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Climate Change

RAISING THE STANDARDS

Analysis of costs and carbon savings from tackling the least energy efficient homes in Scotland

A report by the Energy Saving Trust for WWF Scotland

Contents

1. Introduction

WWF Scotland wanted to explore the impacts of removing the worst performing homes from the private sector in Scotland and from the whole Scottish housing stock by bringing them up to a higher Energy Performance Certificate (EPC) banding and SAP rating. The analysis gives an indication of the CO_2 savings achieved from these scenarios, as well as fuel bill savings and the cost of each scenario.

The analysis of the worst performing homes within the Scottish housing stock was undertaken based on Scottish House Condition Survey (SHCS) 2007-2009 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 EPC bands, and the impact in carbon terms of undertaking such improvements. The three scenarios considered were:

i) bringing all private sector homes banded F & G on an EPC in Scotland to a minimum E-banding;
ii) bringing all private sector homes banded E, F & G on an EPC in Scotland to a minimum D-banding;
iii) bringing all Scottish homes banded E, F & G on an EPC to a minimum D-banding.

Private sector refers to the private rented and owner occupied housing stock.

Five case studies examine the potential impact each proposal might have on a property, depending on the built form of the house and the occupants. In particular, they examine what effect the proposals may have on fuel poverty.

The economic impacts of each proposal were also calculated using the Energy Saving Trust's Economic Impact Model, to assess the jobs supported and the Gross Value Added (GVA) from installation of the measures needed to improve EPC ratings under each scenario.

Context

The Climate Change (Scotland) Act targets of a 42% reduction in greenhouse gas emissions by 2020 and an 80% reduction by 2050 from 1990 levels provides clear direction for reducing Scottish emissions.

Scottish Ministers have the enabling powers in the Climate Change (Scotland) Act[1] to regulate for the energy performance of housing and the Scottish Government has recently published a report which sets out its approach to the use of regulations to improve the energy efficiency of Scotland's housing[2].

Additionally, 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, the Scottish Housing Quality Standard (SHQS) has improved the standard of social housing and Scottish Government has committed to an energy efficiency standard beyond SHQS for social housing[3].

[1] *"The Scottish Ministers must, (a) by regulations provide for the assessment of (i) the energy performance of living accommodation; (ii) the emission of greenhouse gases produced by or otherwise associated with such accommodation; (b) require owners of such accommodation to take steps, identified by such assessments, to (i) improve the energy performance of such accommodation; (ii) reduce such emissions." Climate Change (Scotland) Act 2009. Section 64. http://www.legislation.gov.uk/asp/2009/12/contents/enacted*

[2] *Regulation of Energy Efficiency in Housing. Scottish Government, March 2011. http://www.scotland.gov.uk/Topics/Built-Environment/Housing/privateowners/energyefficiency*

[3] *Homes Fit for the 21st Century: The Scottish Government's Strategy and Action Plan for Housing in the Next Decade: 2011-2020. Scottish Government, 2011. http://www.scotland.gov.uk/Publications/2011/02/03132933/0*

The Scottish Government's *Report on Policies and Proposals* estimates that all current UK and Scottish policies, plus UK and Scottish proposals, in the homes and communities sector could result in a 36% reduction in residential emissions (in the non-traded sector only) by 2020, compared to 1990 levels[4].

Scottish Government work using the DEMScot model[5] suggests that regulations bringing all Scottish homes to a minimum EPC band of D would achieve emissions abatements equivalent to only 70% of the reduction from the existing Scottish housing stock identified from the *Report on Policies and Proposals*.

2. Approach

To analyse the energy, carbon, cost and economic impacts of the three scenarios outlined above, two Energy Saving Trust models were used: the Housing Stock Refurbishment Calculator and the Economic Impact Model, alongside SHCS 2007 to 2009 data.

We have endeavoured to ensure that the content of this report is accurate and representative of housing in Scotland. 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. Figures quoted and utilised from the SHCS use the paired weighted sample from the 2007, 2008 and 2009 surveys, as the larger sample size this provides allowed us to generate a more detailed representation of the Scottish housing stock. Therefore, the results of our analysis may differ from results quoted in the SHCS 2009 Key Findings report, which was based on 2009 data only.

We have used the Housing Stock Refurbishment Calculator on this project – the Energy Saving Trust's best available tool to answer the area of study. The best available data at the time was used for the model but costs and performance of technologies may change over time, particularly where the market for a technology is in development.

It is important to note that the results from our analysis tell us the measures (and resulting costs and carbon savings) required only to get all homes to the EPC banding 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 householders have overcome any motivational or hassle barriers towards improving their homes' energy efficiency, it may be best to maximise the opportunity so they do not have to overcome the same barriers in the future if they want to install further measures.

In addition, where solar photovoltaics were applied, a 1kilowatt-peak (1kWp) system was installed because it was the cheapest option; however, most homes would see significant benefits at a relatively small additional cost by installing a 2kWp system instead.

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[4] *Low Carbon Scotland: Meeting the Emissions Reduction Targets 2010-2022. The Report on Policies and Proposals. Scottish Government, 2011. http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/lowcarbon/rpp . Policies covered by this analysis were: current domestic building energy efficiency policies - the Carbon Emissions Reduction Target (CERT), the Community Energy Saving Program (CESP), the Home Insulation Scheme (HIS) and the Energy Assistance Package (EAP); plus domestic newbuild standards for 2007 and 2010; the Renewable Heat Incentive (RHI); and smart metering. Proposals were: future fuel poverty and insulation programs; and domestic newbuild standards for 2013.*

[5] *Impacts of options for regulating energy efficiency standards in the domestic sector. Scottish Government, March 2011, http://www.scotland.gov.uk/Publications/2011/03/22092740/0*

Future-proofing

The model assumes all measures are installed in one year and the potential fuel bills savings are 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

Our analysis is undertaken without taking account of current policy mechanisms and incentives (e.g. CERT) which can change the cost of measures. Thus, income from Feed in Tariff (FIT) and the forthcoming Renewable Heat Incentive (RHI) is not included as an additional factor in reducing net fuel bills.

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[6]. It is an SAP-based tool, which 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 improvements to each property are carried out over one year.

For this analysis, the tool has been used to inform four key areas:

- the baseline of the housing stock in terms of CO_2 emissions, fuel bills and SAP ratings;
- refurbishment measures necessary[7] to implement across the housing stock to bring homes up to a desired EPC band;
- the cost of installing identified measures;[8]
- the benefits of the scenarios in terms of CO_2 reduction, fuel bill reduction, improvement in SAP ratings etc. for the whole stock and individual house types.

The Refurbishment Calculator gives an indication of a home's SAP rating. SAP ratings are the basis of EPCs in Scotland and across the UK, and SAP-based tools are used to ensure compliance with Building Standards. We do not present results in this report using National Home Energy Rating (NHER), which is a separate type of home energy rating that has been widely used in Scotland and is still used, alongside SAP, on the SHCS.

