Passivhaus Trust

The UK Passive House Organisation

Passivhaus as an alternative means of compliance to the FHS

Passivhaus Trust position paper

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> *"I was working as a physicist. I read that the construction industry had experimented with adding insulation to new buildings and that energy consumption had failed to reduce. This offended me – it was counter to the basic laws of physics. I knew that they must be doing something wrong. So I made it my mission to find out what, and to establish what was needed to do it right."*
>
> — **Prof. Dr. Wolfgang Feist**

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Recommendation

All-electric certified Passivhaus Classic should be deemed to satisfy the Future Homes Standard 2025, and Passive House Planning Package (PHPP) accepted as alternative compliance software.

1. An all-electric certified Passivhaus Classic performs better than both options proposed for the Future Homes Standard (FHS), as well as providing many other benefits (see over).

2. The FHS consultation paper assumes that there is no performance gap or, if there is, then this would apply equally to all levels of the FHS and can therefore be ignored. There is strong evidence[1] for a performance gap between actual energy use and that predicted by design for newbuild homes; the exception to this is for certified Passivhaus projects, where there is strong evidence[2] that Passivhaus projects achieve the performance levels predicted at the design stage, largely because of the additional Quality Assurance associated with certification, and the greater accuracy of PHPP (the Passivhaus Planning Package) compared to both SAP 10 and the beta version of the proposed Home Energy Model (HEM). See Appendix 2.

3. PHPP is proven to be an accurate measuring tool when tested through post occupancy evaluations[3]. When modelled using PHPP, both FHS options are shown to significantly underestimate heating demand, which could lead to problems such as higher energy costs or an inability to provide sufficient heat for occupant comfort.

Introduction

This position paper responds to the recently published consultation paper **The Future Homes and Building Standards: 2023 Consultation**.

In the report, two options are proposed for the new Future Homes Standard (FHS), both of which are based on the fabric parameters currently used in Approved Document L Volume 1: Dwellings 2021 (henceforth referred to as AD L 2021). There is no equivalent to certified Passivhaus Classic, which is shown by modelling to perform better than both options proposed, in terms of:

1. Space heating demand
2. Carbon dioxide emissions
3. Running costs (regulated energy)
4. Certainty of performance
5. Comfort & health benefits.

Using an end of terrace reference building, we have modelled FHS Options 1 & 2 and certified Passivhaus Classic in PHPP 10, the Passivhaus Planning Package, to compare the three standards – Appendix 1 gives the specification for each option. All three modelled options are all-electric, equipped with an air source heat pump. We report on space heating demand, regulated energy demand, carbon emissions and running costs and compare to current building regulations, AD L 2021.

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1 Rajat Gupta and Alkis Kotopouleas, 'Magnitude and extent of building fabric thermal performance gap in UK low energy housing', *Applied Energy vol. 222* (2018). Available online: https://doi.org/10.1016/j.apenergy.2018.03.096

2 David Johnston and Mark Siddall, 'The Building Fabric Thermal Performance of Passivhaus Dwellings—Does It Do What It Says on the Tin?' *Sustainability* (2016). Available online: https://doi.org/10.3390/su8010097 and David Johnston, Mark Siddall et al., 'Are the energy savings of the Passive House standard reliable? A review of the as-built thermal and space heating performance of Passive House dwellings from 1990 to 2018' *Energy Efficiency* (2020) Available online: https://doi.org/10.1007/s12053-020-09855-7

3 Rachel Mitchell and Sukumar Natarajan, 'UK Passivhaus and the energy performance gap', *Energy and Buildings* (2020). Available online: https://doi.org/10.1016/j.enbuild.2020.110240

In our calculations, when modelled in PHPP 10, FHS Options 1 and 2 will have a significantly higher space heating demand than expected. Erroneous predictions of low energy demand can drive decisions to allow direct electric heating in flats, which may lead to much higher energy costs than expected for occupants or to the prioritization of photovoltaics over building fabric, and may result in an inability to provide sufficient heat for occupant comfort.

