Ministry of Housing, Communities & Local Government

English Housing Survey

EPC improvements modelling review

50th Anniversary ENGLISH HOUSING SURVEY 1967 - 2017

Contents

	Introduction	3
Section 1	Overview of the original method and changes	6
Section 2	Development of the new methodology	9
Section 3	Findings	14
Section 4	Recommendations and actions	22
Appendix	Variable names – old and new	23

Introduction

1. The English Housing Survey (EHS) is a continuous national survey commissioned by the Ministry of Housing, Communities and Local Government (MHCLG). It collects information about people's housing circumstances and the condition and energy efficiency of the housing stock in England. The survey has two main components, consisting of around 13,300 face-to-face household surveys and about 6,200 physical surveys each year.

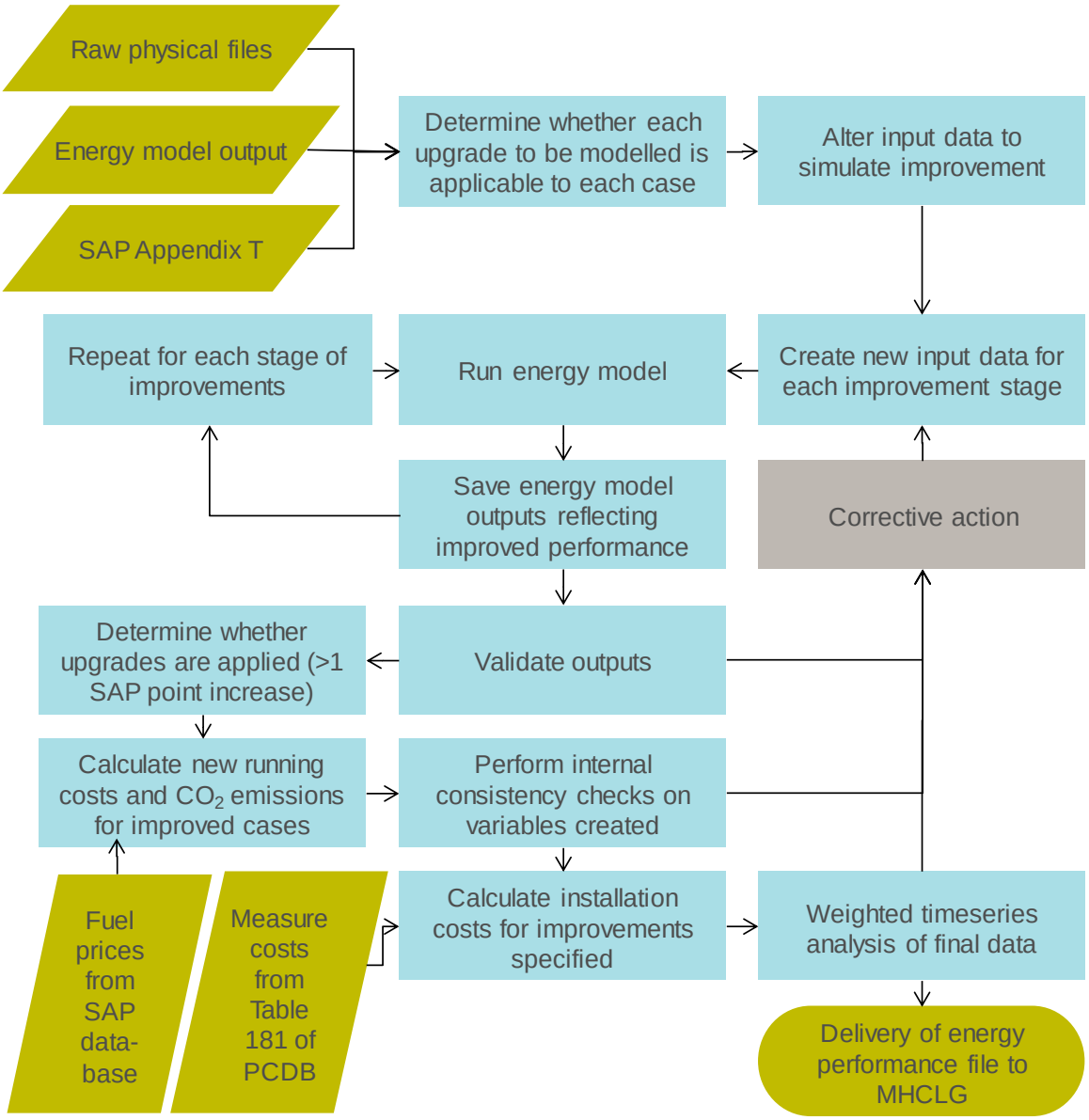
2. The physical surveys are carried out by a qualified surveyor and involve a visual inspection of the property. During the physical survey, the surveyor carries out an internal and external assessment of the property.

3. From the data collected by the interviewers and the surveyors, the EHS team produce a range of derived variables of varying complexity. Derived variables are created either by simply recoding a particular survey question or by combining the information collected from a number of questions, which can involve complex modelling. In some cases, an initial set of 'detailed' derived variables are produced at BRE, which are then summarised in the final derived variables on the three main datasets (called general, interview and physical). This is done when the modelling produces a range of derived outputs, not all of which need to be on the main datasets. All the datasets are provided to MHCLG and made available via the UK Data Archive.

