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BRE Client Report

Analysis to support ECO4 scoring system

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Date: 26 Aug 2021

Report Number: P120859-1001 Issue: 1

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Executive Summary

This report describes analysis undertaken by BRE to support Ofgem in developing proposals for the ECO4 scoring system, prior to consultation with stakeholders.

The work consisted of developing a matrix of running cost savings for moving to and from each EPC band, calculating tables of average savings for 10 individual energy efficiency measures and running examples to show what correction for measure interaction is required to bring the sum of individual measure scores into line (on average) with modelled packages of measures.

The report provides all the tables and equations needed to implement the proposed approach in a scoring tool, albeit for a limited number of improvement measures. If the method is adopted following consultation, data for the full list of measures will need to be calculated.

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1 Introduction

The fourth iteration of the Energy Company Obligation (ECO4) is expected to use a different scoring system from previous schemes, to attribute credit for energy efficiency improvement measures installed against Obligated Suppliers' targets. BEIS and Ofgem have proposed that the score for a package of measures is based on the improvement in the EPC rating of the dwelling as a result of a package installed, with the resulting score expressed as a reduction in the annual fuel costs.

The running cost savings associated with individual measures within a package ('partial project scores') will still be needed to facilitate the timely release of payments to installers, prior to the full package of measures having been completed. It is also intended that individual measure scores are used to deem the EPC rating of the dwelling after the package of measures is installed, with a correction factor applied to allow for measure interactions, rather than requiring an 'after' EPC rating to be created.

For the purposes of scoring, dwellings are to be assigned to a size band based on total floor area (TFA), such that homes in larger bands (where more energy can potentially be saved) are attributed greater credit than those in smaller bands. Four bands have been proposed: TFA<73m², 73m²≤TFA<98m², 98m²≤TFA<200m², 200m²≤TFA.

The overall scoring approach and the choice of dwelling size bands has been chosen by Ofgem and BEIS, based on preliminary analysis led by BEIS. We understand the banding system described above has been chosen to encourage the targeting of the least efficient homes and to keep the system simple, while still providing a benefit for treating larger homes.

On the basis of the overall approaches outlined above, BRE have undertaken further analysis and SAP modelling on behalf of Ofgem to develop the full and partial project scoring system into a more detailed proposal to support a public consultation. This note describes the work undertaken by BRE and the resultant proposed scoring methods.

2 Description of analysis undertaken

2.1 Full project scores

A dwelling's EPC rating is produced using the SAP methodology by calculating the energy requirements of the building, multiplying these by the relevant fuel prices to estimate its annual running costs, normalising by floor area and then converting this to a rating between 1 and 100. This is then assigned an A to G band according to Figure 1 below, taken from the SAP specification[1]:

Table 14: Rating bands

The rating is assigned to a rating band a
and the Environmental Impact rating.

Rating	Band
1 to 20	G
21 to 38	F
39 to 54	E
55 to 68	D
69 to 80	C
81 to 91	B
92 or more	A

Figure 1: Table 14 rating bands

For ECO4 purposes, BEIS/Ofgem have proposed further breaking down of the bands into low and high sub-bands, using the lower and upper half of each standard band, resulting in the following sub-bands:

Band	From	Up to	Mid-point
High_A	96	100+	98
Low_A	92	96	94
High_B	86	91	88.5
Low_B	81	86	83.5
High_C	74.5	80	77.25
Low_C	69	74.5	71.75
High_D	61.5	68	64.75
Low_D	55	61.5	58.25
High_E	46.5	54	50.25
Low_E	39	46.5	42.75
High_F	29.5	38	33.75
Low_F	21	29.5	25.25
High_G	10.5	20	15.25

[1] https://www.bregroup.com/sap/standard-assessment-procedure-sap-2012/

Low_G	1	10.5	5.75

EPC ratings cannot be less than 1 (if so, they are reset to 1)[2], but they can exceed 100 in rare cases.

Because a cost-based metric is used to generate the EPC rating, if the floor area is known it is possible to back-calculate the approximate[3] running costs used to calculate the EPC rating. The proposed approach for scoring whole projects is therefore to use the EPC sub-band before and after the improvement measure, along with the average floor area[4] for the applicable dwelling size band, to determine the reduction in annual running costs. This has been illustrated within the example outlined below.

A. Input data

Actual total floor area (TFA) of dwelling = 90m²

EPC score (band) before improvement package = 25 (F)

EPC score (band) after improvement package = 65 (D)

B. Assign to ECO4 size band and EPC sub-bands

In this example the floor area falls into the 73m²≤TFA<98m² band.

The 'before' EPC rating falls into the 'Low_F' band.

The 'after' EPC rating falls into the 'High_D' band.

C. Assign average floor area and SAP rating for ECO4 bands

The average total floor area for a home in this floor area band is 83.5m². Average floor areas for other bands are shown in Table 1 in Appendix A – this data was provided by BEIS.

