BRE Client Report

Development work relating to a potential new metric for Scottish Energy Performance Certificates

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Executive Summary

EPC ratings are currently based on the calculated running costs per m² of floor area of the dwelling. This takes into consideration how well insulated the dwelling is, but also the choice of heating system and the type of fuel it uses.

The use of a cost-based metric has worked reasonably well in the past, but in recent years with the rapid decarbonisation of the electricity grid, this correlation between the cost and CO2 emissions of fuels has broken down to the extent that a cost-based metric now favours some relatively high carbon outcomes, particularly the continued use of fossil fuels over electric heating systems. The Scottish Government (SG) are therefore considering moving to or supplementing this with a new metric based purely on how well insulated the dwelling is, with the intention that this could be used alongside other policy levers that ensure low carbon systems will be used to provide that energy.

To support SG's requirements, a number of possible metrics for this purpose have been considered. Of these, one ('useful energy'[1] (UE) required per m² of floor area) was examined in more detail, looking at what value would be equivalent in ambition to the current band C threshold.

The impact on the existing and proposed metric of applying energy efficiency improvement measures to the Scottish housing stock was then examined in the context of how many homes would be likely to pass the band C threshold as the housing stock is upgraded.

Key findings of this work were:

1. If a new EPC metric based on the amount of energy required to maintain a comfortable temperature in dwellings were to be adopted, setting this at a level of 162 kWh/yr per m² would be equivalent in ambition to the current EPC band C threshold. Around 40% of homes currently meet this level. The equivalent value using an alternative UE definition (excluding water heating energy) is 120 kWh/yr/m².
2. When a basic set of measures was added (loft insulation, cavity wall insulation) the number of homes reaching the band C equivalent figure of 162 kWh/yr per m² threshold increase from 40.8% to 46.9%. Adding suspended floor insulation) increased this to 64.7%. This shows that, while challenging, it is possible using currently available solutions to bring the majority of the Scottish housing stock past the proposed threshold level.
3. During the analysis it was noted that a significant proportion of the homes receiving highest EPC ratings at present appear to be using means other than further improving fabric insulation (e.g. by having PV systems). These would not improve the rating under the proposed new

[1] The term useful energy is used throughout this report, but a less technical name is likely to be used if this comes into public use.

metric – suggesting the options for achieving high rating (As and Bs) might be limited, or at least expensive – e.g. deep retrofits.

Introduction

BRE were commissioned by the Scottish Government (SG) to undertake analysis work to help inform their decision making in relation to the potential use of a new Energy Performance Certificate (EPC) metric. This report gives a narrative of the work undertaken by BRE and some key results and recommendations from it. Further context is given in SG's Heat in Building Strategy[2].

All UK EPCs currently use as their headline rating a metric based on the predicted running costs of the dwelling, as modelled by the SAP or RdSAP methodology[3], commonly referred to as the 'SAP rating' or 'EPC rating'. This is expressed as a positive whole number, and an A to G rating. The metric behind the numerical rating is the modelled running costs per m² of floor area, which means large homes are not penalised relative to smaller ones. This is then mapped onto 1-100 scale[4], then onto an A-G scale.

The running costs used are the modelled fuel costs for space heating/cooling, water heating, lighting, and pumps and fans associated with heating and ventilation systems. Energy use for domestic appliances is not included. Energy generated by on-site renewables (e.g. PV) is credited when the running costs are calculated, meaning it is possible to achieve low net running costs, and therefore a good SAP rating, even where the home is poorly insulated if enough renewables generation is added.

The use of a cost-based metric has worked reasonably well as a multipurpose metric in the past, when fuels with a high cost per kWh also tended to have a high carbon factor, meaning that using a rating which encouraged householders to take actions to reduce their running costs would also encourage carbon reductions. However, in recent years with the rapid decarbonisation of the electricity grid, this correlation has broken down to the extent that a cost-based metric now favours some relatively high carbon outcomes, particularly the continued use of fossil fuels over electric heating systems, contrary to the target to eliminate direct emissions heating by 2045 referred to in the Heat in Buildings Strategy. In the context of zero emissions heating systems the key focus then becomes demand minimisation and therefore a metric reflecting this is more appropriate.

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[2] Chapter 8 Developing a Regulatory Framework for Zero Emissions Buildings - Heat in Buildings Strategy - achieving net zero emissions in Scotland's buildings - gov.scot (www.gov.scot)

[3] SAP and RdSAP are methodologies used for estimating the energy performance of dwellings in the UK – see here for details. For details see SAP 10.2 - 21-04-2022.pdf (bregroup.com).

[4] In very rare cases it can exceed 100 if on-site renewable generation is used.

SG is therefore considering creating a new EPC metric focussed only on the energy requirement of homes, for use alongside policy levers that ensure low carbon systems will be used to provide that energy.

Work undertaken by BRE in support of SG's decision making on this subject has examined options for a suitable energy requirement metric and modelled the likely impact this would have on the distribution of ratings in the Scottish Housing stock, relative to the current rating system.

Description of the project

The following topics were investigated as part of this project:

- Propose and discuss the pros and cons of potential metrics.
- Model the Scottish housing stock in SAP 10.2 to show the distribution of potential new metrics, relative to the existing metric.
- Determine the value of SG's favoured new metrics that is equivalent in terms of ambition to the current band C threshold level.
- Model the impact on the distribution of proposed and existing metrics of energy efficiency improvement measures and discuss any implications this has for the choice of A to G band thresholds.

Work undertaken on each of these topics is described in the following sections of this report.

Potential new metrics

Following initial discussions with SG about the policy aims driving their desire to use a new metric, a number of potentially suitable metrics were proposed, and their pros and cons considered. The key requirement was for the new metrics to be a more direct measure of the building's energy requirement, regardless of what heat/power sources are used.

Fabric Energy Efficiency

Fabric Energy Efficiency (FEE) is a metric already specified in the SAP methodology document, although it is currently only used in the context of new build assessments (for building regulations); it is not generated by RdSAP software or referred to on EPCs.

For the calculation of FEE, the actual fabric data (U-values etc.) entered by the assessor is used, but instead of the entered space heating and hot water generation system, a standardised direct electric space and water system is assumed in all cases. This ensures that the FEE changes only in response to the fabric specification, allowing a like for like comparison of fabric performance between dwellings, whilst still giving a relatable overall energy consumption total. A benefit of this option is that it is an existing metric which is focussed on fabric performance.

Possible limitations to consider are that FEE doesn't take into account some features that are usually considered to be a key part of dwelling's energy efficiency, such as cylinder insulation and the inclusion of how water saving technologies like waste water heat recovery (WWHR) and solar thermal, which are likely to be relevant whatever water heating system is used. If these are to be covered by the separate policy levers relating to heating systems used, that may be acceptable, but if such technologies were to fall between the cracks it is possible this could disincentivise their use. In particular, WWHR systems, which effectively reduce hot water demand, once installed could be seen as an inherent element of the building's efficiency.

FEE based on local weather

In preliminary discussions, SG suggested it might be desirable to use local weather data when calculating the new metric (in contrast the current EPC rating for which standardised UK average weather data is always used). This would require a minor change to SAP software but is technically easy to achieve. The question is around what impact that would have on ratings and whether it would create any practical difficulties, noting that up to this point local weather data has not been used for any ratings purpose. Existing SAP software does not allow the use of alternative weather data for the ratings or FEE calc, but it does use local weather data when calculating the 'current running costs' presented on EPCs, giving a means to test the likely impact of allowing this. Some examples were run for the same poorly insulated example dwelling (an 89m² 3-bedroom semi-detached dwelling with uninsulated cavity walls, and 50mm loft insulation) in each of the 9 regions in Scotland:

	kWh/yr/m^2	
Region	**Space heating energy**	
SW Scotland	240.78	
Boarders	239.86	
West Scotland	248.80	
East Scotland	254.09	
NE Scotland	265.39	
Highland	280.98	
Western Isles	250.56	
Orkney	269.64	
Shetland	281.87	
Average	**259.11**	
Min	239.86	-7%
Max	281.87	9%

Table 1 – Space heating energy kWh/yr/m^2

This isn't exactly analogous to how the FEE would vary because it doesn't include water heating, but it suggests the FEE (if based on local weather) would vary by no more than about ±8% across Scotland.

The implications of having FEE vary with location are that a higher level of fabric insulation would be required in cooler regions to obtain the same FEE rating – i.e. it would be harder to get a C-rating in colder regions. There is some logic for homes in cold places to be better insulated, but it is possible this could be seen as penalising them if in practice this increases the cost of the measures needed to get to a required standard. It also would make it more difficult to offer universal advice on ‘what to do to get you home up to band C’, or similar; so, the acceptability and practicality of this option should be considered carefully.

Of course, it would be possible to use Scottish average weather data, instead of UK average, without this variation. The only potential downside of this would be to reduce direct comparability with ratings in other UK administrations.

The FEE has never previously been recorded in EPC registry entries, so it would not be possible to update old EPCs to use the new metric[5] – only new EPCs would be able to display the new rating.

Heat loss parameter

The heat loss parameter (HLP) is an intermediate result from the SAP calculation which describes the specific heat loss per unit of the dwelling’s external surface area, in W/m²K. It includes ventilation heat losses as well as conduction heat losses. It is in that respect a very pure measure of the thermal efficiency of the shell of the building. This is therefore another option for use as a fabric efficiency rating metric.