Domestic Sustainable Energy Economic Impact Model[9]

The Economic Impact Model assesses the economic impacts associated with installing energy efficiency and microgeneration measures. It calculates Gross Value Added (GVA), and jobs supported (in the form of full-time equivalency) from installing different low carbon measures to homes. For this report, we are reporting only on the direct impacts which are:

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[6] *The T-zero tool was developed by a range of organisations involved in energy saving and housing. It is supported by the Technology Steering Board and is designed to help householders, landlords, designers or builders to identify the best energy efficiency options for a home (http://www.tzero.org.uk/About.aspx).*

[7] *Under its 'Target SAP' analysis option, the Refurbishment Calculator looks for the cheapest measure or combination of measures required to bring a home up to (or over) the target SAP rating set by the user.*

[8] *This refers only to direct costs for the work being undertaken; it does not include the costs of implementing a policy.*

[9] *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 from the Energy Saving Trust.*

- the levels of employment directly supported by installation demand (i.e. site preparation, architectural or design services, plumbing and installation);
- the GVA directly created – the levels of employment supported, multiplied by the average GVA per head for installation

2.2 Data used

Scottish House Condition Survey 2007-2009

Data from the SHCS was used to identify those types of homes in bands E, F or G on the EPC. The SHCS uses modelling to calculate the SAP ratings that would be given to the homes that are sampled as part of its survey. The SHCS data on each house sampled 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 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.

3. EPC Banding Analysis

The analysis examined three scenarios for removing the worst homes from Scotland's housing stock:

i) bringing all private sector homes banded F & G on an EPC in Scotland to a minimum E-banding;
ii) bringing all private sector homes banded E, F & G on an EPC in Scotland to a minimum D-banding;
iii) bringing all Scottish homes banded E, F & G on an EPC to a minimum D-banding.

The Scottish Housing Stock

There are 2.33 million homes in Scotland. To give an idea of what the Scottish housing stock currently looks like in terms of energy efficiency, the EPC bandings taken from the SHCS 2007 to 2009 data set are given in table 1 below.

Table 1 EPC bands of the Scottish housing stock (2007 to 2009 data set).

	All homes		Private sector stock	
EPC Band	**Number**	**% of the stock**	**Number**	**% of the stock**
B	10,000	<1%	<4000	<1%
C	440,000	19%	240,000	14%
D	1,100,000	47%	780,000	46%
E	590,000	26%	500,000	30%
F	150,000	6%	130,000	8%
G	30,000	1%	30,000	2%
Total	2,330,000	100%	1,690,000	100%

Those homes that are in band F or G on an EPC, and are the most inefficient, make up around 7% of the Scottish housing stock. 33% of the Scottish housing stock is in band E or below. The private sector, which makes up 73% of the total stock in Scotland, has a higher proportion of homes with poor energy efficiency performance. 10% are in band F or G, and 40% are in band E or below.

3.1 Methodology

The SHCS data was analysed to identify for the scenarios: (i) private sector band F & G homes; (ii) private sector band E, F & G homes; and (iii) all band E, F & G homes. The Energy Saving Trust identified the key characteristics required for analysis using the Housing Stock Refurbishment Calculator:

1. **wall type**: solid wall, cavity wall[10];
2. **existing wall insulation:** no insulation, cavity wall insulation, external wall insulation, internal wall insulation;
3. **build type**: detached, semi-detached, end terrace, terrace, detached bungalow, attached bungalow and flat;
4. **number of bedrooms**: 1,2,3,4,5;
5. **level of loft insulation**[11]: not applicable or 0-25mm, 50-100mm, greater than 100mm;
6. **glazing**: single glazed, double glazed (6mm-12mm);
7. **draught proofing**: none, present;
8. **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[12], open coal fire, biomass boiler;
9. **presence/absence of a loft space.**

These factors were chosen to align with the Refurbishment Calculator[13]. By exploring the combinations of these parameters (1-9, listed above), a number of 'house types' were created.

The number of house types for the analysis of each scenario was as follows:

(i) bringing all private sector homes banded F & G to an E banding – 588 house types;
(ii) bringing all private sector homes banded E, F & G to a D banding – 2,288 house types;
(iii) bringing all homes banded E, F & G to a D banding – 2,683 house types.

The house types were uploaded into the Refurbishment Calculator and, for each, their current SAP rating was calculated.

The house types were then analysed using the Refurbishment Calculator to assess the least expensive measures needed to bring them up to the required EPC band. These were manually sense checked once they had been run through the model.

For a small number of house types, the Refurbishment Calculator assigned a different EPC band to that assigned to the same house type by the SHCS data. This is due to the fact that the SHCS and the Refurbishment Calculator use slightly different SAP-based methodologies in calculating SAP ratings. The SHCS 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

[10] *Energy Saving Trust modelling using the Housing Stock Refurbishment Calculator does not currently take account of hard-to-treat cavity walls or lofts (those which for technical reasons cannot be treated with standard cavity wall insulation or loft insulation, or where construction makes treatment difficult and/or more costly than normal). Further research is currently being undertaken in this area.*

[11] *Coombed ceilings are not taken account of in the Refurbishment Calculator. However, this type of ceiling can make a home hard to treat, as only a small area of heat loss from the top of the home can be treated with conventional loft insulation. The remaining heat loss areas require treatment through more costly measures such as the application of insulation board within the rooms.*

[12] *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.*

[13] *Where parameters did not exactly align, the option that gave the best comparable CO_2, energy and measure recommendations was chosen. These were mapped through the analysis to ensure the measures suggested by the tool to improve the home were appropriate based on its original parameters.*

calculations on the dataset). Therefore, some additional modifications to certain house types were made to align the SAP rating generated by the Refurbishment Calculator with the SHCS SAP rating for a few house types. For example, in some homes it was necessary to model a house type in the Refurbishment Calculator with less loft insulation than was detailed in the SHCS data set[14]. For those homes where such adjustments were not sufficient to align the EPC band assigned by the Refurbishment Calculator to that assigned by the SHCS, the SHCS 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 band 'E' by the SHCS and given an SAP rating equivalent to EPC band 'D' 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 cheapest measures to improve the home by the required number of SAP points.

Measures applied

The energy efficiency and 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;
- insulating render[15];
- ground source heat pump;
- air source heat pump;
- biomass boiler;
- solar water heating panel (solar thermal);
- solar photovoltaic panel (PV);
- micro wind turbine.

Other energy efficiency measures (for example installing or re-instating shutters on windows) are not currently included as a measure in the Refurbishment Calculator, and therefore have not been included in this modelling. However, in reality these may be an appropriate improvement for more traditional homes such as tenement flats in Edinburgh or Glasgow.

Insulating render is a cheaper, but less effective, alternative to internal or external solid wall insulation[16]. Insulating render is not a measure that is normally recommended by the Energy Saving Trust. It is not necessarily the best measure in the long term if, for example, installing insulating render means that the home needs to be revisited later to further reduce its emissions.

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[14] *Modifications made were chosen so as not to affect the suitability of the house type for certain improvement measures; for example changing loft insulation from 500-100mm existing insulation to 25mm existing insulation.*

[15] *Insulating render is a cement-based wall render incorporating insulation material, applied to the exterior of solid-wall homes to improve insulation. It is not as effective at insulating walls as external or internal wall insulation, achieving wall U-value of 0.83W/m^{2}K, compared to 0.45 W/m^{2}K for internal wall insulation and 0.35 W/m^{2}K for external wall insulation.*

[16] *Costs assumed for a four bed detached house, for example, are £5,425 for insulating render, compared to £10,325 for internal wall insulation or £14,038 for external wall insulation.*

SAP

The government's Standard Assessment Procedure (SAP) for energy efficiency is at the heart of most home energy saving studies produced in the UK, and SAP is the basis for both some SHCS calculations, and the Refurbishment Calculator. It is important when looking at the results to be aware of the limitations of the SAP methodology.