4. One of the detailed derived files delivered to MHCLG each year is the Energy Performance file, which includes variables that model the current energy use, cost and associated carbon dioxide emissions for each dwelling in the sample, using the standard assumptions from the SAP model. The Standard Assessment Procedure (SAP) is the methodology used by the Government to assess and compare the energy and environmental performance of dwellings. The SAP is used to calculate the energy efficiency rating (EER), also known as the SAP rating, of dwellings. The SAP rating/EER is an index based on calculated energy costs for a standard heating regime and is expressed on a scale of 1 (highly inefficient) to 100 (highly efficient with 100 representing zero energy cost). Reduced Data SAP (RdSAP) was introduced in 2005 as a lower cost method of assessing the energy performance of existing dwellings. RdSAP is used in the calculation of the energy ratings on the Energy Performance Certificate, a document which is required when a home is put up for sale or rent.

5. The modelling for that file is one of the most complex areas undertaken for the EHS. For example, it assumes people heat their homes to a certain level and that the building materials behave in the way assumed by the SAP model. The Energy Performance modelling also calculates what the running cost and carbon dioxide emissions would be if a series of energy efficiency improvements were applied to the dwelling, i.e. what energy use and carbon dioxide emissions would be 'post-improvement'. This aspect of modelling is called the 'EPC improvement modelling' and is the focus of this report.

Figure 1: A flow diagram representing the process of the EPC improvements modelling and data checking



6. The SAP model on which the Energy Performance model is based is regularly updated, e.g. with changed assumptions and new information about the performance of building materials. To maintain the consistency of the EHS and SAP, the calculations upon which the EHS outputs are based were also updated, first to SAP 2009 and then to SAP 2012.

7. However, the EPC improvement modelling had not been updated as regularly. Following updates to the RdSAP model, BRE developed a new methodology for the EPC improvement modelling of the potential for energy efficiency improvements for EHS cases. This report presents a summary of the results of the new methodology and a comparison with the existing methodology. The

changes were implemented to the 2015 EHS and first reported on in the 2015 Potential Stock Improvements report.[1]

Acknowledgements and further queries

8. This report was produced by BRE in collaboration with MHCLG.

9. If you have any queries about this report, would like any further information or have suggestions for analyses you would like to see included in future EHS reports, please contact ehs@communities.gsi.gov.uk.

10. The responsible analyst for this report is: Reannan Rottier, Housing and Planning Analysis Division, DCLG. Contact via ehs@communities.gsi.gov.uk

[1] https://www.gov.uk/government/statistics/english-housing-survey-2015-to-2016-potential-for-stock-improvements

Section 1

Overview of the original method and changes

Original method

1.1 The original method for modelling post-improvement energy performance was created in 2009 using 2007 data from one of the predecessor surveys to the EHS, the English House Condition Survey (EHCS). It used the SAP 2005 calculation methodology. Appendix T of SAP 2005 (version 9.82)[2] listed the energy efficiency measures considered by RdSAP. The list was divided into low cost measures, which were likely to be cost effective, higher cost measures, which may or may not have been cost effective, and further measures, which were less likely to be cost effective but which would still have delivered significant energy savings.

1.2 The improvements included in the original EPC improvement modelling were selected from this list. Not all of the improvements specified in Appendix T were included in the modelling. For example, the model included cost effective measures only and excluded solar water heating, photovoltaics and solid wall insulation, as the survey did not collect the necessary data at that time. The low cost measures D (draft proofing) and E (low energy lights) were not included in the dataset due to modelling constraints at the time of development.

1.3 In May 2011, BRE and DCLG, now MHCLG, considered extending the set of improvement measures modelled and reported on, to include the 'further' measures' in Appendix T, especially solid wall insulation and solar (both photo-voltaic panels and hot water). The Department decided not to include these further measures due to the high installation costs associated with applying these measures to nearly every eligible dwelling in England. In addition, at the time the decision was made the physical survey form did not collect the necessary data to assess the practicality and effectiveness of solar water heating and photovoltaics.

[2] http://projects.bre.co.uk/sap2005/

New RdSAP methodology overview

1.4 In December 2014 the introduction of SAP 2012 and RdSAP version 9.92 included an updated Appendix T.[3] The revisions significantly altered the way that RdSAP software implemented the modelling of potential improvements as part of the Energy Performance Certificates (EPC) production process:

- Additional improvements[4] were included.
- Measures were no longer categorised as low cost, higher cost and further measures.
- The order for considering improvements was updated, with the most relevant being that measure Q (solid wall insulation) was now third priority on the list, and measures R, S and T (upgrading boilers with/without fuel switching) moved up in priority.
- For some improvement measures the criteria and/or improvement specification changed, e.g. for measure A (loft insulation) the improvement was now to increase the insulation to 270mm rather than to 250mm.
- The underlying SAP methodology was updated so that regional weather was used for calculation of all running costs and savings. The SAP and environmental impact ratings were still calculated on UK average climate data.
- The estimates of costs for installing the suggested improvements were significantly revised.

Proposal for change

1.5 When a new version of SAP is released, it is automatically brought into the EHS energy model at the earliest opportunity (i.e. the data modelling cycle following publication of the new SAP). The EHS currently uses SAP 2012 as the basis for its energy calculations. The variables produced for the main part of the Energy Performance file use the main energy model as a base and are therefore also SAP 2012 based, but the modelling of the application of improvement measures had not been updated since it was originally created. This allowed continuity in the reporting of improvements but by 2016 the original method was two SAP versions out of date.

[3] https://www.bre.co.uk/sap2012/page.jsp?id=2759

[4] Seven additional improvement measures were added to Appendix T. For the full list of improvements, please see Table 1. The additional measures added in 2012 were A2 (flat roof insulation); A3 (roof room insulation), W1 and W2 (floor insulation), T2 (flue gas heat recovery), Y (waste water heat recovery); O3 (glazing replacement) and X (insulated doors).