It is perhaps more abstract and less tangible than the FEE (an annual energy consumption figure) and shares the same shortcomings as the FEE in terms of not giving credit for hot water related efficiency features that might be considered relevant. Despite being a long-standing SAP intermediate calculation parameter, it is also not recorded in existing EPC registry data files, meaning it could only be readily used for new assessments.

HLP is not affected by external temperature in the way FEE is, although it does vary with windspeed, which affects ventilation losses. Using an example, the HLP in Shetland (the windiest region) was found to be 8% higher than when the same dwelling was located in the (least windy) Borders region, suggesting a range of about ±4% across Scotland.

Heat loss coefficient

The heat loss coefficient (HLC) is another existing parameter in the SAP calculation that directly represents fabric heat losses. It is similar to the HLP but is not normalised for the surface area of the dwelling, so would result in larger homes receiving worse ratings than smaller ones for the same level of fabric energy efficiency. If this was to be used as a metric it would therefore essentially mean large homes would need to be more efficient to get the same rating as smaller ones, which is likely to be difficult to justify. Following initial discussions, this option was not considered further.

Modified FEE or HLP calculations

It could be possible to modify the FEE or HLP in some way to form a new metric which takes into account other features, e.g., relating to hot water efficiency. FEE is a measure of energy consumption, so the energy impact of

[5] It might be possible to undertake a project to reopen all existing EPCs in the registry using new SAP software and add FEE to the XML. This would be a big undertaking, however.

such features could be calculated to create an adjustment – e.g. the hot water saving from WWHR could be calculated and subtracted from the total when FEE is calculated. Alternatively, the FEE calculation could perhaps be modified so it uses some features of the actual system (e.g. cylinder insulation), while others are standardised (hot water source). The difficulty with this is that some features of interest are possible in combination with one type of system, but not another. For example, for cylinder insulation to be recognised there would have to be a cylinder present (which is not the case with combi boilers). If different system types are assumed for different situations, the consistency of approach which allows like for like comparisons is quickly lost; so, this would probably be quite a complicated and possibly confusing approach.

It is hard to see how any adjustments relating to hot water systems could work if HLP is used, since this metric has units that are very specific to fabric losses (W/m2K), so this option was not considered further.

Useful energy consumption

The sum of the heat required for space heating and hot water (aka 'useful energy', or 'heat demand'), before heat generation efficiency is applied, per square meter of floor area, would give another possible measure of the efficiency of the building. This could take into account all features other than the heating system efficiency, including hot water system saving features (if desired), so might be a good option if these are seen as important. The disadvantages are that things like whether a combi or regular boiler is used, and the type of heating controls present also impact useful energy, so it is not possible to disentangle some features that are specific to the heating system and might no longer apply if a new heating system was installed.

Options for what energy uses could be taken into consideration in a useful energy metric are discussed further below.

Delivered energy consumption

Summing the fuel requirements (i.e. the energy use after the application of the heating system's efficiency) to give the overall fuel requirements of the home for the regulated uses included in SAP would give a wholistic assessment of the energy efficiency of the dwelling and its energy supply systems. However, this is not aligned with the key policy intention to separate fabric efficiency from heating system efficiency. Another potential issue is that homes with heat pumps could get a very favourable rating by this measure on account of their coefficients of performance being much great than 1, even with relatively poor fabric efficiency. However, this option could still be considered further if SG later find that it is going to be problematic to keep to two aspects separate and there is a change of policy direction.

What items could a useful energy metric include?

Following discussion of the above options with SG, the use of a metric from SAP which expresses the energy needs of the dwelling prior to generation efficiency being applied was favoured as a measure of the building's energy efficiency. In SAP terms this is usually referred to as the 'useful energy' (UE) requirement of the building. However, this is a general term and has some optional components, which may or may not be appropriate for the proposed purpose.

Potentially relevant intermediate results from a SAP 10.2 calculation are as follows, where the number in brackets represents the SAP 10.2 worksheet number:

1) Output from water heater[6] in kWh/yr (64)
2) Electricity used for instantaneous electric showers (64a)
3) Space heating energy required in kWh/yr (98a)
4) Space cooling energy required in kWh/yr (108)
5) Electricity used for pumps and fans (231)
6) Electricity used for lighting (232)
7) Electricity saved (used within the dwelling) from PV (233a)
8) Electricity saved (used within the dwelling) from wind turbines (234a)
9) Electricity saved (used within the dwelling) from hydro (235a)
10) Electricity saved (used within the dwelling) from micro CHP (235c)
11) Electricity generated and exported from PV (233b)
12) Electricity generated and exported from wind turbines (234b)
13) Electricity generated and exported from hydro (235b)
14) Electricity generated and exported from micro CHP (235d)
15) Energy saved or generated by Appendix Q items (236a, b, c…)
16) Energy used by Appendix Q items (237a, b, c…)

Items 5) and 6) shaded green depend on the heating system used, so after some initial consideration it was decided to exclude these.

Items 7) to 14) relate to on-site generation. Discussions with SG concluded that this would be inappropriate to include, e.g. to avoid the situation where a dwelling with inefficient fabric could get a high rating by having lots of on-site generation.

It is possible Appendix Q items (15 and 16), i.e. new technologies not yet in SAP, could also be a new form of on-site generation, or otherwise relate to heating system efficiency and therefore be unsuitable for this rating; so there is an argument for excluding these too.

On the other hand, it would be a shame to exclude valid new fabric technologies from the rating. The difficulty here is that, by definition, we don't know what these will be in advance.

To give a feel, the current technologies recognised through Appendix Q are:

– Smart hot water cylinder (increases self-use of PV and minimises standing losses)

[6] This takes into consideration all the system losses (e.g. pipework distribution losses and hot water cylinder standing losses), to represent the heat load on the heat generator.

- Smart air-brick (improves floor U-value and air tightness)
- Solar pre-heater of ventilation system air
- Solar assisted heat pumps

Three of the four listed technologies relate to renewable generation, so on balance it is probably better to exclude appendix Q items to avoid these, or future technologies, impacting the rating in an undesirable or unforeseeable way. So the proposed approach is only to include items from the following four useful energy components:

1) Output from water heater in kWh/yr (64)
2) Electricity used for instantaneous electric showers (64a)
3) Space heating energy required in kWh/yr (98a)
4) Space cooling energy required in kWh/yr (108)

The sum of the energy use of some or all of these items would therefore give the measure of the performance of the building. Limiting it only to space heating and cooling energy would result in a wholly 'fabric only' measure, whereas including water heating and the other sources would extend this to potentially encourage other energy efficiency options, if desired.

The resulting energy consumption figure should be normalised for floor area in some way (prior to being mapped onto an A-G scale) to prevent large homes automatically getting poorer ratings than small ones. The simplest way of doing this is to divide the total useful energy figure by the floor area.

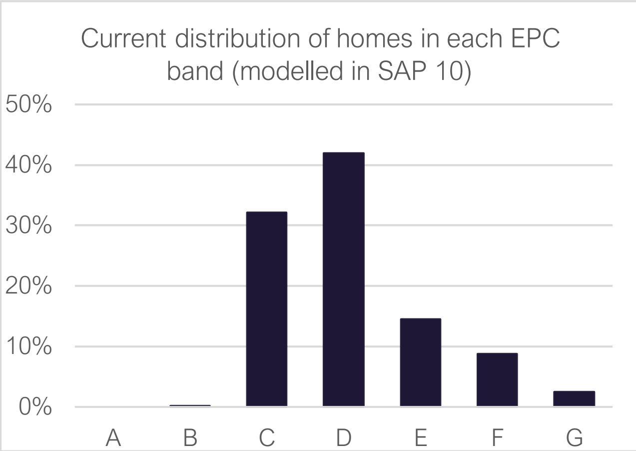
Distribution of existing EPC metrics and the equivalent levels for proposed new ones

4412 homes for which data was available from the Scottish House Condition Survey (SHCS) were modelled using SAP 10.2[7]. The SHCS sample is designed to be representative of the whole housing stock. In each case, the existing EPC rating and other proposed energy metrics were output for comparison. The distribution of the results was examined. The main findings from this work are reported in this section.

Overall distribution

A key aim of the analysis was to suggest what level any new metric should be set at to give an equivalent standard to the existing metric. Understanding the distribution of the current EPC ratings is therefore important background.

[7] 10% of homes in the SHCS were excluded from the analysis due to problems processing the data into the format required. The excluded cases did not appear to be clustered in such a way as would systematically change the proportions.



Graph 1 – Current distribution of homes in each EPC band (modelled in SAP 10)

Band	Count	This analysis
A	0	0.0%
B	6	0.1%
C	1419	32.2%
D	1850	41.9%
E	641	14.5%
F	386	8.7%
G	110	2.5%
Total	4412	100%

Table 2 – Distribution of the current EPC ratings

The above table and graph show the majority of homes in the SHCS sample fall in bands C and D, with very few achieving band B, and a tail of Es, Fs and Gs.