SAP is used to calculate both energy efficiency and CO_2 emissions and tends to provide 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 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[17]. SAP also does not include emissions from electricity used for appliances. On the other hand, unlike the National Home Energy Rating (NHER), SAP does not take into account climatic variation across the UK. This means that for Scotland, at a higher latitude and with homes in more exposed areas, SAP may actually underestimate the heating demand for Scottish homes. Given the lack of clarity around this issue, energy use (and fuel bill costs, CO_2 emissions etc) presented here should be treated as estimates only.

3.2 Results

The results from the three scenarios analysed are given in table 2. However, as homes in EPC bands E, F & G are currently very expensive to heat, it is likely many are currently being under-heated, meaning that, in reality, CO_2 and energy savings from improving insulation levels could be lower than presented here as emissions from these homes before improvement may be over-estimated. However, increasing the internal temperature of homes which are currently being under-heated may result in savings in other areas of the Scottish economy (such as health services) which deal with tackling the effects of cold homes[18].

Headline findings

Table 2. Headline findings from improving EPC bands

	Improving All E,F&G	Improving Private Sector E,F&G	Improving Private Sector F&G
Number of homes	770,000	663,000	162,000
Average SAP rating and EPC band before improvement	37 (F)	37 (F)	28 (F)
Average SAP rating and EPC band after improvement	59 (D)	60 (D)	46 (E)
Total cost of improvements	£2,448,000,000	£2,022,000,000	£420,000,000
Average cost per improved home	£3,200	£3,000	£2,600
Total annual CO_2 saved (tonnes)	2,107,000	1,861,000	496,000

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

[18] *Attempting to quantify these effects has been outside of the scope of this report.*

Average annual CO_2 saving per improved home (tonnes)	**2.70**	**2.80**	**3.10**
Total annual fuel bill reduction	**£445,000,000**	**£395,000,000**	**£105,000,000**
Average annual fuel bill reduction per improved home	**£580**	**£600**	**£650**

The average SAP ratings achieved when improving E, F & G rated private sector homes and all homes were relatively high at a mid D (a D banding goes from SAP 51-65; see appendix for full table of SAP ratings per EPC band).

CO_2 emissions

Bringing private sector band F & G homes in Scotland to a band E could result in a reduction of around 0.5MtCO_2[19] a year from the residential sector. Bringing private sector band E, F & G homes in Scotland to a band D could achieve a reduction of 1.86MtCO_2 a year. Bringing all band E, F & G homes in Scotland to a band D could result in a reduction of 2.1MtCO_2 from the residential housing stock. It is assumed that all measures are installed in one year, therefore the total CO_2 savings presented here are the amounts saved if all measures were installed in one year. In reality, installations would be phased over a number of years, and the full yearly CO_2 saving would be seen once all measures were in place.

Improving all E, F & G rated homes in Scotland to a D band would reduce housing stock emissions by 2.1MtCO_2 a year, bringing total emissions from the residential sector down to an estimated 11.4 MtCO_2 a year once all measures are installed. This is shown by the last column in figure 1. In 1990, emissions from the residential sector were 15.2MtCO_2 per year, so emissions of 11.4 MtCO_2 a year in 2020 would be equivalent to a 25% reduction in housing stock traded and non-traded emissions against a 1990 baseline.

As of 2008 (the latest year for which data is available), emissions from the residential sector have fallen to 13.5MtCO_2 per year.[20]

If the housing sector were to aim for CO_2 reductions in line with the overall Scottish cross-sectoral target of a 42% emissions reduction by 2020, total emissions in 2020 from the residential sector would need to be 8.8MtCO_2 per year (figure 1) – a reduction of 6.4MtCO_2 per year from 1990 levels and a reduction of 4.7MtCO_2 per year from 2008 levels. A saving of 2.1MtCO_2 from bringing all homes to a minimum D band represents 33% of the emissions reduction needed from 1990 levels, and 45% of the emissions reduction needed from the residential sector from 2008 levels, in order to achieve emissions of 8.8MtCO_2 per year by 2020.

[19] *MtCO_2 = megatonnes of carbon dioxide (CO_2), or 1 million tonnes of CO_2.*

[20] *Figures for 1990, 2006 and 2008 taken from the publication Devolved Administration Emissions of the basket of six Kyoto GHGs by End User, AEAT, issue 1, 07/09/2010. http://naei.defra.gov.uk/report_link.php?report_id=620 . Figures refer to emissions of carbon dioxide gas (MtCO_2) from residential combustion and electricity only; they do not include figures on use of non-aerosol consumer products.*

