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Which Way Up – Advance Headline Findings

A report by the Energy Saving Trust for WWF and Friends of the Earth

February 2011

About the Energy Saving Trust

The Energy Saving Trust is the UK's leading impartial organisation helping people save energy and reduce carbon emissions. We do this by directly supporting consumers to take action, helping local authorities and communities to save energy, using our expert insight and knowledge and providing quality assurance for goods and services. Everything we do is about enabling people to save energy in the most cost effective way possible; either directly through our impartial advice network and website or indirectly through our work with partners.

This work was carried out by the Energy Saving Trust on behalf of WWF and Friends of the Earth. The report was written by Frances Downy with analysis by Cate Lyon and Greg Shreeve and input from David Weatherall.

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1. Introduction

WWF and Friends of the Earth wanted to explore two different scenarios for improving the British housing stock. The first looks at improving the worst performing homes in the private rented sector and the whole British housing stock. The second looks at achieving a 60% CO_2 reduction in 7 million homes by 2020 from current levels. The analysis gives an indication of what the CO_2 savings are across the whole housing stock. The results give the energy, CO_2 and fuel bill savings of each scenario along with the cost.

This advance report highlights the finding from the first half of the analysis – improving the worst performing homes in the British housing stock. This work was undertaken based on English Housing Survey 2008 data and used the Energy Saving Trust's Housing Stock Refurbishment Calculator. This investigated the improvement of three areas of the housing stock, based on moving homes out of the lowest Energy Performance Certificate (EPC) bands:

i. Bring all private rented sector homes banded F & G on an EPC in Great Britain to a minimum E-banding;
ii. Bring all private rented sector homes banded E, F & G on an EPC in Great Britain to a minimum D banding;
iii. Bring all homes banded E, F & G on an EPC in Great Britain to a minimum D-banding.

Context
The Climate Change Act and Climate Change (Scotland) Act targets of a 34% and 42% reduction (respectively) in greenhouse gas emissions by 2020 and an 80% reduction by 2050 from 1990 levels, provide clear targets for reducing UK emissions. Home energy use is responsible for over a quarter of these emissions and it is therefore expected that home energy use will also be reduced by 80% as well.

One way to go about this is to tackle the worst performing homes first – those with an E, F or G ratings on their Energy Performance Certificates. The occupiers of these homes often have a greater risk of being in fuel poverty. The private rented sector in particular has a higher proportion of homes with F and G ratings and private landlords have little incentive to improve the properties. Improving the worst performing homes will not only help meet carbon targets but also fuel poverty targets and bring wider benefits by improving the quality of life for those people in damp, cold homes and therefore reduce health and social services costs.

The Energy Bill 2010-2011 proposes to give enabling powers to the Secretary of State and Scottish Ministers to make future regulations requiring private landlords to make reasonable energy efficiency improvements to their buildings where tenants request it.

In the social sector, Decent Homes; the Welsh Housing Quality Standard and the Scottish Housing Quality Standard have improved the standard of social housing and Scottish Government have committed to an energy efficiency standard beyond SHQS for social housing.

2. Approach

To analyse the energy, carbon, cost and economic impacts of the two scenarios a variety of Energy Saving Trust models were used: Housing Stock Refurbishment Calculator; the Housing Energy Model and the Economic Impact Model, alongside English Housing Survey 2008 data.

DISCLAIMER
We have endeavoured to ensure that the content of this report is accurate and representative of housing in Great Britain. However, all outputs are based on modelled data, therefore all results should be interpreted with some degree of caution and not be treated as definitive.

We have used two different housing models on this project - EST's best available tools to answer the two areas of study. We have aligned these models as closely as possible. The best available data at the time was used for each model but costs and efficiencies may change over time, particularly where the market for a technology is in development. Modelling is also used to calculate the SAP ratings that are given to homes in the English Housing Survey, the dataset that formed the basis of our analysis. We have therefore had to make some assumptions to align SAP rating generated by our tools with the EHS findings.

Our results are calculated based on scaling up from English Housing Survey figures to represent the British housing stock (the English housing stock makes up 86% of households in Britain). The results cannot be disaggregated to make inferences about individual nations.