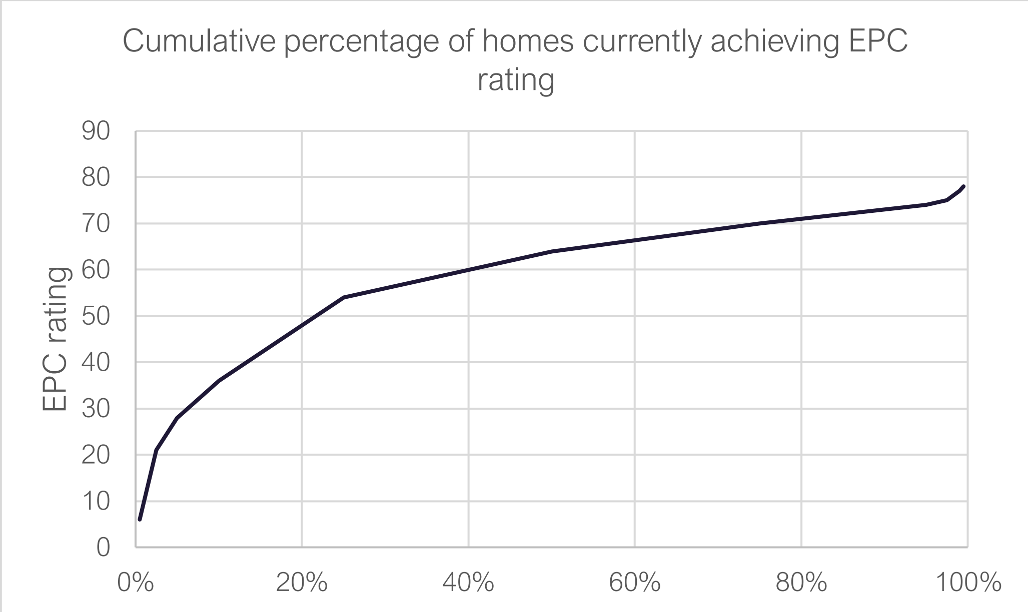
Looking at this another way, using percentiles, the table and chart below show the median EPC rating is 64 (D) and the 75th percentile just exceeds the boundary of band C (69).

Key stats			
Mean	59		
Median	64		
50% are between	54	and	70
90% are between	28	and	74
95% are between	21	and	75
99% are between	6	and	78
Cs and Ds make up	74.1%	of the stock	

Table 3 – EPC rating distribution statistics

Percentile	EPC rating	Band
0.5%	6	G
2.5%	21	F
5%	28	F
10%	36	F
25%	54	E
50%	64	D
75%	70	C
90%	73	C
95%	74	C
97.5%	75	C
99%	77	C
99.5%	78	C
Mean	59	D

Table 4 – EPC rating percentiles

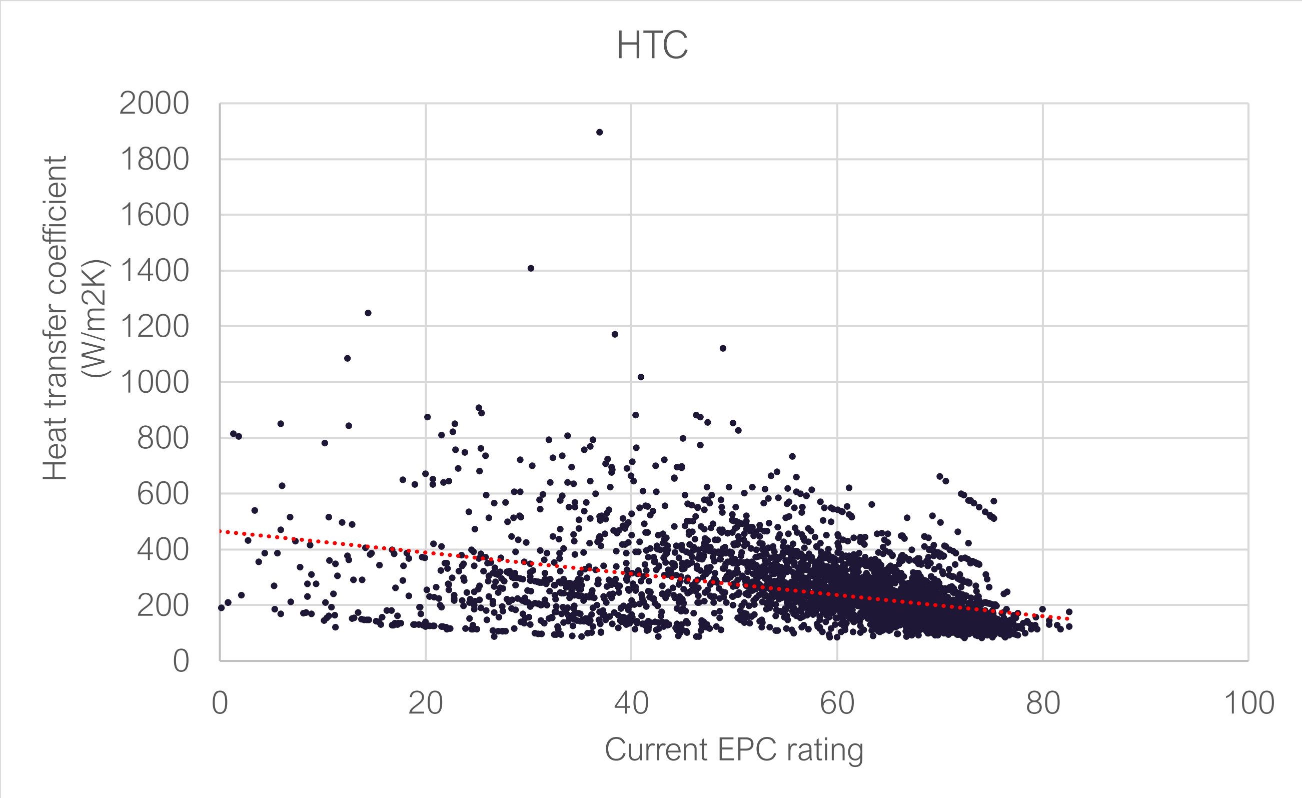


Graph 2 - Cumulative percentage of homes currently achieving EPC rating

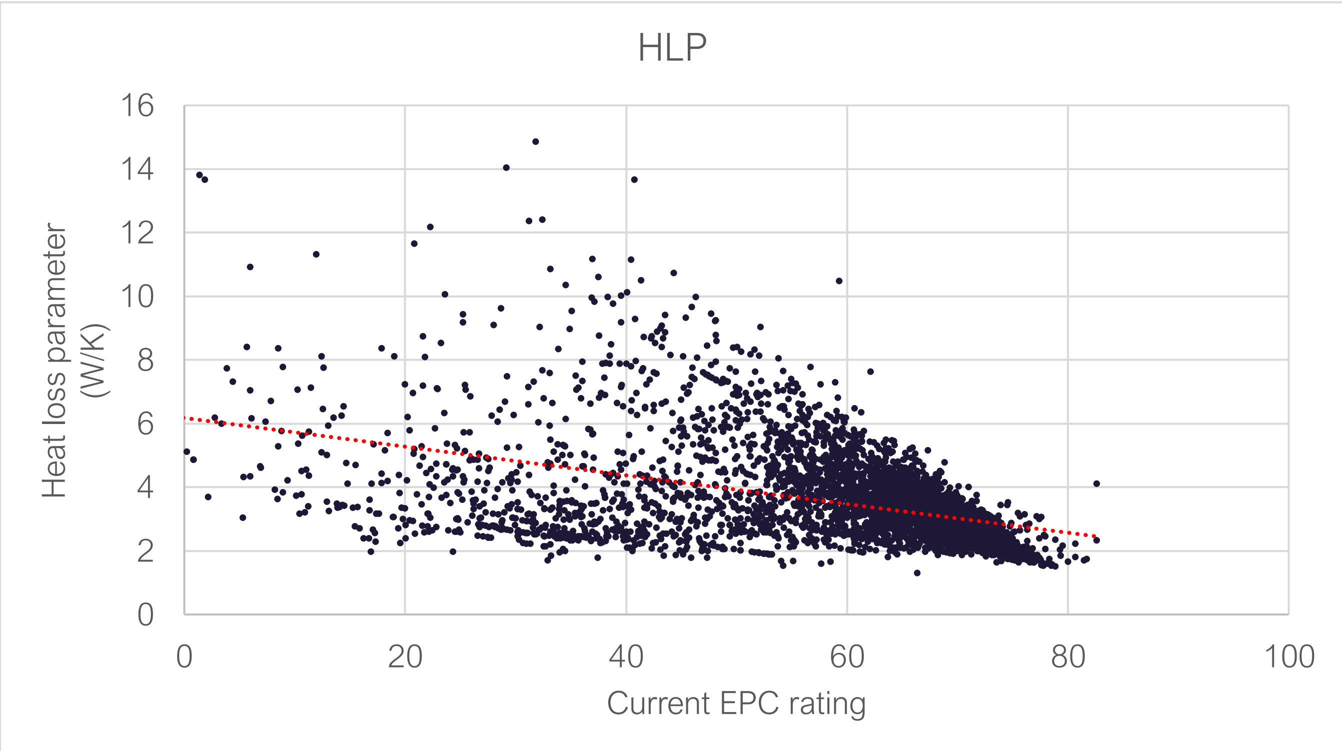
Mapping alternative metrics against the existing EPC metric

A number of energy efficiency metrics[8] were considered (as described above) which focus more on fabric efficiency than the current more wholistic EPC metric, which is based on running costs. For this reason, when plotted against the existing EPC rating (see graphs below) they all show a similar general trend: as the EPC rating rises, the fabric efficiency improves and therefore each of the energy use related indicators fall. However, this is complicated by the fact that homes with lower EPC ratings are much more likely to use expensive heating fuels, so they can be relatively well insulated but still receive a low EPC rating; hence there is a different trend at low existing EPC ratings.

