Passivhaus Trust
The UK Passive House Organisation

EPCs as Efficiency Targets

Lowering emissions, raising standards

April 2020

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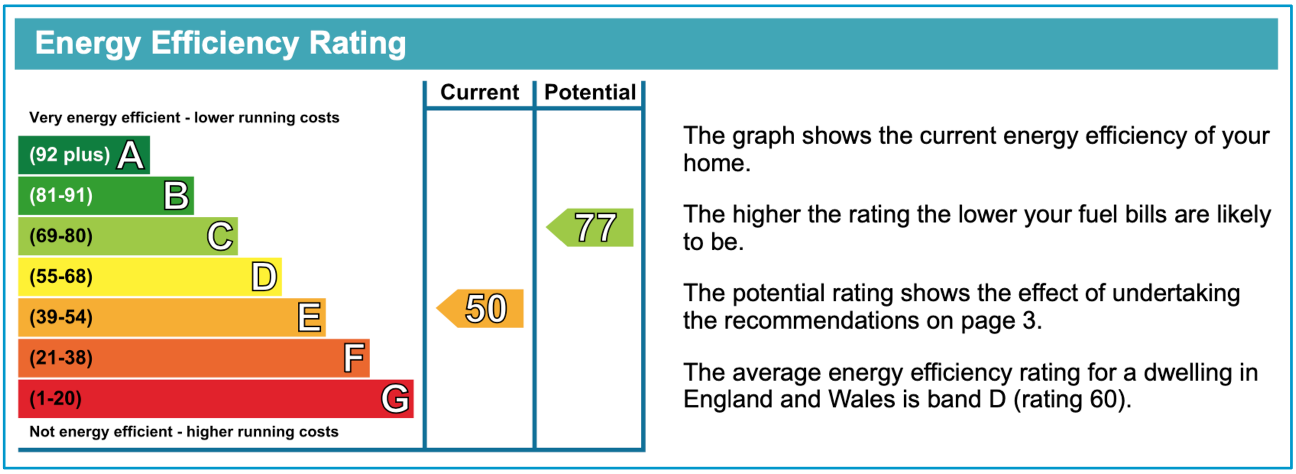
Introduction

All dwellings in the UK have an associated Energy Performance Certificate (EPC). This document provides a headline Energy Efficiency Rating.

Organisations and local authorities searching for a way of setting energy targets for domestic dwellings often consider using the EPC rating as a mechanism to improve energy efficiency. It offers the clean simplicity of specifying a number or level and then setting out a progression over, perhaps, a number of years. However, extending the use of this method beyond pure compliance does not necessarily realise improved performance.

What is the relationship between EPCs, Part L and SAP?

Before continuing further it is important to understand how the various components of our regulatory system interrelate.



An Energy Performance Certificate (EPC) is issued for all new-build dwellings and for existing dwellings at the point of sale or rent. An EPC is intended to give the homeowner an indication of how expensive their home is to run. The headline 'Energy Efficiency Rating' shown on the EPC is therefore actually an energy cost rating. This is a score between 1 and 100 divided into 7 bands, A to G.

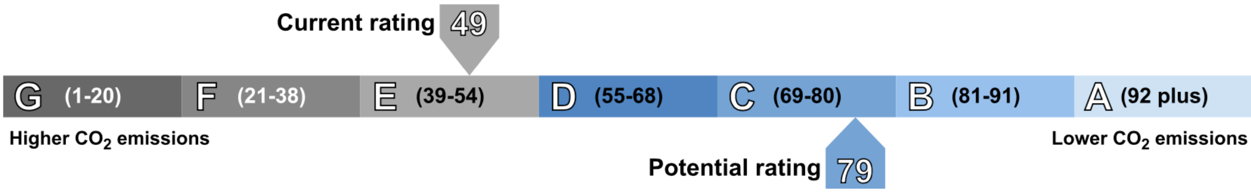
The EPC also includes an environmental impact rating (again a score between 1 and 100 divided into 7 bands) and an indication of space heating demand in kWh/year. However, both these secondary factors are shown on the last page of the EPC and are rarely used or referenced in practice.

