Evidence to Support Responses to The Future Homes Standard Consultation

Produced for the West of England Local Authorities

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Contents

Executive Summary

This evidence has been prepared for the West of England (WoE) Local Authorities (Bath and North East Somerset Council, Bristol City Council, North Somerset Council and South Gloucestershire Council) in response to the Government's Future Homes Standard.

The Future Homes Standard (FHS, October 2019) document proposes to remove the fabric energy efficiency metric and the ability of local authorities to set higher energy efficiency standards than those in the Building Regulations. This report considers the potential impacts of these proposals.

Two sample dwellings (a semi-detached house and mid-floor flat) were modelled using FSAP 2012 software for SAP 2012 methodology (Part L 2013), and the iSAP website[1] for SAP 10.1 methodology (Part L 2020). The key findings of the modelling are as below:

1. The national trajectory for reducing CO_2 emissions at 2020 and 2025 does not reduce emissions as much as the draft zero-carbon WoE policies. The WoE policies, which intend to cover unregulated as well as regulated emissions, would save around 200,588 tCO_2 (41%) between by 2030. If only regulated emissions were covered by the policies, this would be 109,930 tCO_2 (23%) by 2030. Annual saved emissions would increase each year as new dwellings are built.

2. The Part L 2020 standard could allow worse fabric than is currently allowed under Part L 2013, since the FHS consultation proposes to remove the TFEE (Target Fabric Energy Efficiency). Modelling the minimum fabric standards proposed for the 2020 standard resulted in the modelled dwellings failing the Part L 2013 TFEE by 46% (semi-detached house) and 51% (mid-floor flat), while meeting the proposed Part L 2020 requirements, through the use of heat pumps. The TFEE relates to the space heating and cooling demand of dwellings, and therefore the removal of the this may result in dwellings with a high electricity demand and lower thermal comfort for residents.

1 Introduction

The Future Homes Standard (October 2019) proposes changes to Part L (Conservation of Fuel and Power) of the Building Regulations for new homes. Two proposed changes are the removal of the Target Fabric Energy Efficiency standard, and the removal of the ability of local authorities to set higher energy efficiency standards than those in the Building Regulations. This may lead to some consequences such as new homes being built to a poorer fabric standard, and greater carbon emissions from homes where local authorities cannot set their own requirements, such as the proposed WoE zero-carbon policies.

SAP modelling has been carried out to determine possible outcomes from these proposed Part L changes. Two sample dwellings (a semi-detached house and mid-floor flat) were modelled using FSAP 2012 software for SAP 2012 methodology (Part L 2013) and the iSAP website for SAP 10.1 methodology (Part L 2020).

The results of the modelling are shown in this report, which has been prepared as evidence for the WoE response to the Future Homes Standard (FHS) consultation.

[1] https://www.isap.org.uk/index.php?page=00300

2 Fabric Energy Efficiency

2.1 Background

The Target Fabric Energy Efficiency (TFEE) is one of the two main targets of Part L 2013, alongside the Target Emission Rate (TER, measuring carbon emissions). The Dwelling Fabric Energy Efficiency (DFEE) must be equal to or less than the TFEE for the dwelling to comply with Part L, and it essentially puts a limit on the design flexibility of the dwelling, ensuring that it follows a 'fabric first' approach to an extent. The DFEE is the space heating and cooling requirements per m^2 of floor area, calculated with the proposed fabric specification (U-values, openings, thermal bridging and air tightness) with certain set conditions regarding aspects such as ventilation and internal heat gains. The TFEE is calculated the same way but with a notional specification, with 15% added to the calculated value. The TFEE ensures that the fabric specification is a reasonable standard, otherwise developers could design buildings with a poor fabric standard and compensate this with renewable energy and other low carbon technologies to meet the TER.

The current proposal for SAP 10.1 / Part L 2020 includes the removal of the TFEE and the addition of a Target Primary Energy Rate (TPER). It is expected that there will be a minimum requirement for householder affordability, though details of this are not yet determined. Although there are improved minimum fabric standards (U-values and air tightness) in Part L 2020 compared to Part L 2013, the removal of the TFEE could mean that new dwellings are built to a poor fabric standard.

These are some reasons for the importance of a good fabric standard in buildings:

- It has a longer lifespan than services and requires little or no maintenance.
- Fabric is difficult to improve once the dwelling is built, therefore it's important to get this right during initial construction. Building homes that will need retrofitting in 20 years is not cost effective, sustainable or practical.
- It reduces electricity demand for electricity-based heating systems. This is increasingly important as more dwellings move to heat pumps and increase the demand on the grid, which has a limited capacity and will be more sensitive to fluctuations as the energy system moves towards more renewables with less reliance on gas.
- It reduces the cost of fuel/electricity used for heating systems. This is particularly important for electricity-based systems, as the price of electricity is much higher than gas. Based on SAP 10.1 fuel costs, even heat pumps would likely need an SCoP of more than 4 to be as cost effective as gas.
- It provides more comfortable homes, with less draughts and no hot and cold spots.