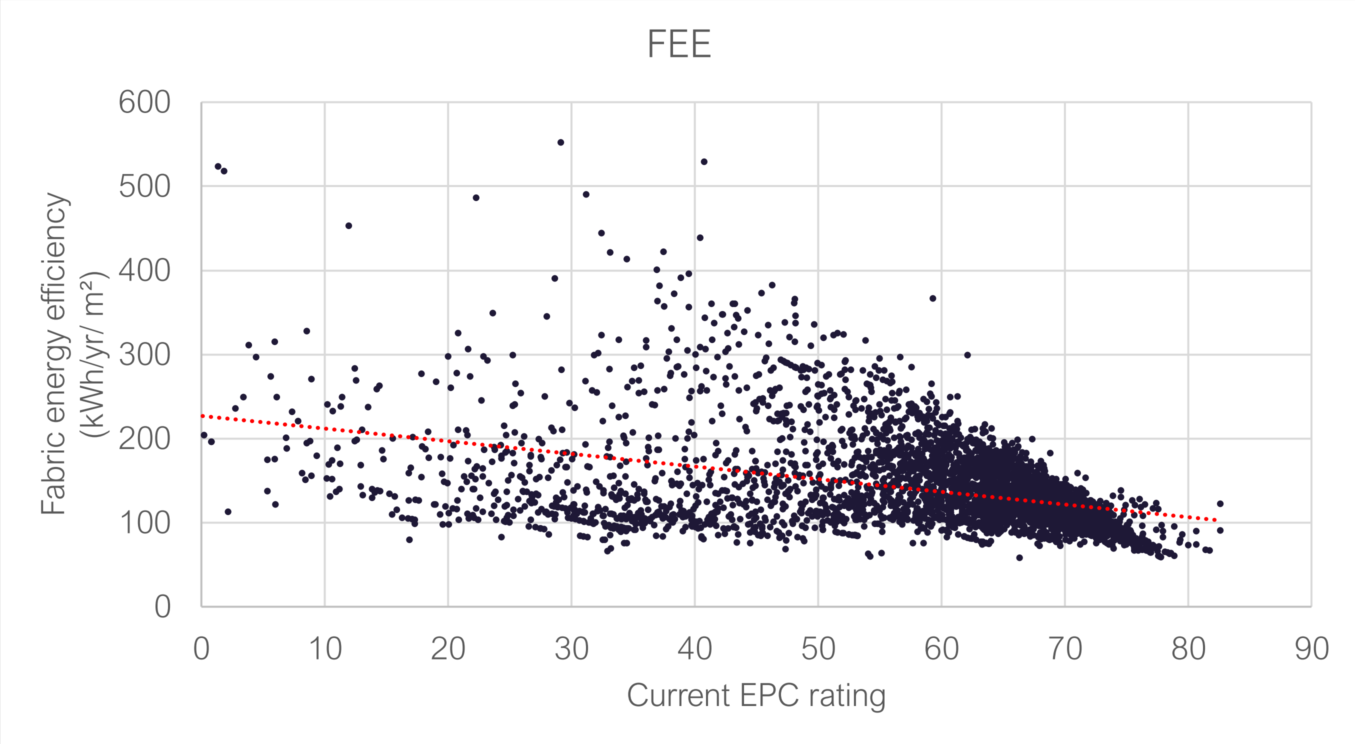
[8] HTC = Heat Transfer Coefficient; HLP = Heat Loss Parameter, DFEE = Dwelling Fabric Energy Efficiency; UE/m² = Useful Energy per m², where UE includes space heating/cooling, water heating, pumps and fans, and lighting energy.



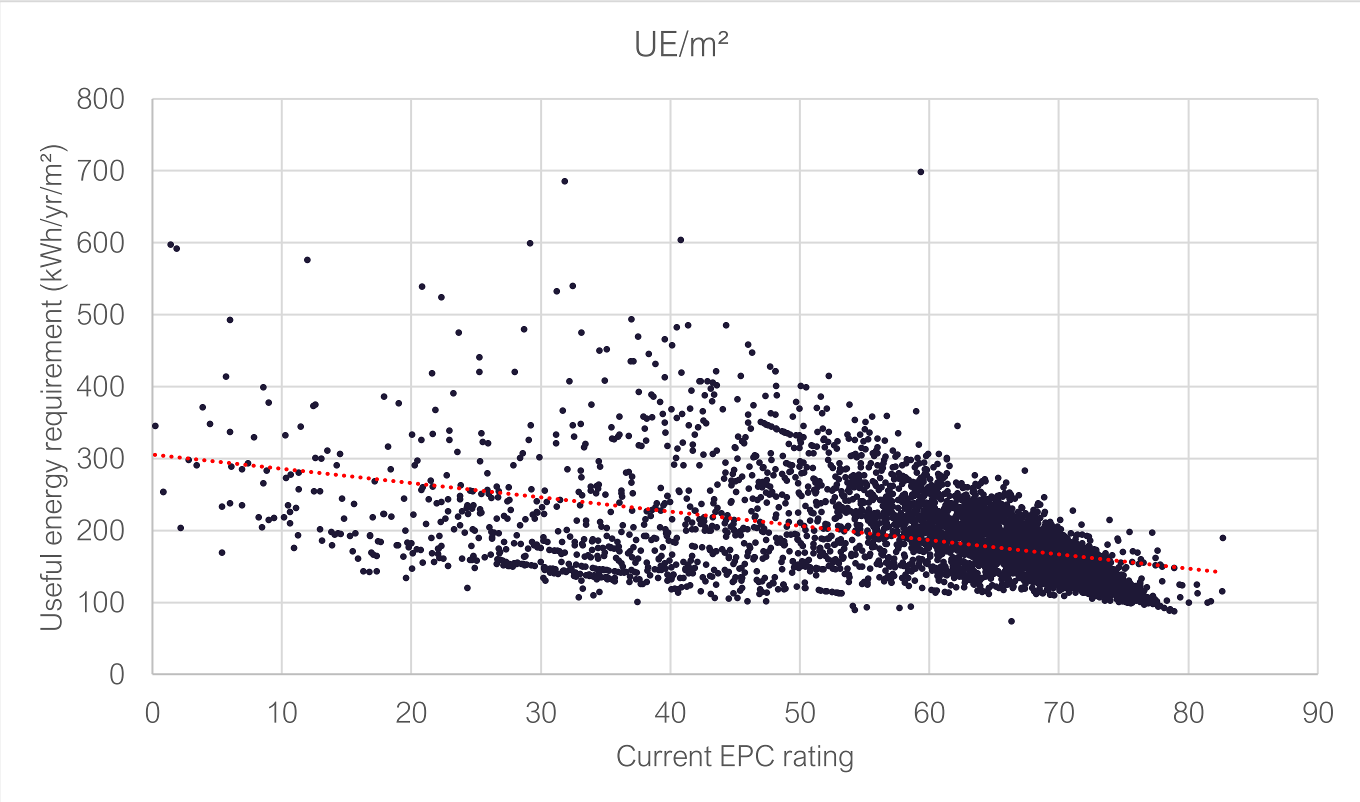
Graph 3 – HTC versus current EPC rating



Graph 4 – HLP versus current EPC rating



Graph 5 – FEE versus current EPC rating

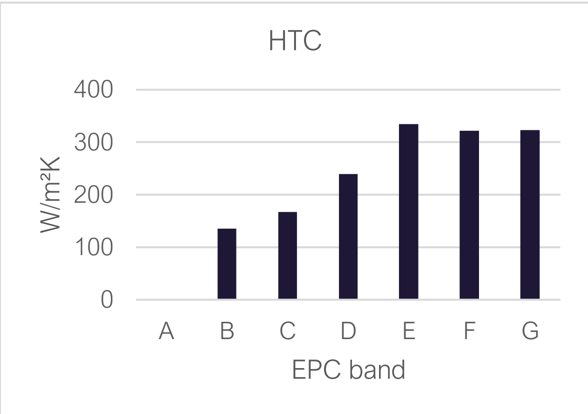


Graph 6 – UE/m^2 versus current EPC rating

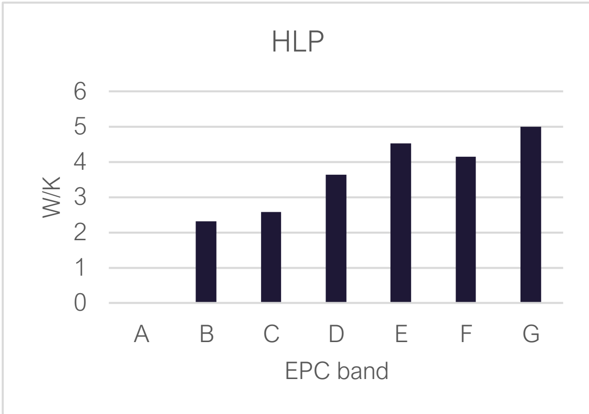
The following table and graphs show how the average 'score' under each metric varies with the current EPC band. This gives a similar picture – fabric efficiency improves with EPC band, but this breaks down for the lowest rated properties. It would appear to be the case that E-rated properties have worse fabric efficiency than F-rated properties for example, and G-rated properties typically have similar levels of fabric efficiency to E-rated properties. This is likely to be because G-rated properties are in that band primarily because have the most expensive heating systems.