2.1 Models used

Housing Stock Refurbishment Calculator

The refurbishment calculator enables a profile of the housing stock to be input and allows optimisation analysis for carbon reduction. It is based on the T-zero tool which has been developed by a widely respected consortium and customised for the Energy Saving Trust to analyse large stock populations. The SAP based tool focuses on the physical measures that can be carried out in each house type and takes account of any interactions between measures – for example reducing assumed carbon savings for improving a property's heating system efficiency once insulation measures are installed. The model assumes that optimisation of each property is carried out over one year and is designed to inform four key areas:

- What is the baseline of the housing stock in terms of CO_2 emissions, fuel bills and SAP ratings?
- What are the most effective refurbishment options to implement across a housing stock?
- How much will the identified carbon reduction scheme cost?
- What are the benefits of the identified scheme in terms of CO_2 reduction, fuel bill reduction, improvement in SAP ratings etc. for the whole stock and individual house types?

Domestic Sustainable Energy Economic Impact Model[1]

The Energy Saving Trust Economic Impacts Model assesses the economic impacts associated with installing energy efficiency and microgeneration measures. It calculates Gross Value Added (GVA), sales and jobs supported (in the form of full-time equivalency) from installing different low carbon measures to homes. The direct impacts only are given which are:

Direct Effects

- value of direct sales– the number of measures multiplied by the total cost of installation
- the levels of employment directly supported by installation demand (i.e. site preparation. architectural or design services, plumbing and installation)
- and the GVA directly created – the levels of employment supported, multiplied by the average GVA/head for installation

2.2 Data used

English Housing Survey 2008

Data from the English Housing Survey (EHS) 2008 was used to identify those types of homes with an E, F or G EPC rating. The data was analysed to provide information on the built form of properties and current energy efficiency measures installed which was then input into the Refurbishment Calculator. The new survey also provides data on the people living in each house type, their tenure and their levels of fuel poverty, which was used to build a number of case studies looking at the potential changes in fuel poverty. Final results were then scaled up to Great Britain household numbers to estimate the impact of these improvements at a GB-wide scale.

3. EPC Banding Analysis

The analysis examined three scenarios for removing the worst homes from the British housing stock:

i. Bringing all private rented sector homes banded F & G on an EPC in Britain to a minimum E-banding
ii. Bringing all private rented sector homes banded E, F & G on an EPC in Britain to a minimum D-banding
iii. Bringing all homes banded E, F & G on an EPC in Britain to a minimum D-banding

The English Housing Stock

The English housing stock makes up 86% of households in Britain. To give an idea of what the English housing stock currently looks like in terms of energy efficiency, the SAP bandings are given in table 1 below.

[1] *Further details of how the model works and the assumptions made can be found in the Economic Impacts Model: Introductory Note and the Economic Impacts Model: Data and Assumptions; available on request.*

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Table 1 SAP bands of current English housing stock

	All homes		Private rented sector	
SAP Band	**Number**	**% of the stock**	**Number**	**% of the stock**
B	69,000	0.3%	14,000	0.5%
C	2.17m	10%	338,000	11%
D	7.61m	36%	1.02m	34%
E	8.04m	38%	1.05m	35%
F	2.79m	13%	402,000	13%
G	714,000	3%	173,000	6%
Total	21.4m	100%	3.00m	100%

Those homes that are rated F or G on an EPC and are the most inefficient make up around 16.4% of the English housing stock. The private rented sector, which makes up 14% of the total stock in England has a greater proportion of G rated homes, and almost 20% of the private rented stock are F or G rated. E rated homes are the most common in the whole stock and the private rented stock.

3.1 Methodology

The English Housing Survey 2008 data was analysed to identify: private rented sector F & G rated homes for analysis i; private rented sector E, F and G for analysis ii; and all E, F and G rated homes for analysis iii. The Energy Saving Trust identified the key characteristics required for analysis using the Housing Stock Refurbishment Calculator:

- **Wall type**: solid wall, cavity wall,
- **Wall insulation:** cavity wall insulation, external wall insulation, internal wall insulation
- **Type of house**: detached, semi-detached, end terrace, terrace, detached bungalow, attached bungalow and bottom floor flat
- **Number of bedrooms**: 1,2,3
- **Level of loft insulation**: not applicable or 0-25mm, 50-100mm, greater than 100mm
- **Glazing**: single glazed, double glazed (6mm-12mm)
- **Draught proofing**: none, present
- **Primary heating system**: old gas boiler, old gas combi boiler, gas condensing boiler, gas combi condensing boiler, old oil boiler, old oil combi boiler, oil condensing boiler, oil combi condensing boiler, electric storage heater, electric panel heater[2], open coal fire, biomass boiler
- **Presence/absence of a loft space**

These factors were chosen to align with the Refurbishment Calculator[3]. By exploring all combinations of these parameters sets of house types were created: for analyses A, B and C there were 196, 323 and 601 house types analysed respectively.

