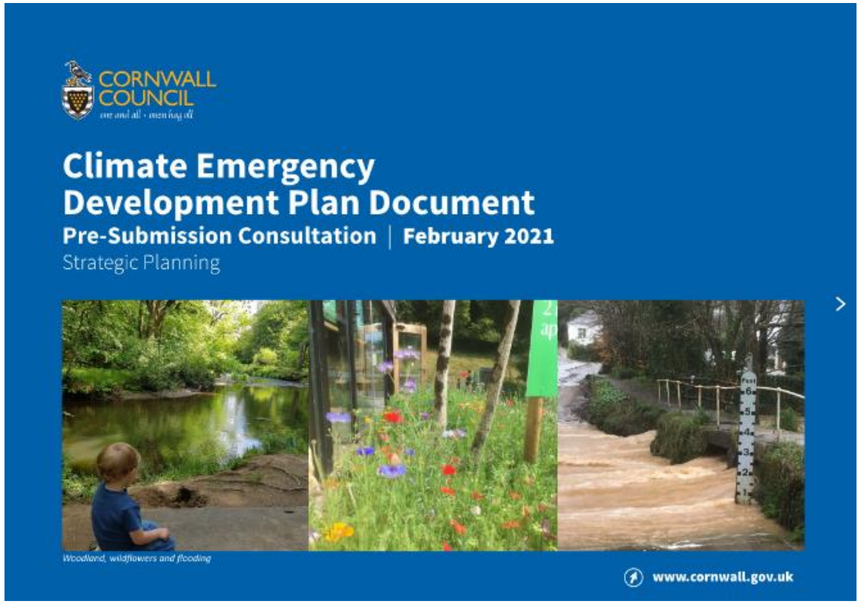
CORNWALL COUNCIL CLIMATE EMERGENCY DPD



TECHNICAL EVIDENCE BASE FOR POLICY SEC 1 - NEW HOUSING

July 2021 I Rev G

Currie & Brown

Etude

Executive Summary

An evidence base for net zero operational carbon buildings

The purpose of these reports* are to provide a technical evidence base in support of Policy SEC 1 of the Climate Emergency Development Plan Document (DPD). The current policy requires new homes to achieve a space heating demand of less than 30kWh/m²/year, a total energy use of less than 40kWh/m²/year, and a net zero energy balance on site through use of solar photovoltaics.

Evaluation of policy options

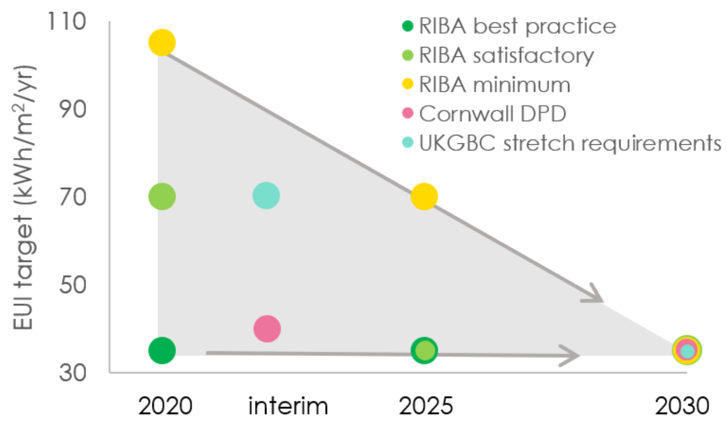
Seven policy scenarios were assessed for six types of building through detailed energy and cost modelling. Policy options included buildings compliant with Part L 2013, Part L 2021 and Part L 2025, UKGBC's net zero definition, the current DPD policy and a future policy option that is in line with RIBA and UKGBC targets for 2030.

Key findings

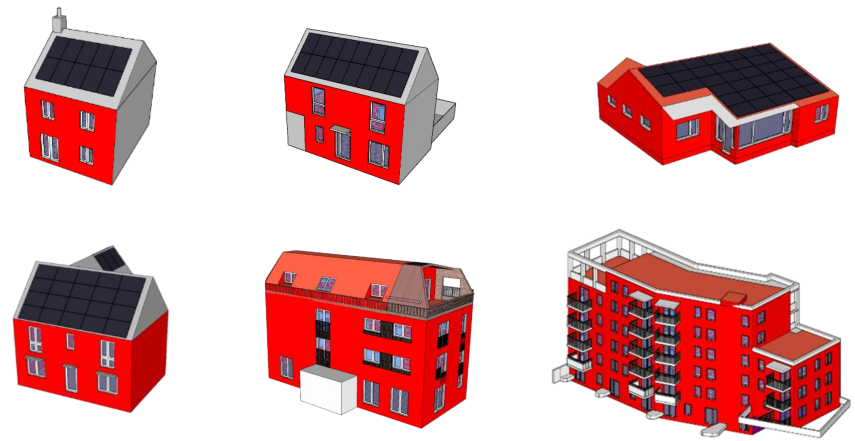
Energy and cost modelling indicates that:

- It is technically feasible for the policies proposed in the current DPD to deliver net zero carbon homes for all building types modelled.
- The current DPD policy would lead to running costs approximately 10-50% lower than a building built to comply with Part L 2021.
- The current DPD policy would deliver net zero carbon homes for a construction cost just 0.5-2.7% more than a home that is compliant with Part L 2021. Cost differences are expected to decrease over time as experience and markets for low carbon buildings grow.
- Actual space heat demand is likely to be 210-560% higher than indicated by SAP calculations.
- Electricity use calculated by energy modelling relates well to metered electricity use data, supporting the use of total energy use targets.

Technical appendices are provided in an accompanying report.



Total energy use targets from RIBA, UKGBC and Cornwall Council's DPD are converging at different rates. Evidence supports early adoption of targets to avoid costly retrofit and remain within carbon budgets.



The technical feasibility and cost impact of Policy SEC 1 of the Climate Emergency Development Plan Document (DPD) has been tested on 6 different housing typologies.

The Climate Emergency DPD

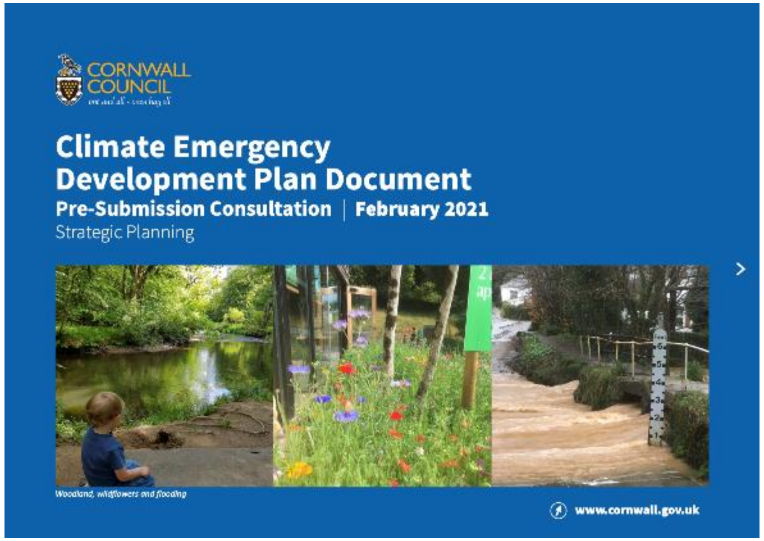
The Cornwall Climate Emergency DPD is part of Cornwall Council's response to the climate emergency and the need for renewal post Covid.

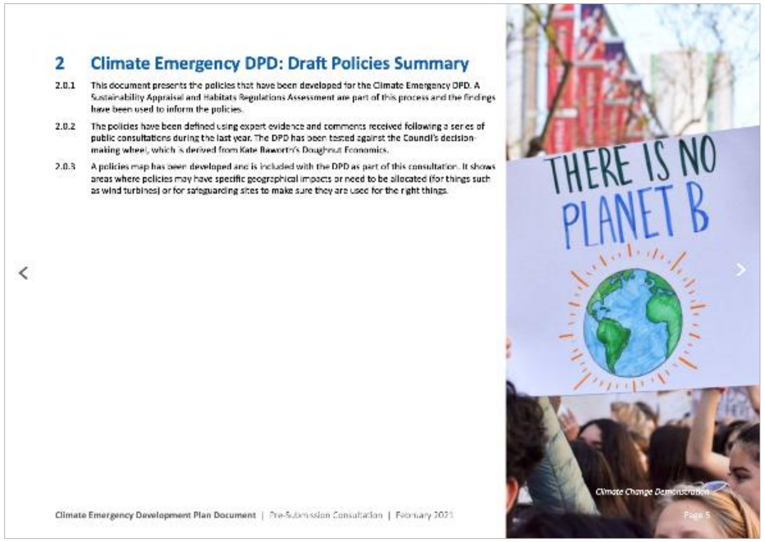
It is a key part of Cornwall's Climate Change Action Plan, which sets out a programme of actions required to respond to the Climate Emergency and to create a carbon neutral Cornwall in 2030, a full 20 years before the UK commitment.

It covers a wide range of areas and issues including:

- Natural climate solutions (Policies G1-4)
- Rural development and diversification (Policies AG1 and AL1)
- Town centres, design and density (Policies TC1-5)
- Sustainable transport (Policies T1-3)
- Renewable energy and sustainable construction (Policies RE1-6)
- Sustainable energy and construction (Policy SEC1)
- Coastal change and flooding (Policies CC1-4)

This evidence base has been prepared in support of **Policy SEC1 Sustainable Energy and Construction**.





Cornwall Council's Climate Emergency DPD (Consultation version – February 2021)

Policy SEC1 Sustainable Energy and Construction

This evidence base focuses on Policy SEC1 Sustainable Energy and Construction and in particular on the requirements under (b) for new residential developments:

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

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

The **technical assessment** (**Section 2.0**) demonstrates that it is technically feasible for a variety of building types to:

- Achieve a space heating demand of less than 30kWh/m²/annum
- Achieve a total energy use of less than 40kWh/m²/annum
- Install on-site renewable generation (in the form of roof mounted solar PV) to match the total energy use

The **cost assessment** (**Section 3.0**) provides an assessment for a variety of building types of the additional construction costs which would be involved in meeting the above requirements. It also outlines the benefits in terms of running energy costs which would be delivered by complying with Policy SEC1.

Policy SEC1 – Sustainable Energy and Construction

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

1. The Energy Hierarchy

All proposals should embed the Energy Hierarchy within the design of buildings by prioritising fabric first, orientation and landscaping in order to minimise energy demand for heating, lighting and cooling. All proposals should consider opportunities to provide solar PV and energy storage.

2a. New Development – Non-Residential

Development proposals for non-residential development should demonstrate how they achieve BREEAM 'Excellent'.

2b. New Development – Residential

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

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

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

3. Existing Buildings

Significant weight will be given to the benefits of development resulting in considerable improvements to the energy efficiency and reduction in carbon emissions in existing buildings.

Proposals that help to increase resilience to climate change and secure a sustainable future for historic buildings and other designated and non-designated heritage assets will be supported where they:

- conserve (and where appropriate enhance/better reveal) the design, character, appearance and historical significance of the building; or
- facilitate their sensitive re-use where they have fallen into a state of disrepair or dereliction (subject to such a re-use being appropriate to the specific heritage asset).

4. Domestic and Non-Residential Renewables

The Council will support domestic and non-residential renewables such as solar panels (including ground mounted) where they require planning permission. Proposals should seek to minimise visual impact wherever possible.

Where fixed to a listed building, proposals must ensure that: technology will not cause significant harm to the appearance and special historic character of the building; require minimal intervention with the fabric of the building; and shall be easily reversible.

5. Water

All dwellings (including conversions, reversions and change of use) should aim to achieve an estimated water consumption of no more than 110 litres/ person/ day through the incorporation of water saving measures where feasible.

Development proposals for 50 or more dwellings and non-residential development with a floor space of 1,000 m2 or more should incorporate water reuse and recycling and rainwater harvesting measures.

6. Materials and Waste

All development proposals should minimise use of materials and creation of waste and promote opportunities for a circular economy through:

a) Prioritising the use of previously developed land and buildings, whilst maintaining and enhancing local character and distinctiveness;
b) Reuse and recycling of appropriate materials that arise through demolition and refurbishment, including the reuse of non-contaminated excavated soil and hardcore within the site;
c) Prioritise the use of locally sourced and/or sustainable materials and construction techniques that have smaller ecological and carbon footprints;
d) Using locally distinctive, resilient, low maintenance materials that are appropriate for Cornwall's damp maritime climate, for example locally won materials such as slate and granite (particularly for areas that will be harder to maintain once the building is occupied) as described in the Cornwall Design Guide;
e) Considering the lifecycle of the development and surrounding area, including how they can be adapted to meet changing community needs and how materials can be recycled at the end of their lifetime;
f) Providing adequate space to enable and encourage greater levels of recycling across residential and non-residential developments. Space requirements for residential developments should follow those outlined in the Cornwall Design Guide.

Important research and guidance on new buildings has been published in the last 18 months.

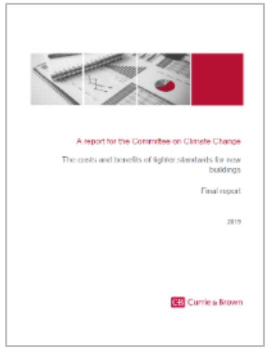
The Committee on Climate Change report 'UK housing – fit for the future?' highlights that we need to build new buildings with 'ultra-low' levels of energy use. It also makes a specific reference to space heating demand and recommends a maximum of 15-20 kWh/m^2/yr for new dwellings.

A supporting technical study undertaken by Currie & Brown and AECOM confirms that a switch to low carbon heating is essential in achieving long term carbon savings, but that this must be supported by significant improvements in energy efficiency in order to manage running costs and avoid external costs to the wider energy system (e.g. electricity infrastructure). The study indicates that significant reductions in space heating demand can be achieved at lower cost than smaller improvements, as it enables savings in the size and extent of the heating system.

There is also a growing consensus on the need for total energy use as a key metric, expressed as an Energy Use Intensity (EUI). One of the key advantages is that it can be checked once the building is occupied without further modelling or analysis.

Generally, these research or guidance documents also highlight that the potential for offsetting from new buildings is extremely limited and should be reserved for exceptional circumstances, rather than standard practice.

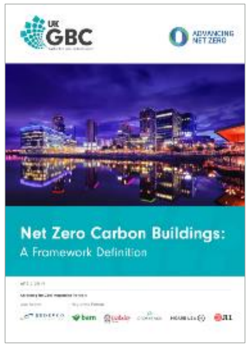
[1] *For comparison, Passivhaus requires 15 kWh/m^2/yr and Etude's experience from energy modelling of new domestic buildings suggests a heating demand ranging between 60-100 kWh/m^2/yr is typical.*

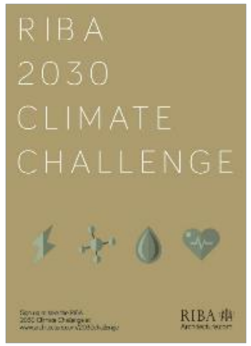


15-20
kWh/m^2/yr

The UK housing: Fit for the future? report *published by the Committee on Climate Change in February 2019 recommends ultra-low levels of energy use and a space heating demand of less than 15-20 kWh/m^2/yr*

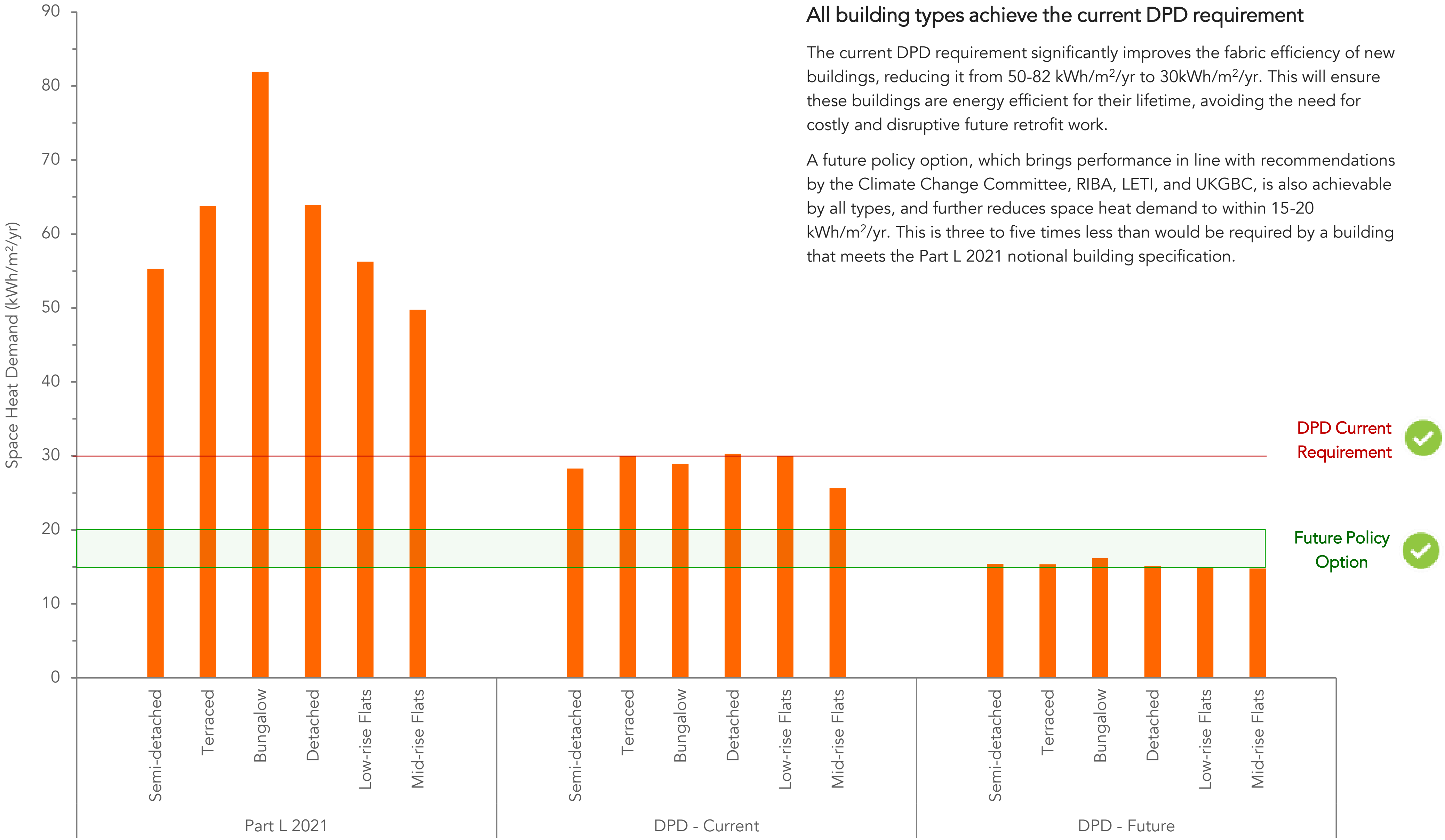
The costs and benefits of tighter standards for new buildings *report, produced by Currie & Brown and AECOM for the Committee on Climate Change's UK housing: Fit for the future? report*





Guidance on the need for net zero carbon buildings and total energy use targets has been published by the UKGBC, the RIBA and LETI

Summary I Space heating demand < 30 kWh/m²/yr I Technical feasibility



All building types achieve the current DPD requirement

The current DPD requirement significantly improves the fabric efficiency of new buildings, reducing it from 50-82 kWh/m²/yr to 30kWh/m²/yr. This will ensure these buildings are energy efficient for their lifetime, avoiding the need for costly and disruptive future retrofit work.

A future policy option, which brings performance in line with recommendations by the Climate Change Committee, RIBA, LETI, and UKGBC, is also achievable by all types, and further reduces space heat demand to within 15-20 kWh/m²/yr. This is three to five times less than would be required by a building that meets the Part L 2021 notional building specification.

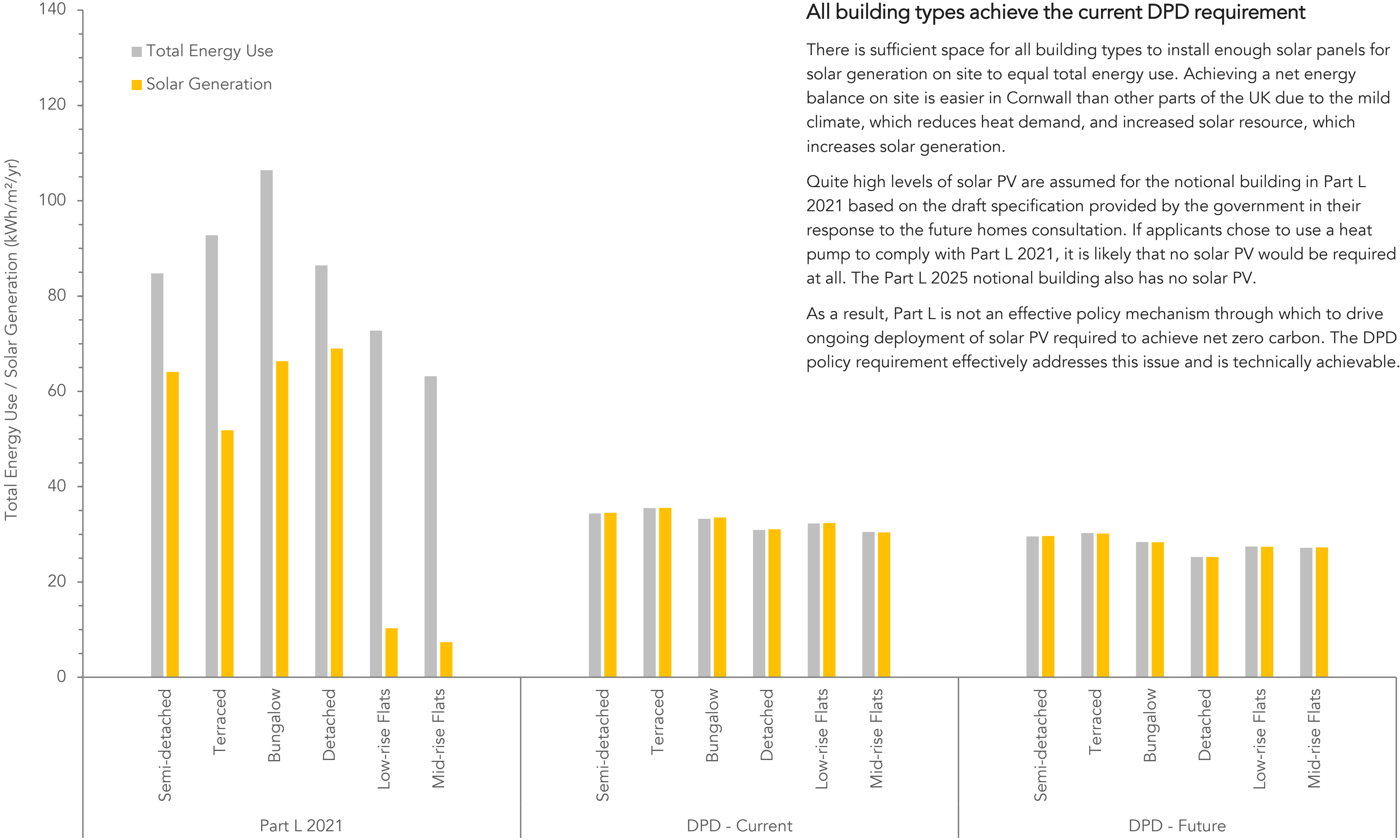
All building types achieve the current DPD requirement

The current DPD requirement significantly reduces the total energy use of new buildings, reducing it from 63-106 kWh/m²/yr to 40kWh/m²/yr. Our energy modelling indicated that all building types would actually exceed the policy requirement, achieving total energy use ranging from just 31-36 kWh/m²/yr.

This is mainly due to the efficiency of heat pumps, which combined with the fabric efficiency requirement results in low total energy use requirements. Our energy modelling indicates the current DPD policy will be effective at requiring applicants to use heat pumps rather than gas boilers, ensuring new housing complies with Cornwall Council's commitment to act on the climate emergency.

The future policy option is also achievable by all types, and further reduces total energy use to below the 35 kWh/m²/yr level recommended by RIBA, LETI and the UKGBC in their net zero definitions.

Summary I Solar generation to equal total energy use I Technical feasibility

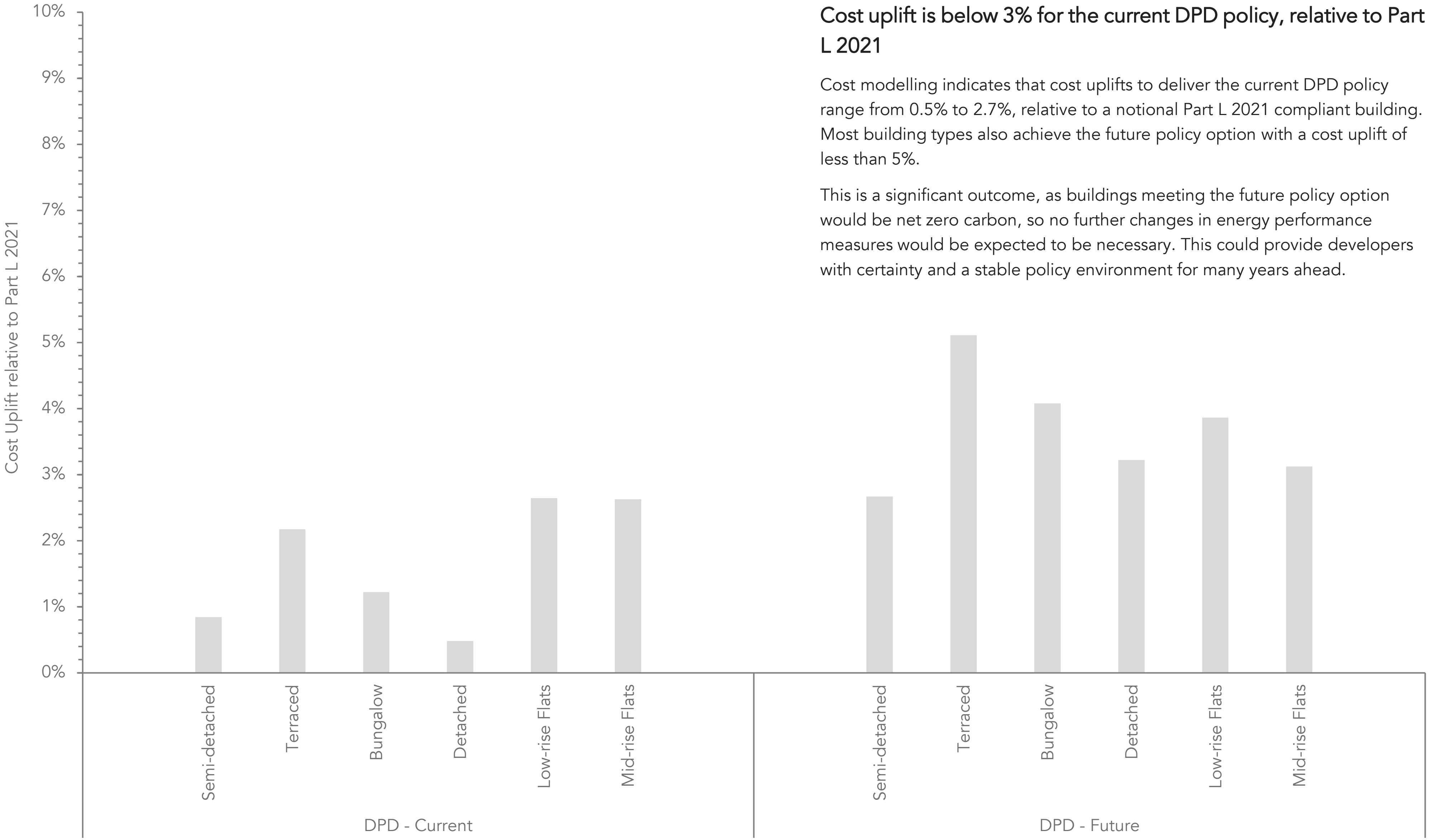


All building types achieve the current DPD requirement

There is sufficient space for all building types to install enough solar panels for solar generation on site to equal total energy use. Achieving a net energy balance on site is easier in Cornwall than other parts of the UK due to the mild climate, which reduces heat demand, and increased solar resource, which increases solar generation.

Quite high levels of solar PV are assumed for the notional building in Part L 2021 based on the draft specification provided by the government in their response to the future homes consultation. If applicants chose to use a heat pump to comply with Part L 2021, it is likely that no solar PV would be required at all. The Part L 2025 notional building also has no solar PV.

As a result, Part L is not an effective policy mechanism through which to drive ongoing deployment of solar PV required to achieve net zero carbon. The DPD policy requirement effectively addresses this issue and is technically achievable.