A certified Passivhaus Classic building would have lower space heating demand than both FHS Option 1 and Option 2. Investing in the building fabric locks the energy reductions into the lifetime of the building, rather than relying on building services (Option 1) which can degrade over time, meaning that there is no guarantee they will maintain the energy savings over time.

In addition, certifying a building to the Passivhaus Classic standard will deliver the following benefits compared to the two proposed options. See *Passivhaus Benefits* (Passivhaus Trust, 2021)[4] for more details.

	FHS OPTION 1	FHS OPTION 2	PASSIVHAUS CLASSIC
Lowest space heating demand	x	x	√
Effectively eliminating the performance gap	x	x	√
Low energy bills	√	x	√
Summer comfort	?	?	√
Winter comfort	?	?	√
Good internal air quality	?	x	√
Protection against condensation and mould	?	?	√
Better quality components	x	x	√
Better build quality	x	x	√
No future retrofit	?	?	√
Lowest peak demand on the grid	x	x	√
Responsive to local climate	x	x	√

Table 1: *Benefits of certifying a building to the Passivhaus Classic standard*

Performance predictions

The performance gap between design and in-use energy performance is well documented[5] and, conservatively, is found to result in a 60% increase in space heating demand. While it is recognised that as part of the uplift to AD L 2021 and the FHS, photographic evidence is required to show that insulation measures are correctly installed, windows are properly specified and building services perform as designed, there is, to date, no evidence that these measures will reduce the performance gap. Therefore, the same 60% performance gap for space heating demand is included in the Option 1 and 2 modelling, but not in certified Passivhaus Classic.

The outputs from modelling an end of terrace house using Options 1 and 2 (FHS) and certified Passivhaus Classic in PHPP are shown below and compared to the benchmark of AD L 2021. All modelled options are all-electric, equipped with an air source heat pump.

4 *Passivhaus Benefits*, Passivhaus Trust (2021). Available online: https://pht.guide/benefits

5 See, for example, David Johnston et al., 'Quantifying the domestic building fabric "performance gap"', *Building Services Engineering Research & Technology* (2015). Available online: https://doi.org/10.1177/0143624415570344

SPACE HEATING DEMAND

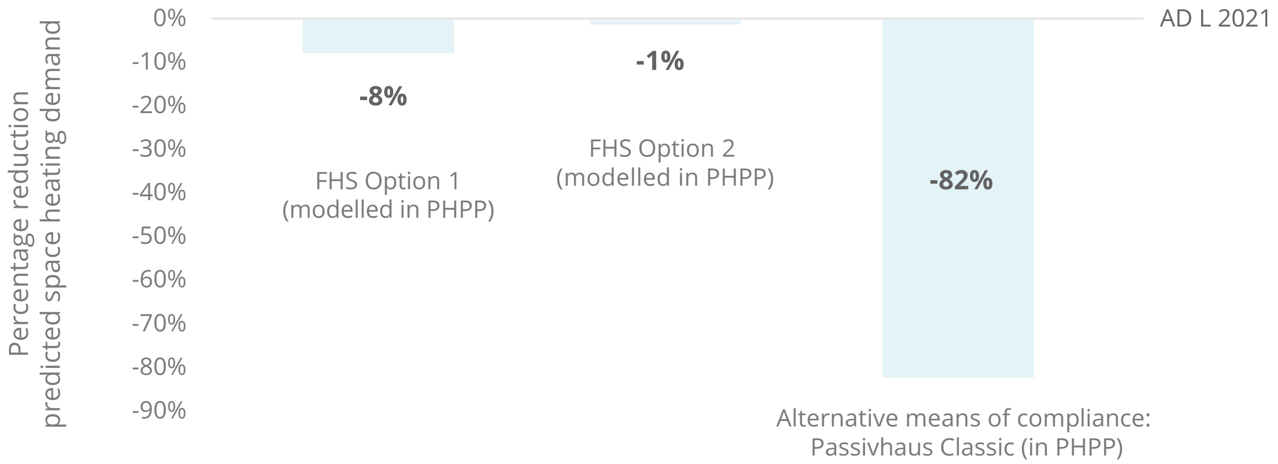

Figure 1: *Predicted space heating demand reduction compared to AD L 2021*

In both Options 1 and 2, space heating demand is similar to AD L 2021, as all have a similar fabric specification. Passivhaus Classic gives a much greater reduction in space heating demand compared to Option 1 and Option 2, as the building fabric exceeds the specification of the proposed Notional Building(s).