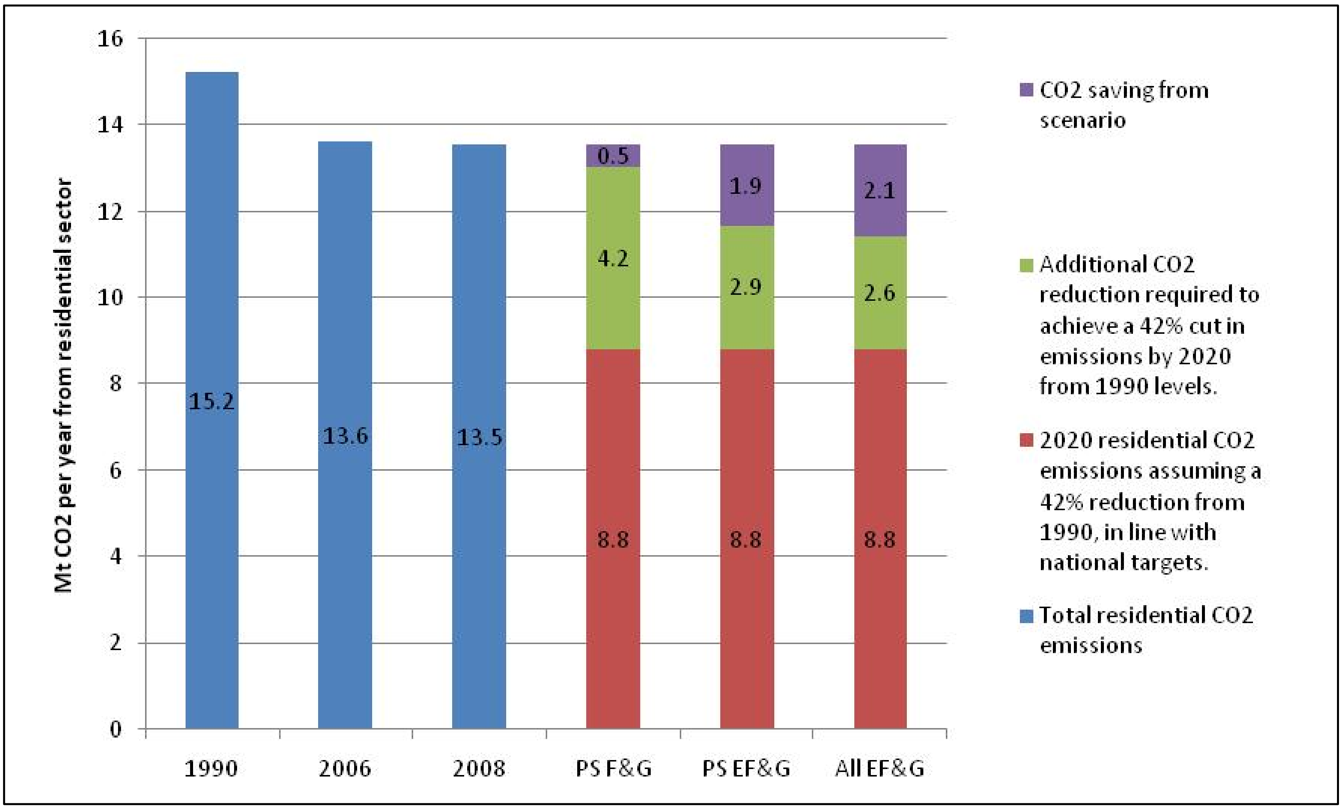

Figure 1 CO_2 emissions reduction of each scenario compared to 1990, 2006 and 2008 residential emission levels. PS = private sector. Figures are for residential fuel combustion and electricity use only; they do not include figures on use of non-aerosol consumer products.

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, rising trends in domestic heating and electricity use[21], increasing household numbers, and year on year external temperature variations could all impact on annual CO_2 savings.

Cost of improvement work and fuel bills savings

Bringing private sector band F & G homes in Scotland to a band E is estimated to cost around £420m. Bringing private sector band E, F & G homes in Scotland to a band D is estimated to cost just over £2bn. Bringing all band E, F & G homes in Scotland to a band D could is estimated to cost £2.45bn.

The assumed cost of improvements to all homes does not include any subsidies (e.g. CERT); likewise our assessment of the benefits does not include incentives such as the Feed in Tariff and Renewable Heat Incentive. The costs given are total costs to carry out the improvement work and no assumptions have been made as to whether householders would bear the full cost of improvement works, or whether this would be supported by government and/or the private sector.

UK average costs were used; however, these will vary across the country, particularly in more remote areas of Scotland where there is little installer competition and extra travel costs. 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

[21] *From 1990 to 2008 electricity use in the domestic sector in the UK has increased by an average of 1.3% per annum (Digest of UK Energy Statistics, DECC (formerly dBERR), 2008). There has also been a trend since the 1970s for average internal temperatures to increase (Domestic Energy Fact File, BRE, 2008).*

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 Regulation requirements and is much more efficient than the average. Additionally, the least efficient incandescent light bulbs will in time be replaced with energy efficient ones.

The costs assumed are based on a single household undertaking the work, and do not include any discounts that might be available through bulk purchase of work or material, or where a number of homes are improved together at the same time.

As noted previously, it is assumed all households heat their homes to 21°C in the living room and 18°C in the rest of the dwelling 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 study because a greater proportion of these homes are in fuel poverty. Based on the dataset used for this project, the 2007 to 2009 SHCS data set, 28% of Scottish households are estimated to be in fuel poverty[22]; however, this rises to 42% for E, F and G rated properties, and to 56% for those households living in private sector F and G rated properties. 50% of fuel poor households live in an E, F or G rated home.

The measures required to bring homes up to the required EPC band in each analysis can be split down into four non-overlapping cost levels.[23]

Level 1: Cheap measures – less than £1,000

The key measures applied to homes in this cost level are loft and cavity wall insulation. Some homes already close to the required rating can be brought up simply through installing CFLs.

Level 2: Upgrading boilers - £2,500 - £3,500

The most frequent measure applied to homes in this cost level involves changing old oil and gas boilers to modern condensing boilers, which can make a significant improvement to the SAP rating of a home for a reasonable cost. A small proportion of the homes to improve in this cost level are flats that require internal solid wall insulation, which is relatively cheap for these homes as they only have small areas of externally facing walls to insulate.

Level 3: Solid wall insulation and solar - £3,500 - £7,250

As the cost to improve the home increases so does the combination of measures that needs to be applied to a home. The predominant measures in this cost level 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 band, but without which the home does not quite reach the required band.

Level 4: Multiple measures/wet central heating system installation/renewable heat technology - £7,250 +

The majority of homes in this band require expensive changes to the heating system, for example to move them from single gas room heater backed up with electric panel heaters to a full wet central heating system and condensing gas boiler, or the installation of an air source heat pump. A number of these homes also require wall insulation (either internal solid wall insulation or insulating render) or double glazing. This is often accompanied by solar water heating. A very small number of the homes

[22] *Looking at SHCS data for only 2009, 33% of Scottish households are estimated to be in fuel poverty.*

[23] *Whether a home is classed in a cost level depends on the total cost to bring the home into its target EPC band. For example, a home requiring only a top-up of its loft insulation (costing £205) would be counted in 'level 1'. A home requiring a top up of its loft insulation, and a new condensing gas boiler (costing £2,705 in total) would be counted in 'level 2'. A home requiring only a new condensing gas boiler (costing £2,500) would also be counted in 'level 2'. Therefore, measures may appear in more than one cost level, depending on what other measures each home requires. However, each home modelled will appear in only one cost level, depending on the total cost to bring it into its target EPC band.*

modelled (for example some detached, off-gas homes with solid walls) cost over £11,000 to bring them up to a band D. This was the case for 0.9% of all E, F & G homes and 1.1% of the private sector E, F & G. None of the homes in the private sector F & G bands cost more than £11,000 to improve. An even smaller sub set of this group require either ground source heat pumps or a combination of other very expensive measures and therefore have costs of over £23,000.

The percentages 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 EPC band for each cost level

Cost level	Improving All E,F&G	Improving Private Sector E,F&G	Improving Private Sector F&G
1 - less than £1,000	**23%**	**23%**	**37%**
2 - £2,500 to £3,500	**44%**	**48%**	**34%**
3 - £3,500 to £7,250	**10%**	**10%**	**17%**
4 - over £7,250	**23%**	**19%**	**12%**
Total	*100%*	*100%*	*100%*

i) Improving private sector F & G rated homes

There are approximately 162,000 private sector homes in band F & G in Scotland which are represented by 588 house types in this analysis. Upgrading all private sector homes in bands F and G to a band E or above could potentially reduce energy use from this sector of the Scottish housing stock by 1.52TWh[24] and cut annual CO_2 emissions from this sector of the housing stock by 0.5MtCO_2 per year.

The total cost to install all measures is £420m and the annual fuel bill savings are potentially £105m 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 nine years, this could add up to fuel bill savings over the nine years of approximately £525m[25]. However, actual fuel bill savings over the lifetimes of these measures will be much greater than this, as they will last over the technology's lifetime and savings will continue to accrue after 2020. In this calculation, the cost of a measure installed in 2019 is counted; however, only one year of fuel bill savings has been counted.