Assuming SAP ratings are approximately randomly distributed through the bands, for scoring purposes the mid-point can be assigned to homes falling within each band. In the case of the Low_F band the mid-point is 25.25. In the case of the High_D band it is 64.75. The improvement in SAP points is therefore 64.75 - 25.25 = **39.5 SAP points.**

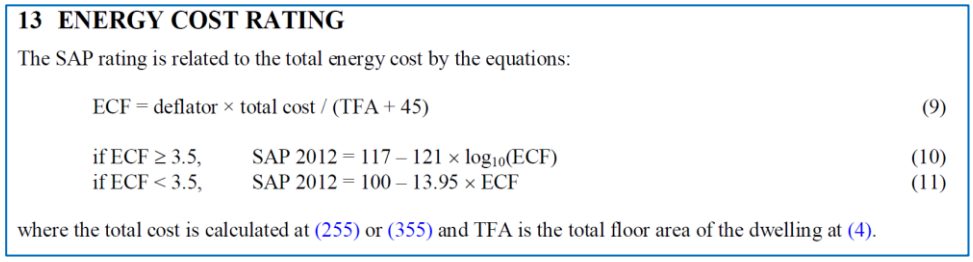
D. Calculating the annual running cost saving

The SAP specification defines the procedure for calculating the SAP rating from the annual running costs using the following formulae (extract from SAP 2012):

[2] The creates the possibility for clustering at the value of 1, making the lowest band potentially unevenly populated.

[3] Since the rating is rounded to a whole number and set to a minimum of 1, it isn't possible to get back to exact running cost.

[4] Using the average floor area (rather than actual) reduces the possibility of incorrect floor areas being entered.



13 ENERGY COST RATING

The SAP rating is related to the total energy cost by the equations:

$$ECF = \text{deflator} \times \text{total cost} / (TFA + 45) \quad (9)$$

$$\text{if } ECF \geq 3.5, \quad SAP\ 2012 = 117 - 121 \times \log_{10}(ECF) \quad (10)$$

$$\text{if } ECF < 3.5, \quad SAP\ 2012 = 100 - 13.95 \times ECF \quad (11)$$

where the total cost is calculated at (255) or (355) and TFA is the total floor area of the dwelling at (4).

Figure 2: Energy cost rating

In SAP 2012, the 'deflator' term (used to make ratings approximately comparable with those calculated using earlier SAP versions) is 0.42.

Rearranging to make running costs the subject of the equations, the following formulae can be used to calculate the annual running costs from a SAP rating:

If SAP rating <51.175, *Annual running cost = (10^(117 - SAP rating) / 121) / 0.42*(TFA+45)*

Otherwise, *Annual running cost = ((100 - SAP rating) / 13.95) / 0.42*(TFA+45)*

Applying these to the before and after mid-band SAP ratings (25.25 and 64.75) gives running costs of £1,754/yr and £773/yr, respectively. The annual saving attributed to this package of measure is therefore 1754 – 773 = **£980/yr.**

The proposed scoring method therefore consists of the steps and equations described above. In practice, the first 2 steps (assigning to bands) can be done by the user of the scoring tool selecting the appropriate band from a drop-down menu, rather than entering the actual floor area and SAP rating. This should reduce the chance and impact of data entry errors.

Tables illustrating the savings for all combinations of floor area band and EPC rating sub-band are shown in Appendix B. These could potentially be used as look up tables by the scoring tool, or it could implement the formulae above directly without using lookup tables.

2.2 Partial project scores

It is possible to attribute scores to individual measures ('partial project scores', or PPS) via a similar scoring system to that used for ECO3, by using tables of pre-calculated rating and running cost improvements for each measure type for all floor area bands and each starting EPC sub-band. Such tables of savings have been generated for 10 common improvement measures to show how the system could work. If the system is adopted for ECO4 all applicable measures will have to be added to the tables later.

The data in these tables for each measure was derived as follows:

i) An archetype dwelling chosen from Table 1 (see Appendix A) was modelled with a wide range of fabric efficiency standards, designed to cover the full range found in the housing stock of Great Britain (GB), described in Table 2 (Appendix A), with and without the improvement measure applied, allowing the running cost savings and SAP points savings to be calculated.

ii) This gave multiple savings for each measure starting from a wide range of EPC sub-bands. The savings were averaged for all cases starting in a particular sub band, to give a single figure for the band. For example, if there were 3 cases where cavity wall insulation was added, all starting in band low_D, the average of the 3 savings were taken to represent the saving of this measure for homes starting in band low_D.

iii) Steps i) and ii) were repeated for each of common heating system type shown in Table 3 Appendix A).

iv) An average was taken of the savings for homes in that EPC sub_band, *weighted by the heating system mix of homes in that band according to national survey data* – see Table 4 (Appendix A). This is important because the heating system makes an enormous difference to the savings for fabric improvement measures and the mix is very different in homes in high EPC bands compared to low ones. Homes in the lowest EPC bands are much more likely to use expensive heating fuels.

v) The above steps were repeated for each of the dwelling archetypes representing the four size bands in Table 1.

vi) The resulting savings for each measure were plotted as a function of the starting SAP rating and a line of best fit (a second order polynomial) was applied to them (see Figure 3 below). This was necessary because of the discontinuities in our modelled results caused by using a fixed set of fabric and heating system efficiencies to represent the continuum found in the real stock, along with a stepped change in heating fuel mix for each EPC band. Due to the high sensitivity to the heating system/fuel mix changing from one band to the next, this caused steps in the modelled results which would not be found if we had modelled the results for every GB home individually.

vii) The equations of the curves giving a smooth fit through the data were then used to recalculate the savings for each measure in each EPC starting band. This approach also allowed extrapolation to the few points at the extremities of the A-G scale not covered by the modelled data[5].

