Tackling Fuel Poverty in Scotland – A Strategic Approach – Technical Annex

Laid before the Scottish Parliament [by the Scottish Ministers] under Section 7(4)(a) of the Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act 2019
November 2021
SG/2021/290

Fuel Poverty Strategy Analytical Annex

This annex provides further analysis underpinning the Fuel Poverty Strategy. It covers analysis of the drivers of fuel poverty, of the characteristics of households which are likely to be in fuel poverty, modelling the scope and cost of energy efficiency improvements for fuel poor households, and summarises the findings of an evidence review of heating system use and related behaviours of those with protected characteristics in Scotland who are at risk of fuel poverty.

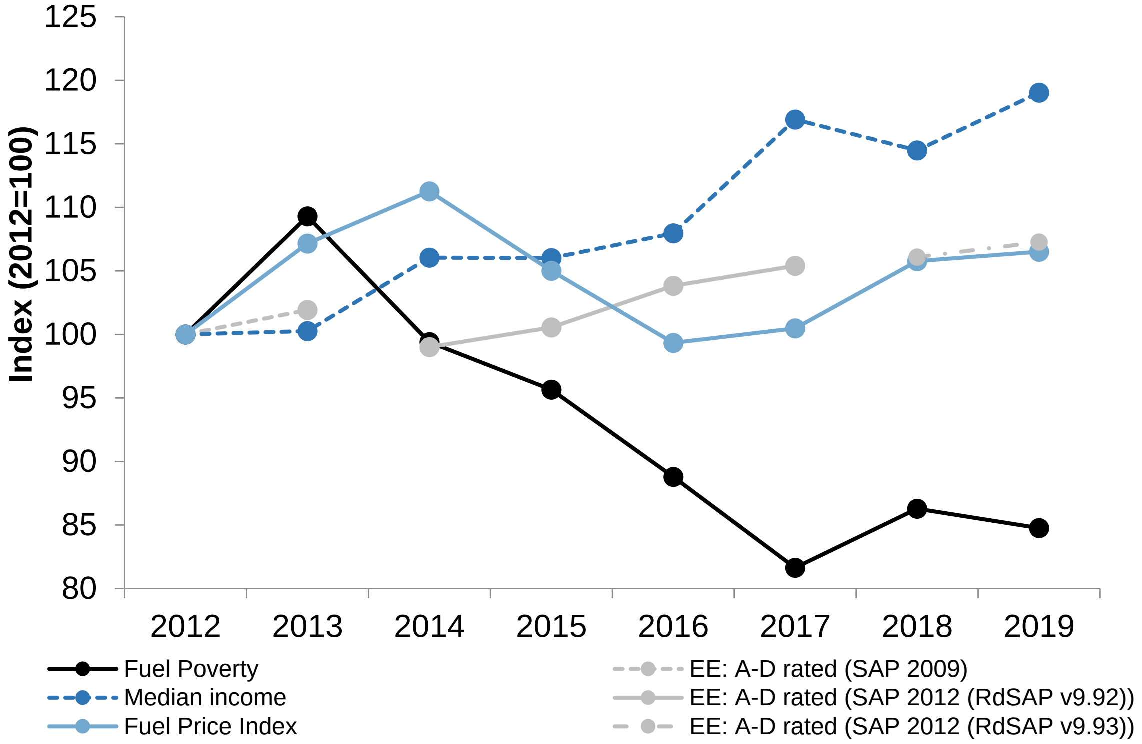
Contents

1. Fuel Poverty Drivers

Fuel poverty is affected by levels of household income, the price of fuel required for space and water heating and other domestic uses, the energy efficiency of housing, and the use of fuel in households. The Scottish House Conditions Survey (SHCS) key findings reports analyse the influence of these factors on changes in fuel poverty rates each year. **Figure 1** shows the trend of fuel poverty levels compared to the three main drivers of fuel poverty which can be analysed by SHCS data, presented as an index with 2012 set to 100.

This demonstrates that the rate of fuel poverty generally follows the price of fuel, increasing or decreasing in line with it unless this is offset by increases in income or energy efficiency. For example in 2014 the rate of fuel poverty did not increase in line with the rise in the average fuel price index as there was an increase in median income which likely offset the fuel price increase. Similarly, in 2017 there was a further reduction in the fuel poverty rate, in line with a large increase in median income and some improvements to energy efficiency.

Figure 1: Trends in Fuel Price, Energy Efficiency and Median Income, 2012 to 2019



The following sections explore each of the drivers of fuel poverty in more detail, with a focus on tenure. Unless otherwise stated, data presented in each section relates to an average over 2017-19 to provide a sufficient sample size to explore characteristics in greater detail.

1.1 Energy Efficiency

The Energy Efficiency Rating (EER) of a dwelling is expressed on a scale of 1-100 where a dwelling with a rating of 1 will have very poor energy efficiency and higher fuel bills, while 100 represents very high energy efficiency and lower fuel bills. For Energy Performance Certificates EERs are presented over 7 bands, labelled A to G. Band A represents low energy cost and high energy efficiency, while band G denotes high energy cost (and low energy efficiency).

Since 2014 (using SAP 2012, with RdSAP v9.92) the energy efficiency profile of Scottish dwellings has risen from a mean of 62.2 to 65.1 (**Table 1**). Similarly, almost half (47%) of all properties in 2019 were rated C or better an increase of 3 percentage points from 2018 and 12 percentage points from 2014. Less than a fifth (15%) were in bands E, F or G – a drop of 6 percentage points over the 5-year period from 2014 to 2018 (**Table 2**). This indicates that dwellings across Scotland are becoming more energy efficient over time (**Figure 1**).

Table 1: Mean SAP 2012 (RdSAP v9.92) Rating by Tenure, 2014 to 2019

Mean SAP 2012 v9.92 rating by tenure								
	Owner occupied	*Sample*	Private rented	*Sample*	Social sector	*Sample*	Scotland	*Sample*
2014	60.84	*1,690*	60.38	*319*	66.45	*673*	62.23	*2,682*
2015	61.83	*1,740*	60.71	*355*	66.66	*659*	62.84	*2,754*
2016	62.57	*1,790*	61.54	*344*	67.58	*716*	63.70	*2,850*
2017	63.39	*1,901*	61.56	*373*	67.82	*728*	64.26	*3,002*
2018	63.78	*1,937*	62.36	*294*	68.36	*733*	64.84	*2,964*
2019	64.18	*1,965*	62.06	*317*	68.87	*715*	65.11	*2,997*

However, the changes have not been uniform across tenures partially due to differences in starting points and in the standards which apply. In the social sector the percentage of dwellings in EPC E, F or G has fallen from 11% in 2014 to 5% in 2019 while the percentage of properties in EPC C or higher has grown from 50% to 58% while the percentage in band D has remained relatively stable (39% in 2014 and 36% in 2019). The private rental sector has also seen a drop in the share of households in EPC E, F or G falling from 29% in 2014 to 21% in 2019. However, there has been no statistically significant change in the proportion rated C or higher in the same period (37% in 2014 and 42% in 2019). Furthermore the owner occupied sector has seen a reduction in both EPC E, F or G rated dwellings (24% to 17%) and

EPC D rated dwellings (48% to 39%) as well as the largest increase in dwellings in EPC C+ bands from 29% in 2014 to 43% in 2019 (**Table 2**).

Figure 2: Mean SAP 2012 (RdSAP v9.92) Rating by Tenure, 2014 to 2019

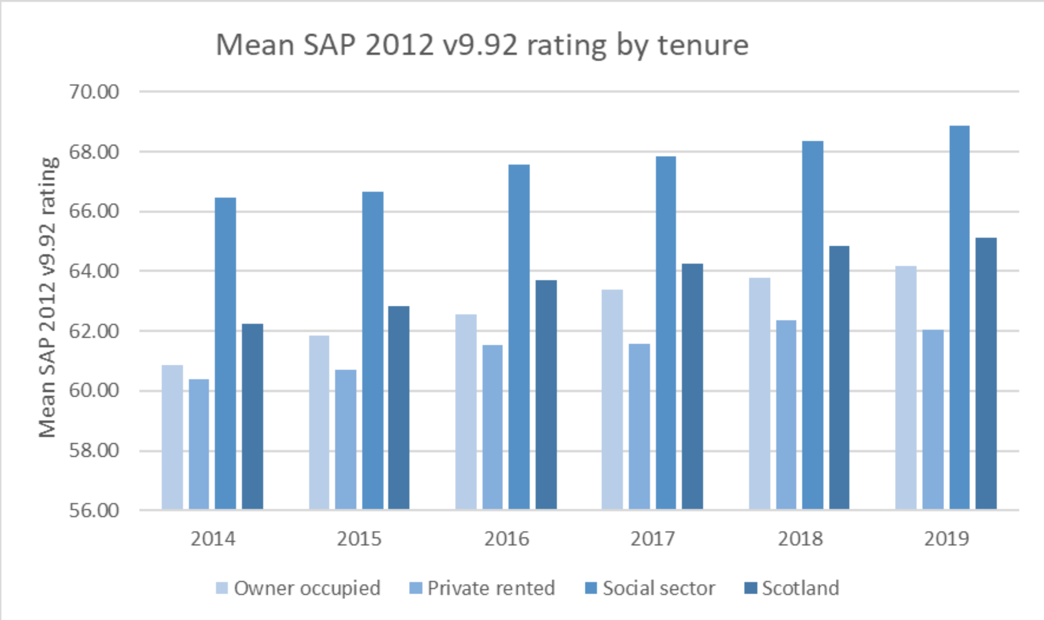


Table 2: Percentage of households by grouped EPC Band (SAP 2012, RdSAP v 9.92) by tenure, 2014 to 2019

Percent of Households in EPC band by Tenure 2014-2019

		Owner occupied	Private rented	Social sector	Scotland	*Sample*
2014	B/C	29%	37%	50%	35%	*853*
	D	48%	34%	39%	43%	*1192*
	E F G	24%	29%	11%	21%	*637*
2015	B/C	32%	34%	49%	37%	*937*
	D	46%	38%	41%	44%	*1189*
	E F G	22%	28%	10%	20%	*628*
2016	B/C	34%	38%	53%	39%	*1024*
	D	47%	36%	40%	44%	*1239*
	E F G	19%	26%	8%	17%	*587*
2017	B/C	38%	39%	55%	42%	*1159*
	D	45%	37%	38%	42%	*1263*
	E F G	18%	24%	7%	16%	*580*
2018	B/C	39%	45%	56%	44%	*1182*
	D	43%	30%	38%	40%	*1231*
	E F G	17%	25%	6%	15%	*551*
2019	B/C	43%	42%	58%	47%	*1285*
	D	39%	37%	36%	38%	*1178*
	E F G	17%	21%	5%	15%	*534*

The energy efficiency of a dwelling depends on its physical characteristics. Factors such as the age of construction, the dwelling type, the heating and hot water systems in use and the extent to which the building fabric is insulated, all affect energy efficiency. In line with the ambition set out in the Heat in Buildings Strategy that all fuel poor households benefit from an energy efficiency rating equivalent to EPC C by 2030 and equivalent to B by 2040, we have set out in **Table 3** a comparison of characteristics of dwellings rated below EPC C with those rated EPC C or above. This considers all dwellings in Scotland and helps to demonstrate the types of dwellings households with low energy efficiency are living in.

Examples of some of the biggest differences include that dwellings rated below EPC C when compared to EPC C+ are[1]:

- less likely to have boilers meeting efficiency standards (52% versus 71% for EPC C+);
- less likely to have wall insulation (40% versus 83%);
- more likely to have solid walls (36% versus 13%);
- more likely to be built before 1945 (42% versus 16%) and less likely to be built after 1982 (12% versus 45%);
- less likely to have newer double glazing from post-2003 (43% versus 59%);
- less likely to be tenements (16% versus 32%);
- less likely to live in urban areas (77% versus 91%);
- less likely to have gas as the primary heating fuel (72% versus 90%) and therefore more likely to have electricity or other fuel types as the primary heating fuel (14% versus 6% for electric, and 14% versus 3% for other).

[1] All differences above are statistically significant and we have highlighted some of the biggest differences, where there is a 15 percentage point or higher change. Table 3 provides a range of characteristics and data which can be explore in more detail.

Table 3: EPC (SAP 2012 v9.92) by selected dwelling characteristics, all households 2017-2019

	EPC C Plus % in Band	EPC Below C % in Band	Significant Difference?	Scotland % in Band
Primary Heating Fuel				
Gas	90%	72%	*	80%
Electric	6%	14%	*	11%
Other	3%	14%	*	9%
Dwelling Type				
Detached	19%	26%	*	23%
Semi-detached	15%	24%	*	20%
Terraced	19%	23%	*	22%
Tenement	32%	16%	*	23%
Other flats	15%	10%	*	13%
House or Flat				
House	53%	73%	*	64%
Flat	47%	27%	*	36%
Age of Dwelling				
pre-1919	8%	28%	*	19%
1919-1944	8%	14%	*	11%
1945-1964	19%	23%	*	21%
1965-1982	20%	23%	*	21%
post 1982	45%	12%	*	27%
Banded Loft Insulation				
<100mm	3%	8%	*	6%
100mm to 199mm	24%	35%	*	31%
200mm or more	73%	57%	*	63%
Are External Walls Insulated?				
No	17%	60%	*	41%
Yes	83%	40%	*	59%
Cavtity or Solid Walls				
Cavity	87%	64%	*	74%
Solid / Other	13%	36%	*	26%
Wall Type and Insulation Level				
Cavity wall no insulation	9%	28%	*	20%
Cavity wall with insulation	78%	36%	*	55%
Solid wall no insulation	8%	32%	*	21%
Solid wall with insulation	6%	4%	*	5%
Number of Bedrooms				
1	14%	12%		13%
2	39%	33%	*	35%
3	31%	37%	*	34%
4 or more	17%	18%		17%
Rural Urban Six Fold Classification				
Large urban areas	40%	32%	*	35%
Other urban areas	39%	32%	*	35%
Accessible small towns	9%	9%		9%
Remote small towns	3%	4%	*	4%
Urban - subtotal	91%	77%	*	83%
Accessible rural	7%	14%	*	11%
Remote rural	2%	9%	*	6%
Rural - subtotal	9%	23%	*	17%
Whether Dwelling has PPM meter				
No	80%	81%		81%
Yes	20%	19%		19%
Extent of Central Heating				
Full	98%	94%	*	96%
Partial or none	2%	6%	*	4%
Whether Dwelling is On Gas Grid				
On Grid	85%	80%	*	83%
Off Grid	15%	20%	*	17%
Type of Glazing				
Single	2%	7%	*	5%
Double, pre 2003	36%	45%	*	41%
Double, post 2003	59%	43%	*	50%
Double, age unknown	2%	3%		2%
Boiler Meets Efficiency Standards				
No	29%	48%	*	39%
Yes	71%	52%	*	61%
Scotland				
	100%	100%		100%

[2]

[2] A "*" in this table indicates the difference between EPC C+ and EPC below C is statistically significant.

The lowest rates of fuel poverty are associated with higher energy efficiency ratings. The fuel poverty rate for households in dwellings rated EPC C or above is 20% rising to 33% for those in bands E, F or G. This pattern holds across all tenure types (**Table 4**). For example, averaged over 2017-19 only 12% of owner occupied dwellings in EPC C or higher are in fuel poverty while 25% in EPC E, F or G are in fuel poverty. Similarly, in the private rental sector those figures are 30% and 47% respectively. For the Social rental sector 31% of all households in EPC C or higher are in fuel poverty while the number climbs to 65% for those in EPC E F or G.

In terms of extreme fuel poverty the rates follow a similar trend across all tenures with owner occupiers having rates of 4% in EPC C or above and 21% in EPC E, F or G. Private rented tenants having rates of 14% in EPC C or above and 37% in EPC E, F or G and Social sector tenants 8% in EPC C or above and 49% EPC E, F or G. respectively.

Furthermore, the median fuel poverty gap (adjusted to 2015 prices) (**Table 14**) also increases as EPC ratings decrease in owner occupied and private and social rented sector dwellings. For private rentals EPCs in the lowest bands have a median fuel poverty gap of £1,410 compared to £570 for those in EPC C or above, similarly owner occupiers have a median fuel poverty gap of £440 pounds in EPC C or above versus a gap of £1,750 in EPC E F or G. Furthermore, in the social sector the median fuel poverty gaps are £1,320 and £320 respectively.

These figures demonstrate that those households living in properties with lower energy efficiency ratings are most likely to be in fuel poverty. However, it is also important to consider the coverage of the fuel poor population these characteristics represent (**Table 4**). For example, owner occupier households are the least likely to be fuel poor (16%) but, due to their share of the overall Scottish population (62%), they represent over two fifths (41%) of all fuel poor households. Similarly, social sector dwellings rated EPC E, F or G have the highest rates of fuel poverty (65%) but due to the size of the social sector and energy efficiency standards which apply, they represent only 11% of all fuel poor dwellings in the social sector and 4% of all fuel poor dwellings overall. This is also true when looking at extreme fuel poverty figures. For example while 4% of owner occupiers in dwellings EPC C or above are in extreme fuel poverty, they represent 19% of all owner occupiers in extreme fuel poverty and 14% of all households in extreme fuel poverty in Scotland.

Table 4: Fuel Poverty Rates (accuracy) and share of households (coverage) which are fuel poor by tenure and EPC rating (SAP 2012, RdSAP v9.92), average over 2017-2019

	Owner occupied				Private Rented				Social				Total			
	Rate	Share of owner occupied	Share of Scotland	*Sample*	Rate	Share of Private Rented	Share of Scotland	*Sample*	Rate	Share of Social Rented	Share of Scotland	*Sample*	Rate	Share of all FP	Share of Scotland	*Sample*
	Fuel Poverty															
EPC C or better	12%	29%	12%	*2,061*	30%	33%	6%	*353*	31%	45%	18%	*1,148*	20%	36%	36%	*3,562*
EPC D	17%	44%	18%	*2,440*	39%	37%	7%	*344*	46%	44%	18%	*814*	26%	43%	43%	*3,598*
EPC E, F or G	25%	27%	11%	*1,212*	47%	30%	6%	*261*	65%	11%	4%	*170*	33%	21%	21%	*1,643*
All	16%	100%	41%	*5,713*	37%	100%	19%	*958*	38%	100%	41%	*2,132*	24%	100%	100%	*8,803*
	Extreme Fuel Poverty															
EPC C or better	4%	19%	14%	*2,061*	14%	27%	3%	*353*	8%	33%	1%	*1,148*	7%	25%	25%	*3,562*
EPC D	8%	39%	11%	*2,440*	20%	33%	8%	*344*	18%	46%	13%	*814*	12%	40%	40%	*3,598*
EPC E, F or G	21%	41%	23%	*1,212*	37%	40%	9%	*261*	49%	21%	18%	*170*	27%	35%	35%	*1,643*
All	9%	100%	48%	*5,713*	22%	100%	20%	*958*	14%	100%	32%	*2,132*	12%	100%	100%	*8,803*

1.2 Income

According to the official poverty definition, individuals are considered to be in relative (income) poverty if their equivalised net household income is below 60 per cent of the median income in the same year. Annual median income of all households in Scotland collected through the SHCS has increased by 19% (around £4,000) in nominal terms since 2012. Between 2018 and 2019, the increase in income offset increases in fuel prices which would otherwise have seen the fuel poverty rate increase[3].

Although low income is correlated with, and is a strong indicator of, fuel poverty, it is not equivalent. While almost three-quarters of all fuel poor households in 2019 would be considered to be in relative poverty after housing costs (73% or 448,000) the other quarter have after housing costs incomes above the relative poverty threshold (27% or 165,000 households) (**Table 5**)**.** Similarly, 86% of income poor households

[3] The SHCS is not designed to capture income as comprehensively as other formal surveys of income and is collected on a self-reported basis. From 2018, total household income, including the income of other adults, has been collected in the survey. However, in order to provide a consistent time series of fuel poverty estimates for 2012 to 2019, we have only taken account of income from the highest income householder and their partner in our fuel poverty and income poverty analysis. We plan to introduce income from other household members, along with other developments under the new definition, in future years. In addition, our measure of income after housing costs deducts full mortgage payments from household income rather than mortgage interest only. This means that our assessment of income poverty will have some differences from other sources.

were fuel poor in 2019, with 48% of income poor households were in extreme fuel poverty in 2019[4] (**Table 6**).

Table 5: Estimated Number and Proportion of Households by Fuel Poverty and Income Poverty Status, SHCS 2018 and 2019

			Income Poor	Not Income Poor	All	*Sample Size*
2018	**Fuel Poor**	**000s**	432	187	619	
		Row %	70%	30%	100%	*732*
	Not Fuel Poor	**000s**	58	1,800	1,858	
		Row %	3%	97%	100%	*2,173*
	All	**000s**	490	1,988	2,477	*2,905*
2019	**Fuel Poor**	**000s**	448	165	613	
		Row %	73%	27%	100%	*742*
	Not Fuel Poor	**000s**	73	1,810	1,883	
		Row %	4%	96%	100%	*2,208*
	All	**000s**	520	1,975	2,496	*2,950*

Table 6: Fuel Poverty Rate and extreme fuel poverty rate (%) by Income Poverty Status, SHCS 2018 and 2019

Fuel Poverty		**2018**	**2019**
Income Poor	%	88%	86%
	Sample size	*551*	*596*
Not Income Poor	%	9%	8%
	Sample size	*2,354*	*2,354*
All	%	25.0%	24.6%
	Sample size	*2,905*	*2,950*
Extreme Fuel Poverty		**2018**	**2019**
Income Poor	%	48%	48%
	Sample size	*551*	*596*
Not Income Poor	%	2%	3%
	Sample size	*2,354*	*2,354*
All	%	11.3%	12.4%
	Sample size	*2,905*	*2,950*

This varies by tenure with households in the PRS more likely than in other sectors to be both fuel and income poor. Averaging three years of data over 2017-19, indicates that 80% of fuel poor households in the PRS may be considered to live in relative

[4] Further details of the methodology behind the calculation of relative income poverty through the SHCS can be found in the Key Findings Report 2019 - Scottish house condition survey: 2019 key findings - gov.scot (www.gov.scot).

poverty after housing costs versus 72% in the social and 67% in the owner occupied sectors (**Table 9**).

Within the new fuel poverty definition, fuel poor households which are not in income poverty are still considered to have incomes which, after receipt of certain benefits for a care need or disability as well as housing, fuel, and childcare costs are deducted, are too low to offer an acceptable standard of living. However, analysis shows that the median fuel poverty gap from 2017 - 2019 for households which are not in relative income poverty but are fuel poor is £470 (adjusted for 2015 prices), while the median gap for those which are in relative income poverty and fuel poor is £700 pounds. This indicates that households which are not in income poverty but are fuel poor have a shallower depth of fuel poverty than those which are in income poverty (**Table 7**).

However, although income poverty is an important factor in identifying fuel poor households, in purely measurement terms, in the majority of cases reducing fuel bills directly, for example through schemes such as Warm Homes Discount, will be a more effective means of reducing fuel poverty rates than providing a more general income-related benefit. This is due to the criteria in the fuel poverty definition that required fuel costs are more than 10% of net income after housing costs. As a result £10 off a fuel bill would have the same effect as increasing income by £100.

