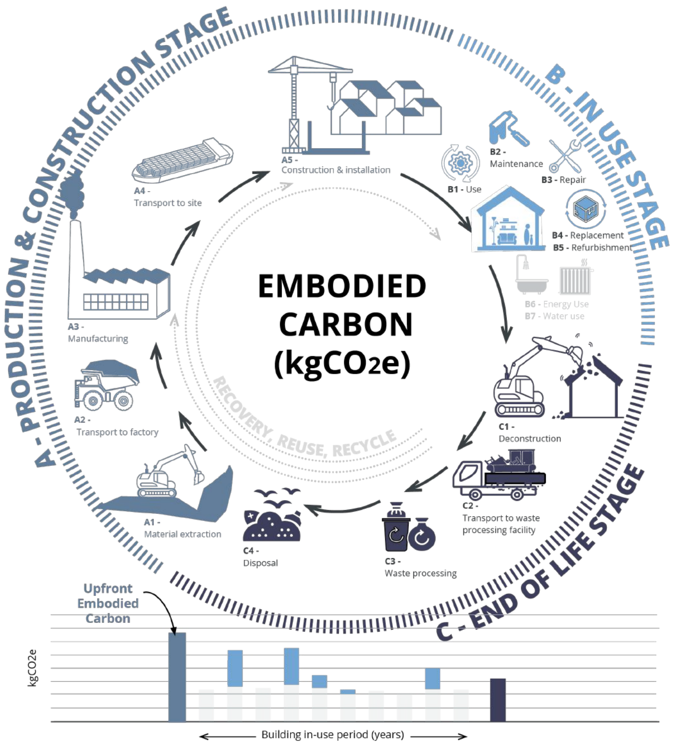
The biggest savings are often in the structure, it is therefore important to collaborate with the structural engineer early and considering how a building can be optimally designed can reduce more embodied carbon than the tinkering of finishing materials later down the line.

Capture embodied carbon of building services

Embodied carbon of building services and in particular the heating systems is likely to be significant proportion of the total for these typologies. It should be included in any assessment.

Upfront embodied carbon

Upfront embodied carbon is the carbon emission up until the building is built. It contributes the biggest proportion of embodied carbon across a building's life cycle and therefore it is important to set a target to significantly reduce this through early design consideration.



Embodied carbon is the carbon emissions associated with the full life cycle of the building: its production, construction, maintenance and end of life stages.

Note that B6 and B7 relate to the energy and water the building uses i.e. the buildings operational impact. It is shown in light grey within this diagram because this is not classed as the embodied carbon of the building but still contributes to the full life cycle carbon emission.

Operational energy related carbon and embodied carbon together make up whole life cycle carbon of the building. The lifecycle is defined by the EN15879 standard and divided in different stages as shown in the diagram above.

(Source: LETI)

A smart electrical system

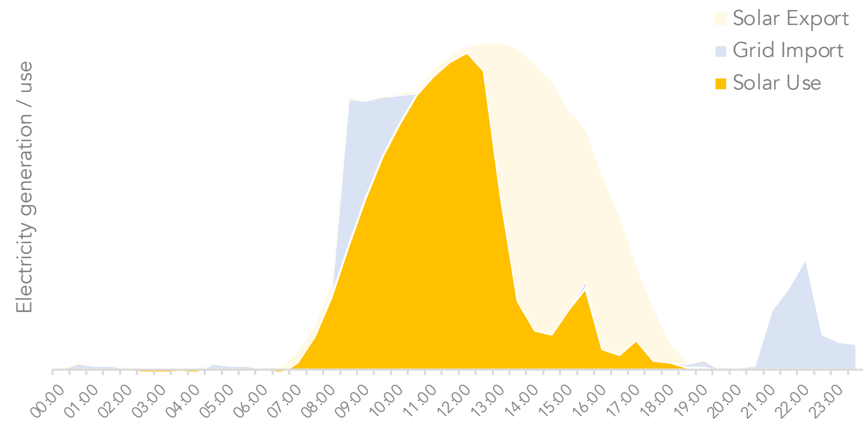
How does a smart electrical system facilitate net zero carbon?

As we move away from gas to electricity for heating homes and hot water, smart electrical systems will allow us to:

- Control when our homes and hot water are heated
- Maximise benefit from on-site renewables by using energy when it is generated,
- And in doing the above, reduce energy costs.

Moreover it will help to decarbonise the grid by spreading out demand, reducing peak loads, and using more energy when renewable energy output is high. When renewable electricity generation is low, demand response measures can reduce the load on the grid, reducing the need to fire up gas fired power stations to meet the grid demand.

A smart electrical system should be considered for all new homes on the Isle of Wight.



This graph shows how solar works in practice on a sunny day. In the morning, solar energy is used to heat the home or a hot water tank, or charge an electric car. By early afternoon the hot water tank and electric car are both fully charged, so most solar energy is then exported. In the early morning and the evening, electricity is imported from the grid.

To maximise solar self-consumption, prioritise smart thermostats, solar hot water diverters, and solar electric vehicle charging..

Beyond carbon: Net Zero carbon homes will reduce fuel poverty and improve health and wellbeing

Reducing fuel bills alongside carbon emissions

Whilst decarbonising homes is important to mitigate climate change, it is not the only reason to build Net Zero new homes. In 2018, one in ten households in England were considered to be in fuel poverty. There is, unsurprisingly, a strong correlation between inefficient homes and fuel poverty with 88% of all fuel poor households living in properties with a Band D EPC or below. Net Zero carbon new homes can deliver lower bills as well as lower carbon emissions[1].

Health and wellbeing

Better quality homes will also deliver higher levels of thermal comfort (both in summer and in winter) and improve indoor air quality through better ventilation. This will have a positive impact on everybody, but especially small children, the elderly and those with respiratory conditions. The International Energy Agency (IEA) and the OECD suggest health improvements might account for 75% of the overall value of improving the energy efficiency of buildings [2].

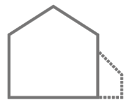
[1] The average Band D annual energy bill is £1600 and the average reduction needed to bring these households out of fuel poverty is £335

[2] Separately, the BRE have estimated that poor quality housing costs the NHS £1.4 billion in avoidable treatments.

Net Zero homes could reduce fuel poverty

Fabric

High performance building fabric loses less heat in winter which reduces heating bills.

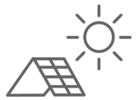


Optimised form

Efficient building forms loses less heat in winter which reduces heating bills.

Optimised building orientation

Optimised building orientation allows for better control of solar heat gains reducing heating bills and mitigating summer overheating.



Renewable energy production on-site

Solar panels on-site can reduce electricity bills.

3.0

How to deliver Zero Carbon homes on the Isle of Wight: practical guidance

This section sets out the recommended specifications and Key Performance Indicators for 5 different typologies.

A timeline with key actions required at this stage can be used as guidance, as well as 10 'focus pages' on different technical considerations.

Our analysis on the Isle of Wight

Five typologies have been chosen to represent a range of potential developments on the Isle of Wight. These have been developed through conversations with the Isle of Wight Council and Southern Housing Group and reviewing some of the current major planning applications for the Isle of Wight. They include:

- a small 3-bed semi-detached house
- a small 3-bed terrace house
- a small 2-bed bungalow
- a fairly large 4-bed detached house
- a medium rise block of apartments.

The different typologies have different form factors (i.e. ratio between the external envelope losing heat and floor area. The form factor is an interesting concept which helps to understand how inherently energy efficient some typologies are (or not), and the likely impact of additional fabric costs.

Energy and cost modelling was undertaken on five different sets of specification:

S1 – Part L 2021

S2 – Future Homes Standard (Part L 2025)

S3 – **Technology first**, with a heat pump

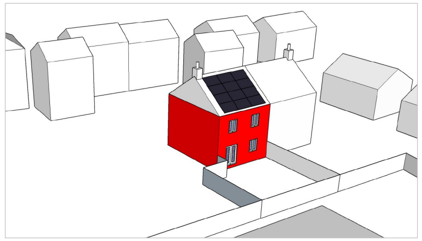
S4 – **Fabric first**, with ultra-low energy specs and direct electric

S5 – **Comprehensive**, with both ultra-low energy specs and a heat pump

3-bed Semi Detached

GIA: 93m²

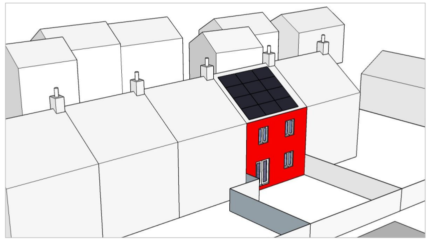
Form heat loss factor: 2.76



3-bed Mid terrace

GIA: 93m²

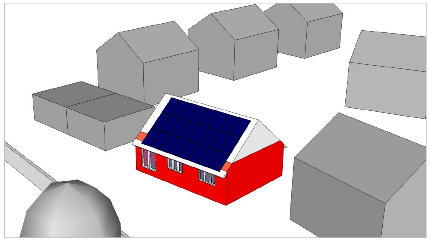
Form heat loss factor: 2.20



2-bed Bungalow

GIA: 74m²

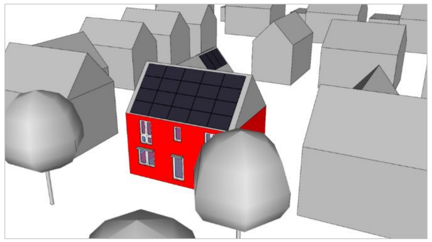
Form heat loss factor: 4.04



4-bed Detached House

GIA: 142m²

Form heat loss factor: 2.95

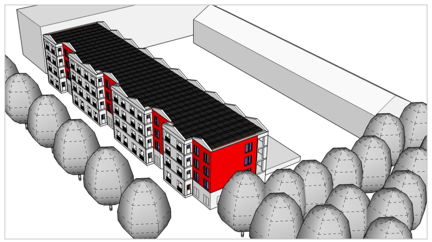


Medium rise block

40-units

GIA: 2362m²

Form heat loss factor: 2.04



Considerations

The specifications we have been arrived at through careful consideration of the issues impacting us today.

Carbon budgets - The extremely limited carbon budget for staying within 1.5-2°C highlights we need to stop emitting carbon now – no more fossil fuels.

We need to use technology that's available here and now – drastic emissions reductions need to take place in the 2020s. Therefore we need to use technology that's available here and now.

Electricity grid - The electrification of heat (and transport) will necessitate upgrades at local and national level. New buildings should therefore reduce the electrical demands they place on the grid as far as possible. They should be energy efficient in order that peak heating is reduced and load shifting is possible – evening out demand.

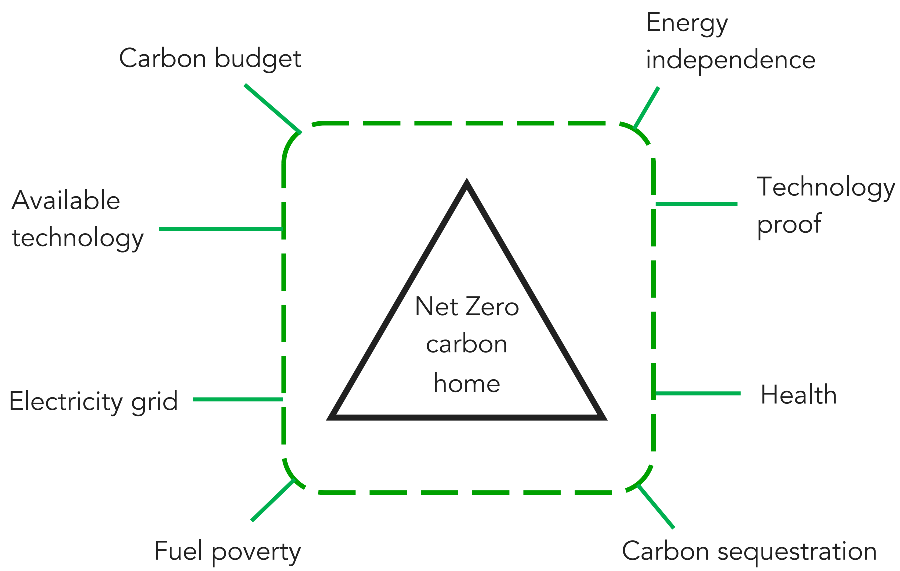
Fuel poverty – energy efficiency reduces energy bills.

Energy independence – energy efficiency and renewable energy generation on-site increases energy independence and reduces reliance on external sources of energy and price fluctuations.

Technology proof – low space heating demands allow occupants flexibility to use different heating systems at any point in the future.

Health – high energy efficiency targets promote construction quality and improved indoor air quality.

Carbon sequestration – the drawdown of CO_2 from the atmosphere will be an essential part of limiting climate change. Potential is limited and therefore zero carbon buildings do not place additional demands.



Other important considerations in the design and delivery of Net Zero carbon homes

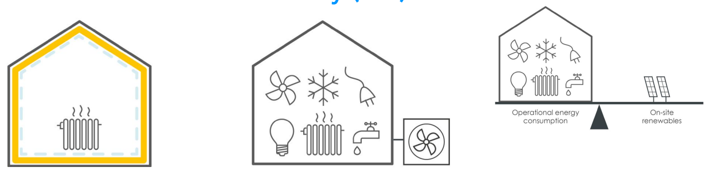
The wider landscape, and therefore rationale, may change in the future

The targets we recommend for net zero carbon homes address multifarious issues that impact us today. The homes that we build today may be in use for decades, even hundreds of years.

The issues that contribute to our conclusion regarding zero carbon targets may also change. For example, clean zero carbon energy may become abundant. New technology may appear and our climate may change.

The key targets we recommend both address the issues we need to address today, but also future proof the homes they are applied to – they will remain relevant for years to come.

Key performance indicators



	Space heating demand 15 kWh/m²/yr	Energy Use Intensity (EUI) 35 kWh/m²/yr	Energy balance Net Zero Balance	Upfront Embodied Carbon *varies with typology 300* $kgCO_{2}e/m_{2}/yr$
Climate Change Committee recommendation	✓			
LETI Net Zero Definition	✓	✓	✓	✓
Alignment with Passivhaus	✓	(✓)		
Reduces heating energy and bills	✓	✓	✓	
Reduces peak energy demand	✓	✓		
Allows for load shifting and energy flexibility	✓	✓		
Compatible with different heating systems	✓	✓	✓	
Less renewable energy required to achieve zero energy balance	✓	✓		
Addresses fuel poverty	✓	✓	✓	
Contributes to a healthy indoor environment	✓			
Reduces carbon overall carbon emitted	✓	✓	✓	✓

Our conclusion

We have compared three scenarios which meet a Net Zero energy balance on-site through different specifications:

- **Technology first** (with a heat pump and PVs)
- **Fabric first** (with ultra-low energy specifications, direct electric* and PVs)
- **Comprehensive** (with both ultra-low energy specifications, a heat pump and PVs).

Part L 2021 and Future Homes scenarios have also been modelled for comparison purposes.

The 'Comprehensive' scenario is recommended

This scenario is the only one to meet all Net Zero carbon KPIs:

- an ultra-low level of space heating demand in line with the recommendations of the Climate Change Committee, i.e. 15-20 kWh/m^2/yr except in the case of the bungalow.
- a fossil fuel free and efficient heating system (i.e. heat pump).
- An Energy Use Intensity (EUI) compliant with LETI/UKGBC and the RIBA Climate Challenge, i.e. less than 35 kWh/m^2/yr except in the case of the bungalow.
- An energy balance with roof-mounted PVs for all typologies.

It would also deliver the lowest energy bills for the residents.

Concerns about the other scenarios

'Technology first' scenario. This strategy does not meet the space heating demand KPI. A large performance gap is more likely. It is (over) reliant on the heat pump, including its successful design, installation and commissioning. It is less carbon efficient.

'Fabric first' scenario. This strategy does not meet the Energy Use Intensity KPI. Energy costs for the residents will be higher.

Net Zero carbon KPIs	Technology First	Fabric First	Comprehensive
15 kWh/m^2/yr – Space Heating Demand	✗	✓	✓
35 kWh/m^2/yr – Energy Use Intensity	✓	✗	✓
Energy balance – Renewable Energy Generation	✓	✓	✓
300* kgCO_2e/m^2/yr – Upfront Embodied Carbon	✓	✓	✓

*varies with typology

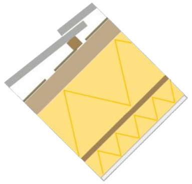
** This focuses on direct electric panel heaters but energy and carbon conclusions are likely to apply to other forms of electric heating, including storage heaters*

Recommended design specification – Semi-detached house

Pitched roof

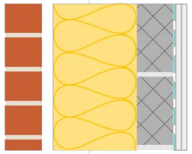
Thickness 480-600mm
U value: 0.100 W/m2.K

N.B Insulation is best placed at ceiling level with the roof void ventilated.



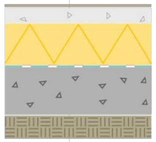
Walls

Thickness 500-600mm
U value: 0.100 W/m^2.K



Ground floor

Thickness 250-350mm
(insulation only)
U value: 0.100 W/m^2.K
(Unadjusted)



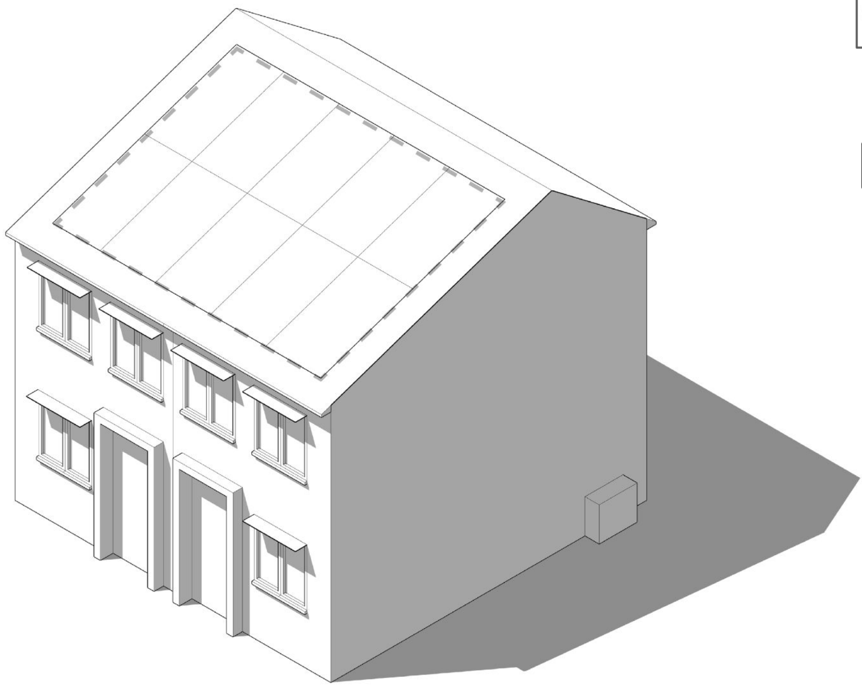
Airtightness

An extremely airtight building fabric of <0.6 ACH in line with Passivhaus (PH) certification.

PH

Renewables

Asymmetric roof to maximise PV panels on south facing roof. Consider shared or split by ownership boundaries of the panels.



Mechanical Ventilation

MVHR 88% efficiency

≤2m duct length from unit to external wall

Heat Pump

Use a heat pump to provide heating and hot water.

Hot Water

Install hot water tank and use wastewater heat recovery in the shower/bath.

Windows

Triple glazed
U Value: 0.8 W/m^2.K

Recommended Window Ratios

North: 10-15%
East/West: 10-20%
South: 20-30%

Externals doors

Insulated
U-value: 0.9 - 1.0 W/m^2.K

* All U-values shown are indicative. They provide a starting point and should be adjusted on a project by project basis to achieve KPIs.

Key Performance Indicators (KPIs)

A strong brief provides tangible targets that can be delivered. Best practice KPIs for new homes are listed here and all KPIs must be met for a home to be termed 'Net Zero carbon'.

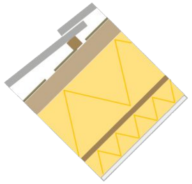
Space Heating Demand	Energy Use Intensity	Renewable Energy Generation	Upfront Embodied Carbon
15 kWh/m^2/yr	35 kWh/m^2/yr	Net zero balance	300 kgCO_2e/m^2/yr

Recommended design specification – Semi-detached house

Pitched roof

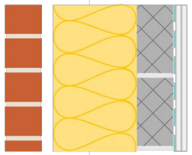
Thickness 480-600mm
U value: 0.100 W/m2.K

N.B Insulation is best placed at ceiling level with the roof void ventilated.



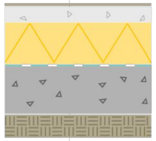
Walls

Thickness 500-600mm
U value: 0.100 W/m^2.K



Ground floor

Thickness 250-350mm (insulation only)
U value: 0.100 W/m^2.K (Unadjusted)



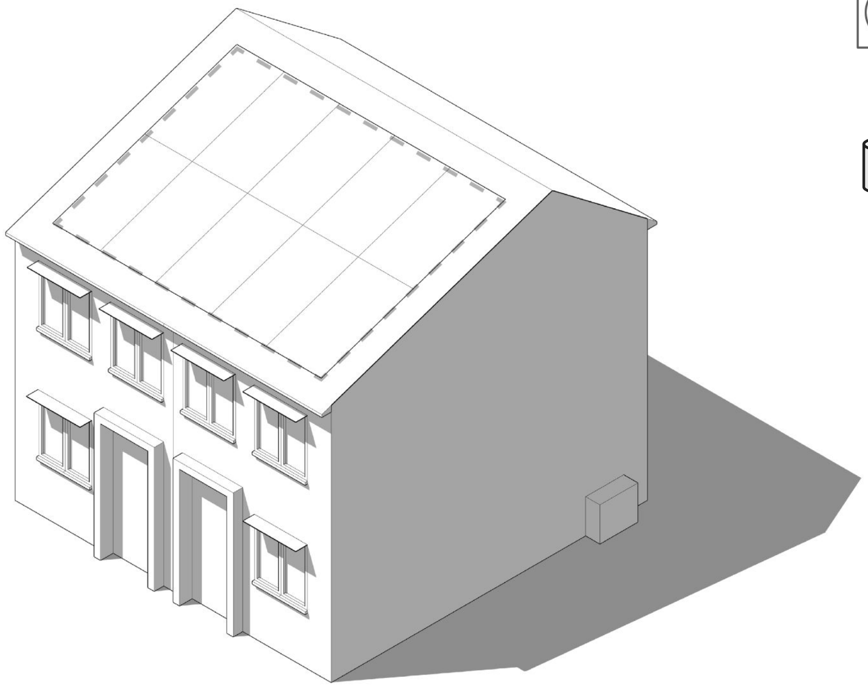
Airtightness

An extremely airtight building fabric of <0.6 ACH in line with Passivhaus (PH) certification.

PH

Renewables

Asymmetric roof to maximise PV panels on south facing roof. Consider shared or split by ownership boundaries of the panels.



Mechanical Ventilation

MVHR 88% efficiency

≤2m duct length from unit to external wall

Heat Pump

Use a heat pump to provide heating and hot water.

Hot Water

Install hot water tank and use wastewater heat recovery in the shower/bath.

Windows

Triple glazed
U Value: 0.8 W/m^2.K

Recommended Window Ratios

North: 10-15%
East/West: 10-20%
South: 20-30%

Externals doors

Insulated
U-value: 0.9 - 1.0 W/m^2.K

* All U-values shown are indicative. They provide a starting point and should be adjusted on a project by project basis to achieve KPIs.

Key Performance Indicators (KPIs)

A strong brief provides tangible targets that can be delivered. Best practice KPIs for new homes are listed here and all KPIs must be met for a home to be termed 'Net Zero carbon'.

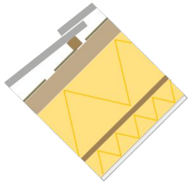
Space Heating Demand	15 kWh/m^2/yr
Energy Use Intensity	35 kWh/m^2/yr
Renewable Energy Generation	Net zero balance
Upfront Embodied Carbon	300 kgCO_2e/m^2/yr

Recommended design specification - Detached house

Pitched roof

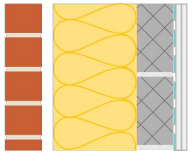
Thickness 450-520mm
U value: 0.090 W/m2.K

N.B Insulation is best placed at ceiling level with the roof void ventilated.



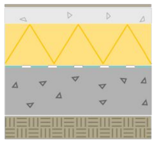
Walls

Thickness 550-600mm
U value: 0.090 W/m².K



Ground floor

Thickness 200-250mm
(insulation only)
U value: 0.09 W/m².K



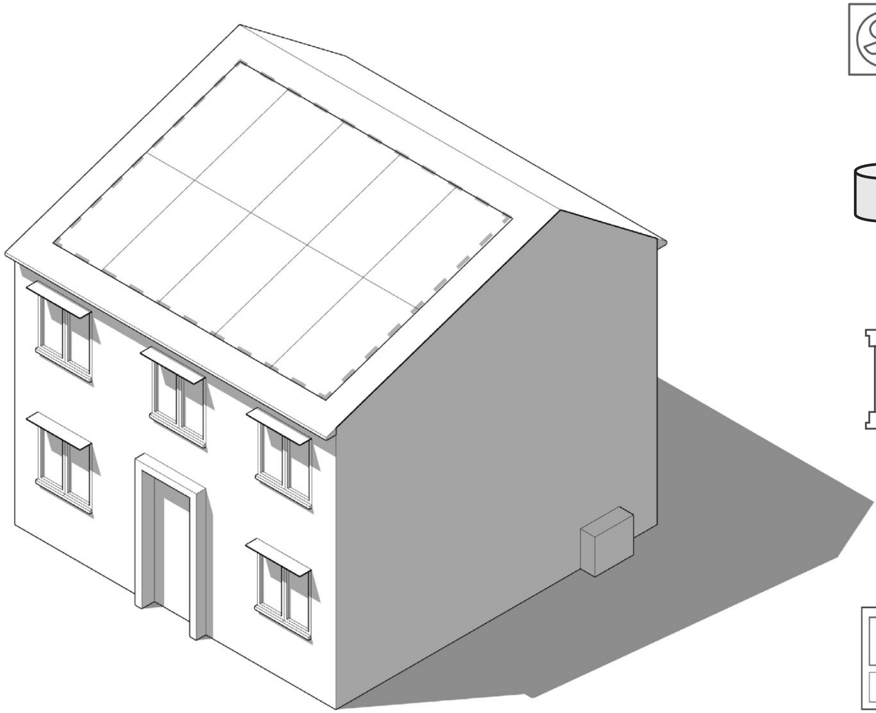
Airtightness

An extremely airtight building fabric of <0.6 ACH in line with Passivhaus (PH) certification.

PH

Renewables

Asymmetric roof to maximise PV panels on south facing roof.



Mechanical Ventilation

MVHR 90% efficiency

≤2m duct length from unit to external wall

Heat Pump

Use a heat pump to provide heating and hot water.

Hot Water

Install hot water tank and use wastewater heat recovery in the shower/bath.

Windows

Triple glazed
U Value: 0.8 W/m².K

Recommended Window Ratios

North: 10-15%
East/West: 10-20%
South: 20-30%

Externals doors

Insulated
U-value: 0.9 - 1.0 W/m².K

* All U-values shown are indicative. They provide a starting point and should be adjusted on a project by project basis to achieve KPIs.

Key Performance Indicators (KPIs)

A strong brief provides tangible targets that can be delivered. Best practice KPIs for new homes are listed here and all KPIs must be met for a home to be termed 'Net Zero carbon'.

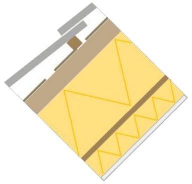
Space Heating Demand	15 kWh/m²/yr
Energy Use Intensity	35 kWh/m²/yr
Renewable Energy Generation	Net zero balance
Upfront Embodied Carbon	300 $kgCO_2e/m^2/yr$

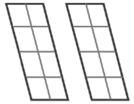
Recommended design specification – Mid-terrace house

Pitched roof

Thickness 480-600mm
U value: 0.100 W/m2.K

N.B Insulation is best placed at ceiling level with the roof void ventilated.





Renewables

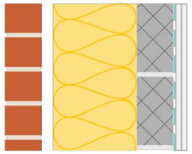
Asymmetric roof to maximise PV panels on south facing roof. Consider shared or split by ownership boundaries of the panels.

Mechanical Ventilation

MVHR 88% efficiency

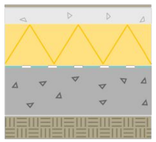
≤2m duct length from unit to external wall

Walls



Thickness 420-500mm
U value: 0.130 W/m^2.K

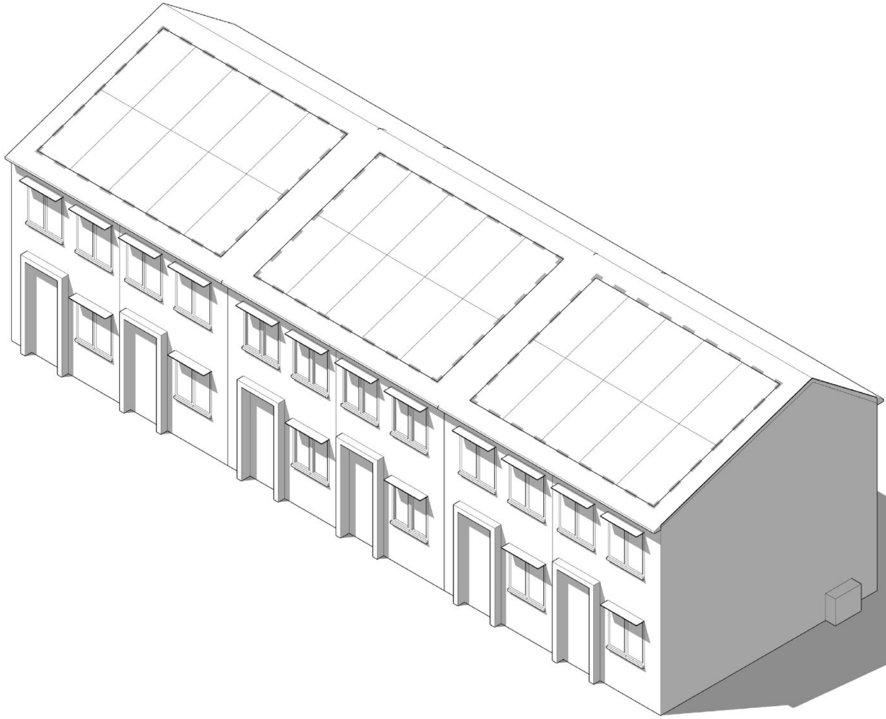
Ground floor



Thickness 250-350mm
(insulation only)
U value: 0.100 W/m^2.K
(Unadjusted)

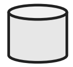
Airtightness

An extremely airtight building fabric of <0.6 ACH in line with Passivhaus (PH) certification.



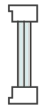
Heat Pump

Use a heat pump to provide heating and hot water.



Hot Water

Install hot water tank and use wastewater heat recovery in the shower/bath.



Windows

Triple glazed
U Value: 0.8 W/m^2.K

Recommended Window Ratios

North: 10-15%
East/West: 10-20%
South: 20-30%

Externals doors

Insulated
U-value: 0.9 - 1.0 W/m^2.K

* All U-values shown are indicative. They provide a starting point and should be adjusted on a project by project basis to achieve KPIs.

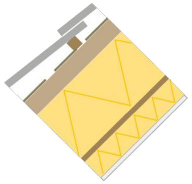
Key Performance Indicators (KPIs)

A strong brief provides tangible targets that can be delivered. Best practice KPIs for new homes are listed here and all KPIs must be met for a home to be termed 'Net Zero carbon'.

KPI	Target
Space Heating Demand	15 kWh/m^2/yr
Energy Use Intensity	35 kWh/m^2/yr
Renewable Energy Generation	Net zero balance
Upfront Embodied Carbon	300 kgCO_2e/m^2/yr

Recommended design specification – Bungalow

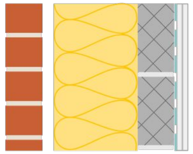
Pitched roof



Thickness 550-650mm
U value: 0.090 W/m2.K

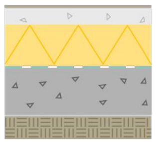
N.B Insulation is best placed at ceiling level with the roof void ventilated.

Walls



Thickness 550-700mm
U value: 0. 090 W/m^2.K

Ground floor

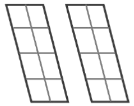


Thickness 280-400mm
(insulation only)
U value: 0.090 W/m^2.K
(Unadjusted)

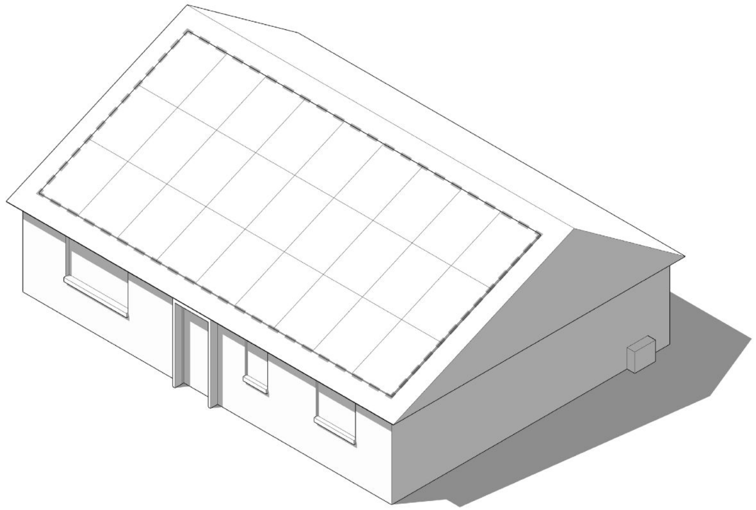
Airtightness

An extremely airtight building fabric of <0.6 ACH in line with Passivhaus (PH) certification.

Renewables



Take advantage of large roof space and use south facing asymmetric or mono pitch roof to maximise PV panels



Mechanical Ventilation

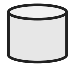
MVHR 90% efficiency

≤2m duct length from unit to external wall

Heat Pump

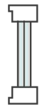
Use a heat pump to provide heating and hot water.

Hot Water



Install hot water tank and use wastewater heat recovery in the shower/bath.

Windows



Triple glazed
U Value: 0.8 W/m^2.K

Recommended Window Ratios

North: 10-15%
East/West: 10-20%
South: 20-30%

Externals doors

Insulated
U-value: 0.9 - 1.0 W/m^2.K

* All U-values shown are indicative. They provide a starting point and should be adjusted on a project by project basis to achieve KPIs.