[5] It is virtually impossible for a home to receive an EPC rating of A if it has a heating system that has a high cost of heat, like direct electric heating; or a G-rating where a heating system has a low cost of heat, like a gas boiler.

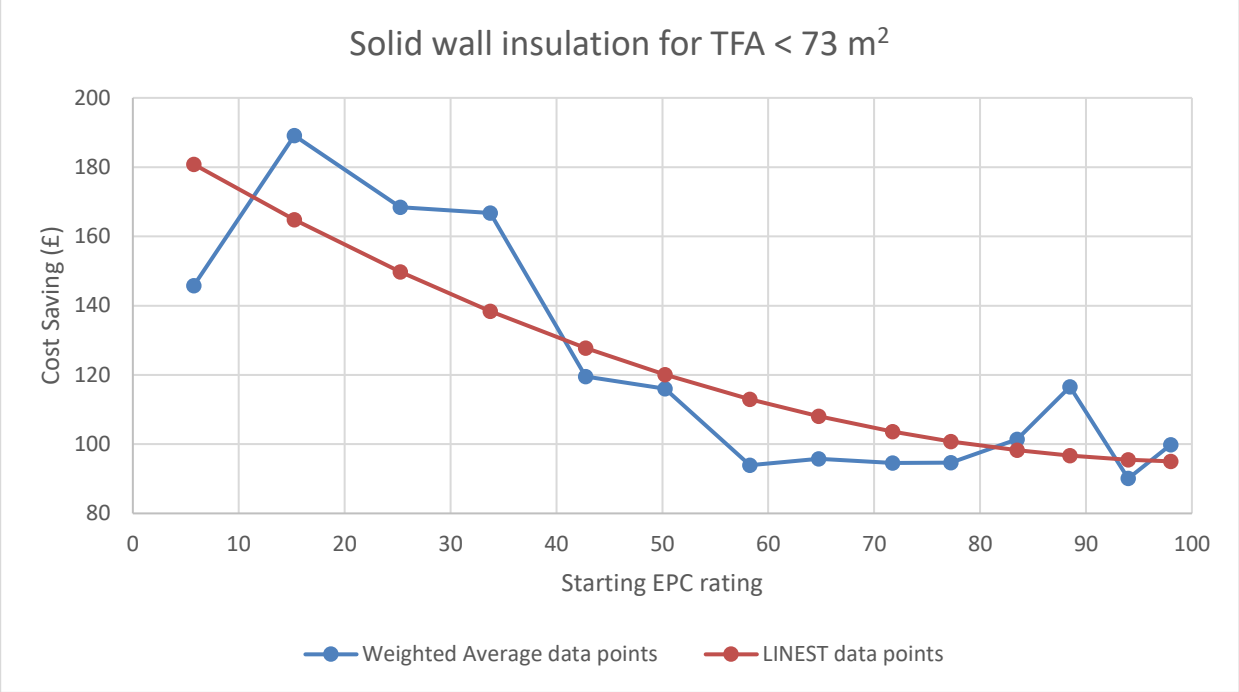


Figure 3: Comparison between the weighted average results of modelling and smoothed values generated from Excel's curve fitting function LINEST

The results derived from this process for cost and SAP point savings were organised into tables for each dwelling size band, which are shown in Appendix B. To make use of these, the tool user would only need to enter the measure type, the starting sub-band and the floor area band for the dwelling being assessed (presumably all from dropdowns); the tool would then look up the energy saving from the appropriate table. The saving for the individual measure could then have a reduction factor applied (see section 2.3) and be subtracted from the costs for the unimproved dwelling to give the costs for the dwelling with the improvement applied. The post-improvement SAP rating and EPC sub-band could then be calculated from the running costs using the standard SAP formulae described as part of the full project scoring method, if required. The following example illustrates this process.

Example partial project scores

Solid wall insulation is applied to a dwelling of floor area 90m² with a starting SAP rating of 25.

The example dwelling is in the 73m²≤TFA<98m² size band and the Low_F EPC sub-band, for which an average floor area of 83.5m² and a SAP rating of 25.25 are assumed. Using the reverse SAP equation described earlier for full project scoring, the running costs for a home of this SAP rating and floor area are calculated as £1,754/yr.

The precalculated running cost saving for the Low_F starting band for the cavity wall measure is taken from the PPS table given in Appendix B, giving a saving of £255/yr. This is multiplied by the reduction factor (see section 2,3) which, for this example, is assumed to be 0.93, giving a net saving of £237/yr. Subtracting this from the running costs for the unimproved dwelling gives a post-improvement running cost of **£1,516/yr**. Using the standard SAP equations, this is converted back to a SAP rating of 32.90, which still leaves it in the Low_F sub-band, but gives a SAP point saving of 7.65.