About the impact of buildings on the environment

One of the biggest contributors to global warming is carbon dioxide. The energy we use for heating, lighting and power in homes produces over a quarter of the UK's carbon dioxide emissions.

The average household causes about 6 tonnes of carbon dioxide every year. Based on this assessment, your home currently produces approximately 5.1 tonnes of carbon dioxide every year. Adopting the recommendations in this report can reduce emissions and protect the environment. If you were to install these recommendations you could reduce this amount by 3.2 tonnes per year. You could reduce emissions even more by switching to renewable energy sources.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating the less impact it has on the environment.

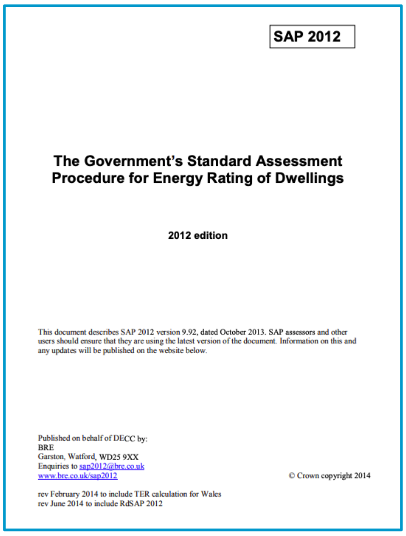


Your home's heat demand

For most homes, the vast majority of energy costs derive from heating the home. Where applicable, this table shows the energy that could be saved in this property by insulating the loft and walls, based on typical energy use (shown within brackets as it is a reduction in energy use).

Heat demand	Existing dwelling	Impact of loft insulation	Impact of cavity wall insulation	Impact of solid wall insulation
Space heating (kWh per year)	13,361	(1,128)	N/A	N/A
Water heating (kWh per year)	3,007			

The EPC is populated using results from a SAP calculation. This is a static building physics modelling method derived from the Building Research Establishment's Domestic Energy Model (BREDEM). It is less flexible than the BREDEM model itself as certain parameters are either fixed or restricted to a specific range. A SAP calculation will model heat loss, internal gains, solar gains, energy balance, carbon emissions, heating, ventilation, internal lighting, cooling and renewable energy sources.


SAP 2012

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

2012 edition

This document describes SAP 2012 version 9.92, dated October 2013. SAP assessors and other users should ensure that they are using the latest version of the document. Information on this and any updates will be published on the website below.

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rev February 2014 to include TER calculation for Wales
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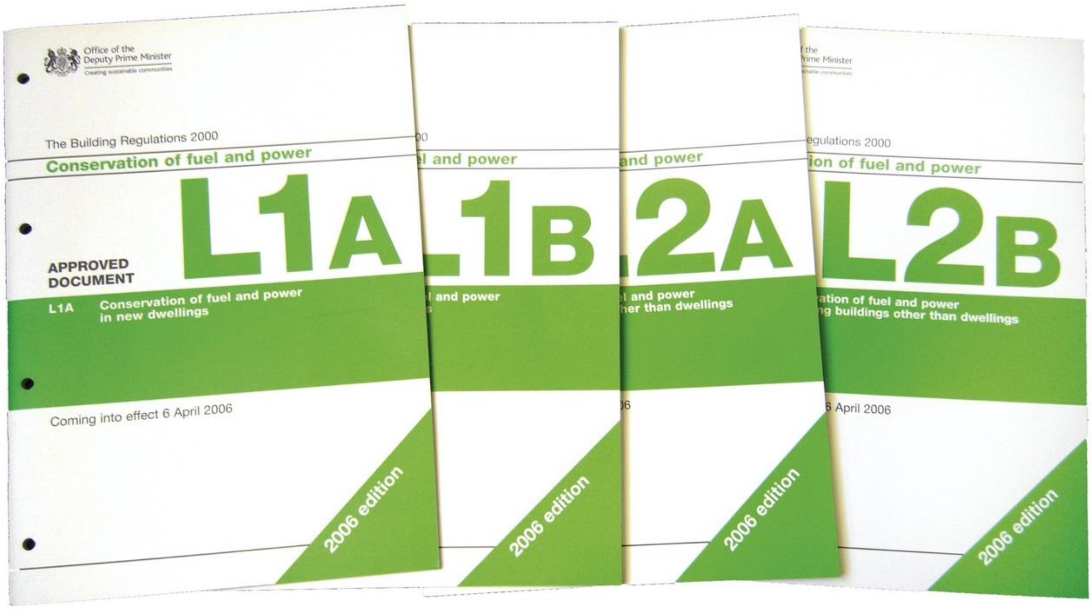
Building Regulations Part L1A sets out how SAP should be used to determine whether a new building will meet current building regulations. There are several criteria – however, the most fundamental part of Part L1A's approach is the 'notional building' method. This method uses a set of pre-defined performance characteristics[1] which are applied to the shape/size and layout of a new building to determine a target emissions level. These performance characteristics have been chosen to reduce emissions levels by a certain percentage from a 1990 baseline and thus have been gradually tightened over the years. The SAP modelling method is used for both the notional and proposed building.