Key Performance Indicators (KPIs)

A strong brief provides tangible targets that can be delivered. Best practice KPIs for new homes are listed here and all KPIs must be met for a home to be termed 'Net Zero carbon'.

15 kWh/m^2/yr
Space Heating Demand

35 kWh/m^2/yr
Energy Use Intensity

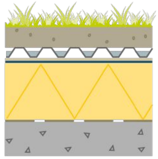
Net zero balance
Renewable Energy Generation

300 kgCO_2e/m^2/yr
Upfront Embodied Carbon

Recommended design specification – Medium rise block of flats

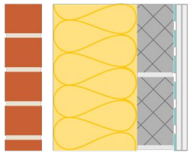
Flat roof

Thickness 450-700mm
U value: 0.110 W/m2.K



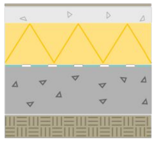
Walls

Thickness 420-520mm
U value: 0.150 W/m^2.K



Ground floor

Thickness 190-270mm (insulation only)
U value: 0.135 W/m^2.K (Unadjusted)

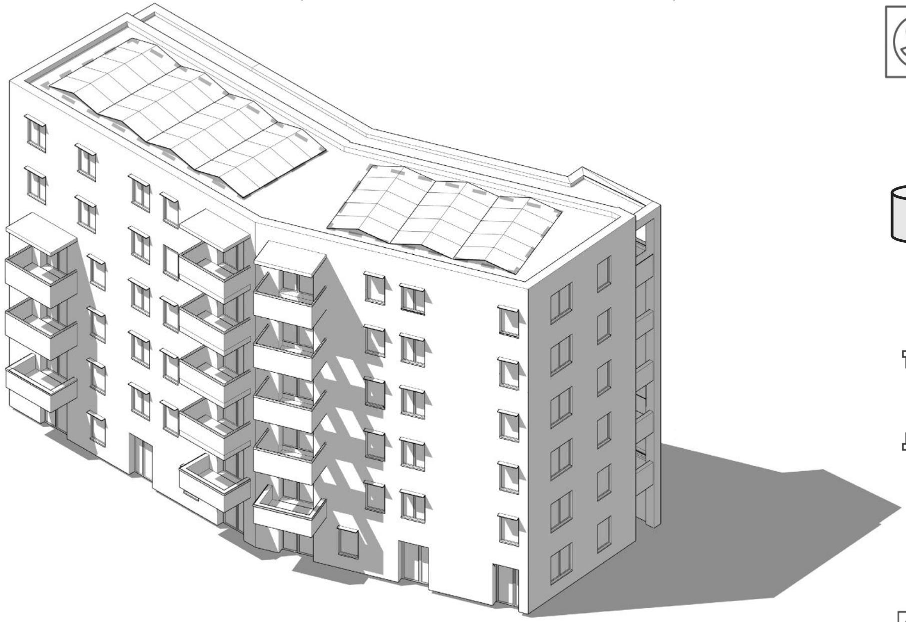


Airtightness

An extremely airtight building fabric of <0.6 ACH in line with Passivhaus (PH) certification.

Renewables

If the building has a flat roof in most cases an east west facing concertina of PV is most efficient as more PV can fit on the roof and therefore generate more power. The best option for the building should be explored.



Mechanical Ventilation

MVHR 88% efficiency

≤2m duct length from unit to external wall

Heat Pump

Use a heat pump to provide heating and hot water. Consider a communal system.

Hot Water

Install hot water tank and use wastewater heat recovery in the shower/bath.

Windows

Triple glazed
U Value: 0.8 W/m^2.K

Recommended Window Ratios

North: 10-15%
East/West: 10-20%
South: 20-30%

Externals doors

Insulated
U-value: 0.9 - 1.0 W/m^2.K

* All U-values shown are indicative. They provide a starting point and should be adjusted on a project by project basis to achieve KPIs.

Key Performance Indicators (KPIs)

A strong brief provides tangible targets that can be delivered. Best practice KPIs for new homes are listed here and all KPIs must be met for a home to be termed 'Net Zero carbon'.

- 15 kWh/m^2/yr — Space Heating Demand
- 35 kWh/m^2/yr — Energy Use Intensity
- Net zero balance — Renewable Energy Generation
- 500 kgCO_2e/m^2/yr — Upfront Embodied Carbon

Additional cost of recommended specifications compared with Part L 2021

Methodology

The costs have been calculated for each of the typologies modelled using the dimensions for each typology, as well as the fabric standards and technologies assumed for each scenario. Costs are based on the expert view of Currie & Brown's cost management team who maintain a live database of costs associated with energy and carbon saving measures in construction and these have been used for the basis of this analysis with adjustment for the local circumstances for Isle of Wight. Baseline construction costs are based on the data held and expertise of our cost management teams including those based in Southampton with experience of the local market.

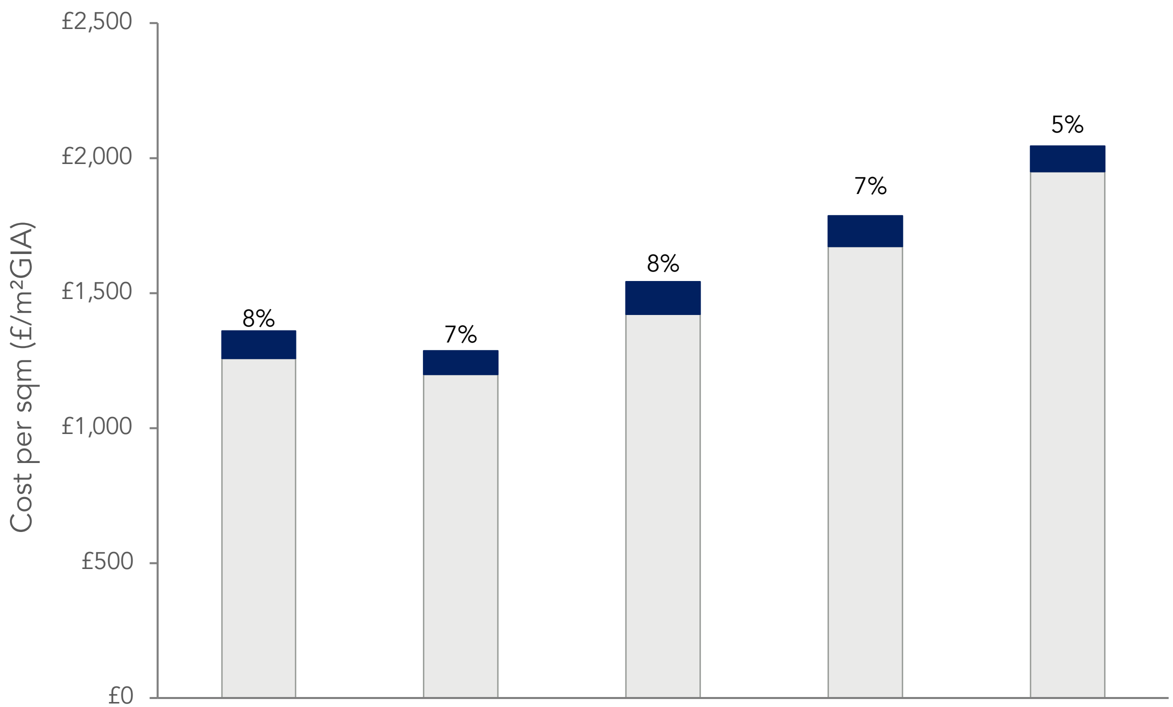
Main conclusion

This page summarises our findings for the comprehensive scenario only. The uplift in construction costs of Net Zero carbon homes in operation compared with Part L 2021 (and Part L 2025) is estimated to be between 5 and 8% depending on the typologies. This 'Net Zero' premium is considered acceptable particularly in comparison with the cost uplift of the other two scenarios and other cost increases affecting the housing market. It is also important to see it as a premium that can only be reduced over the next 30 years as Net Zero becomes the norm.

Alignment to the IoW's LP viability study

In general the floor area of the house types modelled in this study are consistent with those considered in the LP viability study, albeit the 4 bed house is larger.

Our baseline cost information is more granular than that used in the viability study which uses a fixed rate for housing (£1,288/m^2) and for flats (£1,385/m^2). Our figures range from £1,200/m^2 to £1,680/m^2 for houses and are £2,120/m^2 for 6-8 storey blocks of flats.



Cost uplifts /m²GIA	Semi detached	Mid terrace	Bungalow	Detached	Med Rise Flat
Fabric	£74	£63	£101	£83	£53
System (heating & hot water)	£27	£25	£29	£33	£27
PV	£1	£1	-£12	-£4	£8

*Costs per sqm for the **comprehensive scenario** of all typologies. The percentage uplifts are shown in the bar chart and the uplift costs per sqm are shown in the table below.*

Note: The % increase is relative to Part L 2021.

Timeline

PRE-PLANNING		PRE-CONSTRUCTION	CONSTRUCTION	HANDOVER AND USE

Setting the brief and getting the right team

- Include Key Performance Indicators (KPIs) requirements in the brief
- Appoint the relevant consultants
- Assessment of embodied carbon in scope (particularly for medium to large scale developments)
- Predictive energy modelling (e.g. PHPP) in scope

Design considerations

- Optimise building form, orientation and window proportions
- Define building fabric performance e.g. U-values
- Allow sufficient thickness for all insulated walls, roofs and floor
- Incorporate Mechanical Ventilation with Heat Recovery (MVHR)
- Define airtightness strategy
- Consider low carbon heating options e.g. heat pumps
- Design roof to maximise renewables i.e. solar panels
- Carry out assessment and reduce embodied carbon

Detailing, specification and choosing the right products

- Include KPI requirements in the tender
- Detail build ups of all external elements including thickness and conductivity of all materials and contact suppliers for confirmation of U-values
- Identify all thermal bridges and conduct thermal bridge calculations
- Define airtightness testing requirement for contractor
- Specify high performing solar panels
- Agree scope of post-occupancy evaluation.
- Continue to assess and reduce embodied carbon

On-site quality inspections

- Run an ultra low energy workshop on site. Encourage contractor and team training to all attend.
- Review alternative materials or products proposed by the contractor and ensure these meet performance requirements to achieve KPIs
- Attend regular site visits and develop site quality tracker to assess against KPIs
- Witness commissioning of ventilation and heating systems.

Handover and use

- Provide building user guides and instructions e.g. sticker on MVHR for filter replacement routine
- Carry out lessons learnt review
- Carry out post occupancy evaluation (POE) during the first five years of use to verify KPIs have been met
- Ideally, publicise performance against all KPIs and POE reports e.g. on a company website
- Post construction embodied carbon assessment

Best Practice Route

- Appoint Passivhaus consultant
- Energy (PHPP) modelling carried out by Passivhaus consultant to accurately predict energy use
- Detailed U-value calculations and thermal bridge analysis
- Regular inspections on-site by Passivhaus certifier
- Clear responsibility for airtightness and several air testing to meet requirements
- Passivhaus certification
- Final as-built energy (PHPP) model provided at hand-over

10 focus points to understand best practice

Introduction

We have provided best practice guidance based on ten focus points. This should be used by design teams to target the Net Zero Carbon KPIs across the typologies. The first focus points include considerations for the early design, followed by detail and specification. Then concluding with installation on site and future maintenance of the building.

Focus 1 – Site, Orientation and Overshadowing – Thinking about the orientation of the building at an early stage in the design of a building can have a large impact on its performance. It is important to make the most of solar gain to reduce the space heating demand.

Focus 2 – Form, Fabric and Detailing – The design of the form of the building and the specification of the fabric can go a long way to improve its energy efficiency. The building should be a simple and compact as possible.

Focus 3 – Embodied carbon – Design and specification decisions that can be made to make to achieve low embodied carbon in the construction of the building.

Focus 4 – Airtightness – The airtightness of a buildings fabric significantly improves energy efficiency and comfort, often for a relatively modest cost.

Focus 5 – MVHR – Together with good air tightness the installation of a Mechanical Ventilation Heat Recovery (MVHR) unit is critical to maintaining good air quality in a home.

Focus 6 – Heat pumps – This focus sets out the different types of heat pumps. A heat pump should be sized correctly to meet the heating and hot water load.

Focus 7 – PVs – This page sets out what the best practice of designing, specifying and installation PV panels.

Focus 8 – Electricity demand flexibility – This focus suggests measures that may be implemented to maximise the use of on-site renewables and stabilise demand on the grid.

Focus 9 – Construction quality, skills and insulation installation – Insulation and air tightness continuity in construction is critical for an efficient building fabric, and special attention must be paid on site to ensure that this continuity is maintained.

Focus 10 – Maintenance considerations – This focus sets out what maintenance needs to be undertaken and the timeframes as well as considerations must be made at earlier stages such as MVHR to be installed in an accessible location.

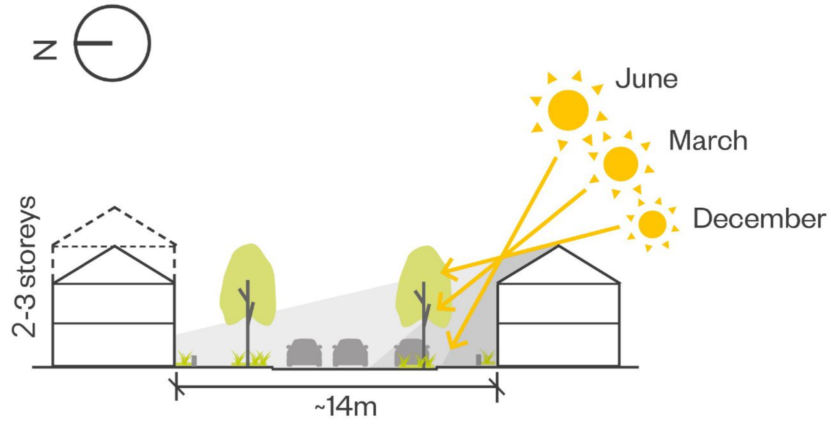
Focus 1 | Site, orientation and overshadowing

Which direction should the building face?

The orientation and massing of the building should be optimised, if possible, to allow useful solar gains and prevent significant overshadowing in winter. Encourage south facing dwellings (+/- 30°) with solar shading and prioritise dual aspect. Overshadowing of buildings should be avoided as it reduces the heat gain from the sun in winter.

Overshadowing

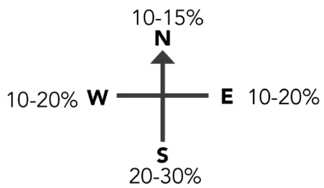
Prioritise the south in orientating masterplans, angling the roofs to make the most of PV opportunities to the south. Allow a distance of 1 to 1.5 times the buildings height between buildings to avoid overshadowing and impacting the dwellings solar gains.



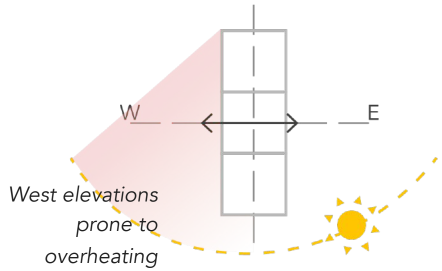
Allow a distance of 1-1.5 times the building's height between buildings

How big should the windows be?

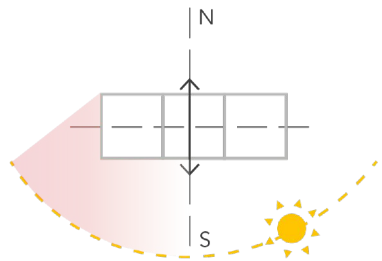
Getting the right glazing-to-wall ratio on each façade is a key feature of energy efficient design. Minimise heat loss to the north (smaller windows) while providing sufficient solar heat gain from the south (larger windows). It is much easier to design smaller windows facing access decks and larger windows facing balconies. Therefore, try to orientate access decks to the north and balconies to the south.



Window Ratio
The ratio of windows to external elevation should be in percentage range shown.



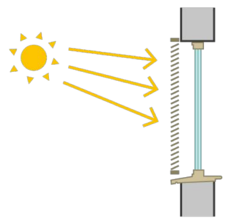
***Inefficient Design** - Avoid east west facing as this can mean the building is prone to overheating*



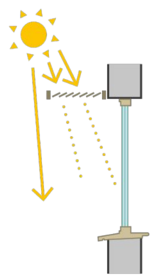
***Optimised Design** - Ideally south facing allows for solar winter gain*

Solar Shading

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



East/West
Low angled sun creates a overheating risk which can be prevented using external vertical shading e.g. shutters.



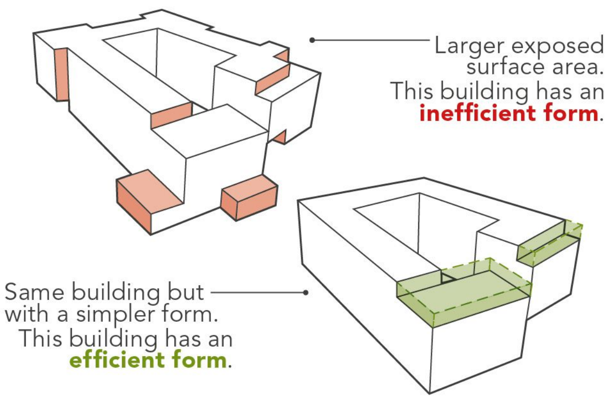
South
High angled sun can be controlled using horizontal shading or balconies above windows.

What should the building form look like?

The building form should be as simple and compact as possible. This will reduce the exposed surface area for heat loss. Avoid or limit the use of stepped roofs, roof terraces, overhangs and inset balconies as these features will decrease the building's energy efficiency. The most efficient house typology is the terrace as they are joined together reducing the exposed external walls and therefore reducing the heat loss. If dormers are within the design, consider joining these together so that it is one form rather than two separate small forms.

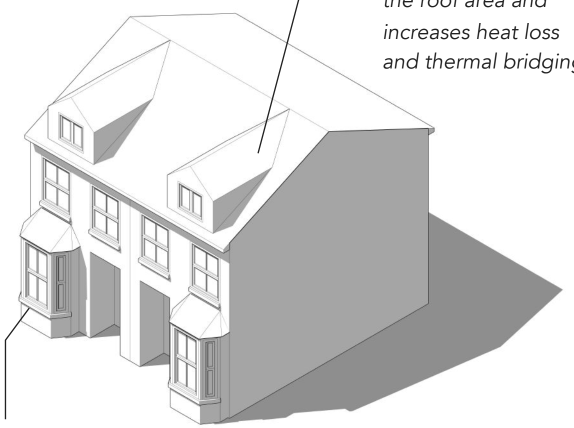
To calculate form heat loss factor, you divide the external surface area by the gross internal floor area which gives you a ratio. The lower this number is the more efficient the form of the building and therefore the better the thermal performance.

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

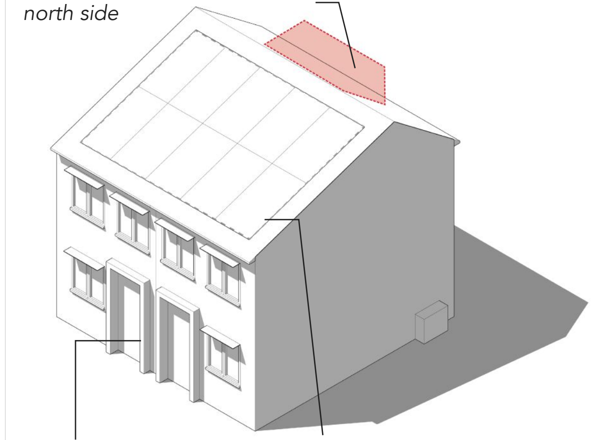


Designing the building to have an efficient form heat loss factor

Less Efficient Form



Optimised Form



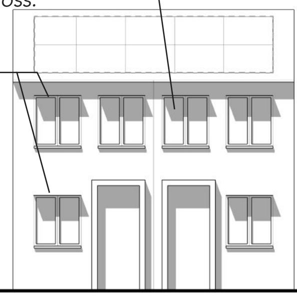
Less Efficient Elevation

South elevation

Window ratio is above recommend value for the orientation

>30% Window ratio

Optimised Elevation



South elevation

Window ratio is within recommend value for the orientation

20-30% Window ratio

Focus 3 | Embodied carbon

This section looks at embodied carbon reduction strategies for various building elements.

Foundations

Cement: Use cement replacement (e.g. GGBS, Fly ash) to reduce the content of Portland cement in concrete. When using replacements, allow for longer setting times which will ensure higher strength grade.

Concreate strength: Specify lower strength concrete whenever possible or exploit replacements and longer curing time instead. C32/40 is the most efficient grade.

Aggregates: Specify recycled aggregates and specify local procurement whenever possible.

Façade design

- Design a simple geometry with limited shelf angles.
- Specify high quality windows with long service life use and timber frames or alu-hybrid.
- Use lime mortar for brick façades to enable bricks to be reclaimed.

Internal Finishes

- Select materials of high quality which do not require additional surface finishes to reduce/eliminate finishes and reduce maintenance.
- Consider the cleaning and maintenance regium of the finishes, as this can have a large effect on embodied carbon.

Building Services

1 Passive Design

Embrace passive design principles in the project, for example robust fabric, good form factor, sensible glazing ratios, optimising orientation. This reduces the load on the MEP systems, which reduces the capacity of the systems, which reduces the size of the systems, and thus the quantity of material associated with the systems. ultra low energy fabric can reduce the embodied carbon of heating systems by 40% (CIBSE TM65.1).

2 Lean design

Reduce the amount and size of equipment as much as possible. For example reduce the lengths of ducts and pipes. Embodied carbon is linked to the weight of a product, reducing the weight of product reduced the embodied carbon of products

3 Material and product choice

Building services equipment often use materials with high embodied carbon, they are also replaced frequently thus impacting the embodied carbon across the hole life cycle. Seek to minimise the use of the following materials; aluminium, brass, copper and zinc.

4 Refrigerant leakage

Products such as heat pumps contain refrigerants. Refrigerants can have high GWP, and high leak rates. For Air source heat pumps, they type of refrigerant uses can increase the embodied carbon of the heating and hot water system by 30%. (CIBSE TM65.1). Take particular care with split heat pump systems – the likelihood of refrigerant leakage is much higher than for packaged systems.

5 Long lifetime

Specify products and systems with long lifetimes, that do not need to be replaced frequently. Ensure equipment is easily accessible, and can be maintained easily. Specify products, where components within the product can be replaced, rather than the whole product.

Focus 4 | Airtightness

The importance of airtightness

Airtightness significantly improves energy efficiency and comfort, often for a relatively modest cost. New buildings must achieve an airtightness of less than10m³/h/m² as a minimum for building regulations, however new homes typically achieve levels of 3-5m³/h/m². Best practice levels are considered to be <1m³/h/m².

Start with a plan

Building airtight starts with a well thought through airtightness and ventilation strategy. Draw the airtightness line on plans and details, identifying which materials will form the airtight layer, and how they will be joined together. Identify challenging junctions, risks to airtightness, and consider how building services will interact with the airtight layer.

Use the right products

Experienced manufacturers of airtightness products such as Isocell, Isover, Pro-clima and Siga have developed their products to achieve airtightness that lasts for many decades. Specify good quality products and ensure that inferior substitutes are not used on site.

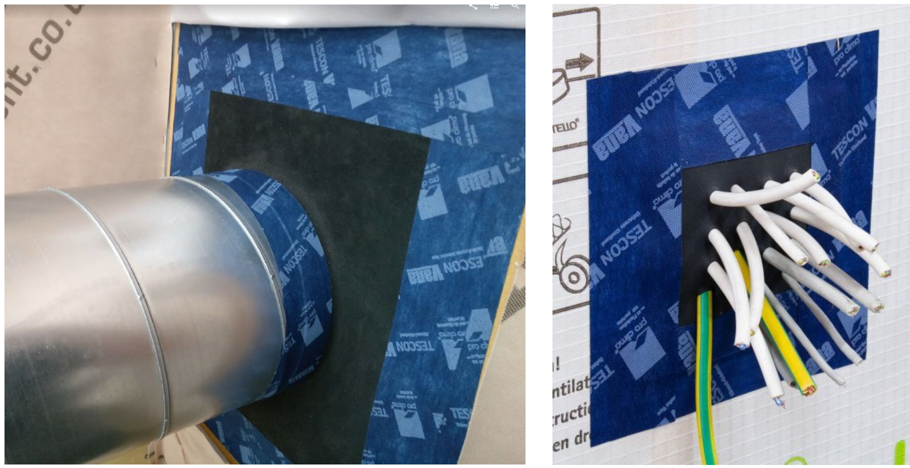
Stick to the plan on site

Once construction starts ensure the airtightness strategy is implemented precisely. Tradespeople should be briefed and the work regularly checked to ensure the airtight layer is being built correctly.

Test, then test again

Plan for at least two air tests. The first test should be completed as soon as the building is weathertight and while joints between different components in the airtight layer are still accessible so leaks can be repaired if necessary. The second test is on completion.

A good airtightness strategy forms the basis of an airtight building. This is an excellent example of taped OSB, with a dedicated service cavity on internal walls. The service cavity means most wires and pipes will not breach the airtight OSB layer.



Services entries present a risk to airtightness, however proprietary grommets are available to ensure airtightness can be achieved. The image on the left is of a ventilation duct as a reminder that airtight buildings must have a robust ventilation strategy.

Focus 5 | MVHR*

Controlled air flow through good airtightness

The key to managing ventilation in new dwellings is being in control of where, when and how air flows through a building. This starts with very good airtightness, to limit any uncontrolled infiltration. Trickle vents should be avoided as they do not control infiltration.

Install a Mechanical Ventilation with Heat Recovery (MVHR) unit

To maintain good air quality, and to reduce heat losses within a home, the use of an MVHR is critical. Not only does this unit supply air into living spaces, and extract air from kitchen and bathroom spaces, it does this using very little energy.

It is important that the unit is positioned as close as possible to an external wall to prevent heat loss from the ductwork that connects to the outside. These ducts should be accurately fitted with adequate insulation to prevent heat loss. Ductwork should avoid having sharp bends which could affect pressure loss and flow.

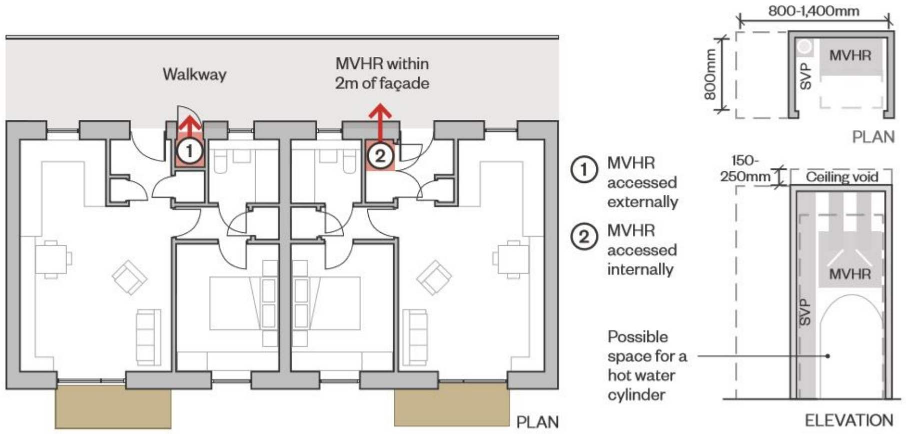
MVHR units include filters that must be changed regularly (usually at least once per year but check the manufacturer's instructions).

You can still open windows

There is a myth that ‘sealing up’ a building means you can no longer open the windows. This is not true. The benefit of an MVHR is that you do not have to open windows in winter for fresh air, letting the heat escape. Residents can open windows and use the homes normally.

Trust the controls

Once a system has been properly commissioned, the controls should not need adjusting. A common issue is a lack of understanding or trust that the unit is working correctly, and then it underperforms due to inappropriate user adjustments, or a user turning off the MVHR.



MVHR systems are an effective way of providing ventilation to airtight homes. The unit should be located within 2m of the façade

Key requirements for a good MVHR system

Distance from external wall	<2m
Specific fan power	<0.85 W/l/s
Heat recovery	>90%
Thickness of duct insulation mm	>25mm
Certification	Passivhaus Certified
Maintenance	Easy access for filter replacement.

In order to have an efficient running MVHR, it is recommended to choose an MVHR that meets the above performance criteria

**This sheet sets out the “modern ventilation specification requirement” for airtight properties.*

Focus 6 | Heat pumps

The electricity grid has decarbonised and will continue to decarbonise, thus the most likely low carbon heat source for now and the future is electricity. This is done most efficiently, and has lower running costs, when using heat pumps.

What types of heat pumps are available?

There are lots of different types of heat pumps, broadly in two categories, individual heat pumps and communal heat pumps. Individual heat pumps are shown in the adjacent diagram. For more information on communal systems continue to the next page.

Designing heat pumps

Make sure that the heat pump is sized correctly to meet the heating and hot water load. Choose a heat pump with a refrigerant that has a low Global Warming Potential (GWP) - propane is currently market best practice. Minimise pipe lengths to reduce the heat losses from distribution. Choose a heat pump with a high efficiency (often referred to as the Coefficient of Performance or COP).

Radiators might be larger

Heat pumps run best at lower temperatures (around 35-45°C degrees) this means that radiators need to be slightly larger to emit the same amount of heat as a traditional radiator. However this may be countered by the fact that ultra low energy homes will require less heat.

Commissioning and handover

Heat pumps should be correctly commissioned ensuring hydraulic systems are pressure tested and balanced. Make sure the user understands how the heat pump works and why it is set to operate in a certain way.

	Heating	Hot Water
 **Monoblock or split heat pump**	✓	✓
 **Ground source heat pump**	✓	✓
 **Heat pump integrated domestic hot water store**	✗ Heating is provided by direct electric panel radiators	✓
 **Exhaust air heat pump**	✓ Takes advantage of heat from exhaust air and is effective for small, ultra low energy dwellings	✓

This diagram above shows four types of individual heat pumps that can be installed in homes

There are various types of heat pump options available for new homes. This page outlines which heat pumps are available and which to choose.

1 Which heat pumps are the best for new homes?

- Monoblock or split (air source) heat pump, generating heating and hot water
- A ground source heating pump system, generating heating and hot water
- Individual heat pump connected to an ambient loop

Why these heat pumps might not be suitable

- **Available space:** These heat pumps require space for indoor or outdoor units
- **Ground conditions:** Some ground conditions are not suitable for ground source heat pumps
- **Size of development**: an ambient loop is only really suitable when there are more than 30 homes

If these systems do not work

2 Which are next best for new homes with a low space heating demand?

- A heat pump integrated into a hot water tank. Heating is delivered through direct electric panel radiators
- An exhaust air heat pump

- An exhaust air heat pump provides comfort heating via an MVHR. This will only meet the heat demand in smaller dwellings (<60m^2) with a space heating <15kWh/m^2.year, Even then, it may need another form of top-up heating.

If these systems do not work

3 Communal heating systems fed by heat pumps (operating at around 60°C or less)

New homes with a high performing fabric need so little heat, that is it not recommended to use communal heating or district heating systems, as so much heat is lost through the distribution.

If this system is not available

4 Consider direct electric heating and hot water

If there is not sufficient space to install a heat pump, then consider direct electric heating and hot water but make sure the energy efficiency KPIs are being delivered to avoid high running costs.

Can you save much with solar PV?

The lifetime cost of solar electricity in the UK is typically around half the price of grid electricity. Solar PV panels will therefore save money and carbon emissions by avoiding the need for your home to import electricity from the grid, and by exporting surplus energy back to the grid. Export tariffs typically pay around 5.4p per unit of electricity sold. Expect to use anywhere from 15%-50%+ of solar energy directly, depending on how well a home's consumption is matched to the sun.

Where to install solar PV panels

Solar PV panels are typically installed on roofs as these often provide unshaded locations facing the sun for much of the day. They can be installed on flat roofs, pitched roofs, and even on walls or pergolas. A solar installer can advise you as to the most suitable locations.

Choosing a good installer

Prices and installation quality vary between installers, so choose carefully. Small residential systems should typically cost around £1,500 per kW. The government regularly publishes *Solar PV cost data* if you want to check the latest prices. Look for a genuine and experienced Microgeneration Certification Scheme (MCS) certified installer that has a track record. Treat offers of 'free solar' with caution, these are typically financed systems, where you enter a long-term contract to pay a monthly fee. This can complicate selling or mortgaging your home.

Specification of panels and inverters.

360Wp solar PV panels are now readily available at comparable costs and panel sizes to lower capacity units.

Specifying microinverters or DC optimisers can help maximise power output from the panels.

Many solar PV panels are now able to more than 360W of power, a significant increase compared with older panels (© LG)

Enphase IQ7 microinverter (© Enphase)

Solaredge P370 power optimiser (© Solaredge)

Focus 8 | Electricity demand flexibility

Intuitive and flexible energy use

Demand response or energy flexibility refers to the ability of a system to reduce or increase energy consumption for a period of time in response to an external driver (e.g. energy price change, grid signal). Energy storage allows these systems to consume, retain and release energy as required in response to specific energy demands. Smart controls respond to these external drivers and demands to manage our systems.

Maximise renewables and stabilise the grid

These measures can help maximise the utilisation of on-site renewables and help stabilise demand on the grid. Moreover it will help to decarbonise the grid: when renewable electricity generation is low, demand response measures reduce the load on the grid, reducing the amount of peak gas plant that must be switched on to meet the grid demand.

What can you do?

Peak reduction

- Use passive measures and efficient systems to reduce heating, cooling and hot water peaks.

Active demand response measures

- These measures reduce the electricity consumption for a certain period.
- Install heating and cooling set point control with increased comfort bands, controlled with smart thermostats or home energy management systems.
- Integrate thermal storage of heat into communal or individuals system within a building.
- Reduce lighting, ventilation and small power energy consumption.

Electricity generation and storage

- Use products that can generate electricity and feed into the grid, or power the building.
- Consider solar to water heat storage.

Electric Vehicle (EV) charging

- It is generally accepted that there will be a large increase in electric vehicles, so it is essential to implement demand response to ensure grid stability.
- Charge EVs only when needed and allow the supplier to cut the charging short during peak times.
- Install 'Vehicle to Grid' / 'Vehicle to Home' technology which allows the EV battery to be used to supply the home during grid peak periods.

Behaviour change

- Raise awareness of how people use electricity and the impacts.
- Consider incentives to reduce peak demand.
- Encourage responsible occupancy.

Microgrids

- Consider being part of a small semi-isolated energy network, separate from the national grid.