CARBON EMISSIONS

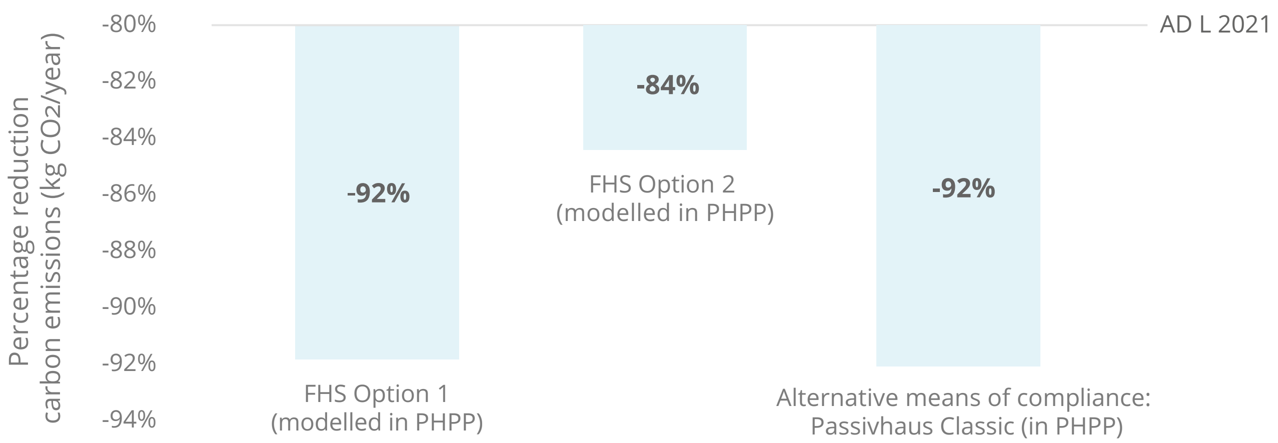

Figure 2: *Predicted reduction in carbon emissions compared to AD L 2021*

The bulk of the carbon emission reductions for all options comes from the transition from a gas boiler (current building regulations) to all electric heating and hot water (in each case an air source heat pump). Only Option 1 has additional PV. Passivhaus Classic will deliver exactly the same carbon emissions reduction compared to Option 1 without the addition of photovoltaics. This means the emission reductions are locked in for the lifetime of the building.