1.6 From 2011 the EHS also collected additional information on the suitability of solar water heating and photovoltaics, e.g. roof pitch and over shading. This was the input required for two of the further improvement measures that could not previously be modelled.

1.7 BRE updated the original modelling of EPC improvement variables and post-improvement energy efficiency performance measures to SAP version 9.92 Appendix T/Appendix S4. The work, described in this report, involved:

- Considering which of the improvements included in Appendix T could now be modelled using EHS data, including revisiting the inclusion of the 'further' set of improvement measures which were originally excluded;
- Creating variables ('flags') for the additional individual improvement measures, indicating whether a dwelling was 'eligible' for the measure, i.e. whether it fits the criteria for potentially having the improvement applied to it (for example, a dwelling with cavity walls but without cavity wall insulation would be 'eligble' for receiving the cavity wall insulation improvement in the model);
- Calculating SAP 2012 post-improvement energy efficiency performance measures, such as SAP (Energy Efficiency Ratings, EER) and Environmental Impact Ratings (EIR) variables based upon all improvement measures (using average climate data); and
- Calculating SAP 2012 post improvement energy efficiency performance costs, savings and total CO2 emissions based upon all improvement measures (using climate data for the region in which the property is situated).

Section 2
Development of the new methodology

Which SAP 2012 improvements could be modelled using the EHS data?

2.1 The first stage of this project assessed which of the improvements specified in Appendix T of SAP 2012 could be modelled using EHS data. The basic premise was that all improvements should be included if they could be modelled. This aligns the EHS outputs as closely as possible to the EPCs produced for individual dwellings.

2.2 BRE considered each measure previously included and assessed whether the way that it is considered within SAP had changed since the original EPC improvement modelling was developed. The table below summarises the results. Eleven measures were modelled under the original methodology, while 30 measures were considered in the latest SAP specification. Of the 11 that were originally modelled, five had seen some change to the assumptions in how they were modelled within RdSAP.

2.3 The analysis showed that the EHS data can be used to model the majority of the suggested improvements, set out in Appendix T. The amount of information collected about each of the elements varies but assumptions can be made that allow the modelling of the application of the improvement.

2.4 However, for the analysis of the 2014-15 data included in this report, BRE used the 2014-15 energy model which does not have the capability to model some of the improvements listed (as some of the required data was not collected and the underlying Energy Performance modelling had not been updated). Those that were not included in this analysis are greyed out in the table below. This leaves 24 measures that were considered as part of this work. The Energy Performance model and the EPC improvements modelling has since been updated as part of the 2015-16 data processing cycle, and it now models these other variables, with later work to include further improvements, as data allows. This report focusses on just the outputs of the updated modelling of the 2014-15 data, as this allows comparison between the original and the new EPC improvement modelling.

Table 1 Improvements specified in SAP 2012 Appendix T[5], whether included in the original EPC improvement modelling, and changes since SAP 2005

Item	Measure	Previously modelled in EHS	Any change to measure since previous version
A	Loft insulation	Yes	Improve to 270mm (previously 250mm)
A2	Flat roof insulation		
A3	Roof room insulation		
B	Cavity wall insulation (CWI)	Yes	
Q	Solid wall insulation (SWI)		
W1	Floor insulation (suspended floor)		
W2	Floor insulation (solid floor)		
C	Hot water cylinder insulation	Yes	
D	Draft proofing		
E	Low energy lighting		
F	Cylinder thermostat	Yes	
G	Heating controls for wet central heating system	Yes	TRVs without room thermostat can be also without programmer
H	Heating controls for warm air system	Yes	
J	Biomass boiler	Yes	
K	Biomass room heater with boiler	Yes	Water cylinder upgraded in addition to heating system
I	Upgrade boiler, same fuel	Yes	
R	Install condensing oil boiler		
S	Condensing gas boiler no fuel switch		
T	Condensing gas boiler fuel switch		
T2	Flue gas heat recovery		
L2	Replacement/New storage heaters	Yes	Change from fan assisted with automatic charge control to high heat retention type. Electric secondary heating no longer included
M	Replacement warm air unit	Yes	Split by fuel type, applies to non-condensing, mains gas units, and LPG units installed before 1998
N	Solar water heating		
Y	Waste water heat recovery		
O	Double glazing		
O3	Glazing replacement		
P	Secondary glazing		
X	Insulated doors		
U	Photovoltaics		
V2	Wind turbine		

Note: It was not possible to model greyed out measures for this report, but some of these have been modelled from the 2015-16 and the 2016-17 surveys.

[5] The SAP 2012 Appendix T also includes some 'alternative measures'. These measures are shown on an EPC if relevant but are not selected for inclusion unless an assessor specifically includes it. These measures are not included in this update to the EPC improvements modelling. The alternative measures are Q2 External insulation with cavity wall insulation, J2 Biomass boiler (alternative measure), Z1 Air or ground source heat pump, Z2 Air or ground source heat pump with underfloor heating and Z3 Micro-CHP). Measure P is considered in the same way as the "alternative" measures in the modelling because it is only considered if the assessor de-selects measure O.

Modelling of post-improvement energy efficiency

2.5 Once the list of measures to be included had been decided, the next step was to model those improvements in the stock. BRE used the 2014-15 dwelling EHS data to conduct this analysis so that the results from the new method could be compared with the original one.

2.6 Both the original and the new methodology considered each measure in the table above in order. If a dwelling was 'eligible' for a particular measure (i.e. could potentially have it installed, for example a cavity wall dwelling without cavity wall insulation is eligible for such insulation), the raw data was altered so that the modelled post-improvement dwelling had that specific energy efficiency improvement. The altered data was then substituted for the original data in the energy model and the model rerun. This was done for all combinations of improvements.