2.2 Modelling

Two dwellings, a semi-detached house and a mid-floor flat, have been modelled at a range of scenarios. They have been modelled using FSAP 2012 software to determine the Part L 2013 fabric energy efficiency values, and the iSAP website to model SAP 10.1 and the Part L 2020 regulations.

For information, the Total Floor Areas of the modelled dwellings are:

House - 106.16 m^2
Flat - 71.81 m^2

Scenarios modelled:

1. Poor fabric with heat pump
U-values and air tightness are entered at the worst possible values allowed by the limiting standards in Part L 2020. Thermal bridging values have been set as default SAP 10.1 values (which are very poor performing). Other elements are aligned with the notional building, including Waste Water Heat Recovery.

2. Notional with solar PV
Specification is closely aligned with the notional specification of Option 2, as set out in the FHS consultation and implemented in SAP 10.1, and just passes Part L 2020. This includes a gas boiler and solar PV.

3. Notional fabric with heat pump
As per scenario 2 above, but with a heat pump instead of the gas boiler, and the solar PV removed.

4. WoE 10% fabric
Starting with scenario 2 above, then improving the fabric specification to achieve at least a 10% reduction in regulation CO_2.

5. WoE 10% fabric with heat pump
As per scenario 2 above, but with a heat pump instead of the gas boiler, and the solar PV removed.

6. Poor fabric with heat pump and PV
As scenario 1, but with 4 kWp solar PV and a PV diverter. This is to test the effect of PV on the running costs/EPC rating. This has only been modelled for the house, as it is assumed that the PV for the flat would be connected to the landlord supply and not to each dwelling, and therefore would not affect running costs.

The full details of the modelled specifications are shown in Table 1.

Table 1: Specification of SAP models

Item		1: Low fabric with heat pump	2: Notional with solar PV	3: Notional with heat pump	4: WoE 10% fabric	5: WoE 10% fabric with heat pump	6: Low fabric with heat pump and PV
U-values ($W/m^2.K$)	Floor	0.18	0.13	0.13	0.11	0.11	0.18
	Roof	0.16	0.11	0.11	0.11	0.11	0.16
	Walls	0.26	0.18	0.18	0.15	0.15	0.26
	Windows	1.6 (double glazing)	1.2 (double glazing)	1.2 (double glazing)	0.8 (triple glazing)	0.8 (triple glazing)	1.6 (double glazing)
	Rooflights	2.2 (double glazing)	1.2 (double glazing)	1.2 (double glazing)	0.8 (triple glazing)	0.8 (triple glazing)	2.2 (double glazing)
	Opaque doors	1.6	1.0	1.0	1.0	1.0	1.6
Thermal bridging		SAP 10.1 Default	Option 2 Notional	Option 2 Notional	Option 2 Notional	Option 2 Notional	SAP 10.1 Default
Air Tightness (m^3/hm^2)		8.0	5.0	5.0	5.0 for house 3.0 for flat	5.0 for house 3.0 for flat	8.0
Ventilation		Natural with extracts	Natural with extracts	Natural with extracts	Natural with extracts	Natural with extracts	Natural with extracts
Heating System		Heat pump	Gas boiler	Heat pump	Gas boiler	Heat pump	Heat pump
Domestic Hot Water Cylinder Specification		300 litres with 2.11 kWh/day loss	None	300 litres with 2.11 kWh/day loss	None	300 litres with 2.11 kWh/day loss	300 litres with 2.11 kWh/day loss
Waste Water Heat Recovery		Recoup Tray+ DSS-S2 System B to all showers					
Heat Emitter Type		UFH screed	Radiators	UFH screed	Radiators	UFH screed	UFH screed
Heating Controls		Time and temperature zone controls					
Solar PV		None	3.27 kWp for house 1.47 kWp for flat SE facing	None	3.27 kWp for house 1.47 kWp for flat SE facing	None	4 kWp with PV diverter for house, S facing
Lighting		As notional	As notional	As notional	As notional	As notional	As notional
Weather Compensation		No	Yes	No	Yes	No	No

Notes

- Only regulated energy and emissions are referred to here. Including unregulated energy would result in additional emissions and a greater electricity demand.
- Any Part L 2020 targets mentioned here assume the more demanding notional specification in SAP 10.1 is used (SAP 10.1 option 2).
- SAP 10.1 does not factor in the solar PV generation when calculating electricity demand figures (i.e. the electricity demand value does not distinguish between using mains

electricity or electricity generated on site), except where a PV diverter is used (because it directly reduces the hot water energy demand).

- The heat pump CoPs used are as below. These were selected from the SAP default tables rather than choosing a model from the SAP database. The reason for this is that the CoP of a chosen heat pump changes depending on the plant size ratio (which depends on the space heating demand), and therefore would change when the fabric specification changes. Using a default CoP keeps this the same throughout, which allows for better comparison of fabric specification improvements. In practice the heat pump would be sized specifically for each scenarios space heating demand to give an effective CoP.