Table 7: Median Fuel Poverty Gap (Adjusted for 2015 prices) 2017-19 by Relative Income Poverty and EPC Rating

Median fuel poverty gap (adjusted for 2015 prices) 2017-19 by poverty and EPC rating				
	Not in Poverty		In Relative Poverty	
	Median	*Sample*	Median	*Sample*
C Plus	180	*129*	440	*590*
D	350	*302*	740	*634*
E F G	1,240	*264*	1,720	*283*
Scotland	470	*695*	700	*1507*

*Values are rounded to the nearest £10.

Characteristics of households in relative poverty

Data from the Poverty and Income Inequality in Scotland 2017-20[5] report indicates the following key findings:

- Most working-age adults (61%) and around two thirds (68%) of children in relative poverty live in working households.
- Some types of households with children are known to be at particularly high risk of poverty. These include households with single parents, three or more children, disabled household members, of a minority ethnic background, with a child under one, or a mother aged under 25. Taken together, these groups cover the majority of households with children that are in poverty.
- Relative poverty rates are highest for singles (27%), divorced and separated (27%), and lowest for married adults (13%).
- Relative poverty rates are higher for ethnic minorities, over 40% of those Asian, Asian British, Mixed, Black or Black British and Other ethnic groups compared to 18% for White – British and 24% for White – Other.(2015- 2020 data).
- Relative poverty rates, with disability benefits removed from household income, are higher where a household member is disabled (29% compared to 16%).
- Almost three quarters (71%) of those who are unemployed are in relative poverty (representing 8% of those in poverty overall).
- 47% of those who are economically inactive or retired are in relative poverty (39% of all in poverty).
- 39% of those renting from a social landlord are in relative poverty (40% of all in poverty).

1.3 Fuel Prices

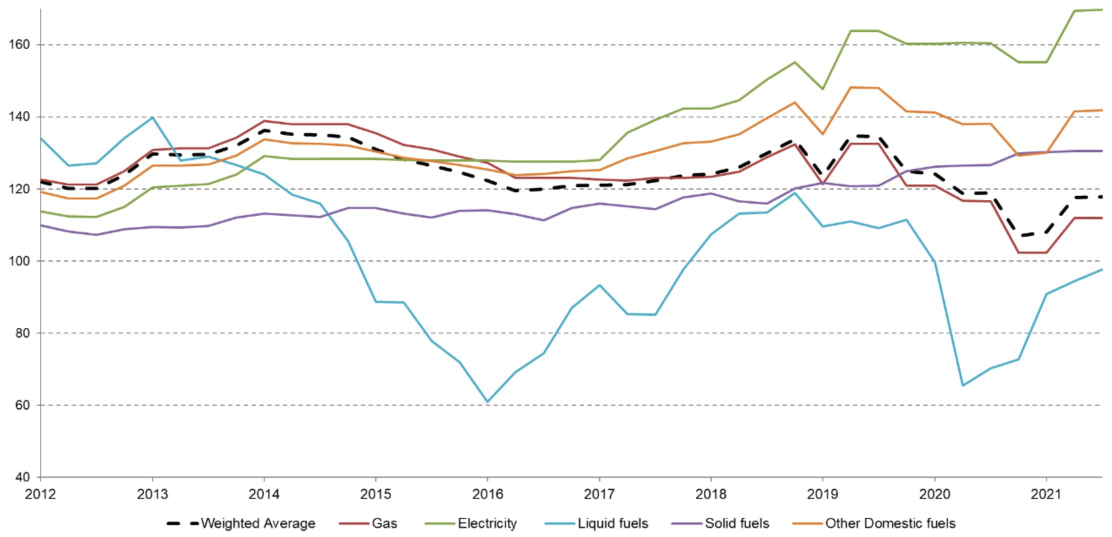
Changes in fuel prices play a key role in the overall fuel poverty rates as the rate of fuel poverty generally follows the price of fuel, increasing or decreasing in line with it unless this is offset by increases in income or energy efficiency. Therefore it will be important to monitor changes in fuel prices over the course of the strategy.

In order to examine the cost of fuels in Scotland we use data on energy prices from BEIS who publish quarterly energy prices data on the price of key fuels which enables us to construct time series for the unit price of fuels for the average Scottish household over the longer term. Using information from the SHCS about the fuels

[5] Poverty and Income Inequality in Scotland 2017-20 (data.gov.scot). Data provided here is based on relative poverty after housing costs i.e. households where equivalised income after housing costs is below 60% of median income in the same year. This is a measure of whether those in the lowest income households are keeping pace with the growth of incomes in the economy as a whole.

used for space and water heating we can weight the published national quarterly fuel price indices, and produce an average index value for the price of the heating fuel requirement for Scotland (**Figure 3**)

Figure 3: BEIS Fuel Price Indices and a Weighted Average for Scotland: 2012 to September 2021



Although fuel prices fluctuate over time due to a variety of factors both domestic and international some fuels have generally increased in price between 2012 and 2019 (the latest year of fuel poverty estimates) (**Table 8**). Of particular note is that the price of electricity has risen 40%, a rate which vastly outpaces median income which has grown 19% during the same time period. It is likely that the share of electricity in the fuel mix will increase in the future as there is a move towards zero-carbon technologies meaning that more households will start to become affected by electricity prices. However, this may be offset to some extent by the greater efficiency of zero carbon technologies such as heat pumps.

BEIS has published fuel price data up to September 2021. Assuming that the fuel mix in Scotland in 2021 is the same as captured by the 2019 SHCS, the weighted average index value for the price of the heating fuel requirement for Scotland will fall driven primarily by the falling price of gas. However, this masks further increases of 4% for electricity and 7% for solid fuels between 2019 and the most current 2021 data. It also does not take account of further fuel price changes after September 2021, such as the projected £136 (£153 for prepayment customers) increase in the average dual fuel bill due to the energy price cap increase or any future levy rebalancing.

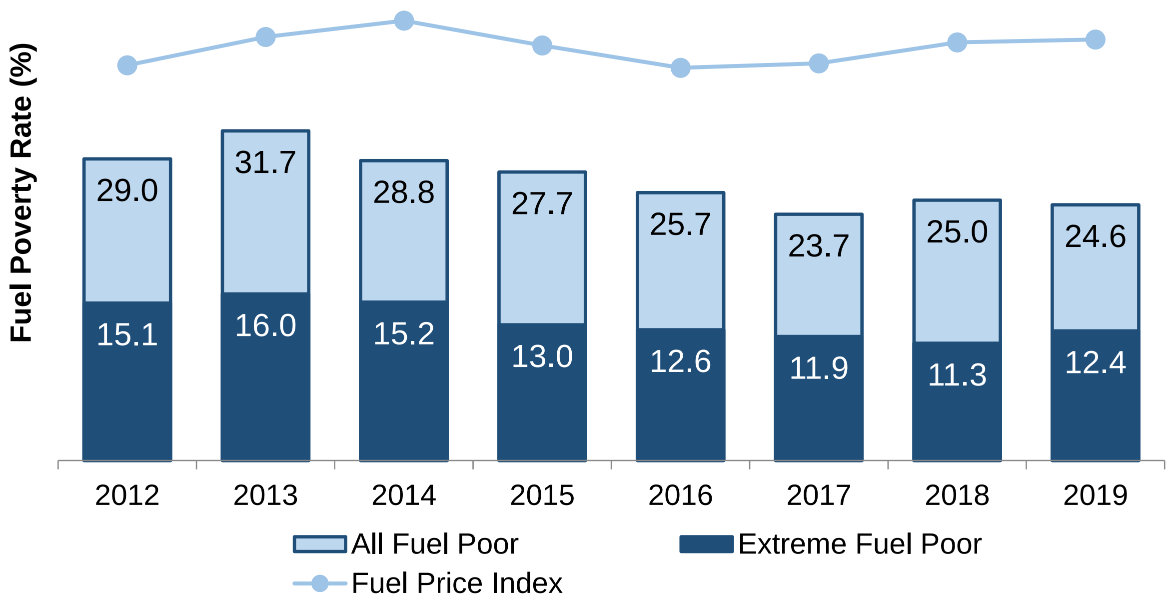
Table 8: BEIS Current Fuel Price Indices and a Weighted Average for Scotland: 2012 – September 2021

Year	Current fuel price indices					
	Gas	Electricity	Liquid fuels	Solid fuels	Other fuels	Weighted Average
2012	122.5	113.4	130.5	108.6	118.7	**121.5**
2013	131.9	121.7	130.8	110.2	127.2	**130.2**
2014	138.2	128.5	116.0	113.2	132.8	**135.2**
2015	131.9	128.0	81.8	113.5	128.4	**127.6**
2016	124.1	127.7	72.9	113.3	124.6	**120.7**
2017	122.8	136.3	90.4	115.9	129.3	**122.1**
2018	127.4	148.1	113.3	117.9	138.0	**128.5**
2019	126.9	158.9	110.3	122.1	143.3	**129.4**
2020	114.2	159.1	77.1	127.3	136.6	**117.2**
To SEP 2021	**108.8**	**164.7**	**94.3**	**130.4**	**137.8**	**114.5**

Source: BEIS Quarterly Energy Prices

Although the fuel price index demonstrates trends over time it is important to remember that not all fuels have the same starting point. For example although liquid fuels (LPG and Bottled gas) fell 30% in 2020 they still remain among the more expensive fuel types per unit price.

Figure 4 Estimates of Fuel Poverty and Extreme Fuel Poverty since 2012



While fuel prices affect all fuel poor households (and indeed all households), those which use fuels with the highest current costs (Electricity, Bottled gas, LPG,) or with inefficient heating systems such as storage heaters and room heaters may be more acutely effected.

For example, averaged over 2017 -19 the rate of fuel poverty for owner occupiers using electricity is 27% (20% in extreme fuel poverty) compared to a rate of 14% (7% in extreme fuel poverty) for mains gas. Similarly, 49% of households in the private rented sector using electricity are in fuel poverty (38% in extreme fuel poverty) compared to 34% and 18% respectively for those on mains gas. The social sector follows a similar pattern whereby 55% of households heating their homes with electricity are in fuel poverty (with 35% in extreme fuel poverty) compared to 36% and 11% for mains gas (**Table 9** and **Table 10**)

However it is important to note that although households heating with electricity have higher rates of fuel poverty, households heating with mains gas make up the majority of fuel poor households overall. Owner occupiers using mains gas make up 71% of all fuel poor owner occupiers while those heating with electricity make up 13%. Similarly, in the private rented sector the figures are 66% and 23% and in the social rented sector the figures are 74% and 21% respectively (**Table 9** and **Table 10**)

Similarly, the median fuel poverty gap for households using electricity for heating (average over 2017-19, adjusted for 2015 prices) is much larger than the gap experienced by households using mains gas £1,100 vs £540 (**Table 14**).

2. Characteristics

A series of crosstab analyses were conducted to examine the individual links between a range of measures and households in fuel poverty and extreme fuel poverty. This is useful as a means of exploring ways of identifying and targeting fuel poor households for interventions.

This explored:

- Accuracy – the percentage of households within the variable category which were in fuel poverty / extreme fuel poverty.
- Coverage – the percentage of households in fuel poverty / extreme fuel poverty which fell within the variable category.

We were interested in variables that had reasonably high accuracy and reasonably high coverage. Having one or the other on their own is not particularly helpful. For example, 72% of fuel poor households are identified as having gas as their primary heating fuel but only 22% of those using gas are fuel poor. The high coverage reflects the fact that gas is the most common heating system across Scotland rather than a unique feature of fuel poor households.

2.1 Characteristics of households likely to be in fuel poverty

Table 9 and **Table 10** describe the fuel poverty rates (accuracy) for some key household and dwelling characteristics as well as the proportion of households for each characteristic which are fuel poor (coverage). **Table 11** and **Table 12** the same for the same for extreme fuel poverty and **Tables 13** to **Table 16** provide information on the fuel poverty gap by the same characteristics. We will keep this analysis under review and update as necessary to ensure that any changes over time which may impact policies or programmes are identified.

The tables demonstrate many of the characteristics associated with particularly high levels of fuel poverty. Some examples[6] (not exhaustive) of these include households which:

- have a low income (households with a weekly income of less than £300 have a fuel poverty rate of 71% and represent 77% of fuel poor households);

[6] To identify those characteristics with the highest rates of fuel poverty to provide as examples, we focused on those around 10 percentage points higher than the national fuel poverty rate (or the associated fuel poverty rate by tenure) or where there is a binary characteristic and there is statistically significant difference of around 10 percentage points or more in the fuel poverty rate between those with and without that characteristic. In addition, where there are similar measures e.g. households in unemployment or households receiving unemployment benefits we have highlighted only one as an example. There are other statistically significant differences between characteristics in terms of fuel poverty rates and these can be identified in Tables 9 to 16. We have also focussed on those characteristics which represent a reasonable coverage of fuel poor households.

- other characteristics associated with low income such as:
- having a highest income householder who is single and not in work (this can include single adult, single pensioner and single parent families, for example, where the single parent is not working as well as mixed adult households where the highest income householder has no partner / spouse) (45% of such households are fuel poor and represent 50% of all fuel poor households);
- live in council tax band A (34% are fuel poor and represent 29% of all fuel poor households);
- being in receipt of council tax reduction (37% of such households are fuel poor and represent 37% of fuel poor households);
- being eligible for cold weather payments (45% of such households are fuel poor and represent 21% of fuel poor households);
- have a member of the household with a health condition lasting 12 months or longer (fuel poverty rate of 31% compared to 19% for those who don't; representing 55% of fuel poor households);
- use electricity as their main heating fuel (41% are fuel poor, representing 18% of fuel poor households);
- rent their accommodation (38% of social renters and 37% of private renters are fuel poor, representing 41% and 19% of fuel poor households respectively);
- live in remote areas (38% of those living in remote rural areas are fuel poor and 34% of those in remove small towns; representing 9% and 5% respectively of fuel poor households);
- live in smaller properties e.g. those with only 1 bedroom (36% are fuel poor, representing 19% of all fuel poor households).
- have a pre-payment meter (37% are fuel poor, representing 29% of fuel poor households);
- live in the properties with the lowest levels of energy efficiency (EPC bands E-G) (33% are fuel poor, representing 21% of all fuel poor households).

Although many of these characteristics show high levels of fuel poverty across all housing tenures, within each tenure there are also particular characteristics which result in higher fuel poverty rates compared to households without those characteristics which are not seen across all tenures. For example:

- In the owner-occupied sector, being in receipt of a disability benefit has a high fuel poverty rate (29%), when compared to 15% for those without while this gap is smaller in other tenure types; using other fuels also has a higher rate of fuel poverty (24%) when compared to gas (14%) older households (22%) have higher fuel poverty rates when compared to families (7%) and other households (16%). Conversely, fuel poverty rates of households with a pre-payment meter (21%) are not much higher than those without (16%).

- In the private rented sector, households where someone has a long-term sickness or disability have higher fuel poverty rates (46%) than those without (33%); fuel poverty rates of households where the highest income householder is in a couple and neither work (60%) and where there is a non-working single person (71%) are much higher than other household types and also much higher compared to other tenures. However, only households in remote rural areas have higher rates of fuel poverty (47%) and not those in remote small towns (37%), when compared to the overall fuel poverty rate in the private rented sector (37%).
- In the social sector, the fuel poverty rate of other households (45%) is higher than for older households (37%) and families (29%); and there is little difference in fuel poverty rates between those with pre-payment meters (39%) and those without (38%) or for those estimated to be eligible for cold weather payments (41%) and those not eligible (37%).

Although there are many similarities between the tenures in the factors with highest levels of fuel poverty rates, there are differences in how big a share of the fuel poor population these represent. For example, rates of fuel poverty increase with lower levels of energy efficiency across all tenures. However, dwellings in the social sector with the lowest energy efficiency ratings (EPC E, F or G) make up a smaller proportion of all fuel poor households in that sector (11%) compared to the owner occupied (27%) and private rented (30%) sectors. Similarly, 82% of fuel poor households in the social sector are found in council tax bands A or B compared to 33% in the owner occupied and 54% in the private rented (**Table 9**). Therefore it is important to consider both the fuel poverty rate for a group and what share (coverage) of the total fuel poor that group represents when seeking to target interventions.

Many of the characteristics highlighted above are also important for extreme fuel poverty and understanding the fuel poverty gap However, there are some differences. For example there is very little difference in extreme fuel poverty rate for those households where at least one member has a long term health condition or disability (14%) and those households where there is not (10%) while this was a distinguishing factor for overall fuel poverty rates.

In particular, EPC rating (and other dwelling characteristics associated with energy efficiency) become a bigger factor for extreme fuel poor households. 27% in EPC E, F or G are extreme fuel poor, representing 35% of all extreme fuel poor households while this group represented 21% of fuel poor households (**Table 11**).

It also does not necessarily follow that those households with the highest rates of fuel poverty have the largest median fuel poverty gaps (adjusted for 2015 prices). For example, those in receipt of council tax reduction have a median gap of £560 while those who are not have a gap of £730 (**Table 13**). This is likely to reflect that those in receipt of council tax reduction are on lower incomes and likely to be living in smaller, potentially more efficient properties while those who are not may be living in larger, inefficient properties. When considering the characteristics of households likely to be fuel poor, it is therefore also important to explore their extreme fuel poverty rates and median fuel poverty gaps.

Table 9: Fuel poverty rates (accuracy) for selected household characteristics and proportion of households for each characteristic (coverage) which are fuel poor, average over 2017-2019

	Owner Occupied			Private Rented			Social			Total		
	FP Rate	Share FP	*Sample*	FP Rate	Share FP	*Sample*	FP Rate	Share FP	*Sample*	FP Rate	Share FP	*Sample*
Household Type												
Older	22%	50%	*2,152*	45%	15%	*140*	37%	31%	*691*	27%	36%	*2,983*
Families	7%	10%	*1,269*	32%	22%	*258*	29%	19%	*540*	17%	16%	*2,067*
Other	16%	40%	*2,292*	38%	63%	*560*	45%	50%	*901*	27%	48%	*3,753*
Council Tax Band												
A	22%	12%	*547*	44%	22%	*188*	38%	49%	*1024*	34%	29%	*1,759*
B	19%	21%	*976*	41%	32%	*281*	41%	33%	*687*	30%	28%	*1,944*
C	16%	16%	*902*	33%	17%	*180*	37%	13%	*316*	23%	15%	*1,398*
D	15%	15%	*934*	32%	14%	*146*	35%	3%	*85*	19%	10%	*1,165*
E	15%	18%	*1,139*	36%	10%	*94*	*	*	*	18%	10%	*1,252*
F-H	13%	18%	*1,213*	*	*	*	*	*	*	13%	8%	*1,280*
Weekly Household Income												
<£300	67%	77%	*1,059*	90%	70%	*271*	69%	80%	*946*	71%	77%	*2,276*
£300 to £400	20%	15%	*727*	43%	20%	*168*	26%	16%	*506*	25%	17%	*1,401*
£400 to £500	6%	5%	*670*	18%	7%	*129*	10%	3%	*278*	9%	5%	*1,077*
£500-£700	2%	3%	*1,124*	5%	3%	*187*	2%	1%	*268*	2%	2%	*1,579*
£700+	0%	0%	*2,133*	*	*	*	*	*	*	0%	0%	*2,470*
Relative Poverty												
No	6%	33%	*5,011*	11%	20%	*657*	16%	28%	*1411*	9%	29%	*7,079*
Yes	87%	67%	*702*	89%	80%	*301*	83%	72%	*721*	86%	71%	*1,724*
Household Member Long Term Sick or Disabled												
No	13%	48%	*3,543*	33%	60%	*617*	35%	34%	*818*	19%	44%	*4,978*
Yes	22%	52%	*2,165*	46%	40%	*341*	41%	66%	*1309*	31%	55%	*3,815*
Highest Income Householder or Spouse in Recipt of a Benefit for Disability or Care Need												
No	15%	86%	*5,275*	37%	91%	*863*	41%	75%	*1508*	23%	82%	*7,646*
Yes	29%	14%	*438*	38%	9%	*95*	33%	25%	*624*	32%	18%	*1,157*
Highest Income Householder or Spouse in Recipt of Any Benefit												
No	10%	22%	*2,060*	30%	38%	*426*	28%	11%	*328*	16%	21%	*2,814*
Yes	20%	78%	*3,653*	43%	62%	*532*	40%	89%	*1804*	29%	79%	*5,989*
Highest Income Householder or Spouse is Eligible Cold Weather Payment												
No	15%	91%	*5,541*	34%	81%	*851*	37%	65%	*1453*	22%	79%	*7,845*
Yes	46%	9%	*172*	65%	19%	*107*	41%	35%	*679*	45%	21%	*958*
Highest Income Householder or Spouse in Recipt of Council Tax Reduction												
No	15%	78%	*4,971*	31%	63%	*722*	35%	48%	*1163*	20%	63%	*6,856*
Yes	25%	22%	*742*	55%	37%	*236*	42%	52%	*969*	37%	37%	*1,947*
Highest Income Householder and / or Spouse Unemployed												
No	16%	96%	*5,642*	35%	90%	*914*	36%	88%	*1998*	23%	92%	*8,554*
Yes	48%	4%	*71*	82%	10%	*44*	68%	12%	*134*	66%	8%	*249*
Working Age Highest Income Householder or Spouse and Income from employment												
no	56%	22%	*349*	79%	42%	*172*	57%	46%	635	60%	35%	1,156
yes	8%	28%	*3,212*	23%	43%	*646*	24%	23%	806	13%	29%	4,664
no - older household	22%	50%	*2,152*	45%	15%	*140*	37%	31%	691	27%	36%	2,983
Household Working status												
Single working adult	17%	16%	*818*	35%	28%	*269*	36%	18%	*425*	26%	19%	*1,512*
Non-working single	35%	38%	*1,014*	71%	48%	*239*	48%	62%	*1039*	45%	50%	*2,292*
Working couple	2%	5%	*2,056*	5%	3%	*267*	6%	2%	*266*	3%	3%	*2,589*
Couple, one works	16%	12%	*661*	29%	9%	*115*	29%	6%	*167*	21%	9%	*943*
Couple, neither work	23%	29%	*1,164*	60%	11%	*68*	43%	12%	*235*	29%	19%	*1,467*
Banded age of Highest Income Householder												
16 to 24	25%	1%	*42*	65%	27%	*124*	49%	3%	*63*	54%	7%	*229*
25 to 34	6%	3%	*454*	26%	19%	*242*	33%	11%	*265*	19%	9%	*961*
35 to 44	7%	6%	*772*	26%	14%	*191*	32%	12%	*292*	16%	10%	*1,255*
45 to 59	12%	22%	*1,715*	36%	20%	*205*	39%	29%	*629*	21%	24%	*2,549*
60 to 74	23%	44%	*1,792*	43%	15%	*138*	41%	30%	*591*	29%	33%	*2,521*
75 plus	25%	24%	*938*	47%	6%	*58*	43%	15%	*291*	30%	17%	*1,287*
SIMD: most deprived 15% (SIMD 2016)												
No	16%	92%	*5,349*	37%	89%	*867*	39%	67%	*1489*	23%	81%	*7,705*
Yes	17%	8%	*364*	37%	11%	*91*	36%	33%	*643*	30%	19%	*1,098*
Ethnicity of Highest Income Householder												
White Scottish / British	16%	95%	*5,400*	37%	74%	*754*	39%	93%	*1982*	24%	91%	*8,136*
Minority Ethnicity	12%	5%	*309*	37%	25%	*203*	32%	7%	*149*	25%	9%	*661*
Gender of Highest Income Householder												
Male	13%	52%	*3,678*	33%	52%	*569*	36%	45%	*1018*	20%	49%	*5,265*
Female	21%	48%	*2,035*	43%	48%	*389*	41%	55%	*1113*	30%	51%	*3,537*
Scotland												
	16%	100%	*5,713*	37%	100%	*958*	38%	100%	*2132*	24%	100%	*8,803*

Notes

1. Based on Scottish House Condition Survey data over 2017 to 2019, with a total sample of 8,803 households. For some characteristics, the total sample may be slightly lower due to non/invalid responses.