Averages for each metric in each band						
Band	SAP rating	HTC	HLP	DFEE	UE/m²	Fuel use/m2
A	(None in sample)					
B	81.6	136	2.31	85	123	88.7
C	71.8	167	2.58	105	146	174.1
D	62.8	239	3.63	143	195	236.7
E	47.5	334	4.52	172	230	284.4
F	31.0	321	4.15	157	215	287.9
G	11.3	323	5.00	188	258	328.4

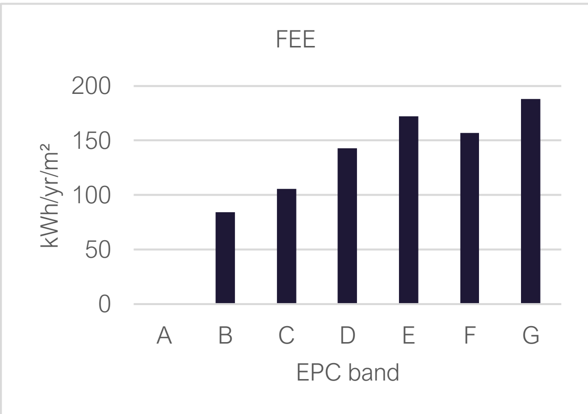
Table 5 – Averages for each metric in each band



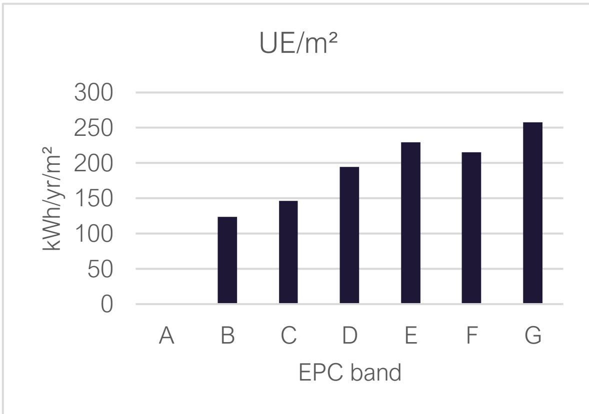
Graph 7 – HTC by EPC band



Graph 8 – HLP by EPC band



Graph 9 – FEE by EPC band



Graph 10 – UE/m² by EPC band

Focussing on useful energy per m²

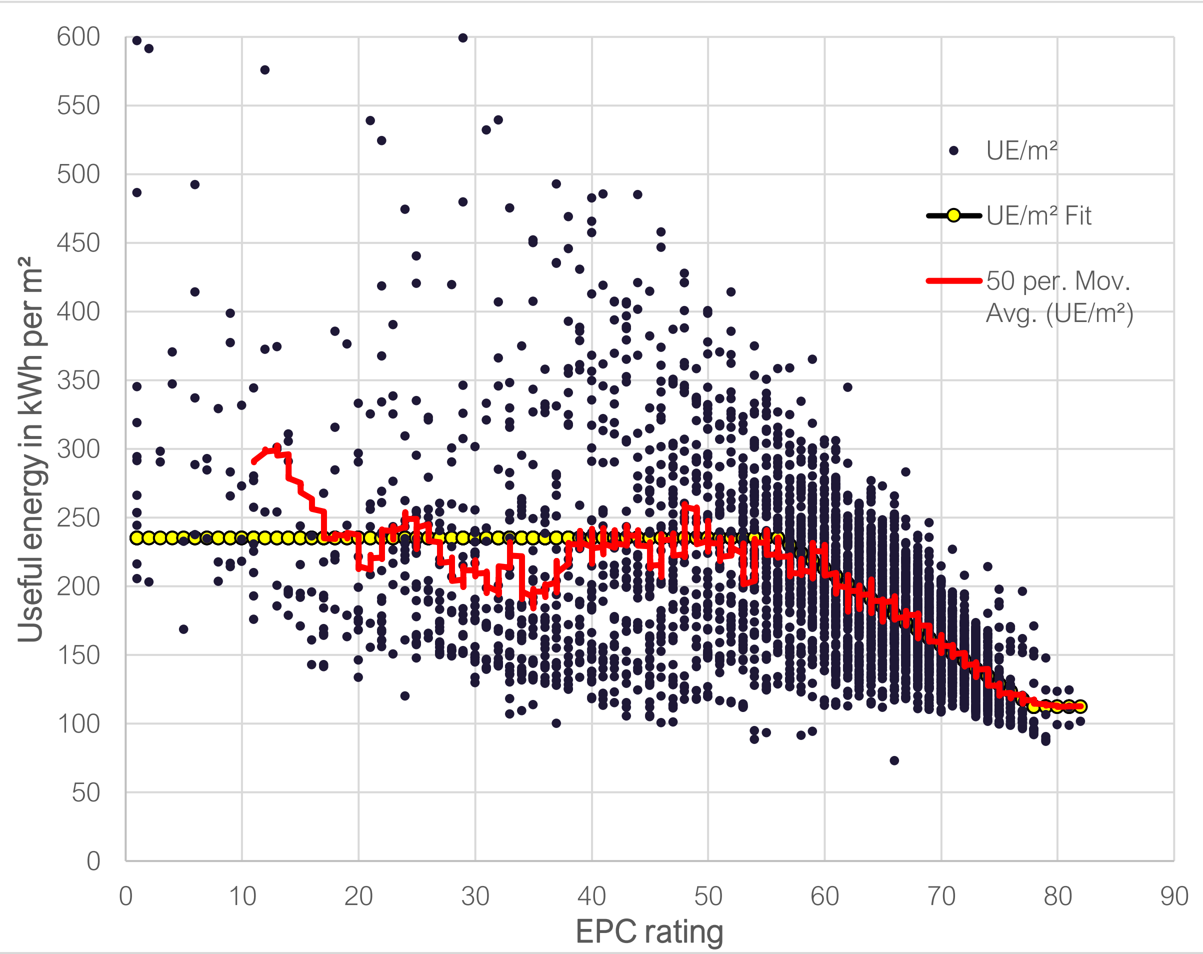
During the project it emerged that the metric which appears most promising as a basis for a future 'fabric only' rating is 'useful energy' per m², hereafter shortened to UE/m². After discussions with SG, this was modelled to include:

- Space heating energy requirement
- Space cooling energy requirement
- Water heating energy requirement

all expressed in kWh/yr per m² of floor area.

Later in the project it was decided to consider a second variant of this with the water heating energy also removed. The analysis that follows discusses the data for version of the metric that includes water heating energy, but all the key results were also generated using the alternative definition. Equivalent tables and graphs to those which follow, but based the alternative UE/m² metric, are given in Appendix A.

In order to look in more detail at the relationship between the existing EPC rating and UE/m² the data was sorted by EPC rating, then replotted (below) allowing averaging to be applied over groups of 50 homes with similar existing EPC ratings, thus making clearer the trends amongst the large scatter of data points.



Graph 11 – Relationship between the existing UE/m² and EPC rating

A 3-stage linear fit was found to approximate the trend observed in the partially smoothed data, showing a particularly good fit at higher existing EPC ratings.

A key point to note is that although there is a downward trend to the right of the graph, at the top end (EPC >78), there does appear to be a flattening off of the trend. This suggests those homes getting EPC ratings >78 may be doing so primarily by adding non-fabric improvements, like PV.[9] This could be significant if it is indicative of the fact that it is hard to improve the (fabric only) UE/m² metric value beyond this point (~112 kWh/yr/m²). It is also notable that there are very few points on the graph where UE/m² is less than 100 kWh/yr/m². This perhaps indicates that it becomes expensive (or otherwise unattractive from a practical point of view) to retrofit homes to beyond this value of UE/m².

In terms of the current bands, it seems feasible to get a substantial proportion of homes to the UE/m² equivalent bottom of band C (69), where UE/m² is 162 kWh/yr/m²[10], on average, but perhaps disproportionately more challenging to target the middle or top end of band C based on the projection of the trendline on the graph.

The following table shows a number of potential reference points in terms of the existing EPC banding and their UE/m² equivalents, based on the trendline.

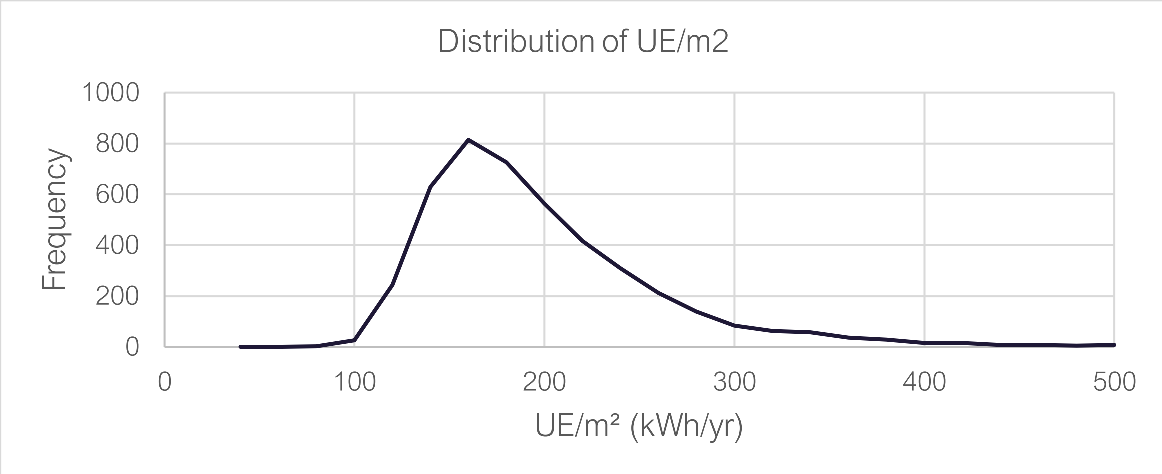
Equivalent to current SAP rating		
Reference point	SAP rating	UE/m² (fit)
Threshold of band C	69	162
Mid-point of band C	74.5	132
Top of band C	80	112
Threshold of band B	81	112
Mid-point of band B	86	112
Top of band B	91	112
Current average	59	218
Current median	64	190

Table 6 - Existing EPC banding and UE/m² equivalents

[9] The UE/m² level at which this levelling off occurs is also dependant on the water heating energy, which will be giving a roughly constant floor level of energy use of around 40 kWh/m² per year.