Table 2: Heat pump CoP

Space heating CoP	Water heating CoP
2.60	2.19

Where a gas boiler has been used, a Worcester Greenstar 28 CDi Compact has been used which has the following SAP values:

Table 3: Boiler efficiency

SAP 2009/2012 annual efficiency (%)	89.8
SAP winter seasonal efficiency (%)	90.7
SAP summer seasonal efficiency (%)	87.5

2.3 Results

Below is a summary of the results from the SAP 10.1 modelling. See Appendix A for the full SAP 10.1 outputs.

Table 4: SAP results of semi-detached house

Semi-detached house					
Scenario	SAP 10.1 CO_2 emissions ($kgCO_2/m^2$/year)	SAP 10.1 Primary Energy Rate (kWh/m^2/year)	SAP 2012 Fabric Efficiency (kWh/m^2/year)	SAP 10.1 Electricity demand (kWh/year)	SAP 10.1 SAP rating
1 Poor fabric with heat pump	TER - 9.35[1] DER - 5.19	TPER - 58.11[1] DPER - 53.82	TFEE - 51.1 DFEE - 74.4 Fails 46%	3675.59	C 77[4]
2 Notional	TER - 9.33[1] DER - 9.20	TPER - 58.01[1] DPER - 57.84		384.92[2]	A 96
3 Notional with heat pump	TER - 9.35 DER - 3.63	TPER - 58.11 DPER - 37.89		2596.94	B 84
4 WoE 10% fabric	TER - 9.33 DER - 8.09	TPER - 58.01 DPER - 51.85		384.92[2]	A 96[3]
5 WoE 10% with heat pump	TER - 9.35 DER - 3.31	TPER - 58.11 DPER - 34.66		2378.37	B 85
6 Poor fabric with heat pump and PV	TER - 9.35 DER - 0.24[5]	TPER - 58.11 DPER - 30.17		3092.58	A 92[4]

Table 5: SAP results of mid-level flat

Mid-level flat					
Scenario	SAP 10.1 CO_2 emissions ($kgCO_2/m^2$/year)	SAP 10.1 Primary Energy Rate (kWh/m^2/year)	SAP 2012 Fabric Efficiency (kWh/m^2/year)	SAP 10.1 Electricity demand (kWh/year)	SAP 10.1 SAP rating
1 Poor fabric with heat pump	TER - 11.01[1] DER - 4.99	TPER - 65.66 DPER - 52.11	TFEE - 39.2 DFEE - 59.1 Fails 51%	2417.78	C 80
2 Notional	TER - 10.93[1] DER - 10.36	TPER - 65.25 DPER - 62.92		331.64[2]	B 86
3 Notional with heat pump	TER - 11.01 DER - 3.74	TPER - 65.66 DPER - 39.44		1837.34	B 85
4 WoE 10% fabric	TER - 10.93 DER - 9.24	TPER - 65.25 DPER - 56.96		334.91[2]	B 87
5 WoE 10% with heat pump	TER - 11.01 DER - 3.34	TPER - 65.66 DPER - 35.36		1650.78	B 87

1. The TER and TPER change slightly depending on whether the building has a cylinder (in the case of heat pumps) or not (in the case of a combi boiler).

2. When a gas boiler is used for heating, the electricity demand only includes energy used for pumps and fans, and lighting. Fabric improvements do not affect this value (except for the flat where changing to triple glazing means a slight increase in lighting energy demand).

3. Although the fabric has improved here from scenario 2, the benefit was not enough to increase the SAP score (improvement less than 1 point).

4. Solar PV offsets running costs due reducing imported electricity, and exporting electricity (export tariff).

5. This shows that the dwelling is theoretically almost zero carbon (regulated emissions only) whilst still having poor fabric.

2.4 Key findings

Scenario 1 models dwellings with a very poor fabric specification but with efficient heating (heat pump). The U-values and air tightness are the worst values allowed as per the limiting standards in Part L 2020. The thermal bridging Psi values are as the SAP 10.1 default values, so are very poor performing. However, by using a heat pump, the dwelling can still pass Part L 2020 regulations (TER and TPER) comfortably. Modelling the same fabric specification in FSAP 2012 fails the Target Fabric Energy Efficiency by 46% (house) and 51% (Flat), which shows that it's possible to achieve compliance with a very poor standard of fabric, much worse than is allowed under Part L 2013. The SAP/ratings for both dwellings are C (77 and 80), which shows that the running costs are relatively high. It's possible these dwellings would not meet the Part L 2020 affordability target (which is yet to be determined). However, running costs can be reduced by adding solar PV, leaving no requirement to improve the fabric standard. Adding 4 kWp of solar PV, with a PV diverter, increases the house's EPC rating to A 92, as shown in scenario 6. The significant conclusion here is that the current proposal for Part L 2020 does not have sufficient requirements for fabric standards.

A low fabric standard dwelling with a heat pump might be seen as a simple route to achieving compliance by developers. These kinds of dwellings (such as scenario 1) have a very high electricity demand, as they use an electricity-based heating system as opposed to gas, and the heat demand is high due to the poor fabric standard. Due to the limited capacity of the grid, intermittency of renewable energy generation, and requirement for energy storage in the future, building dwellings with a high electricity demand is not sustainable. This highlights the importance of a high fabric standard.