Cost uplift is below 3% for the current DPD policy, relative to Part L 2021

Cost modelling indicates that cost uplifts to deliver the current DPD policy range from 0.5% to 2.7%, relative to a notional Part L 2021 compliant building. Most building types also achieve the future policy option with a cost uplift of less than 5%.

This is a significant outcome, as buildings meeting the future policy option would be net zero carbon, so no further changes in energy performance measures would be expected to be necessary. This could provide developers with certainty and a stable policy environment for many years ahead.

DPD compliant buildings will have low energy cost and will be less exposed to energy price inflation

The operational energy costs for electricity and gas, including standing charges, will be low for buildings compliant with the current DPD policy, ranging from £286 to £330. Buildings compliant with the DPD policy will also be less exposed to energy price inflation, with around half of their energy expected to come directly from building mounted solar PV systems. Improved fabric efficiency and hot water storage will also position them to make better use of cheaper off-peak electricity through economy 7 or dynamic tariffs.

For blocks of flats, achieving this level of self consumption will require tenant solar supply through use of a single utility meter with landlord owned submeters, or individual flat connections.

The reduction in operational energy costs is mainly due to solar PV, improved fabric efficiency, and increased flexibility in when electricity is required, allowing greater use of cheaper off-peak tariffs.

1.0

Approach to energy modelling

This section explains our approach to the brief:

- Approach to energy modelling
- The seven policy scenarios
- The six building types

Software

We have modelled the performance of each building type in both **Stroma FSAP 2012** (for standard Part L SAP calculations), and **PHPP 9.6a** using **DesignPH 2.0.06** (for PHPP calculations)

PHPP is the tool used for Passivhaus and AECB certification. Post occupancy studies* have consistently shown that it provides a more reliable prediction of a building's space heating demand and energy use relative to Part L calculations.

DesignPH is used in combination with PHPP to provide more accurate shading analysis, based on a 3D model of the building and its surroundings.

We have also used the European Commission's PVGIS tool to calibrate solar generation calculated by PHPP.

Approach

In developing our assumptions, we have tried to adopt the mindset of a developer, i.e. finding the simplest and most economic ways of complying with each requirement.

Passive House Verification

Building:	Detached House		
Street:			
Postcode/City:			
Province/Country:		GB-United Kingdom/ Britain	
Building type:	Residential		
Climate data set:	GB0005a-Exeter		
Climate zone:	4: Warm-temperate	Altitude of location:	50 m
Home owner / Client:			
Street:			
Postcode/City:			
Province/Country:			

Architecture:	McBains		Mechanical engineer:		
Street:	26 Finsbury Square		Street:		
Postcode/City:	EC2A 1DS	London	Postcode/City:		
Province/Country:	Greater London	GB-United Kingdom/ Britain	Province/Country:		
Energy consultancy:	Etude		Certification:		
Street:	3 Dufferin Avenue		Street:		
Postcode/City:	EC1Y 8PQ	London	Postcode/City:		
Province/Country:	Greater London	GB-United Kingdom/ Britain	Province/Country:		

Year of construction:		Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	25.0
No. of dwelling units:	1	Internal heat gains (IHG) heating case [W/m²]:	2.5	IHG cooling case [W/m²]:	2.5
No. of occupants:	2.8	Specific capacity [Wh/K per m² TFA]:	84	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	131.0				
Space heating	Heating demand	kWh/(m²a)	15	≤	15	-	yes
	Heating load	W/m²	11	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤	-	-	-
	Cooling load	W/m²	-	≤	-	-	
	Frequency of overheating (> 25 °C)	%	0	≤	10		yes
	Frequency of excessively high humidity (> 12 g/kg)	%	0	≤	20		yes
Airtightness	Pressurization test result n_{50}	1/h	0.6	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	27	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	33	≤	45	33	yes
	Generation of renewable energy (in relation to projected building footprint area)	kWh/(m²a)	42	≥	60	41	

[2] Empty field: Data missing; '-': No requirement

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

Task:	First name:	Surname:	Passive House Plus?	yes
Designer	Chris	Worboys	Signature:	
	Issued on:	City:		
		London		

PHPP 9.6a was used to model expected real-world energy performance of the six different building types.

*Examples include the CEPHEUS project and Mitchell, R and Natarajan, S (2020) *UK Passivhaus and the energy performance gap*. Energy and Buildings. Vol 224

Our focus was on modelling seven different scenarios, representing the current national trajectory for building regulations, and several improved specifications that can deliver net zero carbon on site. These scenarios are outlined below.

Part L 2013

This scenario is based on a specification that achieves typical levels of performance required for the Part L 2013 notional building. It has been sense-checked against EPCs from completed projects in Cornwall and observation of site practice at the Nansledan development in Newquay. A gas boiler is assumed to provide all heating.

Part L 2021

This scenario is based on the notional building specification provided by the government in their recent response to the Future Homes Consultation. Changes include modest improvements to insulation, shower drain waste water heat recovery and solar PV. While heating is still based on a gas boiler, it is possible that developers could use heat pumps instead of wastewater heat recovery and solar PV to achieve the required performance. Airtightness is relatively poor at $5m^3/m^2hr$ and ventilation is achieved mechanically without heat recovery.

Part L 2025

This scenario is also based on an additional notional building specification provided by the government in their response to the Future Homes Standard Consultation. Insulation levels and glazing performance is increased close to that required for Passivhaus, however airtightness remains poor and no heat recovery ventilation is required. Shower drain wastewater heat recovery and solar PV are dropped from the notional building, but a heat pump is added. Airtightness remains poor at $5m^3/m^2hr$.

Part L 2025 + PV

This is identical to the previous scenario, with the addition of enough solar PV for the building to achieve a net zero energy balance on site.

UKGBC 2025 Stretch

This scenario is based on the UKGBC's 2025 stretch target, which is based on a fabric efficiency of 15-20kWh/m^2/yr, in line with the Climate Change Committee's recommendations. This requires a similar level of fabric performance to Part L 2025, with the majority of gains delivered by improving the airtightness to $1m^3/m^2hr$ and use of heat recovery ventilation.

The EUI target for this scenario is set at 70kWh/m^2/yr on the basis that a large allowance, of around 45kWh/m^2/yr has been provided for appliances, small power, lighting, pumps and fans. Sufficient solar PV has been installed to achieve a net zero energy balance on site.

Cornwall Council Current DPD (Scenario 2)

This scenario uses a similar fabric specification to Part L 2013, with an improved airtightness of $1m^3/m^2hr$ and use of heat recovery ventilation to achieve a space heat demand of 30kWh/m^2/yr, in line with the draft DPD requirement. This represents a reduction in space heat demand of around 60-70% relative to Part L 2013. Space heating and water heating is provided by a heat pump, which is required to achieve the DPD EUI target of 40kWh/m^2/yr. Sufficient solar PV has been installed to achieve a net zero energy balance on site.

Cornwall Council Future DPD (Scenario 3)

This scenario, used for DPD viability testing, has been considered as a probable future requirement to bring fabric efficiency in line with the Climate Change Committee's recommended 15-20kWh/m^2/yr range, and EUI in line with LETI and RIBA's recommended 35kWh/m^2/yr. Sufficient solar PV has been installed to achieve a net zero energy balance on site.

The six building types

Six types of building were selected to test the technical and financial viability of each policy scenario across a variety of buildings. Testing a diverse selection of buildings was important to ensure that the policy is viable across buildings with different attributes, as discussed below.

Heat Loss Form Factor

The heat loss form factor, often abbreviated to 'form factor', is the ratio of a building's heat loss area to its internal floor area.

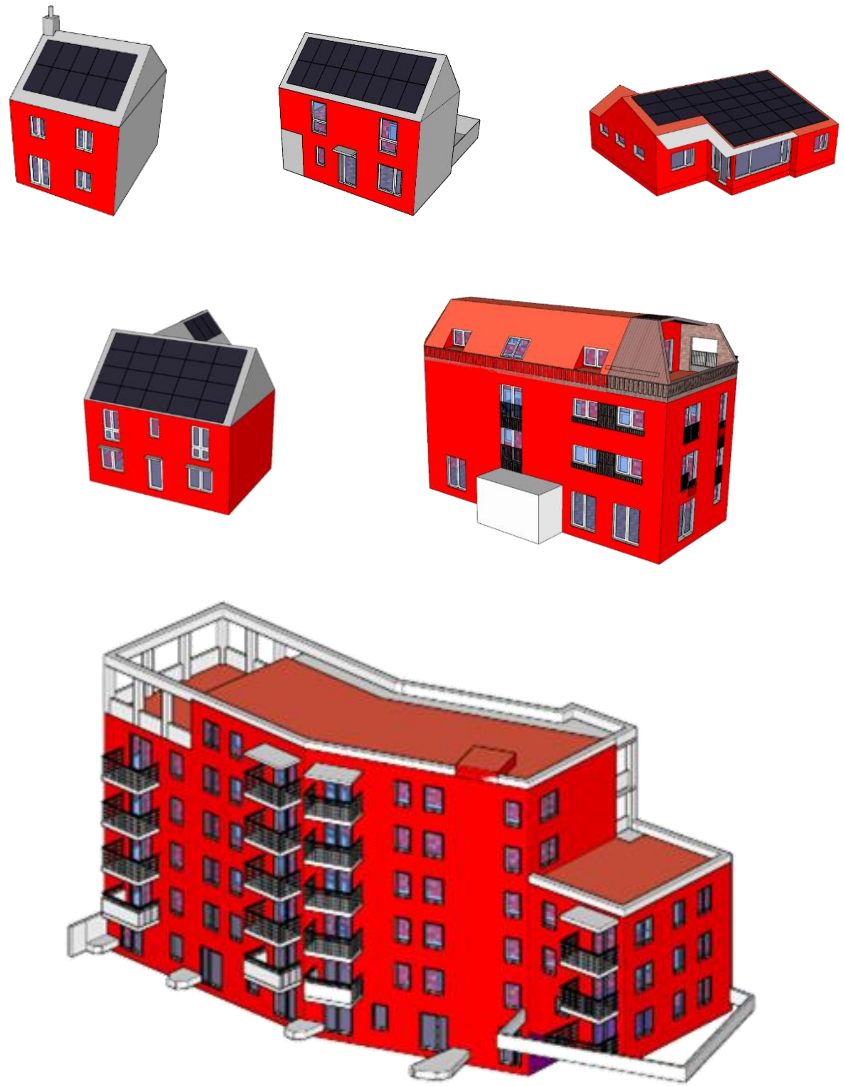
Buildings with a lot of heat loss area and small internal floor area, such as small bungalows, have high form factors, typically around 4 and above. Buildings with a high form factor require higher levels of insulation to reduce heat loss and therefore costs of complying with the policy scenarios may be higher.

Buildings with relatively low heat loss area relative to their internal floor area, such as large blocks of flats, have low form factors, typically below 2.5. As a result, they naturally have lower levels of heat loss and therefore require less insulation to comply with the policy scenarios.

Potential for Solar PV

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

In practice, it is usually possible to achieve a net zero energy balance on site in the UK in buildings up to six stories in height, though this requires best practice fabric efficiency and solar PV design.



A semi-detached house, terraced house, bungalow, detached house, low-rise block of seven flats and mid-rise block of 20 flats were modelled.

2.0

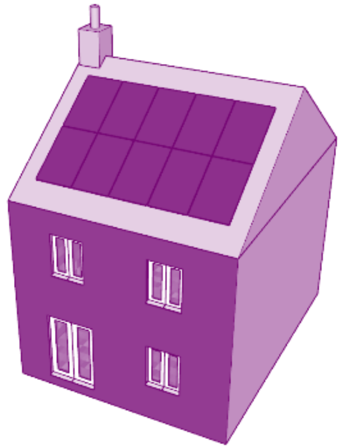
Technical assessment

This section presents:

- Specifications for each building type and policy scenario
- Performance against the three DPD policy requirements:
    1. Space heat demand
    2. Total energy use
    3. On-site solar generation
- Carbon emissions

Semi-detached House

This section contains the specifications, assumptions and modelling results for a 3-bedroom semi-detached house.



Energy modelling | Semi-detached House

This study focuses on six typical housing types to test the impact of different policy approaches. For the semi-detached house, a 3-bedroom home design used by the Duchy of Cornwall was selected from documents submitted in support of a planning application.

Building fabric

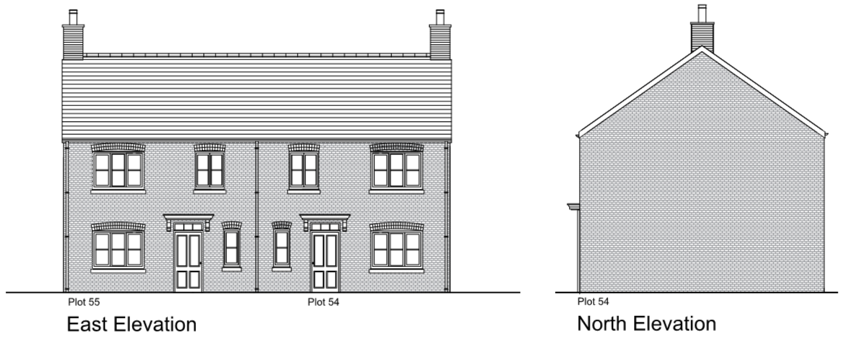
The property has a gross internal floor area of 93m². The main entrance faces the street to the North East, while the rear of the house faces to the South West and features a small garden. The property has typical glazing proportions and layout for this type of home. The form heat loss factor of 2.76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

Low carbon heating

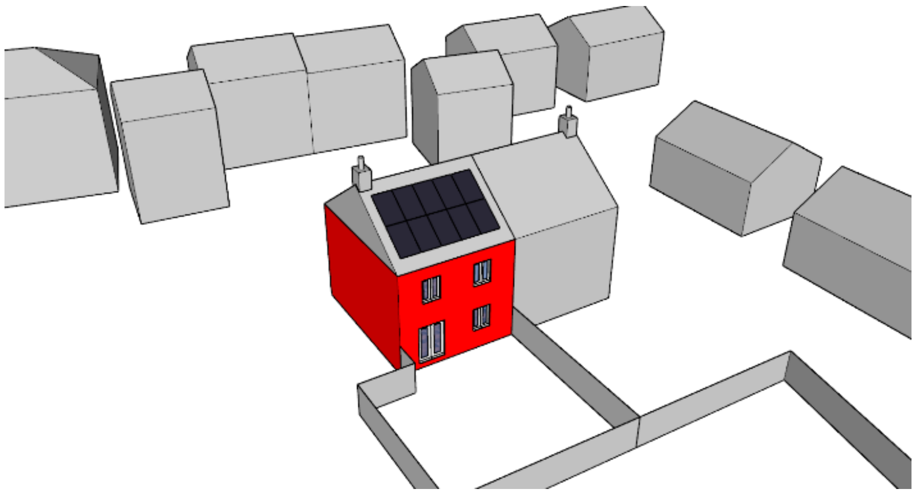
The most suitable low carbon heating system is likely to be an air source heat pump, as the property has space both inside and outside for the necessary hardware. A ground source heat pump would also be suitable. Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency. Direct electric heating would not typically achieve the EUI requirement without cost-prohibitive levels of fabric efficiency.

Solar PV

The property has sufficient space for around 10 solar panels with the main roof facing South (between southeast and southwest). If the property faced East/West this would increase to 20 panels. The number of panels required to achieve net zero on site ranges from 8 in the future policy option scenario to 16 in the UKGBC 2025. It would be possible to install up to 15 panels by moving the roof ridgeline slightly to the North, coming close to the requirement of this policy scenario. In practice, unregulated energy consumption is likely to be much lower than the UKGBC target allows, so this type is likely to be able to achieve net zero on site in most situations.



A typical 3 bedroom semi-detached house was selected from the Wainhomes development at Nansledan, Newquay



A 3D model of the house and surrounding features was created in DesignPH 2.0.06 and used to calculate solar gains and shading for PHPP.

Energy modelling I Semi-detached House Specifications

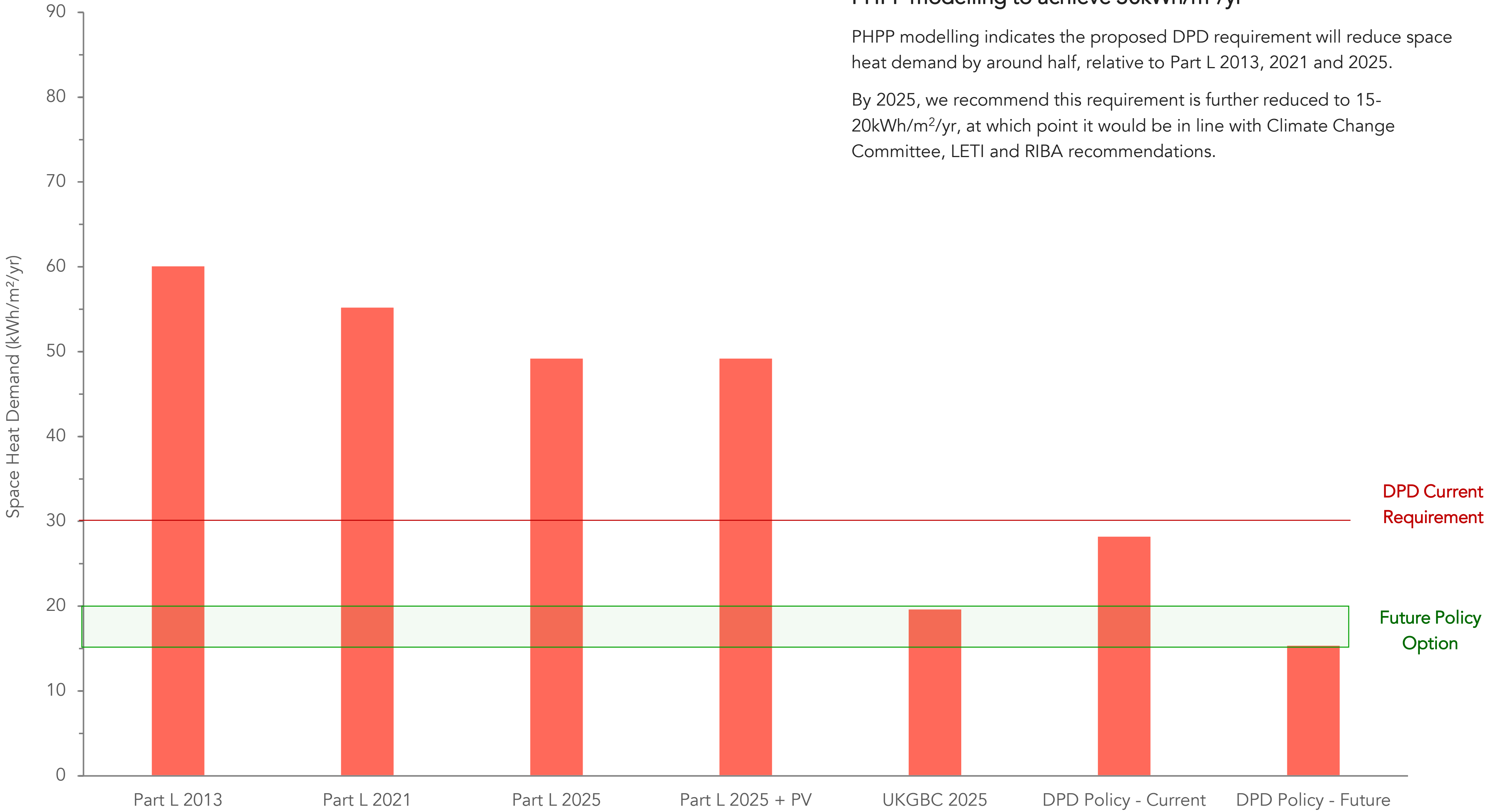
	Part L 2013	Part L 2021	Part L 2025 (FHS)	Part L 2025 (FHS) + PV	UKGBC 2025	DPD Current Policy	Future Policy Option
Description	Typical developer specification to achieve compliance with Part L 2013	Notional building specification for Part L 2021, provided by government	Indicative notional building specification for Part L 2025, provided by government	Indicative notional building specification for Part L 2025, provided by government	15-20 kWh/m²/yr Fabric	Cost optimised fabric with heat pump and solar PV	Passivhaus with heat pump and solar PV
Net zero compliant?	×	×	×	?	?	✓	✓
Floor (W/m²K, SAP adjusted)	0.130	0.130	0.110	0.110	0.110	0.130	0.090
Walls (W/m²K)	0.210	0.180	0.150	0.150	0.150	0.210	0.130
Roof (W/m²K)	0.130	0.110	0.110	0.110	0.110	0.130	0.100
Windows (W/m²K)	1.3 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)
Doors (W/m²K)	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	0.9 – 1.0	1.0 – 1.3	0.9-1.0
Thermal bridging (kWh/m²/yr)	3	2	2	2	2	2	2
Air Permeability (m³/m²/hr)	5	5	5	5	1	1	0.64
Ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	MVHR, 88% heat recovery	MVHR, 88% heat recovery	MVHR, 88% heat recovery
Heating System	Gas Boiler	Gas Boiler. Shower drain waste water heat recovery	5kW Monobloc Air Source Heat Pump supplying radiators at 55˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at 55˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at <45˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at 45˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at <45˚C. 150 litre DHW tank
Solar PV	-	5.76kW	-	3.82kW	6.32kW	3.10kW	2.664kW

Energy Modelling I Semi-detached House – DPD requirement for space heating demand

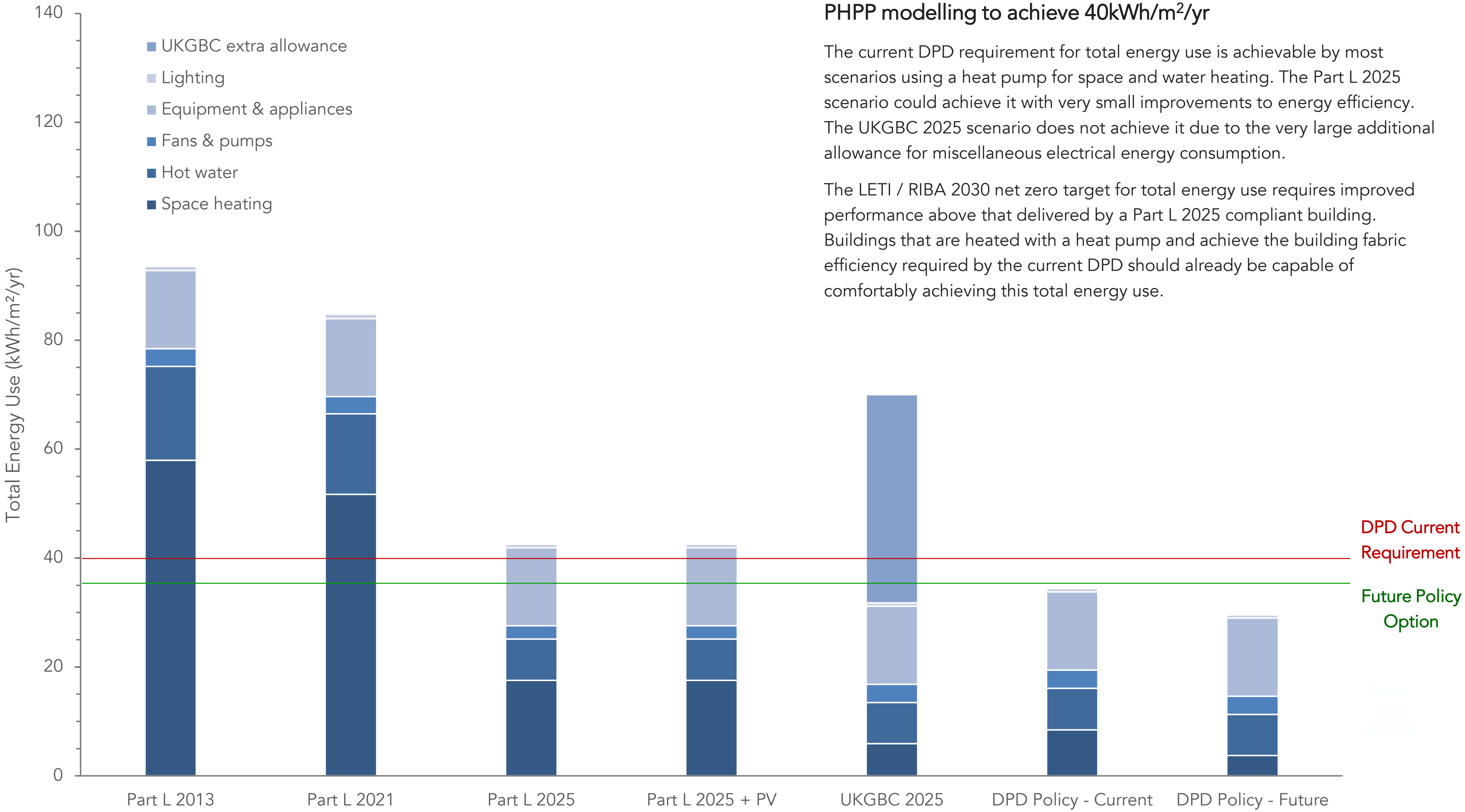
PHPP modelling to achieve 30kWh/m²/yr

PHPP modelling indicates the proposed DPD requirement will reduce space heat demand by around half, relative to Part L 2013, 2021 and 2025.

By 2025, we recommend this requirement is further reduced to 15-20kWh/m²/yr, at which point it would be in line with Climate Change Committee, LETI and RIBA recommendations.



Space heat demand calculated by PHPP 9.6a for each scenario, compared to different policy requirements under consideration.

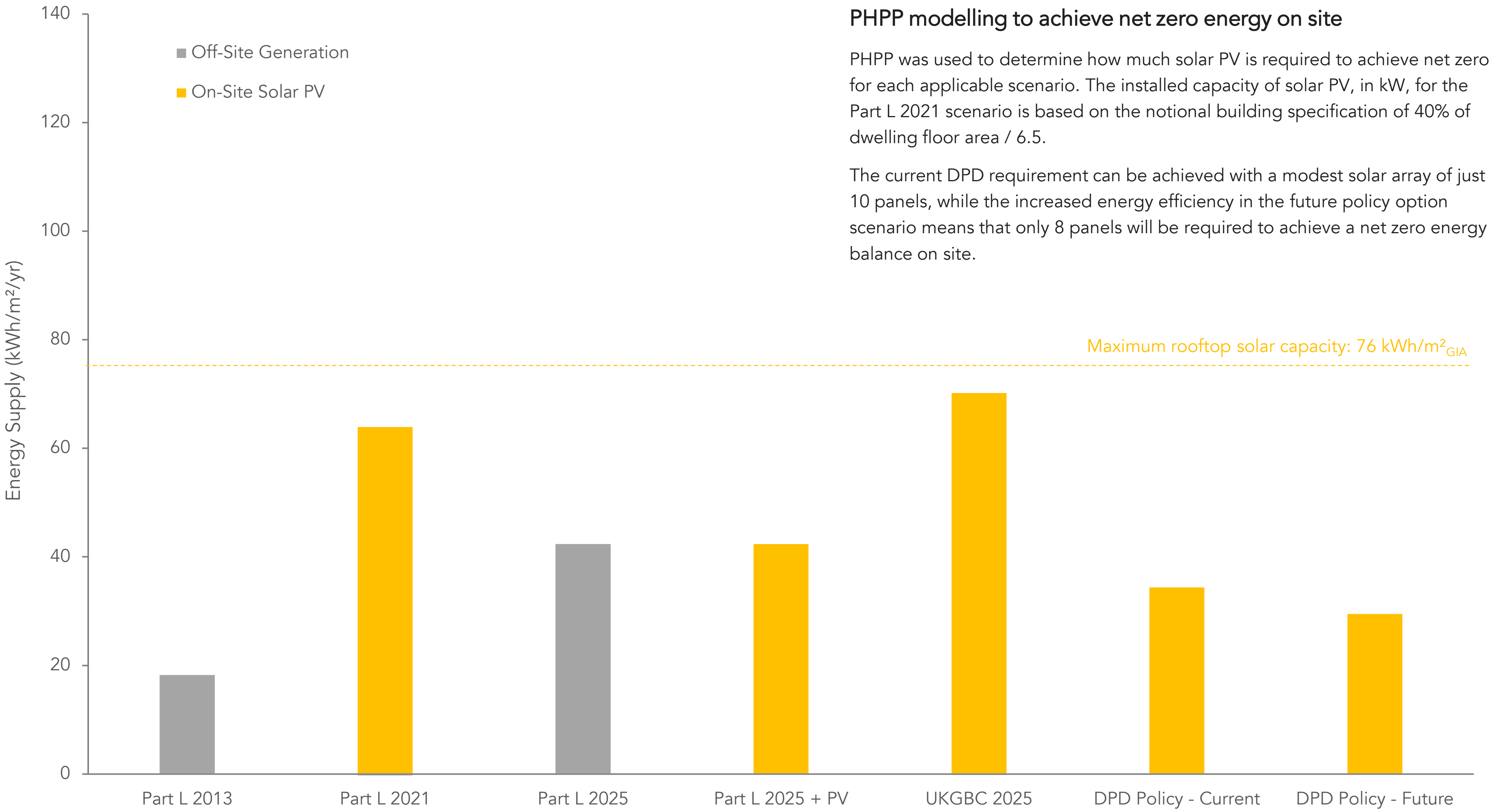


PHPP modelling to achieve 40kWh/m²/yr

The current DPD requirement for total energy use is achievable by most scenarios using a heat pump for space and water heating. The Part L 2025 scenario could achieve it with very small improvements to energy efficiency. The UKGBC 2025 scenario does not achieve it due to the very large additional allowance for miscellaneous electrical energy consumption.