[10] Using the alternative UE metric (excluding water heating energy) the equivalent value is 120 kWh/yr/m².

The following graph and tables show the (modelled) existing distribution of UE/m² in the Scottish housing stock.



Graph 12 – Existing distribution of UE/m² in the Scottish housing stock

UE/m² at percentile	
0.5%	98
2.5%	111
5.0%	117
25.0%	145
50.0%	172
75.0%	214
95.0%	311
97.5%	354
99.5%	466

Table 7 – UE/m² at percentile

Key stats - UE/m²			
Average	188		
Median	172		
50% are between	145	and	214
90% are between	117	and	311
95% are between	111	and	354
99% are between	98	and	466

Table 8 – UE/m² key statistics

To give further perspective on what level of UE/m² it is possible to achieve an example was run for a dwelling with new-build levels of insulation resulting in a figure of 80 kWh/yr/m². An example with approximately 'passive house' levels of fabric efficiency gave figure of about 40 kWh/yr/m².

On the basis of the above, we would recommend caution in setting a target in terms of UE/m² that is much above the value associated with the bottom of band C – e.g. around 162 kWh/yr/m² until it is clearer how achievable this is in practice.

Further, the analysis indicates that there might be a steep increase in difficulty in improving fabric beyond a level of around 112 kWh/yr/m² with current mass market options.

Effect of heating type on useful energy requirement

A possible shortcoming of using a useful energy metric is that, although it is independent of the heating system fuel factors and efficiency, the heating type can still impact the useful energy requirement via the heating control logic assumed in SAP. The key technology this impacts is heat pumps, where longer running hours are needed if the system's output is low relative to the dwelling's heat requirement. This can only be calculated for heat pumps from the Product Characteristics Database[11] (not from table defaults). It is assumed the unit is large relative to the dwelling when the default is used, although the efficiency used is very conservative, so in practice a better overall result is not achieved in terms of the existing EPC metric.

The following tables show the results of example calculations where the space heating energy requirement can be seen to vary if smaller output heat pumps are used. This increase is substantial (20%) where a very low-output heat pump is used in a home with high heat loss[12].

Poorly insulated 88.8m² semi-detached house average[13]

Heating system	Useful energy requirement per m² (kWh/yr per m²)			
	Space heating	Water heating	TOTAL	% rise
Gas boiler	172	27	**199**	0%
Default heat pump	172	27	**199**	0%
PCDB heat pump 12kW	174	27	**201**	1%
PCDB heat pump 10kW	177	27	**204**	2%
PCDB heat pump 8kW	200	27	**228**	14%
PCDB heat pump 5kW	205	27	**232**	16%
PCDB heat pump 3.5kW	214	27	**241**	21%

Table 9 – Useful energy for poorly insulated 88.8m² semi-detached house average

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[11] A database containing energy performance related data for products used in SAP assessments is available here: Building Energy Performance Assessment - Support Website :Product Characteristics Database (PCDB) (ncm-pcdb.org.uk)

[12] This is because in practice such a heat pump would have to run 24 hours per day in order to provide sufficient heat for much of the heating season.

[13] Uninsulated cavity walls, no loft insulation, no floor insulation, old double glazing.

Fairly well insulated 88.8m² semi-detached house average[14]

Heating system	Useful energy requirement per m² (kWh/yr per m²)			
	Space heating	Water heating	TOTAL	% rise
Gas boiler	71	27	**98**	0%
Default heat pump	71	27	**98**	0%
PCDB heat pump 12kW	72	27	**99**	0%
PCDB heat pump 10kW	72	27	**99**	0%
PCDB heat pump 8kW	72	27	**99**	1%
PCDB heat pump 5kW	72	27	**99**	1%
PCDB heat pump 3.5kW	74	27	**101**	3%

Table 10 – Useful energy for fairly well insulated 88.8m² semi-detached house average

For a more sensibly sized heat pump (which is far more likely in practice – to avoid householder complaints), the uplift is much lower, at just a few percent. And once the same dwelling has been retrofitted (cavity wall insulation, loft insulation, modern glazing) its heat loss is reduced to the extent that even a small heat pump results in a small additional useful energy requirement.

This analysis confirms that while this is a factor and in extreme cases (potentially give unexpectedly poor UE/m² ratings), in more reasonable cases it would have only a small impact.

Impact of improvement measures on EPC metrics

This section describes the results of modelling work looking at the likely impact energy efficiency improvement measures could make to the existing and proposed metrics.

Analysis undertaken

Efficiency metrics were initially calculated using SAP 10.2 for SHCS homes in their as-surveyed (i.e. unimproved) state. The first improvement measure listed in the RdSAP 2012[15] improvement measure table (measure A – loft insulation) was added to all homes to which was applicable (according to RdSAP's logic) and the metrics recalculated. The second improvement measure in the RdSAP table was then added (without removing the first) and the results recalculated. The third measure was then added without removing the first and second), and so on until all applicable measures had been added, cumulatively.

By comparing the modelled results where the first measure was added to the those for the unimproved dwelling the benefit of the first improvement measure was calculated. This was repeated for the full sequence of

[14] Insulated cavity walls, 270mm loft insulation, still no floor insulation, post-2012 double glazing.

[15] RdSAP 2012 improvement measure logic was used because RdSAP 10 is not yet available.

measures applied. The improvement in each metric and the increase in the number of homes achieving a rating of C or higher could then be calculated after each additional improvement measure.

Results

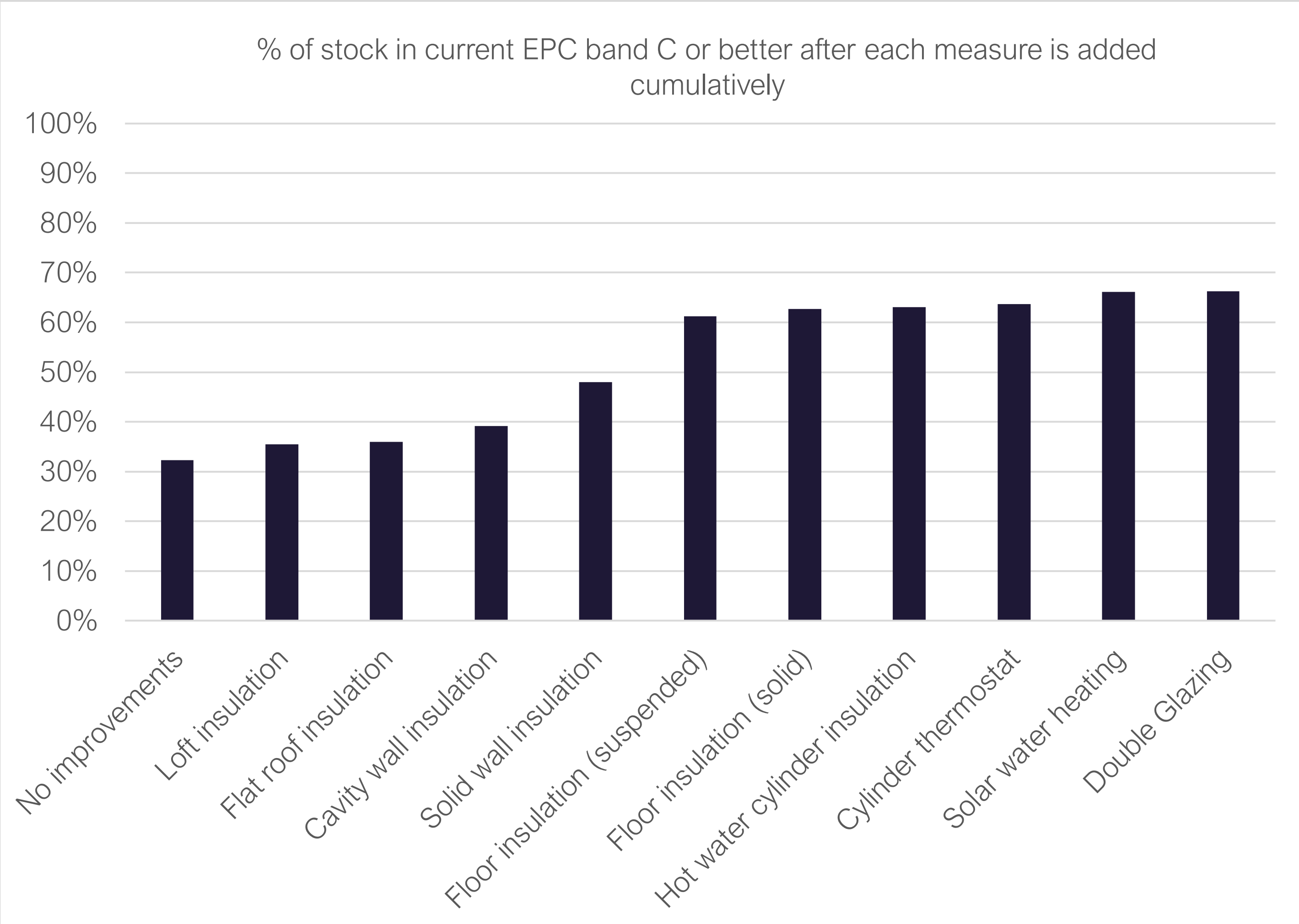
The following table and graph show the potential impact of each improvement measure type on the existing EPC metric and the equivalent UE metric level (162 kWh/yr/m²) for the Scottish housing stock. It can be seen that the improvement potential at the stock level is determined by the saving per home, but also by the number of homes to which the measure can be applied. This explains is why the biggest potential saving is for floor insulation, since a large number of homes can potentially receive this.