ENERGY USE COSTS

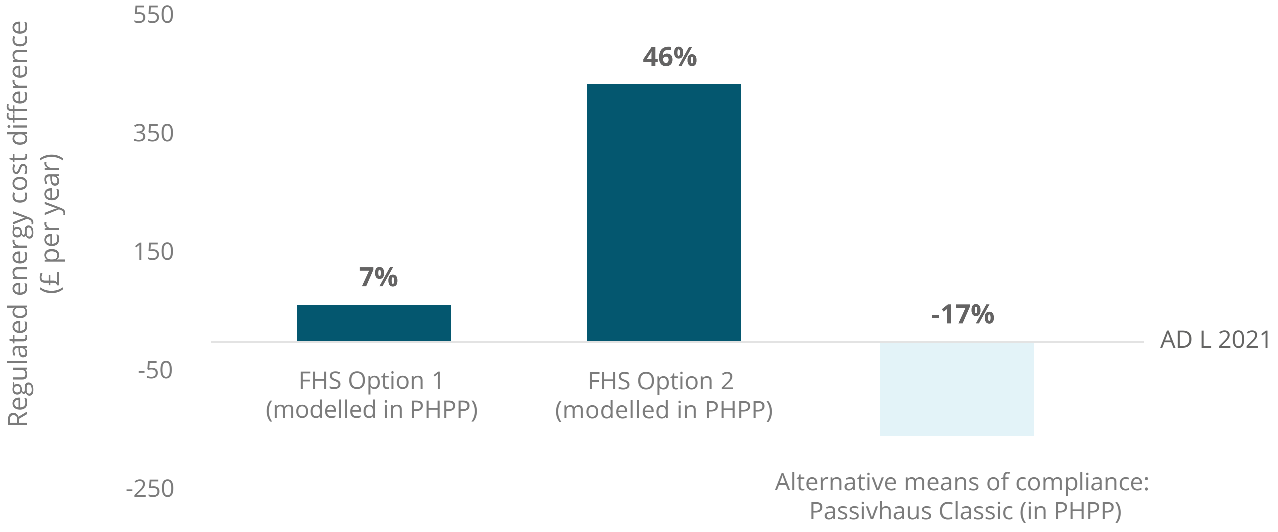

Figure 3: *Predicted regulated energy costs difference compared to AD L 2021*

Passivhaus Classic is predicted to cost less to run than both Option 1 and Option 2. It is noted that Option 2 is predicted to cost the occupant more to run than a dwelling built to current regulations, and this is acknowledged in the impact assessment.

Option 1 relies on photovoltaics to reduce the additional running costs that will arise from switching from gas to electricity. This philosophy works on the building typology chosen; however, flats will have less roof area per dwelling, and therefore the taller the building, the less energy will be generated for each dwelling, and it will not be sufficient to offset costs in the same way. In addition, if direct electric heating is chosen and space heating is higher than predicted, energy costs will increase disproportionately for dwellings with a poorer building fabric.

This is not the case for Passivhaus Classic, which uses only the building fabric to reduce heating costs; these are again locked in for the lifetime of the building.

CONCLUSION

As the building modelling shows, certified Passivhaus Classic will have lower space heating demand, lower carbon emissions and will cost less to run than both Option 1 and Option 2 of the FHS. Therefore, new all-electric dwellings certified to meet the Passivhaus standard should be deemed to satisfy the Future Homes Standard, and PHPP should be accepted as alternative modelling software to demonstrate compliance.

APPENDIX 1

Comparison of specifications

	FHS Option 1	FHS Option 2	Passivhaus Classic
Wall U-value	0.18		0.13
Roof U-value plane	0.11		0.10
Floor U-value	0.13		0.10
Glazing	Double		Triple
Window U-value / centre pane g-value	1.2/0.73		0.8/0.53
Front door U-value	1.0		0.8
Half glazed door U-value	1.2		0.8
Air permeability q_{E50} (m³/hr.m²)	4.0	5.0	0.4*
Ventilation	dMEV 0.15 W (L.s)	Nat vent + extract fans	MVHR
Heating emitter type	Radiators 45ºC flow		
Heating	ASHP 5kW		ASHP 3.5kW
Domestic hot water (DHW)	ASHP		
Wastewater heat recovery (WWHR)	Yes	No	
Shower flow rate	8 l/min		
PV philosophy	40% of roof area in plan	None	
PV installed (kWp)	2.68	0.0	
PV diverter	No		
Battery	No		
Lighting efficiency	120 lm/W		

** The Passivhaus airtightness criterion of 0.6 ACH is equivalent to 0.4 m³/hr.m² air permeability for this particular house form*

Table 2: *Summary of specifications for the notional building for FHS Option 1, FHS Option 2 and certified Passivhaus Classic for end terrace house*