The LETI / RIBA 2030 net zero target for total energy use requires improved performance above that delivered by a Part L 2025 compliant building. Buildings that are heated with a heat pump and achieve the building fabric efficiency required by the current DPD should already be capable of comfortably achieving this total energy use.

Total energy use calculated by PHPP 9.6a for each scenario.



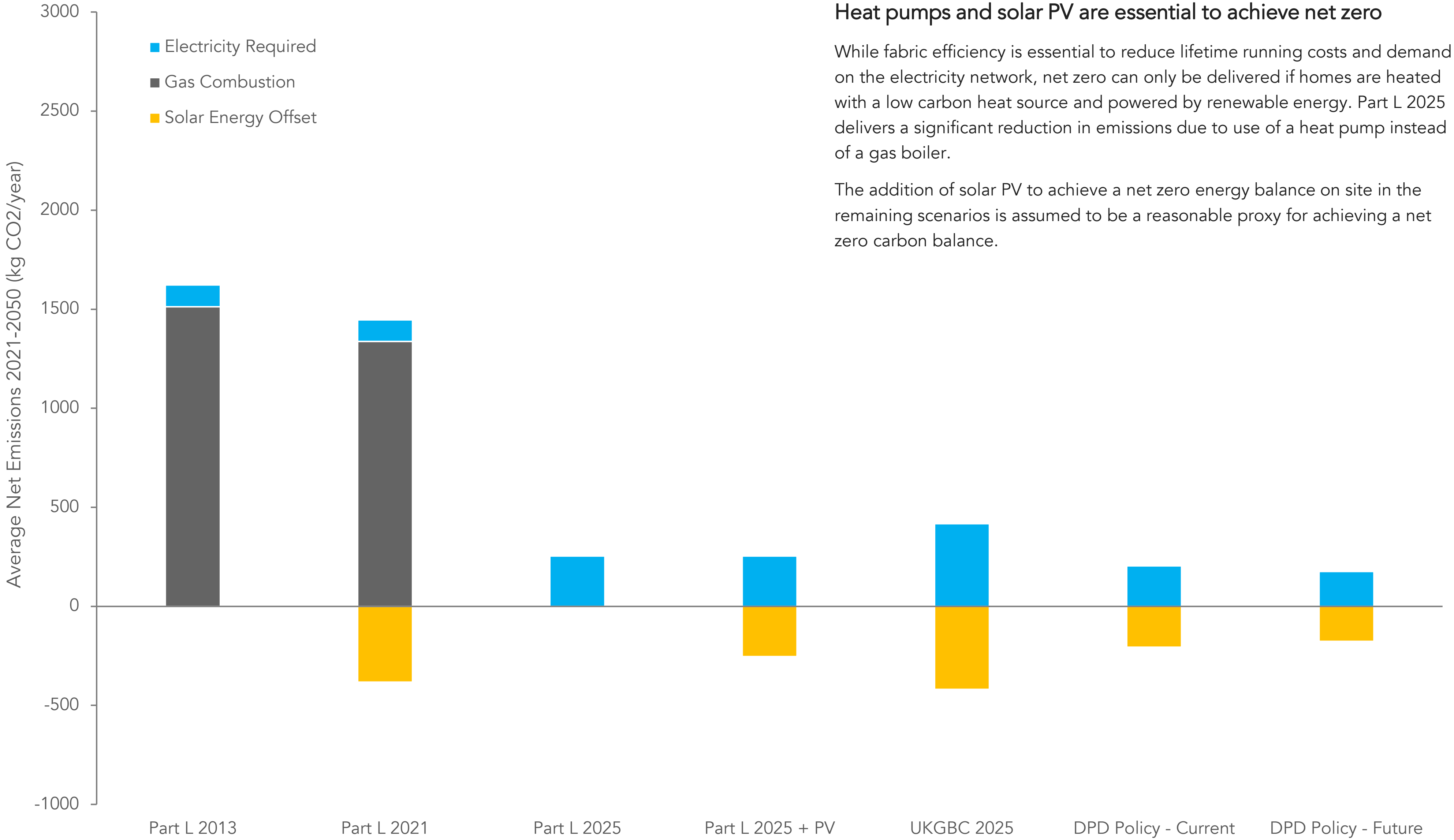
PHPP modelling to achieve net zero energy on site

PHPP was used to determine how much solar PV is required to achieve net zero for each applicable scenario. The installed capacity of solar PV, in kW, for the Part L 2021 scenario is based on the notional building specification of 40% of dwelling floor area / 6.5.

The current DPD requirement can be achieved with a modest solar array of just 10 panels, while the increased energy efficiency in the future policy option scenario means that only 8 panels will be required to achieve a net zero energy balance on site.

On-site solar energy generation calculated by PHPP 9.6a for each scenario. Part L 2013 and 2021 scenarios use a gas boiler, so electricity demand is lower than for other scenarios. Grey bars show off-site electricity generation that must be imported from the electricity grid.

Energy Modelling | Semi-detached house – Operational CO_2 Emissions



Heat pumps and solar PV are essential to achieve net zero

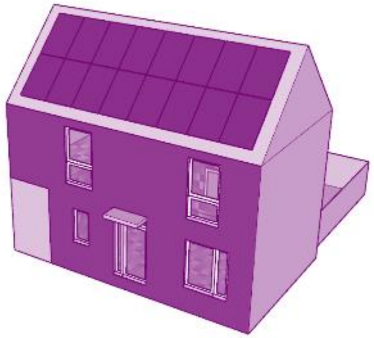
While fabric efficiency is essential to reduce lifetime running costs and demand on the electricity network, net zero can only be delivered if homes are heated with a low carbon heat source and powered by renewable energy. Part L 2025 delivers a significant reduction in emissions due to use of a heat pump instead of a gas boiler.

The addition of solar PV to achieve a net zero energy balance on site in the remaining scenarios is assumed to be a reasonable proxy for achieving a net zero carbon balance.

Average annual net CO_2 emissions for 2021-2050. Assumes 216gCO_2 produced per kWh of gas consumed and electricity carbon intensity figures based on HM Treasury Green Book values.

Terraced House

This section contains the specifications, assumptions and modelling results for a 2-bedroom terraced house.



Etude

Energy modelling I Terraced House

This study focuses on six typical housing types to test the impact of different policy approaches. For the terraced house, a 2-bedroom home designed by Pollard Thomas Edwards Architecture for the developer Hill was selected from documents submitted in support of a planning application.

Building fabric

The property has a gross internal floor area of 84m². The main entrance faces the street to the East, while the rear of the house faces to the West and features a small garden. The property has typical glazing proportions and layout for this type of home. The form heat loss factor of 3.20 is reasonable, though higher than usual for a terraced home. This is due to the 'double frontage' design, with a longer exposed wall front and back compared to the length of the party walls to the sides.

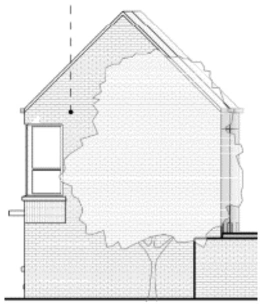
Low carbon heating

The most suitable low carbon heating system is likely to be an air source heat pump, as the property has space both inside and outside for the necessary hardware. A ground source heat pump would also be suitable. Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency. Direct electric heating would not typically achieve the EUI requirement without cost-prohibitive levels of fabric efficiency.

Solar PV

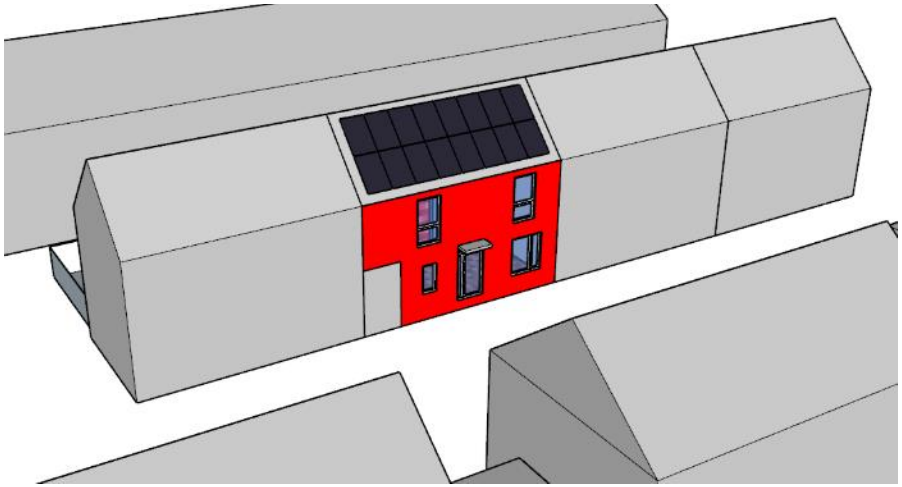
The property has sufficient space for around 32 solar panels with the main roof in an East/West orientation, as designed. If the property faced South (between southeast and southwest), this would reduce to 16 panels as one of the roof planes would have insufficient solar exposure to justify installation of solar panels. The number of panels required to achieve net zero on site ranges from 8 in the future policy option scenario to 18 in the UKGBC 2025 scenario.

East Elevation



End of terrace profile

A typical 2 bedroom terraced house was selected

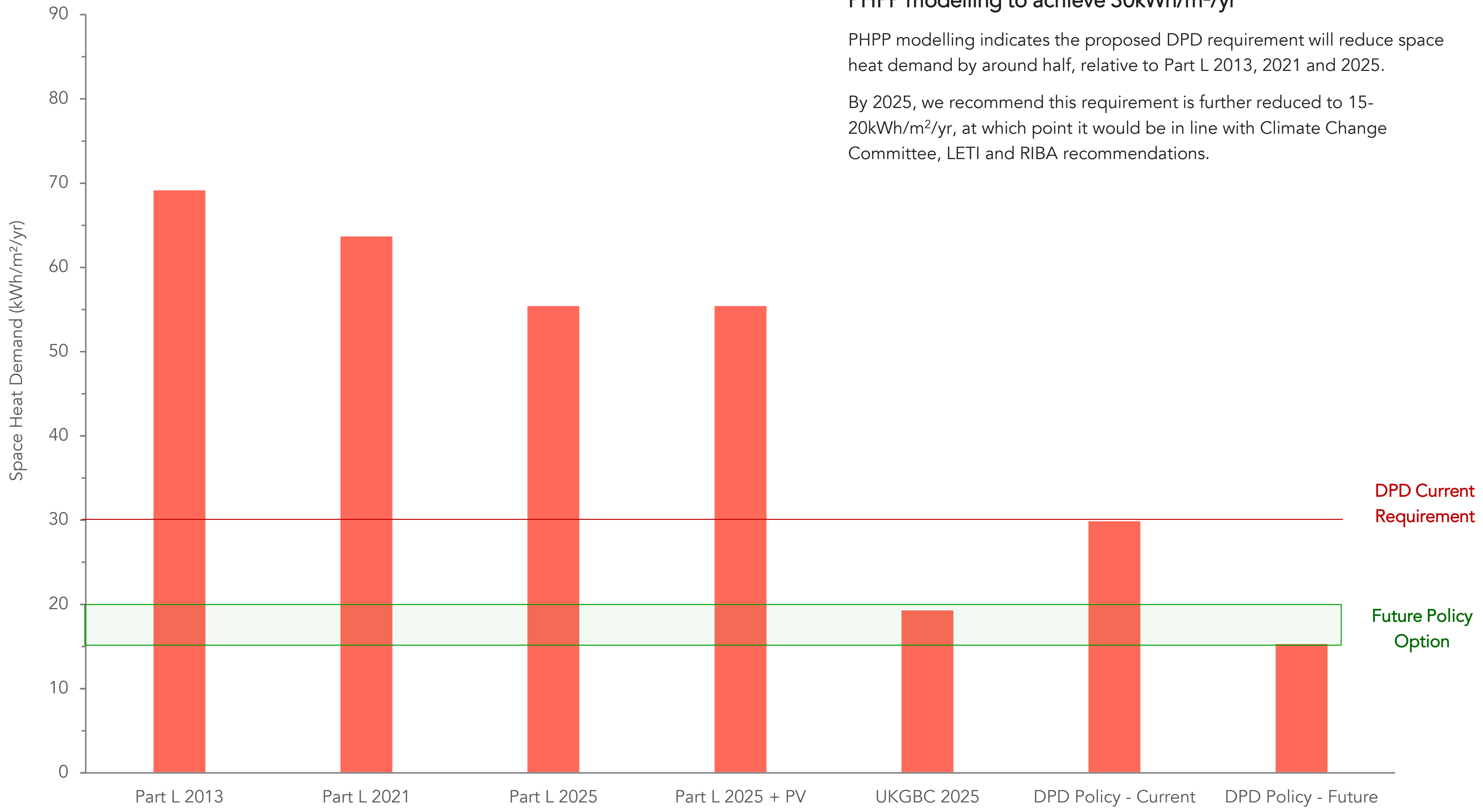


A 3D model of the house and surrounding features was created in DesignPH 2.0.06 and used to calculate solar gains and shading for PHPP.

Energy modelling I Terraced House Specifications

	Part L 2013	Part L 2021	Part L 2025 (FHS)	Part L 2025 (FHS) + PV	UKGBC 2025	DPD Current Policy	Future Policy Option
Description	Typical developer specification to achieve compliance with Part L 2013	Notional building specification for Part L 2021, provided by government	Indicative notional building specification for Part L 2025, provided by government	Indicative notional building specification for Part L 2025, provided by government	15-20 kWh/m²/yr Fabric	Cost optimised fabric with heat pump and solar PV	Passivhaus with heat pump and solar PV
Net zero compliant?	×	×	×	?	?	✓	✓
Floor (W/m²K, SAP adjusted)	0.130	0.130	0.110	0.110	0.110	0.130	0.083
Walls (W/m²K)	0.210	0.180	0.150	0.150	0.090	0.150	0.090
Roof (W/m²K)	0.130	0.110	0.110	0.110	0.090	0.110	0.090
Windows (W/m²K)	1.3 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)
Doors (W/m²K)	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	0.9 – 1.0	1.0 – 1.3	0.9-1.0
Thermal bridging (kWh/m²/yr)	3	2	2	2	2	2	2
Air Permeability (m³/m²/hr)	5	5	5	5	1	1	0.61
Ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	MVHR, 88% heat recovery	MVHR, 88% heat recovery	MVHR, 88% heat recovery
Heating System	Gas Boiler	Gas Boiler. Shower drain waste water heat recovery	5kW Monobloc Air Source Heat Pump supplying radiators at 55˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at 55˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at <45˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at 45˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at <45˚C. 150 litre DHW tank
Solar PV	-	5.04kW	-	4.38kW	6,84kW	3.46kW	2,94kW

Etude

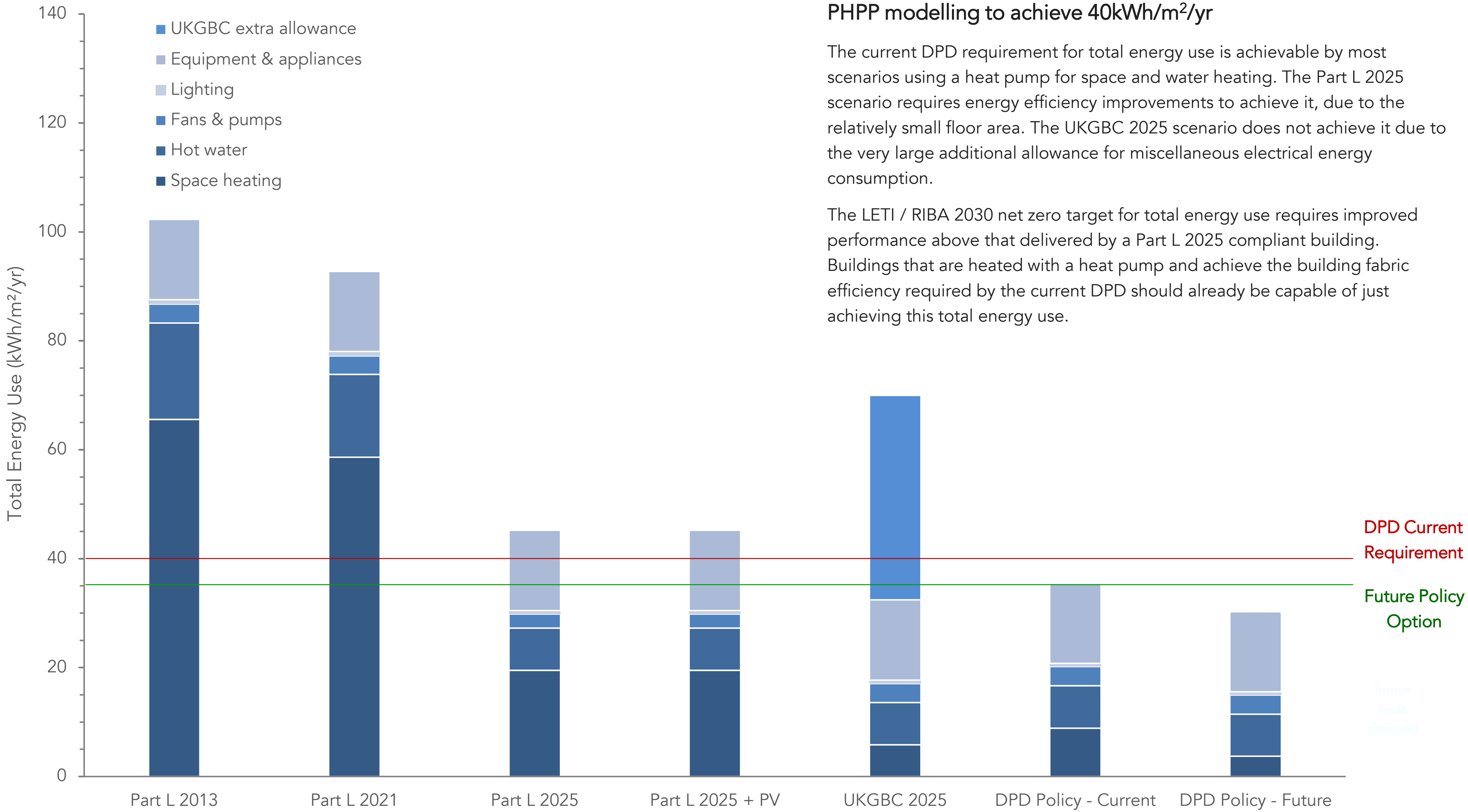


PHPP modelling to achieve 30kWh/m²/yr

PHPP modelling indicates the proposed DPD requirement will reduce space heat demand by around half, relative to Part L 2013, 2021 and 2025.

By 2025, we recommend this requirement is further reduced to 15-20kWh/m²/yr, at which point it would be in line with Climate Change Committee, LETI and RIBA recommendations.

Space heat demand calculated by PHPP 9.6a for each scenario, compared to different policy requirements under consideration.

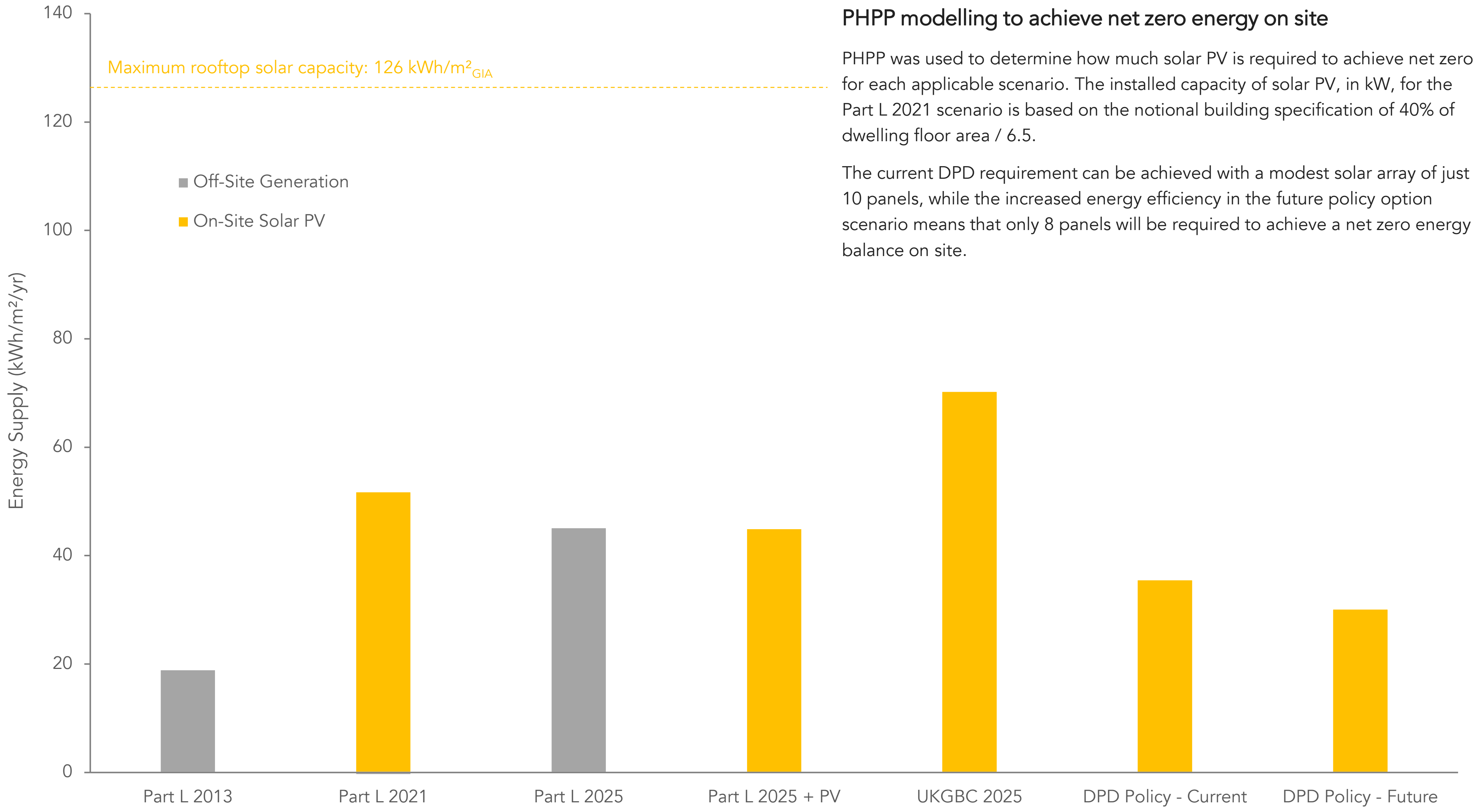


PHPP modelling to achieve 40kWh/m²/yr

The current DPD requirement for total energy use is achievable by most scenarios using a heat pump for space and water heating. The Part L 2025 scenario requires energy efficiency improvements to achieve it, due to the relatively small floor area. The UKGBC 2025 scenario does not achieve it due to the very large additional allowance for miscellaneous electrical energy consumption.

The LETI / RIBA 2030 net zero target for total energy use requires improved performance above that delivered by a Part L 2025 compliant building. Buildings that are heated with a heat pump and achieve the building fabric efficiency required by the current DPD should already be capable of just achieving this total energy use.

Total energy use calculated by PHPP 9.6a for each scenario.



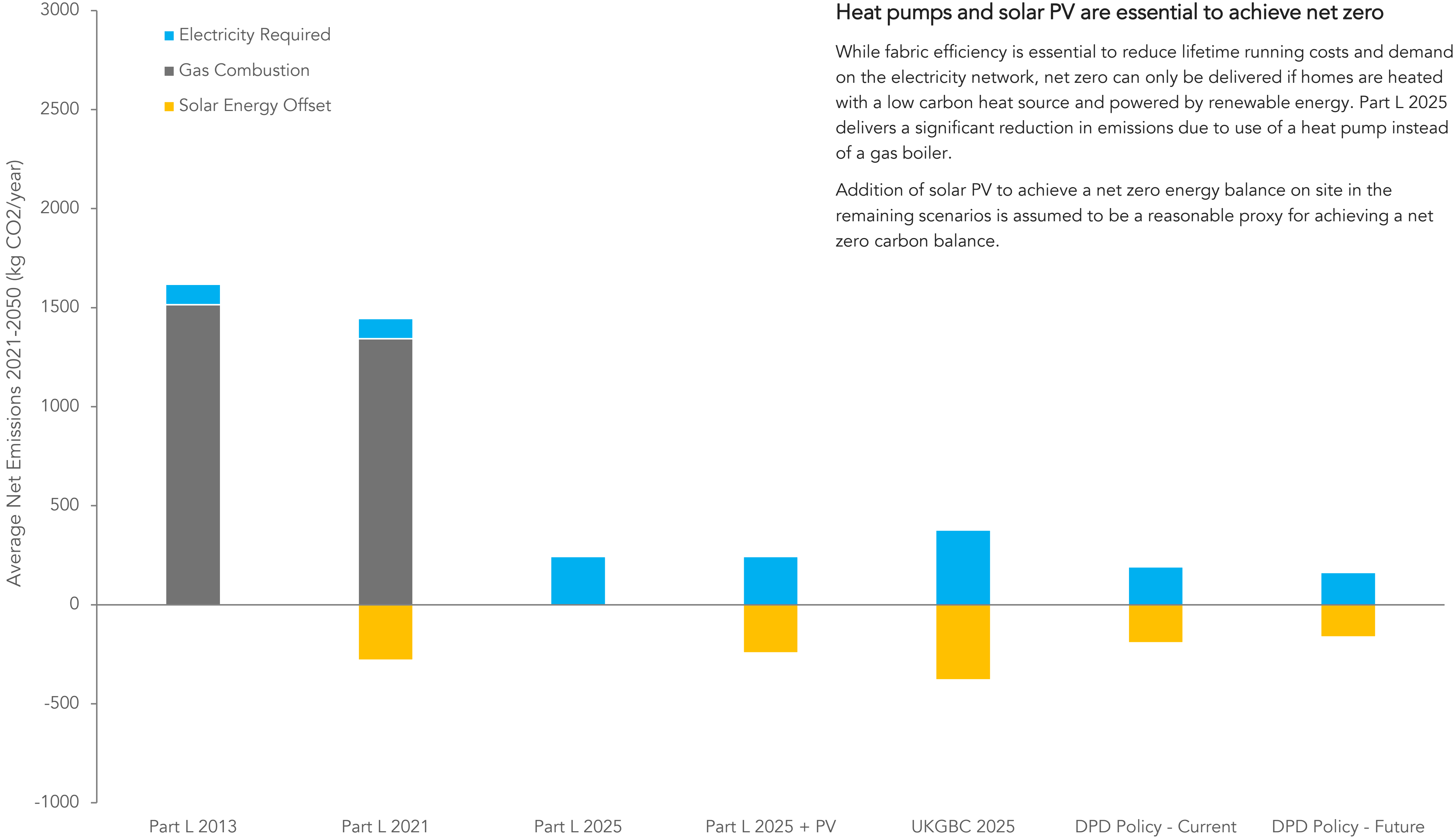
PHPP modelling to achieve net zero energy on site

PHPP was used to determine how much solar PV is required to achieve net zero for each applicable scenario. The installed capacity of solar PV, in kW, for the Part L 2021 scenario is based on the notional building specification of 40% of dwelling floor area / 6.5.

The current DPD requirement can be achieved with a modest solar array of just 10 panels, while the increased energy efficiency in the future policy option scenario means that only 8 panels will be required to achieve a net zero energy balance on site.

On-site solar energy generation calculated by PHPP 9.6a for each scenario. Part L 2013 and 2021 scenarios use a gas boiler, so electricity demand is lower than for other scenarios. Grey bars show off-site electricity generation that must be imported from the electricity grid.

Energy Modelling | Terraced house – Operational CO_2 Emissions



Heat pumps and solar PV are essential to achieve net zero

While fabric efficiency is essential to reduce lifetime running costs and demand on the electricity network, net zero can only be delivered if homes are heated with a low carbon heat source and powered by renewable energy. Part L 2025 delivers a significant reduction in emissions due to use of a heat pump instead of a gas boiler.