	Figures for entire stock				
Cumulatively added improvement measures	% homes able to receive this measure	% in band C or better		% reaching UE/m² target	
		Total	Change	Total	Change
No improvements	-	32.3%	-	40.8%	-
Loft insulation	18.9%	35.5%	3.2%	44.3%	3.5%
Flat roof insulation	1.1%	36.0%	0.5%	44.7%	0.5%
Cavity wall insulation	13.6%	39.1%	3.1%	47.4%	2.6%
Solid wall insulation	19.0%	48.0%	8.9%	57.3%	9.9%
Floor insulation (suspended)	68.3%	61.2%	13.2%	75.1%	17.8%
Floor insulation (solid)	9.0%	62.7%	1.5%	77.9%	2.8%
Hot water cylinder insulation	9.8%	63.1%	1.9%	78.7%	3.5%
Cylinder thermostat	52.4%	63.7%	0.6%	79.3%	0.7%
Solar water heating	78.5%	66.2%	2.5%	85.9%	6.6%
Double Glazing	2.4%	66.3%	0.1%	86.2%	0.3%

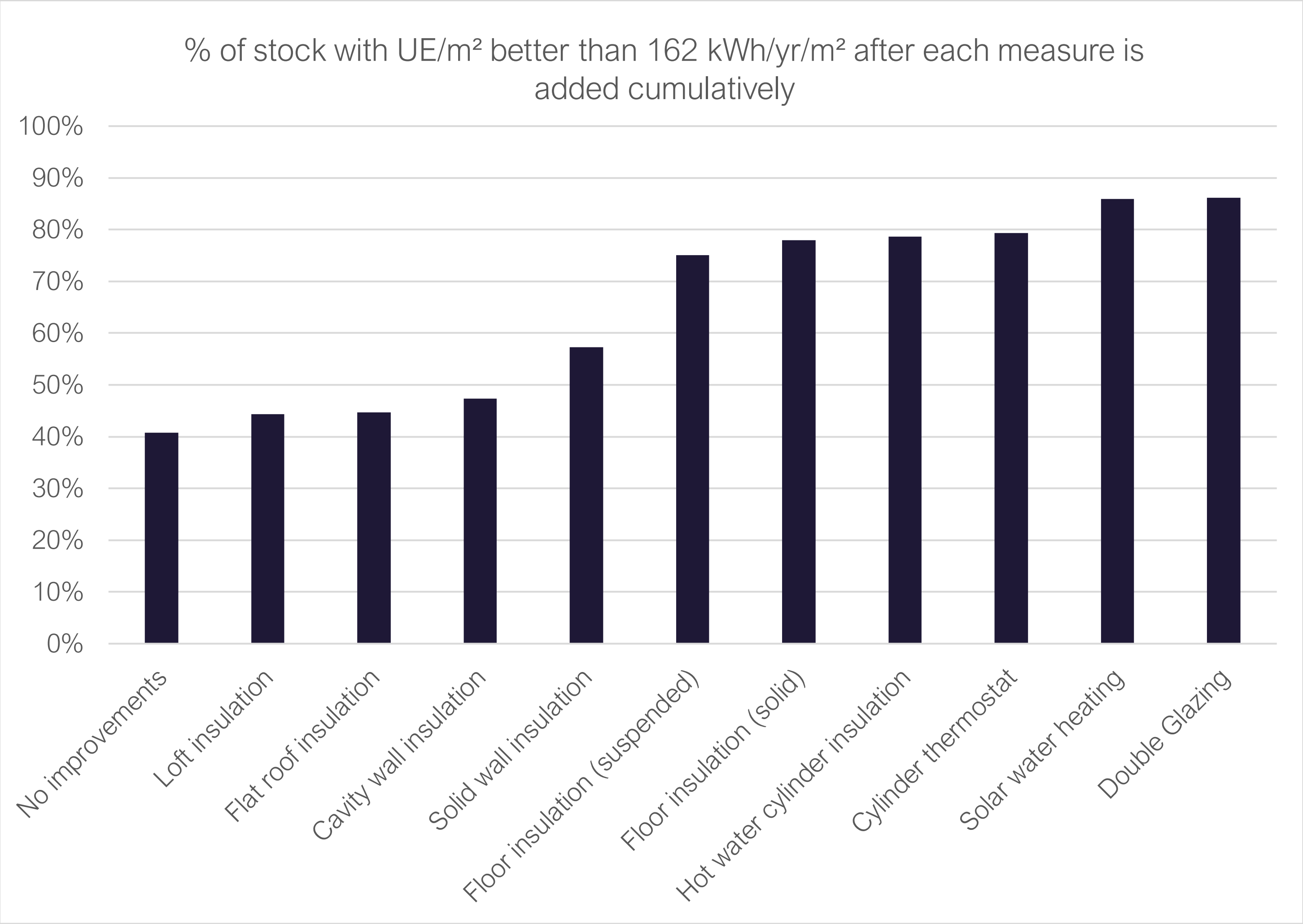
Table 11 – Impact on % in EPC C and UE target of cumulatively added improvement measures for entire stock

	Figures for entire stock								
Cumulatively added improvement measures	% homes able to receive this measure	Mean SAP		Median SAP		Mean UE/m²		Median UE/m²	
		Total	Change	Total	Change	Total	Change	Total	Change
No improvements	-	59.4	-	64	-	187.6	-	172.8	-
Loft insulation	18.9%	60.6	1.2	65	1	179.8	-7.8	168.1	-4.7
Flat roof insulation	1.1%	60.7	0.1	65	0	179.0	-0.8	167.3	-0.8
Cavity wall insulation	13.6%	61.4	0.7	66	1	174.6	-4.4	164.0	-3.3
Solid wall insulation	19.0%	63.4	1.9	68	2	162.5	-12.1	155.5	-8.4
Floor insulation (suspended)	68.3%	66.2	2.9	70	2	145.2	-17.2	138.4	-17.1
Floor insulation (solid)	9.0%	66.6	0.4	71	1	142.7	-2.5	135.9	-2.5
Hot water cylinder insulation	9.8%	66.8	0.6	71	1	142.1	-3.1	135.6	-2.8
Cylinder thermostat	52.4%	66.9	0.1	71	0	141.5	-0.7	134.9	-0.7
Solar water heating	78.5%	67.9	1.0	72	1	133.0	-8.5	126.4	-8.5
Double Glazing	2.4%	68.0	0.1	72	0	132.5	-0.5	125.8	-0.6

Table 12 – Impact on SAP rating and UE of cumulatively added improvement measures for entire stock



Graph 13 – % of stock in current EPC band C or better after each measure is added cumulatively



Graph 14 – % of stock with UE/m² better than 162 kWh/yr/m² after each measure is added cumulatively

Recognising that some measures are considerably more expensive and disruptive to install than others, special consideration was given to the impact of the group of measures considered to be relatively cheap and easy to install (loft insulation, cavity wall insulation, suspended floor insulation).

If just loft insulation and cavity wall insulation were applied to all applicable homes the proportion of homes reaching the threshold UE level of 162 kWh/yr/m² would be raised from 40.8% to 46.9%. Adding suspended floor insulation this would rise to 64.7%.

Mapping to an A to G scale

Apart from recommending an equivalent band C threshold value for the proposed new metric and showing the current distribution for this metric in the Scottish housing stock as background, the rating boundaries for the other rating bands are very much a policy decision for SG to consider – there is no technically 'right' way to do this. For this reason a spreadsheet tool[16] was supplied to SG to help them consider this further, allowing the band boundaries to be adjusted and the resulting change in the distribution of homes in each band to be observed, with and without packages of improvement measures are added.

Conclusions

Currently, an EPC rating for a dwelling is based on its calculated running costs per m² of floor area. This takes into consideration how well insulated the dwelling is, but also the choice of heating system and the type of fuel it uses.

In this report, a number of possible alternative metrics focussed more on fabric efficiency have been considered. Of these, SG's favoured metric was one based on useful energy required per m² of floor area. This includes the amount of heat energy needed to maintain a comfortable internal temperature and the amount of energy required to provide hot water for the dwelling's occupants.

To ensure targets based on the new metric are set at an equivalent level of ambition to those set using the current metric, an analysis was undertaken to model the values obtained by each metric for a representative sample of Scottish homes using data from the Scottish House Condition Survey. By modelling both metrics for each dwelling and determining the relationship between these (on average), it was possible to map a value of the new metric that is equivalent to any level of the existing one. By this approach it was found that homes meeting the threshold level of the current of EPC band C have a useful energy requirement, on average, of **162 kWh/yr/m².** The equivalent value using the alternative UE definition (excluding water heating energy) is **120 kWh/yr/m²** - see Appendix A for details.