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[2] On peak electric panel heaters were not available as a measure in the model, therefore these homes were modelled as having peak under-floor heating which gave comparable cost, CO_2 and energy values.

[3] Where parameters did not exactly align, the option that gave the best comparable CO2, energy and measure recommendations was chosen. These were mapped through the analysis to ensure the measures suggested to improve the home were sensible.

The house types were uploaded into the Refurbishment Calculator and their average SAP rating was calculated.

The house types were analysed using the Refurbishment Calculator to assess the most cost effective options needed to bring them to the required EPC band. These were sense checked once they had been run through the model.

For a minority of house types the Refurbishment Calculator assigned a different EPC banding to those assigned to the same house type by the English Housing Survey. This is because the EHS and the Refurbishment Calculator use different SAP-based methodologies in calculating EPC bandings. The EHS uses a modified version of the SAP methodology. The Refurbishment Calculator uses a reduced data SAP analysis (using a reduced data set is necessary to make it possible to carry out calculations on the dataset).

For those homes where the EPC band assigned by the Refurbishment Calculator differed from the EHS banding, the EHS EPC band was used as a basis for setting a level for improvement for that house type in the Refurbishment Calculator. For example where a house type was described as ‘E’ by the EHS and ‘D’ rated by the Refurbishment Calculator, it was assumed to be a mid-level E rating and a new target SAP rating was calculated accordingly. The house types, with their new target SAP ratings were input into the Refurbishment Calculator which analysed the most cost effective measures to improve the home by the required number of SAP points.

The energy efficiency & renewable energy measures available in the Refurbishment Calculator are:

- Low energy light bulb (CFL)
- Cavity wall insulation
- Loft insulation (full or top-up)
- Draught proofing
- Double glazing (16mm)
- Gas condensing boiler/gas combi condensing boiler
- Oil condensing boiler/oil combi condensing boiler
- Internal solid wall insulation
- External solid wall insulation
- Flexible insulated lining
- Insulating render
- Biomass boiler
- Ground source heat pump
- Air source heat pump
- Solar water heating panel (solar thermal)
- Solar photovoltaics panel

Flexible insulated lining is a flexible latex foam thermal lining with resilient glass fibre mat facing, which can be applied to the internal surface of walls. It is usually installed to combat surface condensation and mould growth, although it does also have insulating properties. Flexible insulated linings are a low-cost and simpler alternative to rigid internal insulation although they offer a much smaller improvement in wall insulation. It is a compromise measure where internal solid wall insulation is too expensive. Its use in this analysis has been limited (to 2% of the homes treated) and the Energy Saving Trust would always recommend internal wall insulation where feasible.

Insulating render is a cement-based wall render incorporating insulation material, applied to the exterior of solid-wall homes to improve insulation and it is not as effective at insulating walls as external wall insulation. Again, it is a compromise measures in place of external solid wall insulation and would not normally be recommended by the Energy Saving Trust, therefore its use in this analysis has been very limited (to 1% of the homes treated).

3.2 Results

Improving private rented sector F & G homes gives the greatest average fuel bill savings out of the three analyses because the homes being improved have the highest energy demand. 74% of these homes can be brought up to an E banding for less than £3,500.

Improving private rented sector (PRS) E, F & G rated homes has the greatest average cost per house as many of these homes require expensive measures to bring them up to a D rating, however 71% of these homes can be brought up to a D rating for less than £3,500.

Improving all E, F & G rated homes would significantly reduce housing stock emissions. 81% of these homes can be brought up to a D rating for less than £3,500.

Headline findings

Table 2. Headline findings from improving SAP bands

	Improving PRS F & G	Improving PRS E, F & G	Improving all E, F & G
No. of homes[4]	754,000	2.03 m	14.06 m
Average SAP rating before improvement	31 (F)	41 (E)	44 (E)
Average SAP rating after improvement	47 (E)	61 (D)	61 (D)
Total cost of improvements	£1.91 billion	£7.92 billion	£36.9 billion
Average cost per improved home	£2,535	£3,890	£2,623
Total annual CO_2 saved	1.87 $MtCO_2$	5.00 $MtCO_2$	30.34 $MtCO_2$
Average annual CO_2 saving per improved home	2.48 tCO_2	2.46 tCO_2	2.16 tCO_2
Total annual fuel bill reduction	£368 million	£968 million	£6.15 billion
Average annual fuel bill reduction per improved home	£488	£476	£437

It is important when looking at the results to be aware of the limitations of the SAP methodology, upon which the Refurbishment Calculator and EHS calculations are based. SAP is used to calculate both energy efficiency and CO2 emissions and tends to provide

[4] *Numbers have been scaled up for Britain and therefore differ from the numbers given in the English housing stock breakdown*

higher estimates of energy requirements and associated emissions for heating, lighting and ventilating dwellings than estimates derived from actual household energy consumption. This is primarily because the assumed heating regime (achieving a temperature of 21°C in the living area of the dwelling and 18°C in the rest of the dwelling for a standard number of hours), and the assumed hot water and lighting requirements (depending on a level of occupancy determined by the floor area of the home rather than actual occupancy) are more likely to result in an overall over estimation than under estimation of actual energy consumption for most dwellings. However, such standardised assumptions are necessary in order to compare the energy performance of one part of the housing stock with another and over time[5].