2.3 Reduction factor for interaction between measures

A reduction factor is needed when multiple measures are installed to avoid the possibility of more credit being given for the installation of an individual measure than it would be due when part of a package of measures. This arises because of the interaction between measures not being considered when scoring measures individually. For example, when a heating upgrade and an insulation upgrade are installed together the sum of their individually calculated savings is less than their combined saving because installing insulation reduces the heating demand. Therefore, the saving achieved by the heating system falls; or alternatively, the saving for installing insulation is reduced when the heating system is already more efficient. In practice, the reduction caused by this interaction will vary with the measures being combined, however for simplicity, the use of a single global reduction factor has been proposed.

A set of individual examples was run to get a feel for the scale of this factor for a range of scenarios – see Appendix C. A correction factor ranging from 0.76 to 1.08 was found from the initial examples run. (Factors of >1 can occur where only fabric improvements are applied.)

To get a fuller understanding, a second more detailed analysis was done whereby all practical combinations of the 10 measures for which individual savings had been derived were modelled as packages, to allow the package saving to be compared to the sum of the individual savings. This amounted to over 600 combinations in total. The following table summarises the results of this exercise in the form of a table of statistics, the key ones being the median and mean (average) which both round to 0.93. This value may therefore be a good choice for an overall reduction factor to apply to individual savings when used to estimate package savings.

Count	616
Average	**0.932**
Min	0.749
10th percentile	0.810
25th percentile	0.861
50th percentile	**0.928**
75th percentile	1.014
90th percentile	1.053
Max	1.122

2.4 Scoring innovative measures

The scoring approach for innovative measures can be treated in a similar way to PPS, following the process described above to score an individual measure. Innovative measures could be added to the lookup tables. Decisions about applying any reduction factors (for example, relating to the quality of evidence for the saving) will be required.

The key difference of note is that innovative measures are usually not modellable in SAP, so in most cases the first (and major) task needed to score them would be the provision of an evidence-based calculation methodology to generate running cost savings for a dwelling in each size band and each EPC sub-band.

3 Conclusion and recommendations

Full project scores can be calculated by the method described in this report using formulae or lookup tables to determine the running cost savings in moving a dwelling from one EPC sub-band to another.

Partial project scores can be determined using lookup tables of precalculated average scores for individual measures, for dwellings in each starting EPC sub-band and floor area band. If these are to be used to calculate the finishing band for determining the full project score, a factor can be applied which will on average correct for the interactions between measures which are not considered when savings are determined for individual measures, then directly summed.

Subject to the findings from the consultation on the approaches provided, a full set of partial project scores for all allowable measures may subsequently be needed for the ECO4 scoring tool.

Appendix A Tables of modelling inputs

Dwelling Archetype	Band	Average Area (m2)
Small 2 ext. Wall Flat	TFA < 73	63.2
Medium Semi-detached 3	73 ≤ TFA < 98	83.5
Medium Semi-detached 4	98 ≤ TFA < 200	120.6
Large Detached	200 ≤ TFA	252.9

***Table 1**: Dwelling types and areas*

Roof U-value	Wall U-value	Window U-value	Floor U-value	PV fraction of main roof
0.10	0.10	0.75	0.10	0.30
0.13	0.20	1.50	0.25	0.28
0.30	0.50	1.60	0.50	0.20
0.59	0.71	2.09	0.57	0.18
0.87	0.93	2.57	0.64	0.13
1.16	1.14	3.06	0.71	0.10
1.44	1.36	3.54	0.79	0.05
1.73	1.57	4.03	0.86	0.03
2.01	1.79	4.51	0.93	0.00
2.30	2.00	5.00	1.00	0.00

***Table 2**: Range of fabric and PV inputs*

Heating System	Efficiency (%)
Electric storage heater	100
LPG boiler non-condensing	75
Electric room heaters	100
Gas boiler 75	75
Gas boiler 88	88
Oil boiler condensing	90
LPG boiler condensing	88
Oil boiler non-condensing2	80
Gas fire with back boiler	50
High heat retention storage heater	100

***Table 3**: Heating systems modelled with the various fabric upgrade measures*

Proportion of heating systems by EPC band							
	EPC band						
Main heating system system	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Mains gas condensing boiler	77.4%	77.4%	82.0%	66.2%	29.2%	2.3%	0.0%
Mains gas non-condensing boiler	0.0%	0.0%	6.4%	18.1%	30.5%	2.7%	0.0%
Gas fire with back boiler	0.0%	0.0%	0.0%	1.0%	2.0%	5.0%	1.0%
Oil condensing boiler	0.6%	0.6%	0.4%	1.4%	5.1%	7.1%	1.1%
Oil non-condensing boiler	0.0%	0.0%	0.0%	1.0%	6.9%	15.7%	5.5%
LPG condensing boiler	0.0%	0.0%	1.0%	5.0%	7.0%	8.0%	8.9%
LPG non-condensing boiler	0.0%	0.0%	0.0%	1.0%	2.0%	9.0%	8.4%
Electric storage heaters	0.0%	2.7%	3.2%	2.2%	8.6%	18.0%	11.1%
Direct electric heaters	0.0%	0.0%	1.0%	1.0%	3.2%	20.1%	42.5%
HHR electric storage heaters	10.7%	8.0%	2.0%	1.0%	0.0%	0.0%	0.0%
Other	11.3%	11.3%	4.0%	2.1%	5.5%	12.1%	21.5%
TOTAL	100%	100%	100%	100%	100%	100%	100%