2.7 This is a significantly more complex process than just modelling all relevant improvements together. It is necessary because RdSAP states that an improvement should only be included if it leads to an increase in SAP of more than 0.95 SAP points. This means that if an improvement specified in the table above does not lead to a sufficiently large increase in SAP it must be skipped and the next improvement in the sequence modelled as if the first improvement had not been made.

2.8 Following the application of each package of improvements the energy model produced the post-improvement SAP rating, environmental impact rating, running costs and carbon dioxide figures. The outputs are selected for the correct combination of measures based on the logic above (eligible measures that produce at least 0.95 SAP points improvement) and this becomes the "post-improvement" model of the stock. This final model applies all possible measures that produce at least 0.95 SAP points improvement and does not look at the impact of individual measures.

Cost of installing the specified improvements

2.9 The Energy Performance modelling also produces the cost of installing all the specified improvements included in the final model. The original method to calculate the costs of applying the improvements was based on an annual uprating of commercial price data that is no longer available. It also did not include costs for some of the additional improvement measures now being modelled. This aspect of the methodology therefore required updating.

2.10 An alternative source of costs was those used for EPCs. These use indicative costs that have been produced and included within the Product Characteristics Database (PCDB). For the majority of measures, a low and high range of costs is provided and the mean of these has been taken for the

EHS modelling. The costs have also been calculated using the low and high prices in order to give an indication of the potential range in the overall cost of improving the stock.

2.11 The costs provided in the PCDB were felt to be the best solution available for the EHS modelling. The PCDB costs have the advantage that they are the same as those used for EPCs. This suited the overarching objective of this work which was to match the EPC method as closely as possible with the available EHS data.

2.12 The table below presents the costs used for each of the improvement measures. The costs for the original method represent the mean cost calculated for all dwellings.

Table 2 Average costs of installing measures - original and new method[6]

Item	Measure	Original method	New method
A	Loft insulation	£375	£225
A2	Flat roof insulation		£1,175
A3	Roof room insulation		£2,100
B	Cavity wall insulation (CWI)	£352	£1,000
Q	Solid wall insulation (SWI)		£9,000
W1	Floor insulation (suspended floor)		£1,000
W2	Floor insulation (solid floor)		£5,000
C	Hot water cylinder insulation	£18	£23
D	Draft proofing		£100
E	Low energy lighting		£20
F	Cylinder thermostat	£30	£300
G	Heating controls for wet central heating system	£145[7]/£151[8]	£400
H	Heating controls for warm air system	£151	£400
J	Biomass boiler	£9,691	£10,000
K	Biomass room heater with boiler	£4,445	£10,000
I	Upgrade boiler, same fuel	£1,152	£2,600
R	Install condensing oil boiler		£5,000
S	Condensing gas boiler no fuel switch		£5,000
T	Condensing gas boiler fuel switch		£5,000
T2	Flue gas heat recovery		£650
L2	Replacement/New storage heaters	£1,156	£1,564
M	Replacement warm air unit	£1,884	£1,875
N	Solar water heating		£5,000
Y	Waste water heat recovery		£655
O	Double glazing		£4,900
O3	Glazing replacement		£1,200
P	Secondary glazing		£1,250
X	Insulated doors		£500/door
U	Photovoltaics		£6,500
V2	Wind turbine		£20,000

[6] Greyed-out rows are not modelled under the new method for the 2014-15 data but will be included in the modelling of later surveys, as data becomes available.

[7] Cost for installing thermostatic radiator valves (TRVs)

[8] Cost of installing a programmer for the heating system, room thermostat and thermostatic radiator valves (TRVs)

Section 3
Findings

3.1 Once the data had been adjusted to reflect the post-improvement positions, the EPC improvements model calculated the post-improvement results and these were analysed to determine the differences between the original and the new EPC improvement methodologies.

Methodology

3.2 As a base layer, the original 2014-15 Energy Performance model, using SAP 2012, for improvements was used for this work without any adjustment so that the results would be directly comparable to the published outputs from that year. The Energy Performance model is reviewed every year to ensure that it makes best use of the EHS data. Some improvements could not be modelled using this version of the data. For example, door insulation could not be improved within the Energy Performance and EPC improvements model used for the 2014-15 data. The Energy Performance model has since been altered; partly as a result of the analysis done for this project, and the subsequent EPC improvement model includes this improvement.

Analysis of the number of dwellings that receive the improvement

3.3 The table below shows the number of dwellings that had the improvement applied under the old and new method respectively.

Table 3 Number of dwellings eligible for measures

2014-15 data (weighted – 1,000s of dwellings)	Original method	New method	Percent difference
Loft insulation (A)	4,696	4,667	-0.6
Flat roof insulation (A2)	N/A	N/A	
Roof room insulation (A3)	N/A	733	
Cavity wall insulation (CWI) (B)	4,838	4,791	-1.0
Solid wall insulation (SWI) (Q)	N/A	5,991	
Floor insulation (solid or suspended timber) (W)	N/A	N/A	
Hot water cylinder Insulation (C)	2,748	2,539	-7.6
Draft proofing (D)	N/A	1,754	
Low energy lighting (E)	N/A	15,265	
Cylinder thermostat (F)	1,132	1,132	0.0
Heating controls for wet central heating system (G)	3,734	5,593	50.7
Heating controls for warm air system (H)	N/A	33	
Biomass boiler (J)	34	10	-69.6
Biomass room heater with boiler (K)	Included in J	0	
Boiler upgrade, no fuel switch (I)	7,544	7,551	0.1
Condensing oil boiler upgrade (R)	N/A	6	
Condensing oil boiler upgrade (S)	N/A	111	
Condensing gas boiler fuel switch (T)	N/A	198	
New or replacement storage heaters (L2)	1,193	1,252	4.9
Replacement warm air (M)	109	117	7.8
Solar water heating (N)	N/A	12,046	
Double glazing (O)	N/A	2,237	
Glazing replacement (O3)	N/A	5,082	
Photovoltaics (PV) (U)	N/A	13,448	
Wind turbine (V2)	N/A	71	

3.4 Where a possible improvement was modelled using both methods, some saw greater change in the numbers receiving the improvement than others. Loft insulation, cavity wall insulation, cylinder thermostat and boiler upgrade (no fuel switch) all showed very similar numbers receiving the upgrade with the new method as with the original method.