The average SAP ratings achieved for improving E, F & G rated private rented sector homes and all homes were relatively high at a mid D (a D banding goes from SAP 51-65). This is because the model gradually adds measures to the home to try and raise it to a D. Raising a home to a D rating (as opposed to an E) can require more advanced measures which although often more expensive, also significantly improve a home's SAP rating, and the addition of a single measure can take that home to a higher SAP rating and sometimes even to a C rating. Therefore the average SAP rating is relatively high.

CO_2 Emissions

It is assumed all measures are installed in one year, therefore the total CO2 emissions here are the amounts saved if all measures were installed this year. To put the savings into context, improving all E, F & G rated homes would reduce housing stock emissions down to 115.3Mt CO_2, as shown by the last column in figure 1, which is a 21% reduction from 2008 levels, and a 26% reduction on 1990 levels.

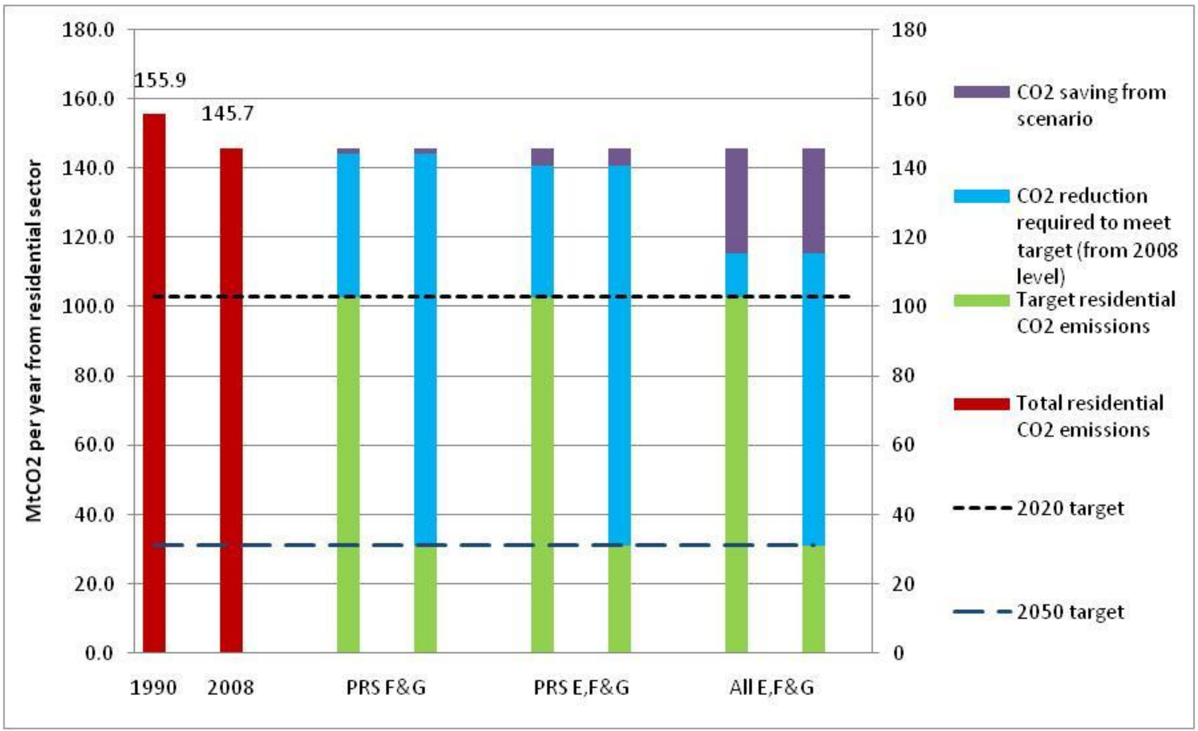

Figure 1 CO2 emissions reduction of each scenario compared to 1990 and 2008 residential emission levels. PRS = private rented sector

[5] *DCLG (2010) Energy efficiency and energy improvements – English Housing Survey technical note.*http://www.communities.gov.uk/documents/housing/pdf/1799108.pdf

CO_2 savings are annual emission reductions and caution should be used when comparing these reductions against future emissions reduction targets as CO_2 savings may not remain the same each year. Factors such as grid decarbonisation or continuing trends in domestic heating and electricity use could impact annual CO_2 savings.