***Table 4**: Mix of heating systems for homes in each starting EPC band, based on EHS 2017-18 data. Green rows required further assumptions to estimate their proportion. 'Other' was pro-rated into previous categories for the final weighting.*

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Appendix B Full and partial project savings

Full project savings (£/yr) for all size and rating bands

TFA<73												
Starting EPC band [v]	Finishing EPC band											
	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G
High_B	95	0	0	0	0	0	0	0	0	0	0	0
Low_B	181	86	0	0	0	0	0	0	0	0	0	0
High_C	289	194	108	0	0	0	0	0	0	0	0	0
Low_C	384	289	203	95	0	0	0	0	0	0	0	0
High_D	505	410	324	216	121	0	0	0	0	0	0	0
Low_D	617	522	436	328	233	112	0	0	0	0	0	0
High_E	754	659	573	465	370	249	137	0	0	0	0	0
Low_E	886	791	704	596	502	381	269	132	0	0	0	0
High_F	1070	975	889	781	686	565	453	316	185	0	0	0
Low_F	1276	1181	1095	987	892	772	659	522	391	206	0	0
High_G	1566	1471	1384	1277	1182	1061	949	812	680	495	289	0
Low_G	1896	1801	1715	1607	1512	1392	1279	1142	1011	826	620	331
73≤TFA<98												
Starting EPC band [v]	Finishing EPC band											
	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G
High_B	121	0	0	0	0	0	0	0	0	0	0	0
Low_B	231	110	0	0	0	0	0	0	0	0	0	0
High_C	368	247	137	0	0	0	0	0	0	0	0	0
Low_C	489	368	258	121	0	0	0	0	0	0	0	0
High_D	643	522	412	275	154	0	0	0	0	0	0	0
Low_D	786	665	555	418	297	143	0	0	0	0	0	0
High_E	961	840	730	592	471	317	175	0	0	0	0	0
Low_E	1128	1007	898	760	639	485	342	168	0	0	0	0
High_F	1364	1243	1133	996	875	721	578	403	235	0	0	0
Low_F	1627	1506	1396	1258	1137	983	840	666	498	263	0	0
High_G	1995	1874	1764	1627	1506	1352	1209	1034	867	631	369	0
Low_G	2417	2296	2186	2048	1927	1773	1630	1456	1288	1053	790	421
98≤TFA<200												
Starting EPC band [v]	Finishing EPC band											
	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G
High_B	162	0	0	0	0	0	0	0	0	0	0	0
Low_B	309	147	0	0	0	0	0	0	0	0	0	0
High_C	493	331	184	0	0	0	0	0	0	0	0	0
Low_C	655	493	346	162	0	0	0	0	0	0	0	0
High_D	862	700	552	368	206	0	0	0	0	0	0	0
Low_D	1053	891	744	560	398	191	0	0	0	0	0	0
High_E	1287	1125	977	793	631	425	234	0	0	0	0	0
Low_E	1511	1349	1202	1018	856	650	458	225	0	0	0	0
High_F	1827	1665	1517	1333	1171	965	774	540	315	0	0	0
Low_F	2178	2016	1869	1685	1523	1317	1125	892	667	352	0	0
High_G	2672	2510	2363	2179	2017	1810	1619	1385	1161	845	494	0
Low_G	3236	3074	2927	2743	2581	2375	2183	1950	1725	1410	1058	564

200≤TFA												
Starting EPC band ᵛ	Finishing EPC band											
	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G
High_B	293	0	0	0	0	0	0	0	0	0	0	0
Low_B	558	266	0	0	0	0	0	0	0	0	0	0
High_C	891	598	332	0	0	0	0	0	0	0	0	0
Low_C	1183	891	625	293	0	0	0	0	0	0	0	0
High_D	1556	1263	997	665	372	0	0	0	0	0	0	0
Low_D	1902	1609	1343	1011	718	346	0	0	0	0	0	0
High_E	2324	2031	1765	1433	1140	768	422	0	0	0	0	0
Low_E	2729	2436	2171	1838	1546	1173	827	405	0	0	0	0
High_F	3298	3006	2740	2408	2115	1743	1397	975	569	0	0	0
Low_F	3934	3641	3375	3043	2750	2378	2032	1610	1205	635	0	0
High_G	4825	4532	4266	3934	3642	3269	2923	2501	2096	1527	891	0
Low_G	5844	5552	5286	4953	4661	4289	3943	3521	3115	2546	1911	1019

Partial project scores - Annual fuel cost savings for individual measures (£/yr)