3.5 Some other measures showed much more significant change in the number of dwellings receiving that measure. The five measures that showed the biggest change are listed in the table below.

Table 4 Measures with the biggest difference between methods

Measure	Reason for difference
Biomass boiler (69.6% drop)	The original model upgraded the main fuel to wood logs. The new version has the capability to model the fuel as wood pellets in line with the RdSAP specification. Pellets are more expensive, therefore fewer cases result in a SAP change greater than the 0.95 point threshold.
Heating controls for wet CH system (50.1% increase)	The same number of measures are considered for an upgrade, however more cases are improved beyond the SAP threshold of 0.95 points in the current update because a boiler interlock is now modelled, which acts to increase the SAP rating.
Replacement warm air system (7.8% increase)	The new model considers both bottled and bulk LPG warm air systems as eligible for the improvement. The original model only considered bulk LPG as eligible.
Cylinder insulation (7.6% drop)	The eligibility criteria were altered from the original model which added additional jacket to cylinders with less than or equal to 80mm insulation, whereas the new model only does this if the insulation is less than 80mm.
New or replacement storage heaters (4.9% increase)	The original method did not consider 'Fan storage heaters' as eligible for this improvement. These are not explicitly mentioned in Appendix T but the EPC reference software now considers them eligible for the improvement, so they have been included in this update.

Comparison of stock level post-improvement estimates

Methodology

3.6 To assess the impact of the changes to the modelling the key statistics at the stock level were calculated for both the original and new models. These are presented in table 5 below. All averages are medians unless otherwise stated because of the skewed nature of the distribution of several of the variables. The rating bands are given as mode, to give information on the most common band.

3.7 The number of measures included in the modelling has risen from 11 to 24, which means that the combined improvements and the associated cost of improvements is much higher on average and in aggregate. This is to be expected and may give a more realistic picture of the potential for improvements contained within the housing stock.

Findings: SAP ratings

3.8 The average pre-improvement SAP rating of the English housing stock in 2014-15 was 61. The original model showed that with the measures under consideration in that model the SAP rating could be increased to an average of 67 at an average cost per dwelling receiving at least one improvements of £1,123. The new model, with the inclusion of the additional measures, showed a much larger potential energy efficiency improvement with the average SAP being increased to 79. The average cost of achieving this rose considerably to £11,750 (per dwelling receiving at least one improvement).

Table 5 Summary outputs from the original and new models

Output	Original post-improvement model	New post-improvement model
Final SAP/EER rating after EPC improvements [EHS SAP2012] (median)	67	79
Final SAP/EER rating band after EPC improvements [EHS SAP2012] (mode)	D	C
Final EIR after EPC improvements [EHS SAP2012] (median)	66	76
Final EIR band after EPC improvements [EHS SAP2012] (mode)	D	C
EPC Water Heating Cost (£/yr) after EPC improvements [EHS SAP2012] (median)	94	75
EPC Space Heating Cost (£/yr) after EPC improvements [EHS SAP2012] (median)	556	499
EPC Total energy Cost (£/yr) after EPC improvements [EHS SAP2012][9] (median)	729	460
Energy upgrade cost - all upgrades (£) (EHS SAP 2012)[10] (median)	1,123	11,750
Cost of all upgrades across whole stock (£) (sum)	14,772,348,000	254,066,997,000

3.9 The updated improvement modelling process alters the distribution of SAP ratings considerably. The three figures below show the percentage of dwellings in each SAP band for each of the tenures for the current pre-improvement position as published in the 2014-15 headline report, the post-improvement position using the original methodology and the post-improvement position using the new methodology. The graphs show that the number of dwellings in bands F and G is reduced to virtually zero with the new methodology.

[9] Renewables are a negative cost and this value is therefore net cost.

[10] Cost of upgrades for those dwellings with at least one upgrade.

Figure 2 Pre-improvement energy efficiency rating bands, by tenure, 2014 headline report

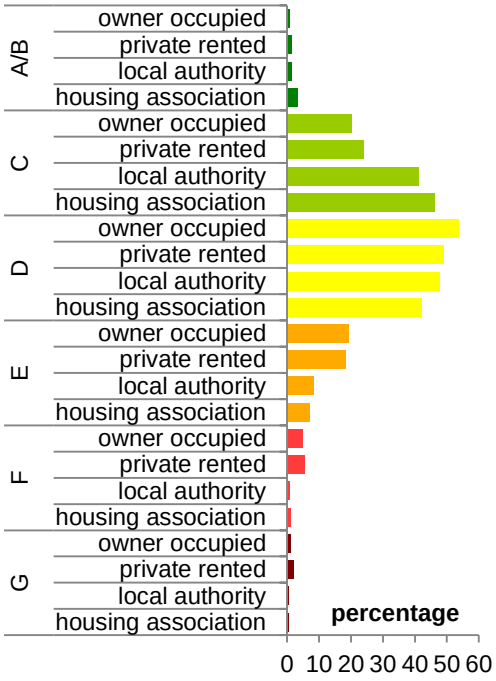


Figure 3 Post-improvement, efficiency Energy rating bands, by tenure, original method