Level 1

37% of homes can be improved with less than £1,000. Spending this amount would result in average annual fuel bill savings of £250 and 1.2 tonnes of carbon dioxide (tCO_2) per year. The energy saving would be around 4,400kWh per year. Improvements can be made by installing basic measures such as increasing the amount of loft insulation, installing cavity wall insulation, draught proofing and installing low energy lighting

Level 2

34% of PS F & G homes can be improved for a cost of between £2,500 and £3,500. The largest fuel bill saving in this scenario, - of around £1,130 a year – is seen in homes in this cost level, along with a carbon dioxide saving of 4.8tCO_2 per year. The energy saving is around 16,400kWh per year. The predominant measure in this cost level is boiler replacement: installing an oil or gas condensing boiler, either combi or non combi.

[24] *TWh = terawatt-hours, or 1billion kWh (kilowatt-hours).*
[25] *This is an indicative fuel bill saving over time; it does not take into account changes in fuel prices or the effects of inflation.*

Level 3
Spending between £3,500 and £7,250 will result in the improvement of 17% of homes. The estimated average annual fuel bill saving is £590 a year and 2.9tCO_2 per year. The energy saving is around 6,900kWh per year. The main measures introduced in this cost level include wall insulation, cavity or solid, along with loft insulation, low energy lighting, solar hot water.

Level 4
Spending over £7,250 is necessary to improve 12% of homes. This will provide an average fuel bill saving of £910 a year and save 6.2tCO_2 per year. The energy saving is on average 10,100kWh per year. Measures include boiler replacement with new radiators, or solar hot water installation, then a mix of loft insulation, solid wall insulation and draught proofing.

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

There are approximately 663,000 private sector homes in bands E, F & G in Scotland, which are represented by 2,288 house types in this analysis. Upgrading all private sector band E, F & G homes to a band D or above could potentially reduce annual energy use by 6.08TWh and cut annual CO_2 emissions from this sector of the Scottish housing stock by 1.86MtCO_2.

The total cost to install all measures is £2.02bn and the annual fuel bill savings are potentially £395m 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 £1.97bn. However, actual fuel bill savings over the lifetimes of these measures will be much greater than this, as they will last over the technology's lifetime and savings will continue to accrue after 2020.

Level 1
23% of homes in this scenario can be improved by spending less than £1,000. When spending less than £1,000 on improvements, average bill savings are estimated to be around £270 a year with a carbon dioxide saving of 1.3tCO_2 per year and 5,800kWh saved annually. Improvements can be made by installing basic measures such as increasing the amount of loft insulation, installing cavity wall insulation, draught proofing and installing low energy lighting.

Level 2
Almost half of homes (48%) can be improved by spending between £2,500 and £3,500. On average, an annual saving of around £770 and 3.4tCO_2 per year can be made. This equates to an average energy saving of around 12,700kWh per year. The main measure included in this price level includes replacement of existing boiler with a new condensing boiler (including combi). Other measures that appear frequently in this band are low energy lighting and some properties getting loft insulation improvements.

Level 3
10% of PS E, F & G homes can be improved by spending between £3,500 and £7,250. The highest average annual saving in this scenario can be achieved in these homes, of £800 per year saved on average, along with 3.6tCO_2 per year and 9,600kWh per year saved. The main measures in this price level include wall insulation (cavity and solid wall insulation), boiler replacement with condensing model and new radiators, some solar hot water and micro wind, as well as draught proofing and low energy lighting, and a very small number of loft insulations.

Level 4
At the most costly level, around 19% of homes can be improved with more than £7,250. An average annual fuel bill saving of £760 is estimated, along with a carbon dioxide saving of 4.1tCO_2 per year and 3,700kWh per year being saved. Like level 3, it too covers boiler replacement (sometimes with radiators being added) or air source heat pump installation, solid wall insulation or cavity wall insulation, loft

insulation, solar hot water or micro wind, and then some double glazing, draught proofing and low energy lighting.

iii) Improving all E, F & G rated homes

There are approximately 770,000 homes in bands E, F & G in Scotland. Upgrading all band E, F & G housing stock to a band D or above could potentially reduce energy use from this sector of the Scottish housing stock by 11.2TWh a year and cut yearly CO_2 emissions by 2.1MtCO_2.

The total cost to install all measures is £2.45bn and the annual fuel bill savings are potentially £445m 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 £2.22bn. However, actual fuel bill savings over the lifetimes of these measures will be much greater than this, as they will last over the technology's lifetime and savings will continue to accrue after 2020.

Level 1

23% of all E, F & G Scottish homes can be improved for under £1,000, and often much less. Improvements can be made by installing basic measures such as increasing the amount of loft insulation, installing cavity wall insulation, draught proofing and installing low energy lighting. On average, this results in a fuel bill saving of £260 a year and 1.3tCO_2 per year. The total average energy saving in this band is around 5,700kWh per year.

Level 2

The majority of homes in this scenario can be improved by having between £2,500 and £3,500 spent on them; this covers 44% of homes. The main measure included in this price bracket includes replacement of existing boiler with a new condensing boiler (including combi). Where a boiler is not installed, a renewable technology such as a micro-wind turbine is included. Other measures installed at this cost level are cavity wall insulation, draught proofing, low energy lighting and some cases of loft insulation. The average bill saving in this bracket is £770 per year, with a carbon dioxide saving of 3.4tCO_2 per year and an energy saving of 12,600kWh per year.

Level 3

Only 10% of E, F & G homes can be improved for this more expensive level of £3,500 to £7,250. The main measures in this price level include wall insulation - cavity and solid wall insulation - plus boiler replacement with condensing model and new radiators, some solar hot water or micro wind, as well as some glazing replacement, draught proofing and low energy lighting, and a very small number get loft insulation as well. An average annual bill saving of £750 per year, 3.4tCO_2 per year and an energy saving of 8,600kWh per year can be obtained with this amount of spend in improvements.

Level 4

The highest band of over £7,250 is applicable to 23% of homes. Like level 3, it too covers boiler replacement or air source heat pump installation and new radiators, solid wall insulation or cavity wall insulation, loft insulation, solar hot water or micro wind, and then some double glazing, draught proofing and low energy lighting. Homes in this level have an average annual fuel bill saving of just over £710 and have a carbon dioxide saving of 3.9 tCO_2 per year. The energy saving is on average 3,000kWh per year.

In this scenario, insulating render was recommended as a measure on a very small proportion of homes, because the Refurbishment Calculator works on finding the least expensive way to reach the required SAP rating needed for the target EPC band. Insulating render is a cheaper, but less effective, alternative to internal or external solid wall insulation[26]. Insulating render is not a measure that is normally

[26] *Costs assumed for a four bed detached house, for example, are £5,425 for insulating render, compared to £10,325 for internal wall insulation or £14,038 for external wall insulation.*

recommended by the Energy Saving Trust. It is not necessarily the best measure in the long term if, for example, installing insulating render means that the home needs to be revisited later to further reduce its emissions. In this analysis, insulating render was applied to those homes which required some form of solid wall insulation as well as another measure (often an upgrade from old boiler to a condensing boiler) to bring them to the required EPC banding, but where the EPC banding could be achieved using insulating render as a cheaper wall treatment instead of the more expensive internal or external solid wall insulation. Only a small number of homes needing some form of improvements to their solid walls could be brought to the required EPC banding through the use of insulating render; most required internal or external solid wall insulation.