Table 10: Fuel poverty rates (accuracy) for selected dwelling characteristics and proportion of households for each characteristic (coverage) which are fuel poor, average over 2017-2019

	Owner Occupied			Private Rented			Social			Total		
	FP Rate	**Share FP**	*Sample*	**FP Rate**	**Share FP**	*Sample*	**FP Rate**	**Share FP**	*Sample*	**FP Rate**	**Share FP**	*Sample*
Primary Heating Fuel												
Gas	14%	71%	*4,251*	34%	66%	*630*	36%	74%	*1605*	22%	72%	*6,486*
Electric	27%	13%	*600*	49%	23%	*174*	55%	21%	*405*	41%	18%	*1,179*
Other	24%	16%	*862*	35%	11%	*153*	33%	5%	*122*	27%	10%	*1,137*
Dwelling Type												
Detached	16%	34%	*2,246*	29%	11%	*174*	*	*	*	18%	16%	*2,449*
Semi-detached	15%	23%	*1,435*	38%	10%	*114*	40%	16%	*420*	21%	17%	*1,969*
Terraced	16%	20%	*1,057*	34%	13%	*152*	42%	30%	*608*	26%	23%	*1,817*
Tenement	16%	13%	*508*	38%	50%	*375*	37%	34%	*596*	30%	28%	*1,479*
Other flats	19%	10%	*467*	44%	16%	*143*	35%	20%	*479*	29%	15%	*1,089*
House or Flat												
House	16%	77%	*4,738*	33%	34%	*440*	41%	46%	*1057*	21%	56%	*6,235*
Flat	17%	23%	*975*	39%	66%	*518*	37%	54%	*1075*	30%	44%	*2,568*
Age of Dwelling												
pre-1919	17%	22%	*1,104*	40%	45%	*361*	45%	6%	*88*	25%	20%	*1,553*
1919-1944	18%	13%	*638*	44%	10%	*87*	43%	14%	*258*	27%	13%	*983*
1945-1964	18%	20%	*1,070*	39%	15%	*155*	37%	32%	*718*	28%	24%	*1,943*
1965-1982	17%	23%	*1,274*	31%	11%	*134*	41%	27%	*565*	25%	22%	*1,973*
post 1982	12%	22%	*1,627*	30%	19%	*221*	34%	21%	*503*	19%	21%	*2,351*
Banded Loft Insulation												
<100mm	16%	5%	*307*	42%	5%	*48*	45%	2%	*44*	23%	4%	*399*
100mm to 199mm	16%	28%	*1,587*	37%	20%	*210*	42%	16%	*322*	23%	22%	*2,119*
200mm or more	16%	53%	*3,134*	35%	28%	*321*	39%	45%	*1021*	23%	45%	*4,476*
Are External Walls Insulated?												
No	18%	48%	*2,390*	41%	64%	*545*	47%	35%	*604*	28%	46%	*3,539*
Yes	14%	52%	*3,323*	31%	36%	*413*	35%	65%	*1528*	22%	54%	*5,264*
Cavtity or Solid Walls												
Cavity	15%	71%	*4,274*	34%	50%	*550*	38%	84%	*1853*	24%	72%	*6,677*
Solid / Other	18%	29%	*1,439*	40%	50%	*408*	41%	16%	*279*	26%	28%	*2,126*
Wall Type and Insulation Level												
Cavity wall no insulation	18%	22%	*1,204*	38%	16%	*174*	46%	25%	*461*	28%	22%	*1,839*
Cavity wall with insulation	14%	48%	*3,070*	33%	34%	*376*	35%	59%	*1392*	22%	50%	*4,838*
Solid wall no insulation	19%	26%	*1,186*	42%	48%	*371*	49%	10%	*143*	27%	24%	*1,700*
Solid wall with insulation	14%	3%	*253*	19%	2%	*37*	31%	6%	*136*	21%	4%	*426*
Number of Bedrooms												
1	17%	5%	*215*	37%	22%	*196*	42%	32%	*594*	36%	19%	*1,005*
2	17%	30%	*1,462*	37%	47%	*427*	34%	42%	*967*	26%	38%	*2,856*
3	17%	45%	*2,498*	37%	23%	*249*	41%	23%	*512*	23%	32%	*3,259*
4 or more	13%	20%	*1,538*	37%	8%	*86*	47%	3%	*59*	16%	11%	*1,683*
EPC Rating SAP 2012 v9.92												
C Plus	12%	29%	*2,061*	30%	33%	*353*	31%	45%	*1148*	20%	36%	*3,562*
D	17%	44%	*2,440*	39%	37%	*344*	46%	44%	*814*	26%	43%	*3,598*
E F G	25%	27%	*1,212*	47%	30%	*261*	65%	11%	*170*	33%	21%	*1,643*
Rural Urban Six Fold Classification												
Large urban areas	14%	28%	*1,467*	37%	47%	*343*	39%	36%	*596*	24%	35%	*2,406*
Other urban areas	14%	31%	*1,881*	36%	26%	*277*	35%	36%	*830*	23%	32%	*2,988*
Accessible small towns	15%	9%	*563*	39%	7%	*71*	36%	9%	*221*	23%	8%	*855*
Remote small towns	27%	6%	*319*	37%	3%	*52*	46%	5%	*158*	34%	5%	*529*
Urban subtotal	15%	74%	*4,230*	37%	82%	*743*	37%	86%	*1805*	24%	80%	*6,778*
Accessible rural	17%	13%	*722*	33%	10%	*119*	39%	7%	*173*	23%	10%	*1,014*
Remote rural	31%	13%	*761*	47%	8%	*96*	63%	6%	*154*	38%	9%	*1,011*
Rural Subtotal	22%	26%	*1,483*	38%	18%	*215*	48%	14%	*327*	28%	20%	*2,025*
Whether Dwelling has PPM meter												
No	16%	90%	*5,307*	33%	67%	*733*	38%	53%	*1196*	21%	71%	*7,236*
Yes	21%	9%	*398*	50%	33%	*224*	39%	47%	*934*	37%	29%	*1,556*
Extent of Central Heating												
Full	16%	95%	*5,448*	35%	87%	*868*	38%	96%	*2067*	24%	94%	*8,383*
Partial or None	22%	5%	*264*	51%	13%	*90*	64%	4%	*65*	37%	6%	*419*
Whether Dwelling is On the Gas Grid												
On Grid	15%	76%	*4,144*	38%	85%	*741*	37%	87%	*1804*	24%	82%	*6,689*
Off Grid	19%	24%	*1,569*	33%	15%	*217*	47%	13%	*328*	25%	18%	*2,114*
Scotland												
	16%	100%	*5,713*	37%	100%	*958*	38%	100%	*2132*	24%	100%	*8,803*

Notes

1. Based on Scottish House Condition Survey data over 2017 to 2019, with a total sample of 8,803 households. For some characteristics, the total sample may be slightly lower due to non/invalid responses.
2. In this analysis, primary heating fuel of gas includes both mains gas (majority) and LPG bulk or bottled.

Table 11: Extreme Fuel poverty rates (accuracy) for selected household characteristics and proportion of households for each characteristic which are fuel poor 2017-2019

	Owner Occupied			Private Rented			Social			Total		
	EXT FP Rate	Share FP	*Sample*	EXT FP Rate	Share FP	*Sample*	EXT FP Rate	Share FP	*Sample*	EXT FP Rate	Share FP	*Sample*
Household Type												
Older	12%	50%	*2,152*	31%	17%	*140*	17%	37%	*691*	14%	38%	*2,983*
Families	3%	7%	*1,269*	13%	16%	*258*	7%	13%	*540*	5%	11%	*2,067*
Other	9%	43%	*2,292*	23%	66%	*560*	17%	51%	*901*	14%	51%	*3,753*
Council Tax Band												
A	9%	10%	*547*	22%	19%	*188*	15%	53%	*1,024*	15%	25%	*1,759*
B	8%	16%	*976*	24%	32%	*281*	14%	30%	*687*	13%	24%	*1,944*
C	10%	17%	*902*	19%	17%	*180*	15%	14%	*316*	12%	16%	*1,398*
D	8%	14%	*934*	23%	17%	*146*	9%	2%	*85*	10%	11%	*1,165*
E	9%	19%	*1,139*	*	*	*	*	*	*	10%	12%	*1,252*
F-H	10%	24%	*1,213*	11%	3%	*66*	*	*	*	10%	12%	*1,280*
Weekly Household Income												
<£300	41%	85%	*1,059*	63%	83%	*271*	30%	94%	*946*	39%	87%	*2,276*
£300 to £400	8%	11%	*727*	15%	12%	*168*	3%	5%	*506*	7%	9%	*1,401*
£400 to £500	2%	3%	*670*	6%	4%	*129*	*	*	*	2%	3%	*1,077*
£500-£700	0%	1%	*1,124*	*	*	*	*	*	*	1%	1%	*1,579*
£700+	*	*	*	*	*	*	-	-	*134*	*	*	*
Relative Poverty												
No	2%	24%	*5,011*	5%	14%	*657*	3%	13%	*1,411*	3%	18%	*7,079*
Yes	55%	76%	*702*	56%	86%	*301*	38%	87%	*721*	48%	82%	*1,724*
Household Member Long Term Sick or Disabled												
No	7%	48%	*3,543*	19%	60%	*617*	13%	34%	*818*	10%	46%	*4,978*
Yes	12%	52%	*2,165*	27%	40%	*341*	15%	66%	*1,309*	14%	53%	*3,815*
Highest Income Householder or Spouse in Recipt of a Benefit for Disability or Care Need												
No	9%	89%	*5,275*	22%	93%	*863*	17%	82%	*1,508*	12%	88%	*7,646*
Yes	12%	11%	*438*	18%	7%	*95*	9%	18%	*624*	11%	12%	*1,157*
Highest Income Householder or Spouse In Recipt of Any Benefit												
No	5%	22%	*2,060*	19%	41%	*426*	9%	9%	*328*	8%	23%	*2,814*
Yes	11%	78%	*3,653*	24%	59%	*532*	15%	91%	*1,804*	13%	77%	*5,989*
Highest Income Householder or Spouse is Eligible Cold Weather Payment												
No	8%	92%	*5,541*	20%	83%	*851*	15%	68%	*1453*	11%	82%	*7,845*
Yes	24%	8%	*172*	35%	17%	*107*	14%	32%	*679*	18%	18%	*958*
Highest Income Householder or Spouse in Receipt of Council Tax Reduction												
No	8%	78%	*4,971*	19%	64%	*722*	14%	52%	*1,163*	10%	66%	*6,856*
Yes	14%	22%	*742*	31%	36%	*236*	15%	48%	*969*	17%	34%	*1,947*
Highest Income Householder and / or Spouse Unemployed												
No	8%	94%	*5,642*	20%	90%	*914*	13%	85%	*1,998*	11%	90%	*8,554*
Yes	38%	6%	*71*	48%	10%	*44*	34%	15%	*134*	37%	10%	*249*
Working Age Highest Income Householder or Spouse and Income from employment												
No	41%	29%	*349*	54%	48%	*172*	23%	49%	635	33%	40%	1,156
Yes	3%	21%	*3,212*	11%	35%	*646*	5%	14%	806	5%	22%	4,664
No - older household	12%	50%	*2,152*	31%	17%	*140*	17%	37%	691	14%	38%	2,983
Household Working status												
Single working adult	7%	12%	*818*	19%	25%	*269*	9%	12%	*425*	10%	15%	*1,512*
Non-working single	22%	43%	*1,014*	49%	56%	*239*	21%	73%	*1,039*	24%	55%	*2,292*
Working couple	1%	4%	*2,056*	2%	2%	*267*	0%	0%	*266*	1%	2%	*2,589*
Couple, one works	8%	10%	*661*	12%	6%	*115*	10%	6%	*167*	9%	8%	*943*
Couple, neither work	14%	31%	*1,164*	32%	10%	*68*	13%	9%	*235*	14%	19%	*1,467*
Banded age of HIH												
16 to 24	20%	2%	*42*	44%	31%	*124*	24%	5%	*63*	35%	9%	*229*
25 to 34	3%	3%	*454*	13%	16%	*242*	8%	7%	*265*	7%	7%	*961*
35 to 44	2%	3%	*772*	11%	10%	*191*	13%	13%	*292*	6%	8%	*1,255*
45 to 59	7%	22%	*1,715*	23%	21%	*205*	14%	29%	*629*	10%	24%	*2,549*
60 to 74	13%	44%	*1,792*	27%	16%	*138*	13%	26%	*591*	14%	32%	*2,521*
75 plus	15%	26%	*938*	29%	6%	*58*	22%	21%	*291*	17%	20%	*1,287*
SIMD: most deprived 15% (SIMD 2016)												
No	9%	95%	*5,349*	22%	91%	*867*	16%	72%	*1,489*	12%	87%	*7,705*
Yes	6%	5%	*364*	18%	9%	*91*	12%	28%	*643*	11%	13%	*1,098*
Ethnicity of Highest Income Householder												
White Scottish / British	9%	95%	*5,400*	21%	73%	*754*	15%	97%	*1,982*	12%	90%	*8,136*
Minority Ethnicity	8%	5%	*309*	23%	27%	*203*	6%	3%	*149*	12%	10%	*661*
Gender of Highest Income Householder												
Male	7%	52%	*3,678*	20%	53%	*569*	14%	47%	*1,018*	10%	51%	*5,265*
Female	12%	48%	*2,035*	24%	47%	*389*	15%	53%	*1,113*	14%	49%	*3,537*
Scotland												
	9%	*100%*	*5,713*	22%	100%	*958*	14%	100%	*2,132*	12%	100%	*8,803*

Notes

1. Based on Scottish House Condition Survey data over 2017 to 2019, with a total sample of 8,803 households. For some characteristics, the total sample may be slightly lower due to non/invalid responses.

Table 12: Extreme Fuel poverty rates (accuracy) for selected dwelling characteristics and proportion of households for each characteristic which are fuel poor 2017-2019

	Owner Occupied			Private Rented			Social			Total		
	EXT FP Rate	**Share FP**	*Sample*	**EXT FP Rate**	**Share FP**	*Sample*	**EXT FP Rate**	**Share FP**	*Sample*	**EXT FP Rate**	**Share FP**	*Sample*
Primary Heating Fuel												
Gas	7%	61%	4,251	18%	58%	630	11%	62%	1,605	9%	61%	6,486
Electric	20%	17%	600	38%	31%	174	35%	35%	405	29%	26%	1,179
Other	19%	22%	862	22%	11%	153	10%	4%	122	18%	14%	1,137
Dwelling Type												
Detached	11%	43%	2,246	21%	13%	174	*	*	*	12%	23%	2,449
Semi-detached	8%	21%	1,435	20%	9%	114	17%	18%	420	10%	17%	1,969
Terraced	7%	16%	1,057	14%	9%	152	16%	31%	608	11%	19%	1,817
Tenement	8%	12%	508	24%	55%	375	13%	32%	596	14%	28%	1,479
Other flats	8%	8%	467	23%	14%	143	12%	18%	479	12%	13%	1,089
House or Flat												
House	9%	80%	4,738	18%	31%	440	16%	50%	1,057	11%	59%	6,235
Flat	8%	20%	975	24%	69%	518	13%	50%	1,075	13%	41%	2,568
Age of Dwelling												
pre-1919	13%	30%	1,104	27%	51%	361	22%	8%	88	17%	28%	1,553
1919-1944	11%	15%	638	26%	10%	87	17%	14%	258	14%	13%	983
1945-1964	8%	17%	1,070	18%	11%	155	14%	33%	718	11%	21%	1,943
1965-1982	8%	19%	1,274	18%	11%	134	15%	28%	565	11%	20%	1,973
post 1982	6%	20%	1,627	16%	17%	221	11%	18%	503	8%	18%	2,351
Banded Loft Insulation												
<100mm	12%	7%	307	33%	7%	48	7%	1%	44	14%	5%	399
100mm to 199mm	10%	29%	1,587	22%	20%	210	17%	17%	322	12%	23%	2,119
200mm or more	9%	51%	3,134	18%	24%	321	16%	49%	1,021	11%	44%	4,476
Are External Walls Insulated?												
No	12%	57%	2,390	24%	65%	545	19%	38%	604	15%	53%	3,539
Yes	7%	43%	3,323	18%	35%	413	13%	62%	1,528	9%	47%	5,264
Cavtity or Solid Walls												
Cavity	8%	63%	4,274	18%	44%	550	14%	81%	1,853	10%	65%	6,677
Solid / Other	12%	37%	1,439	26%	56%	408	18%	19%	279	16%	35%	2,126
Wall Type and Insulation Level												
Cavity wall no insulation	10%	23%	1,204	14%	10%	174	18%	26%	461	13%	21%	1,839
Cavity wall with insulation	7%	40%	3,070	19%	34%	376	13%	56%	1,392	10%	44%	4,838
Solid wall no insulation	14%	34%	1,186	28%	55%	371	22%	12%	143	18%	32%	1,700
Solid wall with insulation	6%	3%	253	9%	2%	37	14%	6%	136	9%	4%	426
Number of Bedrooms												
1	10%	5%	215	18%	18%	196	16%	32%	594	15%	17%	1,005
2	8%	26%	1,462	25%	54%	427	13%	43%	967	13%	38%	2,856
3	9%	45%	2,498	18%	19%	249	14%	22%	512	11%	32%	3,259
4 or more	9%	24%	1,538	25%	9%	86	14%	3%	59	10%	14%	1,683
EPC Rating SAP 2012 v9.92												
C Plus	4%	19%	2,061	14%	27%	353	8%	33%	1,148	7%	25%	3,562
D	8%	39%	2,440	20%	33%	344	18%	46%	814	12%	40%	3,598
E F G	21%	41%	1,212	37%	40%	261	49%	21%	170	27%	35%	1,643
Rural Urban Six Fold Classification												
Large urban areas	7%	27%	1,467	25%	53%	343	12%	30%	596	11%	34%	2,406
Other urban areas	6%	26%	1,881	15%	18%	277	13%	36%	830	9%	27%	2,988
Accessible small towns	7%	7%	563	21%	6%	71	12%	8%	221	10%	7%	855
Remote small towns	15%	6%	319	23%	3%	52	19%	5%	158	17%	5%	529
Urban subtotal	7%	66%	4,230	21%	80%	743	13%	80%	1,805	11%	74%	6,778
Accessible rural	11%	16%	722	18%	9%	119	21%	10%	173	14%	13%	1,014
Remote rural	23%	18%	761	36%	11%	96	37%	10%	154	27%	14%	1,011
Rural Subtotal	16%	34%	1,483	25%	20%	215	27%	20%	327	19%	26%	2,025
Whether Dwelling has PPM meter												
No	9%	92%	5,307	19%	65%	733	14%	53%	1,196	11%	74%	7,236
Yes	9%	7%	398	30%	34%	224	15%	47%	934	16%	26%	1,556
Extent of Central Heating												
Full	8%	93%	5,448	20%	83%	868	14%	92%	2,067	11%	90%	8,383
Partial or None	18%	7%	264	40%	17%	90	49%	8%	65	29%	10%	419
Whether Dwelling is On Gas Grid												
On Grid	7%	67%	4,144	22%	82%	741	13%	82%	1,804	11%	75%	6,689
Off Grid	14%	33%	1,569	23%	18%	217	25%	18%	328	17%	25%	2,114
Scotland												
	9%	100%	5,713	22%	100%	958	14%	100%	2,132	12%	100%	8,803

Notes

1. Based on Scottish House Condition Survey data over 2017 to 2019, with a total sample of 8,803 households. For some characteristics, the total sample may be slightly lower due to non/invalid responses.
2. In this analysis, primary heating fuel of gas includes both mains gas (majority) and LPG bulk or bottled.

Table 13: Median fuel poverty gap by tenure and selected household characteristics 2017-19 (Adjusted for 2015 prices)

	Owner Occupied		Private Rented		Social		Total	
	Median	*Sample*	Median	*Sample*	Median	*Sample*	Median	*Sample*
Household Type								
Older	820	*514*	820	*68*	540	*278*	690	*860*
Families	720	*110*	670	*80*	400	*171*	560	*361*
Other	840	*362*	780	*208*	470	*411*	640	*981*
Council Tax Band								
A	640	*130*	670	*87*	480	*397*	530	*614*
B	610	*209*	730	*113*	400	*301*	550	*623*
C	760	*166*	760	*63*	540	*126*	690	*355*
D	790	*157*	850	*46*	*	*	780	*231*
E	1000	*170*	940	*31*	*	*	970	*209*
F-H	1460	*154*	*	*	*	*	1390	*169*
Weekly Household Income								
<£300	830	*729*	*840*	*244*	*510*	*676*	*680*	*1,649*
£300 to £400	720	*168*	*600*	*74*	*310*	*143*	*470*	*385*
£400 to £500	900	*50*	*	*	*300*	*33*	*550*	*108*
£500-£700	700	*31*	*	*	*	*	*700*	*50*
£700+	*	*	*	*	-	-	*	*
Relative Poverty								
No	630	*363*	650	*84*	270	*248*	470	*695*
Yes	870	*623*	790	*272*	560	*612*	700	*1,507*
Household Member Long Term Sick or Disabled								
No	790	*470*	760	*199*	480	*303*	650	*972*
Yes	870	*516*	830	*157*	470	*555*	650	*1,228*
Highest Income Householder or Spouse in Recipt of a Benefit for Disability or Care Need								
No	820	*846*	780	*319*	500	*650*	670	*1,815*
Yes	760	*140*	690	*37*	390	*210*	550	*387*
Highest Income Householder or Spouse in Recipt of Any Benefit								
No	870	*220*	840	*120*	550	*98*	770	*438*
Yes	810	*766*	750	*236*	470	*762*	630	*1,764*
Eligible for Cold Weather Payment								
No	840	*902*	780	*288*	520	*571*	700	*1,761*
Yes	690	*84*	760	*68*	440	*289*	500	*441*
Highest Income Householder or Spouse in Recipt of Council Tax Reduction								
No	870	*790*	780	*226*	540	*441*	730	*1,457*
Yes	700	*196*	760	*130*	440	*419*	560	*745*
Highest Income Householder and / or Spouse Unemployed								
No	810	*949*	770	*320*	470	*766*	650	*2,035*
Yes	1020	*37*	730	*36*	570	*94*	640	*167*
Working Age Highest Income Householder or Spouse and Income from employment								
no	960	*198*	850	*134*	500	*371*	670	*703*
yes	700	*274*	640	*154*	350	*211*	570	*639*
no - older household	820	*514*	820	*68*	540	*278*	690	*860*
Household Working status								
Single working adult	610	*153*	720	*97*	350	*162*	560	*412*
Non-working single	790	*371*	820	*166*	500	*519*	630	*1,056*
Working couple	810	*56*	*	*	*	*	650	*93*
Couple, one works	900	*113*	580	*38*	650	*50*	790	*201*
Couple, neither work	1080	*293*	820	*40*	490	*107*	820	*440*
Banded age of Highest Income Householder								
16 to 24	*	*	830	*75*	530	*34*	750	*118*
25 to 34	720	*31*	670	*66*	370	*92*	560	*189*
35 to 44	650	*55*	560	*49*	500	*95*	560	*199*
45 to 59	850	*208*	850	*75*	470	*255*	650	*538*
60 to 74	790	*423*	840	*63*	400	*251*	620	*737*
75 plus	930	*260*	*	*	670	*132*	760	*420*
SIMD: most deprived 15% (SIMD 2016)								
No	860	*925*	820	*320*	510	*622*	720	*1,867*
Yes	460	*61*	560	*36*	400	*238*	440	*335*
Ethnicity of Highest Income Householder								
White Scottish / British	810	*945*	760	*275*	480	*811*	650	*2,031*
Minority Ethnicity	1000	*40*	830	*80*	390	*49*	700	*169*
Gender of Highest Income Householder								
Male	840	*521*	820	*184*	470	*376*	660	*1,081*
Female	810	*465*	760	*172*	480	*484*	640	*1,121*
Scotland								
	820	*986*	770	*356*	480	*860*	650	*2,202*

Notes

1. Based on Scottish House Condition Survey data over 2017 to 2019, with a total sample of 8,803 households. For some characteristics, the total sample may be slightly lower due to non/invalid responses.