Addition of solar PV to achieve a net zero energy balance on site in the remaining scenarios is assumed to be a reasonable proxy for achieving a net zero carbon balance.

Average annual net CO_2 emissions for 2021-2050. Assumes 216gCO_2 produced per kWh of gas consumed and electricity carbon intensity figures based on HM Treasury Green Book values.

Bungalow

This section contains the specifications, assumptions and modelling results for a detached 3-bedroom bungalow.

Energy modelling | Bungalow

This study focuses on six typical housing types to test the impact of different policy approaches. For the bungalow, a 3-bedroom home was selected, which had been developed as a new build property.

Building fabric

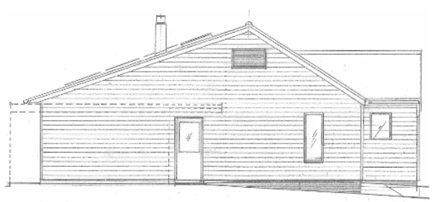
The property has a gross internal floor area of 108m². The main entrance faces the street to the South, while the rear of the house faces to the North and features a small garden. The property has typical glazing proportions and layout for this type of home. The form heat loss factor of 4.33 is poor but is as expected for a detached bungalow. As a result, even with very high levels of insulation, the space heating demand is higher than in the other house types. In practice, we would expect developers to reduce heat loss by optimising the design of the building, as this would be cheaper than using very high levels of insulation. For example, glazing ratios could be reduced.

Low carbon heating

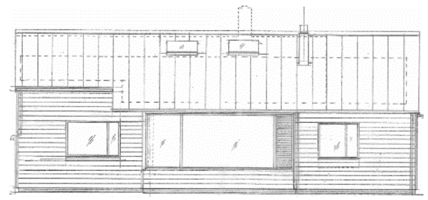
The most suitable low carbon heating system is likely to be an air source heat pump, as the property has space both inside and outside for the necessary hardware. A ground source heat pump would also be suitable. Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency. Direct electric heating would not typically achieve the EUI requirement without cost-prohibitive levels of fabric efficiency.

Solar PV

The property has sufficient space for around 36 solar panels with the main roof facing South (between southeast and southwest). There is additional space for 2 panels on the smaller rear roof section. If the property faced East or West, it would be possible to install more panels on the rear plane of the main roof. The number of panels required to achieve net zero on site ranges from 8 in the future policy option scenario, to 18 in the UKGBC 2025 scenario.

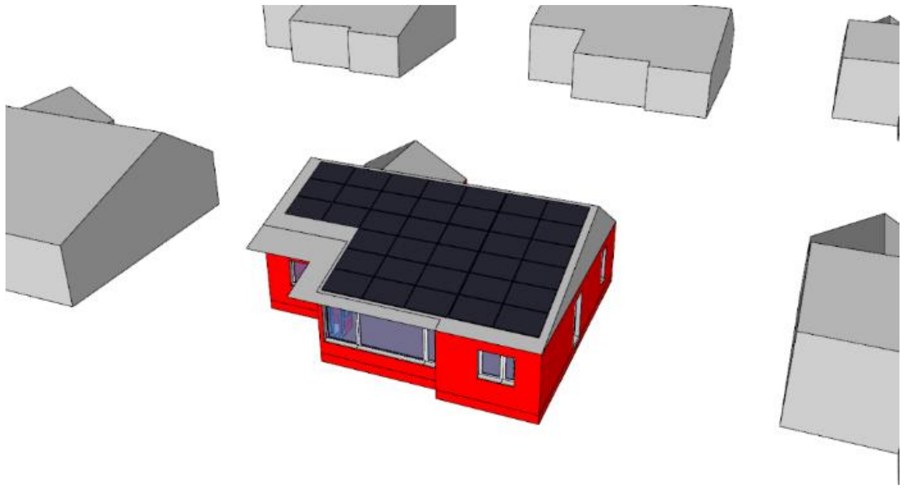


East Elevation



South Elevation

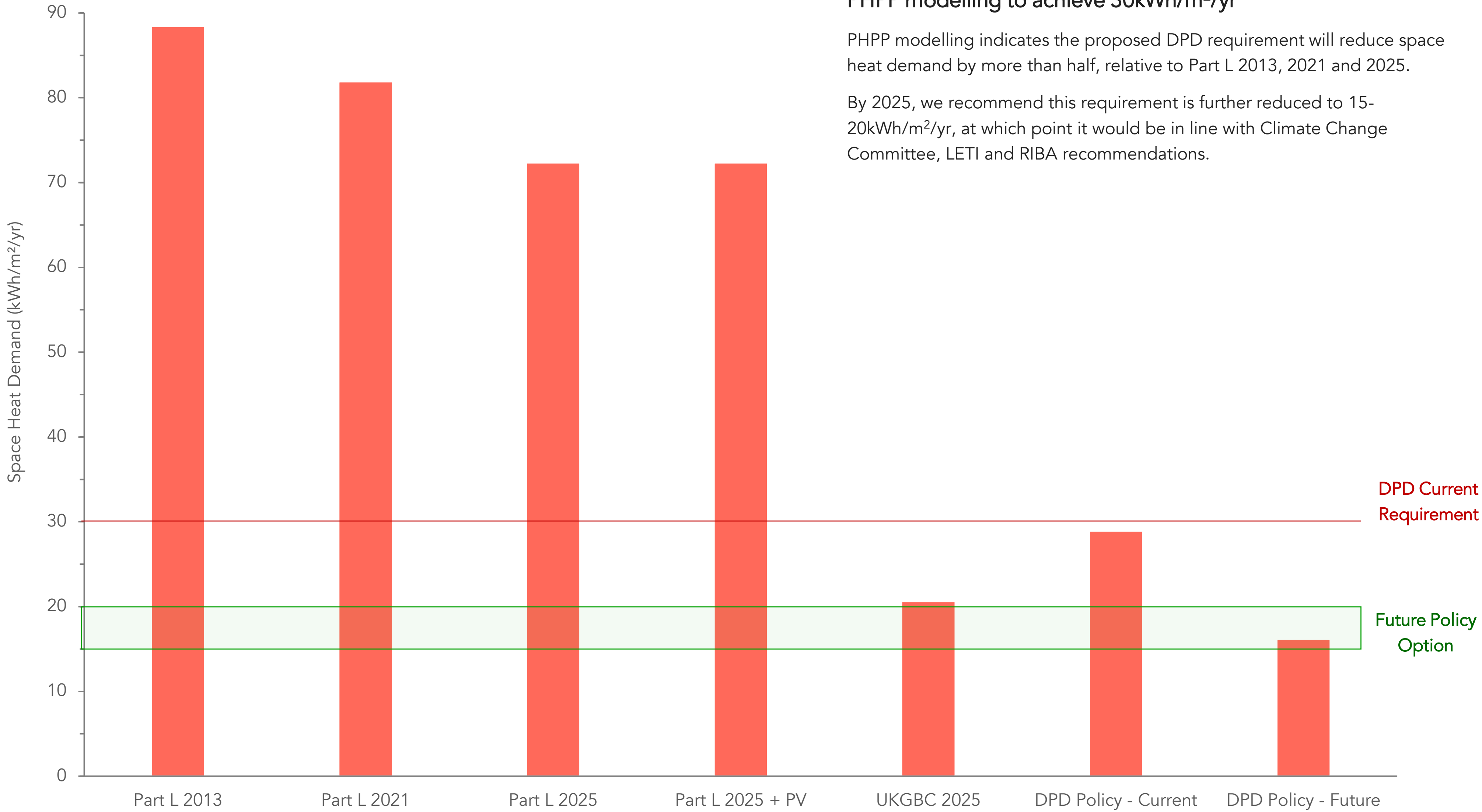
A typical 3 bedroom bungalow was selected



A 3D model of the house and surrounding features was created in DesignPH 2.0.06 and used to calculate solar gains and shading for PHPP.

	Part L 2013	Part L 2021	Part L 2025 (FHS)	Part L 2025 (FHS) + PV	UKGBC 2025	DPD Current Policy	Future Policy Option
Description	Typical developer specification to achieve compliance with Part L 2013	Notional building specification for Part L 2021, provided by government	Indicative notional building specification for Part L 2025, provided by government	Indicative notional building specification for Part L 2025, provided by government	15-20 kWh/m²/yr Fabric	Cost optimised fabric with heat pump and solar PV	Passivhaus with heat pump and solar PV
Net zero compliant?	×	×	×	?	?	✓	✓
Floor (W/m²K, SAP adjusted)	0.130	0.130	0.110	0.110	0.080	0.110	0.080
Walls (W/m²K)	0.210	0.180	0.150	0.150	0.090	0.160	0.090
Roof (W/m²K)	0.130	0.110	0.110	0.110	0.090	0.090	0.090
Windows (W/m²K)	1.3 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)
Doors (W/m²K)	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	0.9 – 1.0	0.9-1.0	0.9-1.0
Thermal bridging (kWh/m²/yr)	3	2	2	2	2	2	2
Air Permeability (m³/m²/hr)	5	5	5	5	1	1	0.45
Ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	MVHR, 88% heat recovery	MVHR, 88% heat recovery	MVHR, 88% heat recovery
Heating System	Gas Boiler	Gas Boiler. Shower drain waste water heat recovery	5kW Monobloc Air Source Heat Pump supplying radiators at 55˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at 55˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at <45˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at 45˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at <45˚C. 150 litre DHW tank
Solar PV	-	6.84kW	-	5.12kW	7.20kW	3.46kW	2.92kW

Energy Modelling I Bungalow – DPD requirement for space heating demand



PHPP modelling to achieve 30kWh/m^2/yr

PHPP modelling indicates the proposed DPD requirement will reduce space heat demand by more than half, relative to Part L 2013, 2021 and 2025.

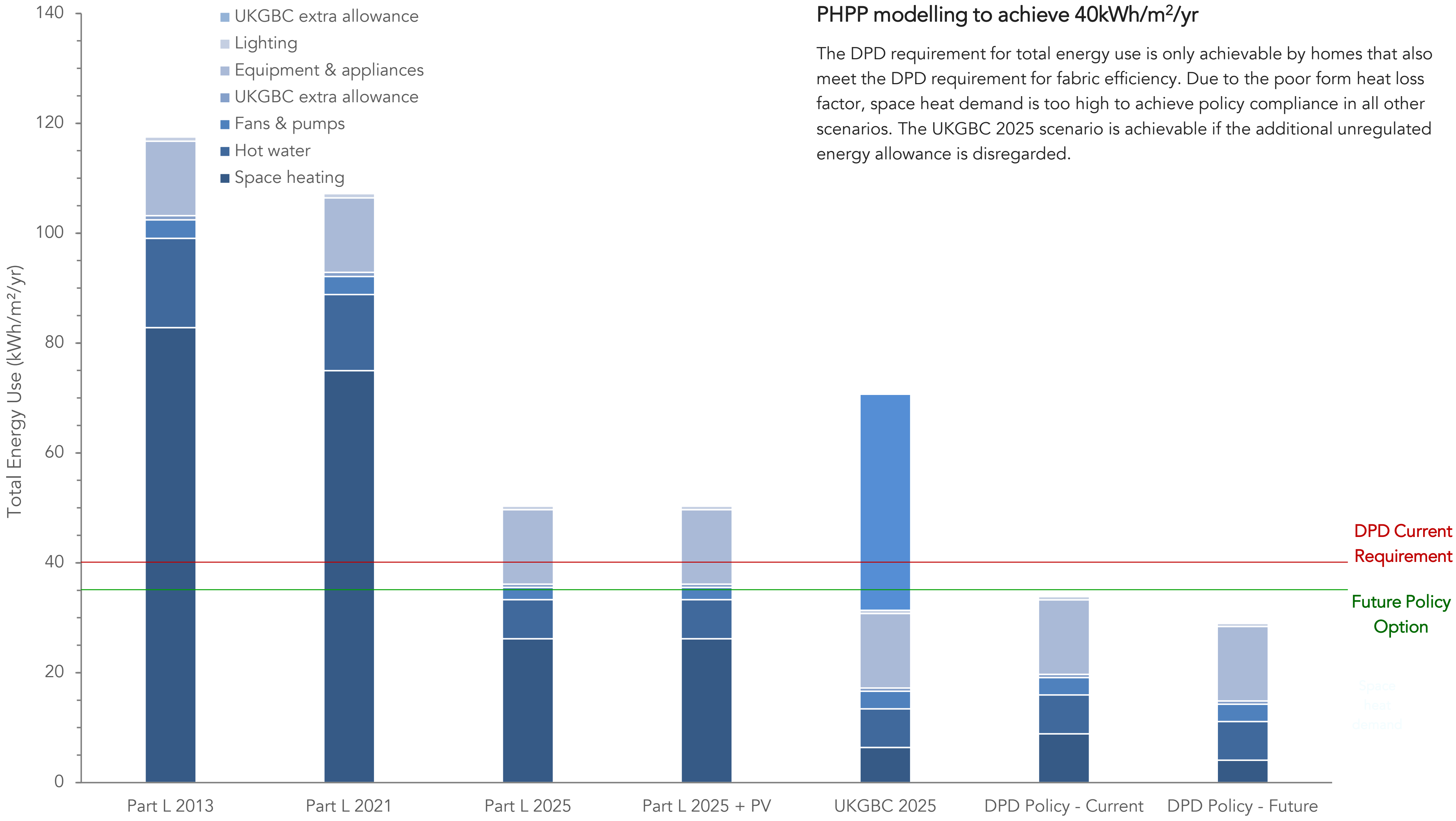
By 2025, we recommend this requirement is further reduced to 15-20kWh/m^2/yr, at which point it would be in line with Climate Change Committee, LETI and RIBA recommendations.

Space heat demand calculated by PHPP 9.6a for each scenario, compared to different policy requirements under consideration.

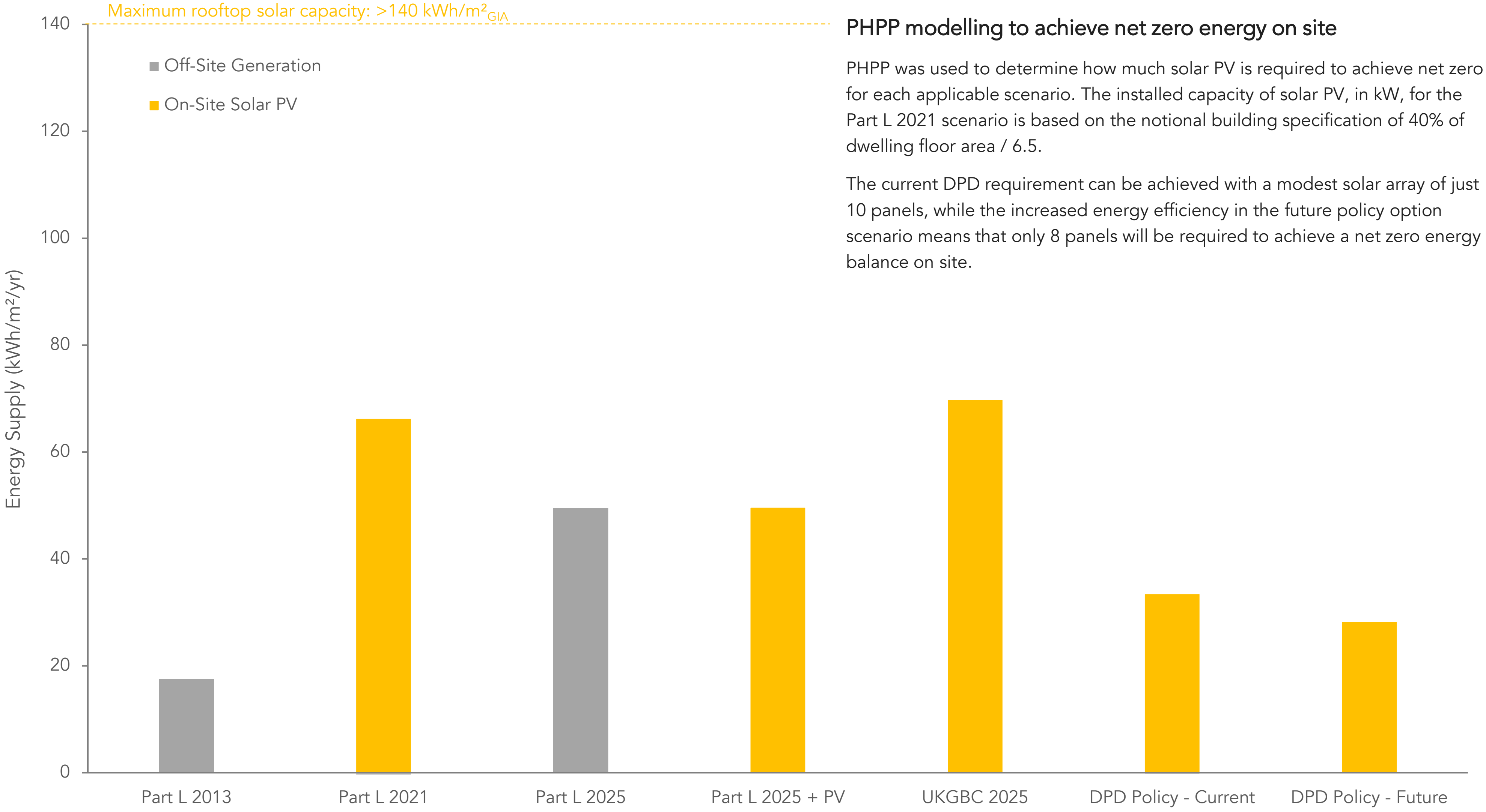
Energy Modelling I Bungalow – DPD requirement for total energy use

PHPP modelling to achieve 40kWh/m²/yr

The DPD requirement for total energy use is only achievable by homes that also meet the DPD requirement for fabric efficiency. Due to the poor form heat loss factor, space heat demand is too high to achieve policy compliance in all other scenarios. The UKGBC 2025 scenario is achievable if the additional unregulated energy allowance is disregarded.



Total energy use calculated by PHPP 9.6a for each scenario.

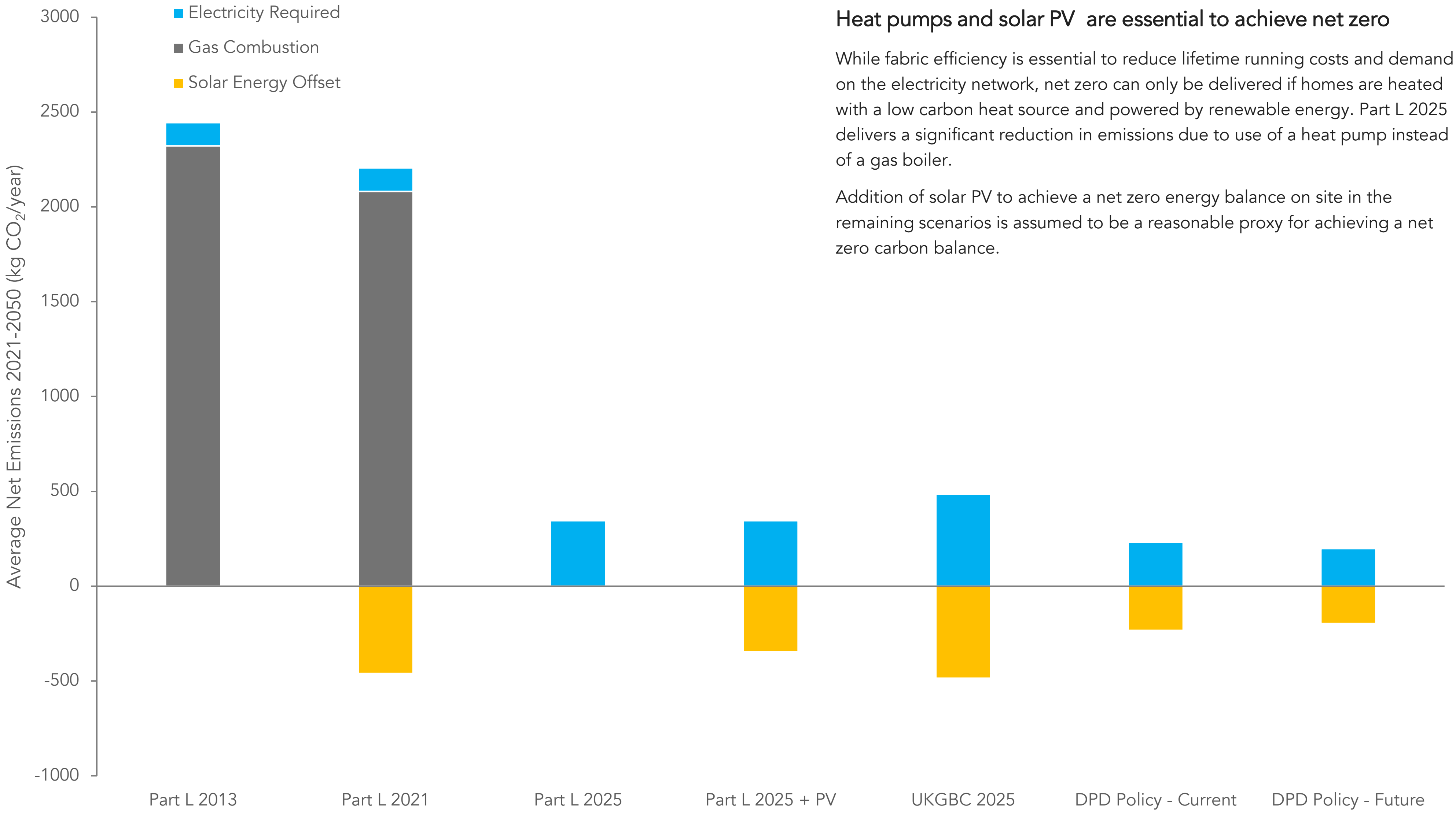


PHPP modelling to achieve net zero energy on site

PHPP was used to determine how much solar PV is required to achieve net zero for each applicable scenario. The installed capacity of solar PV, in kW, for the Part L 2021 scenario is based on the notional building specification of 40% of dwelling floor area / 6.5.

The current DPD requirement can be achieved with a modest solar array of just 10 panels, while the increased energy efficiency in the future policy option scenario means that only 8 panels will be required to achieve a net zero energy balance on site.

On-site solar energy generation calculated by PHPP 9.6a for each scenario. Part L 2013 and 2021 scenarios use a gas boiler, so electricity demand is lower than for other scenarios. Grey bars show off-site electricity generation that must be imported from the electricity grid.



Heat pumps and solar PV are essential to achieve net zero

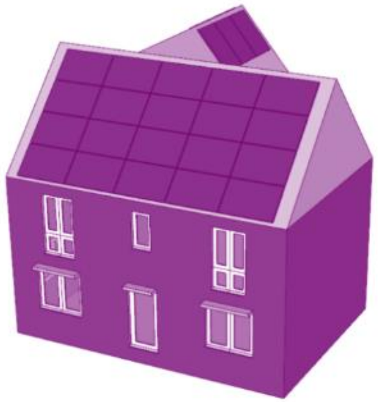
While fabric efficiency is essential to reduce lifetime running costs and demand on the electricity network, net zero can only be delivered if homes are heated with a low carbon heat source and powered by renewable energy. Part L 2025 delivers a significant reduction in emissions due to use of a heat pump instead of a gas boiler.

Addition of solar PV to achieve a net zero energy balance on site in the remaining scenarios is assumed to be a reasonable proxy for achieving a net zero carbon balance.

Average annual net CO_2 emissions for 2021-2050. Assumes 216gCO_2 produced per kWh of gas consumed and electricity carbon intensity figures based on HM Treasury Green Book values.

Detached House

This section contains the specifications, assumptions and modelling results for a detached 4-bedroom house.



This study focuses on six typical housing types to test the impact of different policy approaches. For the detached house, a 4-bedroom home designed by McBains Architecture was selected from a Barrett Homes catalogue that had been submitted in support of a planning application.

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.

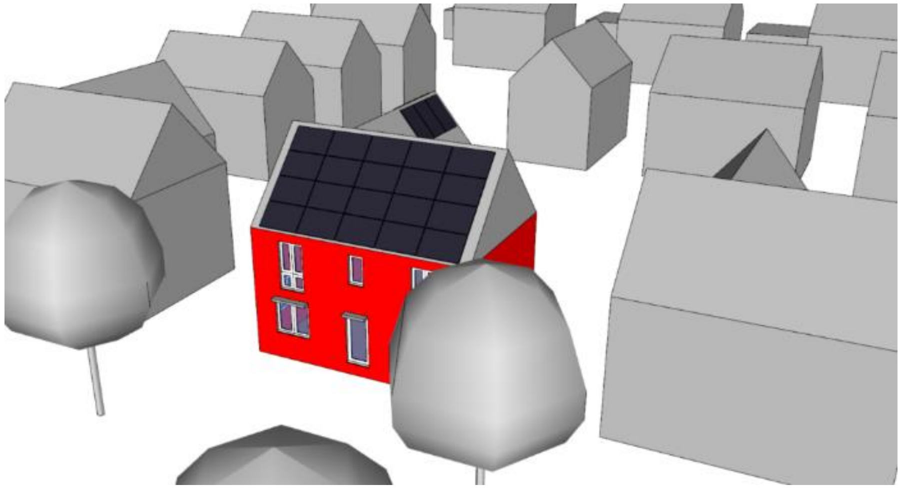
Low carbon heating

The most suitable low carbon heating system is likely to be an air source heat pump, as the property has space both inside and outside for the necessary hardware. A ground source heat pump would also be suitable. Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency. Direct electric heating would not typically achieve the EUI requirement without cost-prohibitive levels of fabric efficiency.

Solar PV

The property has sufficient space for around 22 solar panels with the main roof facing South (between southeast and southwest). This includes allowance for 2 panels on the smaller rear roof section. If the property faced East or West, it would be possible to install more panels on the rear plane of the main roof. The number of panels required to achieve net zero on site ranges from 9 in the future policy option scenario to 22 in the UKGBC 2025 scenario.

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 2.0.06 and used to calculate solar gains and shading for PHPP.

Energy modelling I Detached House Specifications

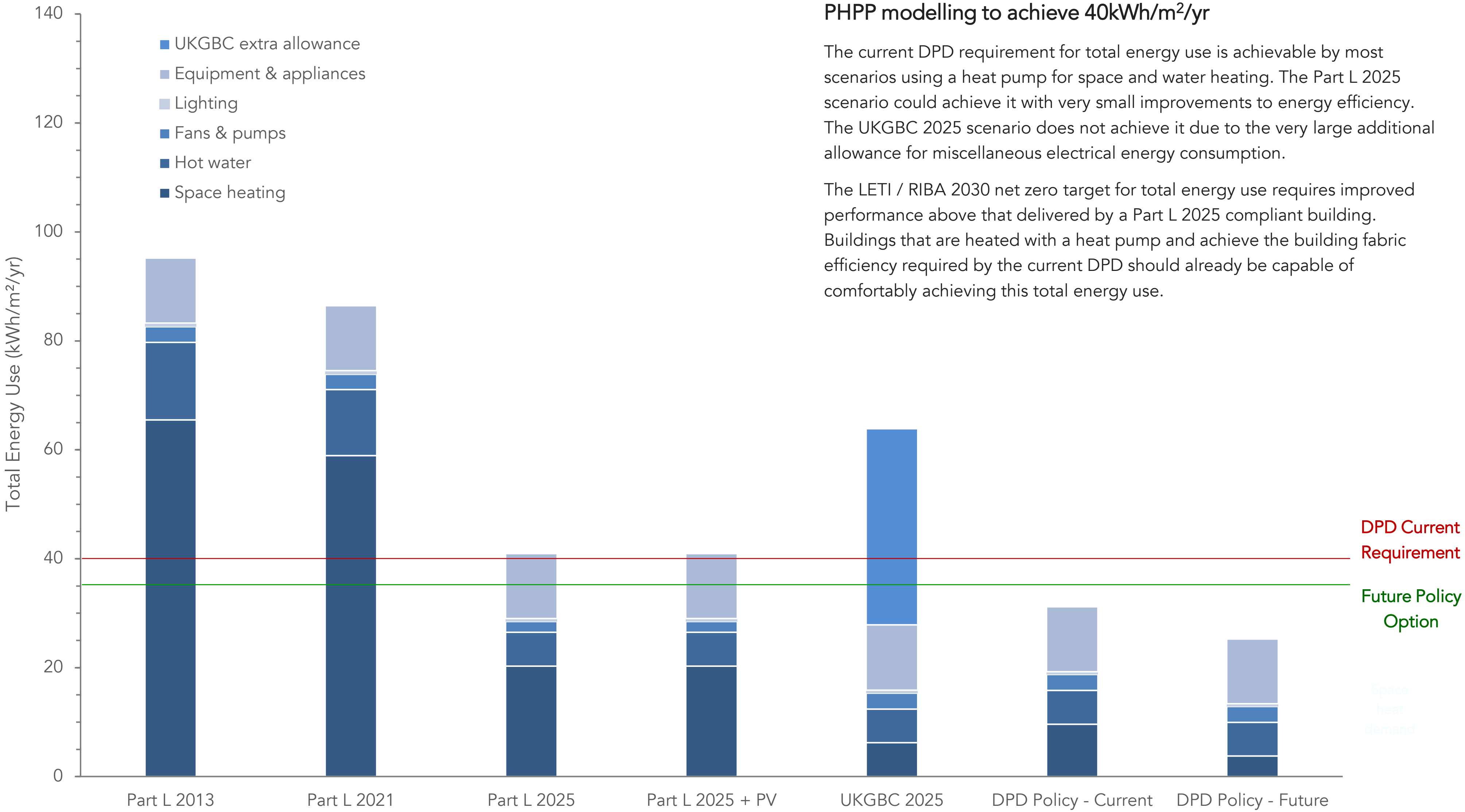
	Part L 2013	Part L 2021	Part L 2025 (FHS)	Part L 2025 (FHS) + PV	UKGBC 2025	DPD Current Policy	Future Policy Option
Description	Typical developer specification to achieve compliance with Part L 2013	Notional building specification for Part L 2021, provided by government	Indicative notional building specification for Part L 2025, provided by government	Indicative notional building specification for Part L 2025, provided by government	15-20 kWh/m²/yr Fabric	Cost optimised fabric with heat pump and solar PV	Passivhaus with heat pump and solar PV
Net zero compliant?	×	×	×	?	?	✓	✓
Floor (W/m²K, SAP adjusted)	0.130	0.130	0.110	0.110	0.110	0.110	0.082
Walls (W/m²K)	0.210	0.180	0.150	0.150	0.110	0.180	0.090
Roof (W/m²K)	0.130	0.110	0.110	0.110	0.090	0.110	0.090
Windows (W/m²K)	1.3 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)
Doors (W/m²K)	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	0.9-1.0	1.0-1.3	0.9-1.0
Thermal bridging (kWh/m²/yr)	3	2	2	2	2	2	2
Air Permeability (m³/m²/hr)	5	5	5	5	1	1	0.66
Ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	MVHR, 88% heat recovery	MVHR, 88% heat recovery	MVHR, 88% heat recovery
Heating System	Gas Boiler	Gas Boiler. Shower drain waste water heat recovery	5kW Monobloc Air Source Heat Pump supplying radiators at 55˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at 55˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at <45˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at 45˚C. 150 litre DHW tank	5kW Monobloc Air Source Heat Pump supplying radiators at <45˚C. 150 litre DHW tank
Solar PV	-	8.8kW	-	5.22kW	8.91kW	3.96kW	3.22kW

PHPP modelling to achieve 30kWh/m²/yr

PHPP modelling indicates the proposed DPD requirement will reduce space heat demand by around half, relative to Part L 2013, 2021 and 2025. While the space heat demand appears to exceed the current DPD policy scenario, it rounds down to remain within the target value.