The distribution of existing EPC ratings was modelled using SAP 10.2. This showed that about 32% of homes achieve EPC band C or better, while less

[16] "Mapping options for new EPC metric 31-01-2023.xlsx"

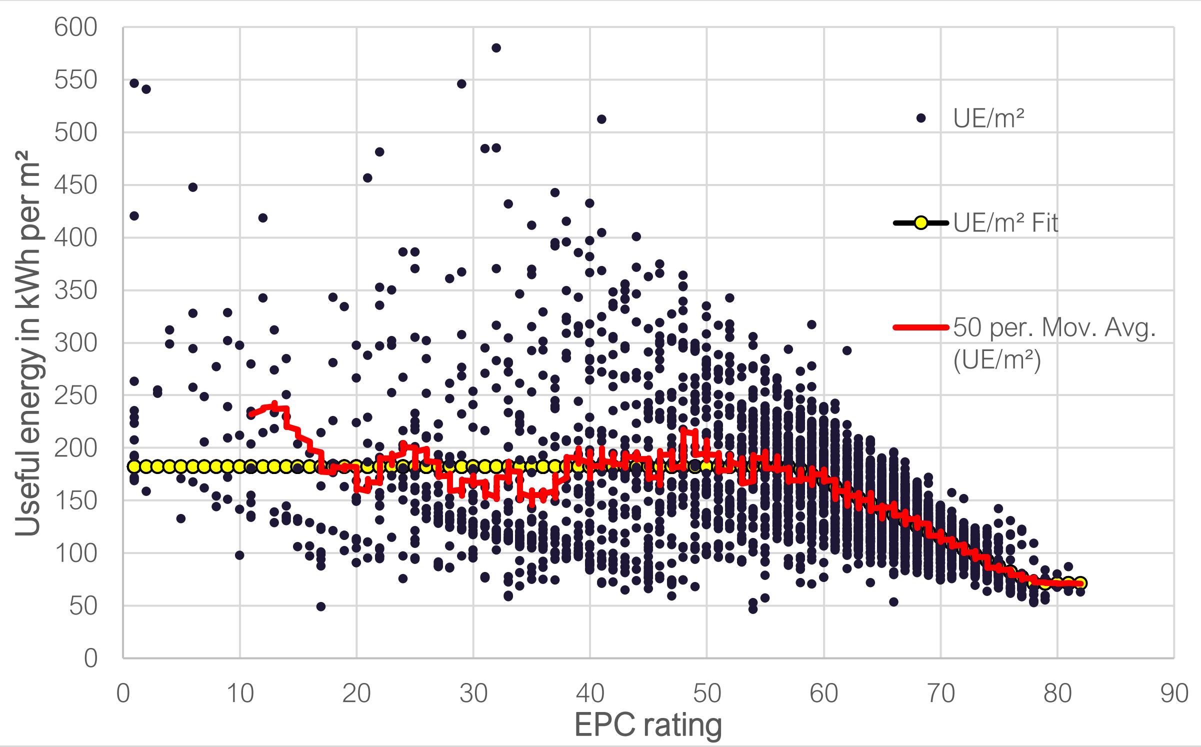
than 1% achieve EPC band B or better. Using the new metric, around 40% of homes would meet or surpass the band C equivalent target of 162 kWh/yr per m^2.

To consider the potential to improve the ratings of homes using the new metric, energy modelling was undertaken to add fabric energy efficiency measures. When a basic set of measures was added (loft insulation, cavity wall insulation) the number of homes reaching the band C equivalent figure of 162 kWh/yr per m^2 threshold increase from 40.8% to 46.9%. Adding suspended floor insulation) increased this to 64.7%. This shows that, while challenging, it is possible using currently available solutions to bring the majority of the Scottish housing stock past the proposed threshold level.

During the analysis it was noted that a significant proportion of the homes receiving highest EPC ratings at present appear to be using means other than further improving fabric insulation (e.g. by having PV panels). These would not improve the rating under the proposed new metric – suggesting the options for achieving high rating (As and Bs) might be limited, or at least expensive – e.g. deep retrofits. It may have to be accepted that bands A and B are going to be occupied mostly by new dwellings.

Appendix A – Graphs and tables for alternative UE/m² metric

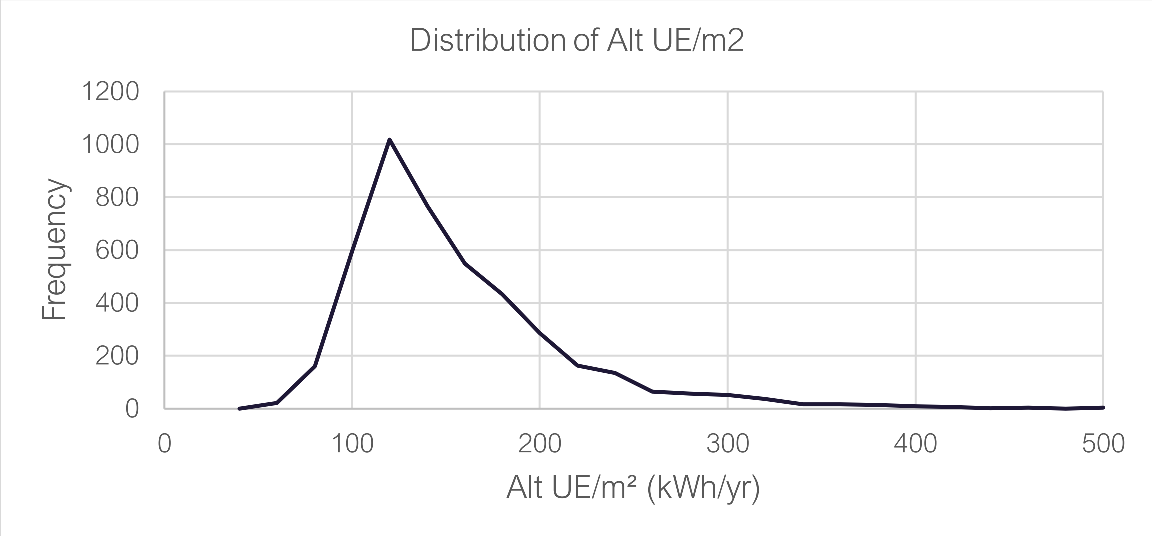
The following graphs and tables are equivalent to the ones shown in the body of this document, but use the alternative definition of UE/m² (with hot water energy excluded) – denoted 'Alt UE/m²'.



Graph A1 – Relationship between Alt UE/m² and the existing EPC rating

Equivalent to current SAP rating		
Reference point	SAP rating	Alt UE/m² (fit)
Threshold of band C	69	120
Mid-point of band C	74.5	90
Top of band C	80	71
Threshold of band B	81	71
Mid-point of band B	86	71
Top of band B	91	71
Current average	59	174
Current median	64	147

Table A1 - Existing EPC banding and Alt UE/m² equivalents



Graph A2 – Existing distribution of Alt UE/m² in the Scottish housing stock

Alt UE/m² at percentile	
0.5%	60
2.5%	75
5.0%	82
25.0%	106
50.0%	129
75.0%	167
95.0%	259
97.5%	301
99.5%	396

Table A2 – Alt UE/m² at percentile

Key stats – Alt UE/m²			
Average	145		
Median	129		
50% are between	106	and	167
90% are between	82	and	259
95% are between	75	and	301
99% are between	60	and	396

Table A3 – Alt UE/m² key statistics

	Figures for entire stock				
Cumulatively added improvement measures	% homes able to receive this measure	% in band C or better		% reaching Alt UE/m² target	
		Total	Change	Total	Change
No improvements	-	32.3%	-	40.8%	-
Loft insulation	18.9%	35.5%	3.2%	45.1%	4.3%
Flat roof insulation	1.1%	36.0%	0.5%	45.5%	0.5%
Cavity wall insulation	13.6%	39.1%	3.1%	49.0%	3.4%
Solid wall insulation	19.0%	48.0%	8.9%	60.9%	11.9%
Floor insulation (suspended)	68.3%	61.2%	13.2%	78.5%	17.6%
Floor insulation (solid)	9.0%	62.7%	1.5%	81.1%	2.6%
Hot water cylinder insulation	9.8%	63.1%	1.9%	81.1%	2.6%
Cylinder thermostat	52.4%	63.7%	0.6%	81.7%	0.6%
Solar water heating	78.5%	66.2%	2.5%	82.0%	0.4%
Double Glazing	2.4%	66.3%	0.1%	82.5%	0.4%

Table A4 – Impact on metrics of cumulatively added improvement measures for entire stock

		Figures for entire stock							
Cumulatively added measures	% homes able to receive measure	Mean SAP		Median SAP		Mean Alt UE/m²		Median Alt UE/m²	
		Total	Change	Total	Change	Total	Change	Total	Change
No improvements	-	59.4	-	64	-	144.7	-	129.3	-
Loft insulation	18.9%	60.6	1.2	65	1	136.9	-7.8	124.7	-4.6
Flat roof insulation	1.1%	60.7	0.1	65	0	136.1	-0.8	124.3	-0.4
Cavity wall insulation	13.6%	61.4	0.7	66	1	131.7	-4.4	120.8	-3.5
Solid wall insulation	19.0%	63.4	1.9	68	2	119.6	-12.1	112.8	-8.0
Floor insulation (suspended)	68.3%	66.2	2.9	70	2	102.4	-17.2	96.4	-16.4
Floor insulation (solid)	9.0%	66.6	0.4	71	1	99.8	-2.5	93.0	-3.3
Hot water cylinder insulation	9.8%	66.8	0.6	71	1	99.9	-2.4	93.1	-3.2
Cylinder thermostat	52.4%	66.9	0.1	71	0	99.5	-0.4	92.7	-0.5
Solar water heating	78.5%	67.9	1.0	72	1	99.3	-0.3	92.4	-0.3
Double Glazing	2.4%	68.0	0.1	72	0	98.8	-0.5	92.0	-0.4

Table A5 – Impact on SAP and EU of cumulatively added improvement measures for entire stock

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