Table 14: Median fuel poverty gap by tenure and selected dwelling characteristics 2017-19 (Adjusted for 2015 prices)

	Owner Occupied		Private Rented		Social		Total	
	Median	*Sample*	**Median**	*Sample*	**Median**	*Sample*	**Median**	*Sample*
Primary Heating Fuel								
Gas	680	*611*	650	*215*	400	*587*	540	*1,413*
Electric	1400	*171*	1080	*88*	1010	*225*	1100	*484*
Other	1640	*204*	1070	*52*	280	*48*	1200	*304*
Dwelling Type								
Detached	1260	*405*	1230	*51*	*	*	1220	*470*
Semi-detached	810	*232*	770	*45*	620	*182*	720	*459*
Terraced	610	*171*	670	*52*	560	*260*	610	*483*
Tenement	570	*84*	730	*145*	360	*227*	540	*456*
Other flats	600	*94*	760	*63*	400	*177*	480	*334*
House or Flat								
House	910	*808*	850	*148*	600	*456*	780	*1,412*
Flat	590	*178*	730	*208*	380	*404*	510	*790*
Age of Dwelling								
pre-1919	1600	*202*	900	*147*	690	*42*	1040	*391*
1919-1944	930	*131*	740	*42*	540	*111*	660	*284*
1945-1964	650	*213*	640	*61*	500	*286*	570	*560*
1965-1982	640	*227*	780	*40*	460	*238*	560	*505*
post 1982	700	*213*	640	*66*	390	*183*	580	*462*
Banded Loft Insulation								
<100mm	1110	*52*	*	*	*	*	900	*92*
100mm to 199mm	900	*279*	820	*78*	610	*145*	750	*502*
200mm or more	840	*538*	760	*112*	540	*420*	690	*1,070*
Are External Walls Insulated?								
No	1100	*478*	840	*225*	560	*284*	790	*987*
Yes	670	*508*	660	*131*	430	*576*	550	*1,215*
Cavtity or Solid Walls								
Cavity	700	*708*	660	*190*	460	*743*	580	*1,641*
Solid / Other	1300	*278*	870	*166*	630	*117*	900	*561*
Wall Type and Insulation Level								
Cavity wall no insulation	840	*241*	670	*69*	540	*214*	620	*524*
Cavity wall with insulation	670	*467*	660	*121*	420	*529*	550	*1,117*
Solid wall no insulation	1340	*237*	900	*156*	630	*70*	960	*463*
Solid wall with insulation	690	*41*	*	*	560	*47*	590	*98*
Number of Bedrooms								
1	640	*43*	500	*77*	390	*254*	450	*374*
2	600	*262*	850	*160*	480	*360*	620	*782*
3	840	*465*	660	*91*	540	*218*	720	*774*
4 or more	1330	*216*	*	*	*	*	1230	*272*
EPC Rating SAP 2012 v9.92								
C Plus	440	*246*	570	*104*	320	*369*	390	*719*
D	790	*423*	670	*132*	570	*381*	660	*936*
E F G	1750	*317*	1410	*120*	1320	*110*	1560	*547*
Rural Urban Six Fold Classification								
Large urban areas	730	*202*	840	*125*	380	*230*	600	*557*
Other urban areas	620	*274*	560	*101*	460	*306*	540	*681*
Accessible small town:	630	*86*	*	*	470	*83*	560	*195*
Remote small towns	1010	*84*	*	*	620	*83*	760	*189*
Urban subtotal	690	*646*	730	*274*	440	*702*	570	*1,622*
Accessible rural	1160	*123*	960	*40*	770	*69*	1000	*232*
Remote rural	1930	*217*	1410	*42*	1070	*89*	1550	*348*
Rural Subtotal	1410	*340*	1090	*82*	900	*158*	1180	*580*
Whether Dwelling has PPM meter								
No	840	*898*	730	*245*	480	*474*	700	*1,617*
Yes	600	*85*	820	*110*	470	*386*	580	*581*
Extent of Central Heating								
Full	800	*909*	740	*312*	460	*818*	630	*2,039*
Partial or None	2060	*77*	940	*44*	1540	*42*	1390	*163*
Whether Dwelling is On Gas Grid								
On Grid	690	*646*	730	*281*	440	*693*	580	*1,620*
Off Grid	1630	*340*	1100	*75*	970	*167*	1280	*582*
Scotland	820	*986*	770	*356*	480	*860*	650	*2,202*

Notes

1. Based on Scottish House Condition Survey data over 2017 to 2019, with a total sample of 8,803 households. For some characteristics, the total sample
2. In this analysis, primary heating fuel of gas includes both mains gas (majority) and LPG bulk or bottled.

Table 15: Median fuel poverty gap by tenure and selected household characteristics 2017-19 (Unadjusted)

	Owner Occupied		Private Rented		Social		Total	
	Median	*Sample*	Median	*Sample*	Median	*Sample*	Median	*Sample*
Household Type								
Older	870	*514*	880	*68*	580	*278*	730	*860*
Families	770	*110*	710	*80*	430	*171*	590	*361*
Other	890	*362*	830	*208*	500	*411*	690	*981*
Council Tax Band								
A	680	*130*	690	*87*	500	*397*	560	*614*
B	650	*209*	790	*113*	420	*301*	590	*623*
C	800	*166*	820	*63*	590	*126*	720	*355*
D	830	*157*	910	*46*	*	*	830	*231*
E	1060	*170*	990	*31*	*	*	1030	*209*
F-H	1560	*154*	*	*	*	*	1470	*169*
Weekly Household Income								
<£300	880	*729*	*880*	*244*	*540*	*676*	*710*	*1,649*
£300 to £400	770	*168*	*640*	*74*	*320*	*143*	*500*	*385*
£400 to £500	950	*50*	*	*	*320*	*33*	*580*	*108*
£500-£700	740	*31*	*	*	*	*	*750*	*50*
£700+	*	*	*	*	-	-	*	*
Relative Poverty								
No	670	*363*	690	*84*	280	*248*	500	*695*
Yes	930	*623*	840	*272*	580	*612*	740	*1,507*
Household Member Long Term Sick or Disabled								
No	830	*470*	810	*199*	500	*303*	690	*972*
Yes	920	*516*	870	*157*	500	*555*	690	*1,228*
Highest Income Householder or Spouse in Recipt of a Benefit for Disability or Care Need								
No	880	*846*	820	*319*	530	*650*	710	*1,815*
Yes	820	*140*	710	*37*	410	*210*	580	*387*
Highest Income Householder or Spouse in Recipt of Any Benefit								
No	930	*790*	820	*226*	570	*441*	760	*1,457*
Yes	740	*196*	810	*130*	460	*419*	610	*745*
Eligible for Cold Weather Payment								
No	890	*902*	820	*288*	560	*571*	730	*1,761*
Yes	740	*84*	800	*68*	460	*289*	520	*441*
Highest Income Householder or Spouse in Recipt of Council Tax Reduction								
No	930	*790*	820	*227*	570	*445*	760	*1,462*
Yes	740	*196*	810	*129*	460	*415*	600	*740*
Highest Income Householder and / or Spouse Unemployed								
No	850	*949*	810	*320*	500	*766*	690	*2,035*
Yes	1080	*37*	760	*36*	600	*94*	690	*167*
Working Age Highest Income Householder or Spouse and Income from employment								
no	1010	*198*	900	*134*	520	*371*	710	*703*
yes	740	*274*	690	*154*	380	*211*	610	*639*
no - older household	870	*514*	880	*68*	580	*278*	730	*860*
Household Working status								
Single working adult	650	*153*	770	*97*	370	*162*	590	*412*
Non-working single	830	*371*	870	*166*	530	*519*	670	*1,056*
Working couple	840	*56*	*	*	*	*	680	*93*
Couple, one works	970	*113*	610	*38*	670	*50*	830	*201*
Couple, neither work	1130	*293*	850	*40*	510	*107*	880	*440*
Banded age of Highest Income Householder								
16 to 24	*	*	870	*75*	560	*34*	790	*118*
25 to 34	750	*31*	720	*66*	400	*92*	600	*189*
35 to 44	690	*55*	610	*49*	530	*95*	590	*199*
45 to 59	900	*208*	910	*75*	490	*255*	670	*538*
60 to 74	840	*423*	900	*63*	430	*251*	660	*737*
75 plus	970	*260*	*	*	700	*132*	800	*420*
SIMD: most deprived 15% (SIMD 2016)								
No	900	*925*	850	*320*	540	*622*	760	*1,867*
Yes	470	*61*	610	*36*	430	*238*	470	*335*
Ethnicity of Highest Income Householder								
White Scottish / British	870	*945*	800	*275*	500	*811*	690	*2,031*
Minority Ethnicity	1070	*40*	870	*80*	420	*49*	730	*169*
Gender of Highest Income Householder								
Male	900	*521*	850	*184*	500	*376*	700	*1,081*
Female	840	*465*	810	*172*	500	*484*	670	*1,121*
Scotland								
	870	*986*	810	*356*	500	*860*	690	*2,202*

Notes

1. Based on Scottish House Condition Survey data over 2017 to 2019, with a total sample of 8,803 households. For some characteristics, the total sample may be slightly lower due to non/invalid responses.

Table 16: Median fuel poverty gap by tenure and selected dwelling characteristics 2017-19 (Unadjusted)

	Owner Occupied		Private Rented		Social		Total	
	Median	*Sample*	**Median**	*Sample*	**Median**	*Sample*	**Median**	*Sample*
Primary Heating Fuel								
Gas	710	*611*	690	*215*	420	*587*	570	*1,413*
Electric	1510	*171*	1110	*88*	1060	*225*	1170	*484*
Other	1760	*204*	1100	*52*	290	*48*	1260	*304*
Dwelling Type								
Detached	1330	*405*	1330	*51*	*	*	1300	*470*
Semi-detached	850	*232*	810	*45*	650	*182*	750	*459*
Terraced	650	*171*	710	*52*	590	*260*	650	*483*
Tenement	590	*84*	770	*145*	380	*227*	580	*456*
Other flats	630	*94*	780	*63*	430	*177*	500	*334*
House or Flat								
House	970	*808*	900	*148*	630	*456*	830	*1,412*
Flat	610	*178*	770	*208*	400	*404*	550	*790*
Age of Dwelling								
pre-1919	1690	*202*	950	*147*	710	*42*	1100	*391*
1919-1944	1000	*131*	770	*42*	570	*111*	690	*284*
1945-1964	690	*213*	690	*61*	530	*286*	600	*560*
1965-1982	680	*227*	810	*40*	490	*238*	590	*505*
post 1982	740	*213*	670	*66*	400	*183*	600	*462*
Banded Loft Insulation								
<100mm	1190	*52*	*	*	*	*	970	*92*
100mm to 199mm	930	*279*	850	*78*	650	*145*	790	*502*
200mm or more	890	*538*	790	*112*	560	*420*	730	*1,070*
Are External Walls Insulated?								
No	1180	*478*	870	*225*	600	*284*	840	*987*
Yes	710	*508*	690	*131*	460	*576*	580	*1,215*
Cavtity or Solid Walls								
Cavity	740	*708*	690	*190*	480	*743*	610	*1,641*
Solid / Other	1370	*278*	930	*166*	660	*117*	950	*561*
Wall Type and Insulation Level								
Cavity wall no	900	*241*	710	*69*	580	*214*	660	*524*
Cavity wall with insulation	710	*467*	690	*121*	440	*529*	580	*1,117*
Solid wall no insulation	1440	*237*	930	*156*	670	*70*	1020	*463*
Solid wall with	750	*41*	*	*	590	*47*	610	*98*
Number of Bedrooms								
1	670	*43*	520	*77*	410	*254*	480	*374*
2	640	*262*	900	*160*	520	*360*	650	*782*
3	900	*465*	710	*91*	570	*218*	760	*774*
4 or more	1380	*216*	*	*	*	*	1320	*272*
EPC Rating SAP 2012 v9.92								
C Plus	470	*246*	590	*104*	340	*369*	420	*719*
D	830	*423*	710	*132*	600	*381*	700	*936*
E F G	1860	*317*	1480	*120*	1400	*110*	1660	*547*
Rural Urban Six Fold Classification								
Large urban areas	760	*202*	870	*125*	390	*230*	630	*557*
Other urban areas	660	*274*	610	*101*	480	*306*	570	*681*
Accessible small towns	660	*86*	*	*	490	*83*	590	*195*
Remote small towns	1050	*84*	*	*	660	*83*	800	*189*
Urban subtotal	730	*646*	770	*274*	460	*702*	610	*1,622*
Accessible rural	1230	*123*	1020	*40*	820	*69*	1060	*232*
Remote rural	2010	*217*	1500	*42*	1100	*89*	1660	*348*
Rural Subtotal	1500	*340*	1130	*82*	960	*158*	1240	*580*
Whether Dwelling has PPM meter								
No	890	898	770	245	500	474	740	1617
Yes	640	*85*	870	*110*	500	*386*	600	*581*
Extent of Central Heating								
Full	840	*909*	780	*312*	490	*818*	660	*2,039*
Partial or None	2180	*77*	990	*44*	1670	*42*	1470	*163*
Whether Dwelling is On Gas Grid								
On Grid	730	*646*	770	*281*	470	*693*	610	*1,620*
Off Grid	1690	*340*	1140	*75*	1000	*167*	1350	*582*
Scotland								
	870	*986*	810	*356*	500	*860*	690	*2,202*

Notes

1. Based on Scottish House Condition Survey data over 2017 to 2019, with a total sample of 8,803 households. For some characteristics, the total sample
2. In this analysis, primary heating fuel of gas includes both mains gas (majority) and LPG bulk or bottled.

2.2 Characteristics of households in fuel poverty living in dwellings which are rated below EPC C

We have also carried out analysis to explore how households living in energy inefficient housing (Below EPC C SAP 2012 v 9.92) who are fuel poor differ from non-fuel poor households living in similarly energy inefficient housing and from those fuel poor households living in properties rated EPC C+ (**Table 17** and **Table 18**).

The commentary below identifies some examples of interest but full results are in the associated tables.

The data illustrates how the fuel poverty rate changes for certain characteristics according to whether the household lives in a home below EPC C or a home above EPC C giving some indication of the potential impact of improving dwellings to a higher level of energy efficiency. We know that, even at the highest levels of energy efficiency, there will still be fuel poor households due to other drivers such as income and fuel prices. This is emphasised when we explore the fuel poverty rates for low income households. Households earning less than £300 a week and living in homes rated below C have a fuel poverty rate of 77% while those living in homes rated C+ have a fuel poverty rate of 63%. This is still very high indicating that low income and / or fuel prices are also key factors although improving the energy efficiency of these homes should still be expected to reduce bills and improve the experience of these fuel poor households if not remove them from fuel poverty entirely.

Some of the biggest differences in fuel poverty rate for dwellings rated below C versus those C or above are for[7]:

- Those where the highest income householder or spouse is in receipt of a benefit for a care need or disability – 42% versus 21%.
- Properties off the gas grid – 33% to 13%.
- Households in the £300 to £400 weekly income band– 33% versus 15% and the £400 to £500 band 13% versus 3%.
- The social rented sector – 49% versus 31%.
- Properties where there is a pre-payment meter – 44% versus 28%.
- Detached dwellings, tenements and other flats (22%, 39% and 35% versus 10%, 24% and 24% respectively).
- Those in the most deprived 15% of areas, 39% to 24%.
- Those where the highest income householder or spouse is eligible for cold weather payment (57% versus 32%) or in receipt of council tax reduction (44% versus 30%).
- The private rented sector – 42% versus 30%.

[7] Highlighting those with at least a 10 percentage point difference and where the EPC C+ rate is 35% or lower.

- Those with a highest income householder who is from an ethnic minority – 31% versus 19% and those with a female highest income householder – 36% to 24%.
- Single working adult households – 31% versus 20%
- One or two bedroom properties (42% and 31% versus 29% and 21% respectively).
- Households living in council tax band A – 43% versus 24%.
- Rural areas 32% versus 17% and remote small towns 38% versus 24%

As highlighted in Chapter 1.1, there are some key characteristics of dwellings that are below EPC C. In order to target energy efficiency interventions at fuel poor households, it is helpful to be aware of the differences in characteristics between fuel poor households living in homes below EPC C compared to non-fuel poor households in similarly inefficient homes. Some examples are:

- More likely to be low income (73% of fuel poor households living in homes below EPC C have income less than £300 per week compared to 8% of non-fuel poor living in homes below EPC C). As per the general characteristics of fuel poor households, those below EPC C are also more likely to demonstrate other indicators of low income.
- Less likely to live in the owner occupied sector (45% versus 75%), and more likely to be in the rental sectors (20% vs 11% private rental and 35% vs 14% social rented)
- More likely to live in the lowest council tax bands A and B (58% versus 37%).
- More likely to be a female headed household (51% vs 35%).
- More likely to have a prepayment meter (29% vs 14%).
- More likely to have someone in the household with a long-term sickness or disability (56% versus 41%).
- Less likely to live in a home heated by gas (64% versus 75%) and more likely to live in a home heated by electricity (22% versus 11%).
- More likely to have only 1 bedroom (19% vs 10%).
- Less likely to be families (15%) than non-fuel poor living in similarly inefficient homes (23%).
- Less likely to live in a detached dwelling (20% versus 28%) or semi-detached (20% vs 26%) and more likely to live in a tenement (22% versus 14%)
- More likely to live in remote rural areas (13% versus 8%).

Table 17: Fuel poverty and EPC (SAP 2012 v9.92) status by selected household characteristics, 2017-2019

	Below Epc C FP Rate	% of all not fuel poor dwellings below EPC C	% of all fuel poor dwellings below EPC C	*Sample*	*Epc C+ FP Rate*	% of all fuel poor dwellings EPC C+	*Sample*
Household Type							
Older Households	30%	35%	39%	*1,971*	*22%*	31%	*1012*
Families	21%	23%	15%	*1,091*	*13%*	18%	*976*
Other Households	30%	42%	46%	*2,179*	*22%*	51%	*1574*
Tenure							
Owner occupied	19%	75%	45%	*3,652*	*12%*	32%	*2061*
Private rented	42%	11%	20%	*605*	*30%*	17%	*353*
Social sector	49%	14%	35%	*984*	*31%*	51%	*1148*
Council Tax Band							
A	43%	15%	30%	*1,002*	*24%*	26%	*757*
B	33%	22%	28%	*1,176*	*27%*	29%	*768*
C	26%	15%	14%	*826*	*20%*	17%	*572*
D	21%	13%	9%	*691*	*17%*	11%	*474*
E	20%	16%	10%	*783*	*14%*	9%	*469*
F G H	16%	18%	9%	*760*	*10%*	7%	*520*
Weekly Household Income							
Less than £299.99	77%	8%	73%	*1,361*	*63%*	83%	*915*
£300 to £399.99	33%	15%	19%	*824*	*15%*	13%	*577*
£400 to £499.99	13%	15%	6%	*627*	*3%*	2%	*450*
£500 to £699.99	3%	24%	2%	*938*	*2%*	2%	*641*
£700 plus	*	*	*	*	*	*	*
Relative Poverty							
No	12%	98%	35%	*4,266*	*4%*	17%	*2813*
Yes	93%	2%	65%	*975*	*78%*	83%	*749*
Household Member Long Term Sick or Disabled							
No	22%	59%	44%	*2,922*	*16%*	45%	*2056*
Yes	35%	41%	56%	*2,316*	*25%*	55%	*1499*
Highest Income Householder or Spouse in Recipt of a Benefit for Disability or Care Need							
No	26%	90%	81%	*4,593*	*20%*	84%	*3053*
Yes	42%	10%	19%	*648*	*21%*	16%	*509*
Highest Income Householder or Spouse in Recipt of Any Benefit							
No	18%	36%	21%	*1,671*	*13%*	21%	*1143*
Yes	33%	64%	79%	*3,570*	*23%*	79%	*2419*
Highest Income Householder or Spouse eligible for Cold Weather Payment							
No	25%	94%	79%	4747	*18%*	78%	2843
Yes	57%	6%	21%	494	*32%*	22%	719
Highest Income Householder or Spouse in Recipt of Council Tax Reduction							
No	23%	82%	65%	*4,157*	*16%*	61%	*2713*
Yes	44%	18%	35%	*1,084*	*30%*	39%	*849*
Highest Income Householder and/or Spouse Unemployed							
No	27%	99%	93%	*5,110*	*19%*	90%	*3444*
Yes	75%	1%	7%	*131*	*56%*	10%	*118*
Working Age and Income from employment							
no	70%	5%	32%	*615*	*50%*	40%	*541*
yes	16%	59%	29%	*2,655*	*10%*	29%	*2009*
no - older household	30%	35%	39%	*1,971*	*22%*	31%	*1012*
Household Working status							
Single working adult	31%	16%	19%	*857*	*20%*	20%	*655*
Non-working single	51%	18%	48%	*1,328*	*38%*	53%	*964*
Working couple	4%	37%	4%	*1,513*	*2%*	3%	*1076*
Couple, one works	24%	11%	9%	*567*	*16%*	8%	*376*
Couple, neither work	31%	17%	20%	*976*	*25%*	17%	*491*
Banded age of HIH							
16 to 24	64%	1%	6%	*117*	*46%*	8%	*112*
25 to 34	25%	10%	9%	*457*	*14%*	10%	*504*
35 to 44	20%	14%	9%	*650*	*13%*	11%	*605*
45 to 59	24%	30%	24%	*1,523*	*18%*	25%	*1026*
60 to 74	31%	29%	33%	*1,610*	*25%*	31%	*911*
75 plus	33%	15%	19%	*883*	*25%*	14%	*404*
SIMD: most deprived 15% (SIMD 2016)							
No	27%	91%	85%	*4,788*	*19%*	76%	*2917*
Yes	39%	9%	15%	*453*	*24%*	24%	*645*
Ethnicity of Highest Income Householder							
White Scottish / British	28%	92%	91%	*4,900*	*20%*	89%	*3236*
Minority Ethnicity	31%	7%	9%	*339*	*19%*	10%	*322*
Gender of Highest Income Householder							
Male	23%	65%	49%	*3,209*	*17%*	49%	*2056*
Female	36%	35%	51%	*2,032*	*24%*	51%	*1505*
Scotland							
Total	28%	100%	100%	*5,241*	*20%*	100%	*3562*