By 2025, we recommend this requirement is further reduced to 15-20kWh/m²/yr, at which point it would be in line with Climate Change Committee, LETI and RIBA recommendations.

Space heat demand calculated by PHPP 9.6a for each scenario, compared to different policy requirements under consideration.



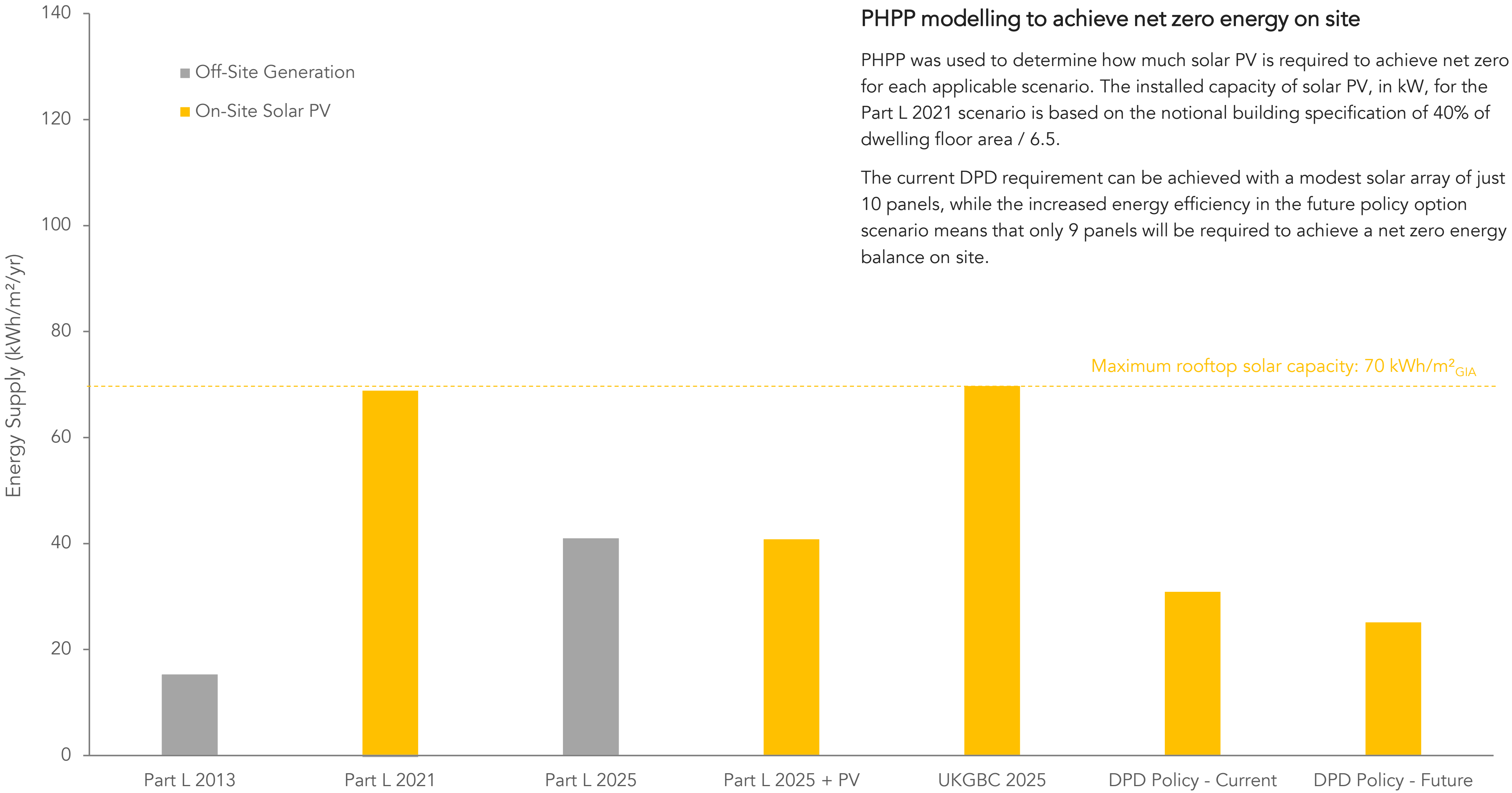
PHPP modelling to achieve 40kWh/m²/yr

The current DPD requirement for total energy use is achievable by most scenarios using a heat pump for space and water heating. The Part L 2025 scenario could achieve it with very small improvements to energy efficiency. The UKGBC 2025 scenario does not achieve it due to the very large additional allowance for miscellaneous electrical energy consumption.

The LETI / RIBA 2030 net zero target for total energy use requires improved performance above that delivered by a Part L 2025 compliant building. Buildings that are heated with a heat pump and achieve the building fabric efficiency required by the current DPD should already be capable of comfortably achieving this total energy use.

Total energy use calculated by PHPP 9.6a for each scenario.

Energy Modelling I Detached house – DPD requirement to achieve net zero energy on site



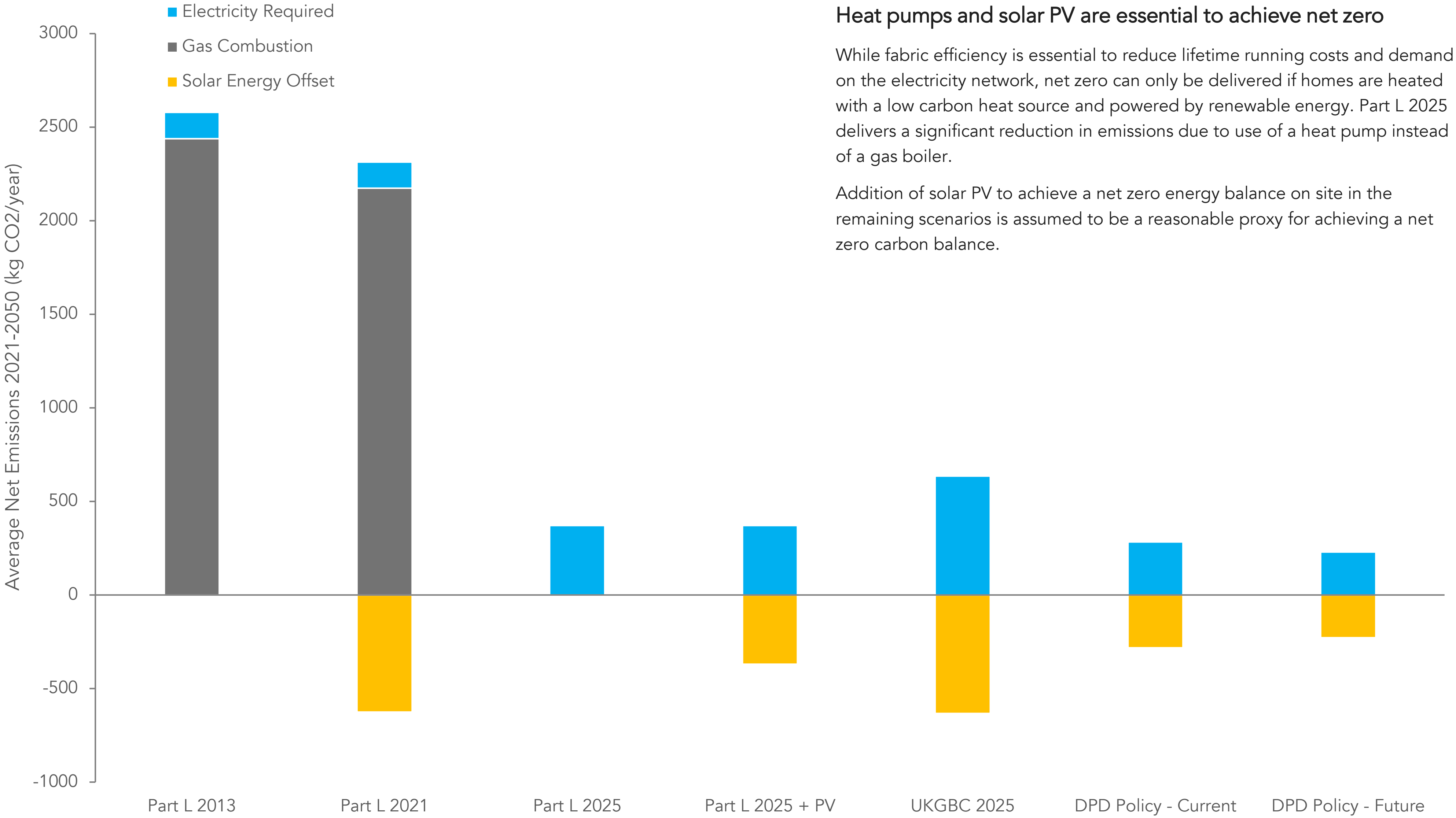
PHPP modelling to achieve net zero energy on site

PHPP was used to determine how much solar PV is required to achieve net zero for each applicable scenario. The installed capacity of solar PV, in kW, for the Part L 2021 scenario is based on the notional building specification of 40% of dwelling floor area / 6.5.

The current DPD requirement can be achieved with a modest solar array of just 10 panels, while the increased energy efficiency in the future policy option scenario means that only 9 panels will be required to achieve a net zero energy balance on site.

On-site solar energy generation calculated by PHPP 9.6a for each scenario. Part L 2013 and 2021 scenarios use a gas boiler, so electricity demand is lower than for other scenarios. Grey bars show off-site electricity generation that must be imported from the electricity grid.

Energy Modelling | Detached house – Operational CO_2 Emissions



Heat pumps and solar PV are essential to achieve net zero

While fabric efficiency is essential to reduce lifetime running costs and demand on the electricity network, net zero can only be delivered if homes are heated with a low carbon heat source and powered by renewable energy. Part L 2025 delivers a significant reduction in emissions due to use of a heat pump instead of a gas boiler.

Addition of solar PV to achieve a net zero energy balance on site in the remaining scenarios is assumed to be a reasonable proxy for achieving a net zero carbon balance.

Average annual net CO_2 emissions for 2021-2050. Assumes 216gCO_2 produced per kWh of gas consumed and electricity carbon intensity figures based on HM Treasury Green Book values.

Low-rise Flats

This section contains the specifications, assumptions and modelling results for a low rise block of 7 flats.

This study focuses on six typical housing types to test the impact of different policy approaches. For the low-rise block of flats a 7-unit building was selected, which had been developed as a new build property.

Building fabric

The property has a gross internal floor area of 641m². The main entrance faces the street to the East Northeast. The property has typical glazing proportions and layout for this type of home. The form heat loss factor of 2.43 is relatively low, as expected for a block of flats.

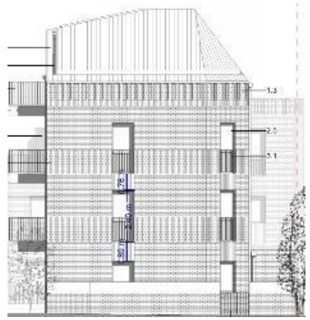
Low carbon heating

The most suitable low carbon heating system is likely to be an air or ground source heat pump. To minimize distribution losses and overheating risk, the system would likely be based around a small individual heat pump in each flat, which would be supplied with water at ambient temperatures via a communal loop. Heat would be fed into the communal loop from a rooftop air source heat pump or ground borehole array. Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency. Direct electric heating would not typically achieve the EUI requirement without cost-prohibitive levels of fabric efficiency.

Solar PV

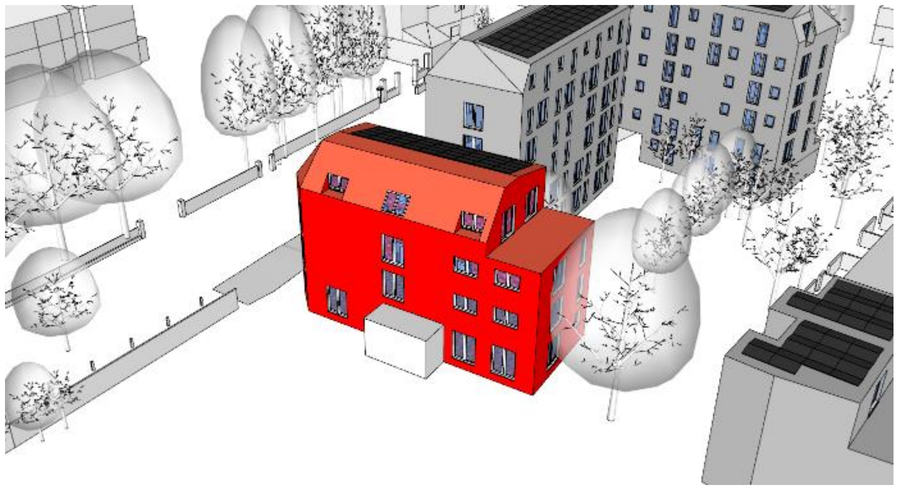
The property has sufficient space for around 70 solar panels assuming they are mounted in an East/West type concertina array. A greater number of panels could be accommodated by optimizing the roof to create a large monopitch solar array. The number of panels required to achieve net zero on site ranges from 48 in the future policy option scenario, to 70 for a building compliant with Part L 2025 that seeks to achieve a net zero energy balance on site. The UKGBC 2025 scenario requires 122 solar panels to achieve a net zero energy balance.

East Elevation



North Elevation

A low-rise block of flats was selected

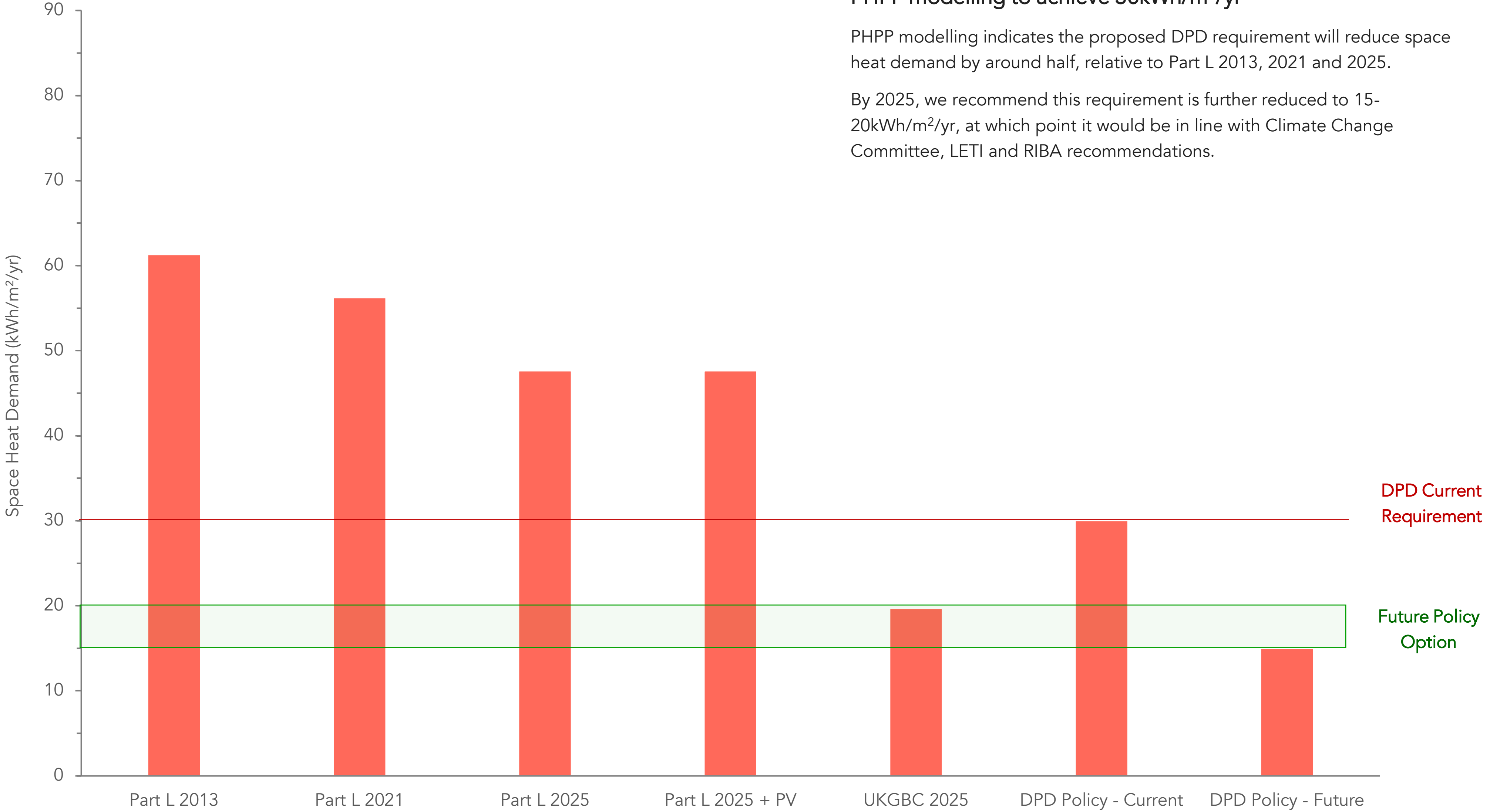


A 3D model of the flats and surrounding features was created in DesignPH 2.0.06 and used to calculate solar gains and shading for PHPP.

Energy modelling I Low-rise Flats Specifications

	Part L 2013	Part L 2021	Part L 2025 (FHS)	Part L 2025 (FHS) + PV	UKGBC 2025	DPD Current Policy	Future Policy Option
Description	Typical developer specification to achieve compliance with Part L 2013	Notional building specification for Part L 2021, provided by government	Indicative notional building specification for Part L 2025, provided by government	Indicative notional building specification for Part L 2025, provided by government	15-20 kWh/m²/yr Fabric	Cost optimised fabric with heat pump and solar PV	Passivhaus with heat pump and solar PV
Net zero compliant?	×	×	×	?	?	✓	✓
Floor (W/m^{2}K, SAP adjusted)	0.130	0.130	0.110	0.110	0.110	0.130	0.087
Walls (W/m^{2}K)	0.210	0.180	0.150	0.150	0.150	0.210	0.130
Roof (W/m^{2}K)	0.130	0.110	0.110	0.110	0.110	0.110	0.100
Windows (W/m^{2}K)	1.3 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)
Doors (W/m^{2}K)	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	0.9-1.0	1.0-1.3	0.9-1.0
Thermal bridging (kWh/m^2/yr)	5	4	4	4	4	5	3
Air Permeability (m^3/m^2/hr)	5	5	5	5	1	1	0.80
Ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	MVHR, 88% heat recovery	MVHR, 88% heat recovery	MVHR, 88% heat recovery
Heating System	Gas Boiler	Gas Boiler. Shower drain waste water heat recovery	Individual heat pumps fed by ambient temp communal loop supplying radiators at 55˚C. 150 litre DHW tank	Individual heat pumps fed by ambient temp communal loop supplying radiators at 55˚C. 150 litre DHW tank	Individual heat pumps fed by ambient temp communal loop supplying radiators at <45˚C. 150 litre DHW tank	Individual heat pumps fed by ambient temp communal loop supplying radiators at 45˚C. 150 litre DHW tank	Individual heat pumps fed by ambient temp communal loop supplying radiators at <45˚C. 150 litre DHW tank
Solar PV	-	7.20kW	-	26.95kW	48.80kW	22.68kW	19.20kW

Energy Modelling | Low-rise Flats – DPD requirement for space heating demand



PHPP modelling to achieve 30kWh/m²/yr

PHPP modelling indicates the proposed DPD requirement will reduce space heat demand by around half, relative to Part L 2013, 2021 and 2025.

By 2025, we recommend this requirement is further reduced to 15-20kWh/m²/yr, at which point it would be in line with Climate Change Committee, LETI and RIBA recommendations.

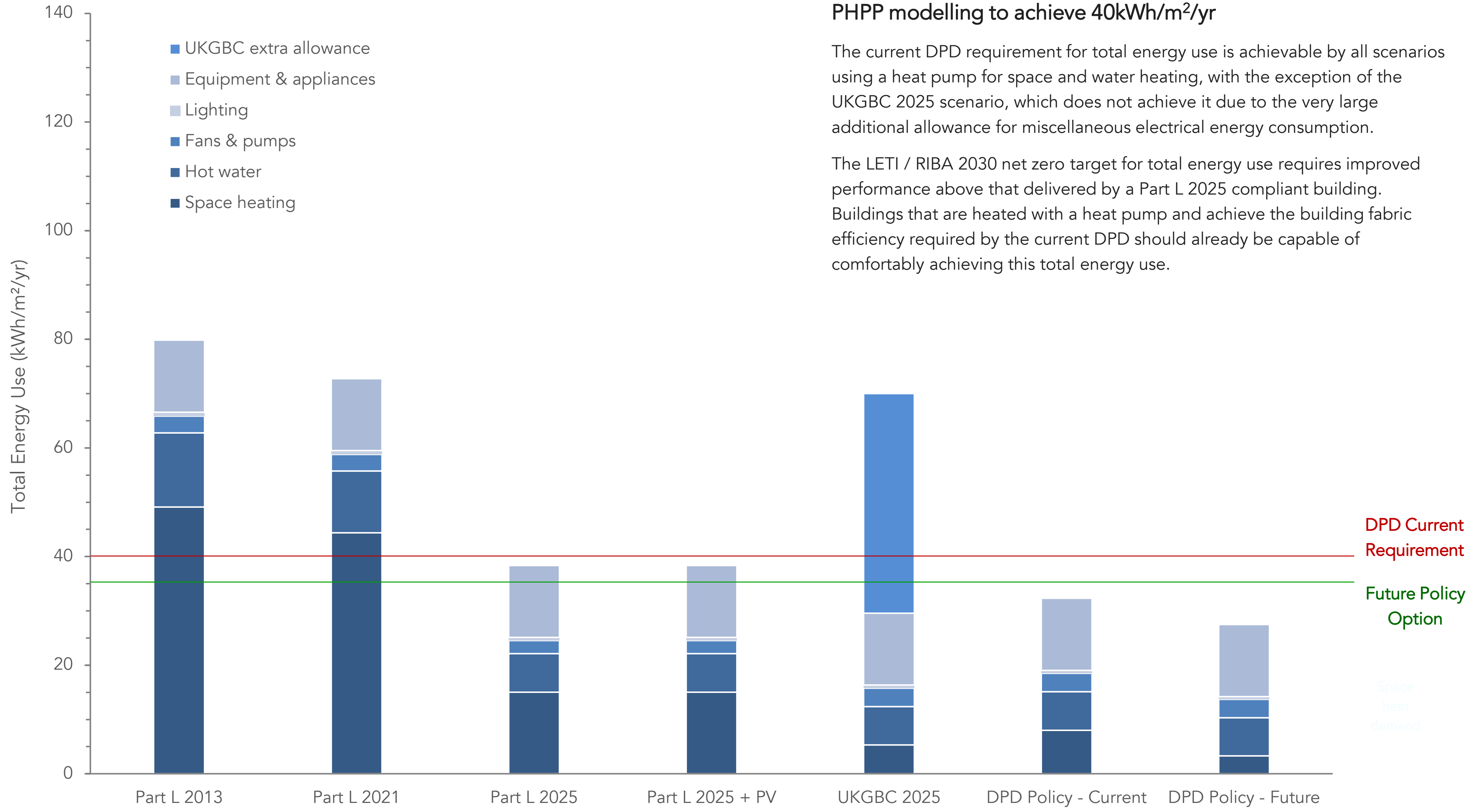
Space heat demand calculated by PHPP 9.6a for each scenario, compared to different policy requirements under consideration.

Energy Modelling | Low-rise Flats – DPD requirement for total energy use

PHPP modelling to achieve 40kWh/m²/yr

The current DPD requirement for total energy use is achievable by all scenarios using a heat pump for space and water heating, with the exception of the UKGBC 2025 scenario, which does not achieve it due to the very large additional allowance for miscellaneous electrical energy consumption.

The LETI / RIBA 2030 net zero target for total energy use requires improved performance above that delivered by a Part L 2025 compliant building. Buildings that are heated with a heat pump and achieve the building fabric efficiency required by the current DPD should already be capable of comfortably achieving this total energy use.

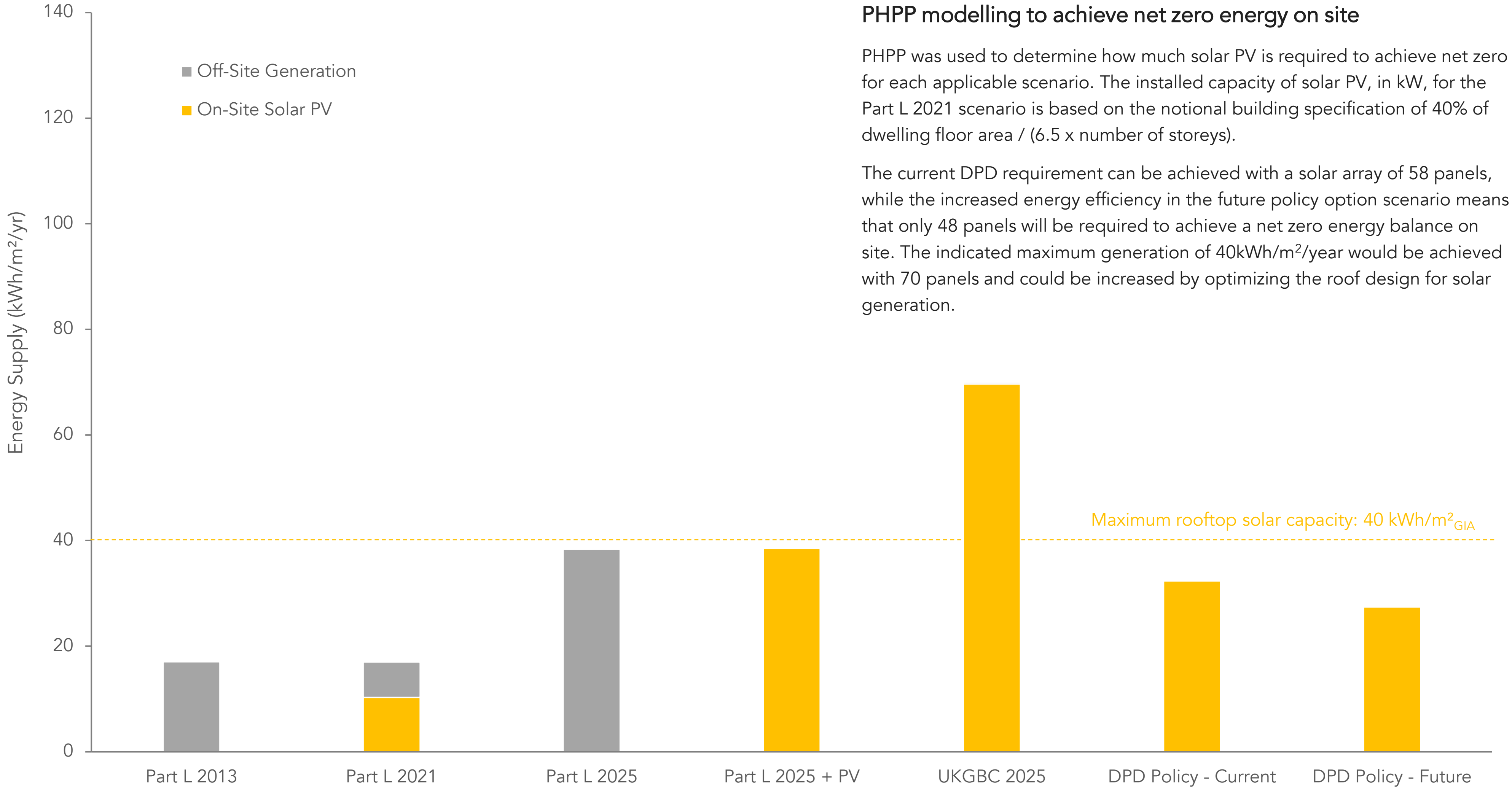


Total energy use calculated by PHPP 9.6a for each scenario.