Cost

The cost of improvements to all homes does not include any subsidies (e.g. CERT). UK average costs were used; however these will vary across the country, particularly in more remote areas where there is little installer competition. Costs cover a typical installation and additional costs such as redecorating or rewiring after internal solid wall insulation or flexible insulated lining are not included. In the case of cavity walls it is assumed they are all easy to fill and additional costs incurred for those homes that are hard to fill have not been included. A proportion of the total costs could be considered standard maintenance costs, for example when a boiler breaks down it will be replaced with a boiler that meets Building Regulations and is much more efficient than the average, additionally all light fittings will in time be replaced with energy efficient ones.

Fuel bill savings do not assume any income from the Feed in Tariff or Renewable Heat Incentive. As noted previously, it is assumed all households heat their homes to 18°C and 21°C in the living room before and after measures are installed. However it is likely that some households are under-heating their homes and therefore will choose to spend some of their fuel bill savings on more fuel to increase the temperature of their home to a healthier level. The levels of under-heating could potentially be greater in the E, F and G homes analysed in this analysis as a greater proportion of these homes are in fuel poverty. Across England 15.6% of households are in fuel poverty, however this rises to 21.5% for E, F and G rated properties, and to 45.5% for those households living in private rented sector F and G rated properties. Three quarters of fuel poor households live in an E, F or G rated home.

The measures required to bring homes up to the required SAP band in each analysis can be split down into five cost bandings:

Band 1 – Cheap measures – less than £900

The key measures are loft and cavity wall insulation, and some homes already close to the required rating can be brought up simply through installing CFLs.

Band 2 – Flexible insulated lining £1,000 – £2,500

A small number of homes had flexible insulated lining installed and also required loft insulation and/or draught proofing.

Band 3 – Upgrading boilers - £2,500 - £3,500

Changing old oil and gas boilers to modern condensing boilers can make a significant improvement to the SAP rating of a home for a reasonable cost. A small proportion of these homes are flats that require wall insulation which is relatively cheap for these homes as they often have small areas of externally facing walls to insulate.

Band 4 -Solid wall insulation & solar - £3,500 - £7,250

As the cost increases so does the combination of measures that could be applied to a home, but the predominant measures in this band are internal solid wall insulation on terraced or semi-detached homes, solar water heating, and/or a small solar photovoltaic panel. Sometimes these measures are accompanied by basic insulation measures (loft insulation or draught proofing) which are not sufficient on their own to achieve the necessary EPC rating but without which the home does not quite reach the required band.

Band 5 – Fuel switching £7,250 +

The majority of homes in this band require fuel switching involving expensive changes to the heating system. A small number of these homes also require wall insulation or double glazing often accompanied by solar water heating. A small sub set of this group require either ground source heat pumps or a combination of very expensive measures and therefore have costs of over £23,000.

The percentage of homes that fall under each band for each analysis are set out in table 3.

Table 3 – Percentage of homes brought up to the required SAP for each analysis

	Percentage of homes brought up		
Band	**PRS F&G to E**	**PRS E,F&G to D**	**All E, F&G to D**
1 - less than £900	37%	32%	46%
2 - £1,000 to £2,500	1%	2%	1%
3 - £2,500 to £3,500	36%	36%	34%
4 - £3,500 to £7,250	21%	4%	7%
5 - over £7,500	5%	25%	12%

In the English Housing Survey 2008 figures, the average SAP rating for a home in the private rented sector was higher than the average SAP rating for a home in the owner occupied sector, the first time this trend has been seen in the EHS (and its predecessor, the English House Condition Survey). However, this hides a split in the private rented sector market. During the buy-to-let boom in the mid-1990s, many modern homes with high SAP ratings were bought, but there is a large number of homes with poor thermal performance at the other end of the scale, which this analysis highlights as being very expensive to treat.

In analyses (i) where private rented homes are brought up to an E, as homes are only being improved by one or two SAP bands this can often be done through less expensive measures and only 5% of homes require measures that cost over £7,250. However, just over a fifth of homes still require measures in band 4 which cost between £3,500 - £7,250 and are therefore not cheap to improve.