[1] These characteristics include fabric u-values, glazing performance, thermal bridging, air permeability, ventilation strategy, heating and hot water systems.



This use of the notional building method generates a Target Emissions Rate (TER) which the Dwelling Emission Rate (DER) of new building must not exceed. The SAP model also includes a Fabric Energy Efficiency (FEE) calculation which is the amount of energy (in kWh/m^2.year) needed to meet the space heating and cooling demand of the dwelling – i.e. it is a measure of the efficiency of the fabric and ventilation of the dwelling. The notional building values are also used as part of this calculation to generate a Target Fabric Energy Efficiency (TFEE) for the new dwelling's Dwelling Fabric Energy Efficiency (DFEE).

To be compliant with Part L, a new dwelling must not exceed either the TER or the TFEE. However, neither of these targets is shown on the EPC, and they do not need to be achieved for an EPC to be generated.

For existing buildings, an up-to-date EPC is required for sale or rent. This is normally generated using the Reduced SAP (RdSAP) methodology. This method involves a qualified assessor visiting the property and providing a reduced set of inputs for the SAP model. Many of the modelling parameters that can be changed in the full SAP model are either fixed, or linked to a series of look-up tables – e.g. entering a building's age and type will generate a set of standard u-values for floors/walls etc. Thus, a RdSAP model is likely to be less accurate than a full SAP model. For an existing property that is not undergoing renovation, there is no requirement to meet any Part L criteria for the EPC to be generated.

It should be noted that Part L (for new dwellings) is currently under review with proposed further reductions in TER of 20% or 32% on current levels.

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How does SAP work?

SAP is often maligned as not being particularly accurate and not suitable for certain situations. However, we should remember that SAP is intended as a compliance tool and it is Part L which sets out how the tool is to be used. To achieve consistency across the country, SAP necessarily makes a few assumptions:

- It places every dwelling in the centre of the country (East Pennines) so that the climate conditions are always the same
- It uses the floor area of the dwelling to work out a typical number of occupants
- It assumes a typical Mon to Fri and Sat/Sun heating cycle

This means that if you built two houses to exactly the same specification, one in Cornwall occupied by a family of four who are out during the day and one in Scotland with a single occupant working from home, you would get the same EPC rating – which is exactly what SAP is supposed to deliver. However, in reality, the actual energy use of each property is likely to be different.

How accurate is SAP?

We thought we'd test the accuracy of SAP by modelling the same building in both SAP and the Passivhaus Planning Package (PHPP). We know that PHPP models actual energy demand to a high level of accuracy. Several studies have shown that the in-use measurement of space-heating demand in low-energy buildings correlates very closely with predicted demand in PHPP[2]. However, PHPP generally requires more detailed input and more training for modellers/designers. Is SAP as good?