Construction quality

Excellent design and detailing need to be matched by high quality construction in order for Net Zero carbon homes to be realised, and for the 'performance gap' between the design and actual in-use energy to be reduced. Identifying and training a Construction Quality Champion can help ensure that all site personnel understand the key principles of low energy design and how they impact the work on site.

Particular foci should be airtightness and insulation. It is also important to have clear and robust processes for checking and signing off, for testing and commissioning parts of the construction, as well as for reporting and carrying out remedial works.

Airtightness

Site personnel need to understand the airtightness strategy and the materials involved. The air barrier completely wraps the heated volume and is on the warm side of the insulation. Specialist materials such as membranes and air-tightness tapes should be used and carefully installed. A preliminary, leak finding test should be carried out prior to the ATTMA TSL4 compliant test.

Insulation

Insulation is fundamental to a low energy building and installation quality is difficult to check. Consideration must be given to the methods of installation and storage. Materials should be kept in original packaging where provided, in a dry location raised off the floor and protected from site vehicle and foot traffic. Generally, insulation materials shall be delivered to site as required so as to limit the need for storage. Insulation must have no air gaps. The building thermal continuity should be tested by thermographic survey covering all conditioned spaces.

Certified Passive House
Passive House Institute

BEPIT
Building Energy Performance Improvement Toolkit

Energy performance standards can help deliver construction quality

Good examples of insulation installed on site, showing methods to illuminate gaps (wedging and overfilling). Left: Goldsmith street © Will South, Right: © Green building store.

Focus 10 | Maintenance considerations

In order to for a building to operate at Net Zero it needs to be maintained properly, particularly in the following areas.

MVHR

MVHR needs to be installed in an accessible location as filters should be cleaned/changed every 3-6 months so that it operates efficiently.

Heat Pumps

An immersion heater should only be used as a back up to heat the water in the hot water store and only manually switched on if the heat pump is not working. If the immersion heater is an automatic back up (might be the case for Exhaust air heat pump) – use of this immersion heater should be closely monitored to make sure that it is not turned on more than it should be.

Airtightness layer

There is a continuous airtightness barrier around the building. It is important that this barrier is not broken, otherwise the airtightness of the building will get worse. Key watchpoints;

- Drilling into the wall – know where the airtightness layer in the building is and avoid damaging it by drilling through / perforating it.
- New penetrations for equipment such as washing machines, should be installed with airtightness grommets so that the water pipes do not increase the air permeability.

Solar PV

Every few months it is good to check the generation meter, to make sure that the panels are generating electricity and there is no fault. It is also important to clean the PV panels every year, to make sure that they are operating as efficiently as they can.

Dirty filter

Clean filter

MVHR filters are easy to remove and clean, clean filters improve energy efficiency

Airtightness grommets need to be used so that service penetrations do not increase air permeability

PV panels need to be cleaned at least once per year

4.0

Policy recommendations

This sections considers planning policy: it sets out why improving policy requirements is necessary and how it can be done.

Current practice and associated issues

Issues with the current standards of housing and construction in relation to the Net Zero objective can be broken down into three main categories: conflicts, missed opportunities and the performance gap.

Conflicts

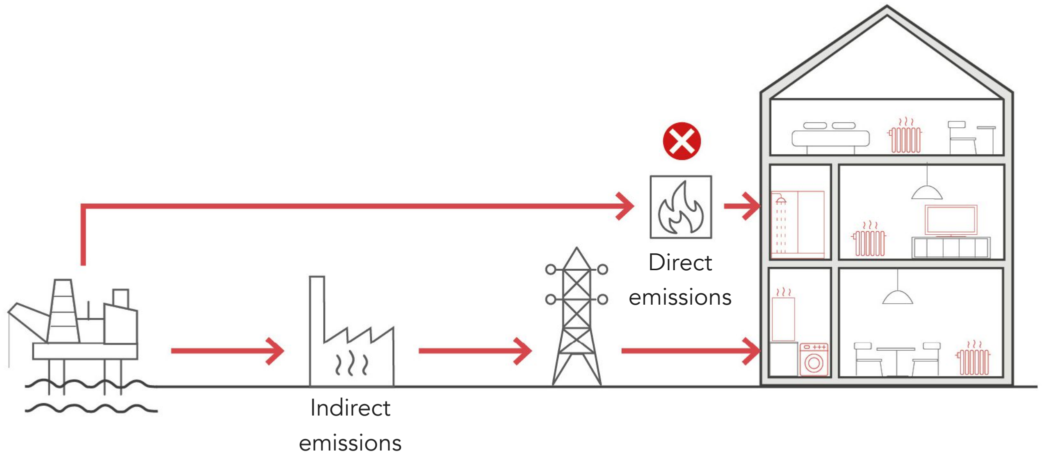
If the Isle of Wight is to achieve Net Zero, it is important to identify as soon as possible the current practices which are clearly conflicting with this objective. The best example of this type of conflict is the installation of gas boilers in new homes. This is not compatible with the Net Zero vision and should stop now. Instead, heating systems using electricity (e.g. heat pumps) should be specified as they are compatible.

Missed opportunities

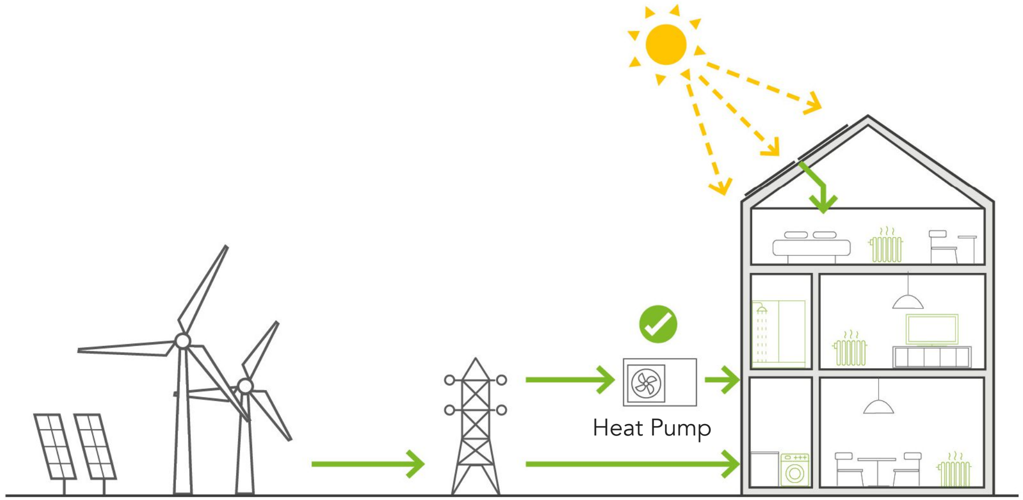
The other set of issues is less critical and is still very important. They are often the result of the lack of coordination between policies at a larger scale and what is happening at the scale of a housing development. A good example of this is renewable energy, and particularly PVs: in order to decarbonise its electricity system the Isle of Wight will need to increase its solar generation capacity. Roofs are an ideal place to put PVs on, particularly as they can benefit residents. It is therefore important to use the opportunities presented by a new housing project to deliver on these wider objectives.

The performance gap

Historically, housing energy performance has not been as good as the design prediction. This is due poor construction, commissioning and handover quality but also to the use of energy modelling tools and software which are not meant to predict energy use. The use of better tools for this purpose (e.g. PHPP) will improve design.



Conflict: *Gas boilers are currently an acceptable source of providing heat which is still being allowed by building regulations and policy. Unfortunately they directly conflict with the Isle of Wight's ambition to be Net Zero by 2030.*



Missed opportunities: *roofs of housing developments are generally ideal for solar PV panels. Although policy requires a small proportion of energy use to be generated from renewable energy on-site, it could go further in order to maximise this opportunity.*

What is the problem with the current building regulations methodology?

The approach based on a percentage improvement is detrimental

Building regulations (and therefore planning policy) are based on a required improvement over a baseline: the 'notional building'. Experience is showing that there are two issues with this approach:

- The setting of the notional building, in particular the fact that it has the same shape, orientation and, up to a point, glazing proportions as the actual building.
- The approach based on relative performance compared to the notional building instead of an absolute performance level, which creates confusion and makes a post-construction verification and feedback loop more complicated.

Improving the design of a dwelling by reducing the extent of heat loss areas and the number of junctions and by distributing glazed areas with consideration of solar gains are widely considered as essential components of an energy efficient design. The notional building almost neutralises most of these measures: it does not reward efficient designs. In addition, a relative performance assessment has a number of issues: it is not a 'physical' metric, it cannot be checked by the occupant during operation and therefore it cannot be used to 'close the loop' and inform the development of SAP through in-use data. Finally, a relative target is not the most effective way to drive towards an absolute objective: Net Zero.

Accelerating the move away from fossil fuels

Reducing our reliance on fossil fuels is one of the most important things we have to do to achieve Net Zero. Unfortunately Part L calculations still use a carbon factor which is out-of-date and significantly incorrect, and it does not reflect the current and future decarbonisation of the grid. Avoiding the use of misleading carbon factors would help the Isle of Wight to drive the right designs and achieve better outcomes.

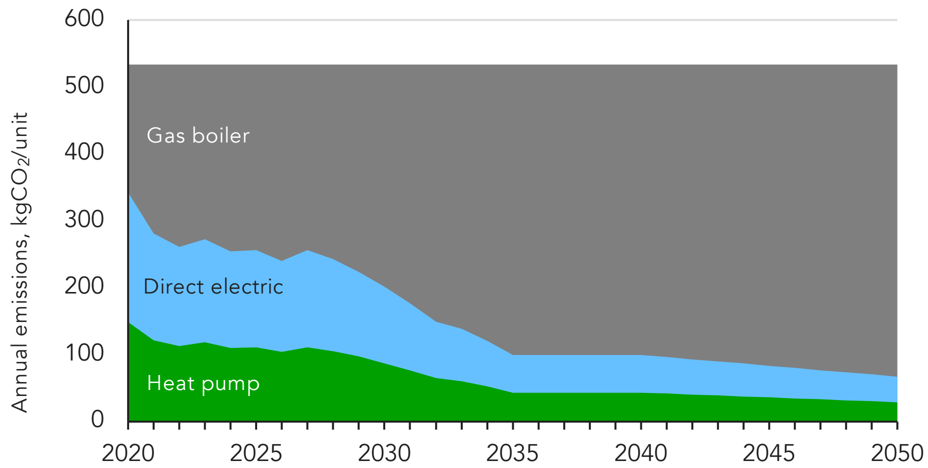
% improvement over notional building

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

kWh/m²/yr at the meter (EUI)

- ✓ Is a 'physical' metric which can be measured
- ✓ Can be understood by all professionals, and most consumers
- ✓ Can be checked against in-use data
- ✓ Can be checked to improve SAP prediction of energy use over time

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



Evolution of annual carbon emissions associated with heating and hot water for a low energy 2-bed flat. While its carbon emissions would remain flat with a gas boiler, they would reduce over time if was heated by direct electric or a heat pump (due to the decarbonisation of the electricity grid). It is clear that using a long term average (e.g. 25-year average) instead of the short term 3-5 year average would be a much better reflection of the actual emissions in the next 20 years.

It is possible for the Isle of Wight to set their own energy and carbon standards

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

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

The **Planning and Compulsory Purchase Act 2004** requires the local plan to ensure that development and use of land contribute to mitigation of climate change.

The **Climate Change Act 2008** sets a clear direction for the UK. It obliges the government to set policy that will enable the UK to meet its carbon budgets.

The Planning and Energy Act 2008 empowers local plans to set "*reasonable requirements*" for new builds to comply with "*energy efficiency standards that exceed … building regulations*" and "*supply a proportion of their energy from nearby renewable or low carbon sources*".

2015-2019: deregulation and the misguided reliance on ambitious national standards (incl. Zero Carbon homes policy)

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

On 25th March 2015, a **Ministerial Statement** stated that for the specific issue of energy performance LPAs will be able to set and apply polices in their local plans which exceed building regulations until change to optional requirements under Deregulation Act 2015 takes place. This was expected to happen alongside the introduction of zero carbon homes policy late in 2016. Until then LPAs were expected not to set conditions with requirements above CfSH level 4 (i.e. 19% improvement over Part L). However, there has been no adoption of a zero carbon homes policy.

Since 2019: the turning point of Net Zero

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

In recognition of UK's net-zero targets, a very large number of local authorities declared a **climate and ecological emergency**.

An updated **NPPF** (National Planning Policy Framework) expects the planning system to contribute to a "radical reduction in green house gas emissions" (Para 148) and plans to take a proactive approach (Para 149).

In 2021, the Government published their **response to the Future Homes Standard consultation** stating the following:

"All levels of Government have a role to play in meeting the net zero target and local councils have been excellent advocates of the importance of taking action to tackle climate change. Local authorities have a unique combination of powers, assets, access to funding, local knowledge, relationships with key stakeholders and democratic accountability. This enables them to drive local progress towards our national climate change commitments in a way that maximises the benefits to the communities they serve."

"We recognise that there is a need to provide local authorities with a renewed understanding of the role that Government expects local plans to play in creating a greener built environment; and to provide developers with the confidence that they need to invest in the skills and supply chains needed to deliver new homes from 2021 onwards. To provide some certainty in the immediate term, the Government will not amend the Planning and Energy Act 2008, which means that local planning authorities will retain powers to set local energy efficiency standards for new homes."

Policy recommendations

All new homes should be net zero carbon

The IPS appears to be the policy tool available to the IWC to implement net zero homes to support the C&ES. We recommend that the local planning policy on the Isle of Wight seeks to ensure that all new homes are built to net zero carbon standards.

Net zero carbon new homes

All buildings should be net zero carbon and comply with the requirements below.

Net zero carbon new homes: Space heating

- All housing should achieve a space heating demand of 15-20 kWh/m^2/yr. Bungalows could benefit from an extra +5-10 kWh/m2/yr
- All heating shall be provided through low carbon fuels (not fossil fuels).
- No new developments shall be connected to the gas grid.

To ensure best practice, predictive energy modelling (e.g. using PHPP or CIBSE TM54 or equivalent) should be carried out, showing that the development meets the space heating demand target. Modelling should be carried out: as part of the detailed planning submission, be reconfirmed pre-commencement, validated pre-occupation and monitored post-completion.

Net zero carbon new homes: Energy Use Intensity (EUI) targets

All housing should achieve an Energy Use Intensity (EUI) of no more than 35 kWh/m^2/yr + an additional 5 kWh/m^2/yr allowance for bungalows.

To ensure best practice, predictive energy modelling (e.g. using PHPP or CIBSE TM54 or equivalent) should be carried, showing that the development meets the EUI target. Modelling should be carried out: as part of the detailed planning submission, be reconfirmed pre-commencement, validated pre-occupation and monitored post-completion.

Net zero carbon new homes: Renewable energy

Renewable energy should be generated on-site for all new developments. The amount of energy generated in a year should match the predicted annual energy demand of the building, i.e. Renewable energy generation (kWh/m^2/yr) = EUI (kWh/m^2/yr).

Net zero carbon new homes: Embodied carbon

Upfront embodied carbon target must be met of < 300kgCO_2/m^2

Upfront embodied carbon emissions (Building Life Cycle Stages A1-A5). Includes Substructure, Superstructure, MEP, Facade & Internal Finishes. Full lifecycle modelling is encouraged. To ensure best practice an embodied carbon assessment should be carried, showing that the development meets the upfront embodied carbon target. Evidence should be shown at detailed planning submission, be reconfirmed pre-commencement, validated pre-occupation and monitored post-completion.

Net zero carbon new homes: Assured performance

All applicants must demonstrate use of an assured performance method in order to ensure that the buildings' operational energy performance reflects design intentions.

The process takes time

The process of updating planning policy, creating the required evidence base to justify its need and technical feasibility, assessing its financial viability and going through the examination process takes months, if not years. That is why only a small number of Local Planning Authorities have already published their proposed policy and evidence base in the public domain. These local authorities have already undertaken a substantial amount of work and their evidence bases should be reviewed as it can constitute at least part of the evidence base which the Isle of Wight Council would require should it wish to introduce some of these policies.

Net Zero carbon buildings

An important common theme between different local authorities, for which constraints and opportunities may be very different, is the introduction of a Net Zero carbon building policy.

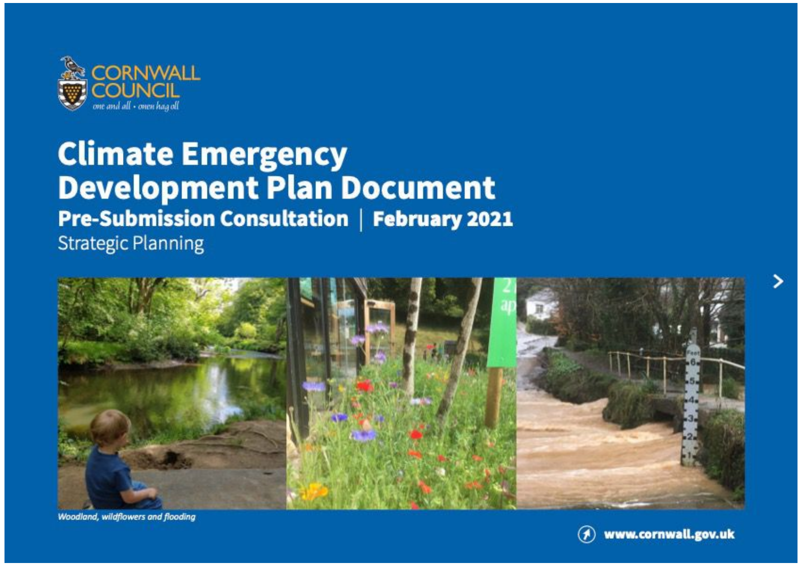
A decisive move towards better metrics

Along with the introduction of a Net Zero carbon building policy, most of these proposed planning requirements introduce a move towards better energy performance metrics in kWh/m^2/yr: space heating demand, energy use intensity (EUI), renewable energy generation and Net Zero balance.

Local authorities leading the way

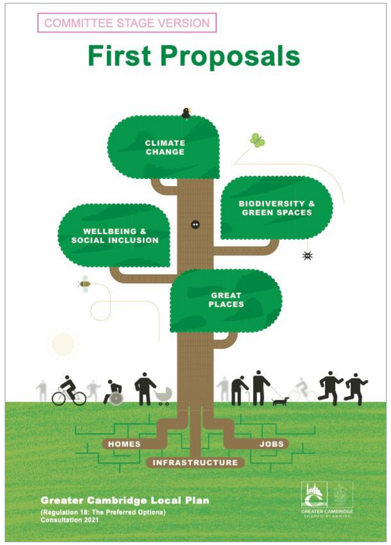
The list below includes the names of local authorities which have already published proposed policies and their evidence base:

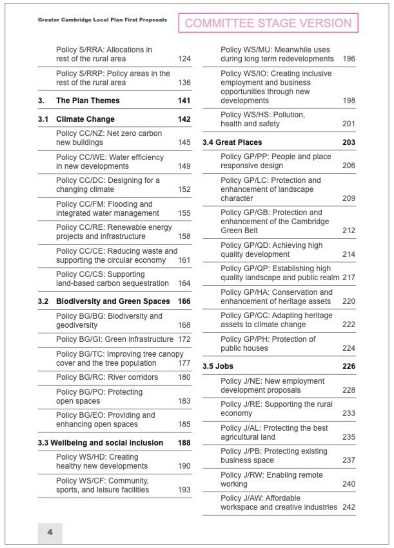
- West Oxfordshire District Council (Salt Cross AAP)
- Greater Cambridge (Local Plan)
- Cornwall Council (Climate Emergency DPD)
- Central Lincolnshire (Local Plan)



Cornwall Council Climate Emergency DPD and associated evidence base

https://www.cornwall.gov.uk/planning-and-building-control/planning-policy/adopted-plans/climate-emergency-development-plan-document/





Greater Cambridge Local Plan First Proposals

COMMITTEE STAGE VERSION

4

Greater Cambridge Local Plan

https://consultations.greatercambridgeplanning.org

How to demonstrate compliance? (e.g. SAP, PHPP)

The main calculation methodology (SAP) and its limitations

SAP is the calculation methodology and tool used in the vast majority of planning applications to demonstrate compliance with policy requirements. The main reason for this is that it is also required at a later stage to demonstrate compliance with building regulations and is relatively simple. However, it is important to note that SAP was originally designed with one key objective: to represent a standardised fuel cost to achieve comfort under given conditions (e.g. occupancy and location) that allows one dwelling to be compared with another and a value placed on energy improvement. It was never meant to perform some of the functions it is now being used for, including the prediction of future energy use.

In particular, comparative SAP/PHPP modelling undertaken on different typologies suggest that SAP underestimates space heating demand by more than 50%. The under-estimation of space heating is detrimental as it leads to under-estimating the potential benefits of measures to reduce space heating demand (e.g. better U-values, triple-glazed windows, more airtight dwellings).

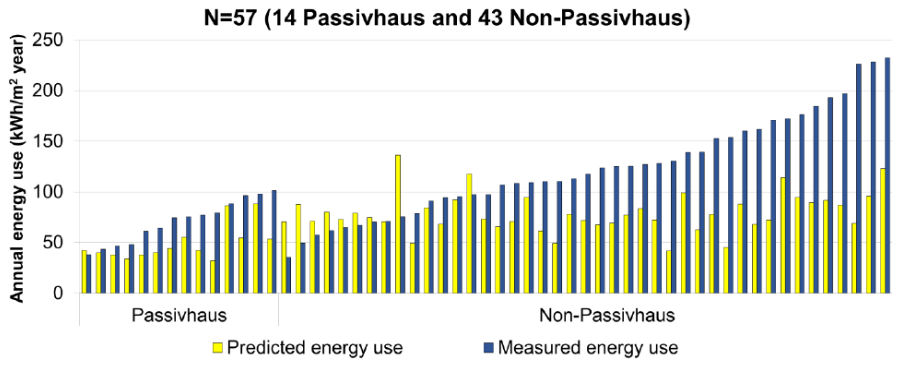
If the use SAP is allowed to demonstrate compliance with Net Zero policies, it is recommended that its outputs are corrected to better represent likely future energy use.

Good practice: the use of the Passive House Planning Package (PHPP)

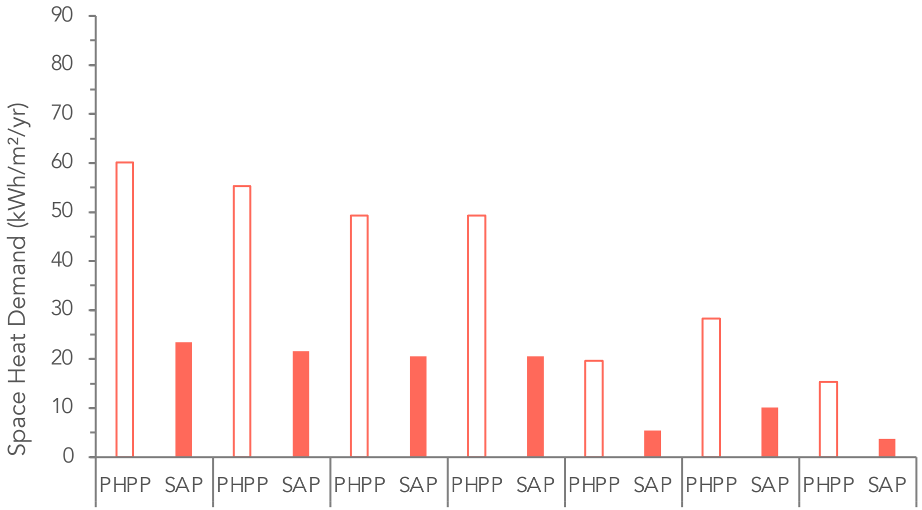
The PHPP methodology and tool have been shown to predict energy use much more accurately. The Isle of Wight could mandate, or at least encourage, the use of PHPP on residential new build projects.

Other alternatives

Although methodologies and tools other than SAP and PHPP could theoretically be used (e.g. Dynamic Simulation Modelling combined with calculations compliant with CIBSE TM54, it is important to note that there are very few examples (if any) of these methodologies accurately predicting future energy use. Caution is therefore recommended.



One of the reasons for the success of the PHPP modelling methodology used in Passivhaus is the ability to better predict average energy use: measured energy is on average lower, but it is also closer to predictions than in other methods (Source: BPN State of the Nation report, 2020)



Comparison between space heating demand estimated by PHPP vs estimated by SAP for a semi-detached house and seven different sets of specifications. This discrepancy is an issue which must be addressed by planning guidance until SAP becomes more accurate at predicting energy use,

Measurement of energy performance

Recent technological developments offer opportunities for faster, cheaper and less intrusive testing of a home's actual energy performance at the as-built and in-use stage.

Airtightness

Low-pressure pulse tests are carried out at near-ambient pressure conditions with less site preparation than for a blower door tests. MHCLG have recently confirmed in the January 2021 response to the Part L and Future Homes Consultation that they will be allowed for Building Regulations purposes.

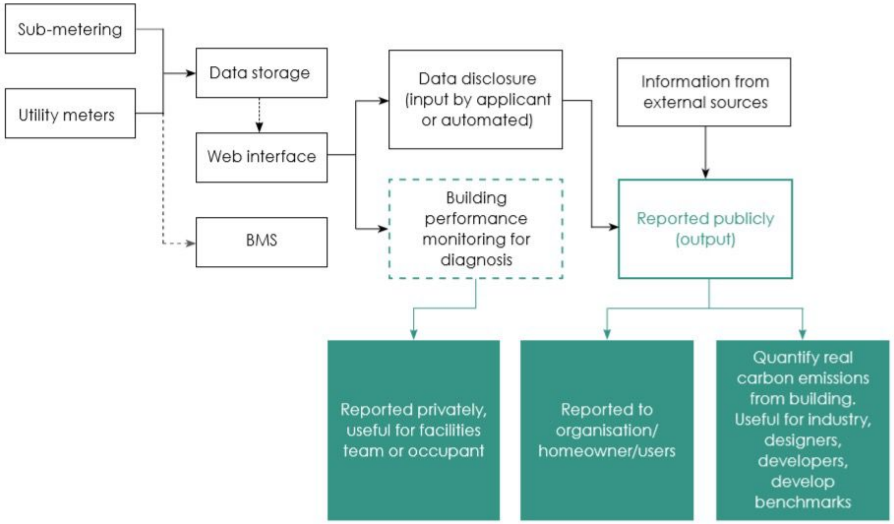
Heat transfer coefficient (HTC)

It is a measure of overall fabric performance and represents the rate of heat transfer per degree of indoor-outdoor temperature difference. HTC has long been recognised as a very useful measure of building performance but until recently the main methodology to measure it was a co-heating test, which typically requires a dwelling to be unoccupied and heated for at least two weeks, and is therefore expensive. Recent innovations could transform this. The SMETER trials, run by BEIS, are testing 8 products which offer estimated HTCs through analysis of meter data (typically smart, but not necessarily) with additional information on the home and household.

Energy use

The combination of a move towards 'all electric' homes and design metrics which are the same as 'in operation' metrics enable simple comparisons which can drive a focus on actual performance and encourage data disclosure, which is a key part of the Net Zero pathway. Results can be benchmarked on a building or stock level, and used to screen homes for poor performance. This could direct detailed investigations to homes that are performing worse than predicted.

Equipment for a pulse airtightness test. The method is non-intrusive and typically takes under an hour to be applied (source: Build Test Solutions)



The flow of information from building metering to reporting. The difference between data for disclosure, data that is publicly reported, and data for building diagnosis is shown. (Source: LETI: Climate Emergency Design Guide)

5.0

Summary of energy and cost modelling

Details of the typologies and scenarios tested

Summary results from the energy modelling

Summary results from the cost analysis

Description of the 5 typologies

Five typologies have been chosen to represent a range of potential developments on the Isle of Wight. These have been developed through conversations with the Isle of Wight Council and Southern Housing Group and reviewing some of the current major planning applications for the Isle of Wight.

The typologies are summarised to the right. There are two small three bed typologies (the semi detached and mid terrace), a small 2-bed bungalow, a fairly large 4-bed detached house and a medium rise block of apartments.

The 3-bed semi detached and 3-bed mid terrace are likely to be the most common typologies seen in future developments. These are based on the same simple floor plan. The forms are relatively efficient for their size due to the lower number of heat loss walls, especially the mid terrace.

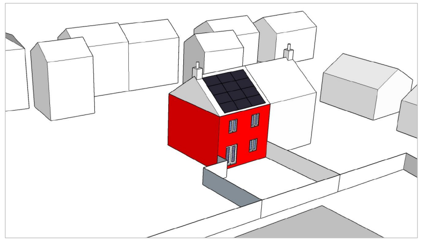
The four-bed detached and the 2-bed bungalow are also common typologies. They have a high extent of exposed surface area relative to floor area. This means a greater potential for heat loss per metre squared, especially for the bungalow which has a very small floor area. These typologies tend to have potential for high PV capacity due to the large roof areas.

Apartment blocks are becoming a more common typology and will be more prevalent on the island as the local plan seeks to steer as much planned growth to sites within existing settlements as possible. This example provides 40 units, has a fairly simple form and a simple roof form that has potential for a large PV capacity.

3-bed Semi Detached

GIA: 93m²

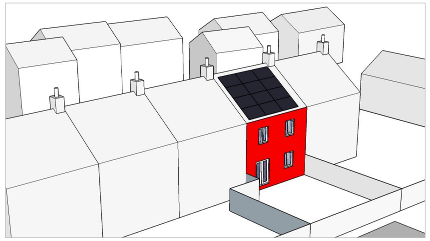
Form heat loss factor: 2.76



3-bed Mid terrace

GIA: 93m²

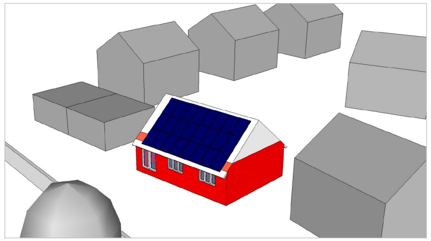
Form heat loss factor: 2.20



2-bed Bungalow

GIA: 74m²

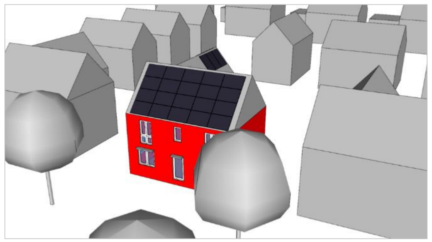
Form heat loss factor: 4.04



4-bed Detached House

GIA: 142m²

Form heat loss factor: 2.95

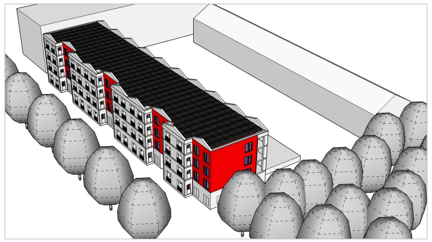


Medium rise block

40-units

GIA: 2362m²

Form heat loss factor: 2.04



Specifications modelled

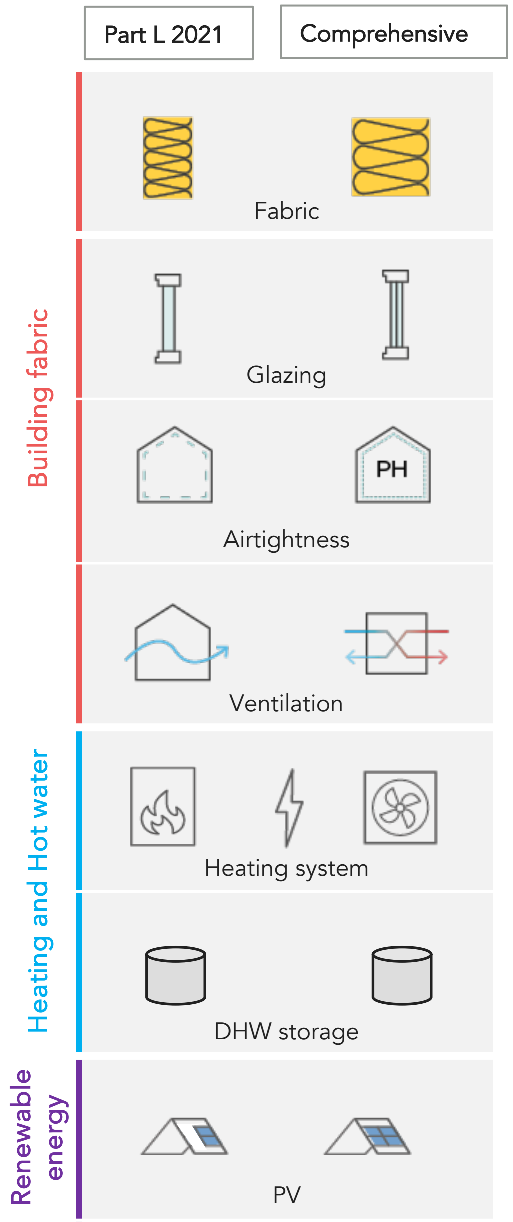
Identifying specifications

The specifications modelled include options that would comply with the current building regulations and the future homes standard respectively, followed by three options for achieving Net Zero Carbon: Technology first, which focuses on an efficient heating system, Fabric first, which prioritises ultra efficient fabric, and Comprehensive, which is a combination of the two.

The exact specifications are catered to the typology being modelled, and are detailed in sections 6.2 to 6.6.

Choosing levels of efficiency

The image on the far right illustrates the baseline and optimal options for different aspects of the design. For example, increased insulation, triple glazing, ultra low airtightness, MVHR for ventilation, direct electric and heat pumps for the heating, larger hot water tank and photovoltaics on the roofs.