Scenarios 2 and 3 are based on the dwellings being closely aligned with the SAP 10.1 option 2 notional specification, however scenario 3 replaces the gas boiler and solar PV with a heat pump. The use of a heat pump compared to PV reduces carbon emissions and primary energy but increases running costs. Comparing scenario 1 and 3 shows that the improvement in fabric specification reduces the electricity demand by 29% (house) and 24% (flat) and increases the SAP/EPC rating (reduces running costs).

The SAP ratings of scenarios 2 and 3 show that with the same fabric standard, a gas and PV route to compliance in this case leads to lower running costs than a heat pump route. This is partly due to the cost of electricity, and partly to the solar PV reducing electricity costs.

In SAP 10.1, standard electricity and gas costs are 17.56 p/kWh and 3.93 p/kWh respectively. The space heating efficiency of the gas boiler used is 90.7%, which effectively gives an energy delivered cost for gas of 4.33 p/kWh. This is less than 25% of the cost of electricity, and so a

heat pump would need a seasonal CoP for heating of more than 4 to give the same running costs as gas heating. CoP values of heat pumps vary, but based on various documents[2] a value of around 3 is understood to be reasonable for a heat pump for space heating. This would give an energy delivered cost of 5.85 p/kWh, which is around 35% more than gas heating. Heat pumps usually have a lower CoP when heating for domestic hot water, and so would likely have a higher energy delivered cost.

Scenarios 4 and 5 are similar to 2 and 3 but with an improved fabric specification so that they achieve at least 10% CO_2 reduction through fabric improvements. This is to represent meeting section 8.3 Climate Change: Carbon Reduction in the document *Bath & North East Somerset Council Local Plan 2016-2036 Options Consultation Winter 2018*. To meet this 10% requirement, a fabric specification very similar to that of the SAP 10.1 option 1 notional building was used (though the flat required a lower air permeability value). The house achieved a 12% reduction and the flat an 11% reduction in carbon emissions. The results of these scenarios show how an even further improved fabric specification has benefits in terms of electricity demand and the SAP/EPC rating.

3 Carbon Emissions: Proposed FHS compared to WoE Policies

3.1 Background

The Climate Change Act 2008 commits the UK to reducing greenhouse gas emissions by 80% compared to 1990 levels by 2050. In June 2019, the UK committed to net-zero greenhouse gas emissions by 2050. Some suggest a sooner net-zero target, such as Extinction Rebellion demanding a 2025 target. In any case, the science indicates the faster and deeper CO_2 is cut, the less risk there is globally to the effects of climate change.

The WoE local authorities have included zero-carbon policies within their draft Local Plans to support their Climate Emergency commitments to achieve carbon neutrality by 2030. The current proposal in the FHS consultation to remove the ability of local authorities to set higher energy efficiency standards than those in the Building Regulations would prevent this from being implemented.

The WoE policies would require net zero unregulated and regulated emissions with a fabric, onsite, and Allowable Solutions component, where this is shown viable through Local Plan viability testing. If this is not found viable, zero regulated emissions may be required similar to the current London Plan. Early indications are that this is viable across the WoE.

The draft WoE policies would be revised following the introduction of the new Building Regulations Part L, but requirements for fabric performance and onsite would remain. If adopted, the policies would come into effect in 2022.

The preferred national trajectory in the FHS consultation is for Part L 2020 to achieve a 31% reduction in regulated emissions compared to a baseline of Part L 2013 (adjusted with SAP 10.1 emissions factors), then for the 2025 FHS to achieve a 75-80% reduction in regulated emissions on the Part L 2013 baseline. The is no reduction for unregulated emissions.

[2] *Getting warmer: a field trial of heat pumps* (2010) and *The heat is on: heat pump field trials phase 2* (2013) by Energy Saving Trust, and *Heat Emitter Guide for Domestic Heat Pumps* which was produced by various Trade Associations including Energy Saving Trust

The modelling and assessment carried out in this report suggests how much 'extra' CO_2 would be emitted per dwelling if built to the proposed national trajectory versus the draft WoE policies.

3.2 Modelling

The assessment is based on the mean modelled emissions of a sample semi-detached house and a mid-floor flat. The Part L 2013 baseline was calculated by using FSAP 2012 to determine the energy consumption values for the dwellings then multiplying these by the relevant SAP 10.1 emissions factors, either for electricity or gas. To simplify the calculation, the average electricity emissions factor was used, whereas SAP 10.1 actually used a different electricity emissions factor for each month of the year. The Part L 2020 and FHS 2025 values were determined by multiplying the regulated emissions by 69% and 25% to represent the respective 31% and 75% reductions (the FHS 2025 is proposed as a 75-80% reduction so the worst case of 75% has been used).