3.3 Case studies

In order to see how these improvements might impact on an individual household, particularly looking at the effect on fuel poverty, five case studies were created covering different house types and tenures. The case studies are based on data from the SHCS 2007 to 2009 data set. Fuel bill costs are those stated in the SHCS and 2009 fuel prices are used. The fuel bills quoted are based upon the fuel required to heat the home adequately, rather than on actual fuel use. The bills therefore do not take into account over-heating or under-heating in homes, or changes in heating demand due to geographical and climatic differences. According to the SHCS, 28% of households are in fuel poverty (using weighting for the 2007 to 2009 survey)[27].

Gas heated social housing flats

Typical household

Approximately 26,000 households in Scotland live in this type of property, paying on average around £790 a year in fuel bills. The majority (96%) of households live in urban areas, mainly in Glasgow City (25%) with a large proportion in North Lanarkshire (9%) and Aberdeen City (7%). The majority of these homes are already relatively energy efficient, with 95% having an EPC banding of a D or above; however, around 4% have an EPC banding of E. These properties are mainly occupied by single people (50%). 21% of occupants are single older people and 13% are loan single parents. Vulnerable people are highly prevalent amongst this property type, with over half (54%) of households containing an occupant with a disability or long-term illness.

Fuel poverty

Fuel poverty is less prevalent in this house type than in the whole stock, with 24% of households in fuel poverty, and 4% of households in extreme fuel poverty. Households in fuel poverty in this type of house need to reduce their fuel bills on average by around £235 to no longer be considered fuel poor.

Measures required

Around 80% of these properties were built with cavity walls, however, only 23% of these properties have cavity wall insulation. Therefore, over 2/3rds of these properties could have cavity wall insulation applied to them. However, as these properties tend to be energy efficient in other ways, only a very small number of these homes are currently below a band D (around 5%). Many of these are only marginally below a band D, and so our analysis suggests that these homes can be brought up to a band D by simply installing low energy lighting. This would cost on average less than £10 per home and according to the Refurbishment Calculator would save around £18 per year.

As so little improvement is needed, bringing these up to a D would do little to reduce fuel bills and therefore little to alleviate fuel poverty. Filling the cavity walls of all these properties (although not required to get these properties up to a D, and although many are already in band D) would probably do more to reduce fuel poverty.

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[27] *33% based on 2009 data only.*

Electrically Heated Private Rented Flats

Typical household

Approximately 51,000 households in Scotland live in this type of property paying on average around £970 a year in fuel bills. Nearly all of these properties are in urban areas (97%) and are most common in Edinburgh City (25%), Glasgow City (23%) and Aberdeen city (7%). Some of these flats, especially in Edinburgh and Glasgow, will be tenements. 53% of these properties have an SAP rating equivalent to an EPC band E or below; 22% are F and below.

These households are mainly occupied by single adult (35%) and small adult (33%)[28] households without children. It is likely that much of this accommodation is occupied by younger shared households such as student accommodation. Fewer households than average (9%) contain occupants of pensionable age.

Fuel poverty

Fewer than average households in this type of property live in fuel poverty; however, it is still prevalent with 25% of households in fuel poverty, 7% of households live in extreme fuel poverty. Households in fuel poverty in this house type need to reduce their fuel bills on average by around £490 to no longer be considered fuel poor.

Measures required

55% of these properties have cavity walls yet only 4% of properties have cavity wall insulation. Therefore, over half of these properties could be improved relatively cheaply with cavity wall insulation.

According to the modelling work we have undertaken, the properties of this type that fall below an E-band can be brought up to a band E for an average cost of £2,950, saving around £220 per year in fuel bills. Most of these properties below a D and E have solid walls. As such, some will require solid wall insulation to bring them up to the required standard. However, some properties can be brought up with just draught proofing and energy efficient lighting.

To bring all of these properties up to a minimum band D would cost on average £4,140 per property and save on average £280 per year in fuel bills. The measures required to achieve this include a range of measures across various properties including external wall insulation, cavity wall insulation, fitting air source heat pumps with wet central heating systems, double glazing and draught proofing. In some properties, suitable microgeneration (PV or solar hot water) may also be required.

For both of these scenarios (improving homes to either a minimum band E or a minimum band D) the resulting fuel bill savings will go some way to reducing the numbers of fuel poor households but would not be sufficient to eradicate fuel poverty.

Gas Heated, Owner Occupied, Semi-detached Houses with cavity walls

Typical household

There are 190,000 houesholds in owner occupied gas heated semi-detached houses with cavity walls in Scotland that pay, on average, £1,150 a year in fuel bills. The majority (80%) were built after the end of the Second World War. 94% of these homes are in urban areas and are most prevalent in Glasgow city (9%) North Lanarkshire (8%) and South Lanarkshire (8%), and Edinburgh (8%) There are also disproportionately high numbers of these homes in East Dunbartonshire and East Renfrewshire in relation to the mix of property types in the national housing stock.

[28] *Small adult households refer to a household of two adults of non-pensionable age, with no children. Scottish House Condition Survey 2009, Key Findings.*

24% of these homes have an SAP rating equivalent to an EPC band E or below; 1% are in band F. These homes are usually occupied by families (27%) – two or more adults with dependent children - or small households with two or more adults (22%).

Fuel poverty
19% of households in these homes live in fuel poverty. Of these, 92% are both vulnerable and fuel poor. 5% of the households in these homes live in extreme fuel poverty. In order to no longer be considered fuel poor, with their existing incomes, these households would need to reduce their fuel bills by an average of £430 per year.

Measures required
According to the SHCS almost 70% of these properties do not have any form of wall insulation and 90% have less than 150mm of loft insulation.

In this analysis to bring all properties up to a minimum SAP rating for an E band EPC, the few properties with an F rating will require merely draught proofing and energy efficient light-bulbs. This would only cost around £110 per house, but would also save around £110 per household per year.

To bring all of these properties up to a minimum D band would cost around £410 per property and save approximately £310 per year per property. The range of measures required to do this includes cavity wall insulation, loft insulation installing condensing boilers, draught proofing as well as energy efficient lighting.

With average annual fuel bill savings of £310, bringing all properties up to a D band would go some way to reducing levels of fuel poverty in these households, but would not entirely eradicate the problem.

Oil heated detached houses and bungalows with solid walls

Typical household
There are approximately 29,000 of these homes across Scotland, the majority (92%) built before 1919. Fuel bills are much higher than average in this property type, with households paying on average £2,610 a year. Nearly all (98%) of these homes are in rural locations: approximately one fifth (18%) are in Dumfries and Galloway with significant amounts in the Highland authority (14%), Scottish Borders (10%) and Perth and Kinross (8%). These homes also make up a significant proportion of housing stock on the islands in Orkney, Shetland, and the Western Islands.

The energy efficiency performance of these homes is generally very poor with the majority (91%) of these homes being in EPC band E or below. 32% are in band F, and 1% are in band G.

There is a roughly even split of household types living in this type of property between single and small adult households (36%), families (28%) and households with older people or single pensioners (28%). Slightly fewer than average people with long-term illnesses or disabilities (27%) occupy this property type.

Fuel poverty
With significantly higher fuel bills than average, half of households living in this property type are in fuel poverty (49%), and 24% are in extreme fuel poverty. In order to no longer be considered fuel poor, with their existing incomes, these households would need to reduce their fuel bills by an average of £1,500 per year.