Example options for each aspect of the design


Space heat demand (kWh/m²/yr)
60
50
40
30
20
10
0
The Technology 1st specification has a poorer performing building fabric than the other two specifications. This results in a significantly higher space heating demand, typically around double that of the Fabric 1st and Comprehensive models.
The space heating demand varies between the typologies because their differences in form and exposed heat loss area impact the rate at which heat is lost from them.
The Fabric 1st and Comprehensive specifications allow for very similar levels of fabric performance, resulting in very similar space heating demands.
As can be seen, the bungalow performs considerably worse than the other typologies, regardless of specification, typically by at least 5kWh/m²/yr. It is also the only typology not to achieve the LETI net zero space heating demand standard in all specifications.
LETI net zero space heating demand
Semi detached
Mid terrace
Bungalow
Detached
Med Rise Flat
Technology 1st
Semi detached
Mid terrace
Bungalow
Detached
Med Rise Flat
Fabric 1st
Semi detached
Mid terrace
Bungalow
Detached
Med Rise Flat
Comprehensive

Summary for the 5 typologies | **Energy Use Intensity (EUI)**

Summary for the 5 typologies | **PV generation required to achieve Net Zero**

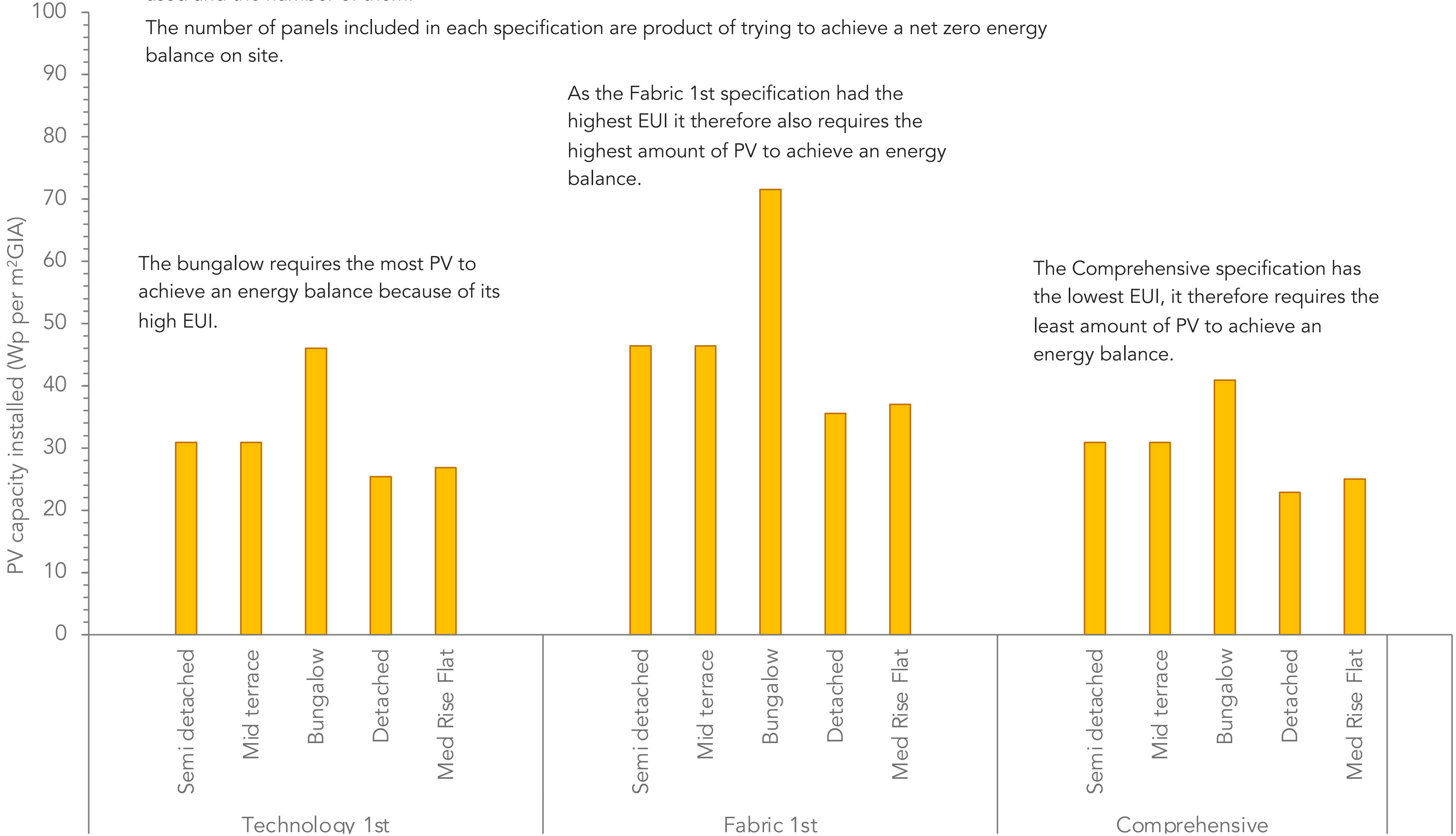
The amount of energy generated by PV (and the subsequent carbon avoided) is a product of the amount of roof space available compared to the floor area, as well as the efficiency of the PV panel used and the number of them.

The number of panels included in each specification are product of trying to achieve a net zero energy balance on site.

The bungalow requires the most PV to achieve an energy balance because of its high EUI.

As the Fabric 1st specification had the highest EUI it therefore also requires the highest amount of PV to achieve an energy balance.

The Comprehensive specification has the lowest EUI, it therefore requires the least amount of PV to achieve an energy balance.



Methodology

The costs have been calculated for each of the typologies modelled using the dimensions for each typology and fabric standards and technologies assumed for each scenario. The following pages present an overview of the results. The first bar chart compares the three scenarios for achieving net zero carbon, for each of the five typologies, normalised by floor area. The following sections show all five scenarios for each typology separately.

Source of cost information

Costs are based on the expert view of Currie & Brown's cost management team. Currie & Brown maintain a live database of costs associated with energy and carbon saving measures in construction and these have been used for the basis of this analysis with adjustment for the local circumstances for Isle of Wight. This information is more current and accurate for volume construction than that held by industry wide databases that rely on voluntary reporting by a self selecting group within the sector. Baseline Part L compliant construction costs are based on the data held and the expertise of our cost management teams, including those based in Southampton with experience of the local market.

Key observations

- The capital cost of the medium rise block is the highest due to a higher base cost of building, but the uplift for reaching net zero carbon is less than most of the other typologies
- For the smaller buildings, a high form factor results in higher uplift costs for reaching net zero carbon.
- The uplift for the fabric first option is generally less than for the technology first option.
- Sometimes the uplift cost of the comprehensive scenario is not the most expensive (bungalow), this is a result of the reduced costs of PV and of internal heat distribution and emitters in these homes.

It is worth noting that the range of percentage uplifts falls easily within the cost variation seen between projects and over a typical recent years where significant and rapid variations in cost are seen for both materials and labour.

Alignment to the IoW's LP viability study

In general the floor area of the house types modelled in this study are consistent with those considered in the viability study, albeit the 4 bed house is larger (viability study assumed to be 110-128m^2, GIA in this study is 141m^2).

Our baseline cost information is more granular than that used in the viability study which uses a fixed rate for housing (£1,288/m^2) and for flats (£1,385/m^2).

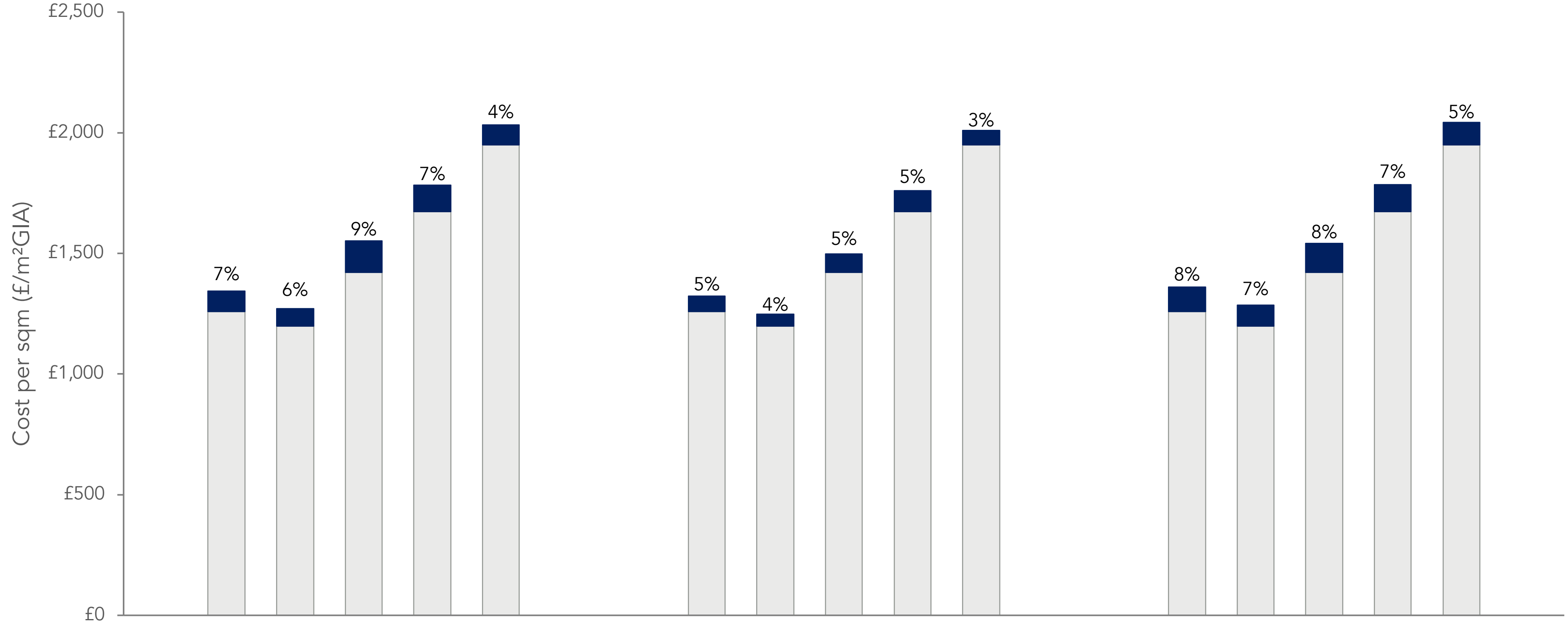
Our figures are below which, depending on mix (assuming largely semi and terraced), align roughly with the those used in the viability study for houses but are higher than the viability study for flats.

Please note our costs are based on current market experience rather than published indexes from previous data, it is possible that the current higher costs experienced across the industry will moderate over time but at this time it is not possible to comment specifically.

Terrace	£1,200/m^2
Semi-detached	£1,260/m^2
Bungalows	£1,430/m^2
Detached	£1,680/m^2
Flats – 4-storey	£1,780/m^2
Flats – 6-8 storey	£2,120/m^2

Costs assigned in LP viability study for adoption of Part L 2021 are those generated by Currie & Brown for DLUHC. Our costs for Part L 2021 in this study are based on the compliance strategy modelled by Etude and are specific to each house type.

Summary for the 5 typologies | Capital costs and estimated increase over Part L 2021



Cost uplifts /m²GIA	Technology first					Fabric first					Comprehensive				
	Semi detached	Mid terrace	Bungalow	Detached	Med Rise Block	Semi detached	Mid terrace	Bungalow	Detached	Med Rise Block	Semi detached	Mid terrace	Bungalow	Detached	Med Rise Block
Fabric	£40	£30	£88	£61	£32	£74	£63	£101	£83	£53	£74	£63	£101	£83	£40
System (heating & hot water)	£45	£41	£51	£52	£36	-£19	-£22	-£30	£0	-£14	£27	£24	£31	£33	£45
PV	£0	£1	-£9	-£2	£14	£9	£10	£6	£4	£20	£0	£1	-£12	-£4	£0

Notes: The % increase is relative to Part L 2021 / Negative cost for PV reflects a reduction in the need for PVs in other scenarios in comparison to PVs required for Part L 2021.

Summary for the 5 typologies | **Energy costs**

Methodology

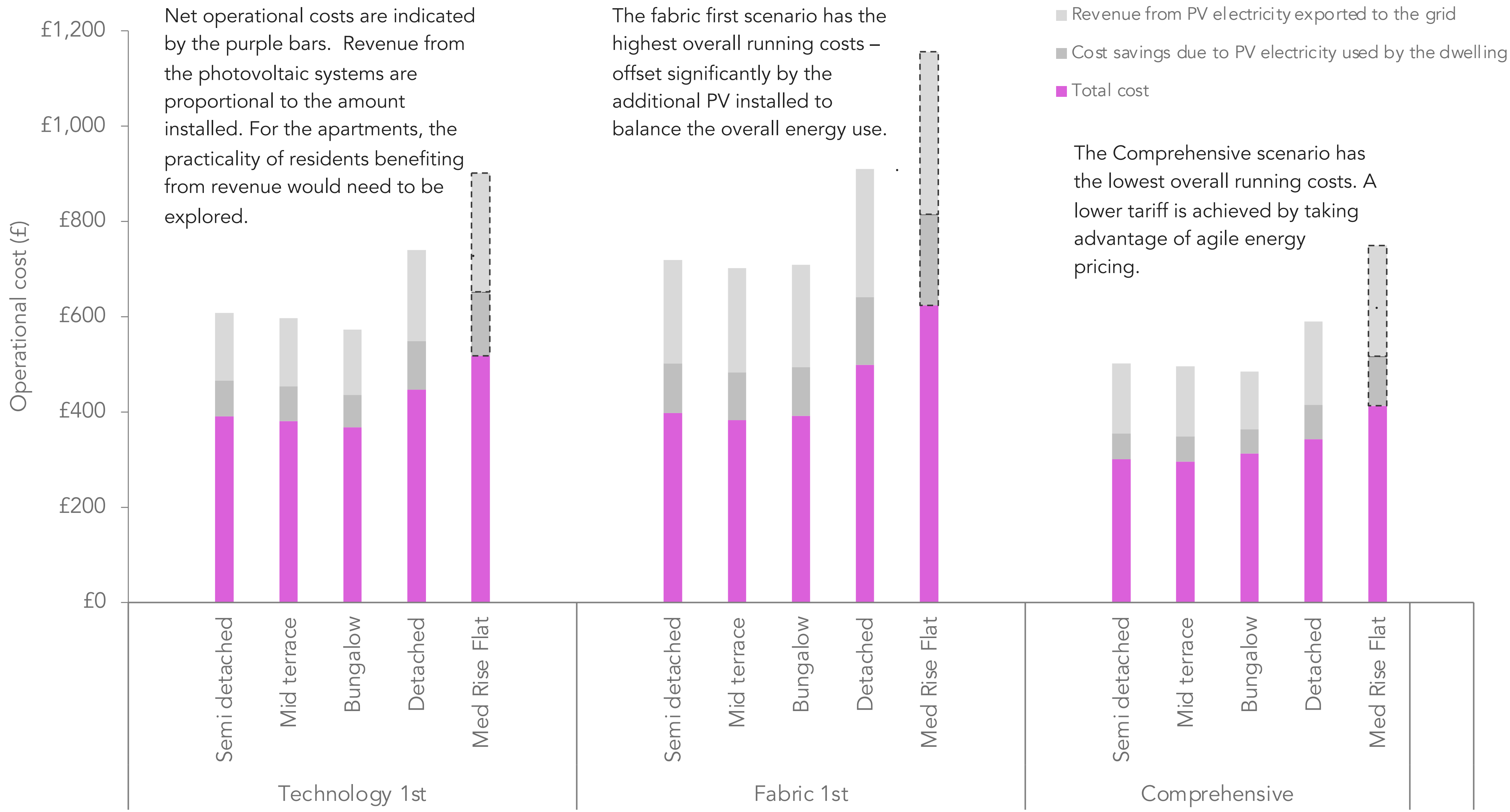
The ongoing operating costs for the residents have been calculated for each of the typologies modelled. This has factored in several variables that could impact costs:

- **Electricity tariffs** – in the specification examined in detail this is purely the cost per unit of electricity.
- **Standing charges** – again based on a single energy source/provider.
- **Maintenance costs** – depending on the number of systems and their complexity this ongoing cost will vary.
- **PV generated energy self-consumption** – the energy generated from PV could either be consumed by the occupant or exported to the grid. This variable is the ratio between the two – *self consumption has been assumed to be 20% of the energy generated in all specifications and typologies.*
- **Export Tariff** – the energy exported to the grid will receive a financial remuneration. The export tariff determines the rate per kWh of this remuneration. *The export tariff has been kept static in all specification and typologies.*

Key observations

- The Comprehensive specification offers the lowest cost to residents, with or without accounting for solar generation.
- Reducing peak heat demand and allowing users to take advantage of agile tariffs will play a significant role in reducing energy costs to residents.
- Operating costs in the Detached home are the highest for all the typologies.

Summary for the 5 typologies | **Energy costs**



Electricity tariff	12p/kWh	12p/kWh	10p/kWh
Standing charge	£80/yr	£80/yr	£80/yr
Maintenance costs	£150/yr	£120/yr	£150/yr

6.0

Appendices

6.1

Detailed timeline

Check list

The importance of a strong brief

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

Option for Passivhaus certification

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

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

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

Information provided by the design team

This design checklist provides a list of key actions that should be carried out in addition to those that designers are used to carrying out.

RIBA Work Stage 2 – Concept Design	
Optimise building orientation to balance solar gain and increase south facing roof area. Design roof to maximise density of renewables.	
Calculate and report the building form factor for design options	
Arrange embodied carbon workshops with design team to target lean design principles and reduce big tickets items e.g. structure	
Identify design team members to carry out embodied carbon assessment. Carry out multiple embodied carbon calculations of key elements to demonstrate low carbon design choices.	
Mark-up insulation line on all plans and sections. Mark unheated external areas on plans.	
Allow sufficient wall construction thickness for all insulated walls, roofs and floors.	
Mark window openings for providing natural ventilation for summer comfort.	
Identify a location for the MVHR next to an external wall.	
Evaluate requirement to connect to the district heating network.	
Carry out preliminary overheating risk assessment using the Good Homes Alliance overheating checklist	
Carry out initial PHPP model.	
For projects using Passivhaus certification this is a good time to consider an appointment.	
RIBA Work Stage 3 – Spatial Coordination	
Review mark-up of insulation line on all plans and sections and carry out initial U-value calculations.	
Carry out heating options appraisal including a low carbon option.	
Hold a thermal bridge workshop. Include the structural engineer for review of columns, masonry support etc.	
Provide MVHR layout including duct distribution and measurement of intake and exhaust duct lengths to external walls for sample dwellings.	
Carry out full embodied carbon assessment of whole building and compare against embodied carbon target. Implement reductions where necessary.	
MEP consultant to review embodied carbon impact of services and reduce the amount of kit where possible. Use CIBSE TM65 embodied carbon in building services to assess impact.	
Carry out PHPP modelling alongside SAP/SBEM calculations. List all model assumptions including U-values, thermal bridges and system specifications etc.	
Carry out overheating assessment and eliminate overheating through passive strategies where possible (TM59 & TM52). Ensure all element assumptions match PHPP and SAP/SBEM models	
Calculate electricity generation intensity of PV arrays and review against KPI.	
Define airtightness strategy and identify airtightness line on plans and sections	
Measure heating and hot water pipe lengths for sample dwellings. Minimise distribution or standing losses. Demonstrate distribution losses have been calculated and reduced.	
Prepare RIBA Stage 3 report and include predicted operational cost to tenant	

Check list

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

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

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

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

6.2

Detailed results for the semi-detached house

This section presents the results from the semi-detached house modeling. First the typology is presented in more detail, then the design assumptions are outlined for each of the five specifications, this is followed by the results and analysis.

Semi-detached house | **Description**

For the semi-detached house, a typical 3-bedroom home design has been chosen. This is based on a development in Cornwall, but similar houses are included in recent Planning applications for the Isle of Wight.

Building fabric

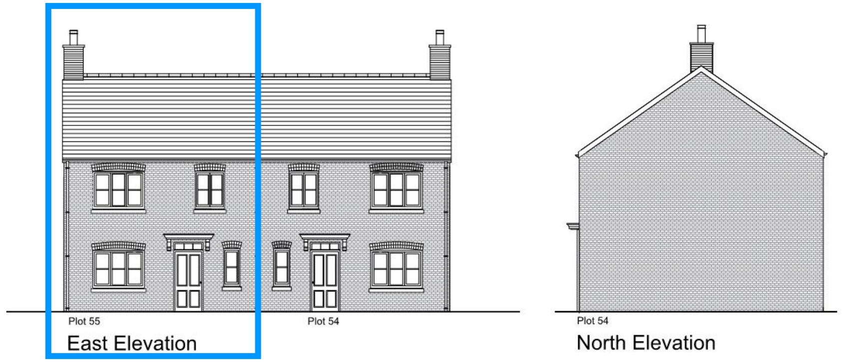
The property has a gross internal floor area of 93m². The main entrance faces the street to the North-East, while the rear of the house faces to the South-West. The property has typical glazing proportions and layout for this type of home. The form heat loss factor of 2.76 is lower than most other house types and is typical for a semi-detached home.

Low carbon heating

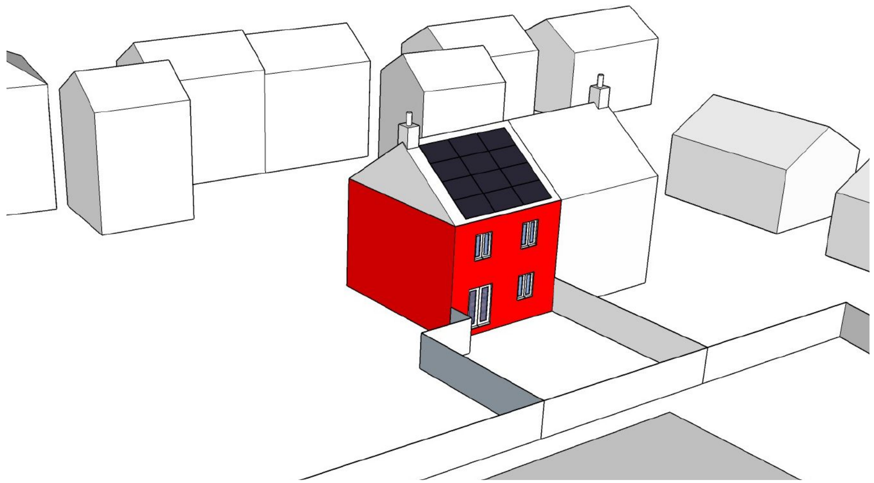
- Air source heat pump / ground source heat pump are both feasible
- Direct electric is also possible. It has advantages and disadvantages though.
- Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency

Solar PV

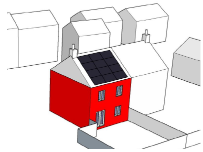
- 12 solar panels is possible for this South facing example
- For East / West orientation 24 solar panels would be possible
- There is potential to optimise the form of the roof to fit more panels



Typical 3-bedroom semi-detached house



A 3D model of the house and surrounding features was created in DesignPH and used to calculate solar gains and shading for PHPP

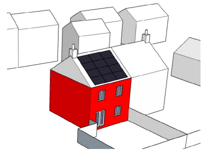


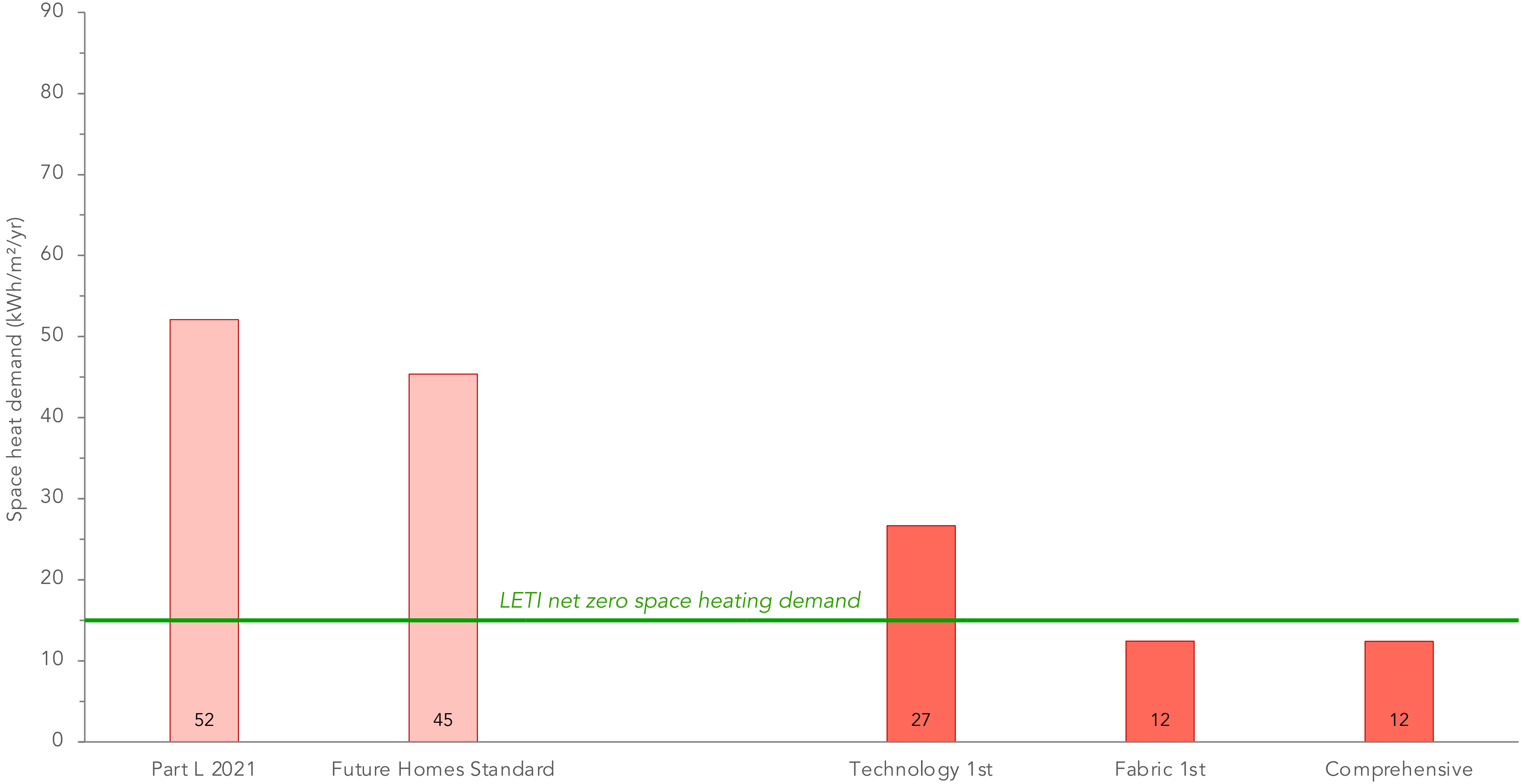
Semi-detached house | **Scenarios**

		Building regulations	Future Homes Standard	Technology First	Fabric First	Comprehensive
Building fabric	Floor / Walls / Roof (W/m^2K)	0.130 / 0.180 / 0.110 — Building regs fabric 2021	0.110 / 0.150 / 0.110 — Building regs fabric 2025	0.110 / 0.120 / 0.110 — Very-low energy fabric	0.100 / 0.100 / 0.100 — Ultra-low energy fabric	0.100 / 0.100 / 0.100 — Ultra-low energy fabric
	Windows / Doors (W/m^2K)	1.2 / 1.0 - 1.3 — Double glazing	0.8 / 1.0 - 1.3 — Triple glazing	1.2 / 1.0 - 1.3 — Double glazing	0.8 / 0.9-10 — Triple glazing	0.8 / 0.9-10 — Triple glazing
	Airtightness (ACH*)	5.0 — Airtightness	5.0 — Airtightness	3.0 — Airtightness 3	0.6 — Passivhaus certified Airtightness < 0.6	0.6 — Passivhaus certified Airtightness < 0.6
	Ventilation heat recovery efficiency (%)	0% — Extract fan only	0% — Extract fan only	88% — High efficiency MVHR	88% — High efficiency MVHR	88% — High efficiency MVHR
Heating and Hot water	Heating system T supply (°C)	60 — Gas boiler	55 — Heat Pump	45 — Heat Pump	60 — Direct Electric	45 — Heat Pump
	DHW storage (litres) / WWHR** efficiency (%)	120 / 0 % — Some DHW storage	180 / 0 % — DHW storage	180 / 36 % — DHW storage	120 / 36 % — DHW storage	180 / 36 % — DHW storage
Renewable energy	Solar panels (number)	8 — PV panels	- — No PV	8 — PV panels	12 — PV panels	8 — PV panels

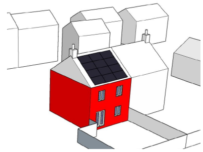
*Air changes per hour indicates the air volume added to or removed in one hour, divided by the volume of the space. Air permeability values in $m^3/h/m^2$ will be slightly different and will vary depending on the volume to surface area ratio of the building.
**Waste-water heat recovery device to showers.

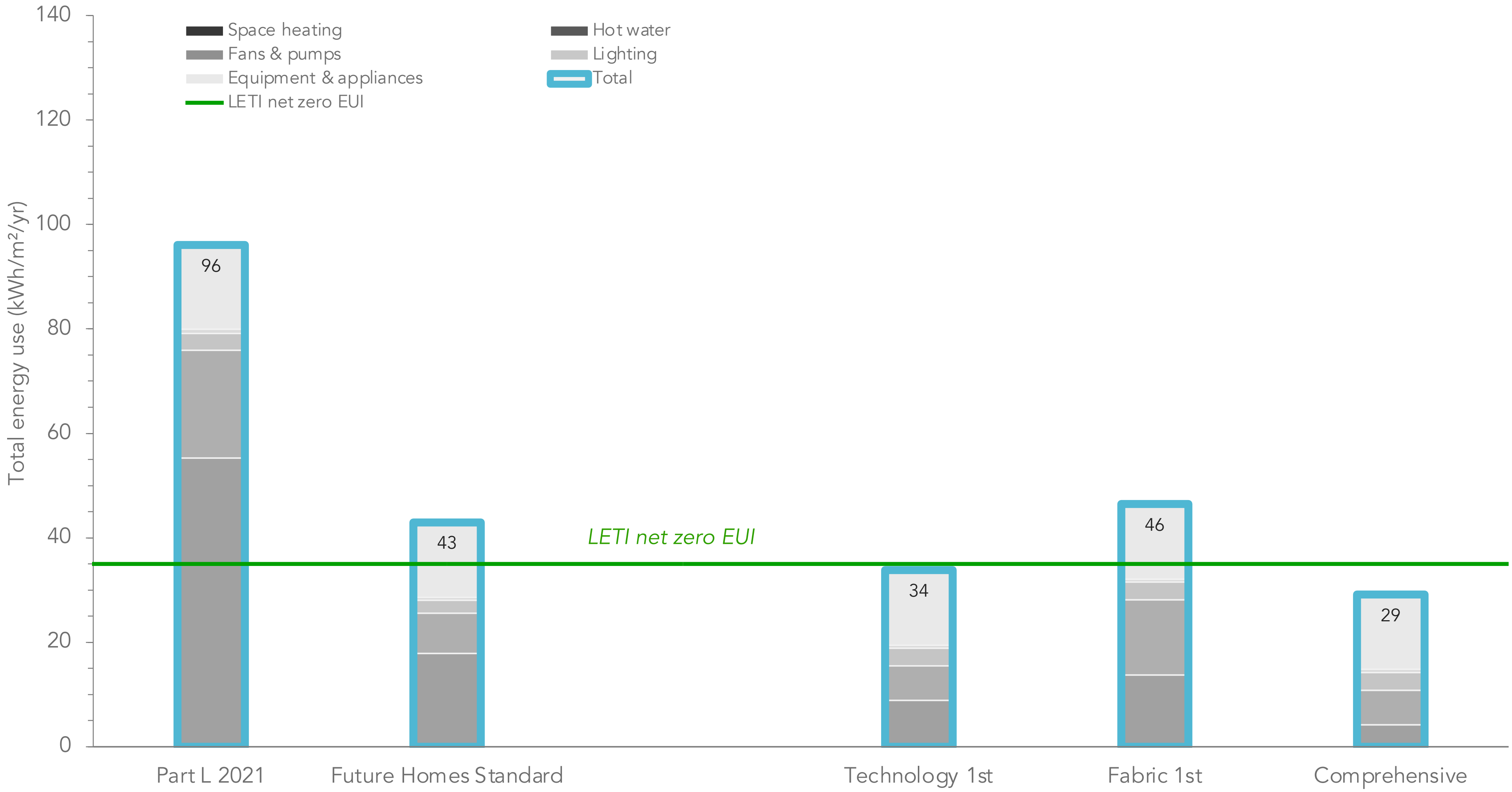
Semi-detached house | **Space heating demand**

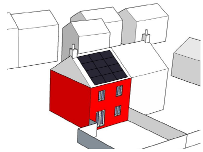


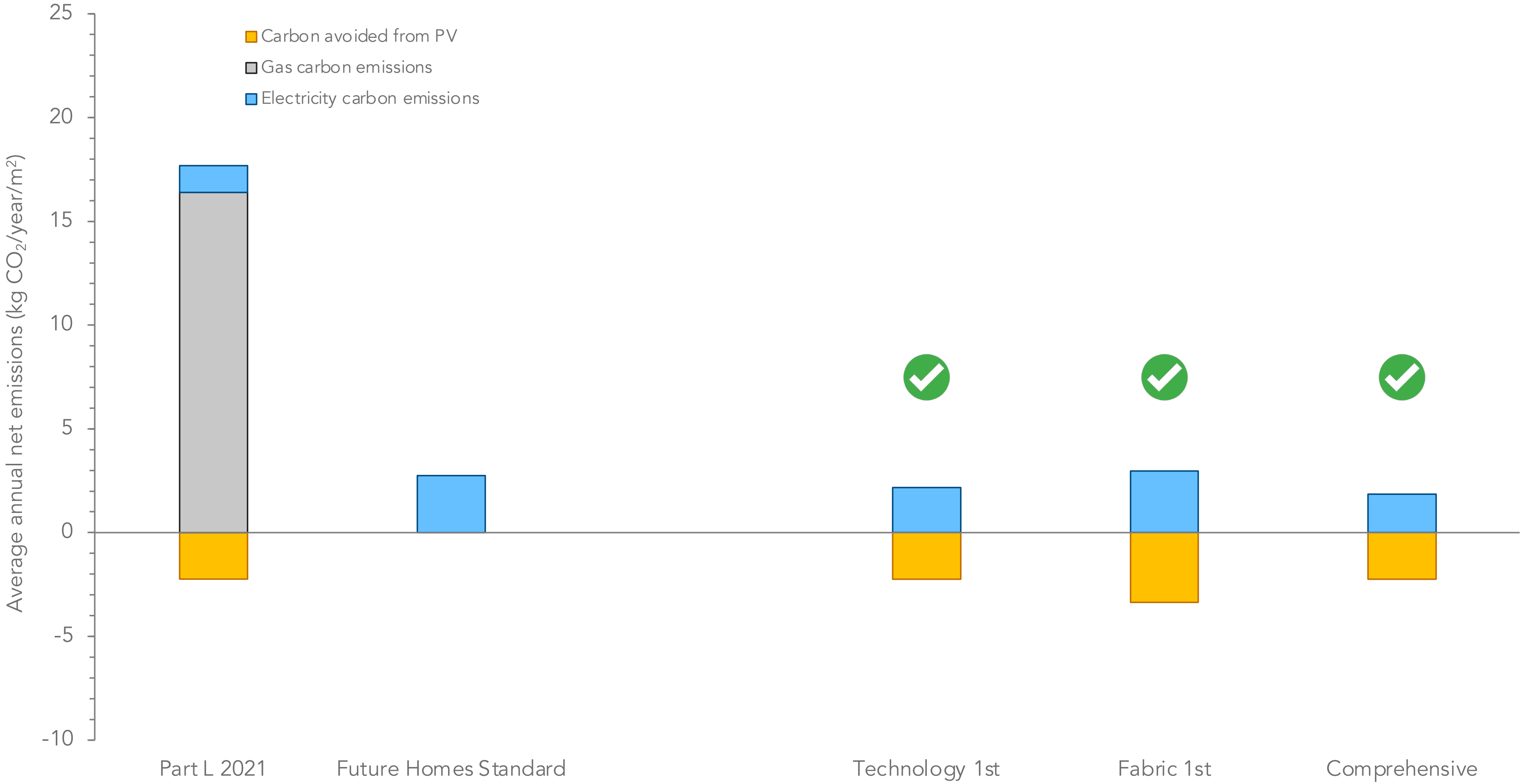


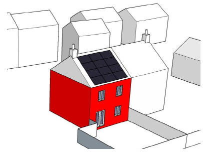
Semi-detached house | **EUI (kWh/m²/yr)**