The Private Rented Sector has a disproportionate number of G rated homes. To bring all homes in the private rented sector up to a D rating therefore requires raising a substantial number of homes (estimated to be 1.675 million in Britain) by 3 SAP bands, from a G to a D. It is for this reason that we see that 25% of PRS homes are in band 5 when considering the costs of reaching a "D" minimum standard, compared to only 12% of all homes.

As the energy efficiency of the private rented sector stock gradually increases, as cheaper energy efficiency measures are installed and boilers which break down are replaced, it is likely that this proportion of very expensive to treat homes will increase (although the total number is likely to change little) as they are left untreated because of their high costs.

i) Improving private rented sector F & G rated homes

There are approximately 754,000 F & G rated private rented sector homes in Britain which are represented by 196 house types in this analysis. Upgrading all private rented F and G rated homes to an E rating or above could potentially reduce energy use from this sector of the British housing stock by 5.97TWh and cut annual CO_2 emissions from this sector of the housing stock by 1.87 $MtCO_2$. However as homes in the sector are currently very expensive to heat, it is likely many are currently being under-heated, meaning in reality CO_2 and energy savings could be lower. On the other side, increasing the temperature of homes being under heated may result in savings in other areas (such as health services) associated with cold homes.

The total cost to install all measures is £1.9 billion and the annual fuel bill savings are potentially £0.37 billion a year once all the measures are installed. If we assume that these measures are installed up to 2020, evenly and in equal numbers across the 9 years, this could add up to fuel bill savings over the nine years of approximately £1.8 billion[6], however actual fuel bill savings will be much greater than this as they will last over the technology's lifetime. The cost of a measure installed in 2019 is counted, however only one year of fuel bill savings has been counted.

Band 1
37% of homes can be improved for under £700 and often much less, using cavity wall insulation, loft insulation, draught proofing and energy efficient lighting. On average this results in an annual fuel bill reduction of £220, saves 1.09 tCO_2 a year and reduces the energy demand by 4,070 kWh annually.

Band 2
1% of homes can be improved for between around £1,400 - £2,050. It has been assumed that the three house types in this band would install flexible insulated lining and loft insulation. This gives an average fuel bill saving of £260, saves 1.31 tCO_2 and reduces energy demand by 6,080 kWh on average.

Band 3
36% of homes can be improved for between £2,500 and £3,500 by replacing their boiler or installing wall insulation – either cheaper (less efficient) flexible insulated lining in larger properties or internal solid wall insulation in smaller properties. On average this saves £630 a year off fuel bills, 3.03 tCO_2 and reduces energy demand by 10,550 kWh.

Band 4
21% of homes can be improved for £3,500 - £7,250. A large number of these homes have electric heating so the cheapest measures needed to reach an E rating are cavity wall insulation with solar water heating, or solid wall insulation. The average fuel bill saving is £620, the average CO_2 saving is 3.05 tCO_2 and the average kWh saving is 7,620, less than band 3 because many of the homes in band 4 have electric heating. This means that the saving in kWh is low compared to the saving in terms of finance or CO_2.

Band 5
5% of homes are the most expensive to treat at over £7,250 as they require one or a combination of three measures: fuel switching including installation of radiators, wall

[6] *This is an indicative fuel bill saving over time; it does not take into account temporal variables such as grid decarbonisation, changes in fuel prices or change in technology costs.*

insulation, or solar water heating. This saves the average home in band 5 £920 a year, however only reduces CO_2 emissions by 0.42 tCO_2. The energy the home is saving is high at 19,190 kWh but the average CO_2 saving is brought down by those house types which currently have wood fuelled (biomass) heating. Their CO_2 emissions are initially low, however their heating demand and spend on fuel is high, therefore they have a low SAP rating. Solid wall insulation, which is expensive, is required to lower their heating demand and bring them up to an E rating, however this has minimal effect on the CO_2 savings and reduces the average CO_2 savings.

ii) Improving private rented sector E, F & G rated homes

There are approximately 2.03 million E, F and G rated private rented sector homes in Britain which are represented by 323 house types in this analysis. Upgrading all private rented E, F and G rated homes to a D rating or above could potentially reduce energy use from this sector of the British housing stock by 16.1 TWh and cut annual CO_2 emissions from this sector of the housing stock by 5.00 $MtCO_2$.

The total cost to install all measures is £7.92 billion and the annual fuel bill savings are potentially £0.968 billion a year once all the measures are installed. If we assume that these measures are installed evenly and in equal numbers across the nine years between now and 2020, this could add up to fuel bill savings of approximately £4.84 billion[7] however actual fuel bill savings will be much greater than this as they will last over the technology's lifetime. For example, the cost of a measure installed in 2019 is counted, however only one year of fuel bill savings has been counted.