Measures required
According to the SHCS, 90% of these households have less than 150mm of loft insulation and 15% have none. As typical with most "hard to treat' properties, these homes require solid wall insulation. 7% of these homes already have solid wall insulation.

According to our analysis, to get each of these properties to a minimum E band would cost on average around £2,800 per property, saving on average £1,300 in fuel bills each year per property. This would require installing condensing oil boilers, and condensing gas boilers in the few properties where a gas connection is available, as well as fitting energy efficient lighting.

To get all properties up to a D band would cost on average £6,400 and save on average £1,300 per year per property. This would require a range of measures across all properties including internal wall insulation, top up loft insulation, draught proofing, double glazing and new oil condensing boilers. Some properties also require some form of microgeneration including solar photovoltaics, solar hot water systems or wind turbines.

With average annual fuel bill savings of £1,300, both of these scenarios would go some way to reducing levels of fuel poverty in these households, but do not look likely to entirely eradicate it.

Gas heated terraces with cavity walls

Typical household
There are approximately 31,000 of these households in Scotland, the majority having been built between 1945 and 1982 (80%). 94% of these properties are in urban locations with the highest prevalence in North Lanarkshire (13%), South Lanarkshire (9%) and Fife (11%). The majority of properties (56%) are in EPC band D, and 11% of properties are in band E.

The majority of households are owner occupiers (62%), but a large proportion (34%) of these homes are owned by the local authority, registered social landlords or housing associations. 29% of households are singletons or single parent families, 14% of these households are single pensioners. 34% of the households contain someone of pensionable age. There is a slightly higher than average proportion of households with occupants who have long-term illnesses or disabilities (40%).

Fuel poverty
Levels of fuel poverty are very slightly lower than average in this type of property with 25% of households in fuel poverty and 6% in extreme fuel poverty. 21% of households (84% of fuel poor households) are vulnerable fuel poor households. On average, people in fuel poverty will need to reduce their annual fuel bills by around £340 per year to no longer be considered fuel poor.

Measures required
Only 34% of properties of this type have cavity wall insulation. 85% of these properties have less than 150mm of loft insulation and 5% have less than 25mm.

In our analysis, to get all properties of this type up to a minimum of a D band would cost on average £230 per property improved and save on average £110 in fuel bills per property per year. The range of measures required to do this include loft insulation, cavity wall insulation, installing condensing boilers, energy efficient lighting and draught proofing. This improvement may have some impact on lowering the levels of fuel poverty but certainly would not eradicate it.

3.4 Economic impact

The Energy Saving Trust Economic Impact Model was used to estimate the jobs supported and gross value added (GVA) by each of the scenarios. In this model:

- the levels of employment directly supported by installation are a factor of the labour requirement of installation; and
- the GVA directly created is the levels of employment supported, multiplied by the average GVA/head for installation.

For a number of reasons, we suggest that these modelled economic impacts may be at the lower end of the range of what would be realised in reality:

1) the analysis used to produce this model is based on UK average costs; these will vary across the country, particularly in more remote areas of Scotland where there is little installer competition and costs of transport will be much higher;
2) not all measures have been modelled in our economic impacts assessment. This is because for the more unusual measures consistent information on their price and labour is not always available – e.g. insulating render;
3) we are focusing only on direct economic impacts. There will be further positive economic effects (and some negative effects) on the economy beyond these direct impacts. For example, extra spending will happen in the measure supply chains as a result of increased sales of energy efficiency measures, and money saved on fuel bills by householders is likely to be spent on other goods and services within the economy, in turn leading to further job support. Negative effects might include job losses or reduced spending in other areas of the economy, as money is spent on energy efficiency improvements rather than in other areas, or due to 'leakage' of economic benefits to areas outside Scotland;
4) like the Refurbishment Calculator, the Economic Impact Model assumes that all measures are installed in one year. Therefore, all jobs supported and GVA are assumed to be generated in one year. For a simple assessment of number of jobs created over time, the total number of FTE jobs generated can be divided by the number of years involved. Thus 7,700 jobs supported equates to 770 people employed over 10 years, assuming that measures are installed at a steady rate over the 10 year period.

Table 4 – Economic impact of improving EPC bands

Cost level	Improving All E,F&G	Improving PS E,F&G	Improving Private Sector F&G
Jobs supported in one year (FTE)	**9,900**	**7,700**	**1,800**
GVA	**£613,400,000**	**£479,000,000**	**£111,900,000**

3.5 Summary of key findings

Cost and CO_2 savings achieved

Bringing private sector band F & G homes in Scotland to a band E could result in a reduction of around 0.5MtCO_2 a year from the residential sector, for a cost of around £420m. Bringing private sector band E, F & G homes in Scotland to a band D could achieve a reduction of 1.86MtCO_2 a year and would cost just over £2bn. Bringing all band E, F & G homes in Scotland to a band D could result in a reduction of 2.1MtCO_2 from the residential housing stock at a cost of £2.45bn. These costs are estimates of the total cost to carry out the improvement work. No assumptions have been made as to whether householders would bear the full cost of improvement works, or whether this would be supported by government and/or the private sector.

Improving all band E, F & G homes has the highest average cost to improve a home (£3,200 per improved home), and the largest percentage of homes requiring a spend of more than £7,250 to bring them to the target EPC band. This reflects the fact that moving from a band G to a band D requires a large number of measures, at a significant cost, compared to moving band G homes to band E.

Improving private sector F & G homes to band E costs on average only £2,600, because of the smaller increase in SAP rating required, which can be achieved without using more costly measures such as a renewable heating technology, solid wall insulation or double glazing. Improving these private sector band F & G homes has the largest average CO_2 saving per home improved, with an average reduction of 3.1tCO_2 per year, compared to savings of 2.8tCO_2 per year (improving private sector E, F & G homes) or 2.7tCO_2 per year (improving all E, F & G homes), and the largest average reduction in fuel bills (£650 a year saved, compared to £600 for private sector E, F & G and £580 saved for all E, F & G homes, because F & G rated homes are the worst stock to begin with).

The average cost to improve a home increases from £3,000 on average when improving private sector E, F & G, to £3,200 on average when improving all E, F & G homes in both the private and social sectors. This reflects the fact that more homes in the social sector which are currently E, F or G rated are likely to require expensive measures than E, F or G rated homes in the private sector. Social homes which can have cheaper measures such as cavity wall insulation, or a new condensing boiler, will already have been improved through the SHQS, so, in effect, the homes in the social sector which still currently have a low SAP rating are the more difficult to treat, requiring more expensive measures such as solid wall insulation to improve their rating.

The costs to install these measures do not include any subsidies (e.g. CERT, or its successors) on the cost of measures. They also do not include any discounts that might be available through bulk purchase of work or material, or where a number of homes are improved together at the same time, which could in practice reduce the total cost of achieving a higher SAP band for a group of homes if they were situated close together geographically or are under the same management (in social sector homes). Work may also cost less (and help to overcome barriers such as the perceived 'hassle-factor') if several measures can be applied to one house in the same round of renovations.