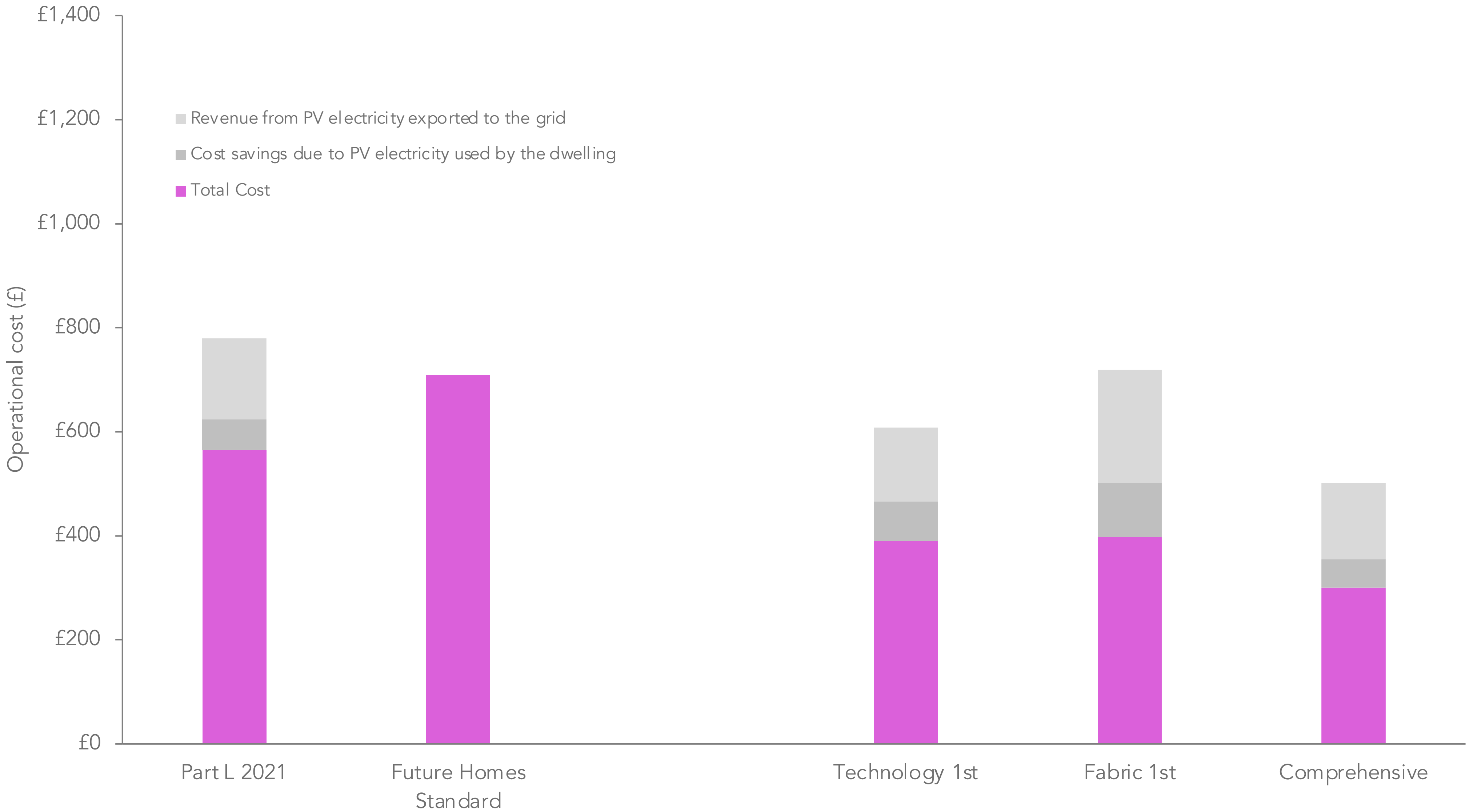


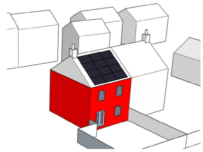





Carbon avoided from PV
Gas carbon emissions
Electricity carbon emissions
Average annual net emissions (kg CO_2/year/m^2)
25
20
15
10
5
0
-5
-10
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive

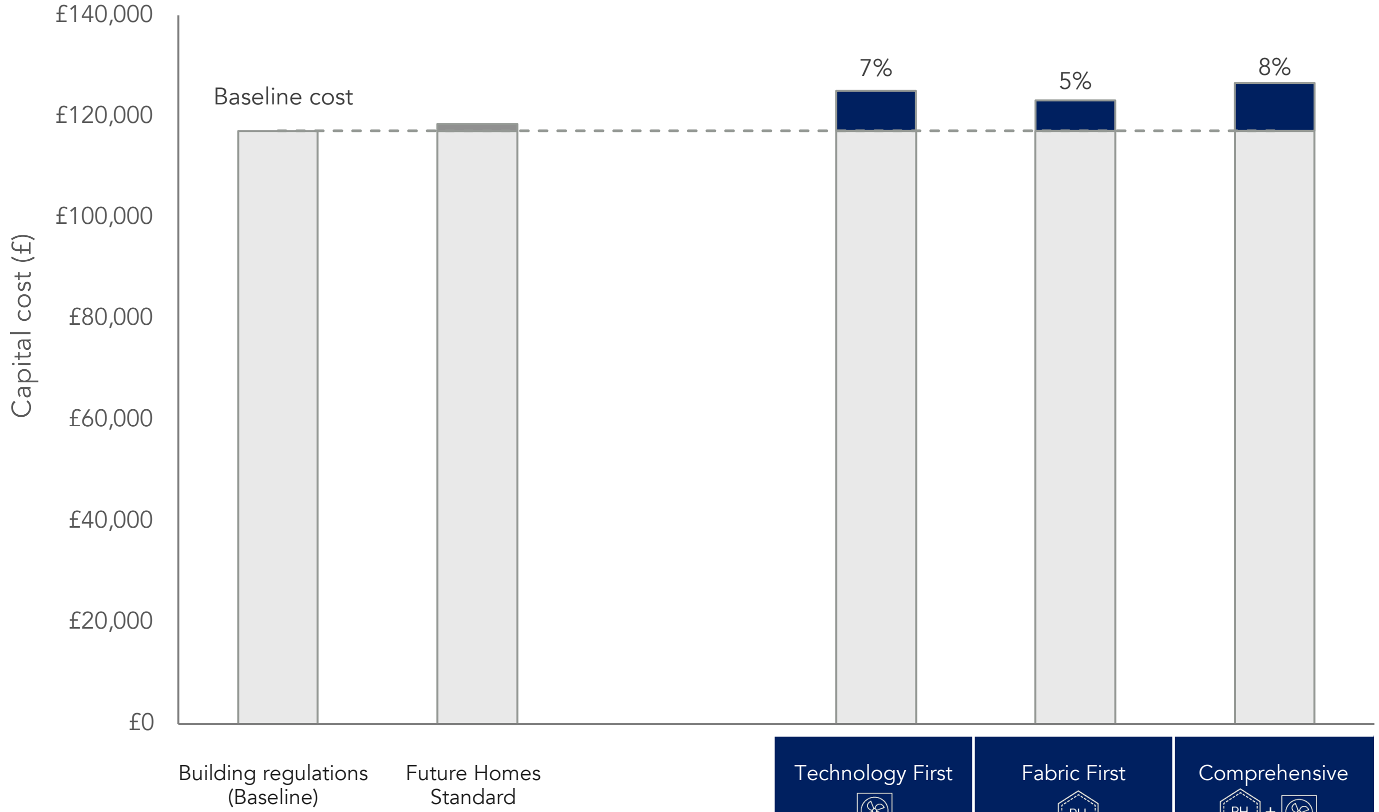



£1,400
£1,200
£1,000
£800
£600
£400
£200
£0
Operational cost (£)
Revenue from PV electricity exported to the grid
Cost savings due to PV electricity used by the dwelling
Total Cost
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive



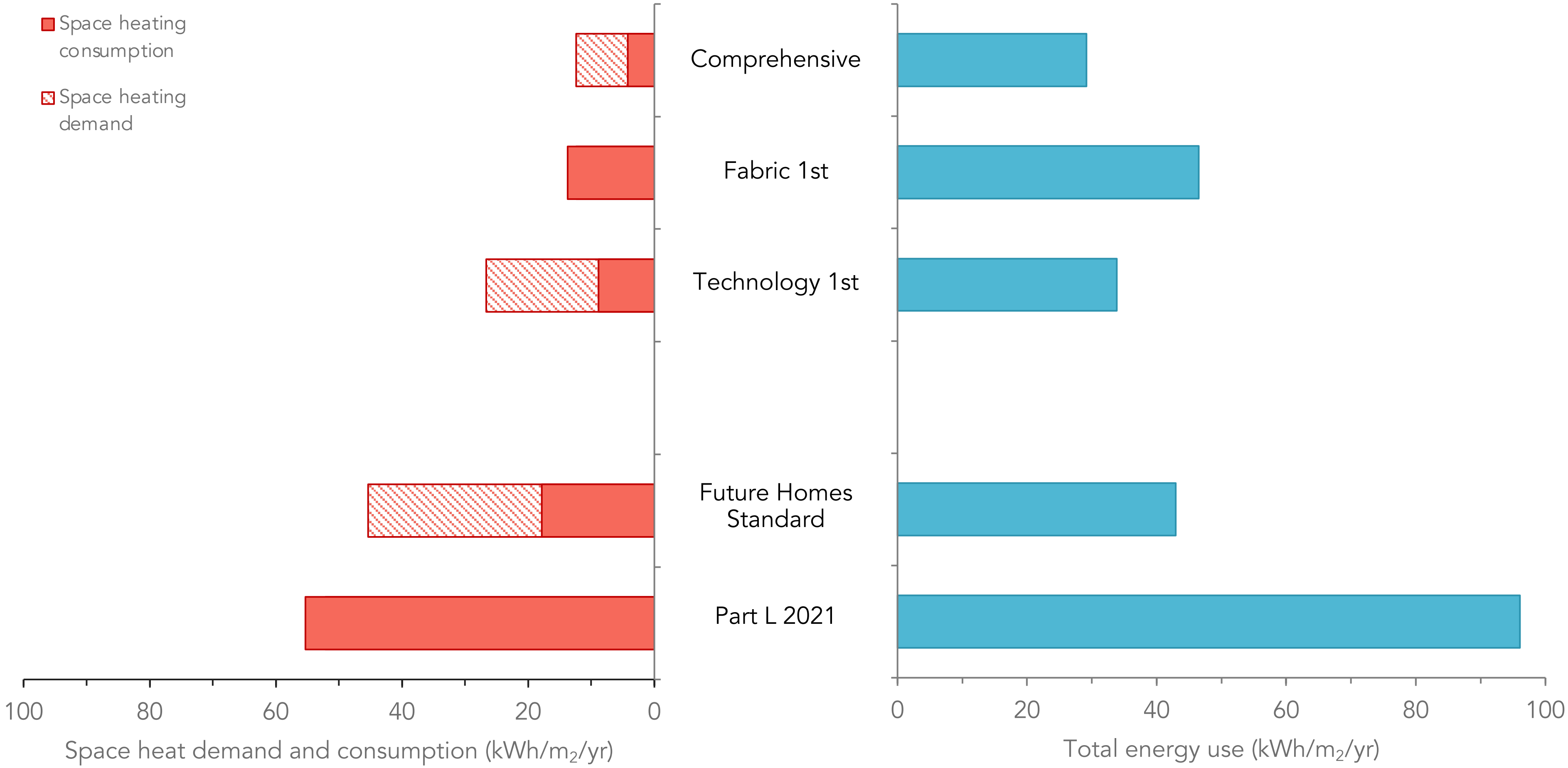
Key observations

- A very small cost uplift arises from the adoption of Future Homes Standard specifications, this is due to the savings from removal of the PV array assumed for the 2021 specification which is equivalent in cost to the fabric and ASHP systems used in the FHS specification
- The fabric first specification includes a significant cost uplift on the fabric elements which is offset by savings in the building services as a result of using a dry direct electric system
- The comprehensive specification is the most expensive option but the total cost is less than might be expected because the combination of fabric efficiency and system efficiency means that the size of the PV array is smaller than would needed for the Fabric First option.



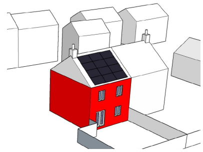
Cost uplifts	Technology First	Fabric First	Comprehensive
Fabric	£3,695	£6,904	£6,904
System (heating & hot water)	£4,206	-£1,767	£2,537
PV	£0	£864	£0

Notes: *The % increase is relative to Part L 2021*
Negative cost for PV reflects a reduction in the need for PVs in other scenarios in comparison to PVs required for Part L 2021.



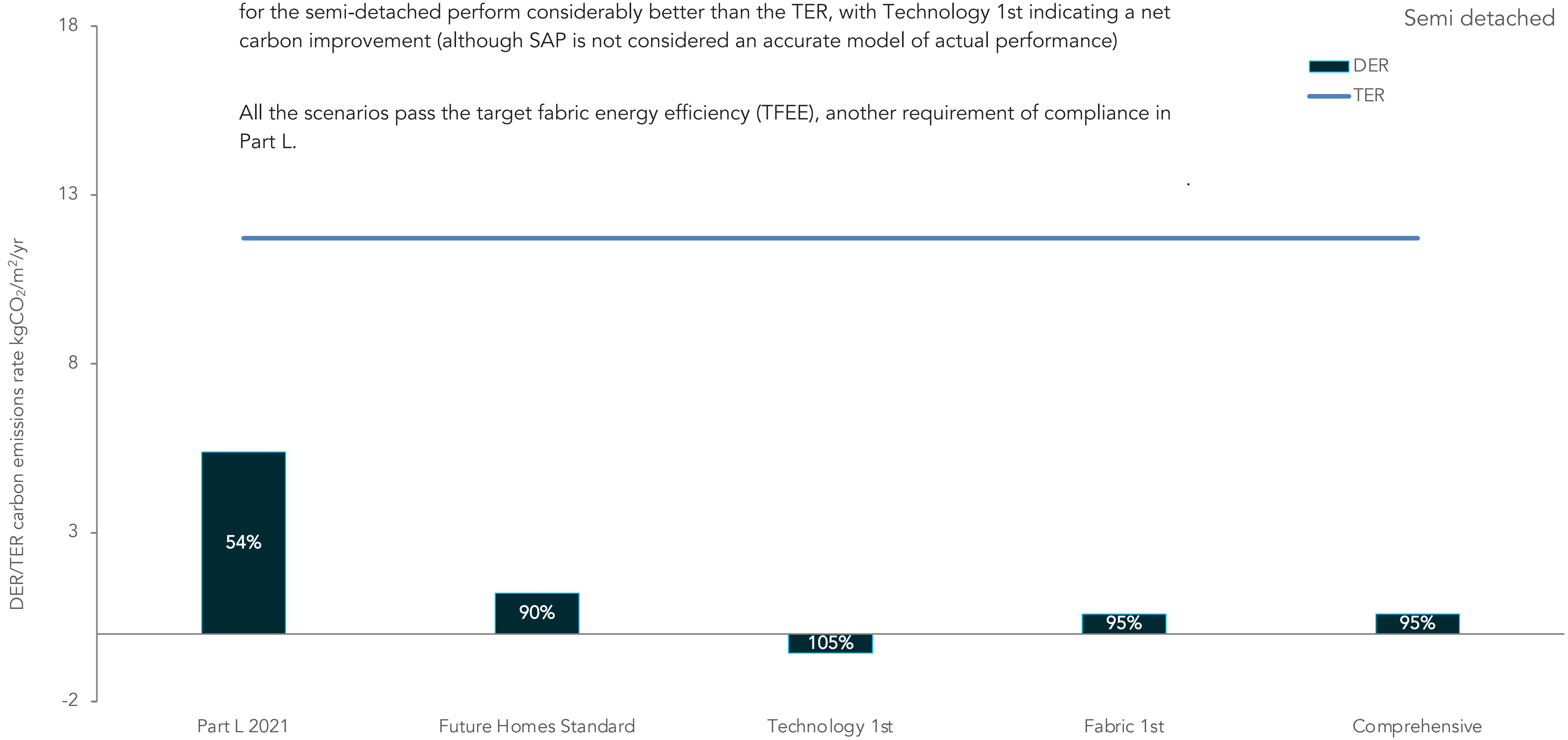
Space heating demand represents the final energy needed to maintain a comfortable temperature in the dwelling whereas consumption includes the heating system's efficiency and losses.

Semi-detached house | **Part L performance measured through SAP10**



The target emissions rate (TER) for dwellings, as defined by Part L and calculated through SAP10, is denoted by the horizontal line in the graph below. The dwelling emissions rate (DER) in all the scenarios for the semi-detached perform considerably better than the TER, with Technology 1st indicating a net carbon improvement (although SAP is not considered an accurate model of actual performance)

All the scenarios pass the target fabric energy efficiency (TFEE), another requirement of compliance in Part L.



6.3

Detailed results for the mid-terrace house

This section presents the results from the mid-terrace house modeling. First the typology is presented in more detail, then the design assumptions are outlined for each of the five specifications, this is followed by the results and analysis.

Mid-terrace house | **Description**

The mid-terrace house is based on the semi-detached house, as this reflects house types that have been included in recent Planning applications for the Isle of Wight.

Building fabric

Like the semi-detached, this property has a gross internal floor area of $93m^2$. The main entrance faces the street to the North-East, while the rear of the house faces to the South-West. The property has typical glazing proportions and layout for this type of home. The form heat loss factor of 2.20 is lower than all other house types and is typical for a mid-terrace home.

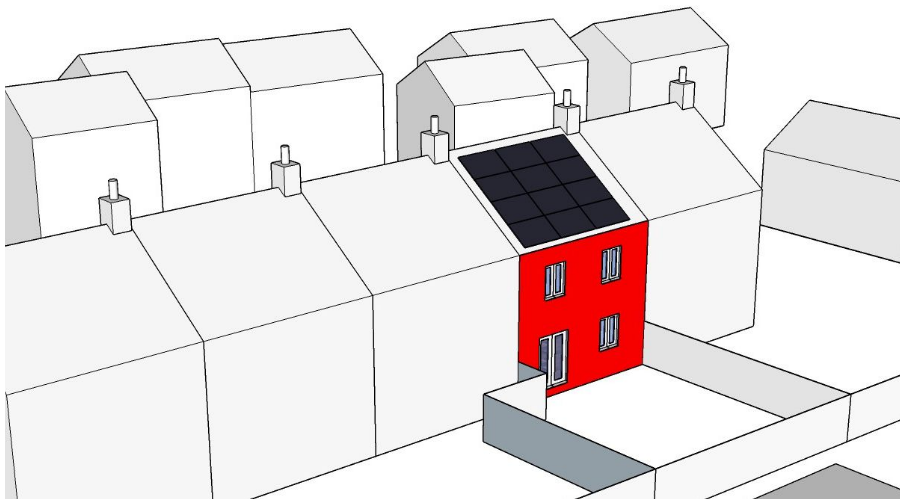
Low carbon heating

- Air source heat pump / ground source heat pump are both feasible
- Direct electric is also possible, advantages and disadvantages are discussed later
- Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency

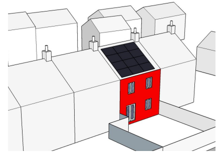
Solar PV

- 12 solar panels is possible for this South facing example
- For East / West orientation 24 solar panels would be possible
- There is potential to optimise the form of the roof to fit more panels

Typical 3-bedroom mid-terrace house



A 3D model of the house and surrounding features was created in DesignPH and used to calculate solar gains and shading for PHPP



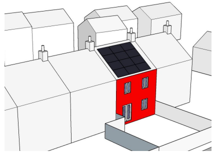
Mid-terrace house | **Scenarios**

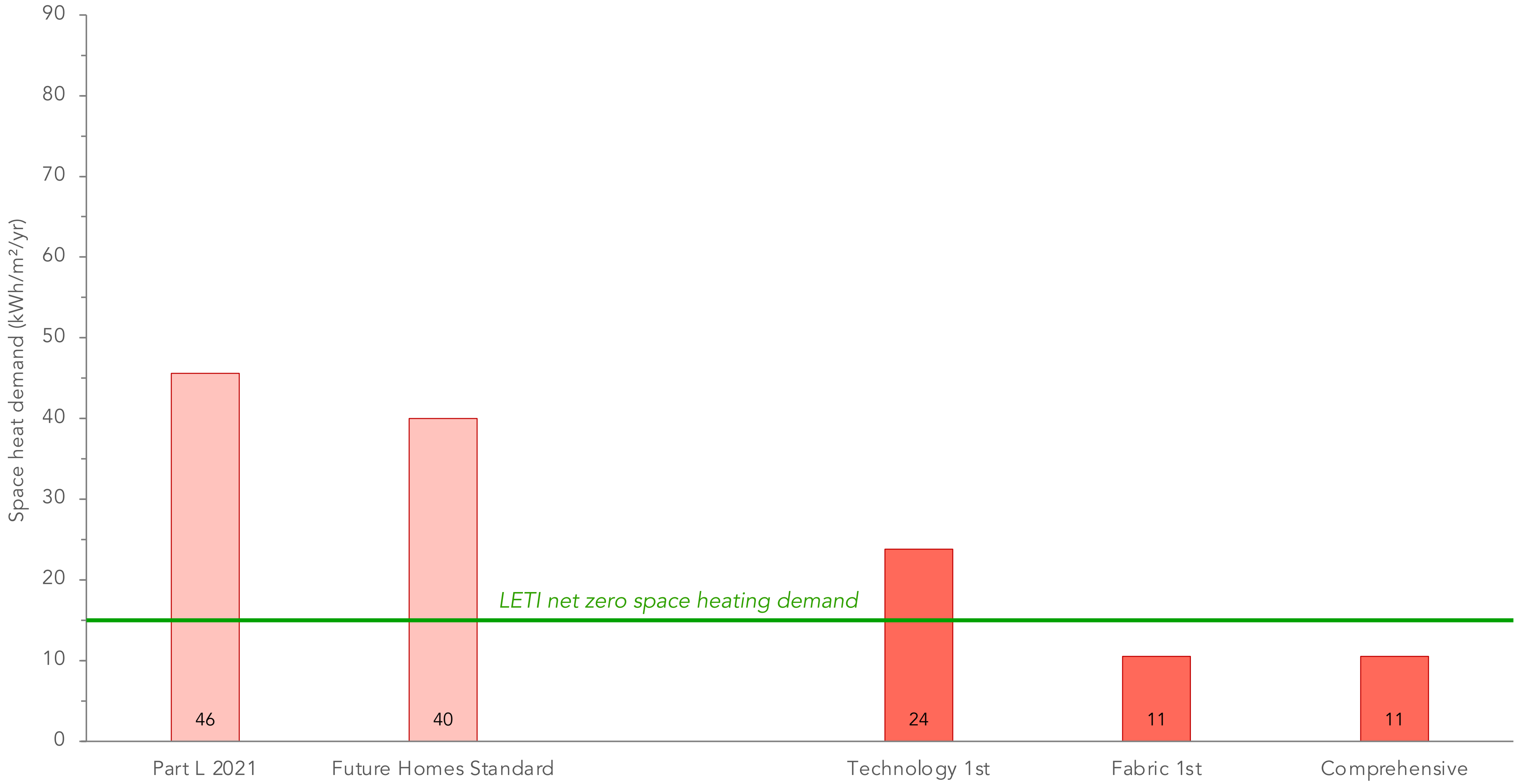
		Building regulations	Future Homes Standard	Technology First	Fabric First	Comprehensive
Building fabric	Floor / Walls / Roof (W/m²K)	0.130 / 0.180 / 0.110 — Building regs fabric 2021	0.110 / 0.150 / 0.110 — Building regs fabric 2025	0.110 / 0.150 / 0.110 — Very-low energy fabric	0.100 / 0.130 / 0.100 — Ultra-low energy fabric	0.100 / 0.130 / 0.100 — Ultra-low energy fabric
Building fabric	Windows / Doors (W/m²K)	1.2 / 1.0 - 1.3 — Double glazing	0.8 / 1.0 - 1.3 — Triple glazing	1.2 / 1.0 - 1.3 — Double glazing	0.8 / 0.9-10 — Triple glazing	0.8 / 0.9-10 — Triple glazing
Building fabric	Airtightness (ACH*)	5.0 — Airtightness	5.0 — Airtightness	3.0 — Airtightness 3	PH 0.6 — Passivhaus certified Airtightness < 0.6	PH 0.6 — Passivhaus certified Airtightness < 0.6
Building fabric	Ventilation heat recovery efficiency (%)	0% — Extract fan only	0% — Extract fan only	88% — High efficiency MVHR	88% — High efficiency MVHR	88% — High efficiency MVHR
Heating and Hot water	Heating system T supply (°C)	60 — Gas boiler	55 — Heat Pump	45 — Heat Pump	60 — Direct Electric	45 — Heat Pump
Heating and Hot water	DHW storage (litres) / WWHR** efficiency (%)	120 / 0 % — Some DHW storage	180 / 0 % — DHW storage	180 / 36 % — DHW storage	120 / 36 % — DHW storage	180 / 36 % — DHW storage
Renewable energy	Solar panels (number)	8 — PV panels	- — No PV	8 — PV panels	12 — PV panels	8 — PV panels

Column header icons: Technology First (heat pump); Fabric First (PH); Comprehensive (PH + heat pump).

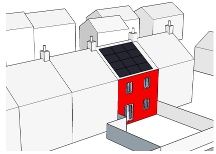
*Air changes per hour indicates the air volume added to or removed in one hour, divided by the volume of the space. Air permeability values in m³/h/m² will be slightly different and will vary depending on the volume to surface area ratio of the building.
**Waste-water heat recovery device to showers.

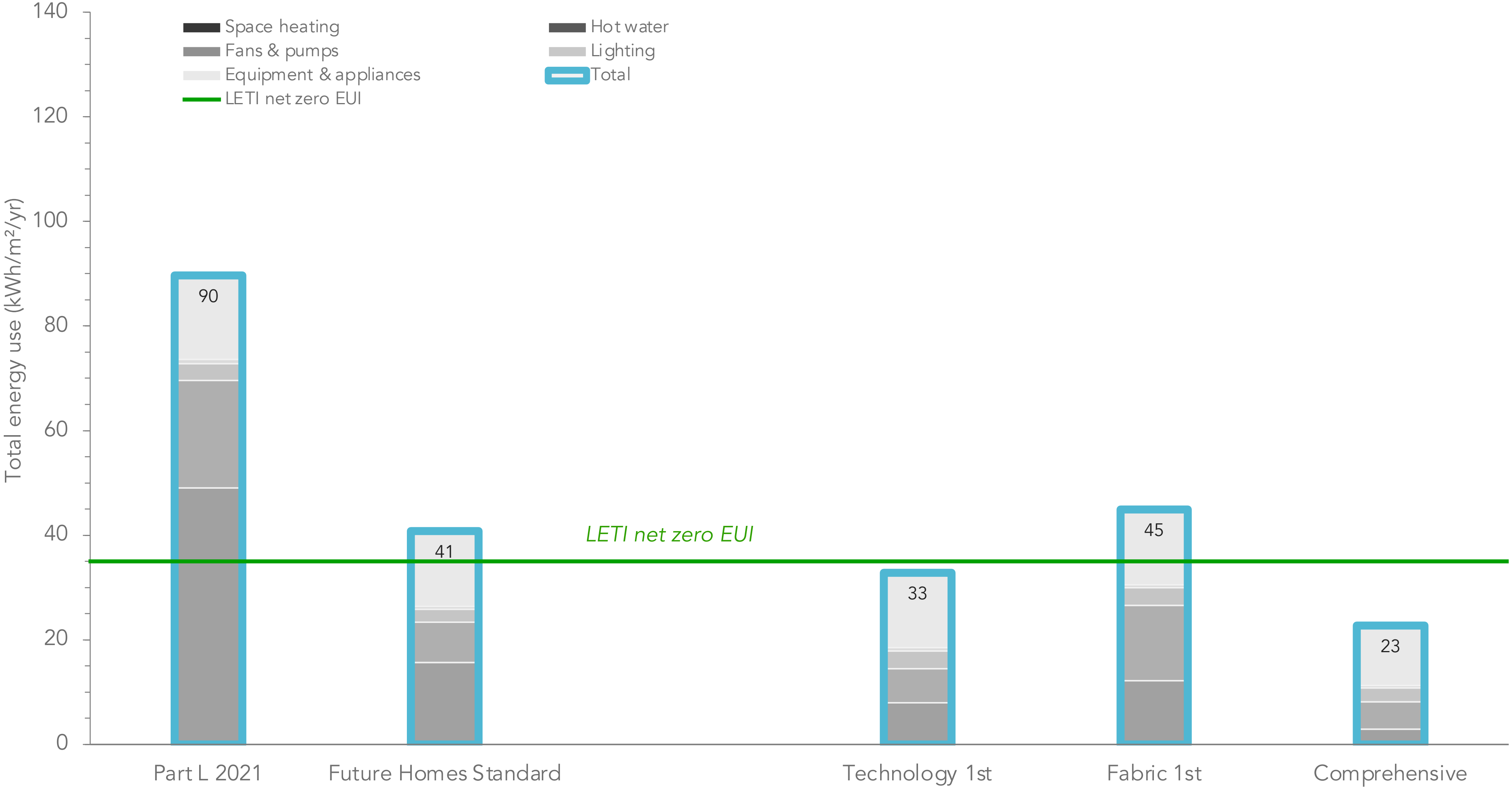
Mid-terrace house | **Space heating demand**