Table 18: Fuel poverty and EPC (SAP 2012 v9.92) status by selected dwelling characteristics, 2017-2019

	Below Epc C FP Rate	% of all not fuel poor dwellings below EPC C	% of all fuel poor dwellings below EPC C	*Sample*	*Epc C+ FP Rate*	% of all fuel poor dwellings EPC C+	Sample
Primary Heating Fuel							
Gas	25%	75%	64%	*3,317*	*19%*	85%	*3169*
Electric	44%	11%	22%	*934*	*34%*	11%	*245*
Other	27%	14%	14%	*989*	*26%*	5%	*148*
Dwelling Type							
Detached	22%	28%	20%	*1,683*	*10%*	10%	*766*
Semi-detached	23%	26%	20%	*1,351*	*17%*	13%	*618*
Terraced	29%	23%	24%	*1,123*	*20%*	20%	*694*
Tenement	39%	14%	22%	*570*	*24%*	39%	*909*
Other flats	35%	9%	13%	*514*	*24%*	19%	*575*
House or Flat							
House	25%	77%	65%	*4,157*	*16%*	42%	*2078*
Flat	37%	23%	35%	*1,084*	*24%*	58%	*1484*
Age of Dwelling							
pre-1919	27%	28%	27%	*1,323*	*18%*	7%	*230*
1919-1944	29%	14%	15%	*709*	*23%*	9%	*274*
1945-1964	30%	23%	25%	*1,227*	*23%*	22%	*716*
1965-1982	28%	22%	23%	*1,243*	*21%*	22%	*730*
post 1982	24%	13%	10%	*739*	*18%*	40%	*1612*
Banded Loft Insulation							
<100mm	24%	7%	6%	*341*	*19%*	2%	*58*
100mm to 199mm	24%	30%	25%	*1,515*	*19%*	16%	*604*
200mm or more	28%	46%	46%	*2,612*	*18%*	44%	*1864*
Are External Walls Insulated?							
No	29%	60%	62%	*2,996*	*22%*	19%	*543*
Yes	27%	40%	38%	*2,245*	*19%*	81%	*3019*
Cavtity or Solid Walls							
Cavity	28%	64%	64%	*3,529*	*20%*	86%	*3148*
Solid / Other	28%	36%	36%	*1,712*	*20%*	14%	*414*
Wall Type and Insulation Level							
Cavity wall no insulation	29%	28%	29%	*1,516*	*24%*	11%	*323*
Cavity wall with insulation	28%	36%	35%	*2,013*	*19%*	76%	*2825*
Solid wall no insulation	29%	32%	33%	*1,480*	*20%*	8%	*220*
Solid wall with insulation	22%	4%	3%	*232*	*20%*	6%	*194*
Number of Bedrooms							
1	42%	10%	19%	*554*	*29%*	20%	*451*
2	31%	31%	36%	*1,578*	*21%*	41%	*1278*
3	25%	39%	33%	*2,081*	*19%*	30%	*1178*
4 or more	19%	20%	12%	*1,028*	*12%*	10%	*655*
Rural Urban Six Fold Classification							
Large urban areas	26%	32%	30%	*1,240*	*22%*	44%	*1166*
Other urban areas	26%	32%	30%	*1,516*	*18%*	36%	*1472*
Accessible small towns	25%	9%	8%	*474*	*20%*	9%	*381*
Remote small towns	38%	4%	6%	*394*	*24%*	3%	*135*
Urban subtotal	27%	78%	74%	*3,624*	*20%*	92%	*3154*
Accessible rural	27%	14%	13%	*733*	*13%*	5%	*281*
Remote rural	40%	8%	13%	*884*	*31%*	3%	*127*
Rural subtotal	32%	22%	26%	*1,617*	*17%*	8%	*408*
Whether Dwelling has PPM meter							
No	24%	86%	70%	*4,339*	*18%*	72%	*2897*
Yes	44%	14%	29%	*896*	*28%*	28%	*660*
Extent of Central Heating							
Full	27%	95%	92%	*4,873*	*20%*	98%	*3510*
Partial or None	38%	5%	8%	*367*	*28%*	2%	*52*
Whether Dwelling is On Gas Grid							
On Grid	27%	81%	77%	*3,700*	*21%*	91%	*2989*
Off Grid	33%	19%	23%	*1,541*	*13%*	9%	*573*
Scotland							
Total	28%	100%	100%	*5,241*	*20%*	100%	*3562*

2.3 Characteristics of households in both fuel and relative income poverty

Table 19: Household and Dwelling Characteristics by Income Poverty and Fuel Poverty, 2019

		Fuel, not Income Poor	Fuel & Income Poor	All Fuel Poor	Income, not Fuel Poor	All Scotland
EPC Band (SAP 2012)						
B-C	000s	36	185	221	51	1,122
	col %	22%	41%	36%	70%	45%
D	000s	79	192	271	22	1,017
	col %	48%	43%	44%	30%	41%
E-G	000s	51	70	121	-	357
	col %	31%	16%	20%	-	14%
Household Type						
Older	000s	67	151	218	19	819
	col %	41%	34%	36%	26%	33%
Families	000s	20	80	100	44	598
	col %	12%	18%	16%	61%	24%
Other	000s	77	217	294	9	1,079
	col %	47%	48%	48%	13%	43%
Urban-Rural (2013/14 urban rural classification)						
Urban	000s	117	371	488	69	2,069
	col %	71%	83%	80%	94%	83%
Rural	000s	49	76	125	4	426
	col %	29%	17%	20%	6%	17%
Primary Heating Fuel						
Gas	000s	95	347	442	71	2,035
	col %	57%	78%	72%	98%	82%
Oil	000s	13	23	36	*	130
	col %	8%	5%	6%	*	5%
Electric	000s	50	63	113	*	261
	col %	30%	14%	18%	*	10%
Other fuels	000s	7	15	22	*	70
	col %	4%	3%	4%	*	3%
Gas Grid						
On grid	000s	117	383	501	68	2,075
	col %	71%	86%	82%	93%	83%
Off grid	000s	48	64	112	5	421
	col %	29%	14%	18%	7%	17%
Sample size		*222*	*520*	*742*	*76*	*2,950*

Households that are considered to be in both relative income poverty and fuel poverty tend to live in more energy efficient dwellings (41% in EPC Bands B-C) compared to other fuel poor households (22%), potentially because of high energy efficiency standards in the social rented sector. They are more likely to use gas for heating (78% versus 57%), live on the gas grid (86% versus 71%) and live in urban locations (83% versus 71%) compared other fuel poor households (**Table 19**). These characteristics point to low income as a key reason for their experience of fuel poverty.

Conversely, households who are not in relative income poverty but experience fuel poverty have a higher likelihood of living in low energy efficiency properties (31% in EPC Bands E-G versus 16%), using electricity for heating (30% versus 14%), and living in rural areas (29% versus 16%) compared to fuel poor and income poor households (**Table 19**). One reason fuel poor households in rural areas are more likely not to be in relative income poverty is the uplifts applied to MIS thresholds for remote rural, remote small town and island areas in the fuel poverty definition. This sets a higher income threshold for households in these areas and therefore means they are more likely to be fuel but not income poor.

2.4 Conclusions

The analysis we have undertaken demonstrates that, as would be expected, there is no single variable on its own that identifies all fuel poor households with complete accuracy and coverage. However, it is clear that household income is extremely important for fuel poverty and for predicting the fuel poverty and extreme fuel poverty status of households. Proxy measures of income (such as receipt of certain benefits[8] / employment status) have lower accuracy and coverage.

No dwelling conditions on their own come close to the accuracy and coverage of low household income. Dwelling characteristics relating to energy efficiency (such as fuel type or wall insulation) are also important as these help to predict the size of the fuel bill which is compared to household income. They also become more important for predicting extreme fuel poverty (35% of all extreme fuel poor households are in EPC bands E, F or G compared to 21% of all fuel poor households, Tables 10 and 12).

This analysis suggests that interventions targeted at a range of household and dwelling characteristics will always exclude some households that are fuel poor and include some that are not, but that the extent of this can vary depending on the indicators used.

[8] Benefit levels reported through the SHCS are higher than the larger SHS sample. Whilst these surveys provide information on benefits, Official Statistics on benefits are produced separately and published by DWP or Social Security Scotland.

3. Evidence Review

Heating system use and related behaviours of those with protected characteristics in Scotland who are at risk of fuel poverty

Background

As acknowledged in a 2020 Scottish Government Evidence Review on the lived experience of fuel poverty in Scotland, “fuel poverty is increasingly recognised to be not a technical problem but a multi-dimensional complex phenomenon” (Baker et al 2019). The evidence review also concluded that experiences are likely to be socially, culturally and contextually situated, and may be intersectional in nature. As such, it is important to understand how people use their own heating systems to maintain thermal comfort, and the barriers to doing so. In order to ensure that actions designed to alleviate fuel poverty are inclusive and non-discriminatory, it is important to understand any additional or specific barriers faced by those with protected characteristics (as defined by the Equalities Act (2010)). These nine characteristics are:

- Age
- Disability
- Gender reassignment
- Marriage and civil partnership
- Pregnancy and maternity
- Race
- Religion or belief
- Sex
- Sexual orientation

To ascertain the current evidence on heating system use and related behaviours by people with protected characteristics in Scotland, a rapid scoping of both academic and grey literature was carried out. This rapid review was not intended to be exhaustive or systematic, but rather to give a broad overview of the state of current evidence. Due to contextual differences in climate, culture, building fabrics, heating systems and policy environments internationally, evidence was mostly confined to data gathered in Scotland or wider studies from the UK or Europe that included or were deemed to have direct relevance to the Scottish context. Previous evidence reviews on relevant topics were also included. Below is a brief summary of the findings of this rapid review.

Evidence base

The evidence base on behaviours that those in fuel poverty use in relation to using their home heating systems is relatively limited, particularly when restricted geographically to studies which include Scotland or Scottish participants. Though some research does explore heating behaviours it typically relies on self-report methods and is often not segmented by groups with protected characteristics. Due to the nature of the research area the majority of research focusing on individuals has been conducted using self-report qualitative or survey methods. There are also a number of case study approaches reviewing the impact of certain specific initiatives on energy efficiency. Much of the evidence on heating system use and associated behaviours comes from the field of energy efficiency so, when considering behaviour change studies arising from these literatures, it was important to be mindful that goals for behaviour change would likely be similar but always not entirely aligned with goals for reducing fuel poverty.

Heating system use and associated behaviours

A 2015 paper by Gauthier and Shipworth suggests that behavioural responses to cold sensation elicit three main types of behavioural response: “increasing clothing insulation level” (for example putting on additional clothing or a blanket); “increasing operative temperature” by turning the heating system on or adjusting it up; and “increasing the frequency, duration and/or amplitude of localized behaviour responses” (p368-9) such as drinking a hot drink or eating hot food, changing position within the room, or changing rooms, (Gauthier and Shipworth, 2015). Broadly, these behaviours can be categorised as either heating system use or as ‘coping strategies’ that avoid the need for heating system use within the home.

Other coping behaviours that were used to avoid turning heating systems on or up within the surveyed literature included: the use of hot water bottles or space heaters (though use of additional heaters was found to be rare in the Scottish Government’s Research into the lived experience of fuel poverty in Scotland (2020a) which focused specifically on fuel poor households); having a shower or using the oven for heat, and going out to public buildings or other people’s houses (De Haro & Koslowski 2013). Additionally, the Scottish Government Evidence Review on the lived experience of fuel poverty in Scotland (2020a) found that householders also employed measures such as taping card over vents, and lining windows and doors with towels to keep out draughts; lining furniture with extra layers to provide additional warmth; used a sleeping bag during the day; wearing outdoor coats indoors; spending evenings in warmer rooms upstairs; and going to bed early.

The Scottish Government’s Research into the lived experience of fuel poverty in Scotland (2020a) also found that limiting heating use was prevalent among lower income householders. A number of strategies were used to limit heating including: “waiting until a set time before putting the heating on (despite cold weather and temperatures indoor)"; "not using the heating at all or once a month during winter"; "not heating certain rooms (often bedrooms, kitchens, hallways)"; "keeping the family in one room and not heating other rooms"; and "keeping a careful eye on the balance on the prepayment meter and limiting use if it was running low"(p29).

In a 2017 Ipsos MORI & Sheldrick survey it was found that while these behaviours are forced by fuel poverty, they may be downplayed by those who use them. This despite the negative impacts on their physical and mental health and that of their families from being unable to heat their homes. However, the behaviours may also be downplayed because they are considered to be socially normative and common strategies that people use in response to their homes being cold. A few studies mention a feeling of pride in being frugal with heating use particularly among the elderly (Wright 2004) and those in island communities (Sherriff et al 2019). For others though, it was distressing that their financial situation meant they could not heat their home to their comfort level (Scottish Government, 2020a).

Criticism has been levelled at the belief-attitude-intention pathway for behaviour change in the field of energy efficiency as being too simplistic (Black and Eismans, 2019). According to the ISM model (Scottish Government, 2013), which integrates behaviour change theory from across multiple behaviour change studies, behavioural triggers and barriers are complex and can occur at the individual, social and material levels. In a 2015 concise literature review included as an annex to the Energy Saving Trust (2016) pilot report, Changeworks employed the ISM model to analyse the individual, social and material factors that influence behaviours in relation to the use of heating controls. They identify individual influencing factors such as a resident's values, beliefs and attitudes towards controls, perceptions of costs and benefits; their emotions (such as fear and discomfort); agency (whether householders feel they can engage with controls); skills and knowledge (do they know how to use controls, to find out how much energy they are using, etc); and habits. The social factors they identify include who residents trust for advice on using controls (friends, family and institutions); social norms around use of heating systems; individual roles and identities within the home (whether it is part of one's role in the household to adjust the heating); tastes and meanings (a preference for frugality or warmth, how they see themselves and their home); and networks and relationships. Material factors identified include rules and regulations around tariffs; the heating technology and infrastructure themselves; objects such as smart meters; and timing and schedules relating to home use patterns.

Although not specific to the fuel poor, a UK wide 2013 DECC review identified a typology of heating system users that included:

Rationers: whose heating system use was driven by a focus on minimising spending.

Ego-centric users: who temperature adjusted manually based on personal feelings.

Hands off users: who avoid thinking about controls unless necessary and have regular routines.

Planners: those who think ahead, avoid use where possible, and regularly adjust timers and radiator valves according to variable routines, and

Reactors: who tend to include those in larger, colder homes. These users are reactive to temperature changes but may use extra heaters and adjust their controls frequently.

Within the reviewed literature, there was very little longitudinal data to explore changes over time, and no research was identified that explored how moving into or out of fuel poverty impacts heating behaviours.

Barriers to heating system use and behaviour change among the fuel poor in Scotland

The majority of studies found in the reviewed literature were concerned with behaviour change interventions to increase energy efficiency of the home. Within these studies, the rebound effect has been observed following energy efficiency interventions. Households may decide to 'take-back' some of the financial savings from interventions by increasing the use of heating to raise their thermal comfort (Berkhout et al., 2000; Greening et al., 2000). This may mean that although homes not have been lifted out of fuel poverty, the depth of their fuel poverty will be lessened and their lived experience of fuel poverty will have improved, although it should be noted that these studies are focussed on energy efficiency rather than fuel poverty.

As previously suggested, personal perceptions of thermal comfort, based on "personality, habituation and expectations, and attitudes to energy conservation" influence use of heating (de Dear and Brager, 1998). Research on energy efficiency suggests habit may the most important of the individual factors. In Gesche et al (2013) habit emerged as the most important barrier to behaviour change with willingness for behaviour change most greatly associated with financial motives. Without reinforcement and strong motivations these householders tended to fall back into their habitual patterns of heating and energy use. However, perhaps unsurprisingly, within the 2020 Scottish Government lived experience study focusing on those in fuel poverty, cost of heating in relation to income was one of the biggest barriers to heating system use.

Hafner et al (2019), in a study of psychological barriers to engaging with energy efficiency measures including effective heating system use, outlined that action inertia; socials norms; emotion; perceived behavioural control; delay discounting; and habit can act as key barriers to behaviour change. A reliance on habitual behavioural patterns was the greatest barrier to change and also had direct impact on energy usage. If this typology is applied to heating system use specifically, these barriers, as identified within the reviewed literature, would include the following:

Hafner et al's (2019) psychological barriers	Examples from the reviewed literature
Action Inertia	Current systems and practices still 'work', reluctant to invest time or resources in changing practices.
Social Norms	Cultural norms around using heating systems, limiting heating, or engaging in coping behaviours, or seeking help.
Emotion	Feelings of stigma or shame, guilt around being unable to heat home for family, trust in organisations who give advice, fear and discomfort.
Perceived Behavioural Control	Renters not feeling able to initiate change to heating system; energy literacy and confidence related to heating system controls (i.e. in relation to electric storage heaters); preference for systems like prepayment meters that offer more control vs fixed monthly payments.
Delay Discounting	Use of/preference for certain heating systems because of short term advantages despite longer term costs.
Habit	Being used to using habitual heating system use patterns

Reviewed evidence suggests that some householders may lack full knowledge about how to control modern heating systems, which can impact heating behaviours. As a result, residents may fall back on ingrained habits instead of adapting their use to suit cheaper energy tariffs. One study demonstrated that individuals revert to old habits and use SMART heating systems in similar ways to traditional heating systems (Walker, et al., 2017). This often negates the benefits of being able to adjust energy usage around peak tariff times and means householders do not fully experience the benefits of SMART metering.

Gilchrist and Craig (2014) identified from Scottish Household Survey that there was a high level of reported engagement with heating controls (85% adjusting thermostats and timers to control their heating). However, elsewhere in the review they identify that people find the controls hard to use and are not using them appropriately or effectively. Gilchrist and Craig (2014) also identify that functional barriers to ease of use (such as hard to read controls, challenging interfaces, and difficult to access locations); uncertainty over the best way to use a system (i.e. which features to use such as setting timed periods or leaving on continuously); and confusion about elements of the system and how they work together (such as timers, thermostats, radiator valves) may lead to people defaulting to the easiest approach, such as using the thermostat as an on/off switch. They also highlight the importance of trusted intermediaries to deliver advice to provide heating system education and encourage effective use of heating controls.

While modern heating systems may provide barriers to effective use because of their perceived complexity, poor quality and outdated heating systems can also prove to be a barrier to effective heating system use. People living in poorer quality housing and with older poor quality storage heaters reported finding it difficult to heat their homes (De Haro & Koslowski 2013) as heat leakage and inefficient equipment means that their heating behaviours could not always adequately control their energy use.

A study by Changeworks (2018) explored how behavioural changes, including installing smart meters and low carbon heating systems, affected energy efficiency. They noted that there was greater attention paid in policy to one off changes than changing habitual behaviours, though they also noted these are more complex to understand and influence. In terms of habitual change they report that the understanding or appetite for widespread changes to the way we use energy to heat our homes in the general public is considered too low to generate change.

In October 2015 the Scottish Government commissioned the Energy Saving Trust to pilot interventions to encourage people to make the best use of their heating systems. Participating households undertook “experiments” to alter their energy use, such as advice on how to adjust their room thermostat or their hot water timer. This advice significantly altered heating system use with 74% of participants reporting having changed at least one heating behaviour during the pilot and 95% of these intended to persist with the change. The advice also helped householders feel more confident in their heating system use with 59% rating their understanding and ability to operate their system as high following the pilot (Energy Savings Trust, 2016).

There has, however, been criticism of behavioural change research in terms of energy efficiency and climate change. Black and Eisemans’ (2019) Climate X

Change report notes that behaviour change research, though dominant in the literature, has not seen any fundamentally different or significantly more effective approach in five years preceding publication of their report. They note a growing evidence base that highlights the limitations of changing beliefs and attitudes with the intention of changing behaviour, as well as highlighting the limitations of manipulating choice architecture or the so called 'nudge' approach. Their review of the evidence concludes that structural factors are much more significant barriers and promoters of behaviour and behaviour change than individual choice. They suggest that segmentation, a marketing technique that divides the population into homogeneous or similar groups, of the Scottish public, may be useful in targeting behaviour change messages, but more attention is needed on how material and social factors are experienced by different groups. Consequently, the complexity and intersectionality of the lived experience of those within groups should not be overlooked.

Heating system use behaviours among people with protected characteristics in Scotland

Research that focuses on participants with protected characteristics was very limited. No research was found that addressed protected characteristics of gender reassignment, marriage and civil partnership, pregnancy and maternity, race, religion or belief, or sexual orientation with reference to heating behaviours in Scotland. It may be that the search strategy was insufficient to discover research dealing in this area or it may be because not all of these protected characteristics are strongly related to fuel poverty. The two key protected characteristics, where individuals were sampled from in the studies, were age and disability. Often the two were related and there was a focus on those above retirement age in a number of the studies reviewed. Single parent families were also mentioned in one study, Kearns et al (2019), as being a group at particular risk of fuel poverty but were not widely sampled in the remaining studies.

Those with, or caring for people with, chronic health conditions or physical disabilities spoke of needing longer periods of heating or higher temperatures in order to stay warm. These groups are also more likely to heat through the night or otherwise restrict their use of energy and be unable to heat their home to comfort (Mould and Baker, 2017). If they are confined to the home they are more likely to heat throughout the day. Needing more energy to use mobility and health devices as well as more regular use of washing facilities also affected energy and heating use (Green 2007). Research has also found that those with learning disabilities can find it hard to relate their use of energy to the bills they are paying. (Pettingell, 2013).

There is limited evidence to suggest that some older people may engage in limiting heating system use for sociocultural reasons including the situating of frugality as virtuous Ipsos MORI (2020), but also that older people recognise the importance of a warm home and may heat the home for visitors (Scottish Government, 2020a). There is also some evidence from Barnes and McKnight's (2014) UK review that there may be generational preferences for certain types of heating system, and that the ease of location of heating system controls may impact on their use for older people. For those in the most difficult circumstances, being unable to heat their homes to the level they would like was having negative impacts on their physical and mental health and that of their families.