The results of the SAP modelling and reductions are shown below:

Table 6: Carbon emissions of modelled dwellings in SAP

	Regulated emissions (tCO_2/year)	Unregulated emissions (tCO_2/year)	Regulated and unregulated emissions (tCO_2/year)
House	1.52	0.60	2.11
Flat	0.99	0.49	1.48
Mean	1.25	0.54	1.80

Table 7: Carbon emissions at different regulations

	Regulated emissions (tCO_2/year)	Unregulated emissions (tCO_2/year)	Regulated and unregulated emissions (tCO_2/year)
Part L 2013	1.25	0.54	1.80
Part L 2020 Option 2 (31% reduction on regulated emissions)	0.87	0.54	1.41
FHS 2025 (75% reduction on regulated emissions)	0.31	0.54	0.85

These figures were then applied to the number of homes proposed to be built each year. The *West of England Joint Spatial Plan Publication Document November 2017* makes provision for the supply of at least 105,500 new homes between 2016 and 2036. For the purposes of this assessment this figure has been divided by 20 to give an average yearly figure of 5,275 homes per year.

The phase-in assumptions in The FHS Consultation have then been applied to this yearly figure of 5,275 to give the number homes built to the Part L 2020 standard each year. The same phase-in schedule has been assumed for the FHS 2025 standard and the WoE policies.

Table 8: Phase-in assumption from FHS Consultation

	2020	2021	2022	2023	2024 onwards
Phase in (% dwellings captured by Part L and F 2020)	20%	50%	75%	95%	100%

Source: MHCLG

The number of dwellings for each year are multiplied by the corresponding carbon emissions from Table 7 to give the total carbon emissions pear year for new build housing. These figures are then multiplied by the number of years remaining to the end of 2030 to give the total carbon emissions contributed by that year's homes up to 2030.

Table 9: Carbon emissions up to 2030 of FHS and WoE

Future Homes Standard 2025 – 75% reduction	Reg & unreg emissions (tCO_2) up to 2030	486,994
	Reg emissions (tCO_2) up to 2030	298,539

Extra emissions from FHS vs WoE	Option 1: Reg & unreg emissions (tCO_2)	200,588	41% saving through WoE policy
	Option 2: Just reg emissions (tCO_2)	109,930	23% saving through WoE policy

The results in Table 9 show that by 2030 the WoE would have saved 200,588 tCO_2 (41% reduction) with both zero regulated and unregulated emissions, or 109,930 tCO_2 (23% reduction) with just regulated emissions, for the modelled dwellings. This only includes emissions saved up to the end of 2030. The emissions saved will continue to increase due to the dwellings already built and new dwellings built to the zero-carbon (either regulated and unregulated or just regulated emissions) standard. 5,275 (the proposed number of new homes built yearly) zero-carbon dwellings saves 4,510 tCO_2 (regulated and unregulated) or 1,654 tCO_2 (just regulated) emissions per year of operation compared to FHS standards. The full results can be seen in Appendix C. The results are based on the simplification that all dwellings are built to the highest emissions allowed under regulations at that time.

4 Conclusion

The modelling shows that the current proposed standards for Part L 2020 allow the possibility of building dwellings with a very poor fabric specification with heat pumps, which will have a high electricity demand (and demand on the grid) with relatively high running costs. In the modelling the dwellings failed the Part L 2013 TFEE by around 50% by using a heat pump despite passing Part L 2020 regulations.

The affordability target will not necessarily help this, as other measures such as solar PV could be used to improve the affordability without changing the fabric specification (as shown in scenario 6). Therefore, an improved fabric standard is required, which could be in the form of better limiting standards, or a TFEE similar to Part L 2013 (but to an improved standard).

The WoE zero-carbon policy would save 200,588 tCO_2 (41%) of carbon emissions up to 2030 for both regulated and unregulated emissions, or 109,930 tCO_2 (23%) for only regulated emissions. These savings would continue to increase past 2030 for each new year of operation, and as new homes are built. If the WoE is not permitted to implement this policy, it will result in significantly greater emissions. Where other local authorities in the UK are not permitted to implement their own energy efficiency targets this will similarly result in more carbon emissions.

5 Appendices

5.1 Appendix A - SAP 10.1 Outputs

Semi-detached (1)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**53.82**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**63.28**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**58.11**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**5.19**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**11.35**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**9.35**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**77**	*Pass*
SAP Band:	**C**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.26**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**0.18**
Roof, W/m^2K:	**0.16**
Opening, W/m^2K:	**1.6**
Rooflight, W/m^2K:	**2.2**
Air permeability, m^3/h.m^2:	**8**

	Energy Use (kWh/year)			
	Actual Energy	**Actual Primary**	**Option 1 Primary**	**Option 2 Primary**
Space heating	2311.23	3633.46	2930.71	3674.64
Water heating	1139.45	1735.1	3307.9	3290.79
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	0	0	133.76	133.76
Lighting	224.92	344.98	345.09	344.98
Special features	0	0	0	0
Total	3675.59	5713.54	6717.46	7444.19