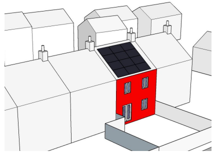


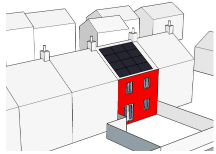
Mid-terrace house | **EUI (kWh/m²/yr)**

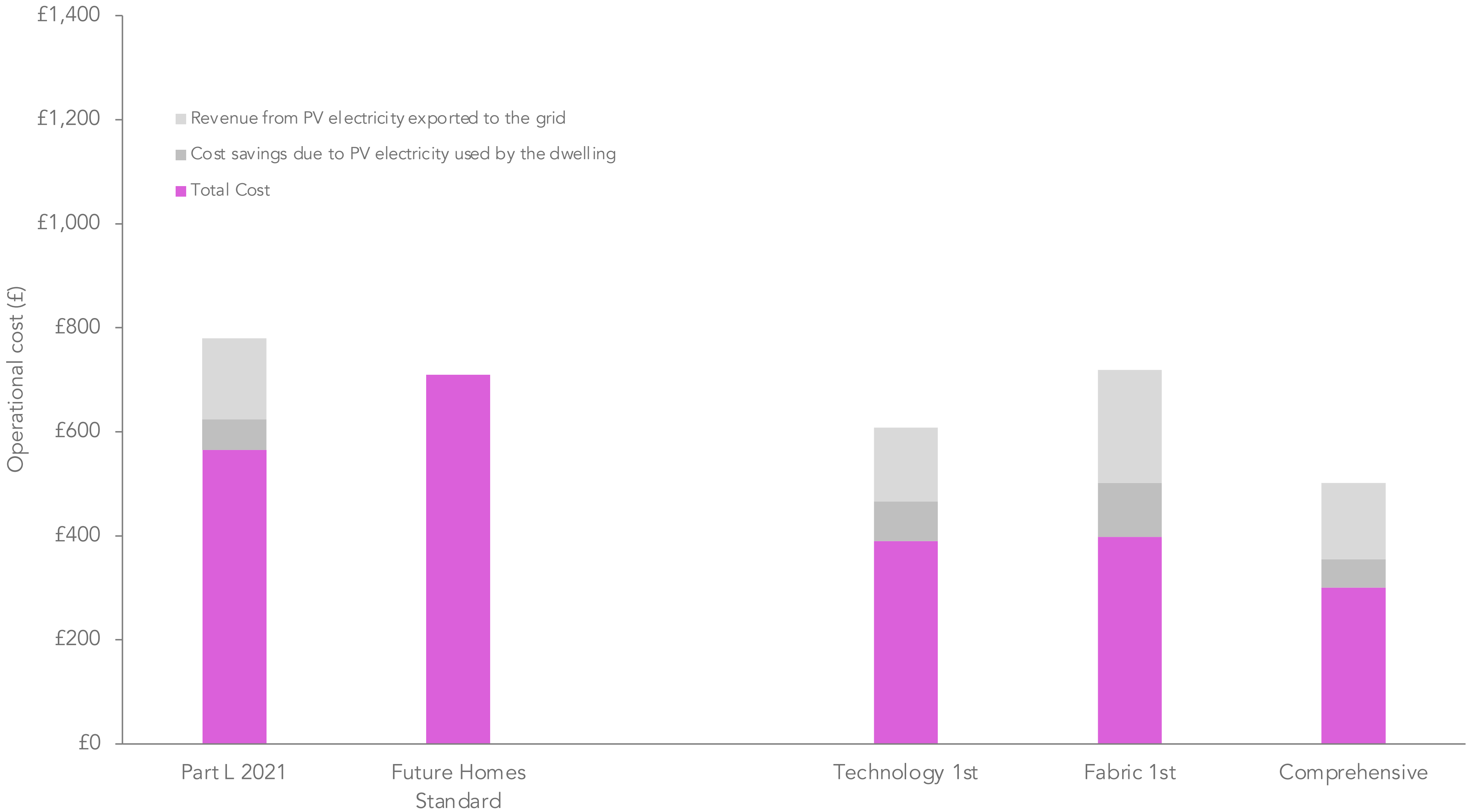


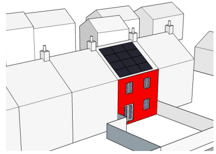


Mid-terrace house | **PV generation and Net Zero balance**



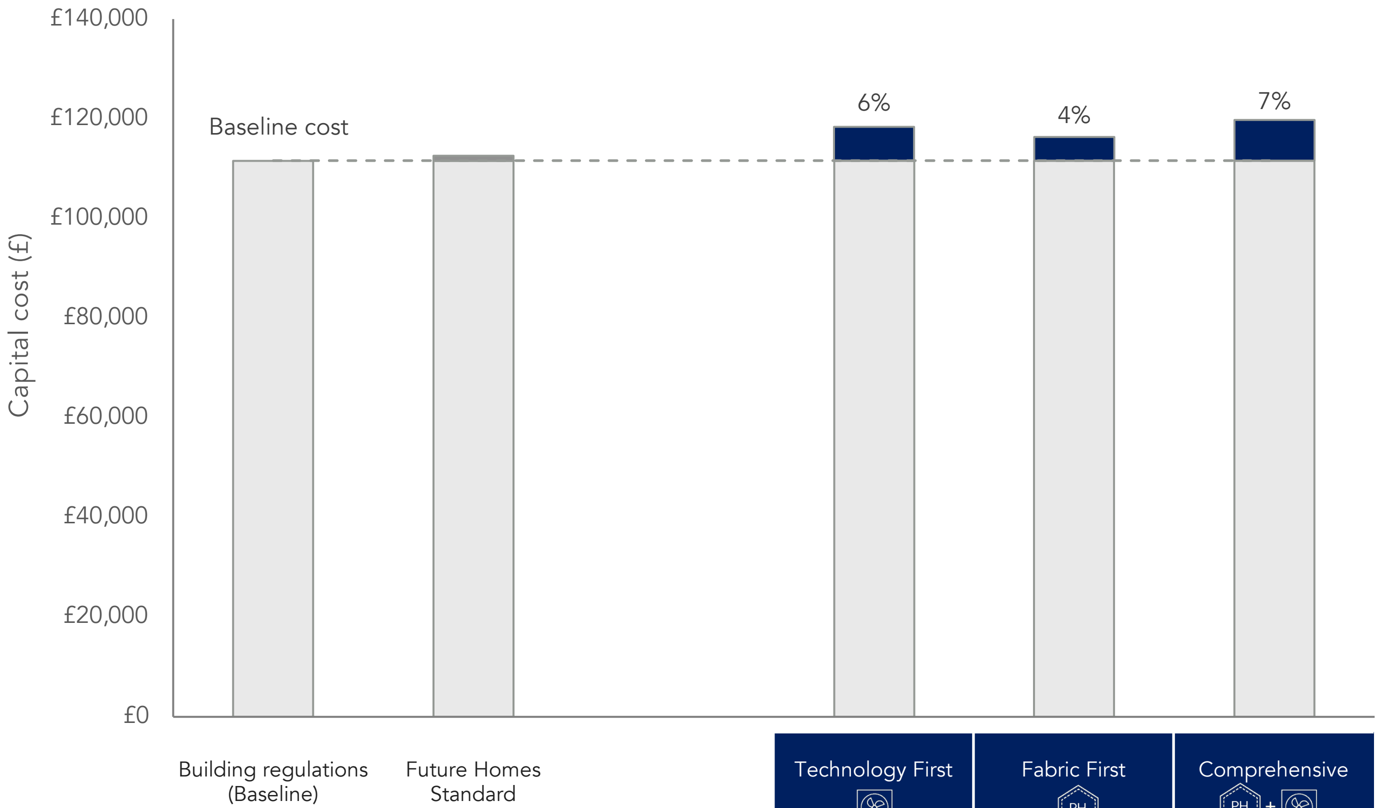



£1,400
£1,200
£1,000
£800
£600
£400
£200
£0
Operational cost (£)
Revenue from PV electricity exported to the grid
Cost savings due to PV electricity used by the dwelling
Total Cost
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive



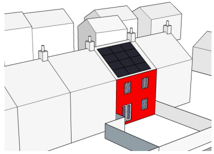
Key observations

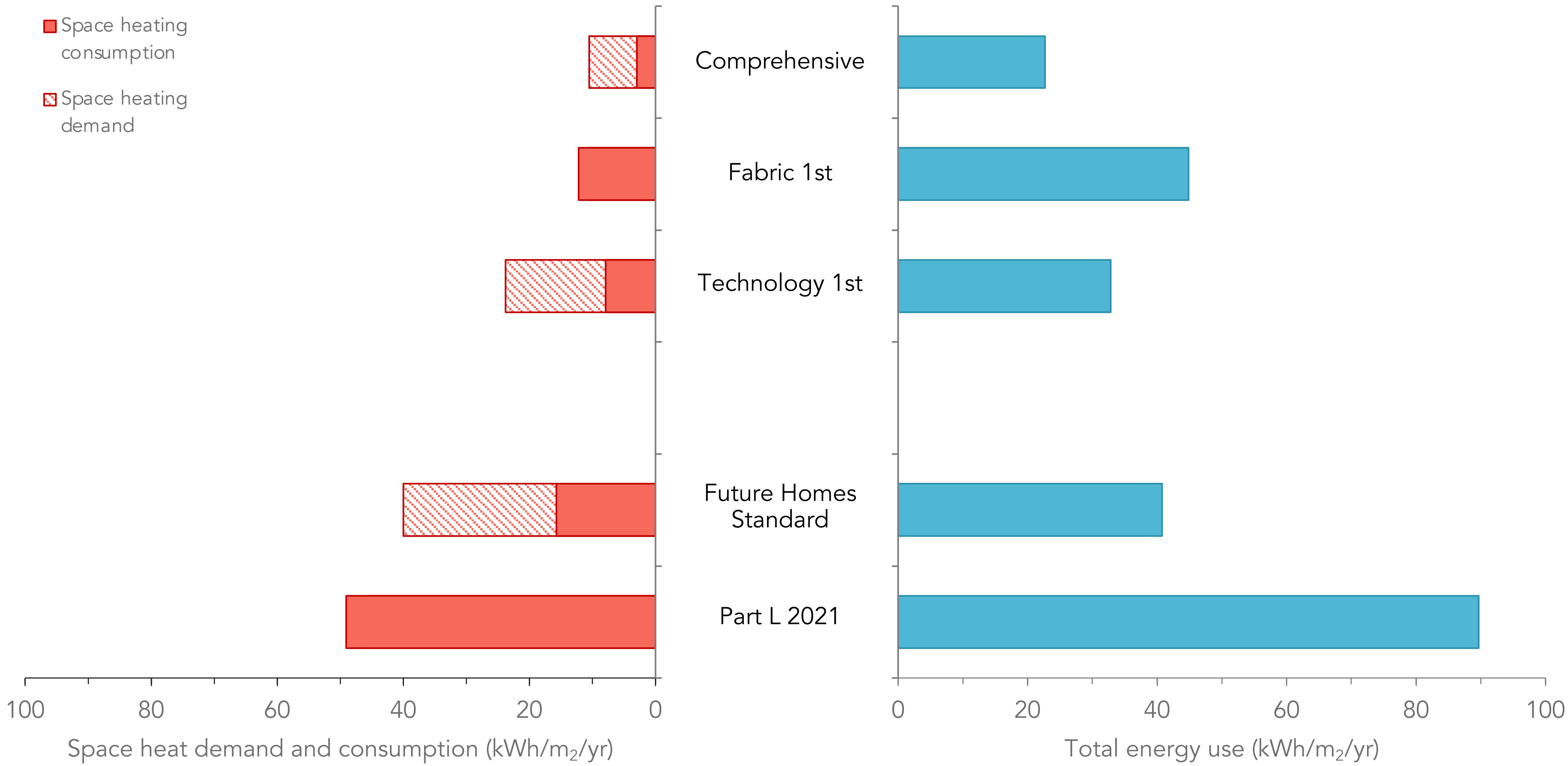
- Very small uplift arises from the adoption of Future Homes Standard specifications, this is due to the savings from removal of the PV array assumed for the 2021 specification which is equivalent in cost to the fabric and ASHP systems used in the FHS specification
- The fabric first specification includes a significant cost uplift on the fabric elements which is offset by savings in the building services as a result of using a dry direct electric system
- The comprehensive specification is the most expensive option but the total cost is less than might be expected because the combination of fabric efficiency and system efficiency means that the size of the PV array is smaller than would needed for the Fabric First option.



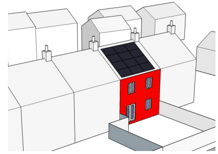
Cost uplifts	Technology First	Fabric First	Comprehensive
Fabric	£2,816	£5,826	£5,826
System (heating & hot water)	£3,853	-£2,052	£2,225
PV	£108	£972	£108

Notes: *The % increase is relative to Part L 2021*
Negative cost for PV reflects a reduction in the need for PVs in other scenarios in comparison to PVs required for Part L 2021.



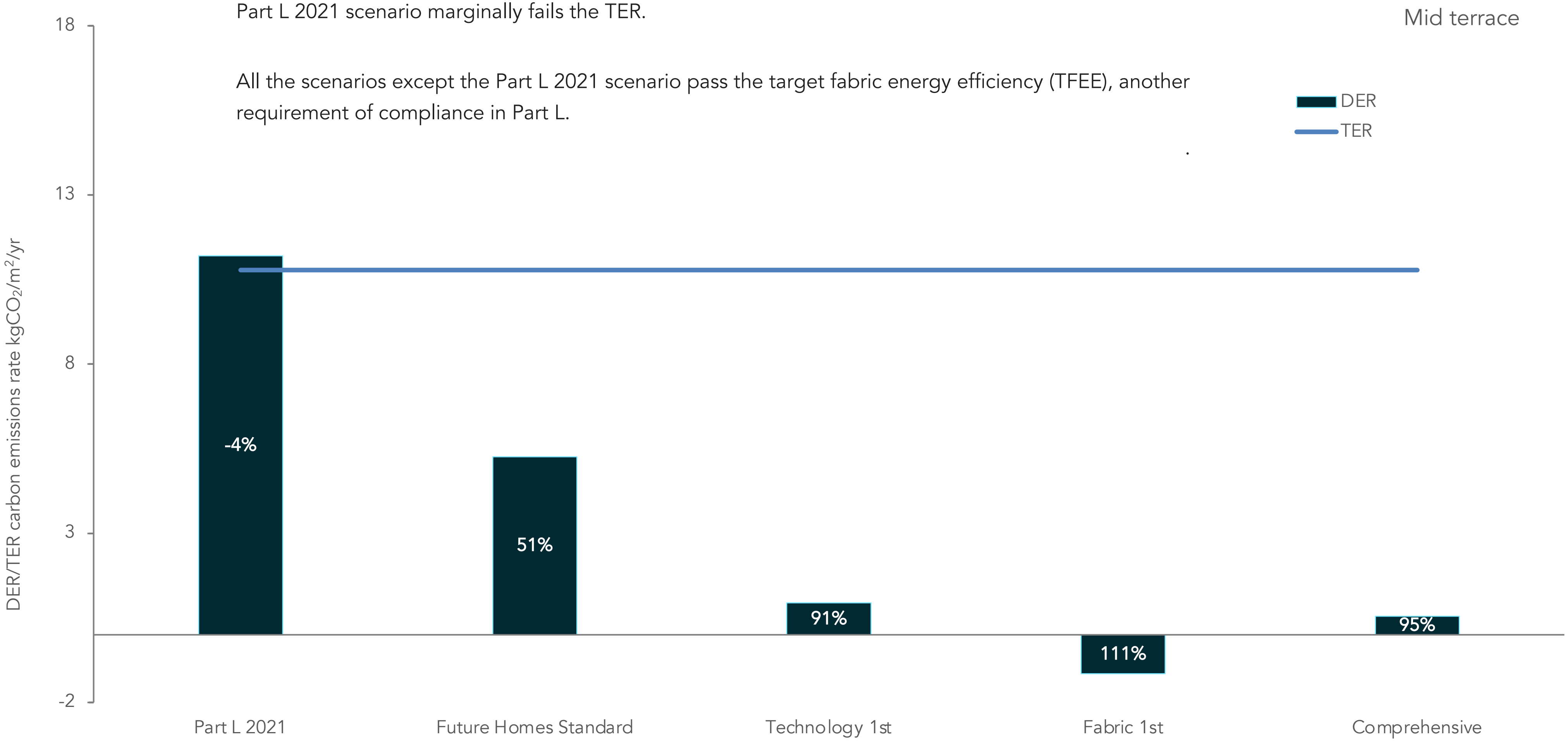


Space heating demand represents the final energy needed to maintain a comfortable temperature in the dwelling whereas consumption includes the heating system's efficiency and losses.



The DER for most of the scenarios is considerably better than the TER, with Fabric 1st indicating a net carbon improvement (although SAP is not considered an accurate model of actual performance). The Part L 2021 scenario marginally fails the TER.

All the scenarios except the Part L 2021 scenario pass the target fabric energy efficiency (TFEE), another requirement of compliance in Part L.



6.4

Detailed results for the bungalow

This section presents the results from the bungalow modeling. First the typology is presented in more detail, then the design assumptions are outlined for each of the five specifications, this is followed by the results and analysis.

Bungalow | Description

This two-bed bungalow is based on a typology included in the recent Planning application for the development at Branstone Farm, Sandown in the Isle of Wight.

Building fabric

This property has a gross internal floor area of 74m². The main entrance faces the street to the East, while the rear of the house faces to the West. The property has typical glazing proportions and layout for this type of home. The **form heat loss factor of 4.04** is higher than all other house types and is typical for a small bungalow. As a result, high levels of insulation are required to achieve the required space heating demand targets.

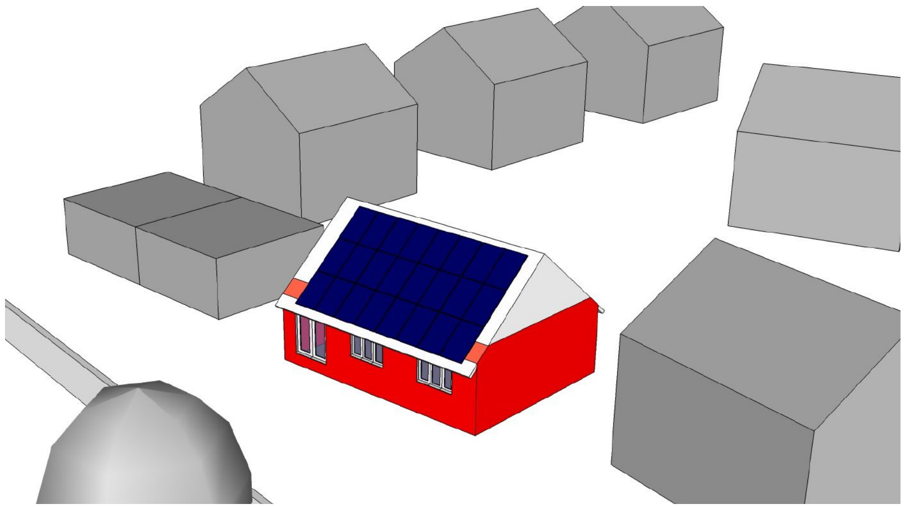
Low carbon heating

- Air source heat pump / ground source heat pump are both feasible
- Direct electric is also possible, advantages and disadvantages are discussed later
- Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency

Solar PV

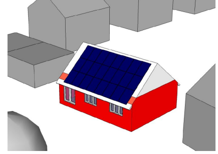
- 48 solar panels is possible for this East / West example
- For a South facing roof 24 solar panels would be possible
- There is potential to optimise the form of the roof to fit more panels

Typical 2-bedroom bungalow (front elevation, rear elevation)



A 3D model of the house and surrounding features was created in DesignPH and used to calculate solar gains and shading for PHPP

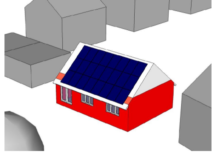
Bungalow | **Scenarios**

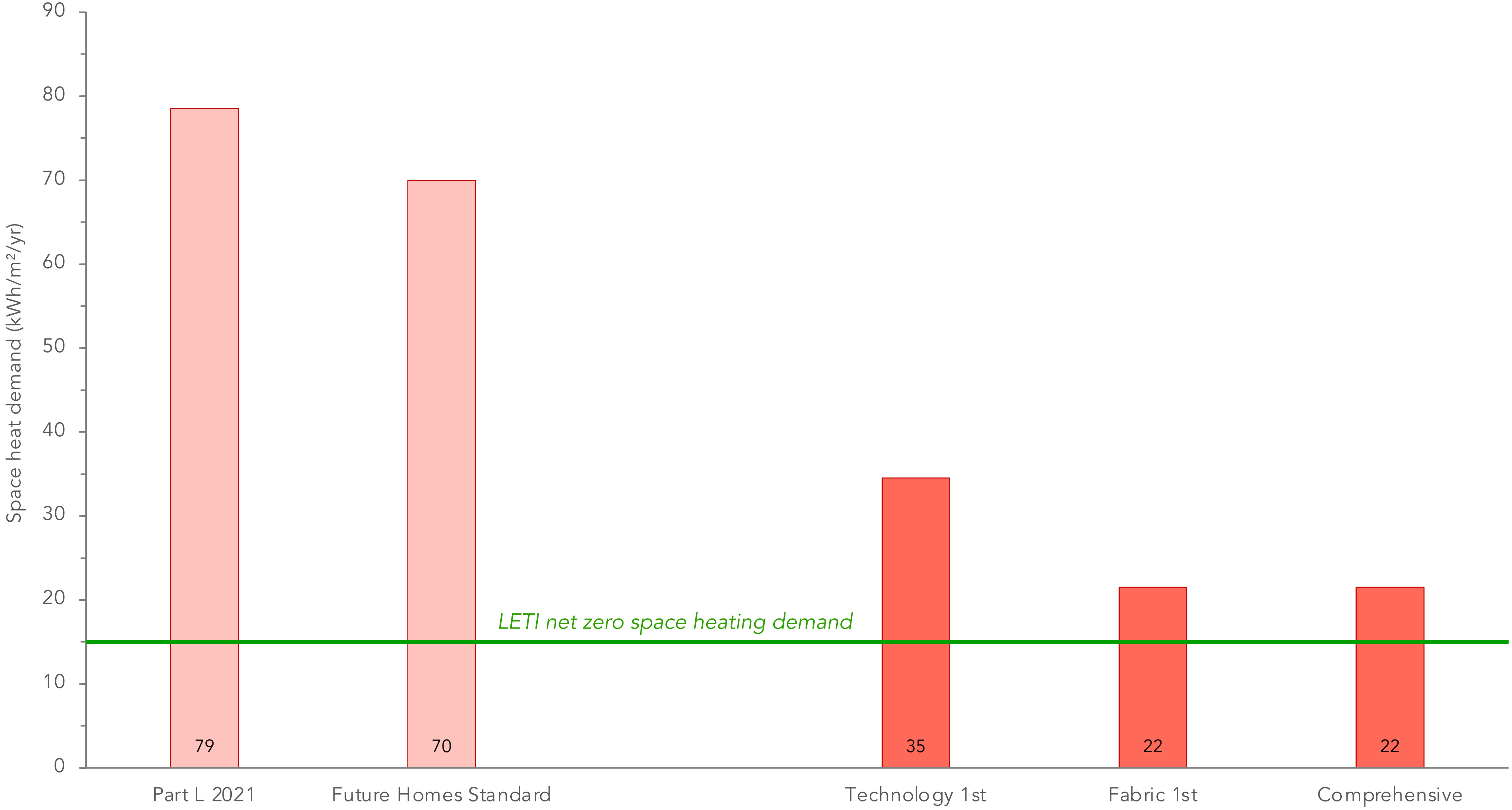


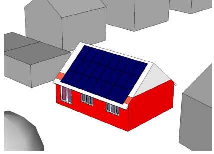
		Building regulations	Future Homes Standard	Technology First	Fabric First	Comprehensive
Building fabric	Floor / Walls / Roof (W/m^2K)	0.130 / 0.180 / 0.110 Building regs fabric 2021	0.110 / 0.150 / 0.110 Building regs fabric 2025	0.090 / 0.090 / 0.090 Very-low energy fabric	0.090 / 0.090 / 0.090 Ultra-low energy fabric	0.090 / 0.090 / 0.090 Ultra-low energy fabric
	Windows / Doors (W/m^2K)	1.2 / 1.0 - 1.3 Double glazing	0.8 / 1.0 - 1.3 Triple glazing	0.8 / 0.9-10 Triple glazing	0.8 / 0.9-10 Triple glazing	0.8 / 0.9-10 Triple glazing
	Airtightness (ACH*)	5.0 Airtightness	5.0 Airtightness	3.0 Airtightness 3	0.6 Passivhaus certified Airtightness < 0.6	0.6 Passivhaus certified Airtightness < 0.6
	Ventilation heat recovery efficiency (%)	0% Extract fan only	0% Extract fan only	90% V high efficiency MVHR	90% V high efficiency MVHR	90% V high efficiency MVHR
Heating and Hot water	Heating system T supply (°C)	60 Gas boiler	55 Heat Pump	45 Heat Pump	60 Direct Electric	45 Heat Pump
	DHW storage (litres) / WWHR** efficiency (%)	120 / 0 % Some DHW storage	180 / 0 % DHW storage	180 / 36 % DHW storage	120 / 36 % DHW storage	180 / 36 % DHW storage
Renewable energy	Solar panels (number)	12 PV panels	- No PV	9 PV panels	14 PV panels	8 PV panels

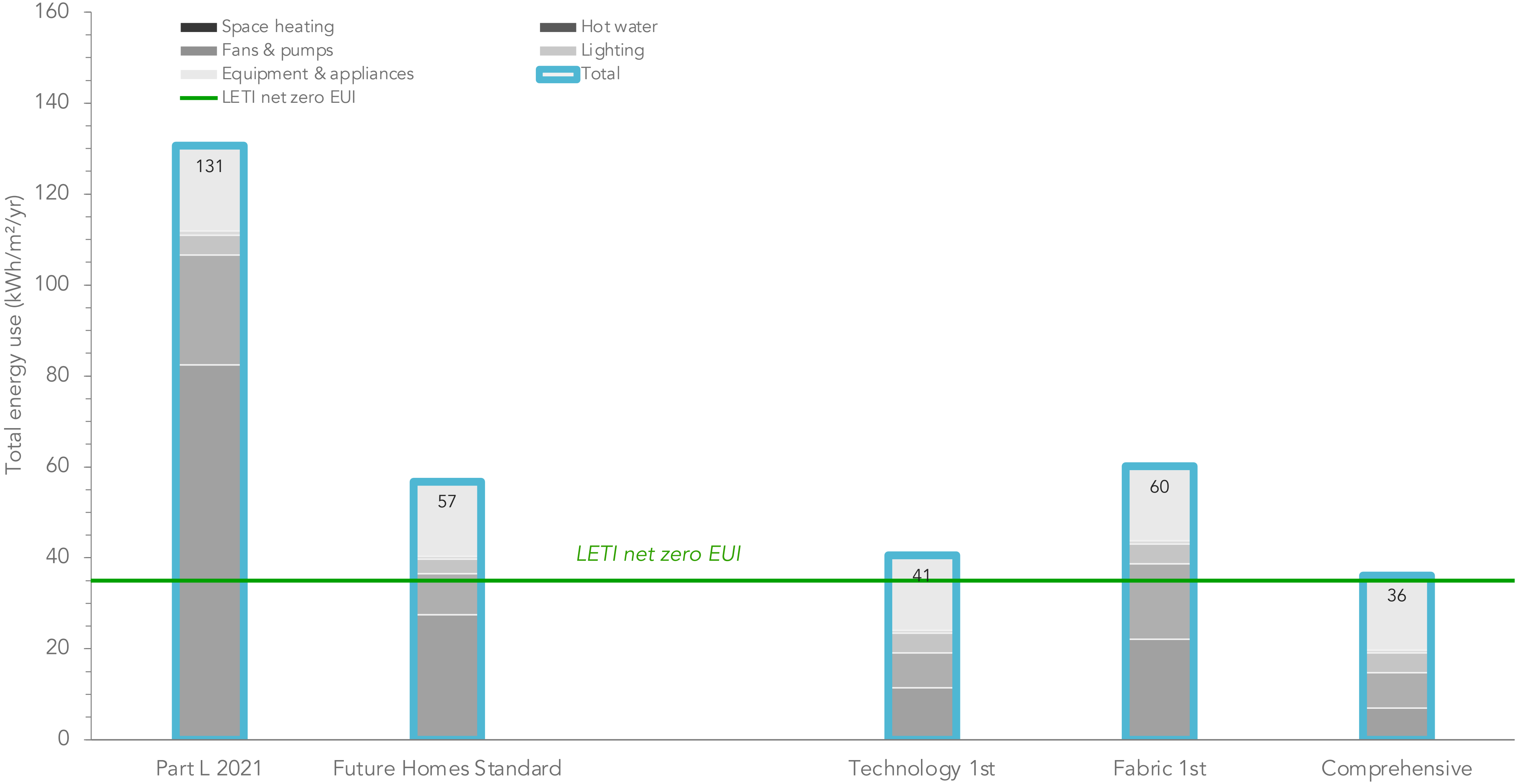
*Air changes per hour indicates the air volume added to or removed in one hour, divided by the volume of the space. Air permeability values in $m^3/h/m^2$ will be slightly different and will vary depending on the volume to surface area ratio of the building.
**Waste-water heat recovery device to showers.

Bungalow | **Space heating demand**



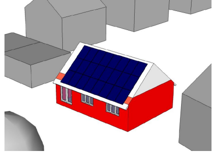


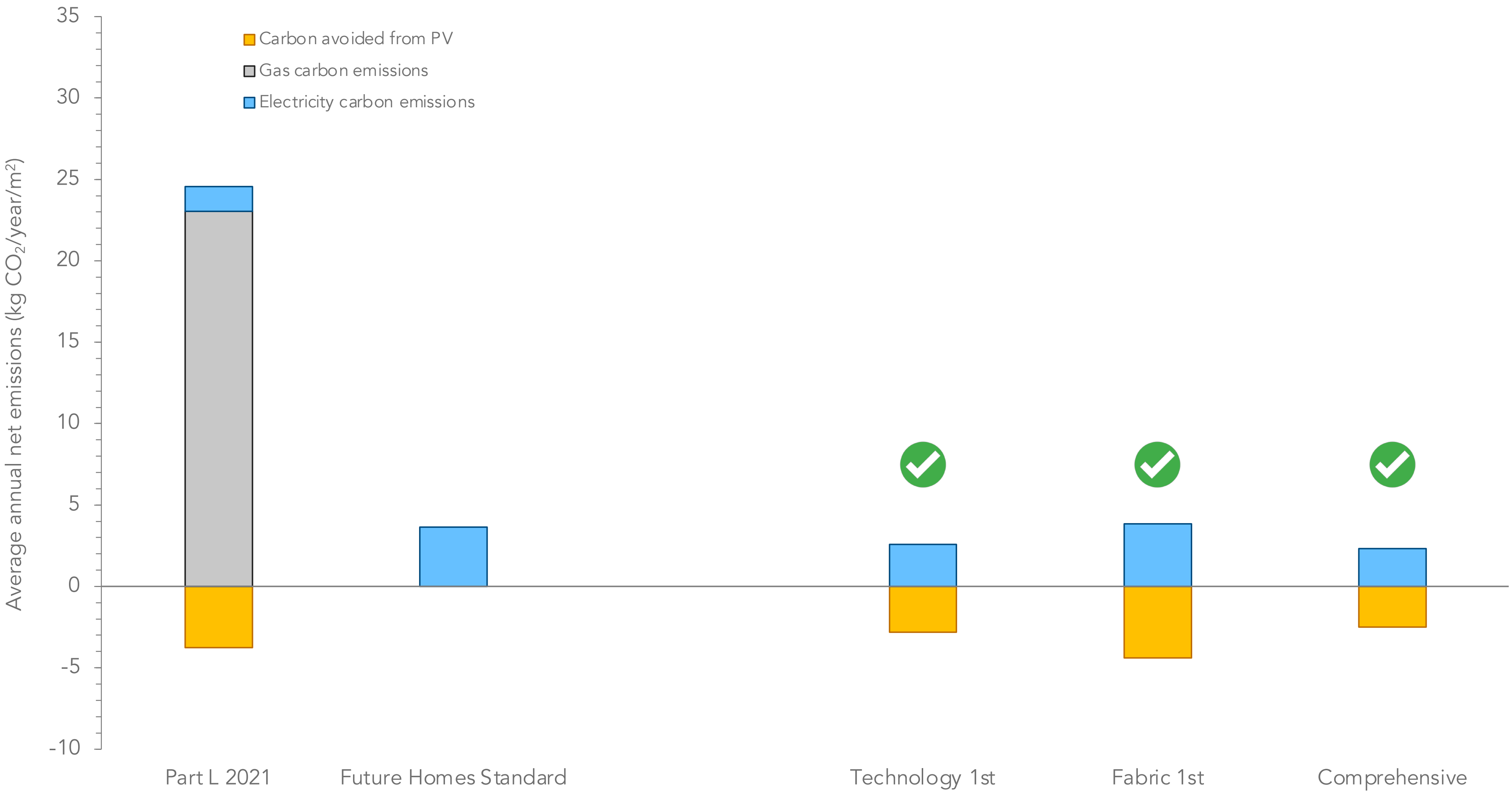


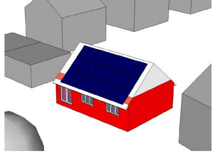


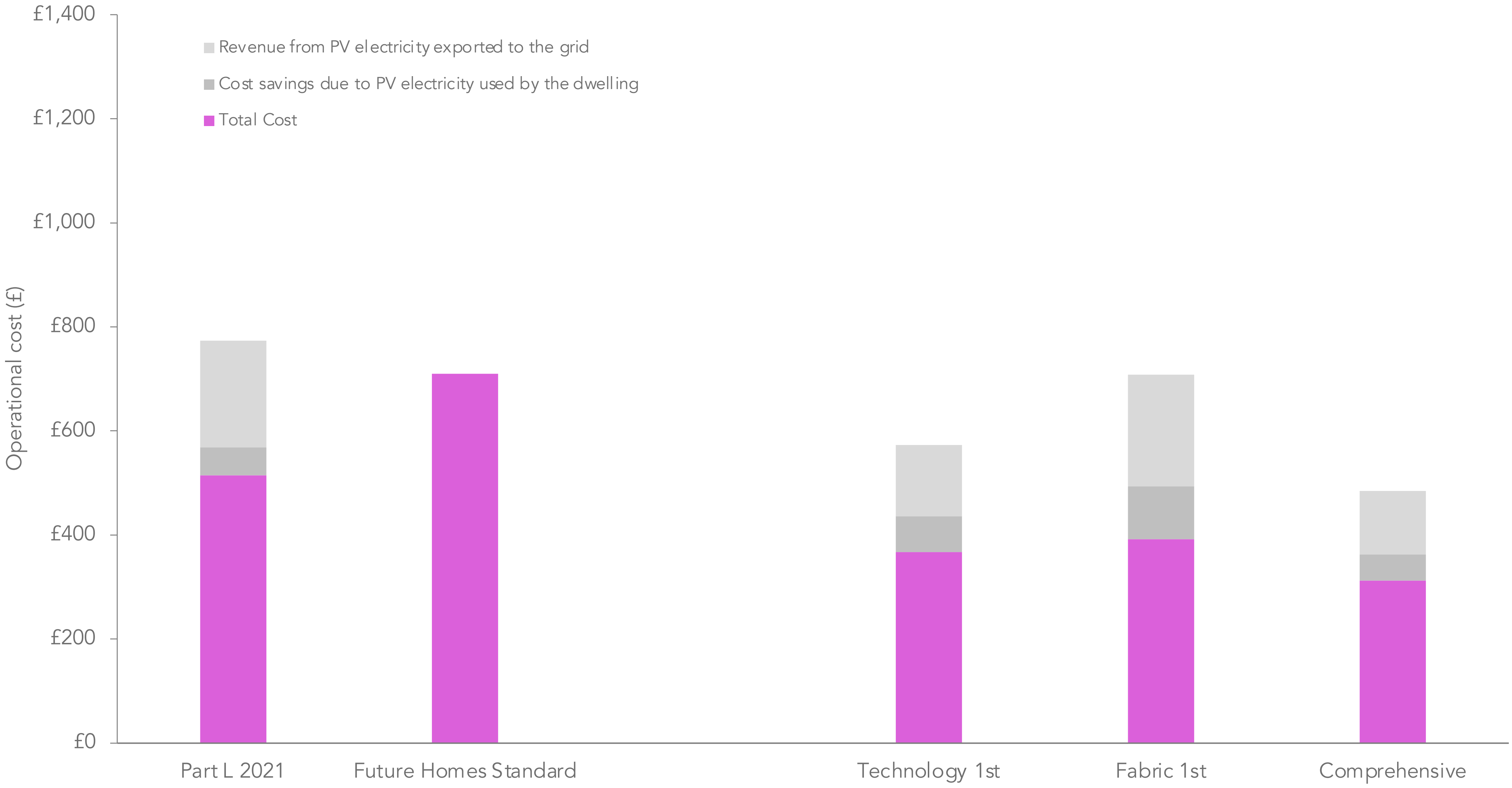
160
140
120
100
80
60
40
20
0
Total energy use (kWh/m²/yr)
Space heating
Hot water
Fans & pumps
Lighting
Equipment & appliances
Total
LETI net zero EUI
131
57
LETI net zero EUI
41
60
36
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive

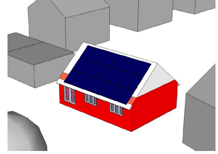
Bungalow | **PV generation and Net Zero balance**





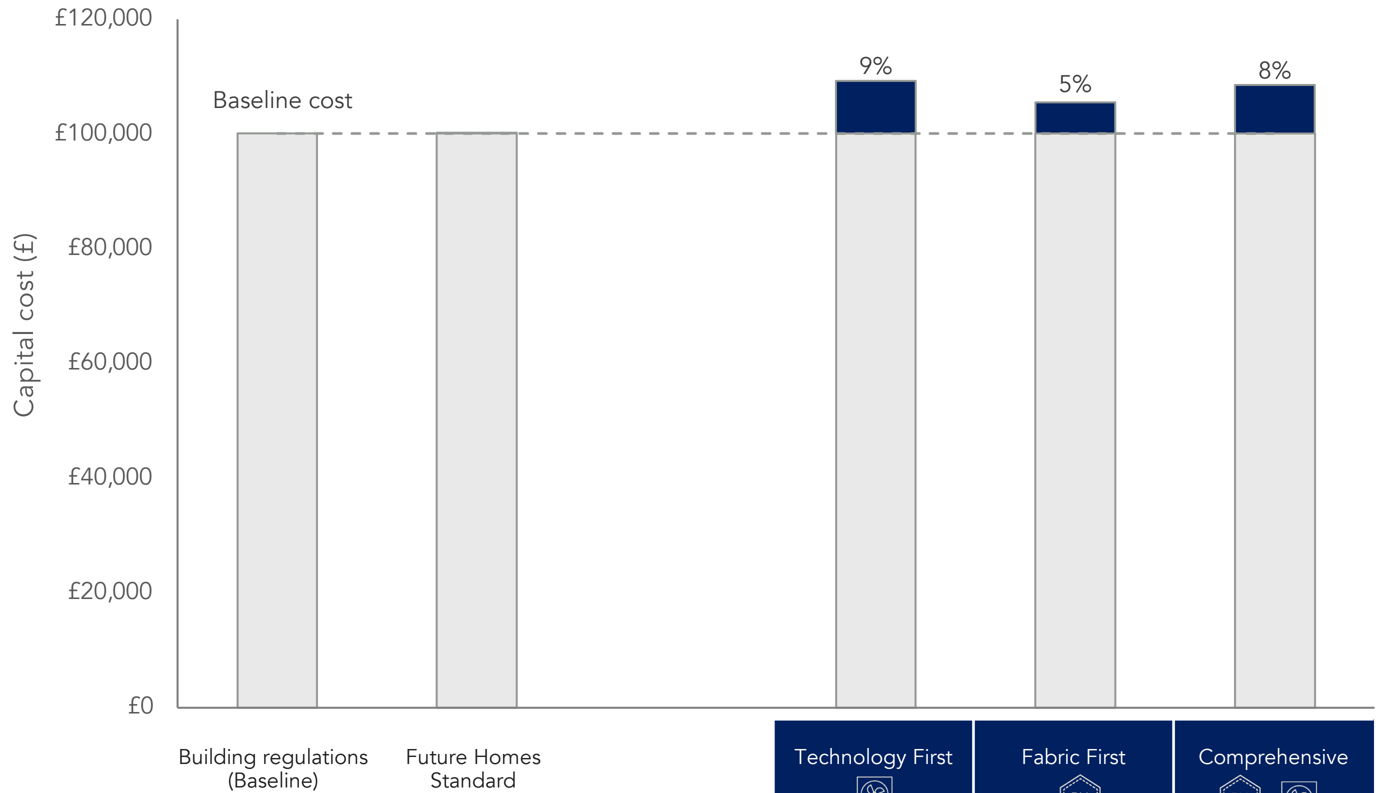



£1,400
£1,200
£1,000
£800
£600
£400
£200
£0
Operational cost (£)
Revenue from PV electricity exported to the grid
Cost savings due to PV electricity used by the dwelling
Total Cost
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive



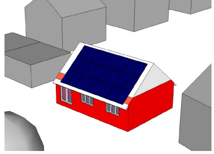
Key observations

- No material cost uplift arises from the adoption of Future Homes Standard specifications, this is due to the savings from removal of the PV array assumed for the 2021 specification which is equivalent in cost to the fabric and ASHP systems used in the FHS specification
- The fabric first specification includes a significant cost uplift on the fabric elements which is offset by savings in the building services as a result of using a dry direct electric system
- The building form factor means that the costs of fabric for the Technology First option are similar to those associated with the Fabric First / Comprehensive options. As a result the fabric cost differential is smaller than in other house types.
- The comprehensive specification is actually less expensive than the Technology First option as the increased level of fabric efficiency means that savings in heating distribution / emitter costs and PV offset the additional cost of the improved fabric.