We modelled a 100m^2 two storey building with 15% of its walls used for glazing. It is located in the East Pennines, uses direct electric heating and an immersion heater for hot water. Its fabric u-values, glazing and thermal bridges are specified to achieve the Passivhaus standard. We got the following results:

Energy Use	SAP Result (kWh/a)	PHPP Result (kWh/a)
Space Heating	1997	1939
Domestic Hot Water	1780	1693
Pumps and fans	255	418
Lighting	410	100
Total	**4442**	**4151**

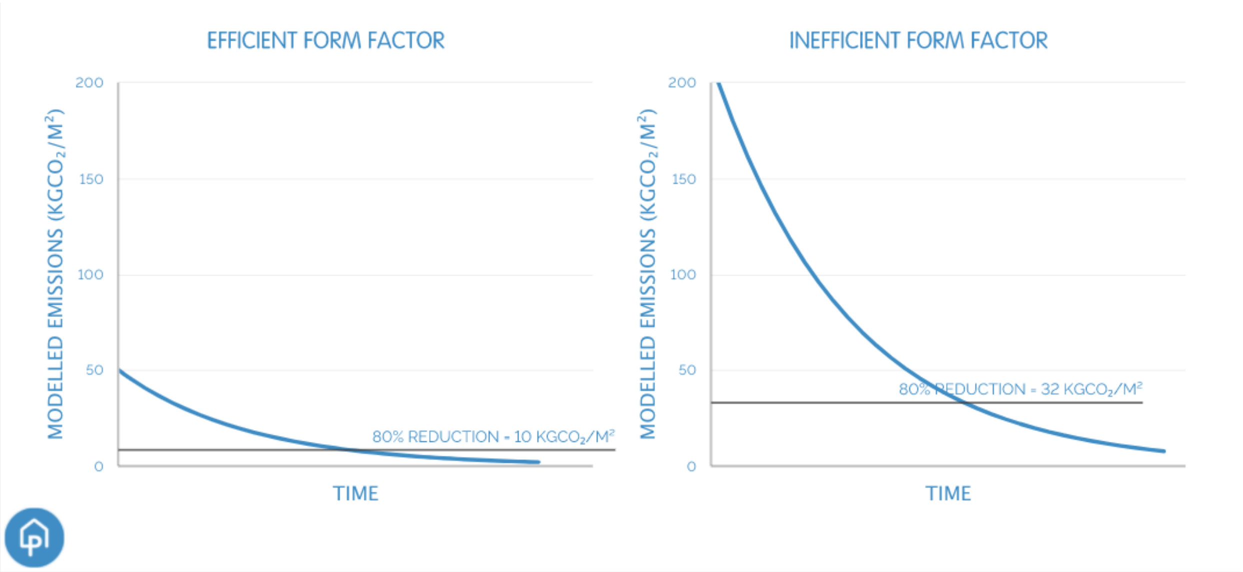
These results show that SAP is actually very close to PHPP for both space heating and hot water in this case. So, SAP is really doing quite a good job at what it is intended to do. However, the more a dwelling diverges from the standard assumptions within SAP, the less accurate the modelling becomes. In particular, Internal Heat Gains and the efficiency of MVHR systems differ significantly from SAP to PHPP. Both of these areas become increasingly important as the fabric performance of the dwelling improves

[2] See, for example, *Passivhaus: the route to zero carbon?* Published March 2019, Appendix 2

Does a better EPC rating equal lower emissions?

Using the EPC rating to try and drive lower emissions is unlikely to work in practice. There are several reasons for this.

First, Part L1A mandates the use of a 'notional building' technique as described above. The problem with this method is that the actual amount of emissions could still be relatively large – particularly if the design of the building is poor. For example, a sprawling, complex shape with lots of glazing will have a relatively high rate of emissions even with reasonably good fabric u-values. This means that you are starting your reductions from, in effect, an arbitrary starting point. This is illustrated in the charts below.



Second, whilst Part L does set a minimum standard for just the fabric elements, these are backstop values designed to prevent poor practice rather than encourage good fabric values. Whilst the Target Fabric Energy Efficiency (TFEE) does force a minnimum level of fabric efficiency, this level is not particularly stringent in most areas and, in particular, the notional building includes only natural ventilation – so extremely high levels of fabric efficiency, achievable only through Mechanical Ventilation with Heat Recovery (MVHR), are not demanded.