Semi-detached (2)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**57.84**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**63.15**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**58.01**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**9.20**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**11.32**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**9.33**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**96**	*Pass*
SAP Band:	**A**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.18**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**0.13**
Roof, W/m^2K:	**0.11**
Opening, W/m^2K:	**1.2**
Rooflight, W/m^2K:	**1.2**
Air permeability, m^3/h.m^2:	**5**

	Energy Use (kWh/year)			
	Actual Energy	**Actual Primary**	**Option 1 Primary**	**Option 2 Primary**
Space heating	3478.8	3931.05	3055.63	3800.57
Water heating	2559.25	2891.95	3169.28	3154.42
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	160	248.86	133.76	133.76
Lighting	224.92	344.98	345.09	344.98
Special features	0	0	0	0
Total	6422.97	7416.84	6703.76	7433.74

Semi-detached (3)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**37.89**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**63.28**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**58.11**	(TPER)
TPER based on Part L 2020 requirements		
Dwelling Emission Rate, kgCO_2/m^2.annum:	**3.63**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**11.35**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**9.35**	(TER)
TER based on Part L 2020 requirements		
SAP Rating:	**84**	*Pass*
SAP Band:	**B**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.18**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**0.13**
Roof, W/m^2K:	**0.11**
Opening, W/m^2K:	**1.2**
Rooflight, W/m^2K:	**1.2**
Air permeability, m^3/h.m^2:	**5**

	Energy Use (kWh/year)			
	Actual Energy	**Actual Primary**	**Option 1 Primary**	**Option 2 Primary**
Space heating	1232.58	1942.65	2930.71	3674.64
Water heating	1139.45	1735.1	3307.9	3290.79
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	0	0	133.76	133.76
Lighting	224.92	344.98	345.09	344.98
Special features	0	0	0	0
Total	2596.94	4022.73	6717.46	7444.19

Semi-detached (4)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**51.85**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**63.15**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**58.01**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**8.09**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**11.32**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**9.33**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**96**	*Pass*
SAP Band:	**A**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.15**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**0.11**
Roof, W/m^2K:	**0.11**
Opening, W/m^2K:	**0.8**
Rooflight, W/m^2K:	**0.8**
Air permeability, m^3/h.m^2:	**5**

	Energy Use (kWh/year)			
	Actual Energy	**Actual Primary**	**Option 1 Primary**	**Option 2 Primary**
Space heating	2908.67	3286.79	3055.63	3800.57
Water heating	2567.2	2900.94	3169.28	3154.42
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	160	248.86	133.76	133.76
Lighting	224.92	344.98	345.09	344.98
Special features	0	0	0	0
Total	5860.78	6781.58	6703.76	7433.74

Semi-detached (5)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**34.66**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**63.28**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**58.11**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**3.31**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**11.35**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**9.35**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**85**	*Pass*
SAP Band:	**B**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.15**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**0.11**
Roof, W/m^2K:	**0.11**
Opening, W/m^2K:	**0.8**
Rooflight, W/m^2K:	**0.8**
Air permeability, m^3/h.m^2:	**5**

Energy Use (kWh/year)

	Actual Energy	Actual Primary	Option 1 Primary	Option 2 Primary
Space heating	1014.01	1599.26	2930.71	3674.64
Water heating	1139.45	1735.1	3307.9	3290.79
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	0	0	133.76	133.76
Lighting	224.92	344.98	345.09	344.98
Special features	0	0	0	0
Total	2378.37	3679.35	6717.46	7444.19

Semi-detached (6)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**30.17**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**63.28**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**58.11**	(TPER)
TPER based on Part L 2020 requirements		
Dwelling Emission Rate, kgCO_2/m^2.annum:	**0.24**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**11.35**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**9.35**	(TER)
TER based on Part L 2020 requirements		
SAP Rating:	**92**	*Pass*
SAP Band:	**A**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.26**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**0.18**
Roof, W/m^2K:	**0.16**
Opening, W/m^2K:	**1.6**
Rooflight, W/m^2K:	**2.2**
Air permeability, m^3/h.m^2:	**8**

Energy Use (kWh/year)	**Actual Energy**	**Actual Primary**	**Option 1 Primary**	**Option 2 Primary**
Space heating	2311.23	3633.46	2930.71	3674.64
Water heating	556.43	873.38	3307.9	3290.79
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	0	0	133.76	133.76
Lighting	224.92	344.98	345.09	344.98
Special features	0	0	0	0
Total	3092.58	4851.82	6717.46	7444.19

Mid-floor flat (1)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**52.11**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**68.55**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**65.66**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**4.99**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**12.23**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**11.01**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**80**	*Pass*
SAP Band:	**C**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.26**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**N/A**
Roof, W/m^2K:	**N/A**
Opening, W/m^2K:	**1.6**
Rooflight, W/m^2K:	**N/A**
Air permeability, m^3/h.m^2:	**8**

Energy Use (kWh/year)