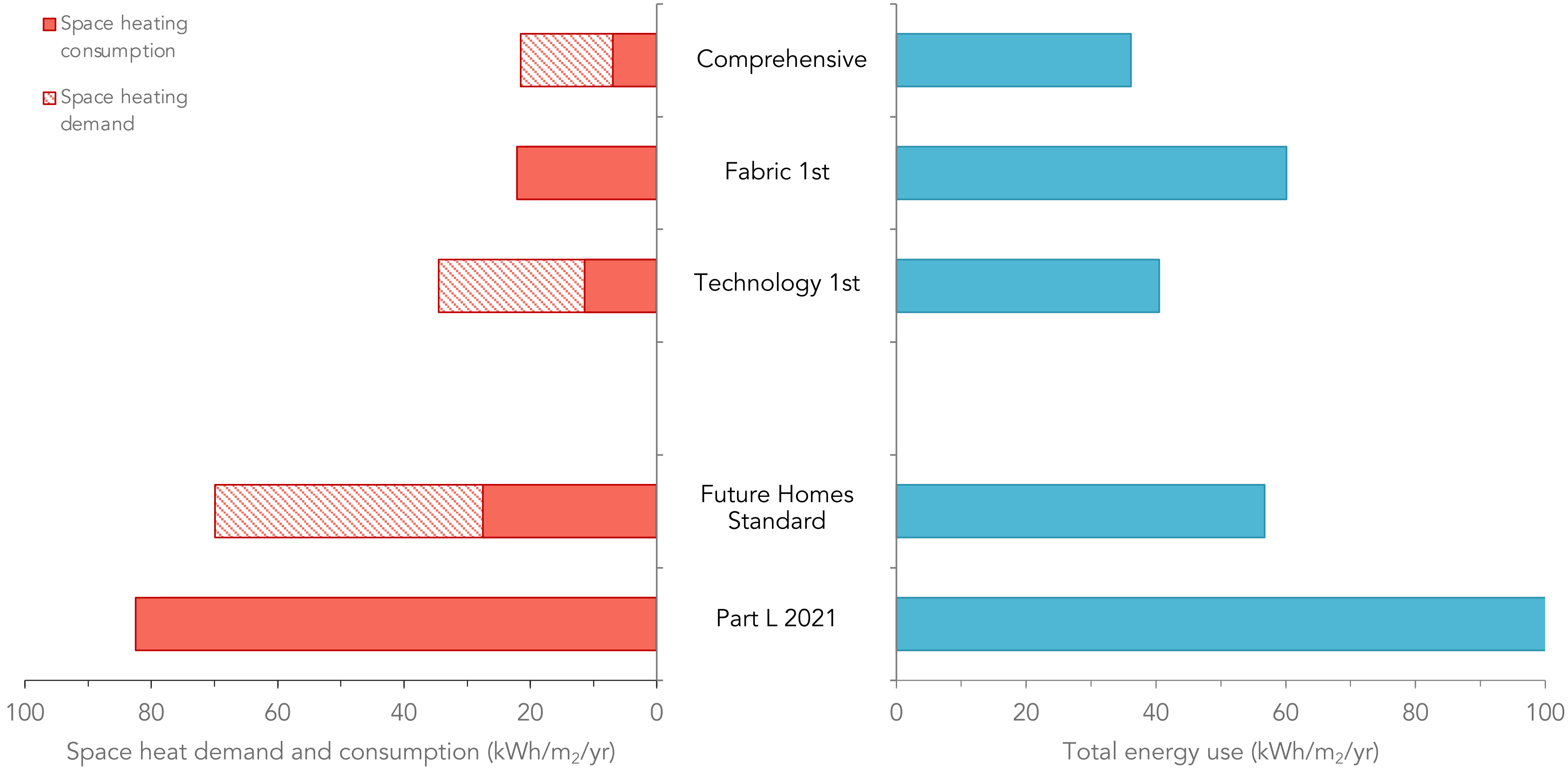


Cost uplifts	Technology First	Fabric First	Comprehensive
Fabric	£6,222	£7,131	£7,131
System (heating & hot water)	£3,599	-£2,128	£2,193
PV	-£648	£432	-£864

Notes: *The % increase is relative to Part L 2021*
Negative cost for PV reflects a reduction in the need for PVs in other scenarios in comparison to PVs required for Part L 2021.

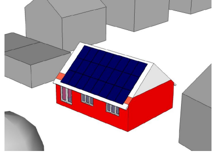


| Understanding the relationship between Space heating demand and EUI



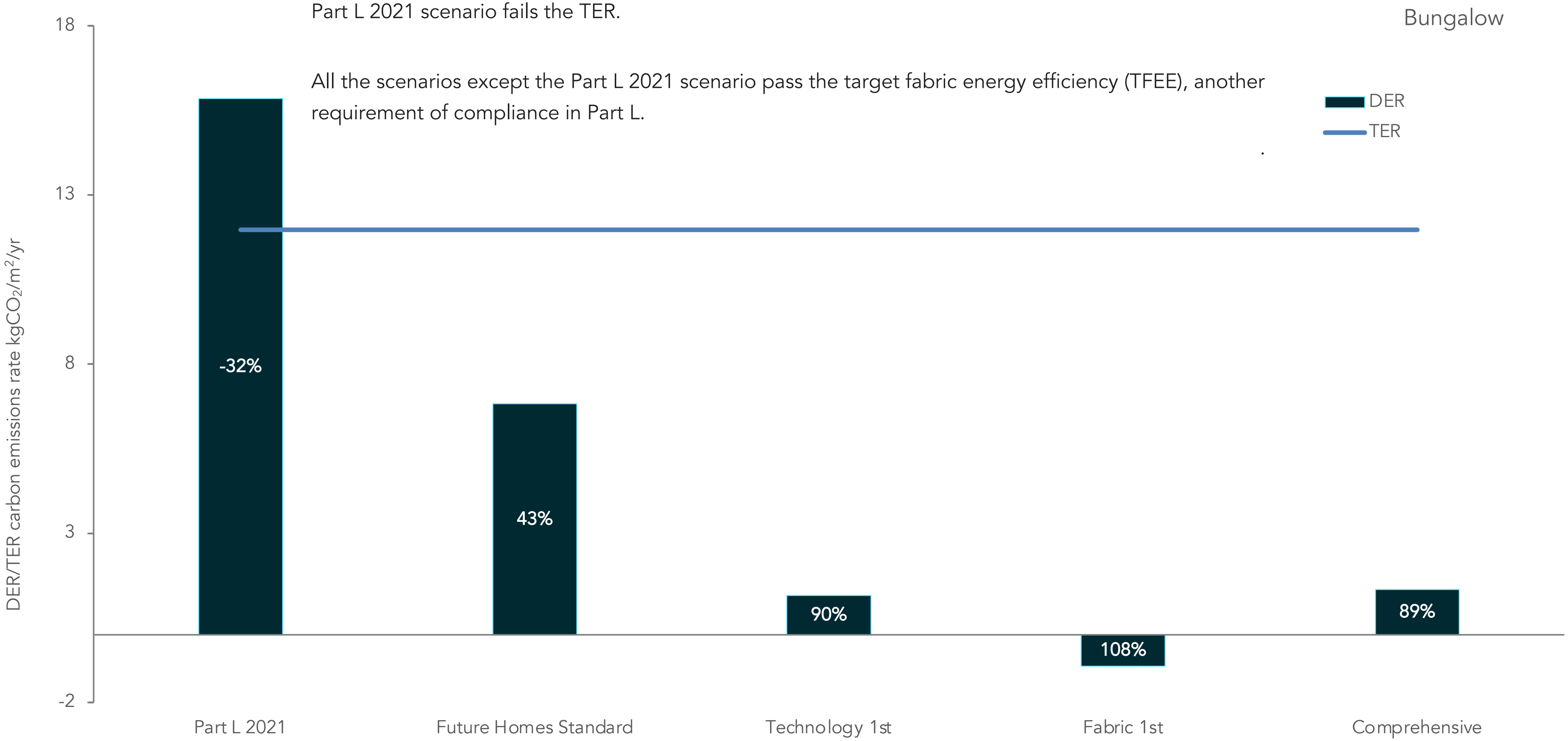
Space heating demand represents the final energy needed to maintain a comfortable temperature in the dwelling whereas consumption includes the heating system's efficiency and losses.

Bungalow | Part L performance measured through SAP10



The DER for most of the scenarios is considerably better than the TER, with Fabric 1st indicating a net carbon improvement (although SAP is not considered an accurate model of actual performance). The Part L 2021 scenario fails the TER.

All the scenarios except the Part L 2021 scenario pass the target fabric energy efficiency (TFEE), another requirement of compliance in Part L.



6.5

Detailed results for the detached house

This section presents the results from the detached house modeling. First the typology is presented in more detail, then the design assumptions are outlined for each of the five specifications, this is followed by the results and analysis.

Detached House | **Description**

For the detached house, a typical 4-bedroom home was selected from a Barrett Homes catalogue used on a development in Cornwall. Similar houses are included in recent Planning applications for the Isle of Wight.

Building fabric

The property has a gross internal floor area of 142m². The main entrance faces the street to the South, while the rear of the house faces to the North and features a small garden. The property is a typical developer spec detached house, with reasonable glazing proportions and layout. The form heat loss factor of 2.95 is fairly poor but is as expected for a small detached home. As a result, high levels of insulation are required to achieve the required space heating demand targets.

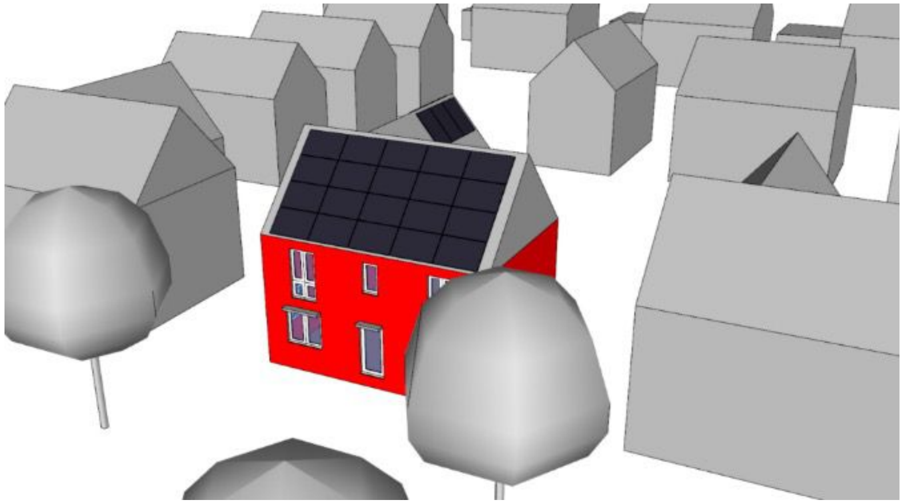
Low carbon heating

- Air source heat pump / ground source heat pump are both feasible
- Direct electric is also possible, advantages and disadvantages are discussed later
- Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency

Solar PV

- 20 solar panels on the main South facing roof, and 3 on the smaller rear roof facing East.
- If the property faced East or West, it would be possible to install more panels on the rear plane of the main roof.
- There is potential to optimise the form of the roof to fit more panels

A typical 4 bedroom detached house was selected from a Barret Homes planning application.



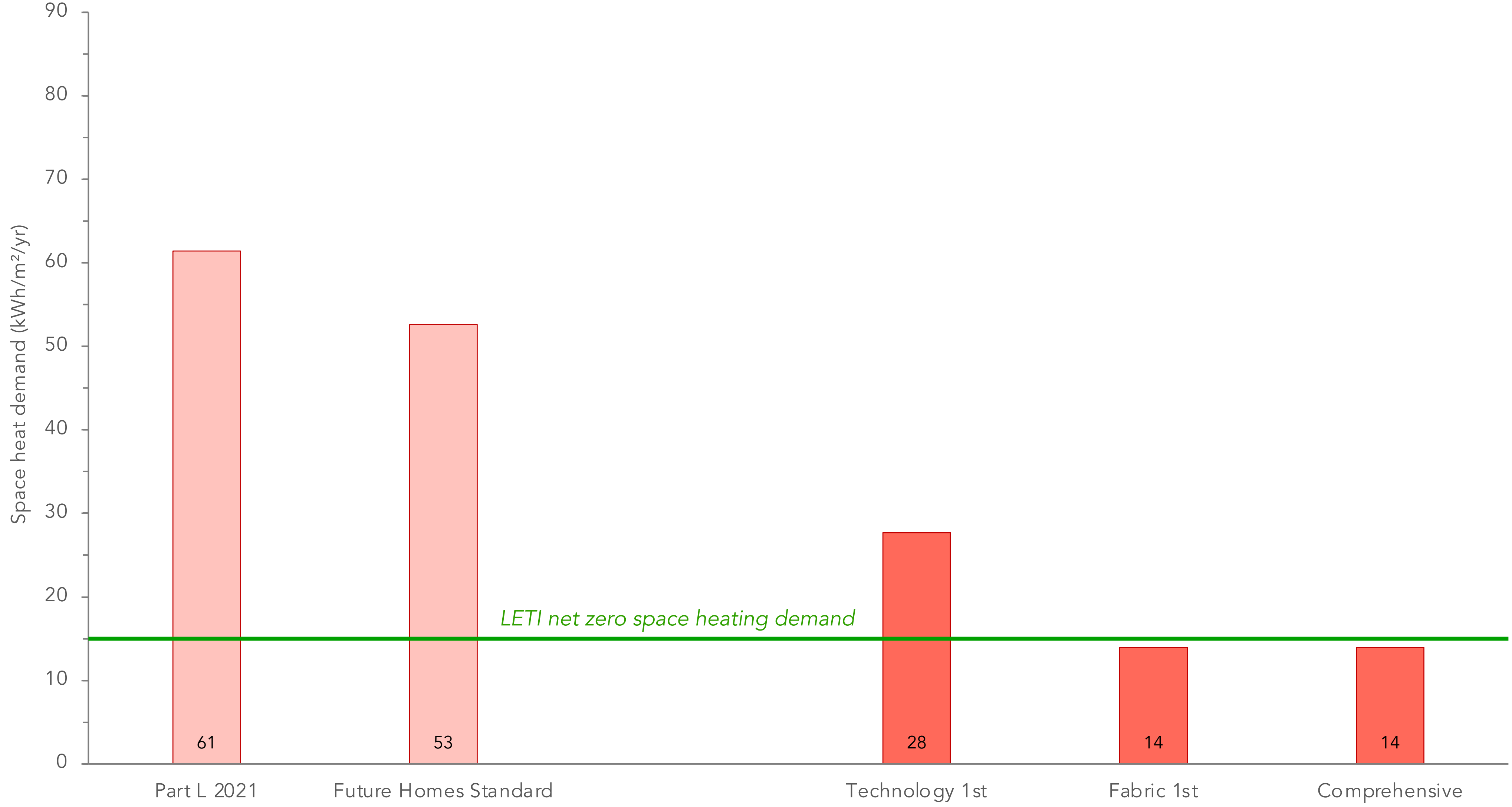
A 3D model of the house and surrounding features was created in DesignPH and used to calculate solar gains and shading for PHPP

Detached house - Scenarios

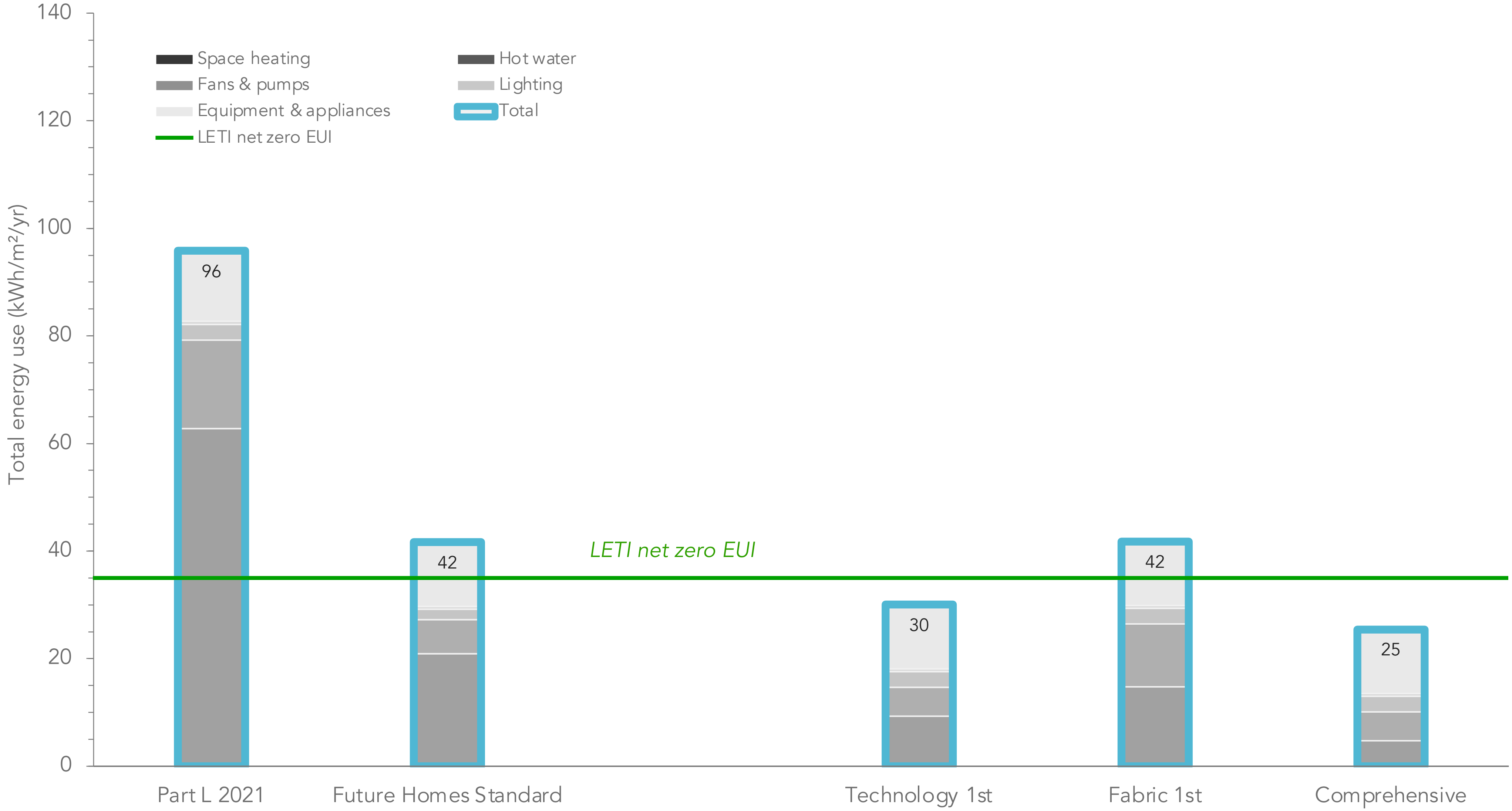
		Building regulations	Future Homes Standard	Technology First	Fabric First	Comprehensive
Building fabric	Floor / Walls / Roof (W/m^2K)	0.130 / 0.180 / 0.110 Building regs fabric 2021	0.110 / 0.150 / 0.110 Building regs fabric 2025	0.090 / 0.130 / 0.090 Very-low energy fabric	0.090 / 0.090 / 0.090 Ultra-low energy fabric	0.090 / 0.090 / 0.090 Ultra-low energy fabric
	Windows / Doors (W/m^2K)	1.2 / 1.0 - 1.3 Double glazing	0.8 / 1.0 - 1.3 Triple glazing	0.8 / 0.9-10 Triple glazing	0.8 / 0.9-10 Triple glazing	0.8 / 0.9-10 Triple glazing
	Airtightness (ACH*)	5.0 Airtightness	5.0 Airtightness	3.0 Airtightness 3	0.6 Passivhaus certified Airtightness < 0.6	0.6 Passivhaus certified Airtightness < 0.6
	Ventilation heat recovery efficiency (%)	0% Extract fan only	0% Extract fan only	88% High efficiency MVHR	90% V high efficiency MVHR	90% V high efficiency MVHR
Heating and Hot water	Heating system T supply (˚C)	60 Gas boiler	55 Heat Pump	45 Heat Pump	60 Direct Electric	45 Heat Pump
	DHW storage (litres) / WWHR** efficiency (%)	120 / 0 % Some DHW storage	180 / 0 % DHW storage	180 / 36 % DHW storage	120 / 36 % DHW storage	180 / 36 % DHW storage
Renewable energy	Solar panels (number)	12 PV panels	- No PV	10 PV panels	14 PV panels	9 PV panels

*Air changes per hour indicates the air volume added to or removed in one hour, divided by the volume of the space. Air permeability values in $m^3/h/m^2$ will be slightly different and will vary depending on the volume to surface area ratio of the building.
**Waste-water heat recovery device to showers.

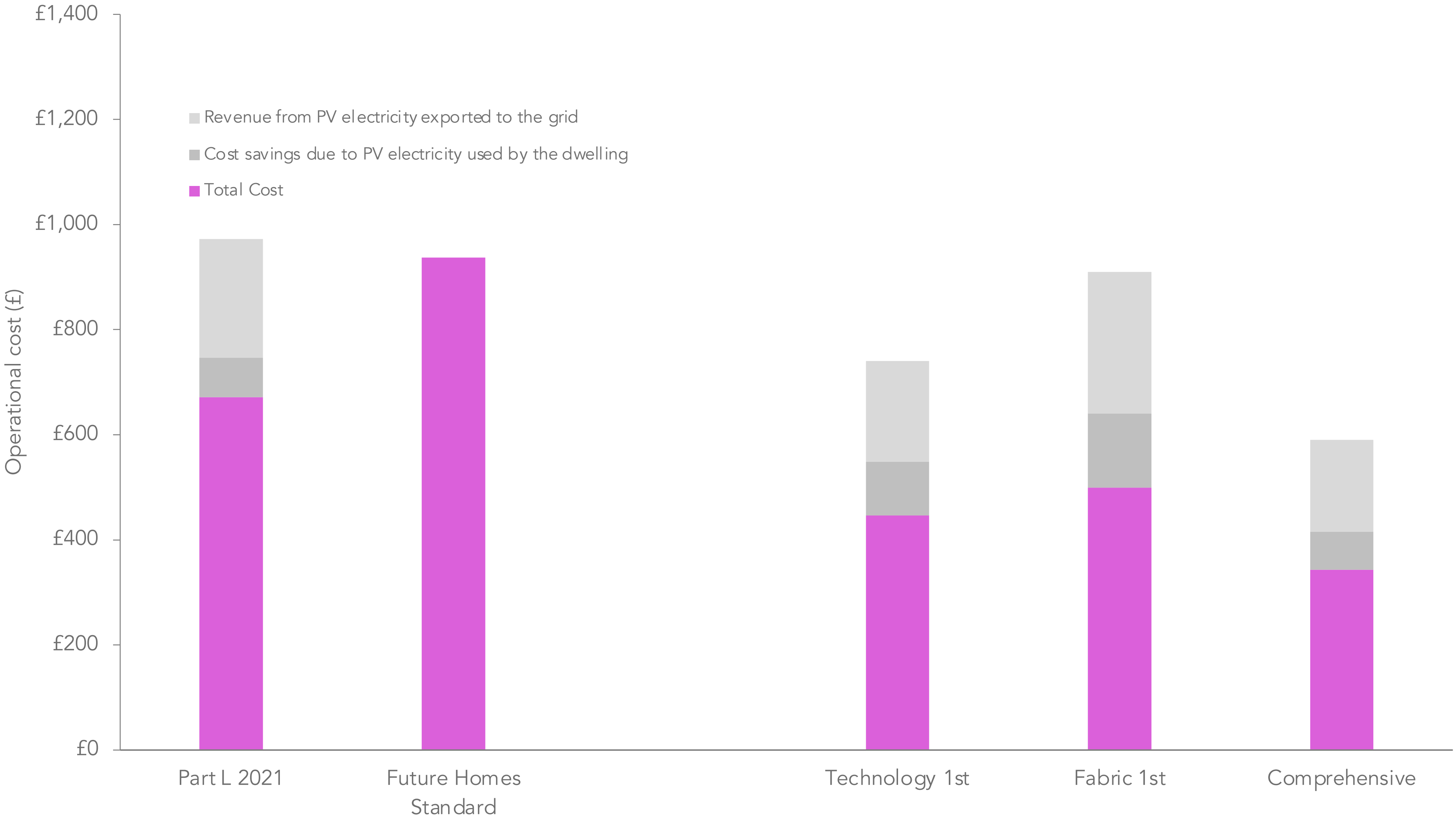
Detached House | **Space heating demand**



Detached House | **EUI (kWh/m²/yr)**



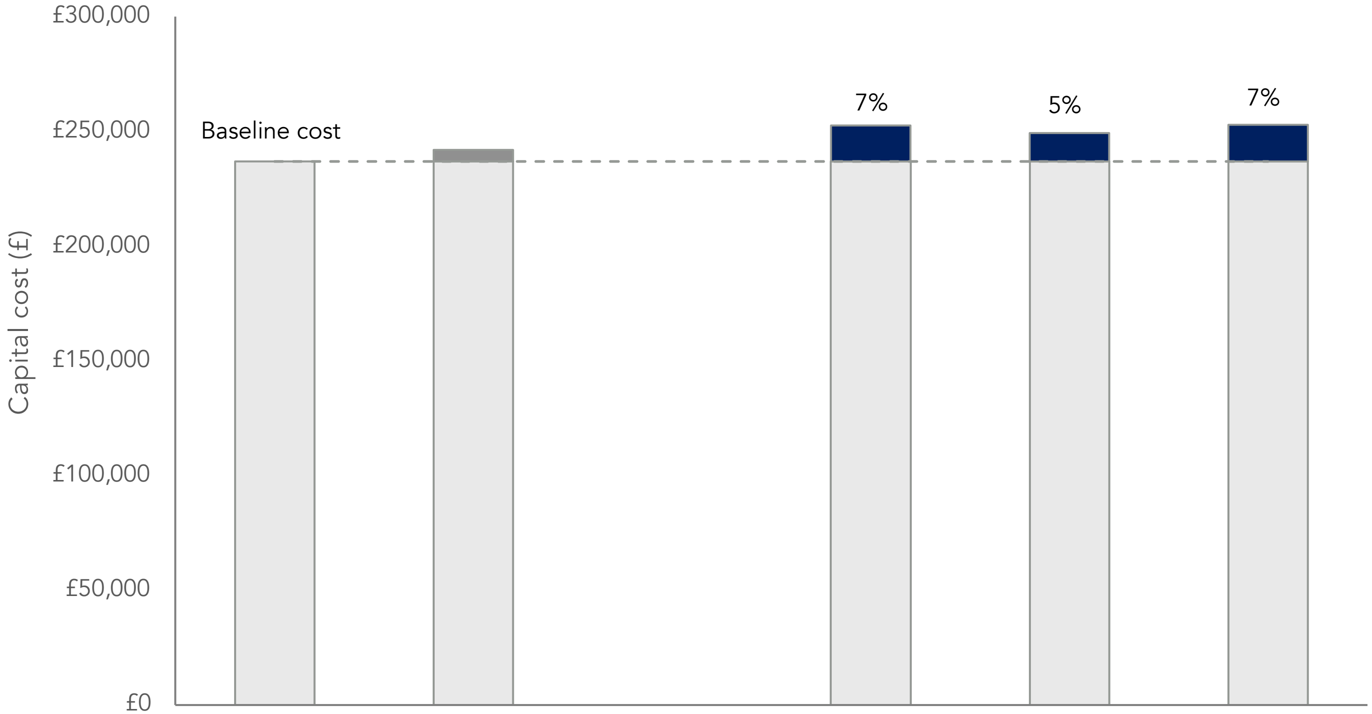

Carbon avoided from PV
Gas carbon emissions
Electricity carbon emissions
Average annual net emissions (kg CO_2/year/m²)
25
20
15
10
5
0
-5
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive


£1,400
£1,200
£1,000
£800
£600
£400
£200
£0
Operational cost (£)
Revenue from PV electricity exported to the grid
Cost savings due to PV electricity used by the dwelling
Total Cost
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive

Detached House | **Capital costs**

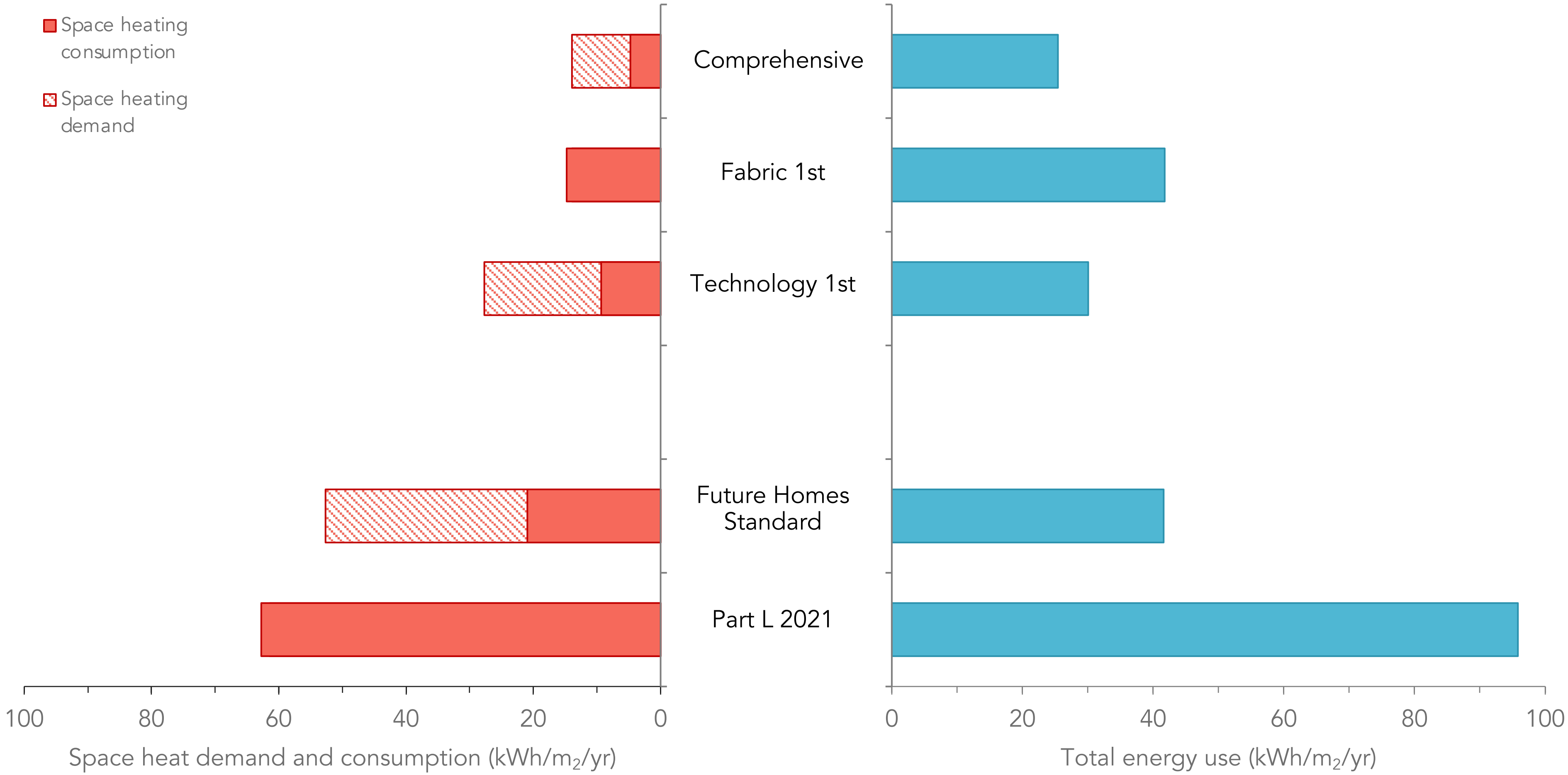
Key observations

- Only a small cost uplift arises from the adoption of Future Homes Standard specifications, this is due to the savings from removal of the PV array assumed for the 2021 specification which is only slightly less expensive than the fabric and ASHP systems used in the FHS specification
- The fabric first specification includes a significant cost uplift on the fabric elements which is offset by significant savings in the building services as a result of using a dry direct electric system
- The building form factor means that the costs of fabric for the Technology First option are similar to those associated with the Fabric First / Comprehensive options. As a result the fabric cost differential is smaller than in the semi-detached, terraced house and flat types.
- The comprehensive specification is equivalent in cost to the Technology First option as the increased level of fabric efficiency means that savings in heating distribution / emitter costs and PV offset the additional cost of the improved fabric.