Critically, the Dwelling Emission Rate and EPC rating includes the offsetting effect of any photovoltaic panels and so you can achieve a very high EPC rating on a dwelling with an average fabric performance by adding a modest amount of PV generation.

You might say that's acceptable as the electrical energy generated by the PV offsets the energy used by the dwelling. However, the problem is that the emission rate associated with electricity is reducing due to more renewables at national level and is already lower than gas. As this reduces further, the emissions associated with a dwelling which uses gas (e.g. for heating and hot water) will far outweigh the emissions saving from generating electricity. This will be reflected in the environmental impact rating shown on the EPC, but, as mentioned earlier, this is rarely used and is not placed prominently on the EPC.

Finally, the EPC rating itself is a **cost-based** index – i.e. the final score is linked to how much the type of energy used costs. As gas is (and is likely to remain) far cheaper than electricity, a dwelling that uses electricity in preference to gas for heating will be penalised. However, as set out above, with the emissions rate for electricity dropping, an electric-based dwelling will result in a lower rate of emissions.

An example

Consider two dwellings. One is a single storey 100m^2 building with 20% of its walls used for glazing and a 2.5kWp solar PV array on the roof. It uses a gas boiler for heating and hot water. The fabric u-values, glazing and thermal bridging are specified to achieve a minimum pass against the SAP fabric criteria.

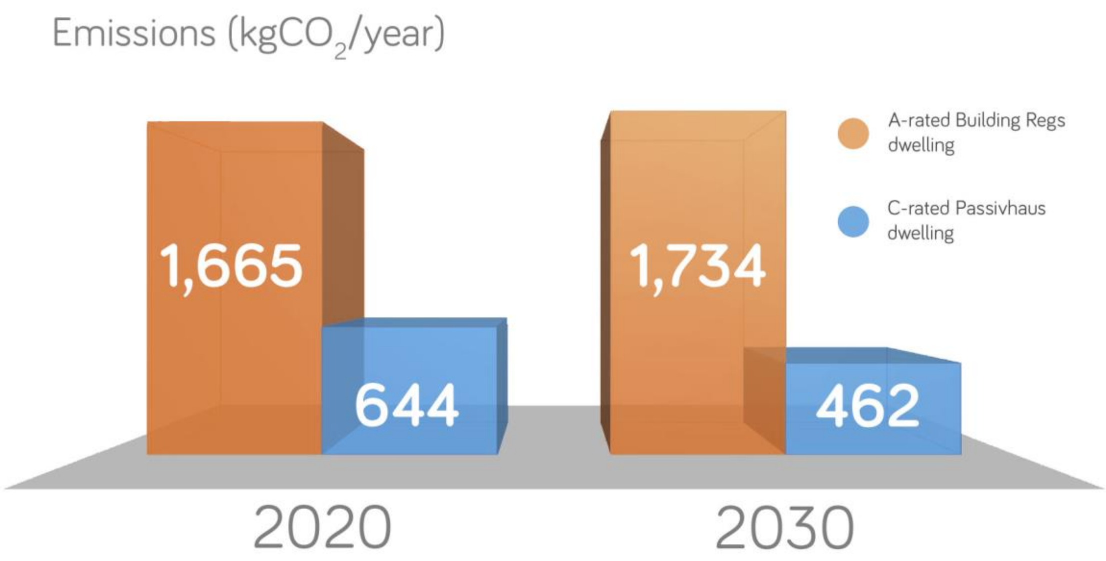
The second is a 100m^2 two storey building with 15% of its walls used for glazing. It has no solar PV, and uses direct electric heating and an immersion heater for hot water. Its fabric u-values, glazing and thermal bridges are specified to achieve the Passivhaus standard.

We've modelled both buildings in SAP and the second one in the Passivhaus modelling software PHPP (to check it passes the Passivhaus criteria). We've then used the SAP results from within the SAP software to calculate the emissions rate for both buildings. We've done this for two different scenarios:

- Using the projected 2020 emissions level for electricity of 0.145 kgCO_2/kWh from the National Grid's Future Energy Scenarios and the latest proposed emissions figure from SAP 10.1 for gas of 0.21 kgCO_2/kWh.