There is some limited evidence that single parent households (and particularly those in which single parents are women (Citizens Advice Scotland, 2021)), and those who have children, may try to keep their homes warmer for their children and find this stressful (Scottish Government, 2020a). Some evidence suggests that there can be gendered differences in the perception of heat within the home, with women preferring a warmer temperature, which may lead to tensions between partners with different perceptions of appropriate temperature settings for their heating systems (Scottish Government, 2020; Wright 2004).

In relation to race, in an analysis of Scottish Household Survey data, a Citizens Advice Scotland (CAS) report (Citizens Advice Scotland, 2021) found that poverty and extreme fuel poverty rates were statistically similar for minority ethnic households (27% and 13%) and 'White Scottish/British' households (25% and 12%). However, they note that 2011 Census data showed a higher proportion of minority ethnic households had a lack of a "reliable heating source" (reported having no central heating in the 2011 Census) which would generally be considered an indicator of fuel poverty. Only 1.7% of 'White' respondents lacked a heating system which was lower than 'Asian' (3.3%), 'Mixed' (2.6%) and 'Other ethnic' groups (2.7%).This disparity was particularly evident in relation to 'Caribbean or Black' (3.7%) and 'African' (4.4%) groups, but little is known about associated heating system use behaviours for these groups.

Although not a protected characteristic in itself, non-homeowners can feel disempowered to seek changes to their heating systems from their landlords. This is more often the case in the private sector but can also be an issue in the social sector if there are poor relations with tenants (Abdel-Wahab et al , 2011). This is of relevance because, within Scotland, there are a proportionately more minority ethnic households in private than social renting than would be expected given overall population demographics. Social housing also typically has higher levels of energy efficiency than the private sector (Scottish Government, 2019). Disabled people and families in fuel poverty often live in the poorest quality houses and have additional needs that require support throughout the retrofit process. As this can make it more expensive for scheme providers and installers, these households may end up being sidelined (Snell et al 2018).

It was clear from the reviewed literature that protected characteristics should be viewed as intersectional as people could experience multiple forms of vulnerability simultaneously.

SUMMARY

Behaviours related to heating system use are complex, and barriers and promoters of behaviours exist at the individual, social and material levels. Structural factors such as income and cost of heating remain a key behavioural driver when it comes to heating system use for the fuel poor, and may be overlooked if behaviour change interventions focus on individual factors.

There is little research that explores heating system use by those with protected characteristics in Scotland, but existing evidence focuses predominantly on older people and those living with disabilities. Within the reviewed literature, there was little longitudinal research on heating behaviours, so understanding of how moving into or out of fuel poverty impacts heating behaviours is limited. Better data collection on household lifestyles, energy use, and conservation behaviours to better understand the behaviours of those with protected characteristics is needed. Interventions that improve heating system literacy or other identified barriers (i.e. by including advice from trusted sources, fostering more equal relationships between tenants and landlords/housing associations) may help to empower fuel poor households to use their heating systems effectively.

BIBLIOGRAPHY

Abdel-Wahab, M., Moore, D., & MacDonald, S. (2011). Exploring the adoption of low carbon technologies by Scottish housing associations. International Journal of Low Carbon Technologies, 318-323.

Ambrose, A., (2015) Improving energy efficiency in private rented housing: Why don't landlords act? Indoor and Built Environment, 24(7), 913–924.

Baker, K. et al. (2019). Never try and face the journey alone: Exploring the face-To-face advocacy needs of fuel poor householders in the United Kingdom. Energy Research & Social Science. 51, 210-219.

Barnes, M. and McKnight, A. (2014). Understanding the behaviours of households in fuel poverty: A review of research evidence. UK: Department of Energy and Climate Change. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332122/understanding_behaviours_households_fuel_poverty_review_of_research_evidence.pdf

Berkhout, P.H.G., Muskens, J.C., Velthuijsen, J.,(2000) Defining the rebound effect Energy Policy, 28 (2000), pp. 425-432

Black, I., and Eiseman, D. (2019) Climate Change Behaviours - Segmentation Study, ClimateXChange Available at: https://www.climatexchange.org.uk/media/3664/climate-change-behaviours-segmentation-study.pdf

Citizens Advice Scotland (2021) Fuel poverty advice and the protected characteristics: An analysis of data from the Citizens Advice network in Scotland

Citizen's Advice Scotland (2018a). Speaking up -understanding fuel poverty support needs. Consumer Futures Unit, Citizen's Advice Scotland. Available at: https://www.cas.org.uk/publications/speaking-understanding-fuel-poverty-support-needs

Changeworks (2018) The Role of Behaviour Change in Scottish Climate Change Policy available at: https://www.changeworks.org.uk/sites/default/files/Behaviours_in_Scottish_Climate_Policy.pdf

DECC (2013) What people want from heating controls: a qualitative study; DECC. Available at: https://www.gov.uk/government/publications/what-people-want-from-their-heating-controls-a-qualitative-study

De Haro, M.T. & Koslowski, A. (2013) Fuel poverty and high-rise living: using community-based interviewers to investigate tenants' inability to keep warm in their homes. Journal of Poverty and Social Justice. 21(2), 109-121.

Dear de, R.J., Brager, G.S, (1998) Developing an adaptive model of thermal comfort and preference Am. Soc. Heating Refrig. Air Cond. Eng. Trans., 104 (Part 1) (1998), pp. 1-18

Energy Savings Trust (2016) The behaviour change pilot encouraging households to make better use of their heating systems. Available at: https://www.energysavingtrust.org.uk/sites/default/files/reports/SEEP%20-%20Advice%20%20Information%20-%20Behaviour%20change%20pilot%20-%20FINAL_06Jul16.pdf

Legislation.gov.uk. (2010). Equality Act 2010. Available at: http://www.legislation.gov.uk/ukpga/2010/15/contents

Firth, S., Lomas, K., Wright, A., Wall, R., (2008) Identifying trends in the use of domestic appliances from household electricity consumption measurements Energy Build., 40 (2008), pp. 926-936

Gauthier, S. and Shipworth, D., (2015) Behavioural responses to cold thermal discomfort Building Research & Information Pages 355-370

Gesche, M., Huebner, J., & Cooper, K. J. (2013). Domestic energy consumption—What role do comfort, habit, and knowledge about the heating system play? Domestic energy consumption—What role do comfort, habit, and knowledge about the heating system play? Energy and Buildings, 626-636.

Gilchrist and Craig (2014) Home Energy Efficiency - A review of evidence on attitudes and behaviours; Climate Exchange. Available at: https://www.climatexchange.org.uk/media/1844/cxc_brief_home_energy_efficiency_review_-_full_report.pdf

Green, M. (2007). Voices of people experiencing poverty in Scotland. Joseph Rowntree Foundation. Available at: https://www.jrf.org.uk/sites/default/files/jrf/migrated/files/2020-experiencing-poverty-scotland.pdf

Greening, I.A. , Greene, D.L. , C. Difiglio (2000) Energy efficiency and consumption – the rebound effect – a survey Energy Policy, 28 (2000), pp. 389-401

Hafner, R., Elmes, D., & Read, D. (2019). Promoting behavioural change to reduce thermal energy demand in households: A review. Renewable and Sustainable Energy Reviews, 205-214.

Ipsos MORI & Sheldrick, B. (2017). Support needs of those in fuel poverty – research report. Ipsos MORI Scotland.

Kearns, A., Whitley, E., Curl, A., (2019) Occupant behaviour as a fourth driver of fuel poverty (aka warmth & energy deprivation) Energy Policy Volume 129, June 2019, Pages 1143-1155

Melone, H. (2019), Gender-based perspectives of fuel poverty in Scotland, MRes thesis, Glasgow Caledonian University

Mould, R., Baker, K., (2017) Documenting fuel poverty from the householders' perspective Energy Res. Soc. Sci., 31 (2017), pp. 21-31

Pettingell, J. (2013), Winter Warmer Project, Generate Opportunities Available at: https://www.fuelpovertylibrary.info/sites/default/files/EAGA27%20%282013%29%20SUMMARY%20Generate%20Opportunities%20-%20Winter%20Warmer%20Project%20%28link%20to%20EAGA29%29.pdf

Scottish Government (2019) Scottish house condition survey: 2019 key findings Available at: https://www.gov.scot/publications/scottish-house-condition-survey-2019-key-findings/

Scottish Government (2020) Evidence review: The lived experience of fuel poverty in Scotland Available at: https://www.gov.scot/publications/evidence-review-lived-experience-fuel-poverty-scotland/

Scottish Government (2020a) Lived experience of fuel poverty: Research Available at: https://www.gov.scot/publications/research-lived-experience-fuel-poverty-scotland/

Sheriff, G. et al. (2019). Fuel Poverty in the Western Isles: 10 Lessons, Interim Report of the Moving Together Project. Sustainable Housing & Urban Studies Unit, University of Salford. Available at: http://usir.salford.ac.uk/id/eprint/56800/

Scottish Government (2013) influencing behaviours moving beyond the individual a user guide to the ISM tool Available at: https://www.gov.scot/publications/influencing-behaviours-moving-beyond-individual-user-guide-ism-tool/pages/2/

Walker, G., Taylor, a., Whitte, C., Lynn, C., Docherty, C., Stephen, B., Galloway, S. (2017). A practical review of energy saving technology for ageing populations. Applied Ergonomics, 247-258.

Webb, J., Hawkey, D., Mccrone, D., & Tingey, M. (2016). House, home and transforming energy in a cold climate. Families, Relationships and Societies, 411-429.

Wright, F. (2004). Old and Cold: Older People and Policies Failing to Address Fuel Poverty. Social Policy & Administration. 38(5), 488-503.

4. National Housing Model – quantifying scope and cost of energy efficiency improvements for fuel poor households

5. Introduction

The Scottish Government commissioned the Centre for Sustainable Energy (CSE) to model the technical feasibility and cost implications of achieving the energy efficiency targets laid out in the 2018 Energy Efficiency Scotland Route Map[9].

These tenure specific milestones have since been superseded by those laid out in the Heat in Buildings Strategy[10] and Programme for Government[11], with both the owner occupied and private rented sector now expected to achieve an EPC C earlier than had been specified in the Energy Efficiency Scotland Route Map.

For the private rented sector, regulations had been laid that would have required the stock to be improved gradually, first to an EPC E by 2022 and then to an EPC D by 2025. However due to the pressures of COVID-19, restrictions were put in place preventing non-essential works from being undertaken in domestic properties. These restrictions coincided with the dates by which the regulations mandating a minimum standard of energy efficiency in private rented sector properties were due to come into force. These interim targets were therefore dropped to ease the pressure on the private rented sector, and have since been replaced with the target to achieve an EPC C from 2025, with a backstop date of 2028. In the owner occupied sector, the Heat in Buildings Strategy outlines that the date by which all owner occupied homes are expected to achieve an EPC C has been brought forward to 2033. Despite the acceleration of these timescales, the costs presented in this technical annex should still provide a reasonable indication of the likely capital outlay required to achieve an EPC C.

This modelling exercise used housing stock profile data available in 2019[12] and fuel price data from 2017. This technical annex sets out the methodology used to produce the results reported in Chapter 2 – How much it will cost - in the fuel poverty strategy.

The results throughout this technical annex pertain to those households identified as being in fuel poverty at the time of the modelling. Table 1 details the estimated costs of achieving an EPC C and EPC B for fuel poor households, as included in the fuel poverty strategy. These estimates used 2017 fuel prices to calculate the number of households in fuel poverty, and do not therefore take account of the recent substantial increase in fuel prices. This increase in fuel prices is likely to increase the

---

[9] Energy Efficient Scotland Route Map, 2018

[10] Heat In Buildings Strategy: Achieving Net Zero Emissions in Scotland's Buildings (www.gov.scot)

[11] A Fairer, Greener Scotland: Programme for Government 2021-22 (www.gov.scot)

[12] Due to publication lags, housing stock data which was available in 2019 generally related to earlier years.

number of fuel poor households relative to our estimate at the time of this modelling exercise. The estimated costs of attaining EPC B and C for fuel poor households would therefore likely be higher than outlined in Table 1 if this analysis was undertaken using recent fuel prices.

Table 1. Estimated cost (£bn) to achieve an EPC C and EPC B across fuel poor households[13].

Scenario	Cost to achieve EPC C target	Cost to achieve EPC B target	Cumulative Cost
Standard	2.0	3.7	5.7
Low Carbon 1	5.3	4.5	9.8

6. About the National Household Model

The energy efficiency modelling was performed using the National Household Model (NHM). This is a policy modelling tool that was commissioned by and developed for the Department of Energy and Climate Change (DECC) – now the Department for Business, Energy and Industrial Strategy (BEIS) – of the UK Government. It is an open-source model and has been used by a number of other organisations including the Committee on Climate Change (CCC), the Committee on Fuel Poverty (CFP), the Welsh Government, various housing providers such as housing associations and local authorities, as well as the Scottish Government in previous work.

The NHM is summarised below in Box 1. It is a BREDEM-based model and uses a specific scenario language that allows users to programme a range of scenarios to be enacted on housing and households over a specified time frame. In this particular modelling exercise, functions in the model were utilised to calculate SAP ratings, install energy efficiency measures, and calculate fuel bills and fuel poverty using a Scottish housing stock data set.

Box 1. The National Household Model

The National Household Model (NHM) was designed and developed by CSE for DECC (now BEIS) in 2012. The NHM is a model that provides consistency across different policies, visibility of assumptions and flexibility to vary input parameters. The NHM uses data collected on dwellings and households to represent different

[13] These costs include the cost of retrofitting all owner occupied fuel poor households to an EPC B from their current energy efficiency rating; the cost to achieve an EPC B for fuel poor households in the social rented sector, from an EESSH 1 baseline; and the cost to achieve an EPC B for fuel poor households in the private rented sector, from an EPC D baseline. These costs do not therefore include the cost to achieve an EPC D for fuel poor households in the private rented sector, which was estimated to cost £0.1bn.

housing stock and its inhabitants (where applicable/available), and the BREDEM algorithm to calculate the energy performance of dwellings. The application includes a discrete event modelling engine to simulate the passage of time and the exposure of households to changes during simulated time, with modelling scenarios specified using a scenario definition language developed specifically for the purpose.

6.1 Stock

Data from the Scottish House Condition Survey (SHCS)[14] was used to create a stock file for use in the NHM. The SHCS is an annual survey of house conditions in Scotland, and is designed to be representative of all domestic households across Scotland. The baseline NHM stock was derived from a three-year combined SHCS survey data covering the years 2015 – 2017. This choice struck a balance between having a rich dataset which captures the variety of housing types across Scotland (8,606 properties were surveyed in this 3-year period representing 2.45 million dwellings) while using relatively recent data, since the energy efficiency of Scottish housing is improving over time.

6.2 Measures employed in the modelling

A variety of insulation options, energy conservation measures, heating systems and low carbon or renewable technologies have been modelled in the NHM. These are listed below.

Insulation and conservation measures:

- Standard cavity wall insulation
- Standard cavity wall insulation installed in dwellings built between 1984-1991
- Hard to treat non-cavity brick cavity wall insulation
- Hard to treat (narrow cavities) cavity wall insulation
- Double glazing
- Draught proofing
- External wall insulation
- Floor insulation
- Internal wall insulation

[14] https://www.gov.scot/collections/scottish-house-condition-survey/

- Low energy lighting (LED)
- Secondary glazing
- Hot water tank insulation
- Loft insulation

Heating systems and renewable/low carbon technologies:

- Air source heat pump
- Biomass boiler
- Mains gas combination boiler
- Ground source heat pump
- Hybrid heat pump
- LPG combination boiler
- Oil combination boiler
- Solar photovoltaics
- Solar thermal heating
- Storage heater

The technical specifications and suitability criteria (which ascertained which dwellings were suitable for a certain measure) are outlined in the Appendix in Table 7 and Table 8 for insulation measures and for heating/renewable systems, respectively. Details in the tables summarise which dwellings were flagged as being suitable for each measure. The Appendix includes a description of any proxies used when full information was unavailable in the stock data. Where any data is taken from SAP documentation this is also referenced in the tables.

Not all possible energy efficiency measures or microgeneration technologies available for installation in domestic properties have been included in the modelling. A summary of some of these measures and why they have not been included is contained in the appendix (after Table 9).

The appendix also provides additional detail on the assumptions used to assess heat pump suitability, measure suitability across the housing stock (Table 9), the cost functions used to estimate the capital costs of each measure (Table 10), and the cost modifiers applied to these cost functions reflecting the additional cost to install measures in more rural locations (Table 11).

6.3 Fuel costs

Two sets of fuel costs were used. Firstly, because the SAP methodology prescribes which fuel costs should be used when calculating the Energy Efficiency Rating (EER) (which had been used to set the Energy Efficient Scotland SAP targets), the SAP fuel costs were used when calculating the EER. However since the SAP fuel costs were eight years out of date at the time of the modelling, fuel cost data from 2017 was used to estimate the cost of modelled energy consumption, fuel bill savings from the installation of measures, and when calculating the incidence of fuel poverty.

The unit costs of each fuel type embedded in the modelling do not therefore reflect the significant increase in the cost of energy that has occurred since 2017, particularly over the course of 2021.

6.4 Fuel Poverty

The 2018 Energy Efficiency Scotland Route Map set a target of achieving an EPC C across all fuel poor households in the private sector by 2030, and an EPC B by 2040 for those households who remain in fuel poverty after the stage to EPC C.

In order to model the costs and technical feasibility of achieving these targets for fuel poor households, it was necessary to first calculate which households are in fuel poverty in the year in which the target applies, before measures to meet the target are installed.

A new definition of fuel poverty was introduced by legislation in Scotland in 2019.[15] At the time this research was being conducted the new fuel poverty definition had not yet been enacted and was subject to ongoing refinement through the legislative process. However, the SHCS stock made available to CSE contained a series of variables that allowed a close approximation of the new definition of fuel poverty: this included information identifying which heating regimes should apply to particular households[16], After housing cost incomes (AHC), benefit payment amounts (to subtract from AHC incomes), minimum income standards and uplift factors to apply to these for different types of households.

[15] The Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act.

1.1 [16] Under the new fuel poverty definition, a household is assigned to one of four different heating regimes depending on the characteristics of its members. See Heating regimes applied to estimate modelled energy consumption
Table 12 in the appendix.

The fuel poverty definition applied in the modelled is as follows. A household was classified as being in fuel poverty if:

- The total fuel costs required to maintain a satisfactory heating regime are more than 10% of the household's net income[17] after adjusting for housing costs [18]; and
- after deducting fuel costs, benefits received for a care need or disability and childcare costs, the household's remaining AHC net income is insufficient to maintain an acceptable standard of living.

The remaining AHC net income must be at least 90% of the UK Minimum Income Standard[19] to be considered an acceptable standard of living, with an additional amount added for households in remote rural, remote small town and island areas.

Fuel poor households are banded in two categories: 'fuel poverty' and 'extreme fuel poverty'. A household is said to be in extreme fuel poverty if they need to spend more than 20% of their AHC net income on fuel costs (as well as having insufficient income to maintain an acceptable standard of living).

A comparison of the fuel poverty statistics calculated through the NHM with those published by the Scottish Government is shown below in Table 2 . Overall, there is good alignment with the headline statistics for all dwellings. Looking at specific tenures, the numbers of fuel poor households in the NHM estimates are slightly lower in the PRS sector than the Scottish Government numbers and slightly higher for the owner occupied sector. There is good alignment with the social rented sector.

[17] Net income is household income after deducting income tax and national insurance.
[18] Housing costs include rent or mortgage costs, council tax and charges for water services and sewerage.
[19] https://www.lboro.ac.uk/research/crsp/mis/

Table 2: A comparison of NHM estimated fuel poverty numbers with statistics published by the Scottish Government (during the fuel poverty consultation process)

Tenure	NHM calculation		Scottish Government statistics[20]	
	Number of fuel poor households (000s)	% of households in fuel poverty	Number of fuel poor households (000s)	% of households in fuel poverty
Owner occupied	224	15.0%	206	13.4%
Local authority	138	38.9%	146	39.0%
Housing association	98	38.1%	99	39.0%
PRS	125	36.9%	132	39.0%
All dwellings	**585**	**23.9%**	**583**	**23.7%**

The results reported throughout this annex therefore relate to the 585,000 households calculated as being in fuel poverty at the time of the modelling. Given the substantial increase in fuel prices in recent years, the estimated number of households in fuel poverty would likely be higher than denoted in Table 2 if 2021 fuel prices were used.

7. Modelling approach

7.1 Energy efficiency targets

The energy efficiency targets modelled in this exercise were aligned with those set out in the 2018 Energy Efficiency Scotland Route Map.

The modelling aimed to get dwellings of different tenures to meet the energy efficiency standards by the specified years by selecting a set of energy efficiency improvement measures which increase a dwelling's SAP score (as measured by the EER), while satisfying a minimum cost approach.

7.1.1 Selecting packages of measures

Within the NHM, all measures are collected into separate groups or buckets of related measures, such as 'wall insulation' measures. All buckets include a 'do-nothing' option (which may be the best or only suitable option for certain dwellings). Where a dwelling fell below the SAP target, the NHM selected one option from each group/bucket at a time to generate a package of measures, and this was repeated to generate all possible combinations of measures. Where a measure was deemed to

[20] https://www.gov.scot/publications/latest-estimates-fuel-poverty-extreme-fuel-poverty-under-proposed-new-definition-following-stage-2-fuel-poverty-targets-definition-strategy-scotland-bill/pages/2/

be unsuitable for a dwelling, based on the assumptions set out in Table 7 and Table 8, any combinations with that measure were ignored.

The model then calculated the impacts of all the suitable combinations of measures for each dwelling. When calculating the impact of a given combination of measures, the effect of installing the first measure is calculated before moving on to the next measure. This ensures that interaction effects between measures are taken into account, since savings from a measure will generally be lower when previous measures installed have increased the energy efficiency of the dwelling. The order in which measures are installed is determined by the order that the 'buckets' of measures are written in the modelling scenario.

This has particular significance when installing insulation measures before heating systems in a combination of measures. As an example, let's envisage a scenario with a bucket of wall insulation measures (e.g. different types of cavity and solid wall insulation) followed by a bucket of low carbon heating measures (e.g. biomass boiler, heat pump, solar PV, etc.). If the selected combination of measures involves installing both wall insulation and a low carbon heating system, the wall insulation will be installed before the heating system. The heating system sizing function in the model is based on the heat load of a dwelling; the insulation – if installed first – will reduce that heat load and thus the required size and also possibly the capital costs of the heating system. For heat pumps, which have a maximum size cap included in the measure specification, insulation may need to be installed for some larger dwellings in order to reduce the heat load to a suitable level in order to allow the largest heat pumps to be installed.

The approach followed in this modelling is more comprehensive than an approach that installs measures in a set order (such as that set out in SAP Appendix T[21]) and only installs measures later in the order if all earlier measures have been installed. While it is the case that within a given package of measures, the NHM installs measures in a set order (since this allows proper sizing of heating systems, as described above), the process used to generate measures in the NHM allows a measure to be chosen from a bucket which features later in the order without selecting a measure from a bucket earlier in the order. For example, it might be possible to hit the target EPC by upgrading the heating system without also having to install insulation – the NHM would allow this combination to be assessed.