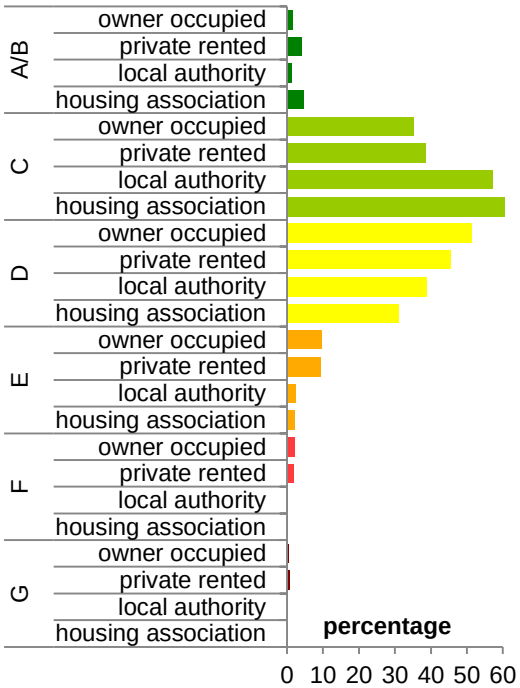
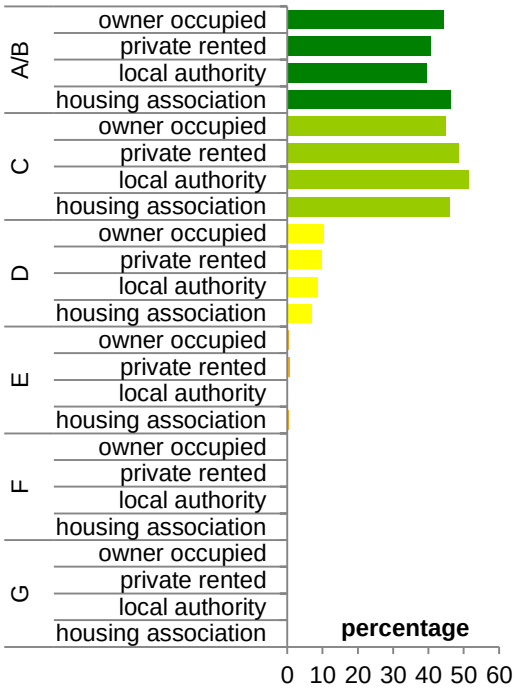


Figure 4 Post-improvement, energy efficiency rating bands, by tenure, new method



Methodology: running costs and regional temperatures

3.10 To calculate running costs post improvement BRE used the fuel prices built into the SAP methodology. These differ from the prices used to calculate the annual running costs for an EPC. The EPC uses prices that are updated every six months so as to provide estimates that are more realistic to the occupant. BRE kept the SAP prices for this report to enable a more like-for-like comparison of post-improvement costs. BRE proposed that for modelling going forward, the prices would be updated for each cycle to those used to produce EPCs in July of that year. This has since been implemented.

3.11 As with fuel prices, the external temperatures used to produce the running costs quoted on an EPC differ from those used to produce the SAP rating in the EHS. RdSAP 2012 uses regional temperatures based on a location in the centre of the UK to enable comparability. For running costs on an EPC the calculation is effectively repeated but with external temperatures for the region in which the dwelling is located. BRE proposed to follow the EPC methodology for the production of the post-improvement running costs for the new suite of energy performance variables going forward, but for this report, they retained the standard RdSAP2012 external temperatures to facilitate comparison with the original methodology. The use of the EPC methodology has since been implemented.

Findings: cumulative cost of each measure

3.12 Table 6 and 7 provides details of the cumulative cost of each measure. This highlights the measures that were driving the increase in costs seen in table 5.

3.13 Table 6 provides the unit cost of each of the measures and table 7 the cumulative cost once the measure has been applied to all eligible dwellings. The number of dwellings receiving each measure is given in table 3. There are three levels of cumulative cost for the new method. This used the low, average and high cost estimates included in the Product Characteristics Database (PCDB). The unit cost provided for the new method is the average of the PCDB costs.

3.14 The inclusion of additional measures in the new method increased the post-improvement performance by 12 SAP points. This represents a reduction in average (median) post-improvement running costs (based on standard SAP prices) from £815 pre-improvement to £460 post-improvement. In the original method the median post-improvement running cost was £729.

3.15 Commensurate with this was a considerable rise in the overall cost of installing the measures. The aggregate cost of measures rose from around £15bn for the original method to around £254bn for the new method. Although the new aggregate cost is much higher than that modelled by the original

method, BRE believe that the new methodology provides a more comprehensive picture of the energy efficiency potential of the English housing stock. The average (median) cost of making the improvements included in the model is £11,750 per dwelling, which is considered a reasonable overall cost for a package of improvements.