TFA<73	Band													
Measure	High_A	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G	Low_G
SWI 1.7	95	96	97	98	101	104	108	113	120	128	138	150	165	181
SWI 1.0	59	59	59	59	60	61	63	65	68	72	78	84	92	101
CWI	56	56	56	56	57	58	60	63	67	72	79	86	96	107
Floor insulation	39	38	38	38	38	39	41	44	48	52	59	67	77	89
Pitched roof Insulation	62	62	63	63	64	65	66	68	70	73	77	81	86	92
Flat roof Insulation	194	199	207	216	227	239	255	271	294	316	346	377	416	457
Double glazing	60	60	60	61	62	64	67	71	77	83	92	102	116	130
Upgrade gas boiler (no controls)	55	61	69	77	88	99	113	128	148	168	194	220	254	288
Replace electric heaters with ASHP (no controls)	265	265	265	271	286	306	341	384	448	521	625	740	894	1061
Heating controls (gas boiler)	24	31	41	50	59	67	77	85	93	101	108	113	118	120

73≤TFA<98	Band													
Measure	High_A	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G	Low_G
SWI 1.7	159	168	181	194	212	229	252	276	307	339	381	423	476	531
SWI 1.0	119	123	129	134	142	149	159	168	181	193	209	225	246	266
CWI	104	110	119	127	138	147	159	170	184	197	213	228	246	263
Floor insulation	47	46	46	46	47	48	51	54	58	64	71	80	91	103
Pitched roof Insulation	48	47	46	45	45	45	47	49	52	56	63	70	80	91
Flat roof Insulation	157	157	158	160	165	171	180	191	208	226	251	279	316	356
Double glazing	97	96	96	97	100	103	109	117	128	140	158	177	203	232
Upgrade gas boiler (no controls)	75	79	85	93	105	117	136	156	185	215	256	300	357	417
Replace electric heaters with ASHP (no controls)	362	362	362	362	370	388	426	475	555	649	787	941	1154	1387
Heating controls (gas boiler)	30	37	48	57	69	79	93	105	121	135	153	169	189	208

98≤TFA<200	Band													
Measure	High_A	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G	Low_G
SWI 1.7	229	237	250	264	284	304	332	361	402	444	500	558	633	711
SWI 1.0	154	162	172	182	194	204	218	231	247	263	281	299	320	341
CWI	137	144	155	166	179	191	207	222	241	260	284	307	335	364
Floor insulation	58	57	57	57	59	60	63	67	73	80	89	100	114	130
Pitched roof Insulation	64	62	61	60	60	61	63	65	70	76	84	93	107	122
Flat roof Insulation	197	199	204	210	219	228	243	259	282	307	341	377	425	475
Double glazing	125	125	127	130	135	140	150	160	175	192	215	241	275	311
Upgrade gas boiler (no controls)	93	100	110	121	137	153	175	199	232	267	313	360	422	486
Replace electric heaters with ASHP (no controls)	485	485	485	485	491	510	552	609	703	814	979	1164	1420	1701
Heating controls (gas boiler)	42	52	66	78	93	107	123	138	155	171	190	208	227	245

200≤TFA	Band													
Measure	High_A	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G	Low_G
SWI 1.7	491	508	535	563	604	645	703	765	849	937	1054	1176	1333	1497
SWI 1.0	337	350	369	386	409	429	456	481	514	546	585	624	672	719
CWI	320	329	343	359	380	402	432	464	508	553	612	674	754	837
Floor insulation	134	130	127	125	124	126	130	136	147	160	180	203	235	270
Pitched roof Insulation	140	136	131	129	127	128	131	136	145	156	174	194	223	255
Flat roof Insulation	427	430	438	448	466	485	515	549	598	651	725	803	908	1019
Double glazing	267	264	263	263	267	274	286	302	326	354	395	440	501	568
Upgrade gas boiler (no controls)	160	172	192	214	244	274	318	363	425	489	574	663	778	897
Replace electric heaters with ASHP (no controls)	972	972	972	972	972	972	1042	1141	1309	1512	1814	2158	2635	3161
Heating controls (gas boiler)	72	99	134	165	200	229	262	290	321	346	370	388	403	411