7.1.2 Other modelling assumptions

In order to make the large number of scenarios tractable, the simplifying assumption was made that all upgrades to meet a target are undertaken in the year in which that target applies. In reality, the delivery of measures will be spread over the years leading up to the deadline.

[21] The Government's Standard Assessment Procedure for Energy Rating of Dwellings

Fuel prices, measure costs, household incomes and housing costs were kept constant across the various years of the target. This can be interpreted as assuming that these variables rise in line with inflation. This simplifying assumption was relied upon to circumvent the challenge of forecasting how these factors are expected to change relative to inflation over a twenty year horizon.

It is evident that fuel prices have since increased beyond the rate of inflation, which as addressed is likely to increase the number of fuel poor households relative to the time of the modelling.

By assuming measure costs rise in line with inflation, the monetary values informing the estimated cost of improving the energy performance of those households calculated as being in fuel poverty at the time of the modelling can therefore be regarded as being in today's prices, i.e. as having been adjusted for inflation.

7.2 Varying the set of measures – standard and low carbon scenarios

Different scenarios were modelled to assess how the technical feasibility and costs associated with achieving the energy efficiency targets vary depending on which measures were made available in reaching the targets. Principally this involved placing restrictions on the deployment of fossil fuelled heating systems.

Three scenarios were modelled. The first of which allowed for all possible energy efficiency measures, including both fossil fuelled and low carbon heating systems, and a second and third approach which assumed that only low carbon heating systems could be installed, although this restriction was applied in different ways. These are described in more detail below.

Standard scenarios

The 'standard scenarios' used the full list of energy efficiency improvement measures, including all fossil fuel boilers, and applied a minimum cost approach when attempting to get to the required energy efficiency standard. However, no new fossil fuel systems were installed where none currently exist; for example, gas boilers were only installed where dwellings currently use gas for heating, and no new gas connections were allowed in the modelling.

Low carbon scenarios – version 1

The first version of the low carbon scenarios proceeded by initially removing any existing fossil fuelled main heating systems from dwellings and temporarily replacing them with electric room heaters. This serves to artificially inflate the fuel poverty rate prior to the stage to EPC C.

The temporary switch to electric room heaters is a modelling device to ensure the model can function. When a dwelling is decarbonised, the NHM needs to select a new heating system and other upgrades depending on what the objective of the modelling is, e.g. to reach the highest EPC at the lowest capital cost. However, the NHM needs to compare various combinations of low-carbon heating systems and insulation packages with an existing heating system and levels of insulation, in order to decide which combination best meets the objective. Since the fossil fuel heating system cannot remain in place, it cannot serve as the default heating system. The NHM therefore uses electric room heaters as the default heating system, and then compares this to other low carbon heating systems. It is the most natural default system since they are suitable across all domestic properties.

In the vast majority of cases, the use of room heaters is just a modelling device which helps determine the package of measures which best meets the objectives, i.e. in reality, the household will move directly from the fossil fuel system to the most appropriate low carbon heating system, such as a heat pump.

Due to complexities of deciding whether households are in fuel poverty when modelling decarbonisation and energy efficiency upgrades together for those households which are currently on a fossil fuel heating system, the approach followed in the NHM modelling when deciding if a household was in fuel poverty was to look at the point where the fossil fuel heating system was removed but before any other measures were installed, e.g. if a household was previously using a gas boiler, the gas boiler would first be replaced with a room heater, and then the household's fuel poverty status would be determined. If the household is in fuel poverty at this point, then the subsequent costs relating to installing the most efficient low carbon heating system, as well as various forms of insulation, etc., would be treated as being part of the costs of tackling fuel poverty.

Given that there is no one obvious answer as to whether a household is in fuel poverty when modelling a package which includes both decarbonisation and other energy efficiency upgrades, it was decided that this approach was conservative in that it was very unlikely to underestimate the costs that could be attributed to fuel poor households.

The results from the low carbon 1 scenario at the stage to EPC C, and to EESSH 2 in the social rented sector, therefore include some households who may not otherwise have been classified as fuel poor[22], where fuel costs have increased due to the installation of inefficient room heaters with no supporting fabric measures.

This scenario then proceeded as the standard scenarios, i.e. by applying measures to achieve the target SAP score using a minimum cost approach, but only allowing low carbon heating systems (air and ground source heat pumps, biomass boilers, and storage heaters) to be considered, as well as all the standard insulation and lighting measures, as possible energy efficiency improvements.

[22] See Table 3

Version 1 of the low carbon scenarios can be regarded as one way of modelling a full decarbonisation of the housing stock, assuming the electricity grid can be fully decarbonised.[23]

Low carbon scenarios – version 2

The second version of the low carbon scenarios did not remove any existing fossil fuel systems but only allowed low carbon heating systems (air and ground source heat pumps, biomass boilers, and storage heaters) to be considered, as well as all insulation, microgeneration and lighting measures, when attempting to reach energy efficiency standards.

This second version therefore took an intermediate approach between the standard scenario and the first version of the low carbon scenarios. It went further than the standard scenarios in that it only permitted low carbon heating systems to be installed (the standard scenario allowed new fossil fuel heating systems to be installed provided the existing heating system was fossil-fuelled), but not as far as the first version of the low carbon scenarios, in that it did not require existing fossil fuel systems to be removed if it was not cost effective to install a low carbon heating system.

8. Results

8.1 Fuel Poor Households - Private sector – EPC C – Attainment rates and costs

The discussion in this section looks at the costs of retrofitting all fuel poor households in the private sector to an EPC C. The 2018 Energy Efficiency Scotland Route Map outlined an intention to gradually improve the energy performance of the poorest performing dwellings in the private rented sector, such that all private rented housing stock achieved an EPC D by 2025. These commitments were laid before parliament in 2019, but were paused due to the COVID-19 pandemic. The private rented sector is now expected to go directly to an EPC C with a backstop date of 2028. While the expected date of compliance differs between the owner occupied and private rented sectors, the path to EPC C is now therefore similar across both tenures, in that all private sector homes will be improved from their current EPC rating to an EPC C, with no iterative stages.

The results set out below relate to raising fuel poor households in the private rented sector to an EPC C from an EPC D[24], and are reported alongside the results for raising all owner occupied fuel poor households to an EPC C in the same year.

---

[23] For example, electric storage heaters were considered to be low carbon. Options for decarbonising the gas grid were beyond the scope of the current research.

[24] The 2019 Scottish House Condition Survey estimated that 20% of private rented sector housing stock was rated EPC E, F or G. the costs presented here do not therefore reflect the cost of first raising these properties to an EPC D, estimated at £0.1bn .

Table 3 summarises the attainment rates, total and average costs under the standard and low carbon scenarios.

Table 3: Summary results for fuel poor households in the private sector at the stage to EPC C. PRS costs are based on attaining an EPC C from an EPC D baseline.

	PRS			OO		
	Standard	**Low carbon 1**	**Low carbon 2**	**Standard**	**Low carbon 1**	**Low carbon 2**
Attainment rate	81%	71%	77%	83%	72%	80%
Total upgrade cost (£bn)	0.6	1.3	0.6	1.4	4.0	1.5
Average (mean) upgrade cost	£6,700	£9,000	£6,500	£8,900	£12,500	£9,600
Dwellings Upgraded[25]	83,000	143,700	85,900	162,000	319,300	160,500

Figure 1 illustrates how the attainment rates vary across the different scenarios and tenures, while Figure 2 illustrates how the average (mean) cost per upgraded dwelling varies.

[25] That more dwellings are upgraded in the low carbon 1 scenario reflects the simulated removal of all fossil fuel heating systems at the stage to EPC C. As the model temporarily replaces these systems with inefficient electric rooms heaters, this serves to artificially increase the modelled fuel costs of all households who were previously using fossil fuels; inflating the estimated number of fuel poor households prior to the stage to EPC C relative to the other scenarios. The costs reported in this scenario therefore also include the costs of decarbonising some non fuel poor households, who have only entered into fuel poverty as a result of havingreplaced fossil fuel heating systems with inefficient electric room heaters.

Figure 1. EPC C attainment rates in the private sector across each of the scenarios modelled

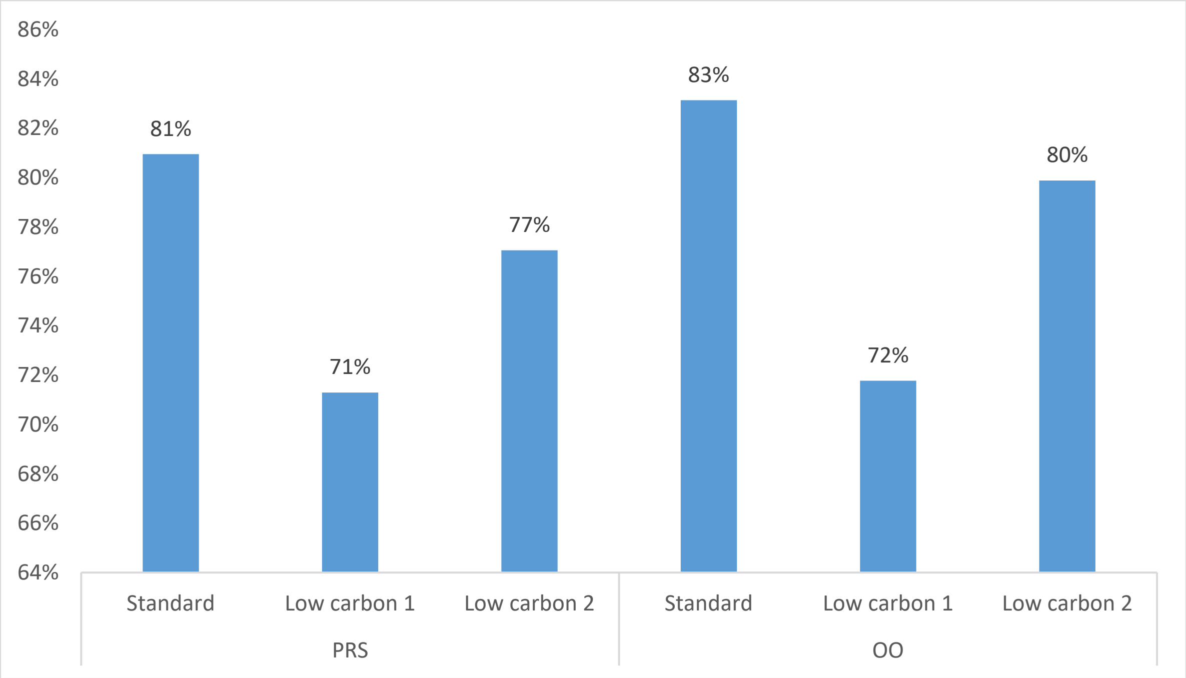
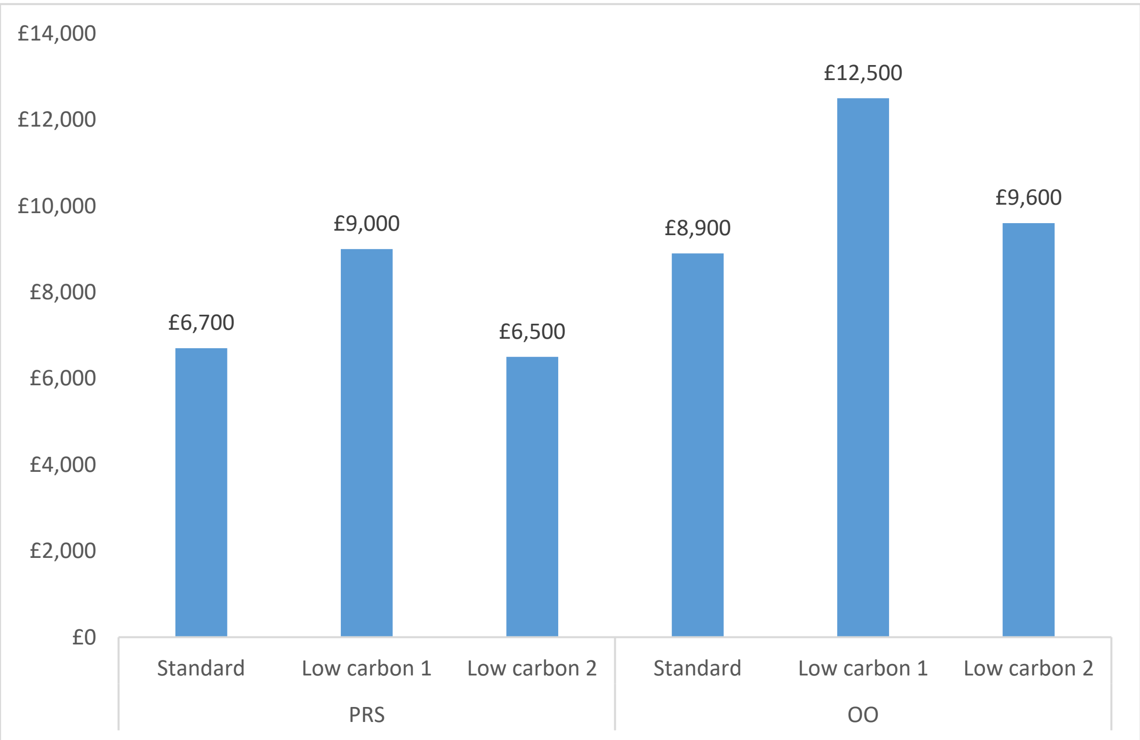


Figure 2. EPC C average (mean) upgrade cost per upgraded dwelling in the private sector across each of the scenarios modelled



The results show that, under the standard scenario, an 81% EPC C attainment rate can be achieved at an average upgrade cost of £6,700 per dwelling and a total cost of £0.6bn in the private rented sector, while a 83% attainment rate, at an average cost of £8,900, and a total cost of £1.4bn can be achieved in the owner occupier sector. The main reason for the marginally lower attainment rate in the private rented sector is the greater proportion of stone dwellings, since solid wall insulation can be more challenging to install in these dwellings and so may not be considered as a suitable measure.[26]

When restricting upgrades to low carbon measures, and in particular the more stringent low carbon 1 scenario, which requires all existing high carbon heating systems to be replaced, the maximum attainment falls to 71% in the private rented sector and 72% in the owner occupier sector. Meanwhile, costs increase significantly, with the average cost per upgraded dwelling rising to £9,000 and the total cost to £1.3bn in the private rented sector, and the average cost to £12,500 and the total cost to £4bn in the owner occupier sector.

Under the hybrid low carbon 2 scenario, which does not require existing high carbon heating systems to be replaced if that would lower the dwelling's EPC, the change in the attainment rates from the standard scenario are not as marked. In the private rented sector the attainment rate falls from 81% in the standard scenario to 77%, while the average upgrade cost falls marginally from £6,700 to £6,500, while in the owner occupier sector, the attainment rate falls from 83% to 80%, and the average cost rises from £8,900 to £9,600.

8.2 Fuel Poor Households - Private sector – EPC B for fuel poor households – Attainment rates and costs

The Route Map had set a target that where households are in fuel poverty, the property should be raised to an EPC B by 2040, where technically feasible, cost effective and affordable. The 2040 target relates to the private sector, since fuel poor households in the social rented sector are covered by the EESSH2 target to maximise the number of properties (whether the household is in fuel poverty or not) by 2032.

Table 4 sets out the summary results for the stage to EPC B for fuel poor households in the private sector.

Table 4. Summary results for EPC B for fuel poor households in the private sector across each of the scenarios modelled. Costs relate to raising private sector fuel poor households from EPC C to EPC B.

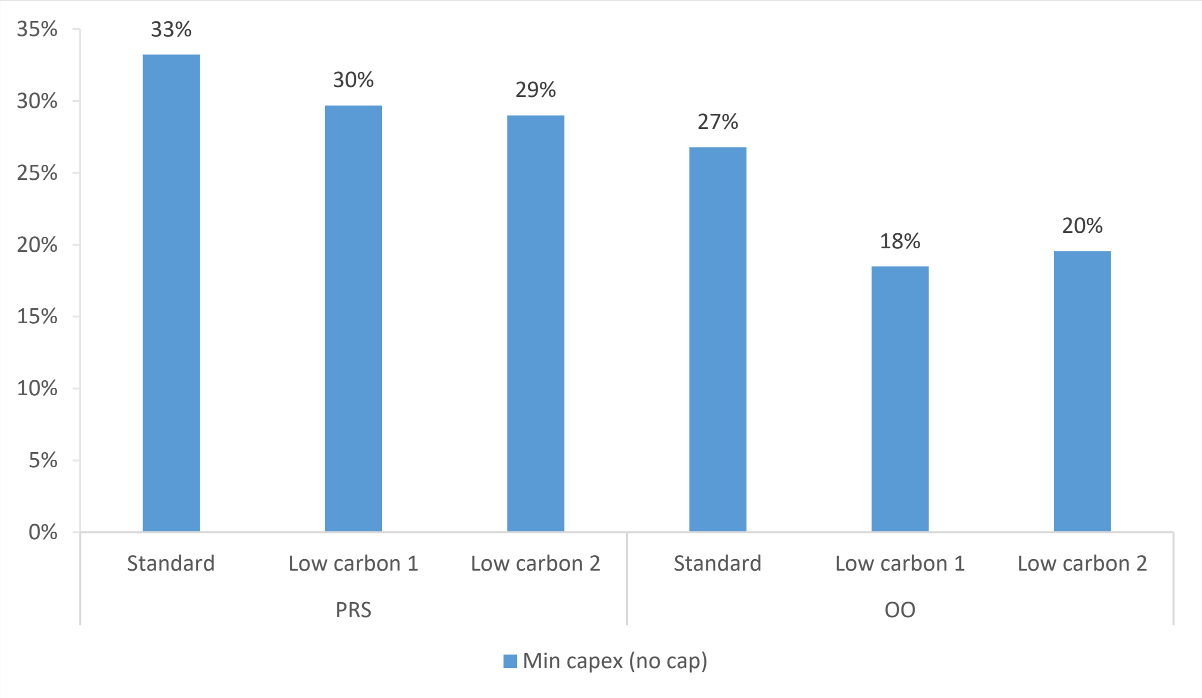
[26] As set out in Table 7 it is assumed that 50% of pre-1919 dwellings with stone walls are suitable for solid wall insulation.

	PRS			OO		
	Standard	Low carbon 1	Low carbon 2	Standard	Low carbon 1	Low carbon 2
Attainment rate	33%	30%	29%	27%	18%	20%
Total upgrade cost (£bn)	0.58	0.47	0.49	1.49	1.01	1.27
Average (mean) upgrade cost	£7,900	£5,900	£6,800	£10,600	£8,600	£9,700
Dwellings Upgraded	74,000	80,000	71,500	140,000	118,000	130,000

Figure 3 shows that attainment rates for EPC B are much lower than for EPC C. That is, based on the set of measures available in the NHM, and given the assumptions that have been made as to when these measures are suitable, it is not possible to increase the EPC as high as a B for most properties. For example, under the standard scenario, the attainment rate falls from 81% at the stage to EPC C to 33% at the stage to EPC B in the private rented sector, and from 83% to 27% in the owner occupier sector. This is due to fact that in general the more energy efficient a property becomes, the smaller is the increase in energy efficiency when additional measures are installed. However, even where a property is not able to reach an EPC B, it might be possible to raise its EER, even where it remains within the EPC C band. For example, in the standard scenario, although only 33% of fuel poor households in the private rented sector live in dwellings which meet or can be upgraded to an EPC B, a further 40% of fuel poor households are able to benefit from their dwelling's EER being increased within the C band. In the owner occupier sector, where the EPC B attainment rate is 27%, a further 52% of fuel poor households can benefit from a higher EER within the EPC C band.

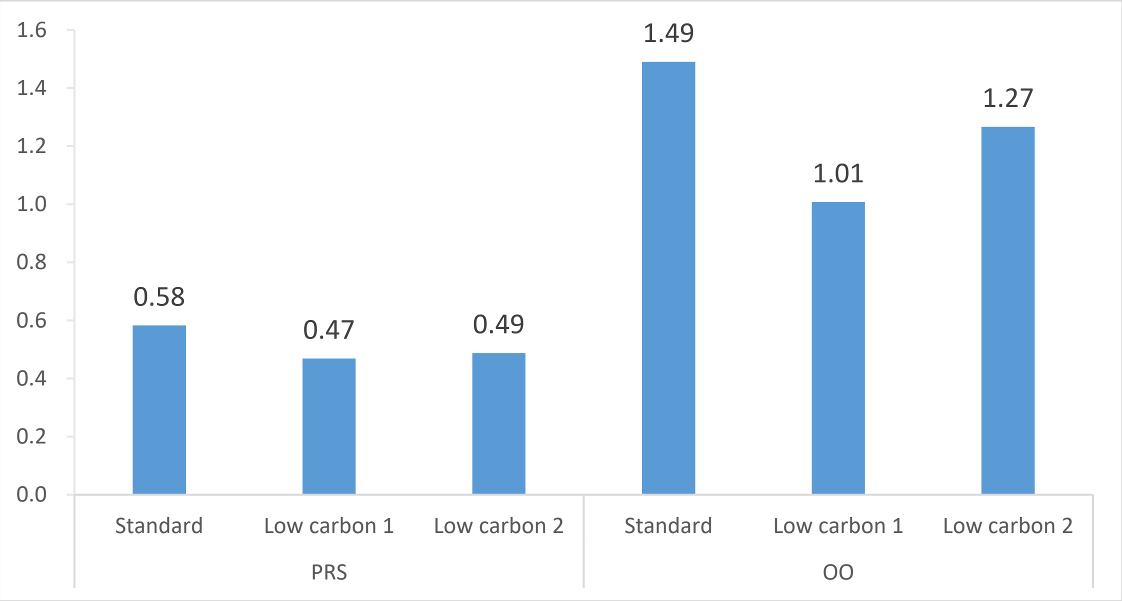
Figure 3. EPC B attainment rates for fuel poor households in the private sector across each of the scenarios modelled

Figure 4 shows the average costs per upgraded property. By comparing Figure 4



with Figure 2 it can be seen that the average cost per upgraded dwelling is higher at the stage to EPC B than at the stage to EPC B for the standard and low carbon 2 scenarios, in both the private rented and owner occupier sectors. The largest increase is in the owner occupier sector under the standard scenario, where the average cost at the EPC B stage is £10,600, compared with £6,700 at the stage to EPC C, a difference of £3,900. This is because the lowest cost measures have been installed at the stage to EPC C.

Figure 4. Average (mean) upgrade cost per upgraded dwelling in the private sector for EPC B target for fuel poor households



In contrast, under the low carbon 1 scenario, the average upgrade cost is lower at the stage to EPC B than at the stage to EPC C. This reflects that the replacement of all existing fossil fuel heating systems with zero carbon alternatives in the low carbon 1 scenario is assumed to happen at the stage to EPC C.

Table 5 summarises the costs to achieve an EPC C, then an EPC B, across each of the scenarios modelled.

As one would expect, the stipulation that all fossil fuel heating systems must be replaced with a suitable low carbon alternative in the low carbon 1 scenario delivered the largest estimate of the cost to achieve an EPC B, at £1.76bn and £4.99bn for the private rented and owner occupied sectors respectively.