Table 6 Unit costs, in pounds

Item	Measure	Original unit cost	New unit cost
A	Loft insulation	375	225
A3	Roof room insulation		2,100
B	Cavity wall insulation (CWI)	352	1,000
Q	Solid wall insulation (SWIP		9,000
C	Hot water cylinder insulation	18	23
D	Draft proofing		100
E	Low energy lighting		20
F	Cylinder thermostat	30	300
G	Heating controls for wet central heating system	151	400
H	Heating controls for warm air system	151	400
J	Biomass boiler	9,691	10,000
K	Biomass room heater with boiler	Included in J	
I	Upgrade boiler, same fuel	1,152	2,600
R	Install condensing oil boiler		5,000
S	Condensing gas boiler no fuel switch		5,000
T	Condensing gas boiler fuel switch		5,000
L2	Replacement/new storage heaters	1,156	1,564
M	Replacement warm air unit	1,884	1,875
N	Solar water heating		5,000
O	Double glazing		4,900
O3	Glazing replacement		1,200
U	Photovoltaics		6,500
V2	Wind turbine		20,000

Table 7 Cumulative cost of each measure, in thousands of pounds

Item	Measure	Original method cumulative cost	New method, low estimate, cumulative cost	New method, mean estimate, cumulative cost	New method, high estimate, cumulative cost
A	Loft insulation	1,761,638	466,729	1,050,141	1,633,552
A3	Roof room insulation		1,100,075	1,540,104	1,980,134
B	Cavity wall insulation (CWI)	1,700,508	2,395,467	4,790,934	7,186,401
Q	Solid wall insulation (SWIP		23,965,599	53,922,599	83,879,598
C	Hot water cylinder insulation	44,732	38,081	57,122	76,163
D	Draft proofing		140,298	175,373	210,448
E	Low energy lighting		309,590	309,590	309,590
F	Cylinder thermostat	27,268	226,431	339,646	452,861
G	Heating controls for wet central heating system	557,255	1,957,701	2,237,373	2,517,045
H	Heating controls for warm air system	7,268	11,455	13,091	14,728
J	Biomass boiler	192,162	72,380	103,400	134,421
K	Biomass room heater with boiler	Included in J			
I	Upgrade boiler, same fuel	9,145,813	16,612,773	19,633,277	22,653,781
R	Install condensing oil boiler		19,399	32,331	45,264
S	Condensing gas boiler no fuel switch		334,133	556,889	779,644
T	Condensing gas boiler fuel switch		593,771	989,618	1,385,466
L2	Replacement/new storage heaters	1,378,732	1,566,234	1,957,792	2,349,351
M	Replacement warm air unit	205,123	146,710	220,065	293,420
N	Solar water heating		48,185,405	60,231,756	72,278,107
O	Double glazing		7,383,598	10,963,524	14,543,450
O3	Glazing replacement		5,082,252	6,098,702	7,115,152
U	Photovoltaics		67,241,699	87,414,208	107,586,718
V2	Wind turbine		1,072,097	1,429,462	1,786,828

Section 4
Recommendations and actions

4.1 BRE recommended the adaptation of the new methodology for modelling potential improvements to the stock. The previous method was devised some time ago for a specific purpose and had not been revisited since. The landscape of energy efficiency improvements is rather different now. In particular, photo-voltaic panels have become much more prevalent, as have solid wall insulation.

4.2 The new method is aligned to the current methodology used in the production of EPCs. The list and order of measures to be considered is substantially different from earlier versions of SAP. The effect of the improvements on the dwelling has also been reviewed and updated. The new method uses more relevant costs and describes the post-improvement position in a way that is more transparently linked to the EPC method. These improvements should all contribute to a suite of variables that is of increased value to users within MHCLG and BEIS and beyond.

4.3 MHCLG accepted the recommendations to implement the new methodology. The new EPC improvement modelling has been used for reporting from the 2015 EHS, for example in the 2015 Potential Stock Improvements report.[11] The underlying data was made available through the UK Data Archive, as part of the 2015 Housing Stock Special Licence datasets.

[11] https://www.gov.uk/government/statistics/english-housing-survey-2015-to-2016-potential-for-stock-improvements, especially Annex Table 2.14.

Appendix
Variable names – old and new

The first table below shows the variables contained on the previous Energy Performance file, along with their descriptions. The second table lists the proposed new variables with suggested variable names.

Table 8 Original variable list for Energy Performance file

Variable	Label
aacode/serialanon	Key field
EPcco212e	Notional total CO2 current emissions (tonnes/yr) (EHS SAP 2012)
EPcltc12e	Notional lighting current cost (£/yr) (EHS SAP 2012)
EPcwhc12e	Notional water heating current cost (£/yr) (EHS SAP 2012)
EPcshc12e	Notional space heating current cost (£/yr) (EHS SAP 2012)
EPcrnc12e	Notional renewable electricity current cost (negative) (£/yr) (EHS SAP 2012)
EPcalc12e	Notional total energy current cost (£/yr) (EHS SAP 2012)
EPcuse12e	Notional primary energy use (kWh/m2 per year) (EHS SAP 2012)
EPulin12e	Energy upgrade (low cost measure): loft insulation (EHS SAP 2012)
EPucwi12e	Energy upgrade (low cost measure): cavity wall insulation (EHS SAP 2012)
EPucyi12e	Energy upgrade (low cost measure): cylinder insulation (EHS SAP 2012)
EPucyt12e	Energy upgrade (higher cost measure): cylinder thermostat (EHS SAP 2012)
EPuctr12e	Energy upgrade (higher cost measure): heating controls (EHS SAP 2012)
EPublr12e	Energy upgrade (higher cost measure): boiler (EHS SAP 2012)
EPubms12e	Energy upgrade (higher cost measure): biomass system (EHS SAP 2012)
EPustr12e	Energy upgrade (higher cost measure): storage radiators (EHS SAP 2012)
EPuwas12e	Energy upgrade (higher cost measure): warm air system (EHS SAP 2012)
EPpsap12e	Post-improvement Energy efficiency rating (EHS SAP 2012)
EPpeeb12e	Post-improvement Energy efficiency rating band (EHS SAP 2012)
EPpeir12e	Post-improvement Environmental impact rating (EHS SAP 2012)
EPpeib12e	Post-improvement Environmental impact rating band (EHS SAP 2012)
EPpco212e	Post-improvement notional total CO2 current emissions (tonnes/yr) (EHS SAP 2012)
EPpwhc12e	Post-improvement notional water heating current cost (£/yr) (EHS SAP 2012)
EPpshc12e	Post-improvement notional space heating current cost (£/yr) (EHS SAP 2012)
EPpalc12e	Post-improvement notional total energy current cost (£/yr) (EHS SAP 2012)
EPucos12e	Energy upgrade cost - all upgrades (£) (EHS SAP 2012)