Partial project scores - SAP point savings for individual measures

TFA<73	Band													
Measure	High_A	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G	Low_G
SWI 1.7	3.52	3.93	4.45	4.88	5.35	5.72	6.11	6.41	6.67	6.83	6.89	6.82	6.59	6.21
SWI 1.0	2.13	2.36	2.64	2.87	3.12	3.30	3.48	3.60	3.69	3.71	3.65	3.51	3.25	2.90
CWI	2.12	2.32	2.57	2.77	3.00	3.18	3.38	3.53	3.67	3.75	3.80	3.79	3.70	3.55
Floor insulation	1.41	1.58	1.78	1.96	2.15	2.30	2.46	2.59	2.70	2.77	2.80	2.78	2.70	2.56
Pitched roof Insulation	2.19	2.48	2.83	3.11	3.40	3.61	3.80	3.92	3.97	3.93	3.77	3.50	3.04	2.46
Flat roof Insulation	4.37	5.96	8.00	9.71	11.63	13.13	14.78	16.06	17.29	18.10	18.64	18.72	18.26	17.28
Double glazing	2.07	2.36	2.72	3.03	3.37	3.63	3.91	4.12	4.31	4.43	4.48	4.44	4.29	4.05
Upgrade gas boiler (no controls)	1.42	2.22	3.25	4.13	5.15	5.96	6.90	7.67	8.49	9.12	9.70	10.07	10.30	10.30
Replace electric heaters with ASHP (no controls)	3.23	5.86	9.32	12.29	15.78	18.63	21.99	24.82	27.93	30.47	33.04	34.98	36.67	37.67
Heating controls (gas boiler)	1.00	1.52	2.19	2.75	3.38	3.87	4.41	4.83	5.23	5.50	5.68	5.70	5.55	5.23

73≤TFA<98	Band													
Measure	High_A	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G	Low_G
SWI 1.7	5.87	6.75	7.91	8.89	10.03	10.95	12.00	12.87	13.78	14.49	15.15	15.57	15.84	15.85
SWI 1.0	5.55	5.77	6.06	6.32	6.62	6.86	7.15	7.40	7.68	7.91	8.16	8.35	8.53	8.65
CWI	4.92	5.25	5.68	6.04	6.45	6.79	7.17	7.49	7.82	8.08	8.31	8.46	8.54	8.54
Floor insulation	2.07	2.11	2.16	2.20	2.26	2.30	2.36	2.41	2.47	2.52	2.58	2.63	2.69	2.74
Pitched roof Insulation	2.15	2.14	2.14	2.14	2.14	2.14	2.16	2.17	2.20	2.23	2.27	2.32	2.40	2.47
Flat roof Insulation	6.67	6.90	7.20	7.47	7.79	8.06	8.38	8.67	9.00	9.29	9.62	9.89	10.19	10.43
Double glazing	4.09	4.23	4.43	4.60	4.80	4.96	5.16	5.33	5.52	5.68	5.85	5.99	6.12	6.22
Upgrade gas boiler (no controls)	2.77	3.31	4.03	4.66	5.40	6.03	6.77	7.41	8.14	8.75	9.42	9.96	10.50	10.91
Replace electric heaters with ASHP (no controls)	14.23	15.19	16.52	17.75	19.29	20.66	22.43	24.09	26.16	28.12	30.51	32.80	35.53	38.17
Heating controls (gas boiler)	1.11	1.60	2.24	2.77	3.38	3.86	4.40	4.83	5.27	5.59	5.84	5.96	5.96	5.80

98≤TFA<200	Band													
Measure	High_A	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G	Low_G
SWI 1.7	7.64	8.32	9.21	10.00	10.95	11.75	12.71	13.57	14.55	15.41	16.36	17.18	18.05	18.77
SWI 1.0	5.75	6.08	6.51	6.88	7.30	7.63	8.01	8.32	8.64	8.88	9.08	9.20	9.24	9.18
CWI	4.93	5.36	5.91	6.37	6.90	7.32	7.79	8.16	8.53	8.80	9.01	9.11	9.09	8.93
Floor insulation	2.06	2.11	2.17	2.22	2.28	2.33	2.40	2.46	2.53	2.59	2.67	2.73	2.81	2.87
Pitched roof Insulation	2.15	2.18	2.22	2.25	2.29	2.33	2.37	2.41	2.45	2.49	2.53	2.57	2.61	2.65
Flat roof Insulation	6.77	7.10	7.55	7.93	8.39	8.77	9.23	9.63	10.09	10.48	10.90	11.25	11.60	11.87
Double glazing	4.36	4.56	4.81	5.03	5.29	5.50	5.75	5.96	6.19	6.38	6.57	6.71	6.83	6.90
Upgrade gas boiler (no controls)	2.94	3.50	4.23	4.87	5.62	6.25	6.99	7.62	8.33	8.92	9.54	10.04	10.51	10.84
Replace electric heaters with ASHP (no controls)	14.84	15.92	17.38	18.70	20.33	21.74	23.52	25.15	27.11	28.93	31.06	33.04	35.31	37.41
Heating controls (gas boiler)	0.88	1.51	2.31	2.96	3.69	4.25	4.84	5.27	5.65	5.85	5.90	5.75	5.32	4.68