	Actual Energy	Actual Primary	Option 1 Primary	Option 2 Primary
Space heating	1197.36	1882.5	1453.83	1842.22
Water heating	1048.78	1596.59	3066.61	3050.72
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	0	0	133.76	133.76
Lighting	171.64	263.27	268.29	263.27
Special features	0	0	0	0
Total	2417.78	3742.36	4922.49	5289.98

Mid-floor flat (2)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**62.92**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**68.04**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**65.25**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**10.36**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**12.14**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**10.93**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**86**	*Pass*
SAP Band:	**B**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.18**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**N/A**
Roof, W/m^2K:	**N/A**
Opening, W/m^2K:	**1.18**
Rooflight, W/m^2K:	**N/A**
Air permeability, m^3/h.m^2:	**5**

Energy Use (kWh/year)

	Actual Energy	Actual Primary	Option 1 Primary	Option 2 Primary
Space heating	1718.31	1941.69	1569.17	1962.31
Water heating	2334.92	2638.46	2914.89	2901.08
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	160	248.86	133.76	133.76
Lighting	171.64	263.27	268.29	263.27
Special features	0	0	0	0
Total	4384.87	5092.28	4886.11	5260.43

Mid-floor flat (3)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**39.44**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**68.55**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**65.66**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**3.74**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**12.23**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**11.01**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**85**	*Pass*
SAP Band:	**B**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.18**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**N/A**
Roof, W/m^2K:	**N/A**
Opening, W/m^2K:	**1.18**
Rooflight, W/m^2K:	**N/A**
Air permeability, m^3/h.m^2:	**5**

	Energy Use (kWh/year)			
	Actual Energy	**Actual Primary**	**Option 1 Primary**	**Option 2 Primary**
Space heating	616.92	972.03	1453.83	1842.22
Water heating	1048.78	1596.59	3066.61	3050.72
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	0	0	133.76	133.76
Lighting	171.64	263.27	268.29	263.27
Special features	0	0	0	0
Total	1837.34	2831.9	4922.49	5289.98

Mid-floor flat (4)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**56.96**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**68.04**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**65.25**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**9.24**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**12.14**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**10.93**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**87**	*Pass*
SAP Band:	**B**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.15**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**N/A**
Roof, W/m^2K:	**N/A**
Opening, W/m^2K:	**0.82**
Rooflight, W/m^2K:	**N/A**
Air permeability, m^3/h.m^2:	**3**

	Energy Use (kWh/year)			
	Actual Energy	**Actual Primary**	**Option 1 Primary**	**Option 2 Primary**
Space heating	1324.71	1496.92	1569.17	1962.31
Water heating	2345.39	2650.29	2914.89	2901.08
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	160	248.86	133.76	133.76
Lighting	174.91	268.29	268.29	263.27
Special features	0	0	0	0
Total	4005.02	4664.37	4886.11	5260.43

Mid-floor flat (5)

Summary

Dwelling Primary Energy Rate, kWh/m^2.annum:	**35.36**	(DPER)
Target Primary Energy Rate Option 1, kWh/m^2.annum:	**68.55**	(TPER)
Target Primary Energy Rate Option 2, kWh.annum*:	**65.66**	(TPER)

TPER based on Part L 2020 requirements

Dwelling Emission Rate, kgCO_2/m^2.annum:	**3.34**	(DER)
Target Emission Rate Option 1, kgCO_2/m^2.annum:	**12.23**	(TER)
Target Emission Rate Option 2, kgCO_2/m^2.annum*:	**11.01**	(TER)

TER based on Part L 2020 requirements

SAP Rating:	**87**	*Pass*
SAP Band:	**B**	

Please note that the SAP rating and band have been calculated using a scale that was designed to work with SAP 10.1 fuel prices. The scale will be recalibrated in line with updated fuel prices when SAP 10.2 is finalised, so these results should be treated as provisional.

***Results updated since 14th November.**

Fabric backstops:

External wall, W/m^2K:	**0.15**
Party wall, W/m^2K:	**N/A**
Floor, W/m^2K:	**N/A**
Roof, W/m^2K:	**N/A**
Opening, W/m^2K:	**0.82**
Rooflight, W/m^2K:	**N/A**
Air permeability, m^3/h.m^2:	**3**

Energy Use (kWh/year)

	Actual Energy	Actual Primary	Option 1 Primary	Option 2 Primary
Space heating	427.08	674.04	1453.83	1842.22
Water heating	1048.78	1596.59	3066.61	3050.72
Electric showers	0	0	0	0
Cooling	0	0	0	0
Pumps and fans	0	0	133.76	133.76
Lighting	174.91	268.29	268.29	263.27
Special features	0	0	0	0
Total	1650.78	2538.92	4922.49	5289.98

5.2 Appendix B - SAP 2012 Outputs

Semi-detached house

1b TFEE and DFEE	
Target Fabric Energy Efficiency (TFEE)	51.1 kWh/m²
Dwelling Fabric Energy Efficiency (DFEE)	74.4 kWh/m²
	Fail

Excess energy = 23.27 kg/m² (45.5 %)