PHPP modelling to achieve net zero energy on site

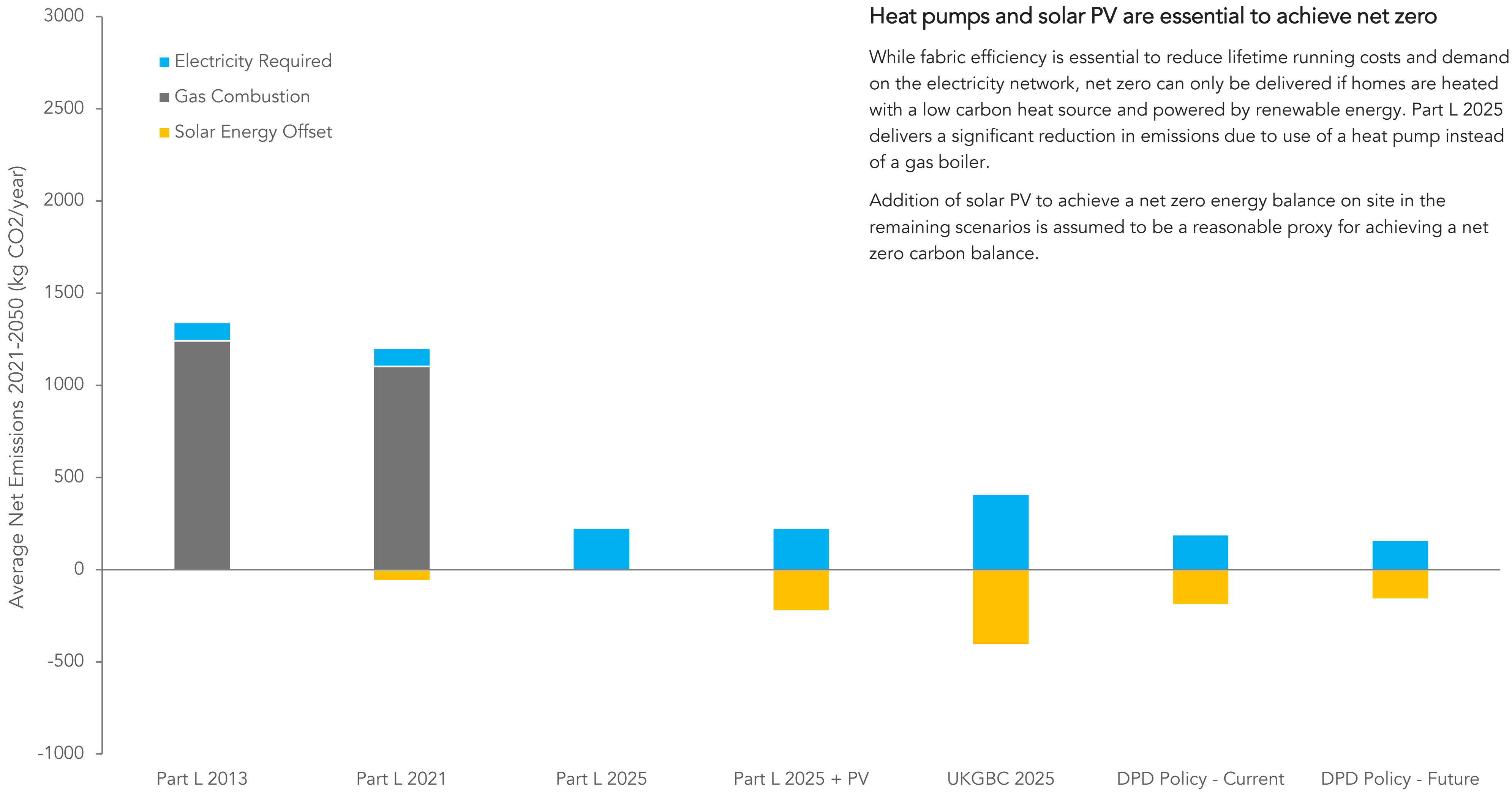
PHPP was used to determine how much solar PV is required to achieve net zero for each applicable scenario. The installed capacity of solar PV, in kW, for the Part L 2021 scenario is based on the notional building specification of 40% of dwelling floor area / (6.5 x number of storeys).

The current DPD requirement can be achieved with a solar array of 58 panels, while the increased energy efficiency in the future policy option scenario means that only 48 panels will be required to achieve a net zero energy balance on site. The indicated maximum generation of 40kWh/m^2/year would be achieved with 70 panels and could be increased by optimizing the roof design for solar generation.



On-site solar energy generation calculated by PHPP 9.6a for each scenario. Part L 2013 and 2021 scenarios use a gas boiler, so electricity demand is lower than for other scenarios. Grey bars show off-site electricity generation that must be imported from the electricity grid.

Energy Modelling | Low-rise Flats – Operational CO_2 Emissions



Heat pumps and solar PV are essential to achieve net zero

While fabric efficiency is essential to reduce lifetime running costs and demand on the electricity network, net zero can only be delivered if homes are heated with a low carbon heat source and powered by renewable energy. Part L 2025 delivers a significant reduction in emissions due to use of a heat pump instead of a gas boiler.

Addition of solar PV to achieve a net zero energy balance on site in the remaining scenarios is assumed to be a reasonable proxy for achieving a net zero carbon balance.

Average annual net CO_2 emissions for 2021-2050. Assumes 216gCO_2 produced per kWh of gas consumed and electricity carbon intensity figures based on HM Treasury Green Book values.

Medium-rise Flats

This section contains the specifications, assumptions and modelling results for a medium-rise block of 20 flats.

This study focuses on six typical housing types to test the impact of different policy approaches. For the mid-rise block of flats a 20-unit building was selected, which had been developed as a new build property.

Building fabric

The property has a gross internal floor area of 1,590m². The main entrance faces the street to the East Northeast. The property has typical glazing proportions and layout for this type of home. The form heat loss factor of 2.04 is very low, as expected for a large block of flats with a straightforward design.

Low carbon heating

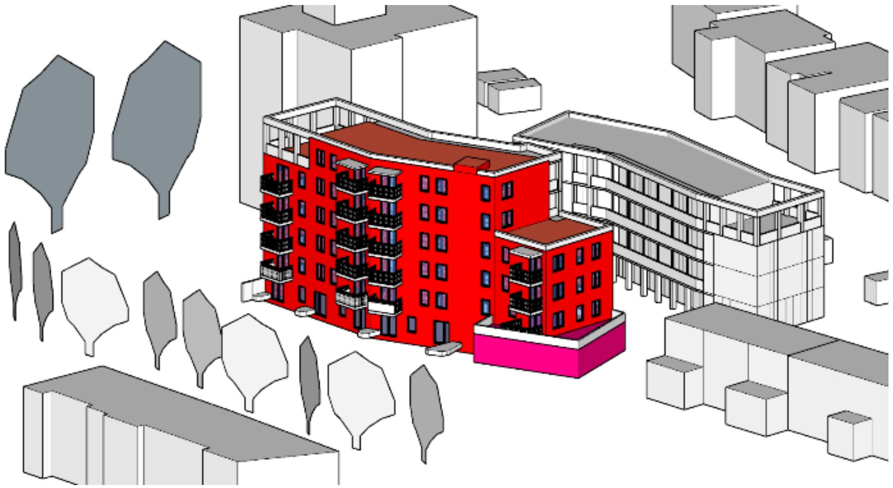
The most suitable low carbon heating system is likely to be an air or ground source heat pump. To minimize distribution losses and overheating risk, the system would likely be based around a small individual heat pump in each flat, which would be supplied with water at ambient temperatures via a communal loop. Heat would be fed into the communal loop from a rooftop air source heat pump or ground borehole array. Suitable heat emitters include radiators, or underfloor heating for scenarios with poorer fabric efficiency. Direct electric heating would not typically achieve the EUI requirement without cost-prohibitive levels of fabric efficiency.

Solar PV

The property has sufficient space for around 128 solar panels assuming they are mounted in an East/West type concertina array. A greater number of panels could be accommodated by optimizing the roof to create a large monopitch solar array, or by adding more roof area to the Northern rooftop terrace. The number of panels required to achieve net zero on site ranges from 120 in the future policy option scenario, to 154 for a building compliant with Part L 2025 that seeks to achieve a net zero energy balance on site. The UKGBC 2025 scenario requires 304 solar panels to achieve a net zero energy balance.

North Elevation *East Elevation*

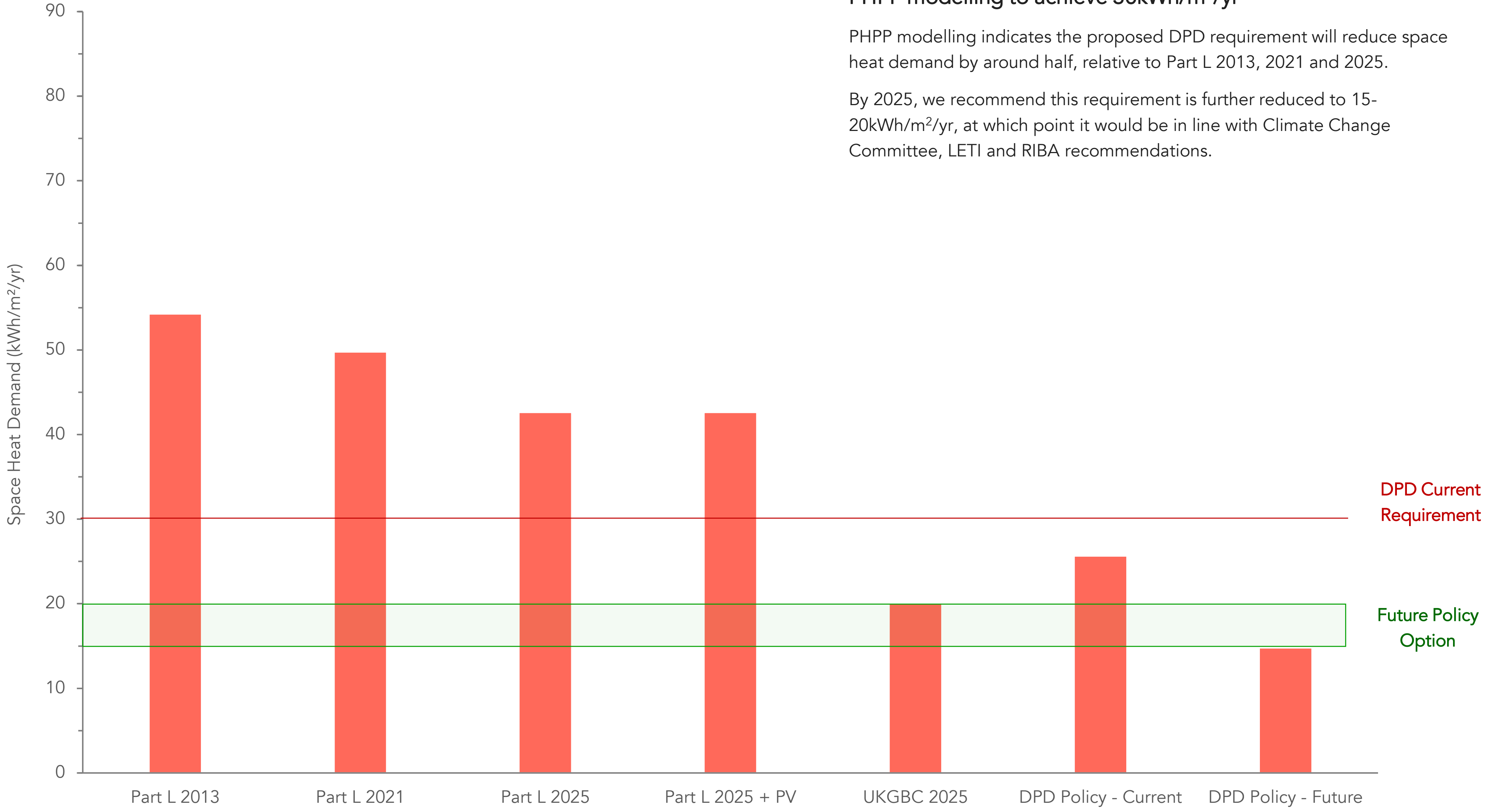
A mid-rise block of flats was selected



A 3D model of the flats and surrounding features was created in DesignPH 2.0.06 and used to calculate solar gains and shading for PHPP.

Energy modelling I Mid-rise Flats Specifications

	Part L 2013	Part L 2021	Part L 2025 (FHS)	Part L 2025 (FHS) + PV	UKGBC 2025	DPD Current Policy	Future Policy Option
Description	Typical developer specification to achieve compliance with Part L 2013	Notional building specification for Part L 2021, provided by government	Indicative notional building specification for Part L 2025, provided by government	Indicative notional building specification for Part L 2025, provided by government	15-20 kWh/m²/yr Fabric	Cost optimised fabric with heat pump and solar PV	Passivhaus with heat pump and solar PV
Net zero compliant?	×	×	×	?	?	✓	✓
Floor (W/m^{2}K, SAP adjusted)	0.130	0.130	0.110	0.110	0.110	0.130	0.130
Walls (W/m^{2}K)	0.210	0.180	0.150	0.150	0.210	0.210	0.150
Roof (W/m^{2}K)	0.130	0.110	0.110	0.110	0.110	0.130	0.110
Windows (W/m^{2}K)	1.3 (double-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	0.8 (triple-glazed)	1.2 (double-glazed)	0.8 (triple-glazed)
Doors (W/m^{2}K)	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	1.0 – 1.3	0.9-1.0	1.0-1.3	0.9-1.0
Thermal bridging (kWh/m^2/yr)	5	4	4	4	4	5	3
Air Permeability (m^3/m^2/hr)	5	5	5	5	1	1	0.88
Ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	Positive input mechanical ventilation	MVHR, 88% heat recovery	MVHR, 88% heat recovery	MVHR, 88% heat recovery
Heating System	Gas Boiler	Gas Boiler. Shower drain waste water heat recovery	Individual heat pumps fed by ambient temp communal loop supplying radiators at 55˚C. 150 litre DHW tank	Individual heat pumps fed by ambient temp communal loop supplying radiators at 55˚C. 150 litre DHW tank	Individual heat pumps fed by ambient temp communal loop supplying radiators at <45˚C. 150 litre DHW tank	Individual heat pumps fed by ambient temp communal loop supplying radiators at 45˚C. 150 litre DHW tank	Individual heat pumps fed by ambient temp communal loop supplying radiators at <45˚C. 150 litre DHW tank
Solar PV	-	12.80kW	-	61.60kW	122.60kW	52.80kW	47.40kW



PHPP modelling to achieve 30kWh/m^2/yr

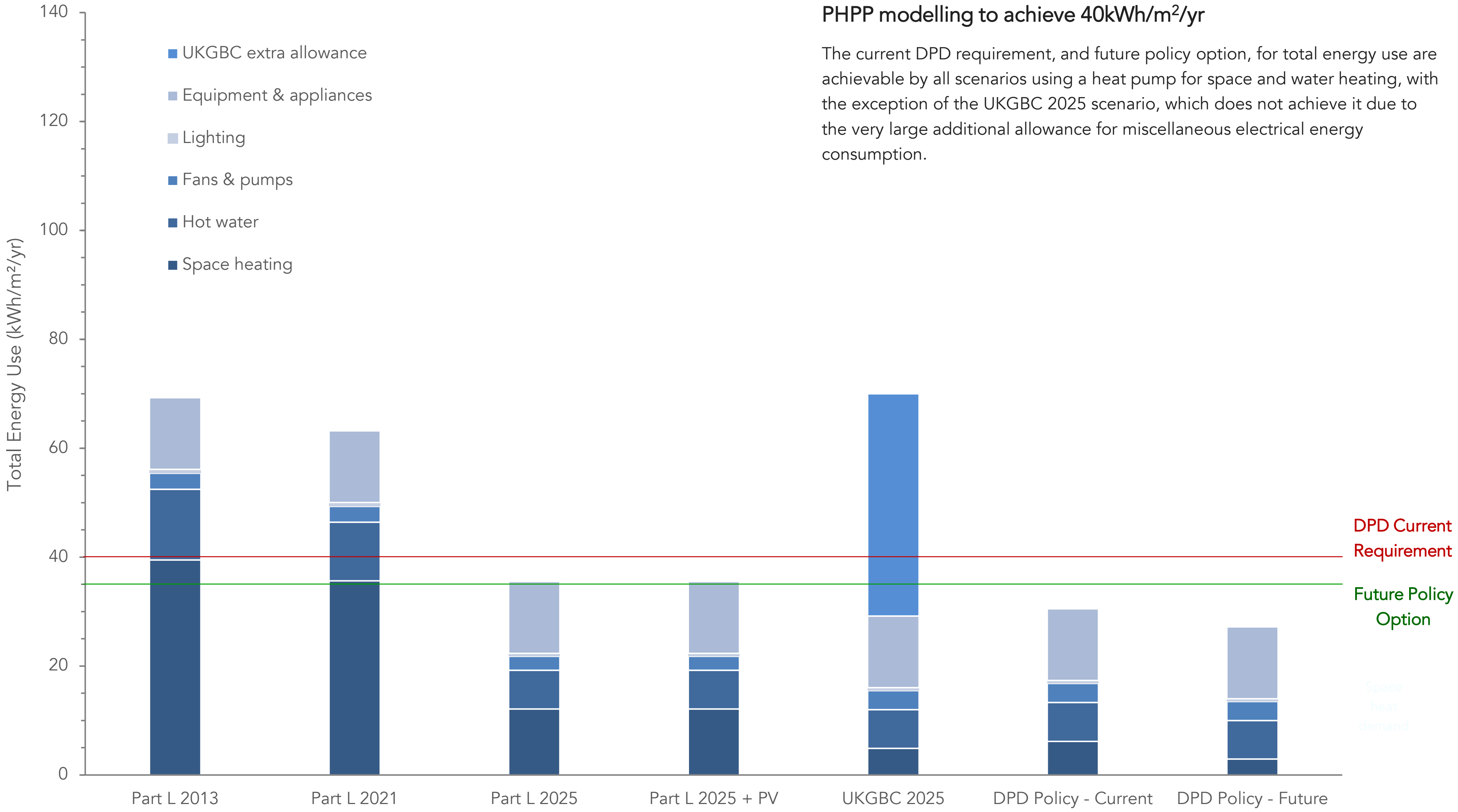
PHPP modelling indicates the proposed DPD requirement will reduce space heat demand by around half, relative to Part L 2013, 2021 and 2025.

By 2025, we recommend this requirement is further reduced to 15-20kWh/m^2/yr, at which point it would be in line with Climate Change Committee, LETI and RIBA recommendations.

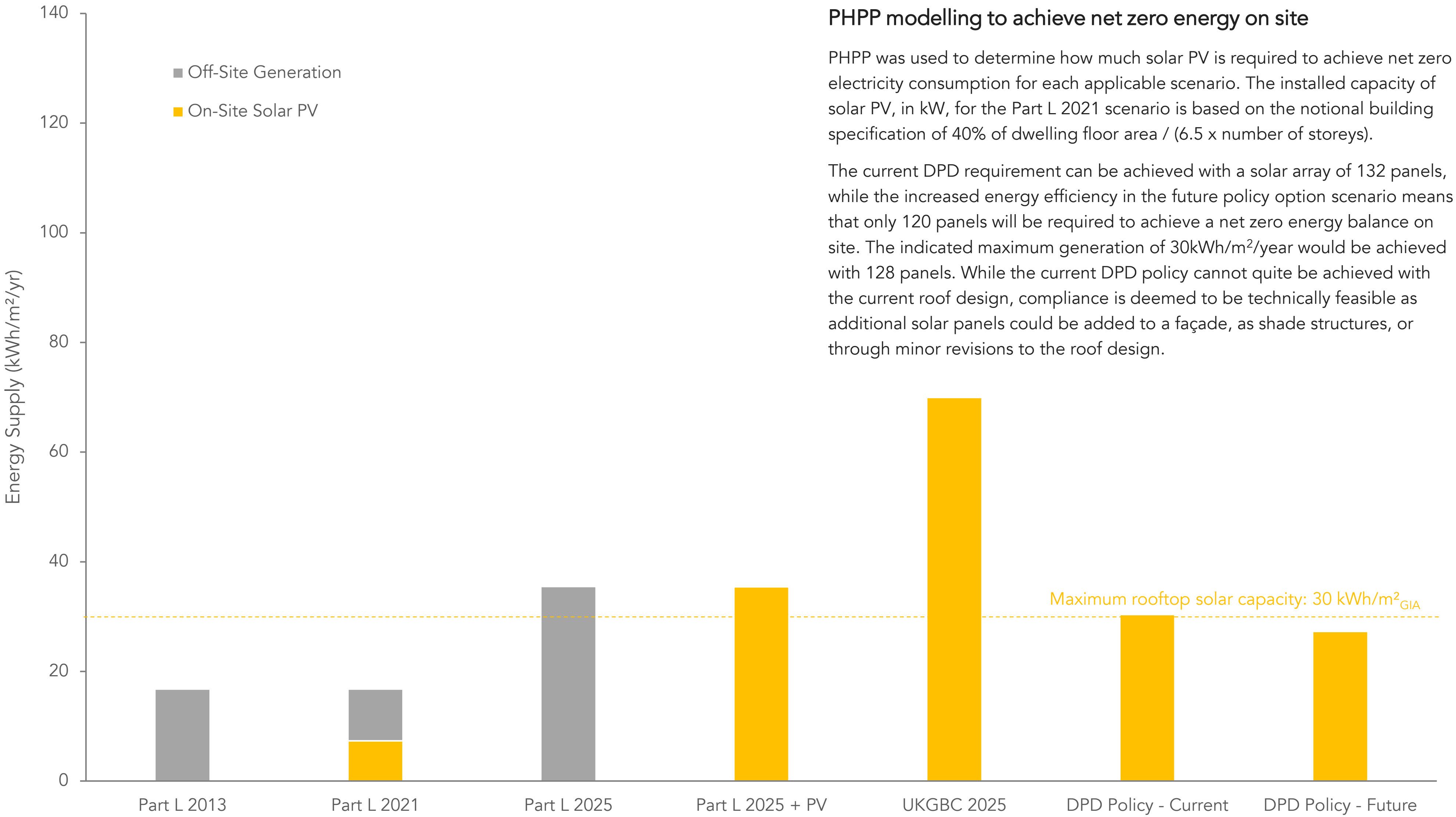
Space heat demand calculated by PHPP 9.6a for each scenario, compared to different policy requirements under consideration.

PHPP modelling to achieve 40kWh/m²/yr

The current DPD requirement, and future policy option, for total energy use are achievable by all scenarios using a heat pump for space and water heating, with the exception of the UKGBC 2025 scenario, which does not achieve it due to the very large additional allowance for miscellaneous electrical energy consumption.



Total energy use calculated by PHPP 9.6a for each scenario.

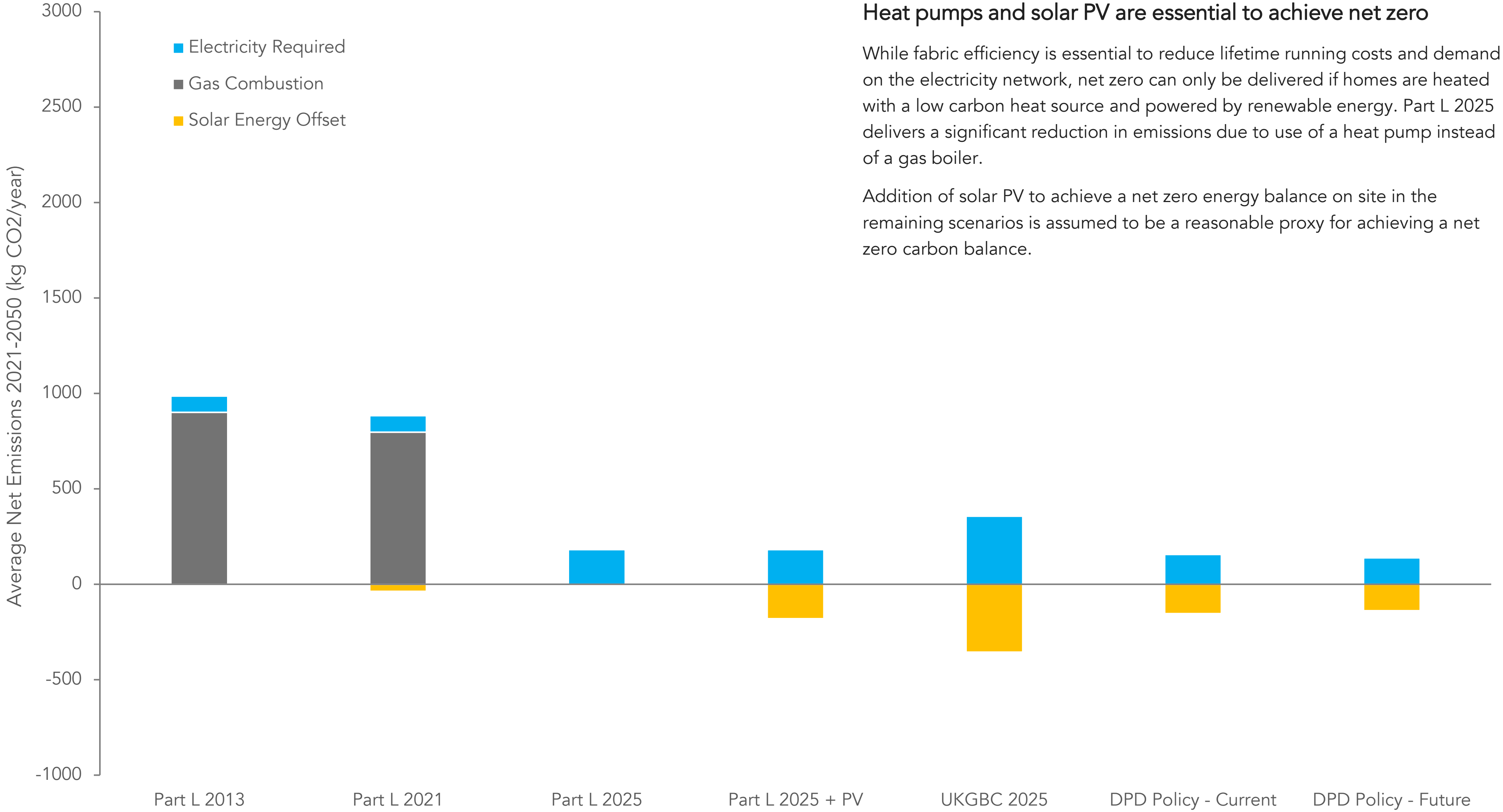


PHPP modelling to achieve net zero energy on site

PHPP was used to determine how much solar PV is required to achieve net zero electricity consumption for each applicable scenario. The installed capacity of solar PV, in kW, for the Part L 2021 scenario is based on the notional building specification of 40% of dwelling floor area / (6.5 x number of storeys).