200≤TFA	Band													
Measure	High_A	Low_A	High_B	Low_B	High_C	Low_C	High_D	Low_D	High_E	Low_E	High_F	Low_F	High_G	Low_G
SWI 1.7	6.39	7.59	9.15	10.50	12.09	13.40	14.94	16.24	17.69	18.88	20.10	21.05	21.90	22.45
SWI 1.0	4.45	5.25	6.27	7.11	8.05	8.77	9.55	10.13	10.66	10.96	11.09	10.96	10.52	9.80
CWI	4.55	5.31	6.28	7.09	7.99	8.69	9.46	10.04	10.59	10.93	11.12	11.08	10.77	10.20
Floor insulation	2.12	2.23	2.37	2.49	2.62	2.72	2.83	2.92	3.00	3.06	3.09	3.09	3.06	2.99
Pitched roof Insulation	2.06	2.18	2.32	2.44	2.58	2.68	2.80	2.88	2.96	3.01	3.04	3.04	2.99	2.90
Flat roof Insulation	5.69	6.52	7.58	8.47	9.48	10.28	11.16	11.85	12.54	13.01	13.35	13.46	13.32	12.92
Double glazing	4.08	4.40	4.82	5.16	5.55	5.86	6.20	6.46	6.72	6.90	7.02	7.06	6.99	6.82
Upgrade gas boiler (no controls)	1.59	2.42	3.49	4.40	5.45	6.30	7.27	8.06	8.89	9.53	10.11	10.47	10.67	10.64
Replace electric heaters with ASHP (no controls)	12.88	14.53	16.70	18.59	20.82	22.67	24.87	26.76	28.89	30.67	32.55	34.07	35.53	36.59
Heating controls (gas boiler)	0.41	1.30	2.42	3.32	4.30	5.03	5.77	6.27	6.64	6.74	6.55	6.06	5.08	3.77

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Appendix C Examples for consideration of correction factor

Example 1 - 88.8m2 semi - 65% gas boiler			
Measure	**£/yr before**	**£/yr after**	**£/yr saved**
SWI 1.7-0.3	1104.72	838.53	266.19
LI 1 - 0.2	1104.72	1025.32	79.4
DG 4.8 - 1.8	1104.72	1015.9	88.82
Upgrade gas boiler 65% - 90%	1104.72	878.96	225.76
Total			**660.17**
All at once	**1104.72**	**534.74**	**569.98**
Correction factor required to avoid overestimate			**0.86**

Example 1a - 88.8m2 semi - 80% gas boiler			
Measure	**£/yr before**	**£/yr after**	**£/yr saved**
SWI 1.7-0.3	949.84	730.7	219.14
LI 1 - 0.2	949.84	884.66	65.18
DG 4.8 - 1.8	949.84	876.89	72.95
Upgrade gas boiler 80% - 90%	949.84	878.96	70.88
Total			**428.15**
All at once	**949.84**	**534.74**	**415.1**
Correction factor required to avoid overestimate			**0.97**

Example 1b - 88.8m2 semi - 80% gas - FABRIC ONLY			
Measure	**£/yr before**	**£/yr after**	**£/yr saved**
SWI 1.7-0.3	949.84	730.7	219.14
LI 1 - 0.2	949.84	884.66	65.18
DG 4.8 - 1.8	949.84	876.89	72.95
Floor ins 0.684 - 0.25	949.84	914.72	35.12
Total			**392.39**
All at once	**949.84**	**524.48**	**425.36**
Correction factor required to avoid overestimate			**1.08**

Example 2 - 88.8m2 semi - electric direct			
Measure	**£/yr before**	**£/yr after**	**£/yr saved**
CWI 1.6 - 0.5	2202.2	1778.12	424.08
LI 2.3 - 0.13	2202.2	1746.16	456.04
Floor insulation 0.684 - 0.25	2202.2	2114.65	87.55
ASHP 345.4% (PCDB 101101)	2202.2	1032.91	1169.29
Total			**2136.96**
All at once	**2202.2**	**577.24**	**1624.96**
Correction factor required to avoid overestimate			**0.76**

Example 2a - 88.8m2 semi - electric direct to storage			
Measure	**£/yr before**	**£/yr after**	**£/yr saved**
CWI 1.6 - 0.5	2202.2	1778.12	424.08
LI 2.3 - 0.13	2202.2	1746.16	456.04
Floor insulation 0.684 - 0.25	2202.2	2114.65	87.55
HHRSHs	2202.2	1234.36	967.84
Total			**1935.51**
All at once	**2202.2**	**660.35**	**1541.85**
Correction factor required to avoid overestimate			**0.80**

Example 3 - 88.8m2 semi - 75% LPG boiler			
Measure	**£/yr before**	**£/yr after**	**£/yr saved**
SWI 1.7-0.3	2008.07	1495.99	512.08
LI 1 - 0.2	2008.07	1854.77	153.3
DG 4.8 - 1.8	2008.07	1836.54	171.53
Upgrade LPG boiler 72% - 90%	2008.07	1667.75	340.32
Total			**1177.23**
All at once	**2008.07**	**944.06**	**1064.01**
Correction factor required to avoid overestimate			**0.90**

Example 4 - 88.8m2 semi - 72% gas boiler (no controls)			
Measure	**£/yr before**	**£/yr after**	**£/yr saved**
Boiler 75% - 90%	1312.27	1134.36	177.91
Controls - None to prog, stat + TRVs + interlock	1312.27	1137.98	174.29
PV 4 kWp	1312.27	911.03	401.24
LI 2.3 - 0.13	1312.27	1103.1	209.17
SWI 2.1 - 0.3	1312.27	980.23	332.04
Total			**1294.65**
All at once	**1312.27**	**173.63**	**1138.64**
Correction factor required to avoid overestimate			**0.88**