- Using the projected 2030 emissions level for electricity of 0.102 kgCO_2/kWh, also taken from the National Grid's Future Energy Scenarios. Gas emissions are assumed to remain as for 2020.

The illustration and table below show the relative EPC scores and net emissions levels of the two buildings for both scenarios.



Dwelling	EPC Rating	Emission Rate with 2020 SAP Figures (kgCO_2/year)	Emission Rate with 2030 Projections (kgCO_2/year)
Single storey 100m^2 with gas heating and hot water. Building Regulations fabric standards. 2.5kWp of PV.	A(93)	1665	1734
Two storey 100m^2 with electric heating and hot water. Passivhaus fabric standards. No PV.	C(80)	644	462

The results show that the two storey building with its more efficient shape, better fabric values and all electric heating/hot water produces around 60% less emissions in 2020 which increases to more than 70% less by 2030. The net emissions from the single storey dwelling actually increase over the same period as the PV has less of an offset effect against the gas.

This shows that using an EPC rating to try and achieve carbon emissions reductions is unlikely to have the desired effect, as the cheapest way to achieve a higher EPC rating is to add even a small amount of PV. Instead, we need to find a way to drive improvements in the fabric performance, which will have a much more significant and long-lasting effect and will also be independent of energy sources whose carbon intensities are constantly changing over time.

This conclusion is backed up by real-world monitoring. The chart below shows the measured total energy use and EPC band for a sample of 410 homes. The SAP calculation does not include detailed modelling of occupancy behaviour, nor does it include unregulated energy use (i.e. appliances and plug loads), so a discrepancy between modelled energy and actual energy use is expected. However, with space heating constituting by far the largest percentage of energy demand in most dwellings, some sort of positive correlation between EPC band and overall energy use would be expected. In fact, there is a very weak correlation with the best performing Band E home out-performing the best performing Band B dwelling. Whilst there may be other underlying reasons behind this data such as errors in EPC assessments and occupant behaviour, it neatly illustrates the futility of using the EPC rating as a measure of energy efficiency.

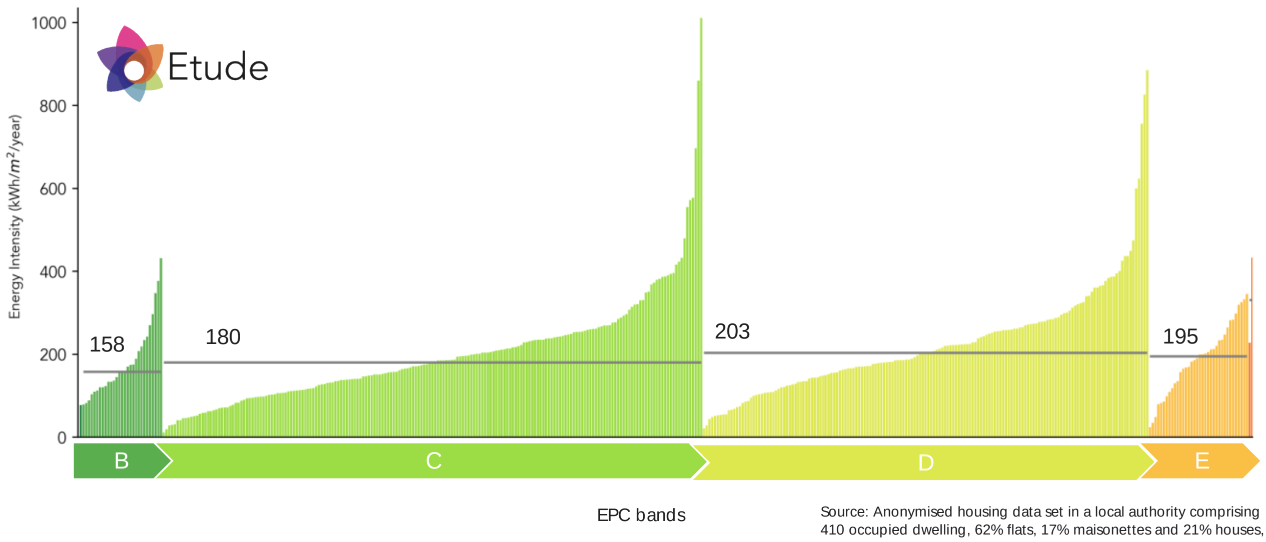


Figure 1: Illustration of disconnect between EPC bands and actual energy consumption in the domestic sector: Energy intensity of 410 homes across a local authority in England, by EPC rating. Each bar represents a single dwelling's energy intensity over the course of a year (credit: Etude)

So what's the alternative?