Band 1
32% of homes can be improved for under £800 and often much less, with a combination of cavity wall insulation, loft insulation, draught proofing and energy efficient lighting. On average this results in a fuel bill reduction of £230, saves 1.12 tCO_2 and reduces the energy demand by 5,270 kWh.

Band 2
2% of homes can be improved for between around £1,200 - £2,500. It is assumed that all these house types will use flexible insulated lining and loft insulation, with some needing draught proofing to bring them to a D. This gives an average fuel bill saving of £190, saves 1.01 tCO_2 and reduces energy demand by 4,970 kWh on average.

Band 3
36% of homes can be improved for between £2,500 and £3,500 by replacing their boiler or installing wall insulation – either cheaper (less efficient) insulating render in terraced properties or internal solid wall insulation in flats. The vast majority of the measures in band three are gas boiler improvements. On average this saves £570 a year off fuel bills, 2.62 tCO_2 and reduces energy demand by 10,970 kWh.

Band 4
4% of homes can be improved for £3,500 - £7,250. For those homes which are off-gas, solar water heating is the main measure to be installed, and internal solid wall insulation is generally the main measure to be installed on gas heated homes. Some homes require both

[7] *This is an indicative fuel bill saving over time; it does not take into account temporal variables such as grid decarbonisation, changes in fuel prices or change in technology costs.*

measures. The average fuel bill saving is £370, the average CO_2 saving is 1.64 tCO_2 and the average kWh saving is 6,410. Again, CO_2 and kWh savings are less than band 3 because many of the homes that fall into band 4 for improvements are electrically heated, meaning improvements lead to a small saving in kWh. In addition, homes in cost band 4 have a lower average SAP rating before improvement than those in cost band 3, with an average SAP rating before improvement of 51 in band 4 and SAP 43 in band 3.

Band 5
25% of homes are the most expensive to treat at over £7,250. Many homes are treated by fuel switching including installing radiators, including a small subset of electrically heated flats where air source heat pumps are installed. For some homes solid wall insulation is not enough to bring them to a D and other measures (such as draught proofing or solar water heating) are also required. Finally, there are a very small number of homes (0.4%) where ground source heat pumps are required which, together with other measures mean the costs are over £23,000. For band 5 the average home saves £690 a year, reduces CO_2 emissions by 4.09 t CO_2 and the energy saved is 6,980 kWh.

iii) Improving all E, F & G rated homes

There are approximately 14.1 million E, F & G rated homes in Britain. These are represented by 601 house types in this analysis. Upgrading all E, F and G rated stock to a D rating or above could potentially reduce energy use from this sector of the British housing stock by just over 100 TWh and cut yearly CO_2 emissions by 30.3 $MtCO_2$.

The total cost to install all measures is £36.9 billion and the annual fuel bill savings are potentially £6.15 billion a year once all the measures are installed. If we assume that these measures are installed evenly and in equal numbers across the nine years between now and 2020, this could add up to fuel bill savings of approximately £30.7 billion[8] however this is only the fuel bill savings up to 2020. Actual fuel bill savings will be much greater than this as they will last over the technology's lifetime and well beyond 2020 for measures such as solid and cavity wall insulation. Additionally measures installed in 1919 will only have generated one year's worth of fuel bill savings.

Band 1
46% of homes can be improved for under £900. Again, the measures are loft and cavity wall insulation, draught proofing and energy efficient lighting. A higher proportion of homes in this analysis can be brought up to a D in band compared to the private rented sector. This is because a greater proportion of all E, F and G homes were E rated to begin with and therefore required relatively few measures to bring them to a D. Additionally, there are proportionally less homes with a cavity wall construction in the private rented E, F and G stock (43%) compared to the whole stock (60%). The average fuel bill saving is £240, the average CO_2 saving is 1.2 tCO_2 and the average kWh saving is 5,630.

Band 2
1% of homes can be improved for between around £1,000 - £2,500. They key measures in this band are flexible insulated lining with loft and/or draught proofing. Average fuel bill savings are £210, CO_2 savings are 1.09 tCO_2 and average kWh savings are 5, 270.

[8] *This is an indicative fuel bill saving over time; it does not take into account temporal variables such as grid decarbonisation, changes in fuel prices or change in technology costs.*

Band 3
34% of homes can be improved for between £2,500 and £3,500 by replacing their boiler – the greatest proportion of these is improving a gas boiler. A small proportion of these homes also require wall insulation (either flexible insulated lining or internal solid wall insulation). Average fuel bill savings are £620, CO_2 savings are 2.86 t CO_2 and average kWh savings are 11,960.