Table 9 Proposed new variables names and labels for Energy Performance file

Variable	Label
aacode	Key field
EPCshcst12	EPC Space Heating Cost (£/yr) [EHS SAP2012]
EPCwhcst12	EPC Water Heating Cost (£/yr) [EHS SAP2012]
EPCltcst12	EPC Lighting Cost (£/yr) [EHS SAP2012]
EPCrncst12	EPC Renewables Cost (negative) (£/yr) [EHS SAP2012]
EPCenuse12	EPC primary energy use [EHS SAP2012]
EPCco212	EPC CO2 emissions [EHS SAP2012]
EPCimpshcst12	EPC Space Heating Cost (£/yr) after EPC improvements [EHS SAP2012]
EPCimpwhcst12	EPC Water Heating Cost (£/yr) after EPC improvements [EHS SAP2012]
EPCimpltcst12	EPC Lighting Cost (£/yr) after EPC improvements [EHS SAP2012]
EPCimprncst12	EPC Renewables Cost (negative) (£/yr) after EPC improvements [EHS SAP2012]
EPCimptotencst12	EPC Total energy Cost (£/yr) after EPC improvements [EHS SAP2012]
EPCimpsap12	Final SAP (Energy Efficiency Rating, EER) rating after EPC improvements [EHS SAP2012]
EPCimpEEB12	Final SAP (Energy Efficiency Rating, EER) rating band after EPC improvements [EHS SAP2012]
EPCimpco212	Final CO2 emissions (tonnes/yr) after EPC improvements [EHS SAP2012]
EPCimpEIR12	Final Environmental Impact Rating (EIR) after EPC improvements [EHS SAP2012]
EPCimpEIRB12	Final Environmental Impact Rating (EIR) band after EPC improvements [EHS SAP2012]
EPCcost12	Energy upgrade cost - all upgrades (£) (EHS SAP 2012)
EPCmeasureA	Dwelling eligible for loft insulation measure (A) [EHS SAP2012]
EPCmeasureA3	Dwelling eligible for flat roof insulation measure (A3) [EHS SAP2012]
EPCmeasureB	Dwelling eligible for cavity wall insulation (CWI) measure (B) [EHS SAP2012]
EPCmeasureQ	Dwelling eligible for solid wall insulation (SWI) measure (Q) [EHS SAP2012]
EPCmeasureW	Dwelling eligible for floor insulation (solid and suspended floors) measure (W) [EHS SAP2012]
EPCmeasureC	Dwelling eligible for cylinder insulation measure (C) [EHS SAP2012]
EPCmeasureD	Dwelling eligible for draft proofing measure (D) [EHS SAP2012]
EPCmeasureE	Dwelling eligible for low energy lighting (LEL) measure (E) [EHS SAP2012]
EPCmeasureF	Dwelling eligible for cylinder thermostat measure (F) [EHS SAP2012]
EPCmeasureG	Dwelling eligible for heating controls for wet central heating system measure (G) [EHS SAP2012]
EPCmeasureH	Dwelling eligible for heating controls for warm air system measure (H) [EHS SAP2012]
EPCmeasureJ	Dwelling eligible for biomass boiler measure (J) [EHS SAP2012]
EPCmeasureK	Dwelling eligible for biomass room heater with boiler measure (K) [EHS SAP2012]
EPCmeasureI	Dwelling eligible for boiler upgrade no fuel switch measure (I) [EHS SAP2012]
EPCmeasureR	Dwelling eligible for condensing oil boiler upgrade measure (R) [EHS SAP2012]
EPCmeasureS	Dwelling eligible for condensing oil boiler upgrade measure (S) [EHS SAP2012]
EPCmeasureT	Dwelling eligible for condensing gas boiler fuel switch measure (T) [EHS SAP2012]
EPCmeasureL2	Dwelling eligible for new or replacement storage heaters measure (L2) [EHS SAP2012]
EPCmeasureM	Dwelling eligible for replacement warm air measure (M) [EHS SAP2012]

Variable	Label
EPCmeasureN	Dwelling eligible for solar water heating measure (N) [EHS SAP2012]
EPCmeasureO	Dwelling eligible for double glazing measure (O) [EHS SAP2012]
EPCmeasureO3	Dwelling eligible for glazing replacement measure (O3) [EHS SAP2012]
EPCmeasureU	Dwelling eligible for photovoltaics (PV) measure (U) [EHS SAP2012]
EPCmeasureV2	Dwelling eligible for wind turbine measure (V2) [EHS SAP2012]

This document/publication is also available on our website at www.gov.uk/mhclg

If you have any enquiries regarding this document/publication, complete the form at http://forms.communities.gov.uk/ or write to us at:

Ministry of Housing, Communities and Local Government
Fry Building
2 Marsham Street
London
SW1P 4DF
Telephone: 030 3444 0000
Email: ehs@communities.gsi.gov.uk

For all our latest news and updates follow us on Twitter: https://twitter.com/mhclg

July 2018

ISBN: 978-1-4098-5288-9