The current DPD requirement can be achieved with a solar array of 132 panels, while the increased energy efficiency in the future policy option scenario means that only 120 panels will be required to achieve a net zero energy balance on site. The indicated maximum generation of 30kWh/m^2/year would be achieved with 128 panels. While the current DPD policy cannot quite be achieved with the current roof design, compliance is deemed to be technically feasible as additional solar panels could be added to a façade, as shade structures, or through minor revisions to the roof design.

On-site solar energy generation calculated by PHPP 9.6a for each scenario. Part L 2013 and 2021 scenarios use a gas boiler, so electricity demand is lower than for other scenarios. Grey bars show off-site electricity generation that must be imported from the electricity grid.



Heat pumps and solar PV are essential to achieve net zero

While fabric efficiency is essential to reduce lifetime running costs and demand on the electricity network, net zero can only be delivered if homes are heated with a low carbon heat source and powered by renewable energy. Part L 2025 delivers a significant reduction in emissions due to use of a heat pump instead of a gas boiler.

Addition of solar PV to achieve a net zero energy balance on site in the remaining scenarios is assumed to be a reasonable proxy for achieving a net zero carbon balance.

Average annual net CO_2 emissions for 2021-2050. Assumes 216gCO_2 produced per kWh of gas consumed and electricity carbon intensity figures based on HM Treasury Green Book values.

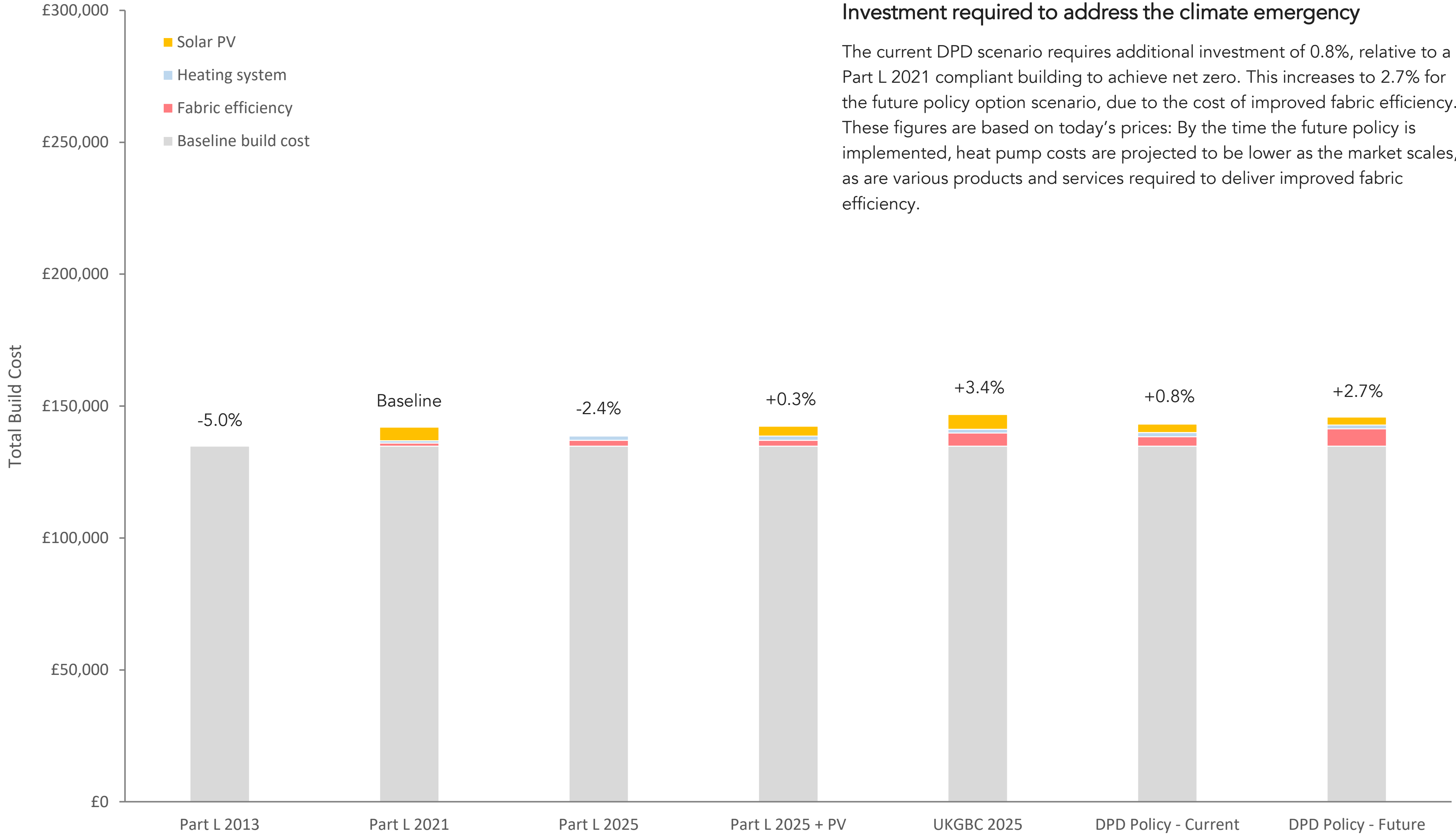
3.0

Cost assessment

For each building type and policy scenario, this section presents:

- Capital costs (assuming a typical level of fit out and specification)
- Operational energy costs

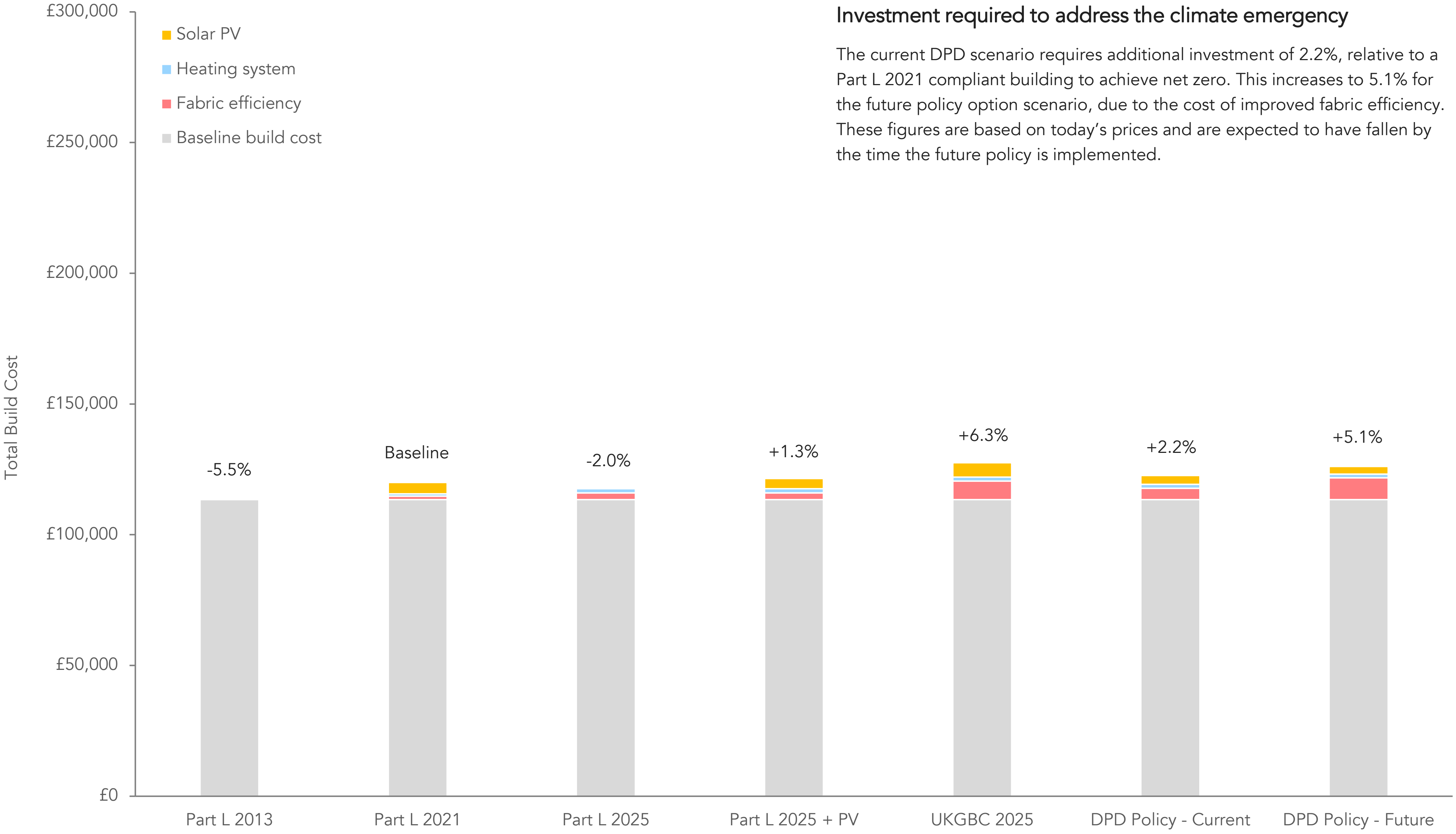
Cost Modelling | Semi-detached house – Capital cost comparison



Investment required to address the climate emergency

The current DPD scenario requires additional investment of 0.8%, relative to a Part L 2021 compliant building to achieve net zero. This increases to 2.7% for the future policy option scenario, due to the cost of improved fabric efficiency. These figures are based on today's prices: By the time the future policy is implemented, heat pump costs are projected to be lower as the market scales, as are various products and services required to deliver improved fabric efficiency.

Total build costs for the terraced house based on analysis by Currie and Brown. Percentage cost uplift relative to a Part L 2021 compliant building is also shown.

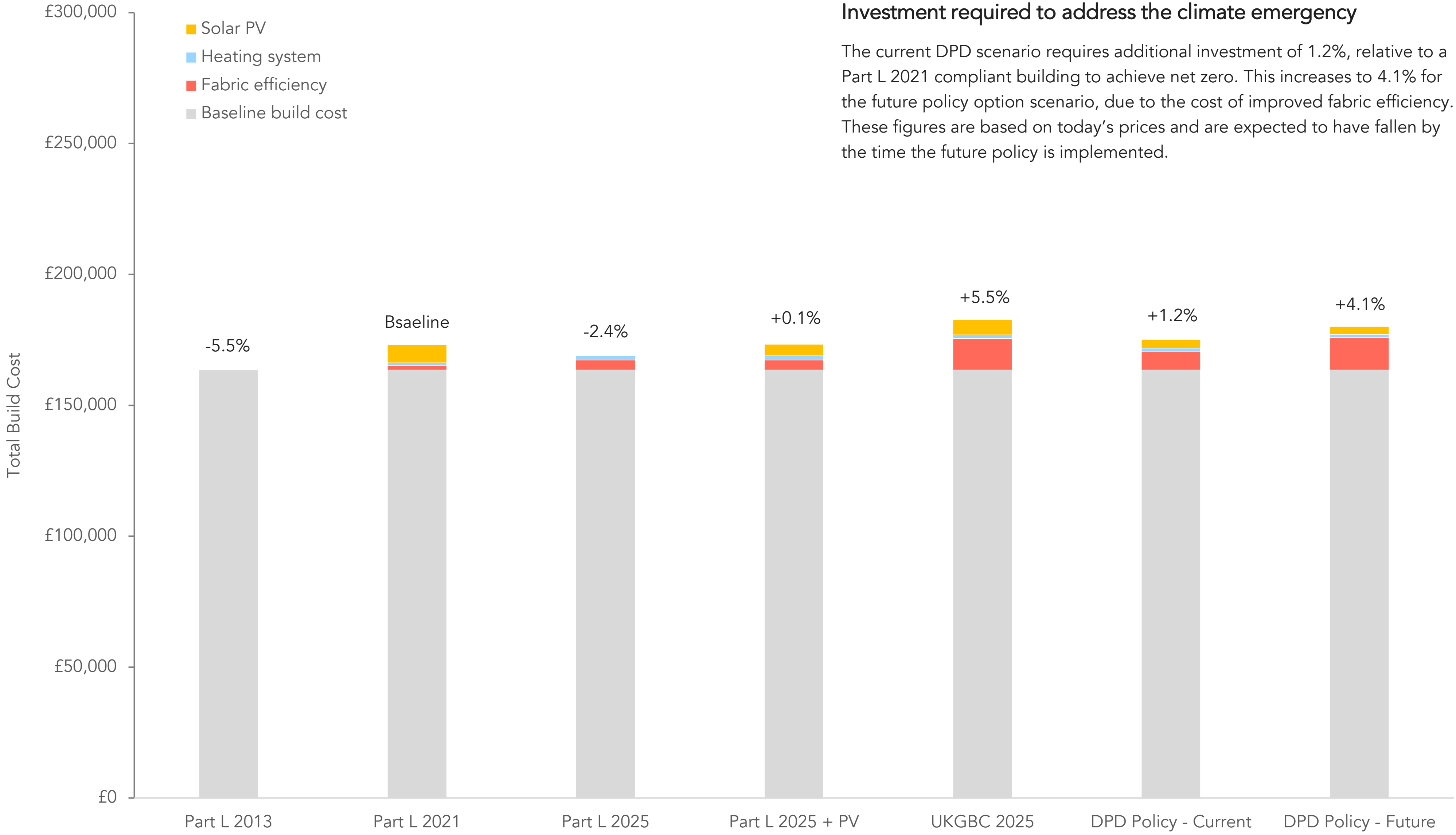


Investment required to address the climate emergency

The current DPD scenario requires additional investment of 2.2%, relative to a Part L 2021 compliant building to achieve net zero. This increases to 5.1% for the future policy option scenario, due to the cost of improved fabric efficiency. These figures are based on today's prices and are expected to have fallen by the time the future policy is implemented.

Total build costs for the terraced house based on analysis by Currie and Brown. Percentage cost uplift relative to a Part L 2021 compliant building is also shown.

Cost Modelling I Bungalow – Capital cost comparison

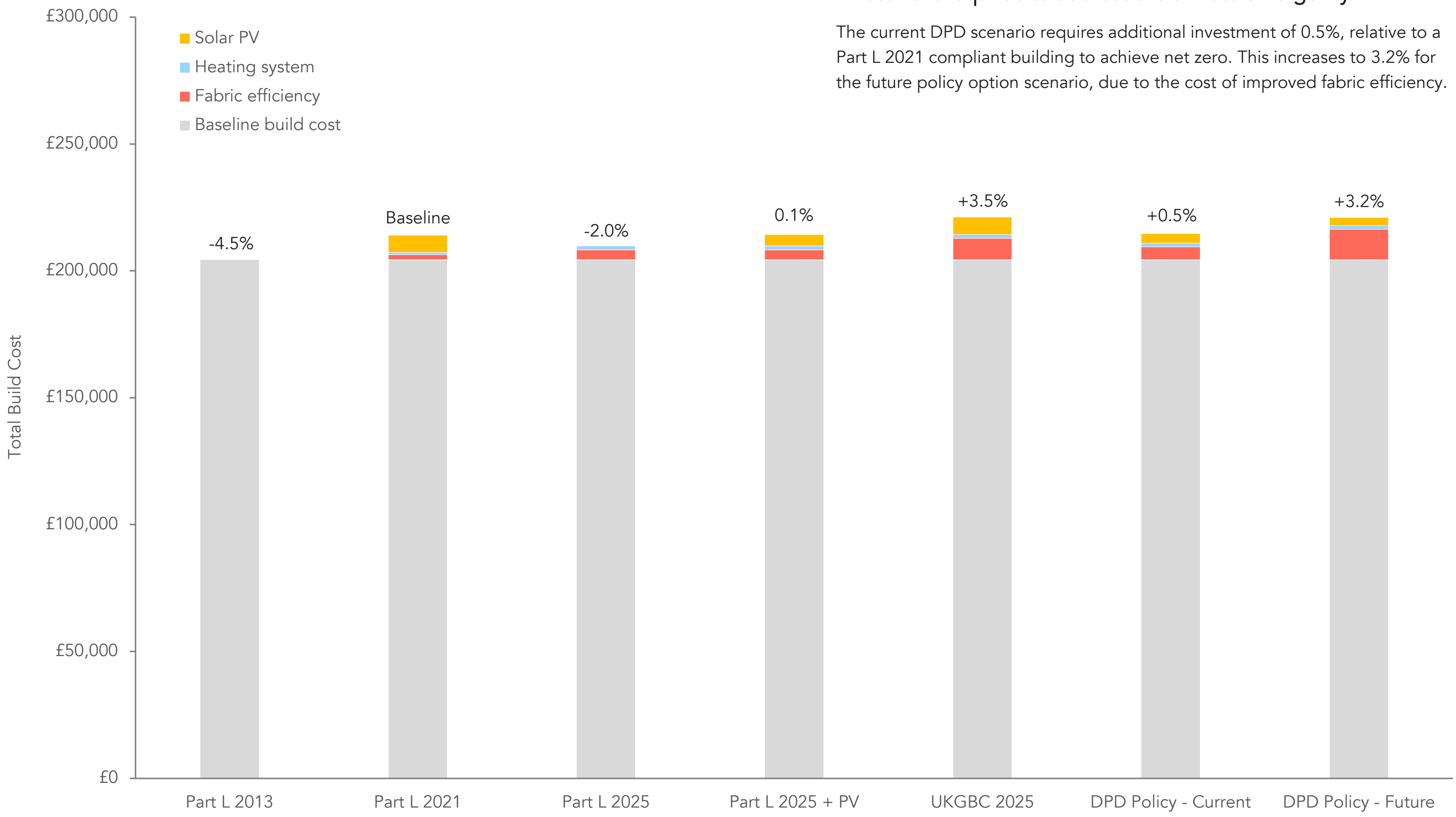


Investment required to address the climate emergency

The current DPD scenario requires additional investment of 1.2%, relative to a Part L 2021 compliant building to achieve net zero. This increases to 4.1% for the future policy option scenario, due to the cost of improved fabric efficiency. These figures are based on today's prices and are expected to have fallen by the time the future policy is implemented.

Total build costs for the bungalow based on analysis by Currie and Brown. Percentage cost uplift relative to a Part L 2021 compliant building is also shown.

Cost Modelling I Detached house – Capital cost comparison

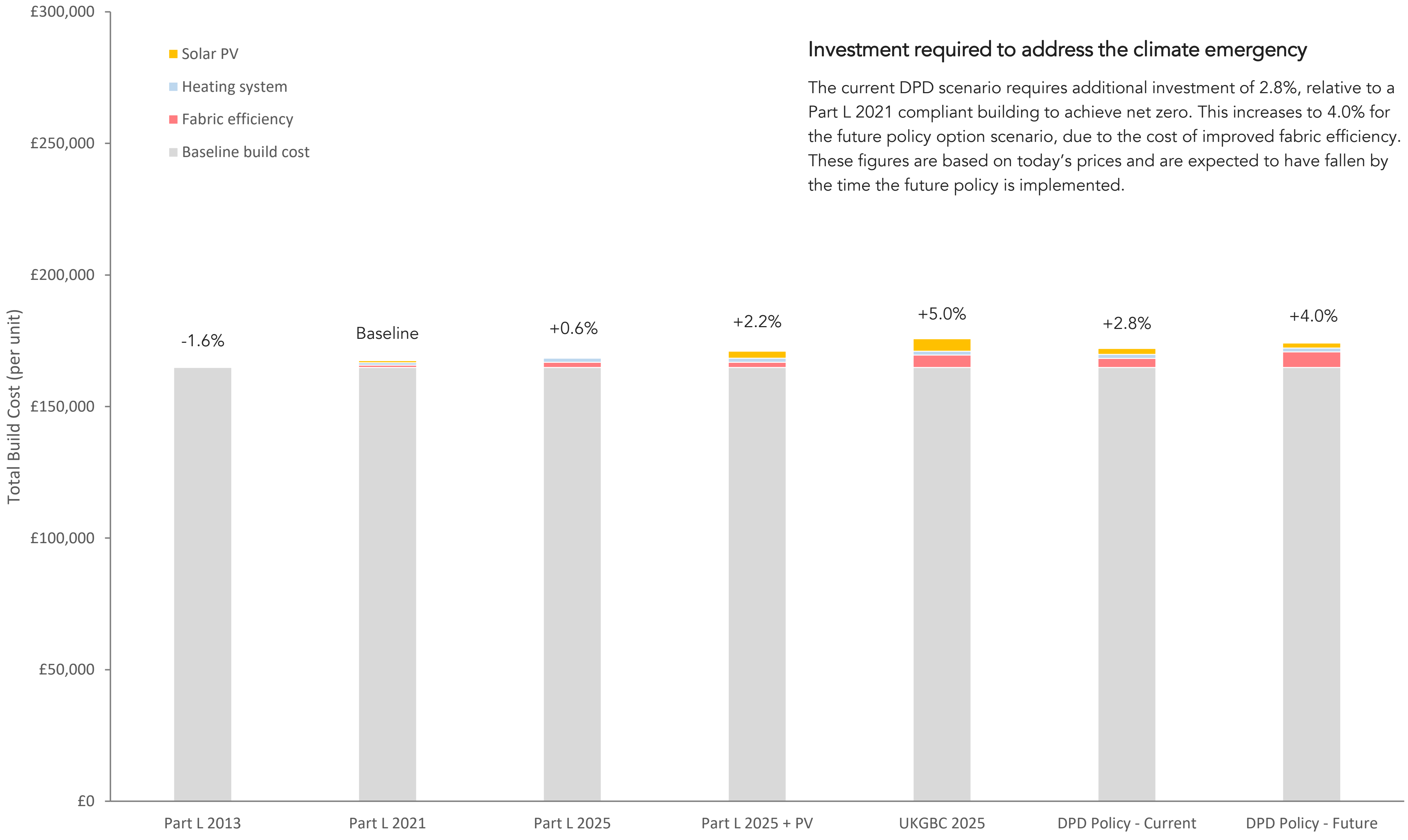


Investment required to address the climate emergency

The current DPD scenario requires additional investment of 0.5%, relative to a Part L 2021 compliant building to achieve net zero. This increases to 3.2% for the future policy option scenario, due to the cost of improved fabric efficiency.

Total build costs for the detached house based on analysis by Currie and Brown. Percentage cost uplift relative to a Part L 2021 compliant building is also shown.

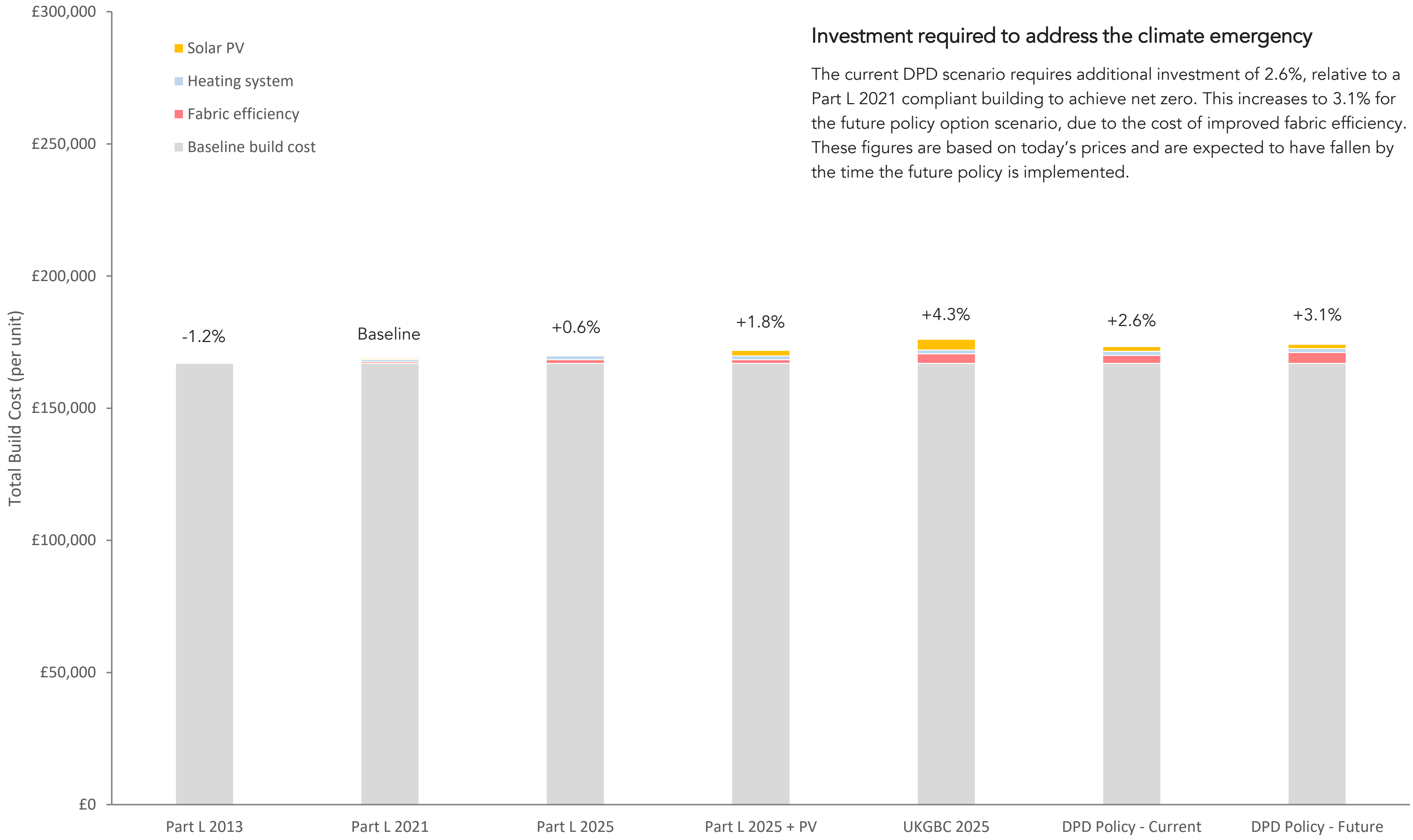
Cost Modelling | Low-rise Flats – Capital cost comparison



Investment required to address the climate emergency

The current DPD scenario requires additional investment of 2.8%, relative to a Part L 2021 compliant building to achieve net zero. This increases to 4.0% for the future policy option scenario, due to the cost of improved fabric efficiency. These figures are based on today's prices and are expected to have fallen by the time the future policy is implemented.

Total build costs for the detached house based on analysis by Currie and Brown. Percentage cost uplift relative to a Part L 2021 compliant building is also shown.



Investment required to address the climate emergency

The current DPD scenario requires additional investment of 2.6%, relative to a Part L 2021 compliant building to achieve net zero. This increases to 3.1% for the future policy option scenario, due to the cost of improved fabric efficiency. These figures are based on today's prices and are expected to have fallen by the time the future policy is implemented.

Total build costs for the detached house based on analysis by Currie and Brown. Percentage cost uplift relative to a Part L 2021 compliant building is also shown.

The importance of electricity tariffs

Energy costs in all electric net zero buildings are determined by the cost of grid electricity and the amount of solar energy that can be used on site. Several types of electricity tariff are available. The ability to take advantage of cheaper tariffs and free solar energy is 'unlocked' by policy scenarios with excellent levels of fabric efficiency, such as the current DPD scenario.

Homes with excellent levels of fabric efficiency lose heat very slowly, which means that heat pumps can be turned off for many hours at a time without the indoor temperature significantly changing. All scenarios that use a heat pump are also assumed to have a hot water tank, which can store water for many hours without significant reductions in temperature. This means that homes in several of the policy scenarios would be able to operate their heat pumps when electricity is cheap, or free in the case of solar energy. In practice, smart controls would perform this function automatically in the background.

Fixed Tariffs

The Part L 2013 and Part L 2021 scenarios are assumed to be on a traditional fixed electricity tariff of 15.8pence per kWh, as they both use gas boilers, therefore have limited potential to use cheap off-peak electricity.

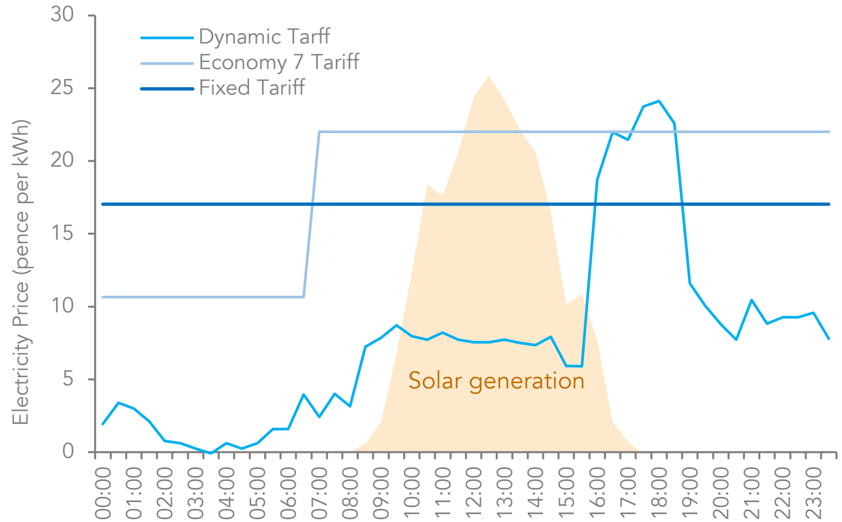
Economy 7 or 10 Tariffs

Any of the remaining scenarios could use Economy 7 or Economy 10 tariffs, however we have assumed the ability of homes in the Part L 2025 scenario to take advantage of these tariffs is somewhat limited by their poor airtightness. These homes could still lose heat quickly in windy weather, so heating may still be required during times of peak electricity pricing. For these scenarios we have assumed an average electricity cost of 12 pence per kWh.