Band 4
7% of homes can be improved for £3,500 - £7, 250. Solar water heating is again often chosen in combination with wall insulation for those homes on electric or oil heating as it's cheaper than installing a new heating system. Solid wall insulation by itself, or a small solar photovoltaic panel are also required, although less often. The use of solar water heating means the fuel, CO_2 and kWh savings are less than band 3 as only hot water heating is being tackled (as opposed to space and hot water heating when a boiler is replaced). The average fuel bill savings are £440, average CO_2 savings are 2.00 tCO_2 and average kWh savings are 7,180.

Band 5
12% of homes are the most expensive to treat at over £7,250. The main measure here is fuel switching, and for some homes this is combined with solid wall insulation. There are a small number of homes (1.7%) where double glazing is required. Again, there is a small number (0.2%) of very expensive to treat homes where solid wall insulation and ground source heat pumps are required, costing over £23,000. The average fuel bill savings in this group are £700, average CO_2 savings are 3.97 tCO_2 and average kWh savings are 6,800.

3.3 Conclusions

CO_2 Reduction

Tackling all E, F and G rated homes reduces emissions by 21% from 2008 levels (26% from 1990 levels).. As the private rented sector makes up a relatively small proportion of the housing stock even tackling the highest emitting of those homes will have a relatively small impact on total CO_2 emissions.

Long term goals

The measures suggested in this analysis are those required only to get to the SAP rating specified and not any further. They may not be the most cost effective way to improve the energy efficiency of a home in the long term as it is often cheaper to install multiple measures at the same time – for example installing double glazing at the same time as solid wall insulation. Additionally, once a householder has overcome any motivational or hassle barriers towards improving their homes' energy efficiency it may be best to maximise the opportunity so they don't have to overcome the same barriers in the future if they want to install further measures.

As the model is looking for the cheapest way to reach the required SAP level, some flexible insulated lining and insulating render were recommended. These are cheaper, but less effective alternatives to internal and external solid wall insulation. Although these measures are the cheapest and sometimes more cost effective, they are not necessarily the best measures in the long term if installing, for example, flexible insulated lining means that the home needs to be revisited later on to further reduce its emissions.This also applies to the small number of cases where solar photovolatics were applied. Each time a 1kW system was installed because it was the cheapest, however most homes would have a greater benefit from a 2kW system even though it would be more expensive.

Future-proofing

The model assumes all measures are installed in one year and their cost effectiveness is therefore based on 2008 fuel prices. Any future increase in fuel prices will mean energy efficiency measures will become more cost effective.

Feed in Tariff and Renewable Heat Incentive

The Feed in Tariff has not been modelled as our analysis is undertaken without taking account of current policy mechanisms and subsidies (eg CERT) which can change the cost-effectiveness of measures. Few solar photovoltaic (PV) systems have been installed therefore, because they are not the most cost effective option. Including income from the Feed in Tariff in this analysis would almost certainly increase the number of solar PV panels installed, and increase the overall cost effectiveness of some packages.

Similarly, the Renewable Heat Incentive has not been modelled: there is anyway not yet clarity as to what the scheme will look like. In the analysis air and ground source heat pumps were only installed in electrically or coal heated homes as these were the only properties in which they were cost effective, however for many of these homes the model found that installing condensing oil boilers with radiators was the cheapest option. Some installations of ground source heat pump installations were not cost effective overall but were the only option available in detached homes. Cost effectiveness was calculated by looked at the best long term value (Net Present Value) – the difference in cumulative costs over 30 years discounted at 3.5% (with a fuel price increase at 2% per annum). The Renewable Heat Incentive and any future rises in fuel prices could make these heating systems much more cost effective and able to compete with oil boilers.

Expensive to treat homes

A very small number of the homes modelled (0.2%) cost over £23,000 to bring them up to a D rating. If these homes were to be future-proofed and raised to at least a C rating then costs would be even greater. Often these homes were not cost effective to upgrade which will pose policy challenges.

CO_2 savings vs SAP rating

The refurbishment calculator is based on SAP which primarily looks at the energy demand and cost to heat a home and is not affected by CO_2 savings. Some of the detached electric and coal heated homes could have benefitted from biomass boilers, and installing these could reduce CO_2 emissions by over 7t per house. However, because wood pellets are relatively expensive biomass boilers did not reach the required SAP rating. This differs to the 60% analysis where CO_2 reduction is the target so biomass boilers are favoured over heat pumps as unlike, heat pumps, they don’t require electricity to run.