So, if you want to drive energy efficiency, and EPC ratings are not the answer, then what options are available? As mentioned above, the EPC rating is just one of the outputs from the SAP model. A full SAP model[3] produces several other outputs which would actually be more useful to drive energy efficiency. The SAP methodology is in the public domain[4] and the accredited software packages that undertake the SAP calculation produce detailed output reports which are required to demonstrate compliance with Building Regulations. Included in these reports is a definitive number for the space heating demand of the building, expressed in kWh/m^2.year. Whilst this number has been calculated by the SAP methodology, it is equivalent to the space heating demand calculated in a PHPP model. This number is also not related to the notional building method – it is simply the amount of energy required to heat the building over the course of the year. It will be higher for a building with an inefficient form factor and worse fabric performance, it is independent of any add-on renewable energy generation, and it is unaffected by fluctuations in price, so doesn't have the disadvantages of the EPC rating.

Is it accurate enough? The calculation above shows that a SAP model can correlate well with a PHPP model, but certain building features prevalent in low-energy dwellings[5], will make the modelling less accurate. Furthermore, Reduced SAP (RdSAP) models are likely to demonstrate significant variance as a result of the increased number of underlying assumptions. So, this indication of space heating demand may not always be as accurate as we would like. However, with no other national methodology available, we have to rely on the output from the tools we have.

Setting a target for this definitive number, the space heating demand, offers a viable potential alternative to using EPC ratings to drive efficiency. As space heating demand is affected primarily by the quality of the fabric, ventilation strategy and the efficiency of form/orientation[6], this is, in effect, mandating that the fabric of the building meet minimum efficiency targets. To ensure that the dwelling is also affordable to run, the EPC rating could be retained to complement this metric.

A second advantage of using a definitive energy demand target is the actual energy use can then be predicted and, when offset by sufficient renewable energy generation, either locally or regionally, it can be shown that a net zero target has been achieved.

Analysis by the Passivhaus Trust[7] has shown that new dwellings are currently being designed with a predicted average space heating demand of around 54 kWh/m2.year.

So, an example of a staged policy approach to target dwelling energy efficiency might be:

	(2019)	2020	2022	2024	2026
Space Heating Demand (kWh/m^2.year)	55	45	30	20	15
Minimum EPC Rating	C	C	B	B	A

[3] As noted earlier, a full SAP model is likely to be more accurate than a Reduced SAP (RdSAP) model.
[4] See https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf accessed 20 Mar 2020
[5] Such as: very low thermal bridging values, high performance triple glazing and Mechanical Ventilation Systems with Heat Recovery.
[6] Space heating demand is also affected by internal heat gains, but these are fixed in the SAP model and thus are not part of a designer's remit.
[7] See *Passivhaus: the route to zero carbon?* Published March 2019

Conclusion

SAP is a modelling procedure that produces a number of potentially useful outputs and is used in several different ways for different purposes. It is actually very good at what it is intended to be – a compliance tool.

However, the current Part L and EPC methodology means that an overall cost-based rating for the EPC, based on the notional building method, is the headline metric which is being used to try and drive energy efficiency. As the carbon emissions associated with expensive electricity continue to reduce, this makes the EPC rating system increasingly inaccurate and means that a highly rated dwelling could potentially produce a very high rate of emissions.

Organisations seeking to drive improvements in energy efficiency should therefore use **space heating demand** as the primary metric, derived either from a SAP or PHPP calculation, alongside the EPC's cost-based index, in order to drive the sector towards buildings which are both affordable, highly energy efficient and low in emissions.

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