Cost uplifts	Technology First	Fabric First	Comprehensive
Fabric	£8,652	£11,813	£11,813
System (heating & hot water)	£7,349	£23	£4,700
PV	-£324	£540	-£540

Notes: *The % increase is relative to Part L 2021*
Negative cost for PV reflects a reduction in the need for PVs in other scenarios in comparison to PVs required for Part L 2021.

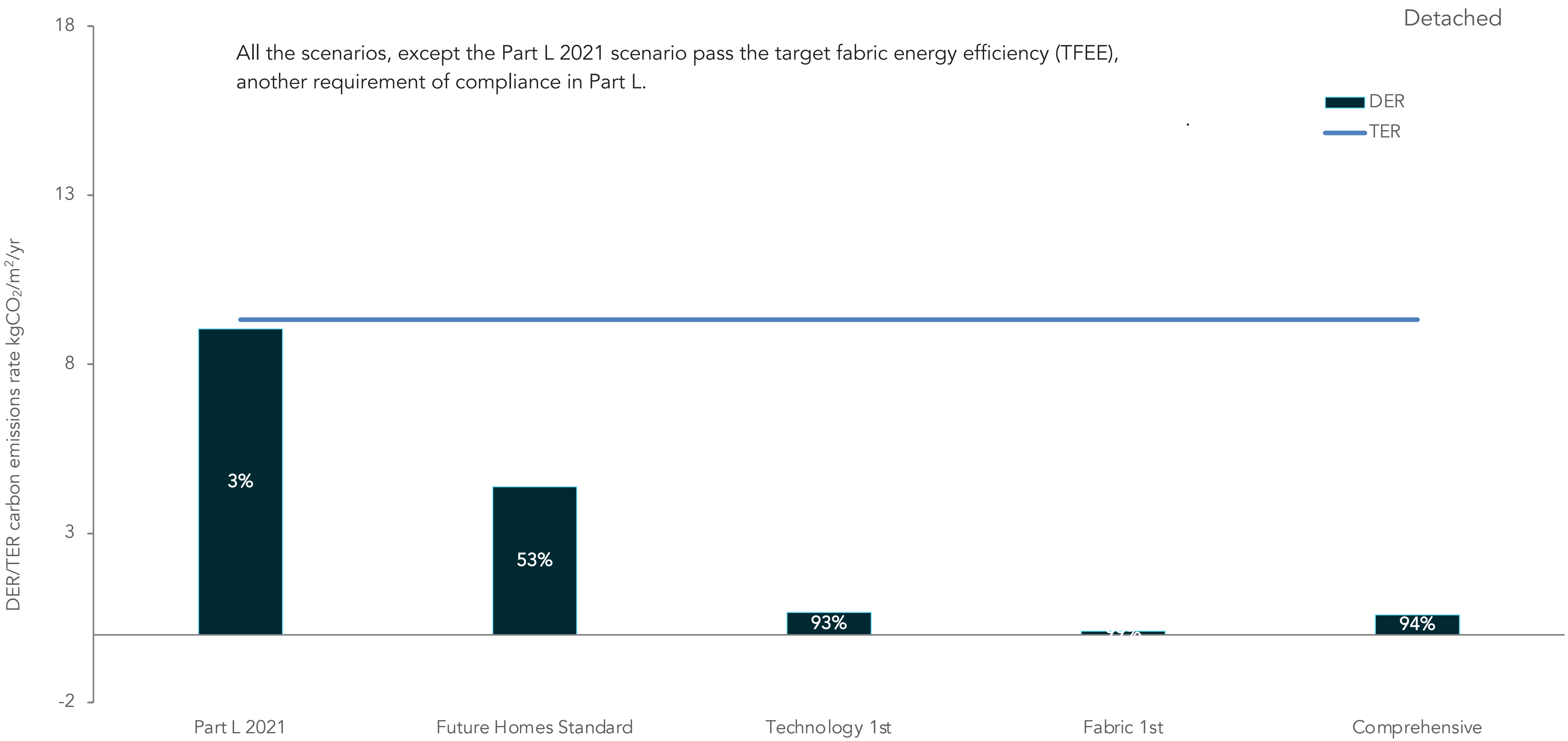


Space heating demand represents the final energy needed to maintain a comfortable temperature in the dwelling whereas consumption includes the heating system's efficiency and losses.

Detached House | **Part L performance measured through SAP10**

The DER for most of the scenarios is considerably better than the TER. The Part L 2021 scenario marginally passes the TER.

All the scenarios, except the Part L 2021 scenario pass the target fabric energy efficiency (TFEE), another requirement of compliance in Part L.



6.6

Detailed results for the medium rise block of flats

This section presents the results from the medium rise apartment block modeling. First the typology is presented in more detail, then the design assumptions are outlined for each of the five specifications, this is followed by the results and analysis.

Medium rise block | **Description**

For the detached house, a typical 4-bedroom home was selected from a Barrett Homes catalogue used on a development in Cornwall. Similar houses are included in recent Planning applications for the Isle of Wight.

Building fabric

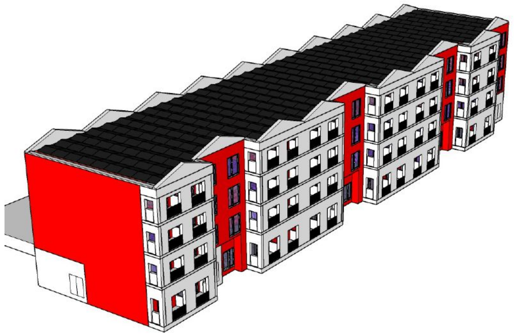
The property has a gross internal floor area of 2362m². The main entrances faces the street to the East Northeast. The property has typical glazing proportions and layout for this type of housing development. The form heat loss factor of 2.04 is low, as expected for a large block of flats with a straightforward design.

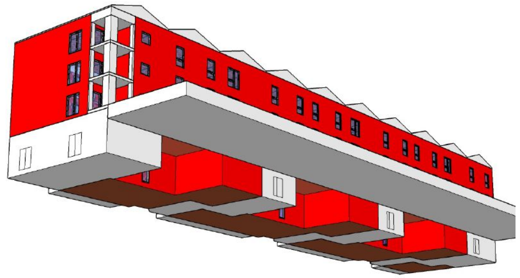
Low carbon heating

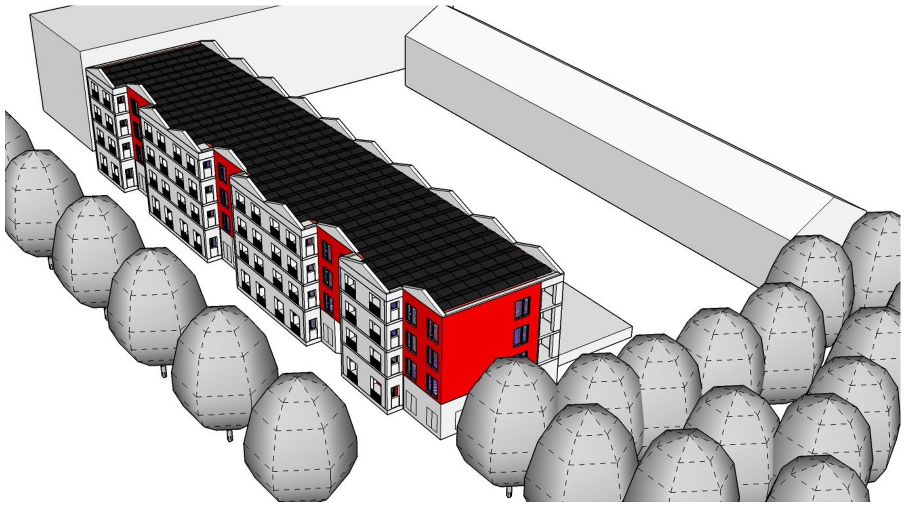
- Air source heat pump / ground source heat pump are both feasible
- Small individual heat pump in each flat would be supplied with water at ambient temperatures via a communal loop to reduce distribution losses
- Direct electric is also possible, advantages and disadvantages are discussed later
- Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency

Solar PV

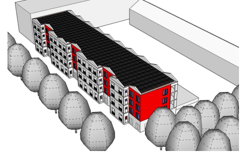
- 400 solar panels are possible in an East/West concertina arrangement.
- This in an example of a highly optimised roof for PV. Less well optimised roofs achieve less than half the number of panels. This should be carefully considered by designers.







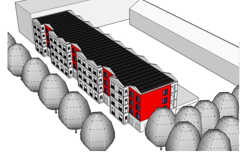
A 3D model of the house and surrounding features was created in DesignPH and used to calculate solar gains and shading for PHPP

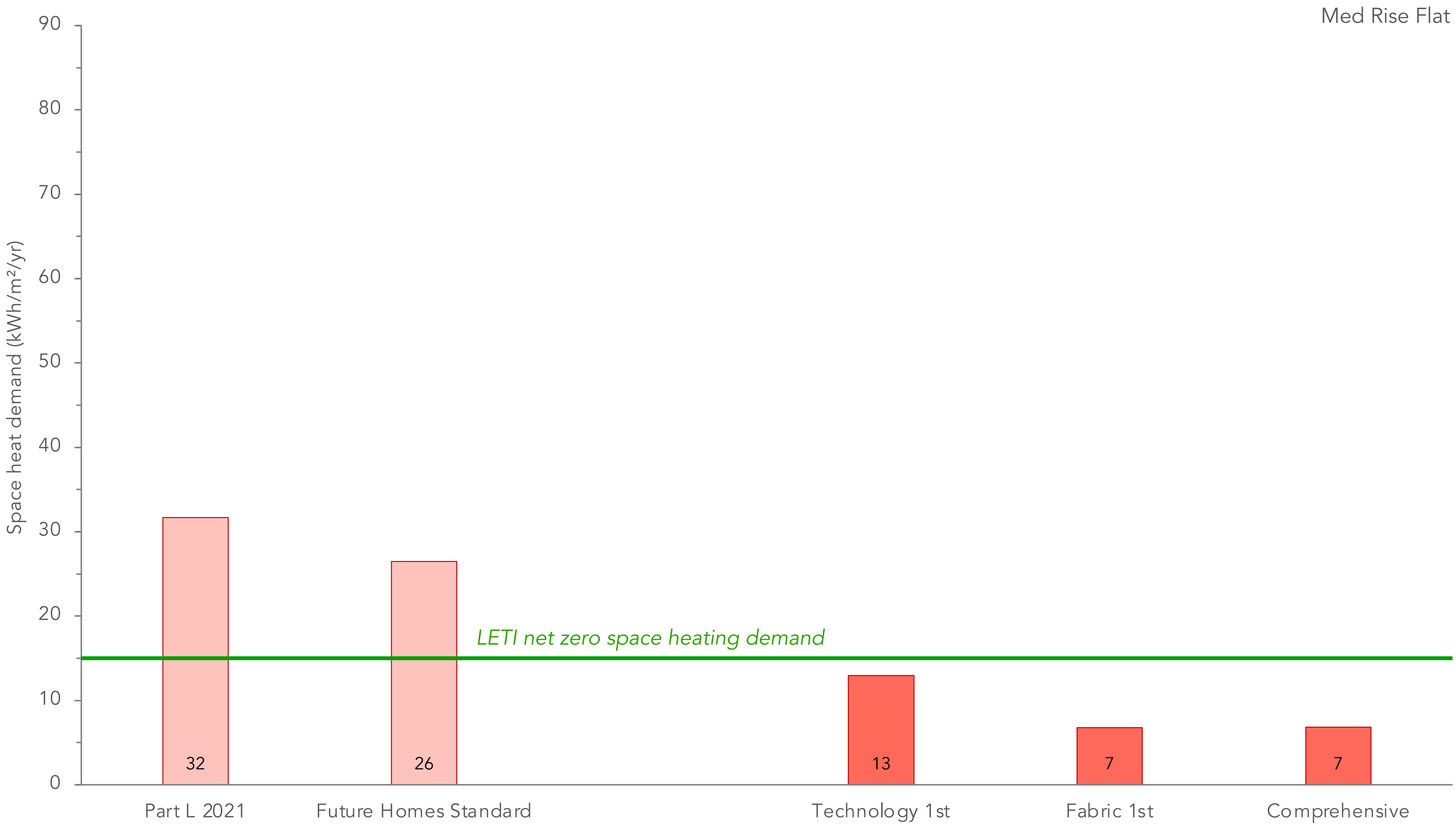


Low rise blocks of flats - Scenarios

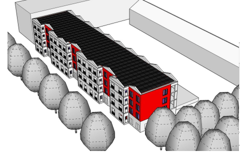
		Building regulations	Future Homes Standard	Technology First	Fabric First	Comprehensive
Building fabric	Floor / Walls / Roof (W/m²K)	0.150 / 0.210 / 0.130 Building regs fabric 2021	0.150 / 0.180 / 0.110 Building regs fabric 2025	0.135 / 0.150 / 0.110 Very-low energy fabric	0.135 / 0.150 / 0.110 Ultra-low energy fabric	0.135 / 0.150 / 0.110 Ultra-low energy fabric
Building fabric	Windows / Doors (W/m²K)	1.2 / 1.0 - 1.3 Double glazing	0.8 / 1.0 - 1.3 Triple glazing	0.8 / 0.9-10 Double glazing	0.8 / 0.9-10 Triple glazing	0.8 / 0.9-10 Triple glazing
Building fabric	Airtightness (ACH*)	5.0 Airtightness	5.0 Airtightness	3.0 Airtightness 3	0.6 Passivhaus certified Airtightness < 0.6	0.6 Passivhaus certified Airtightness < 0.6
Building fabric	Ventilation heat recovery efficiency (%)	0% Extract fan only	0% Extract fan only	88% High efficiency MVHR	88% High efficiency MVHR	88% High efficiency MVHR
Heating and Hot water	Heating system T supply (˚C)	60 Gas boiler	55 Heat Pump	45 Heat Pump	60 Direct Electric	45 Heat Pump
Heating and Hot water	DHW storage (litres) / WWHR** efficiency (%)	80 / 0 % Some DHW storage	150 / 0 % DHW storage	150 / 36 % DHW storage	80 / 36 % DHW storage	150 / 36 % DHW storage
Renewable energy	Solar panels (number)	42 PV panels	- No PV	290 PV panels	400 PV panels	270 PV panels

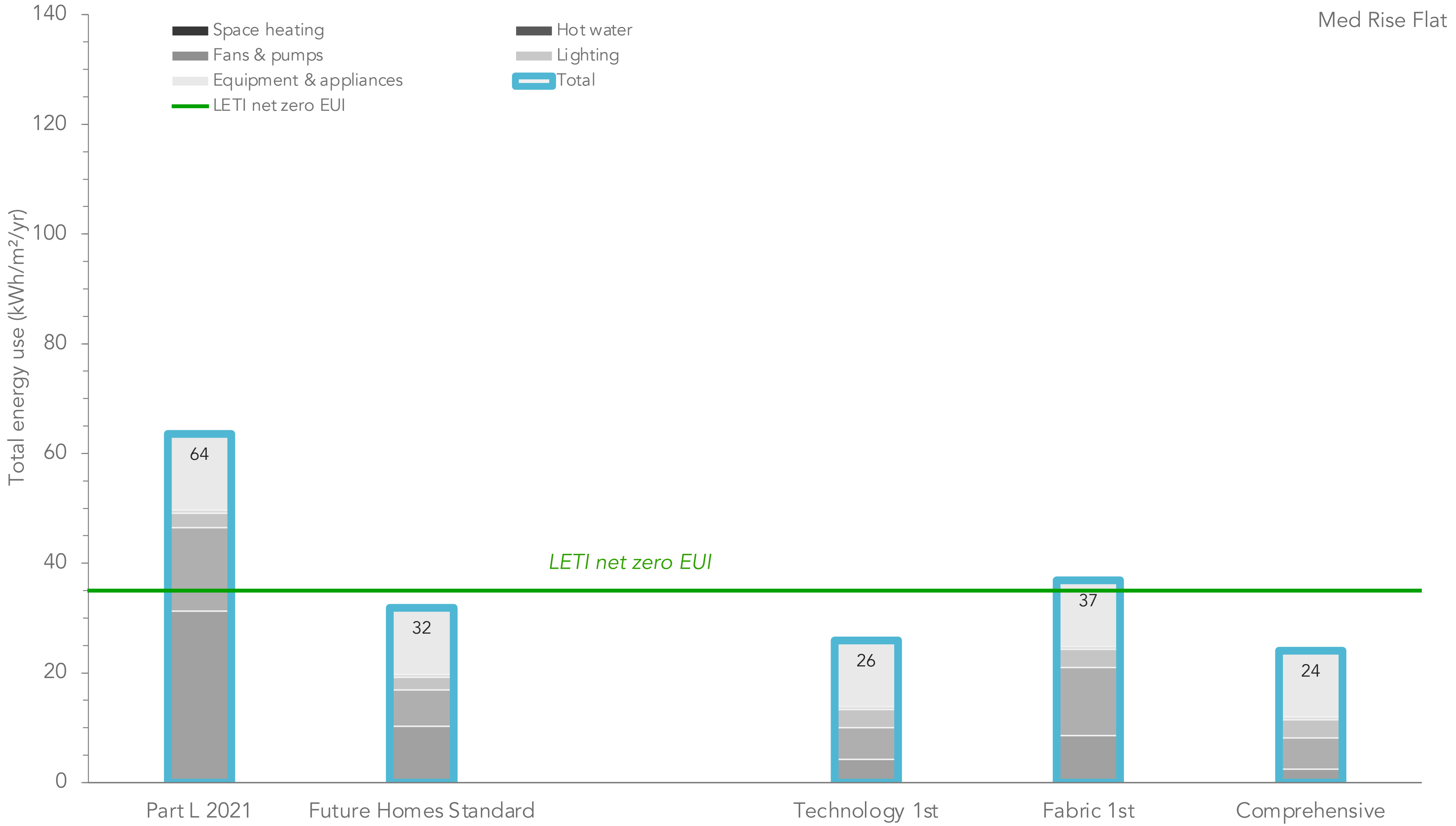
*Air changes per hour indicates the air volume added to or removed in one hour, divided by the volume of the space. Air permeability values in m³/h/m² will be slightly different and will vary depending on the volume to surface area ratio of the building.
**Waste-water heat recovery device to showers.



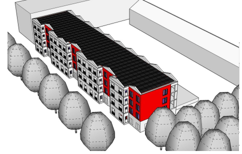

Med Rise Flat
Space heat demand (kWh/m²/yr)
0
10
20
30
40
50
60
70
80
90
LETI net zero space heating demand
32
26
13
7
7
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive

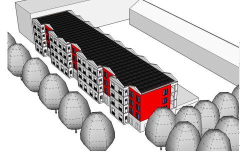
Medium rise block | **EUI (kWh/m²/yr)**

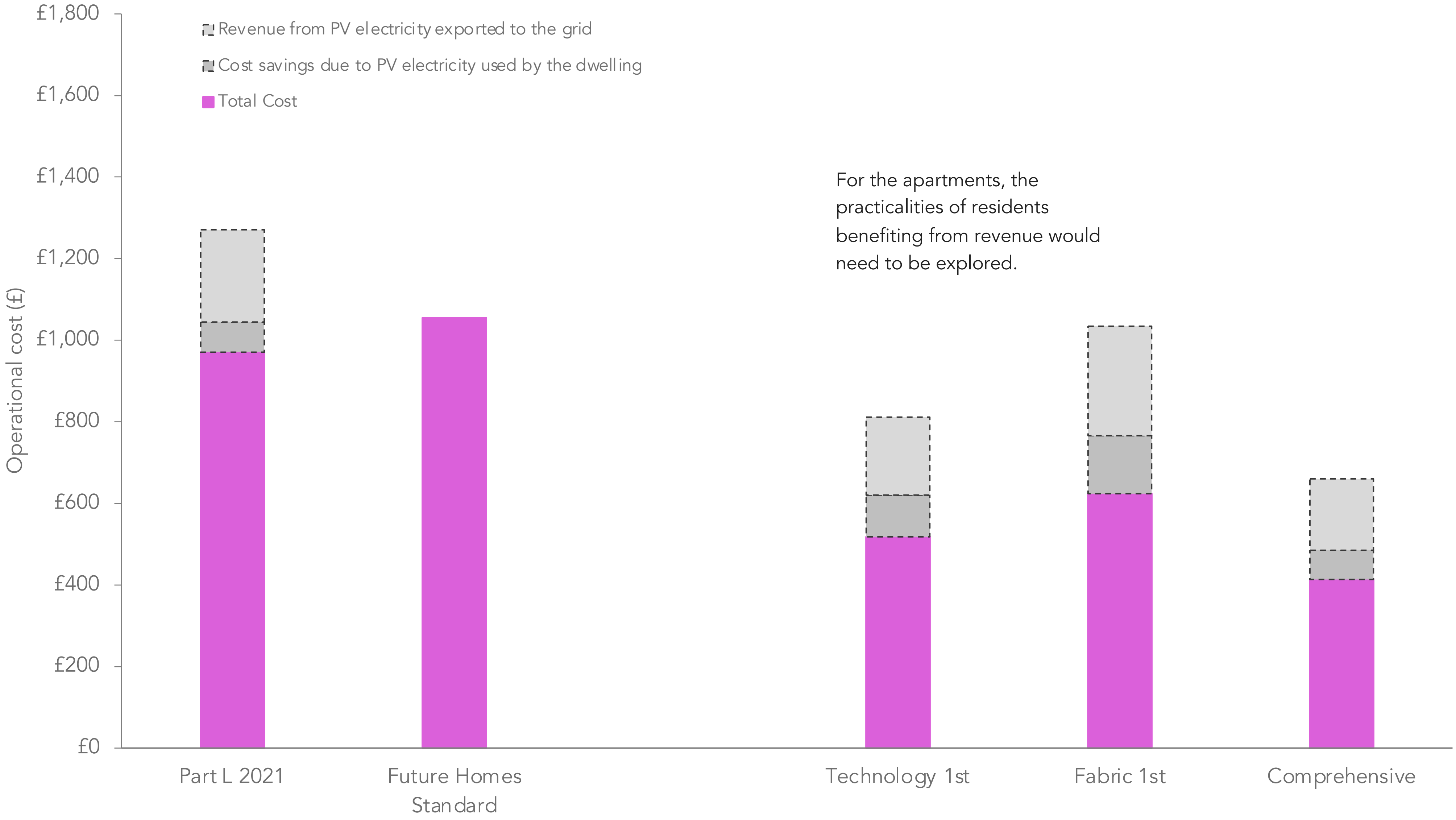




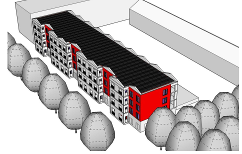
Medium rise block | **PV generation and Net Zero balance**





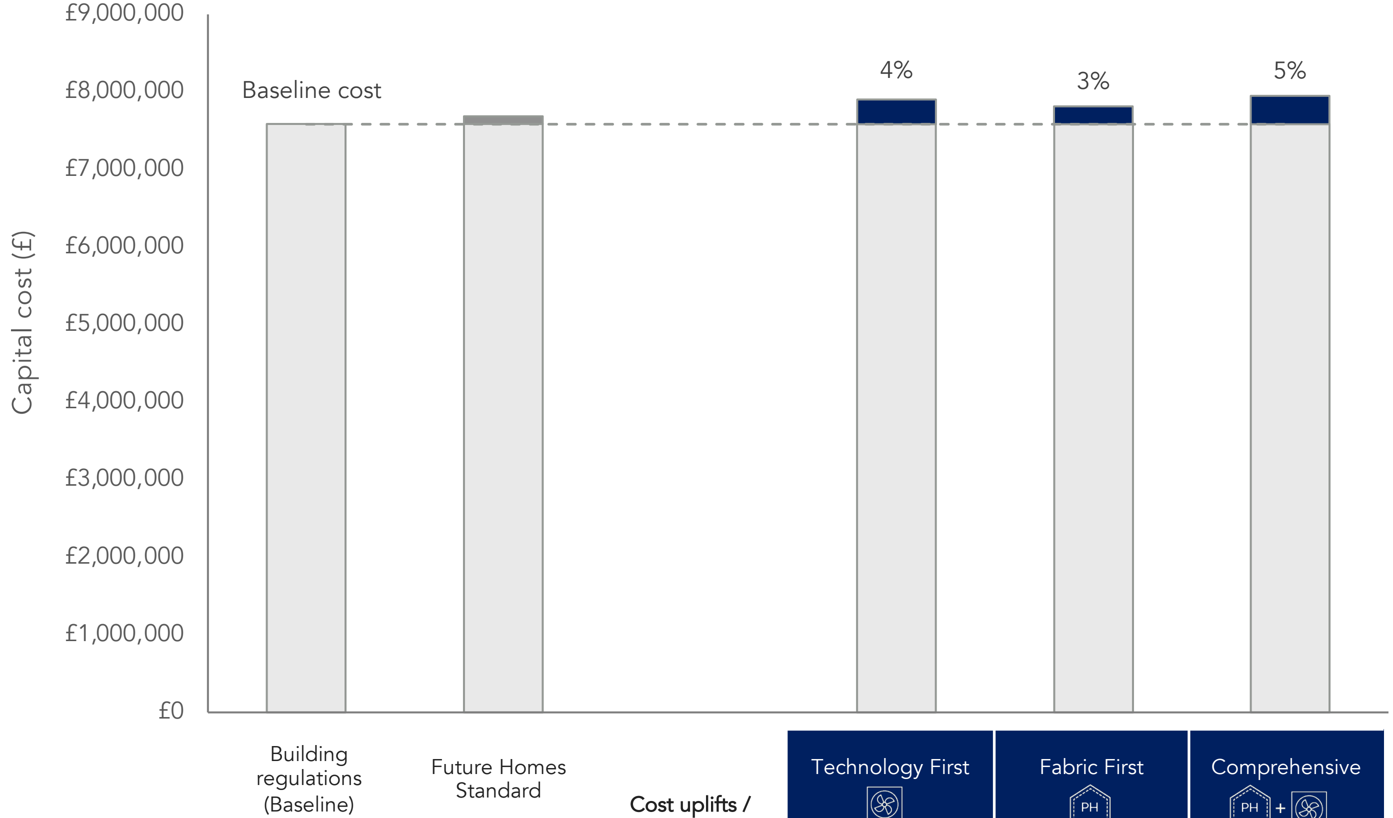

£1,800
£1,600
£1,400
£1,200
£1,000
£800
£600
£400
£200
£0
Operational cost (£)
Revenue from PV electricity exported to the grid
Cost savings due to PV electricity used by the dwelling
Total Cost
For the apartments, the practicalities of residents benefiting from revenue would need to be explored.
Part L 2021
Future Homes Standard
Technology 1st
Fabric 1st
Comprehensive

Medium rise block | **Capital costs**



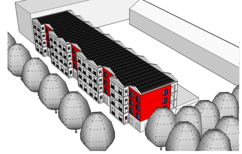
Key observations

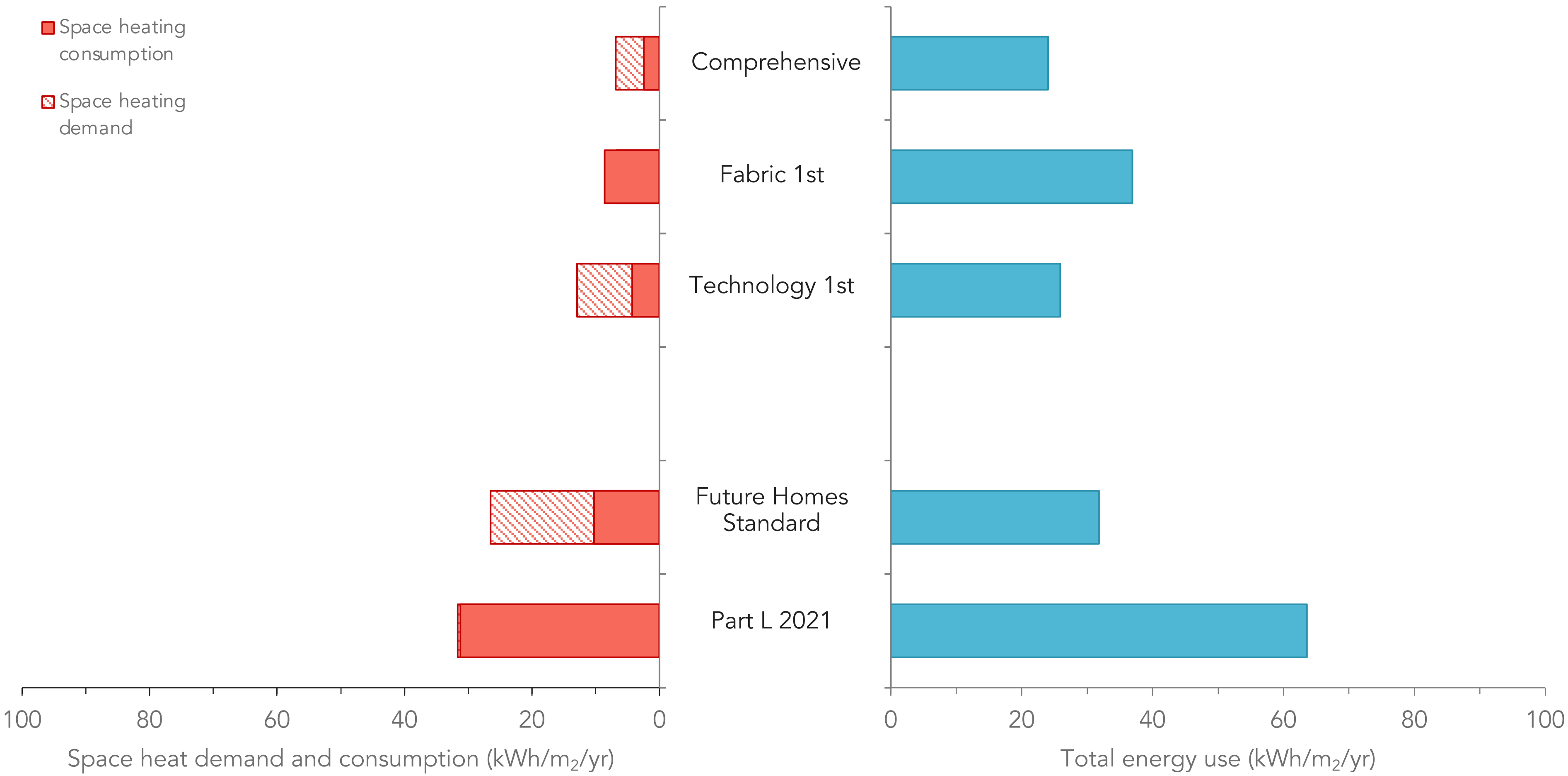
- Only a small cost uplift arises from the adoption of Future Homes Standard specifications, this is due to the savings from removal of the PV array assumed for the 2021 specification which is only slightly less expensive than the fabric and ASHP systems used in the FHS specification
- The fabric first specification includes a significant cost uplift on the fabric elements which is offset by savings in the building services as a result of using a dry direct electric system
- The comprehensive specification is the most expensive option but the total cost is less than might be expected because the combination of fabric efficiency and system efficiency means that the size of the PV array is smaller than would needed for the Fabric First option.



Cost uplifts / per unit	Technology First	Fabric First	Comprehensive
Fabric	£3,119	£5,148	£5,148
System (heating & hot water)	£3,510	-£1,322	£2,769
PV	£1,339	£1,933	£1,231

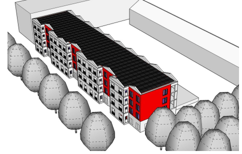
Notes: *The % increase is relative to Part L 2021*
Negative cost for PV reflects a reduction in the need for PVs in other scenarios in comparison to PVs required for Part L 2021.





Space heating demand represents the final energy needed to maintain a comfortable temperature in the dwelling whereas consumption includes the heating system's efficiency and losses.

Medium rise block | **Part L performance measured through SAP10**



The DER for most of the scenarios is considerably better than the TER, with Fabric 1st indicating a net carbon improvement (although SAP is not considered an accurate model of actual performance). The Part L 2021 scenario fails the TER.

All the scenarios pass the target fabric energy efficiency (TFEE), another requirement of compliance in Part L.