Dynamic Tariffs

The three scenarios with the best levels of fabric efficiency are assumed to be able to take good advantage of dynamic electricity tariffs. Comparison of energy monitoring and dynamic tariff pricing data for an existing net zero home with a heat pump in 2019 and 2020 indicates that an average electricity cost of around 10 pence per kWh is possible. This rate has been assumed for operational energy cost calculations.

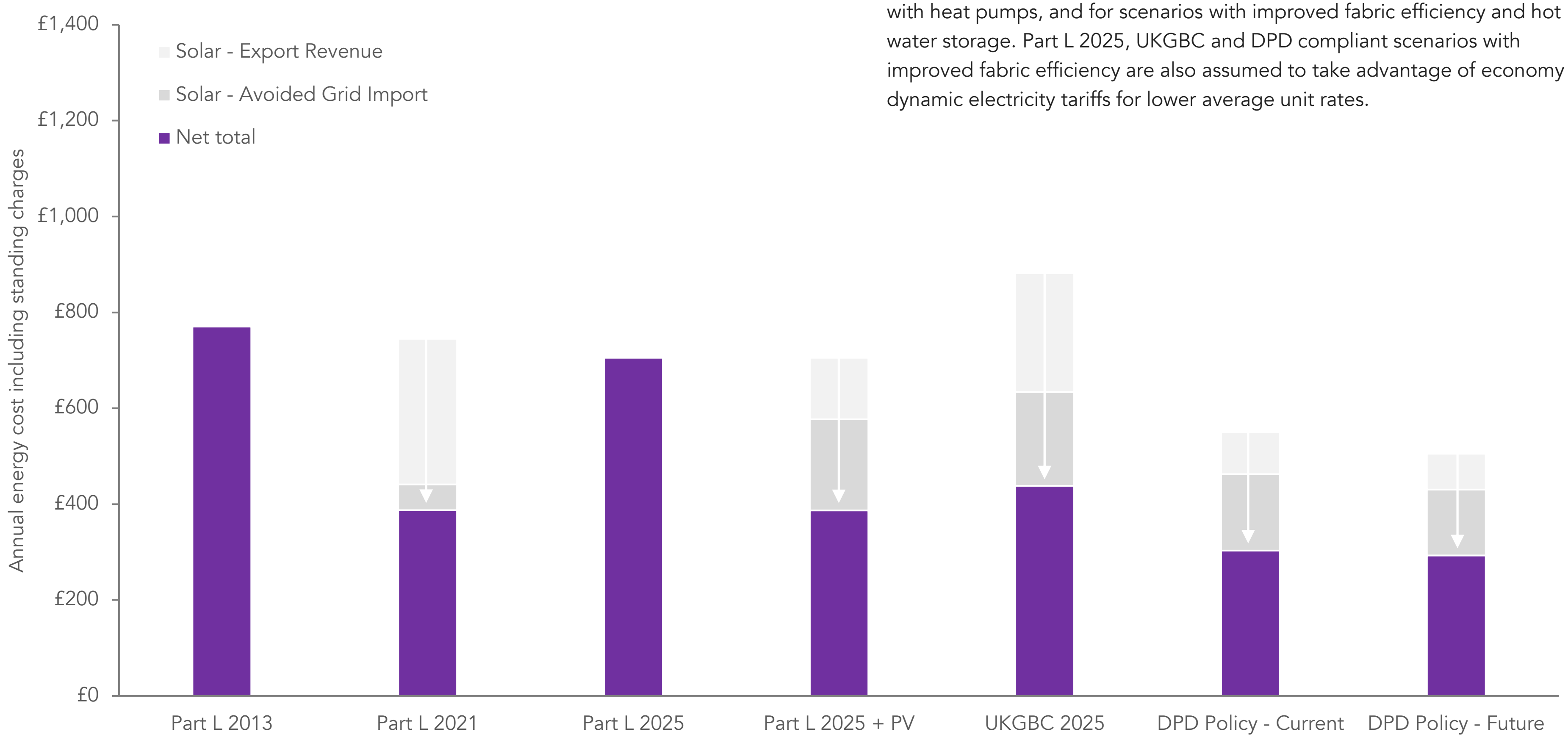
Smart thermostats, solar hot water diverters, and solar electric vehicle chargers are already on the market and provide effective ways to maximise solar self consumption.



Electricity prices and typical solar generation profile for a winter's day. Most net zero buildings are expected to have heat pumps, which can use cheap off-peak electricity, or free solar electricity, so the average cost is cheaper than a fixed tariff. Heat demand in net zero buildings is typically so low that solar can still provide useful amounts of energy for most of the winter.

PHPP modelling to predict energy costs

PHPP results were used to predict indicative operational energy costs for each scenario. Solar self-consumption rates are assumed to be higher for scenarios with heat pumps, and for scenarios with improved fabric efficiency and hot water storage. Part L 2025, UKGBC and DPD compliant scenarios with improved fabric efficiency are also assumed to take advantage of economy 7 or dynamic electricity tariffs for lower average unit rates.



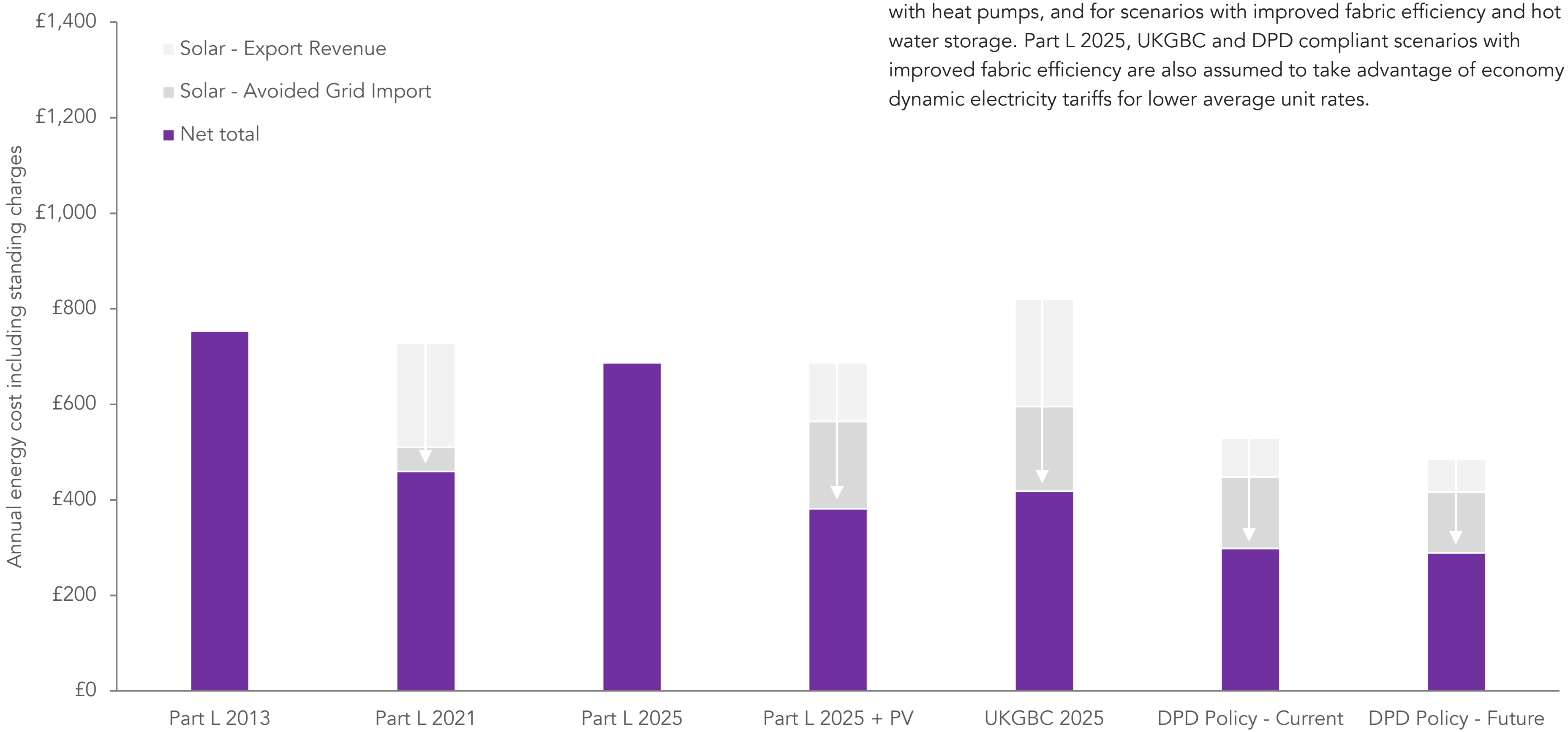
	Part L 2013	Part L 2021	Part L 2025	Part L 2025 + PV	UKGBC 2025	DPD Policy - Current	DPD Policy - Future
Gas Price (p/kWh)	3.0	3.0	-	-	-	-	-
Average Electricity Price (p/kWh)	15.8	15.8	12.0	12.0	10.0	10.0	10.0
Solar Consumption	-	20%	-	40%	30%	50%	50%

Annual energy costs including standing charges, based on PHPP predicted energy use. Solar PV savings from avoided grid import, and value of exported solar energy also shown.

Etude

PHPP modelling to predict energy costs

PHPP results were used to predict indicative operational energy costs for each scenario. Solar self-consumption rates are assumed to be higher for scenarios with heat pumps, and for scenarios with improved fabric efficiency and hot water storage. Part L 2025, UKGBC and DPD compliant scenarios with improved fabric efficiency are also assumed to take advantage of economy 7 or dynamic electricity tariffs for lower average unit rates.



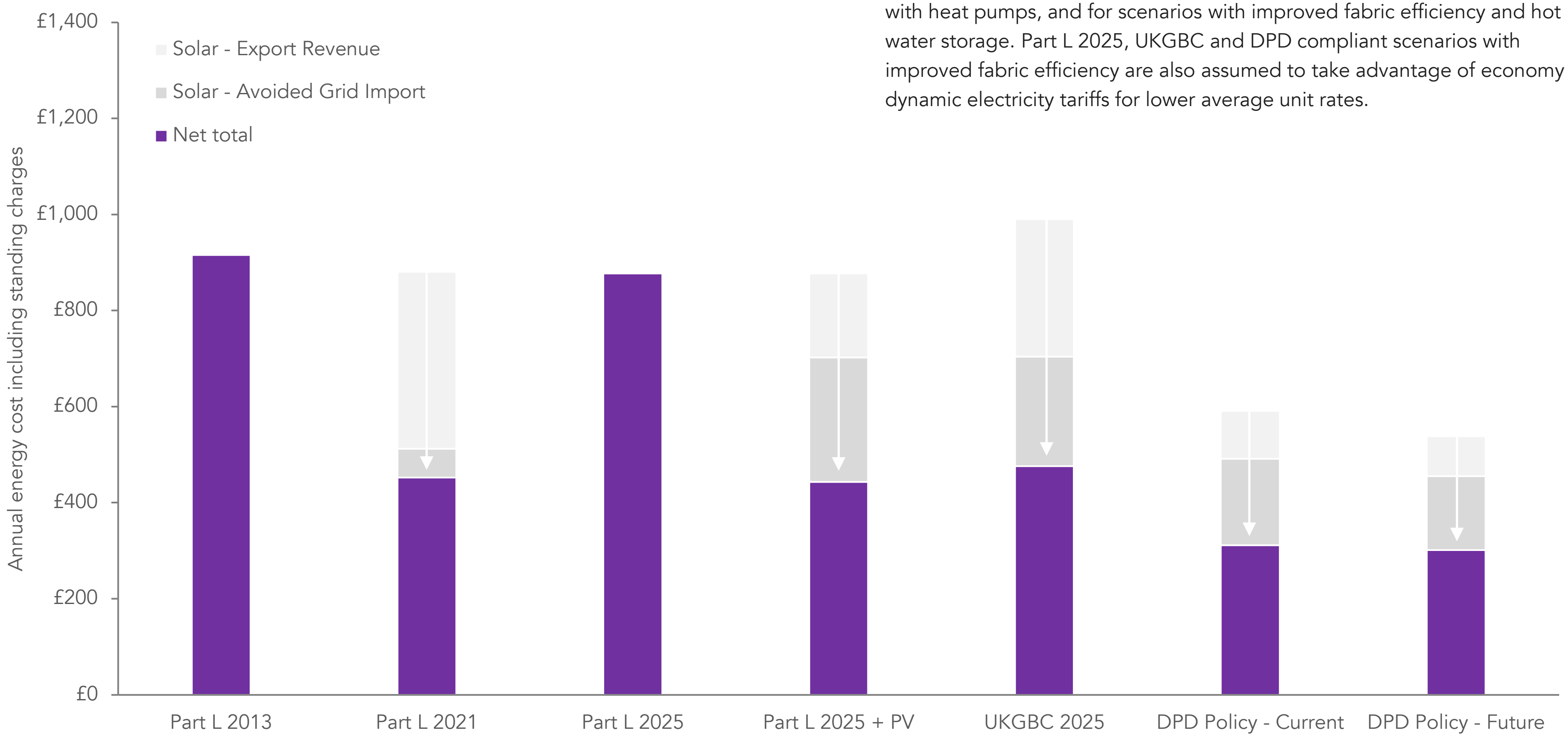
	Part L 2013	Part L 2021	Part L 2025	Part L 2025 + PV	UKGBC 2025	DPD Policy - Current	DPD Policy - Future
Gas Price (p/kWh)	3.0	3.0	-	-	-	-	-
Average Electricity Price (p/kWh)	15.8	15.8	12.0	12.0	10.0	10.0	10.0
Solar Consumption	-	20%	-	40%	30%	50%	50%

Annual energy costs including standing charges, based on PHPP predicted energy use. Solar PV savings from avoided grid import, and value of exported solar energy also shown.

Cost Modelling | Bungalow – Energy cost comparison

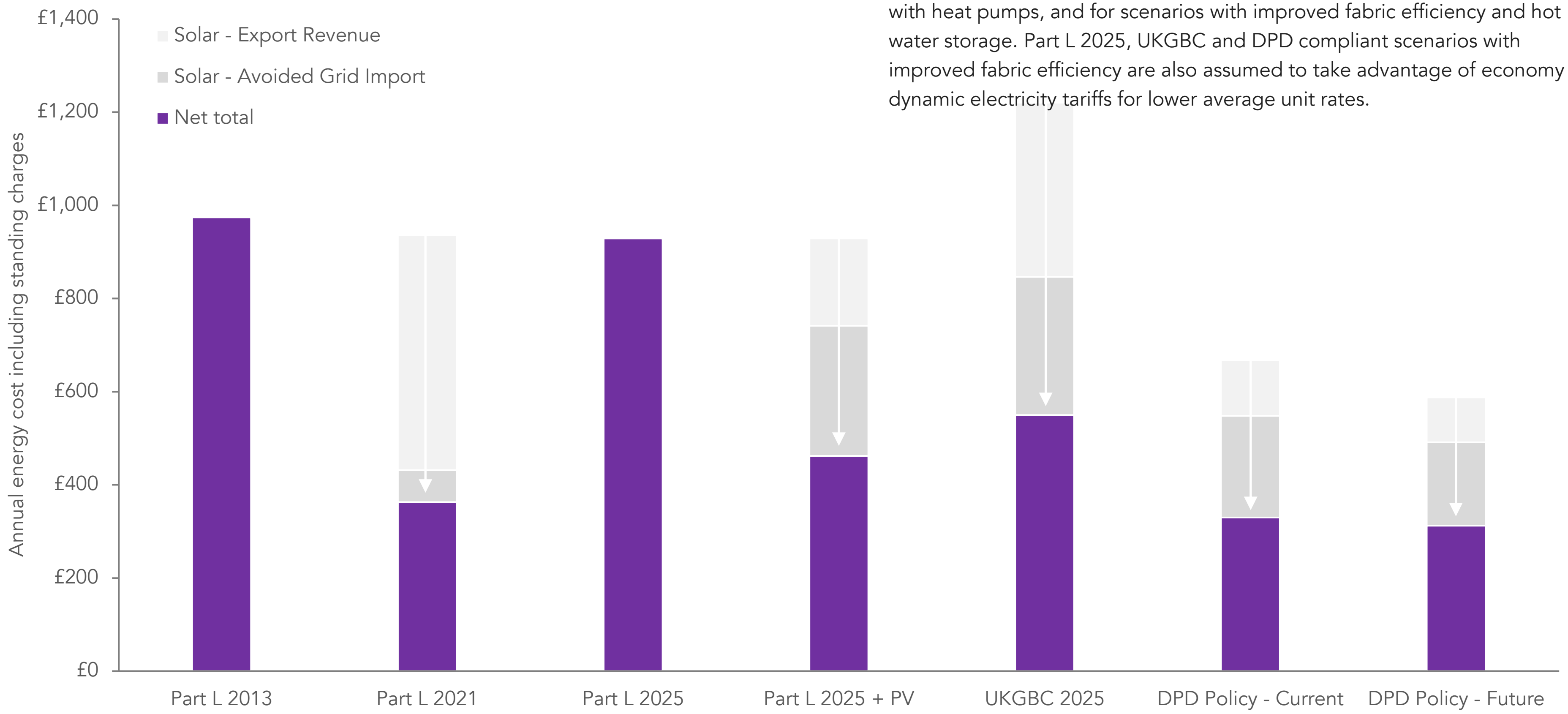
PHPP modelling to predict energy costs

PHPP results were used to predict indicative operational energy costs for each scenario. Solar self-consumption rates are assumed to be higher for scenarios with heat pumps, and for scenarios with improved fabric efficiency and hot water storage. Part L 2025, UKGBC and DPD compliant scenarios with improved fabric efficiency are also assumed to take advantage of economy 7 or dynamic electricity tariffs for lower average unit rates.



	Part L 2013	Part L 2021	Part L 2025	Part L 2025 + PV	UKGBC 2025	DPD Policy - Current	DPD Policy - Future
Gas Price (p/kWh)	3.0	3.0	-	-	-	-	-
Average Electricity Price (p/kWh)	15.8	15.8	12.0	12.0	10.0	10.0	10.0
Solar Consumption	-	20%	-	40%	30%	50%	50%

Annual energy costs including standing charges, based on PHPP predicted energy use. Solar PV savings from avoided grid import, and value of exported solar energy also shown.



PHPP modelling to predict energy costs

PHPP results were used to predict indicative operational energy costs for each scenario. Solar self-consumption rates are assumed to be higher for scenarios with heat pumps, and for scenarios with improved fabric efficiency and hot water storage. Part L 2025, UKGBC and DPD compliant scenarios with improved fabric efficiency are also assumed to take advantage of economy 7 or dynamic electricity tariffs for lower average unit rates.

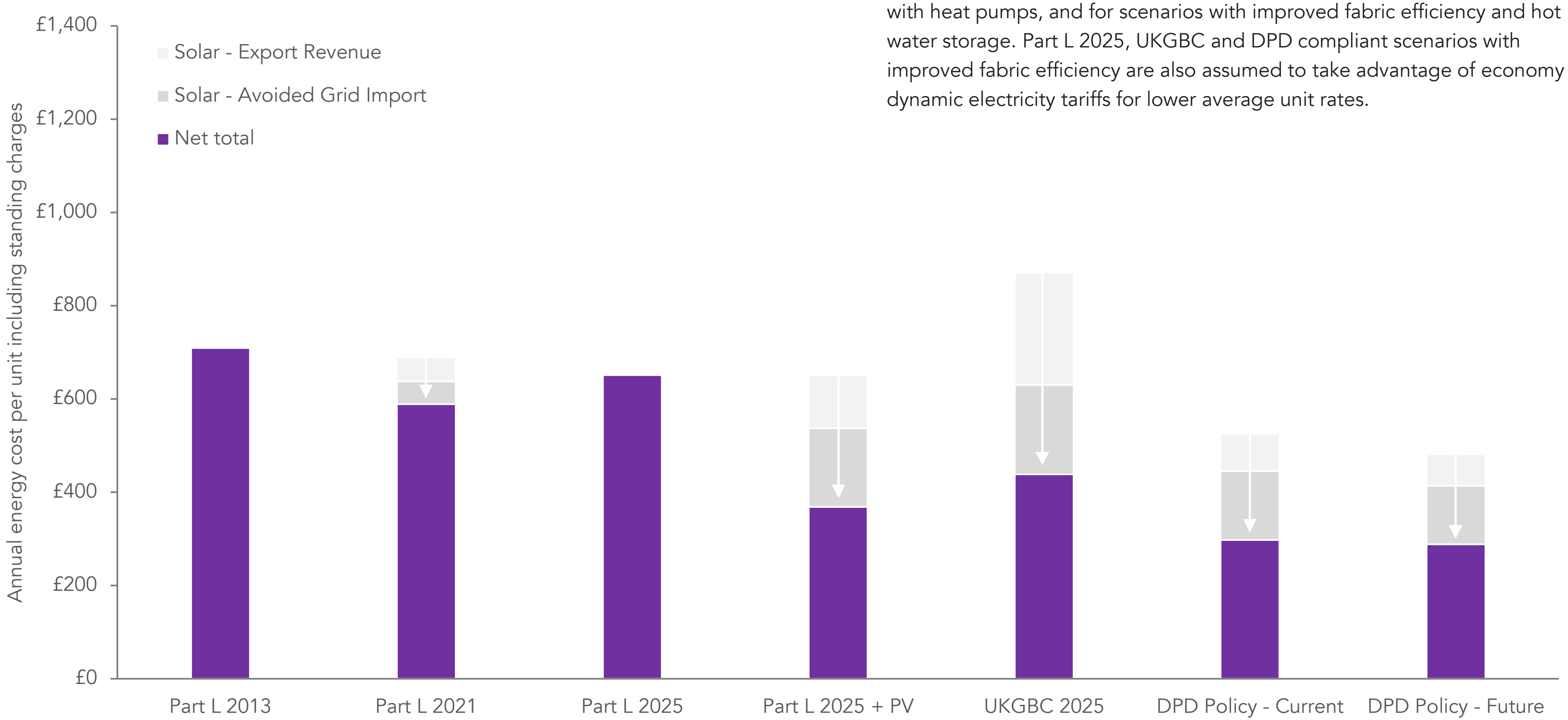
	Part L 2013	Part L 2021	Part L 2025	Part L 2025 + PV	UKGBC 2025	DPD Policy - Current	DPD Policy - Future
Gas Price (p/kWh)	3.0	3.0	-	-	-	-	-
Average Electricity Price (p/kWh)	15.8	15.8	12.0	12.0	10.0	10.0	10.0
Solar Consumption	-	20%	-	40%	30%	50%	50%

Annual energy costs including standing charges, based on PHPP predicted energy use. Solar PV savings from avoided grid import, and value of exported solar energy also shown.

Cost Modelling | Low-rise Flats – Energy cost comparison

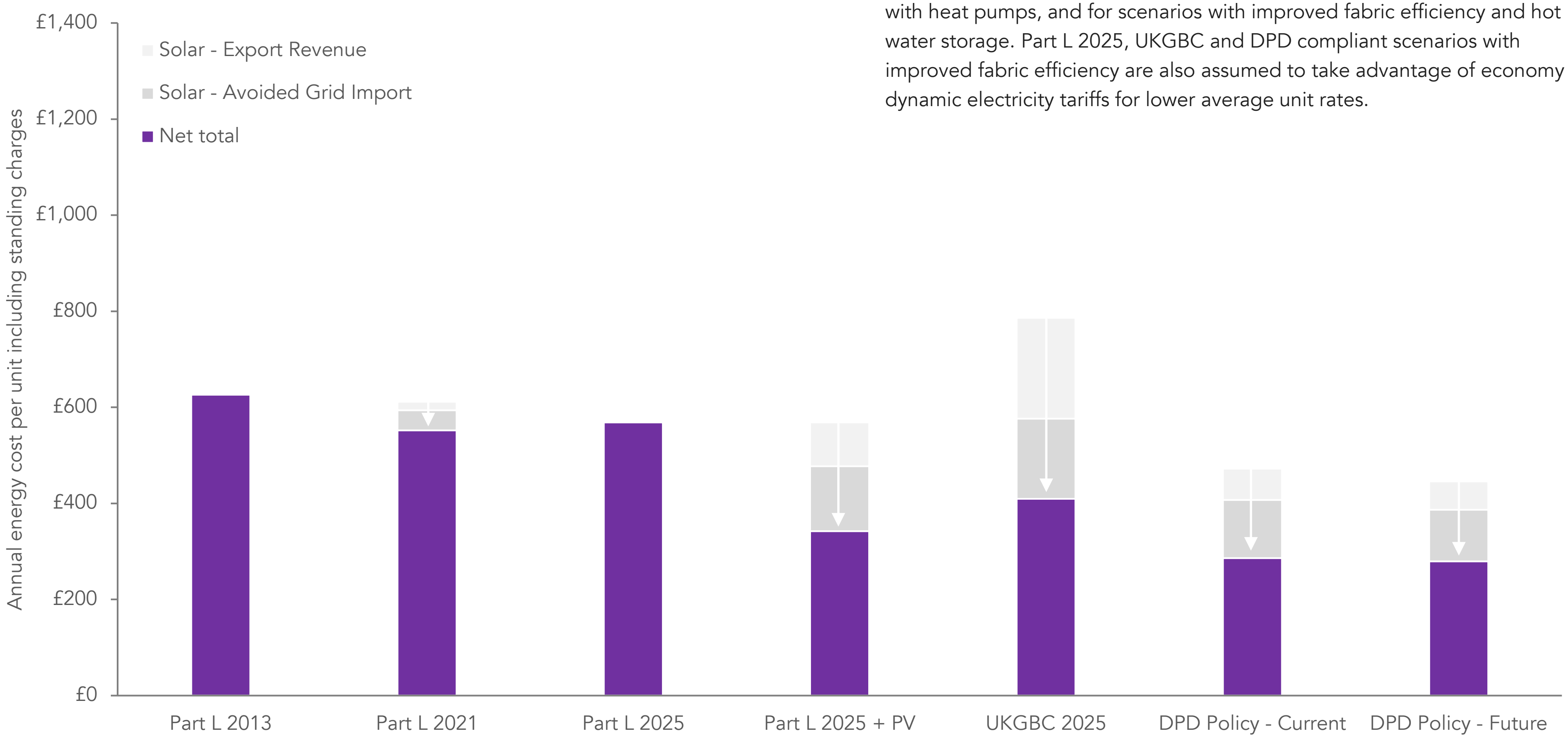
PHPP modelling to predict energy costs

PHPP results were used to predict indicative operational energy costs for each scenario. Solar self-consumption rates are assumed to be higher for scenarios with heat pumps, and for scenarios with improved fabric efficiency and hot water storage. Part L 2025, UKGBC and DPD compliant scenarios with improved fabric efficiency are also assumed to take advantage of economy 7 or dynamic electricity tariffs for lower average unit rates.



Gas Price (p/kWh)	3.0	3.0	-	-	-	-	-
Average Electricity Price (p/kWh)	15.8	15.8	12.0	12.0	10.0	10.0	10.0
Solar Consumption	-	20%	-	40%	30%	50%	50%

Annual energy costs including standing charges, based on PHPP predicted energy use. Solar PV savings from avoided grid import, and value of exported solar energy also shown.



PHPP modelling to predict energy costs

PHPP results were used to predict indicative operational energy costs for each scenario. Solar self-consumption rates are assumed to be higher for scenarios with heat pumps, and for scenarios with improved fabric efficiency and hot water storage. Part L 2025, UKGBC and DPD compliant scenarios with improved fabric efficiency are also assumed to take advantage of economy 7 or dynamic electricity tariffs for lower average unit rates.

	Part L 2013	Part L 2021	Part L 2025	Part L 2025 + PV	UKGBC 2025	DPD Policy - Current	DPD Policy - Future
Gas Price (p/kWh)	3.0	3.0	-	-	-	-	-
Average Electricity Price (p/kWh)	15.8	15.8	12.0	12.0	10.0	10.0	10.0
Solar Consumption	-	20%	-	40%	30%	50%	50%

Annual energy costs including standing charges, based on PHPP predicted energy use. Solar PV savings from avoided grid import, and value of exported solar energy also shown.