APPENDIX 2

SAP 10, HEM and PHPP space heating demand outputs

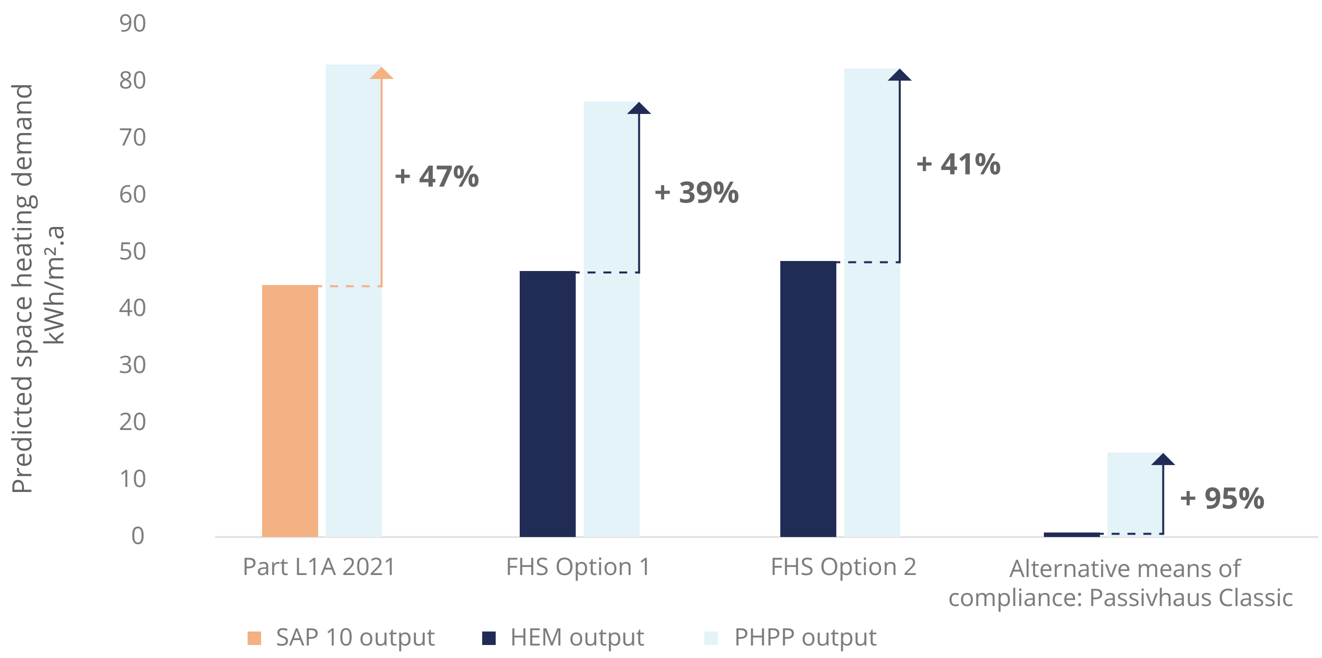

Figure 4: *Differences in space heating demand modelled in SAP 10/HEM and PHPP 10 with percentage difference.*

The end terrace house has been modelled in SAP 10 (for the AD L 2021 output) and the Beta version of the HEM (for Option 1, Option 2 and Passivhaus Classic), as well as PHPP for all options. Please note that the HEM is still in the development stage and the results may not be the output of the final modelling tool.

The modelling shows that both SAP 10 and the HEM are underestimating space heating demand, and the greater the fabric improvements, the greater the difference between the two models. When modelling a Passivhaus, the HEM predicts space heating demand to be less than 1 kWh/m².a, compared to a 15 kWh/m².a output from PHPP.

As it is known that PHPP accurately models space heating demand, based on in use monitoring[6], it is reasonable to assume the inaccuracy is within the HEM.

6 Rachel Mitchell and Sukumar Natarajan, 'UK Passivhaus and the energy performance gap', *Energy and Buildings* (2020). Available online: https://doi.org/10.1016/j.enbuild.2020.110240

The Passivhaus Trust is an independent, non-profit organisation that provides leadership in the UK for the adoption of the Passivhaus standard and methodology.

Passivhaus is the leading international low energy design standard, backed with over 30 years of building performance evidence. It is a tried & tested solution that enables a meaningful transition to net-zero now. Over 65,000 buildings have been certified to this standard worldwide. The Trust promotes Passivhaus as a robust way of providing high standards of occupant comfort and health AND slashing energy use and carbon emissions from buildings in the UK.

Please find us on Twitter, Linkedin, Instagram, & Facebook @PassivhausTrust. Keep up to date with all things Passivhaus by joining our mailing list.

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