Mid-floor flat

1b TFEE and DFEE	
Target Fabric Energy Efficiency (TFEE)	39.2 kWh/m²
Dwelling Fabric Energy Efficiency (DFEE)	59.1 kWh/m²
	Fail

Excess energy = 19.95 kg/m² (51.0 %)

5.3 Appendix C - Carbon emissions under proposed FHS and WoE

Table 10: Carbon emissions under proposed FHS

Emissions under FHS scenario for WoE New Build Housing		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2020-2030
2013 Part L with 10.1 emission figures	Phase in- % homes to this standard	80	50	25	5	0	0	0	0	0	0	0	
	No houses to this standard	4,220	2,638	1,319	264	0	0	0	0	0	0	0	8,440
	Reg emissions (tCO_2)	5,294	3,308	1,654	331	0	0	0	0	0	0	0	10,587
	Reg & Unreg emissions (tCO_2)	7,578	4,736	2,368	474	0	0	0	0	0	0	0	15,156
2020 "Option 2" – 31%	Phase in- % homes to this standard	20	50	75	95	100	80	50	25	5	0	0	
	No houses	1,055	2,638	3,956	5,011	5,275	4,220	2,638	1,319	264	0	0	26,375
	Reg emissions (tCO_2)	913	2,283	3,424	4,337	4,566	3,653	2,283	1,141	228	0	0	22,828
	Reg & unreg emissions (tCO_2)	1,484	3,711	5,566	7,050	7,421	5,937	3,711	1,855	371	0	0	37,105
Future Homes Standard 2025 – 75% reduction	Phase in- % homes to this standard	0	0	0	0	0	20	50	75	95	100	100	
	No houses	0	0	0	0	0	1,055	2,638	3,956	5,011	5,275	5,275	23,210
	Reg emissions (tCO_2)	0	0	0	0	0	331	827	1,241	1,572	1,654	1,654	7,279
	Reg & unreg emissions (tCO_2)	0	0	0	0	0	902	2,255	3,382	4,284	4,510	4,510	19,842
Total	Reg emissions (tCO_2) per year	6,207	5,591	5,078	4,668	4,566	3,983	3,110	2,382	1,800	1,654	1,654	40,694
	Cumulative reg emissions (tCO_2) up to 2030	68,273	55,913	45,706	37,346	31,960	23,900	15,550	9,528	5,399	3,308	1,654	298,539
	Reg & unreg emissions (tCO_2) per year	9,062	8,447	7,934	7,524	7,421	6,839	5,965	5,237	4,655	4,510	4,510	72,103
	Cumulative reg & unreg emissions (tCO_2) up to 2030	99,683	84,467	71,405	60,189	51,947	41,033	29,827	20,950	13,966	9,019	4,510	486,994

Table 11: Carbon emissions under WoE policy

WoE Policy scenario		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2020-2030
WoE Policies	Phase in- % homes to this standard	0	0	20	50	75	95	100	100	100	100	100	
	No houses	0	0	1,055	2,638	3,956	5,011	5,275	5,275	5,275	5,275	5,275	39,035
WoE Option 1: Zero Reg & unreg emissions	Regulated emissions saved (tCO_2)	0	0	1,016	2,334	3,424	3,784	3,110	2,382	1,800	1,654	1,654	21,159
	Unregulated emissions saved (tCO_2)	0	0	571	1,428	2,142	2,713	2,855	2,855	2,855	2,855	2,855	21,130
WoE Option 2: Zero Reg emissions	Regulated emissions saved (tCO_2)	0	0	1,016	2,334	3,424	3,784	3,110	2,382	1,800	1,654	1,654	21,159

Table 12: Extra carbon emissions from proposed trajectory vs WoE policy

Extra emissions from FHS vs WoE		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total 2020-2030
Option 1: Reg & unreg emissions	Extra reg & unreg CO_2 (tCO_2) per year	0[1]	0[1]	1,587	3,762	5,566	6,497	5,965	5,237	4,655	4,510	4,510	**42,288**[3]
	Cumulative extra reg & unreg CO_2 (tCO_2) up to 2030	0	0	14,281[2]	30,094	38,961	38,981	29,827	20,950	13,966	9,019	4,510	**200,588**[4]
Option 2: Just reg emissions	Extra regulated CO_2 (tCO_2) per year	0	0	1,016	2,334	3,424	3,784	3,110	2,382	1,800	1,654	1,654	**21,159**[3]
	Cumulative extra regulated CO_2 (tCO_2) up to 2030	0	0	9,141	18,673	23,970	22,705	15,550	9,528	5,399	3,308	1,654	**109,930**[4]

1. No emissions are saved during 2020 and 2021 as the WoE zero-carbon policies would not be implemented until 2022
2. This figure is the emissions from the dwellings built in 2022 until the end of 2030. It is calculated by multiplying the CO_2 savings per year (1,587) by the number of years remaining until the end of 2030 (9 years).
3. This figure is the yearly emission savings for the year 2030 from all the dwellings built to the zero-carbon policies up to that point
4. This figure is the cumulative emissions savings for all the dwellings built to the zero-carbon policies until the end of 2030