When continuing to permit the installation of fossil fuel heating systems in the standard scenario, the total cost estimate fell to £1.14bn and £2.93bn for the private rented and owner occupied sectors. That these costs were marginally higher than the low carbon 2 scenario was due to the model installing measures in fewer households at the stage to EPC B in the low carbon 2 scenario relative to the standard scenario. Reflecting that for a subset of dwellings in both the owner occupied and private rented sectors it was not possible to further improve the SAP score at the stage to EPC B using only low carbon heating measures, with the model already having installed key conservation and microgeneration technologies at the stage to EPC C.

Table 5. Private sector cost to achieve an EPC B (£bn), including the cost to first achieve an EPC C.

	PRS			OO		
	Standard	**Low carbon 1**	**Low carbon 2**	**Standard**	**Low carbon 1**	**Low carbon 2**
Cost to EPC C	0.55	1.29	0.56	1.44	3.99	1.54
Cost to EPC B	0.58	0.47	0.49	1.49	1.01	1.27
Cumulative cost	1.14	1.76	1.04	2.93	4.99	2.81

8.3 Results for the Social rented sector

The trends identified in the private sector are largely mirrored in the results for the social rented sector. Note that due to regulatory framework in the social sector, dwellings in this sector were modelled to be upgraded from EESSH1 (largely a mix of EPC C and D properties) directly to an EPC B.

Table 6 does though show that while, as the in private sector, only a minority of dwellings are modelled as being able to reach an EPC B, the highest EPC B attainment rate in the social rented sector is, at 41%, notably higher than the 27% rate in the owner occupied sector under the same scenario.[27] This will in part be due to the greater share of flats in the social sector than in the owner occupied sector, since with fewer exposed surfaces, flats are typically easier to insulate. However, it is also significantly higher than the 33% achieved in the private rented sector, which has a similar share of flats. The reason for this is dwellings in the social sector tend to be of more recent vintage, and the social sector therefore has a significantly lower share of traditional build dwellings, for which insulation options are not always technically feasible, than the private rented and owner occupied sectors.[28]

[27] See Table 4.
[28] Scottish House Condition Survey 2019 - Table 9

Table 6. Summary results for EESSH2 for fuel poor households in the social rented sector, from an EESSH1 baseline.

	Standard	Low carbon 1	Low carbon 2
Attainment rate	41%	31%	32%
Total upgrade cost (£bn)	1.6	3.1	1.4
Average (mean) upgrade cost	£ 8,900	£ 14,100	£ 8,000
Dwellings upgraded	181,726	216,204	170,905

Table 6 shows that attainment rates under the low carbon 1 and low carbon 2 scenarios are again lower than those under the standard scenario, at 31% and 32% respectively. These attainment rates are closer to the rates achieved under the same scenarios in the private rented sector, but are still significantly higher than in the owner occupied sector.[29]

Again we see that using the set of measures made available in the modelling, and applying the suitability criteria set out in Table 8 and Table 9, it is not possible to achieve an EPC B for the majority of social rented properties. Under the standard scenario, 41% of the social rented stock achieves an EPC B. A further 50% have a package of measures installed to improve the energy efficiency of the dwelling, such that the average SAP rating amongst those dwellings that weren't capable of reaching an EPC B improved from 68 to 75.

Table 6 shows that the average cost to achieve an EPC B is higher under the Low Carbon 1 scenario at £14,100 than under the standard (£8,900). This is driven by the requirement to replace all existing high carbon heating systems in the low carbon 1 scenario which, despite a lower attainment rate than under the standard scenario, then resulted in a higher total upgrade cost of £3.1bn, as compared to a total cost of £1.6bn under the standard scenario.

Under the hybrid low carbon 2 scenario, which only replaced high carbon heating systems with low carbon alternatives if this succeeded in achieving a higher SAP rating, but did prevent the installation of new high carbon heating systems, this

[29] The likely reason for this is that the advantage the social rented sector enjoys relative to the private rented sector in terms of fewer traditional build homes is largely offset by the greater difficulty of reaching the minimum EER required for an EPC B while using low carbon fuels, although the average EER achieved in the social sector is higher than in the private rented sector in both these scenarios.

scenario delivered an attainment rate of 32% at a total cost of £1.4bn and an average cost of £8,000. That a lower proportion of dwellings were capable of achieving an EPC B in the low carbon scenarios, relative to the standard scenario, is due to a subset of social rented properties where the installation of zero carbon heating systems could not achieve a higher SAP rating than the incumbent fossil fuel heating system.

This is driven in part by the unit cost differential between gas and electricity under SAP 2012. Heat pumps have been modelled in this exercise to be 2.7 times more efficient than gas boilers (see Table 8), yet the unit price differential between gas and electricity stands at 3.8 in SAP 2012. This means that without also being able to reduce a dwelling's heat demand, either through the installation of fabric or microgeneration measures, the installation of even highly efficient low carbon heating systems is incapable of improving the SAP score.

That we see lower attainment rates at the stage to EPC B, particularly for the low carbon scenarios, is therefore due to the key conservation measures having already largely been deployed across the stock to achieve EESSH 1, making it challenging to further reduce heat demand and therefore improve the SAP rating using low carbon heating systems at the stage to EPC B.

Appendix

The following section provides details on how the cost of each measure was calculated.

Table 7: Technical specification and suitability for insulation and conservation measures

Insulation/ Conservation Measure	Technical specifications	Suitability assumptions
Cavity wall insulation	Thickness: 50mm; final u-value of insulated wall is 0.35, depending on age of dwelling - this follows the SAP 2012 methodology: SAP 9.92, Appendix S, table S7.	Dwellings built before 1984 with uninsulated traditional cavity brick walls that are 'easy to treat' (have normal cavity widths and are easily accessible)
Cavity wall insulation - for dwelling built between 1984-1991	Thickness: 50mm; final u-value of insulated wall is 0.35, depending on age of dwelling - this follows the SAP 2012 methodology: SAP 9.92, Appendix S, table S7.	Dwellings built between 1984-1991 with uninsulated traditional cavity brick walls that are 'easy to treat' (have normal cavity widths and are easily accessible)
Cavity wall insulation - hard to treat version 1	Cavity insulation in these walls was not an option in SAP 2012 u-value tables at time of modelling. As a work around, internal insulation was specified instead, which has very similar behaviour to cavity wall insulation for other wall types, in terms of final wall u-value. Thickness: 50mm; final u-value of system build/timber frame/metal frame walls with insulation varies between 0.60 and 0.40, depending on age of dwelling - see SAP 9.92, Appendix S, table S7.	Dwellings with uninsulated cavities in timber frame, metal frame or system built dwelling (i.e. non-traditional homes)
Cavity wall insulation - hard to treat version 2	Thickness: 50mm; final u-value of insulated wall varies between 0.50 and 0.40, depending on age of dwelling - this follows the SAP 2012 methodology: SAP 9.92, Appendix S, table S7.	A sample of dwellings with uninsulated cavity brick walls assumed to be 'hard-to-treat' (narrow or inaccessible cavities). Scenario selects: 8% of urban houses (new or existing), 7% of urban houses (new or existing), 14% of flats (new or existing).
Double glazing	Settings equivalent to double glazing with 12mm gap, upvc frame, air filled (low-E,en = 0.05, soft coat), u-value: 2.0. This follows the SAP 2012 methodology: SAP 9.92, Table 6e.	All dwellings with less than 100% double glazing, except those with solid stone walls built before 1919.

Insulation/ Conservation Measure	Technical specifications	Suitability assumptions
Secondary glazing	U-value after installation: 2.4. This follows the SAP 2012 methodology: SAP 9.92, Table 6e	50% of dwellings built before 1919 with solid stone walls which have less than 100% double glazing.
Draught proofing	Installs full draught-proofing in any dwellings will less than 50% draught proofing in doors and windows	All dwellings with less than 50% double glazing (a RD SAP assumption for draught proofing suitability), except those with solid stone walls built before 1919.
External wall insulation	Thickness: 100mm; final u-value of insulated wall varies between 0.35 and 0.16, depending on age of dwelling - this follows the SAP 2012 methodology: SAP 9.92, Appendix S, table S7.	Can be installed in: all solid brick wall dwellings, all stone walled dwellings built after 1919, and 10% of stone walled dwellings built before 1919 (but not those flagged as suitable for IWI)
Floor insulation	150mm installed on suspended timber floors with no insulation, final u-value of insulated floor: 0.22 - this follows the SAP 2012 methodology: SAP 9.92, Appendix S, table S12	Installed on suspended timber floors only with no insulation
Hot water tank insulation	Topped-up to either 25mm if factory insulated or 80mm if is a jacket	Dwelling has a hot water cylinder with factory insulation of less than 25mm or with jacket insulation of less than 80mm
Internal wall insulation	Thickness: 50mm; final u-value of insulated wall varies between 0.60 and 0.21, depending on age of dwelling - this follows the SAP 2012 methodology: SAP 9.92, Appendix S, table S7.	Can be installed in: all solid brick wall dwellings, all stone walled dwellings built after 1919, and 40% of stone walled dwellings built before 1919 (but not those flagged as suitable for EWI)
Loft insulation	loft insulation installed or topped-up to 300m. This results in a final u-value of insulated heat loss roof of 0.14 for slate/tile roofs, 0.11 for thatched roof. These are taken from SAP 9.92, Appendix S, Table S9.	Any dwelling with a loft and where the loft insulation is less than 300mm in thickness
Low energy lighting	Replaces any incandescent bulbs with LED bulbs	Any dwelling where existing levels of low energy lighting (incandescent bulbs) are less than 100%

8.4 Restrictions for traditional dwellings

In traditional dwellings, there may be particular challenges relating to whether measures such as double glazing and wall insulation are suitable. In the absence of detailed information on the suitability of measures in individual dwellings, we have adopted a proxy approach. Dwellings built before 1919 are categorised as traditional build. It is assumed that only a certain percentage of these type of dwellings are suitable for each of the measures denoted below. A flag is therefore randomly assigned to each dwelling to indicate whether or not it is suitable for the measure, to ensure the total number of dwellings deemed suitable is in line with our assumption.

The exact proportion of traditional dwellings which will be suitable for a particular measure is uncertain, especially as technology progresses and greater experience is acquired in installing measures, an increasing share of traditional dwellings are likely to be able to have measures installed. We have therefore taken the following simplified approach:

- Wall insulation - Assume 40% of solid stone walled dwellings built pre-1919 are suitable for internal wall insulation and a further 10% are suitable for external wall insulation.

- Glazing – Assume no solid stone walled dwellings built pre-1919 are suitable for double glazing, but that 50% of those with single glazing are suitable for second glazing.

- Draught proofing – Assume that no solid stone walled dwellings built pre-1919 are suitable for draught proofing. However, professional installation of secondary glazing would also ensure air tightness and qualifies as a draught proofing measure. So those pre-1919 stone dwellings which had secondary glazing installed could also be said to have been draught proofed.

Table 8: Technical specification and suitability for heating systems and low carbon/renewable technologies

Heating system/ renewable technology	Technical specifications	Suitability assumptions
Air source heat pump	Coefficient of performance: 2.4) (Coefficient of performance based on review of external literature and reports of typical heat pump performance[30]. In reality, heat pump performance is likely to vary significantly due to a range of dwelling characteristics and external factors.)	Suitable for any dwellings other than those currently using heat pumps as main heating system
Biomass boiler	Boiler efficiency: 91% (A-rated boiler efficiency); Cylinder volume: 190 l; Cylinder insulation: 50mm **(Boiler efficiency from Product Characteristics Database (PCDB))**	Rural houses only (not flats or urban dwellings) with sufficient external space for fuel storage (SHCS: no information on external plot dimensions, assumed all rural houses have suitable space)
Gas combi boiler	Boiler efficiency: 91% (A-rated boiler efficiency) **(Boiler efficiency from Product Characteristics Database (PCDB))**	Installed in dwellings with a gas connection that currently have heating systems with an efficiency of 85% or less (e.g. a SEDBUK boiler rating of C or below)
Ground source heat pump	Coefficient of performance: 3.4 (Coefficient of performance based on review of external literature and reports of typical heat pump performance. In reality, heat pump performance is likely to vary significantly due to a range of dwelling characteristics and external factors.)	Rural houses only (not flats or urban dwellings), not currently using heat pumps as main heating system, with sufficient external space for equipment (SHCS: no information on external plot dimensions, assumed all rural houses have suitable space)
Gas hybrid heat pump	Coefficient of performance: 2.4; Hybrid fuel: Mains gas; Hybrid efficiency: 91%; Hybrid performance: 67% (Hybrid heat pump specifications based on external research[31])	Not installed in dwellings currently using heat pumps as main heating system, must have gas connection
LPG combi boiler	Boiler efficiency: 91% (A-rated boiler efficiency) **(Boiler efficiency from Product Characteristics Database (PCDB))**	Installed in off-gas dwellings that currently have heating systems with an efficiency of 85% or less (e.g. a SEDBUK boiler rating of C or below), and not existing electricity systems (e.g. heat pumps)
Oil combi boiler	Boiler efficiency: 91% (A-rated boiler efficiency) **(Boiler efficiency from Product Characteristics Database (PCDB))**	Installed in off-gas dwellings that currently have heating systems with an efficiency of 85% or less (e.g. a SEDBUK boiler rating of C or below), and not existing electricity systems (e.g. heat pumps)

Solar PV	Panels are assumed to be installed on south facing roofs and tilted at 30 degrees. In accordance with SAP assumptions, the model assumes that 50% of generated electricity is used on site, and the remaining 50% is exported.[32] Suitable roof area, and therefore panel size, from SHCS data.	Solar PV suitability is flagged in the SHCS survey data[33]
Solar thermal	$8m^2$ panel. Zero-loss efficiency: 0.8; Linear heat-loss coefficient: 4.0; Cylinder volume: $75m^3$. (Specifications based on RD SAP)	Solar thermal suitability is flagged in the SHCS survey data[33]
Storage heater	Fan storage heaters with Celect-type control. Celect system has electronic sensors throughout the dwelling linked to a central control device. It monitors the individual room sensors and optimises the charging of all the storage heaters individually. *(These specifications align with the most efficient storage heaters listed in SAP 9.92 documentation – Table 4b)*	**Standard scenarios:** Only suitable in dwellings with existing electric heating systems[34] **Low carbon scenarios:** Suitable for all dwellings except those with communal heating systems

8.5 Heat pump suitability assumptions

The suitability for heat pumps, and particularly air source heat pumps, has been based primarily on the existing fuel type and hasn't included wider suitability criteria. The specific characteristics of certain dwellings may make them unsuitable for the installation of heat pumps in their current state, although data in the stock is not sufficient to make this judgement. Therefore, it is possible that the suitability of air source heat pumps may have been overestimated in the modelling. However, a maximum sizing constraint has been placed upon heat pumps so that where the

[30] E.g. https://www.gov.uk/government/publications/hybrid-heat-pumps-study
[31] https://www.gov.uk/government/publications/hybrid-heat-pumps-study
[32] See Appendix M: Energy from Photovoltaic (PV) technology, small and micro wind turbines and small-scale hydro-electric generators, SAP 2012 documentation. Available at: https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf
[33] Note: The assessment of solar suitability for the SHCS survey takes account of the orientation of the roof (solar thermal systems are deemed suitable on roofs oriented within 150 ° – 210°, solar PV systems where roofs lie within 135° – 225°). It also considers any overshading from buildings or trees, and roof areas must be greater than 8m2.
[34] In the standard scenarios (i.e. non-low carbon), no dwelling was switched to electric heating unless it was already using that as a main heating fuel. A fuel switch to electricity using standard electric heating systems (e.g. not heat pumps) tends to reduce SAP ratings and increase fuel bills. Furthermore, initial testing showed that relaxing the suitability criteria did not increase the numbers of storage heaters being installed across the stock. However, when trying to meet targets with only low carbon or renewable heating systems, with the assumption that electricity will significantly decarbonise, storage heaters are likely to play a more significant role in providing low carbon heat. Hence, the suitability for storage heaters was broadened for the low carbon scenarios.

modelled heat demand is above a certain threshold, those dwellings have not been flagged as suitable for heat pumps. This has attempted to limit the number of heat pumps being recommended for large or inefficient dwellings where heat pumps may struggle to provide sufficient heat.

The suitability for measures across the housing stock is shown below in Table 9, split by different tenures[35].

Table 9: Measure suitability by housing tenure

Measure	Owner occupied	Private rented	Social housing
Air source heat pump	1,120,345	274,742	566,408
Biomass boiler	425,737	63,952	94,755
Cavity wall insulation	231,690	49,149	99,232
Cavity wall insulation (1984-1991)	37,701	8,649	15,876
Cavity wall insulation - hard to treat version 1	95,447	12,385	31,087
Cavity wall insulation - hard to treat version 2	19,952	4,339	11,981
Double glazing	20,777	8,354	4,813
Draught proofing	20,777	8,354	4,813
External wall insulation	96,934	26,834	20,341
Floor insulation	946,039	140,779	296,826
Gas combi boiler	579,550	124,202	193,019
Ground source heat pump	358,057	56,333	93,288
Hybrid heat pump	1,206,491	229,081	485,431
Internal wall insulation	174,682	63,404	29,103
Low energy lighting	1,276,443	288,269	505,205
LPG combi boiler	104,387	24,828	8,084
Oil combi boiler	104,387	24,828	8,084
Secondary glazing	31,413	18,863	923
Solar PV	856,096	134,682	233,388
Solar thermal	535,721	84,433	144,513
Storage heater	93,864	49,996	79,607
Tank insulation	149,475	37,627	48,442
Top up loft insulation	1,196,016	173,918	344,616

[35] Estimated by applying the suitability assumptions in Table 7 and Table 8 and applying to the dwelling characteristics of the Scottish Housing stock as identified by the 2015 – 2017 Scottish House Condition Survey.

8.6 Measures not included in the modelling

The NHM does not have the built-in functionality to model all possible energy efficiency measures or heating technologies. For example, it is not possible to simulate the installation of anaerobic digesters, micro-wind turbine or mini-hydro systems. However, at the domestic level these measures are unlike to play a significant role in retrofit of the housing stock and efforts to decarbonise the housing stock.

In addition, district heating systems have not been modelled in the NHM scenarios. The NHM does have a rudimentary simulation of district heating systems but it is not a spatial model and thus cannot connect multiple dwellings to individual heating systems.

8.7 Measure costs

The capital costs of energy efficiency improvement measures can be defined using a cost function which allows users to define fixed and variable costs. The variable costs can be applied to the size of the measure. The size can be specified as the area of an insulation measure installed (m^2 - which is calculated by the NHM) or the power rating of a heating system (kW).

Prior to this modelling exercise, CSE had developed a data set of costs for different energy efficiency measures. These costs were reviewed as part of this project. This included reviewing any relevant publications from the Scottish Government as well as the UK government, online research, and a review of any available secondary research that on the costs of energy efficiency improvements. In some instances, these were supplemented with information from a selection of manufacturers and suppliers. The final set of cost functions derived from this exercise and used in the modelling are presented below in Table 10.

Table 10: Measure cost functions used to calculate installed measure costs for each measure modelled.

Measure description	Fixed costs	Variable costs	Variable cost basis	Lifetime of measure (ECO)
Air source heat pump	£3,000	£400	per peak load (kW) of dwelling	15
Biomass boiler	£6,000	£400	per peak load (kW) of dwelling	20
Standard cavity wall insulation	£150	£5	per m2 of wall area insulated	42

Measure description	Fixed costs	Variable costs	Variable cost basis	Lifetime of measure (ECO)
Standard cavity wall insulation installed in dwellings built between 1984-1991	£100	£2	per m2 of wall area insulated	42
Hard to treat non-cavity brick cavity wall insulation	£200	£3	per m2 of wall area insulated	42
Hard to treat (narrow cavities) cavity wall insulation	£300	£4	per m2 of wall area insulated	42
Double glazing	£100	£200	per metre square of window insulated	20
Draught proofing	£50	£10	per metre square of window/doors draught proofed	10
External wall insulation	£2,500	£65	per m2 of wall area insulated	36
Floor insulation	£500	£3	per metre square of floor insulated	42
Mains gas combination boiler	£800	£200	per peak load (kW) of dwelling	12
Ground source heat pump	£8,000	£400	per peak load (kW) of dwelling	20
Hybrid heat pump	£5,000	£300	per peak load (kW) of dwelling	15
Internal wall insulation	£1,000	£45	per m2 of wall area insulated	36
Low energy lighting (LED)	£100	£25	per number of bedrooms	10

Measure description	Fixed costs	Variable costs	Variable cost basis	Lifetime of measure (ECO)
LPG combination boiler	£1,500	£180	per peak load (kW) of dwelling	12
Oil combination boiler	£1,500	£180	per peak load (kW) of dwelling	12
Secondary glazing	£1,200	£30	per metre square of window insulated	10
Solar photovoltaics	£550	£1,700	per peak load (kW) of dwelling	25
Solar thermal heating	£4,500			25
Storage heater	£250	£450	per habitable room in each dwelling	20
Hot water tank insulation	£45			10
Loft insulation	£50	£6	per m2 of roof space insulated	42

Note: also includes the estimated lifetime of each measure based on UK Energy Company Obligation (ECO) figures.)

8.8 Measure cost variation by rurality

The costs of measures were varied depending on the location of dwellings. This was based on an external review of measure cost data by the Scottish Government, which demonstrated the variable costs associated with installing measures in different parts of the country, and notably the variation between urban and more rural areas.

The summary outputs of this review are presented in Table 11. These factors were applied to the cost functions outlined above in Table 10, to account for the relative difference in costs to install measures between urban and more rural areas.

Table 11: Measures cost variation by rural and urban areas applied in the NHM.

Rurality	Measure cost multiplier
Large urban areas	0.96
Other urban areas	0.96
Accessible small towns	0.96
Remote small towns	0.96
Accessible rural	1.08
Remote rural	1.44

8.9 Heating regimes applied to estimate modelled energy consumption

Table 12: Heating regimes applied in the fuel poverty calculation

Heating regime	Temperature		Duration	
	Zone 1	Zone 2	Weekday	Weekend
Standard	21°C	18°C	9 hours	16 hours
Heating Regime 1	23°C	20°C	16 hours	16 hours
Enhanced Heating Regime 2	23°C	20°C	9 hours	16 hours
Enhanced Heating Regime 3	21°C	18°C	16 hours	16 hours

Heating regime 1 applies where the dwelling is frequently occupied during the morning or afternoon or both on weekdays by any member of the household when it is cold and where any member of the household has one or more of: i) a physical or mental health condition or illness which has lasted or is expected to last for a minimum period of 12 months; ii) is in receipt of benefits for a care need or disability; iii) is 75 years old or over.

Enhanced heating regime 2 applies where the dwelling is not frequently occupied during the morning or afternoon or both on weekdays by any member of the household when it is cold and where any member of the household has one or more of: i) a physical or mental health condition or illness which has lasted or is expected to last for a minimum period of 12 months; ii) is in receipt of benefits for a care need or disability; iii) is 75 years old or over.

Enhanced heating regime 3 applies here dwelling is frequently occupied during the morning or afternoon or both on weekdays by any member of the household when it is cold and where any member of a household is a child aged 5 years old or under and where heating regimes 1 or 2 do not apply.