Additionally, our assessment of the benefits to households does not include incentives such as the Feed in Tariff (FIT) and Renewable Heat Incentive (RHI). The FIT generation tariff could provide income of around £368 per year[29] for each home which required a PV panel to get them up to their target EPC band. This would bring a benefit of around £164,000 a year to PS homes moving from bands E, F & G to band D, or around £166,000 a year to homes in all tenures moving from bands E, F & G to band D[30]. Details on levels of financial benefit from either an RHI tariff or the Renewable Heat Premium Payments have not yet been released, but are expected to provide additional financial benefits to householders installing renewable heat technologies[31].

The cheapest option to reach a target EPC band may not always be the best long-term option for reducing CO_2 emissions from a home. For example, some solid wall homes would be able to reach their target EPC band using insulating render, which is less effective, but cheaper, than internal or external solid wall insulation. However, once insulating render has been applied to a house, a home owner would be unlikely to later apply a more effective form of solid wall insulation. In some cases finding the

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[29] *£368 per year based on a 1kWp panel, generating 850kWh per year, and FIT generation tariff of 43.3p per kWh as of 1 April 2011.Generation tariff rates are adjusted annually according to changes in the Retail Price Index, with new tariff rates applying from 1 April. Income is also available through the FIT export tariff (3.1p per kWh as of 1 April 2011). The amount each home could expect to earn from the export tariff will vary depending on the amount of electricity from the PV panel exported to the grid, rather than used in the home.*

[30] *PV panels were not a measure which the Refurbishment Calculator assigned to any PS F&G homes to move them to band E.*

[31] *Renewable Heat Incentive. DECC, March 2011.* http://www.decc.gov.uk/assets/decc/What%20we%20do/UK%20energy%20supply/Energy%20mix/Renewable%20energy/policy/renewableheat/1387-renewable-heat-incentive.pdf

cheapest option for meeting the target EPC band may lead to energy efficiency measures being applied to a home in an order the Energy Saving Trust would not normally recommend. Some homes can be brought up to their target EPC band through upgrading their gas or oil boiler to a new condensing model. However, some of these homes may also have unfilled cavity walls, or lofts containing less than 270mm of loft insulation (the recommended depth). Best practice for improving these homes would be to fill these lofts and cavities first, before installing a new boiler, to make sure the new boiler is correctly sized for the property. However, if either of these measures is not enough to reach the target EPC band, but improving the boiler alone is sufficient, this is the measure which has been recommended for the house type in this analysis.

A reduction of 2.1MtCO_2 a year from the residential sector (the saving possible from bringing all E, F & G homes to a D) represents a 25% reduction in residential emissions from 1990 levels, across the traded and non-traded sectors. This reduction would go a third (33%) of the way to reaching a 42% emissions reduction target by 2020 from a 1990 emissions baseline, if the housing sector were to aim for CO_2 reductions in line with the cross-sectoral Scottish target of a 42% emissions reduction by 2020.

Impact of the scenarios on fuel poverty

The estimated fuel bill savings that can be achieved in different house types from bringing them into a higher EPC band can be significant. For example, bringing all oil heated, detached houses and bungalows with solid walls up to a minimum D on their EPC would, on average, reduce fuel bills per house by £1,300 a year.

However, fuel poverty was not eliminated from the group of homes in any case study, despite raising the energy performance to a minimum E or even D rating. The expected average fuel bill saving was always less than the average amount by which a household needed to reduce fuel spend in order to no longer be classed as fuel poor.

The case studies which came closest to eliminating fuel poverty through the improvements needed were the gas heated, owner-occupied semi-detached houses with cavity walls, and the oil heated, detached houses and bungalows with solid walls. In the former, average fuel bill savings from bringing all homes currently below band D to a D rating would save approximately £310 a year per property. However, in order to no longer be fuel poor, households in these homes would need to reduce their fuel bill spend (or increase their household income) by £430 a year on average. In the oil heated detached houses and bungalows with solid walls, bringing homes below a D band on their EPC up to a minimum of D would reduce fuel bills per house by £1,300 a year, but fuel poor households need to reduce fuel bill spend (or increase household income) by on average £1,500 to no longer be classed as fuel poor.

Economic impact of improving the least efficient homes

Bringing all E, F & G homes in Scotland to a minimum band D rating would generate £613m GVA, and support employment equivalent to approximately 9,900 jobs (at full time equivalent). Improving only private sector E, F & G homes in Scotland to a minimum band D rating would generate around £479m in GVA, and support employment equivalent to approximately 7,700 jobs. Bringing private sector homes in bands F & G to a minimum band E rating would generate around £112m in GVA, and support employment equivalent to approximately 1,800 jobs.

These figures represent only the direct economic effects of the installations (the GVA and levels of employment supported by the installation of the measures required). There will be further effects beyond these - for example in the supply chain and from re-spend of the money which householders would save on their fuel bills – which have not been quantified here.

Comparing results with Scottish Government modelling

A reduction of 2.1MtCO_2 a year from the residential sector (the saving possible from bringing all band E, F & G homes in Scotland to a D) represents a 25% reduction in residential emissions from 1990 levels, across the traded and non-traded sectors.

The Scottish Government estimates that all current UK and Scottish policies, plus UK and Scottish proposals, in the homes and communities sector could result in an emissions reduction of 36% in residential emissions (in the non-traded sector only) compared to 1990 levels[32]. This represents an emissions reduction of 1.098MtCO_2e[33] compared to business as usual projections for 2020, in the non-traded sector only. Of this, 0.48MtCO_2e of abatement comes from policies and proposals targeting energy efficiency measures at the existing buildings (the domestic building energy efficiency policies, and the proposal on fuel poverty and insulation programmes).

Scottish Government work using the DEMScot model[34] suggests that regulations bringing all Scottish homes to a minimum EPC band of D would achieve emissions abatements equivalent to only 70% of the reduction from the existing Scottish housing stock identified from the *Report on Policies and Proposals* (0.34MtCO_2e).

The results presented in this report are not directly comparable to the DEMScot results or RPP modelling, as:

- the results presented here cover emissions from the traded sector as well as the non-traded sector;
- Scottish Government modelling uses the units of carbon dioxide equivalent (CO_2e), rather than carbon dioxide (CO_2), i.e. they include the global warming potential of other greenhouse gas emissions associated with each sector. The results presented here focus only on emissions of CO_2,although this will lead to only minor differences between the results as the majority of greenhouse gas emissions from the residential sector are of CO_2;
- the DEMScot modelling of bringing homes to a minimum D-rating did not cover installing heat pumps as a measure, but this measure was included in the analysis here;
- Scottish Government modelling is presented as abatement relative to a reference projection. The Refurbishment Calculator does not take account of any reference projection in emissions, for example due to routine replacement of old boilers with condensing models as the old ones break, or other baseline trends.

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32 *Low Carbon Scotland: Meeting the Emissions Reduction Targets 2010-2022. The Report on Policies and Proposals. Scottish Government, 2011.* http://www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/lowcarbon/rpp

33 *CO_2e refers to carbon dioxide equivalent.*

34 *Impacts of options for regulating energy efficiency standards in the domestic sector. Scottish Government, March 2011,* http://www.scotland.gov.uk/Publications/2011/03/22092740/0

4. Appendix – SAP ratings and EPC bands

EPC band	SAP 2005 rating
A	92-100
B	81-91
C	69-80
D	55-68
E	39-54
F	21-38
G	1-20