Economic impact of improving the energy efficiency of fuel poor households in Scotland

Report for Consumer Futures Scotland – Final Report

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Executive Summary

This study was commissioned by Consumer Futures to assess the social, environmental and macroeconomic impact of investing carbon tax revenues in energy efficiency programmes for fuel poor households in Scotland. It follows on from a similar UK-wide study[1] commissioned by Consumer Futures in 2012 that demonstrated that investing money raised through carbon taxes into household energy efficiency creates more jobs and growth than other kinds of major Government investment or tax cuts, in addition to delivering environmental and social benefits. This study focusses specifically on assessing and quantifying these benefits within the Scottish context.

The Scottish Government has legally binding targets to cut greenhouse gas emissions by 42% by 2020 and 80% by 2050 over 1990 baseline. The housing sector alone accounts for around a quarter of the Scotland's greenhouse gas emissions. The government also has a commitment to end fuel poverty, as far as is reasonably practical, by 2016. To progress towards these targets, the Scottish Government has maintained its commitment to public funding of energy efficiency and fuel poverty schemes. The Home Energy Efficiency Programmes for Scotland (HEEPS) has been in operation since April 2013.

According to recent data published by the Scottish Government, around 28% of households in Scotland are fuel poor. Moreover, rising fuel prices are pushing an increasing number of households into fuel poverty. Tackling the problem will require additional resources than currently committed. The recycling of carbon taxes from EU ETS and carbon price floor into domestic energy efficiency offers a potential revenue stream. Scotland is especially well placed to benefit (socially, economically and environmentally) from energy efficiency measures as it has a housing stock that is widely regarded as inefficient and which has the potential to be improved using existing well-established technologies and fabric improvement measures.

Despite the likely benefits of implementing an enhanced nationwide energy-efficiency programme, we appreciate that any additional public spending must be carefully justified, regardless of the source of income. This research aims to provide such a justification by providing quantitative economic analysis of the impacts of investing in household energy efficiency.

Increased fuel poverty levels in 2016

Analysis carried out using data from Scottish Housing Condition Survey (SHCS) suggests that fuel poverty in Scotland will increase from 654,300 households in 2010[2] to 945,000 households by 2016, which corresponds to 40% of all Scottish homes. This increase is mainly driven by the projected increases in energy prices which are likely to push more and more households into fuel poverty. Approximately 350,000 of these households will be in 'extreme fuel poverty', which is defined by the Scottish Government as those households which need to spend 20% or more of their income on keeping themselves warm.

[1] Jobs, Growth and Warmer Homes - Evaluating the Economic Stimulus of Investing in Energy Efficiency Measures in Fuel Poor Homes, 2012
[2] Scottish Housing Condition Survey (SHCS) dataset, 2009-2011

The total investment cost of alleviating fuel poverty across these 945,000 Scottish households would be £7.4 billion at an average cost of £7,800 per property. Apart from the social benefits, this investment would deliver total carbon savings of 2.3 million tonnes of CO_2 per annum.

Investing Scotland's share of carbon tax revenues to address fuel poverty

Scotland's share of carbon tax revenues from EU ETS and carbon price floor mechanism was estimated at £4.8 billion between now and the end of the fourth carbon budget period in 2027. Scotland's share was calculated on a pro-rata population basis, which equates to 8% of the UK total. The projected carbon revenue figure would not be large enough to cover the full £7.4 billion required to address all fuel poor households in 2016. However, it would provide sufficient funds to remove 611,500 households from fuel poverty providing an average energy bill saving per property of £552 per year.

The analysis therefore investigated capping the level of energy efficiency funding per property at £10,000 so as to eliminate high expenditure on particular hard-to-treat properties and thereby increase the overall number of properties that could benefit from energy efficiency measures. When applying this £10,000 funding limit per property, the £4.8 billion carbon tax revenues could fund energy efficiency measures across 823,500 fuel poor properties (a 35% increase in the number of households receiving measures), with an average investment of £5,800 per property and an average energy bill saving of £505. Even though the average energy savings decrease, the overall increase in the number of homes receiving energy efficiency measures results in an increase in total energy savings of 25%. However, only 538,500 of these households would be fully removed from fuel poverty, with the remaining 285,000 households benefitting from a reduction in the severity of fuel poverty that they face.

Macroeconomic benefits of investing in energy efficiency in fuel poor households

Economic modelling was undertaken to assess the impact of investing in energy efficiency measures in fuel poor households between now and 2027. It shows that there would be an additional economic benefit of investing in energy efficiency compared to other fiscal stimulus or a direct transfer to incomes.

The investment scenarios are all positive, by design, and so it is the comparison between scenarios that is important to consider, rather than considerations against the baseline. Four scenarios were modelled:

- Energy Efficiency (EE_SC) - investing the money in energy-efficiency measures in fuel poor homes
- Government spending (G0_SC) - adding an equivalent sum to government expenditure (on nurses, teachers, etc.)
- Government investment (GK0_SC) - adding an equivalent sum to government investment (in roads, schools, hospitals, etc.)
- Income transfers (I0_SC) - an income transfer, giving a sum equivalent to the per household investment in energy-efficiency measures to each fuel poor household for them to spend as they wish.

The energy efficiency measures scenario has three distinct economic effects; it simultaneously increases investment in the economy, which results in an increase in demand for construction, reduces output of the utilities sector (the majority of which is imported) by reducing fuel demand, and boosts household disposable income by reducing fuel bills.

Two sub-scenarios for investment in energy efficiency measures were modelled; the primary scenario caps investment costs at £10,000 per household, while the second did not cap the investment costs per household.

Under the primary energy-efficiency (capped) scenario, approximately 8,900 jobs would be created in Scotland in the long-term compared to around 6,500 from a fiscally-equivalent government spending package, or 4,500 from an equivalent government investment.

In the short term, the boost to construction has the largest impact; in 2015 and 2020 construction GVA is almost 2% higher than in the baseline and there are an additional 3,400 jobs. However, as the number of households that have received treatment accumulates over time, the reduction in household energy expenditure has an increasingly large negative impact on utilities' GVA while increasing GVA in services and (to a lesser extent) manufacturing. By the end of the forecast period in 2027 the number of additional jobs generated in services, at 3,800, is greater than those created in construction by the continued investment. Although gross value added in utilities declines, reflecting a reduction in spending on electricity and gas in treated households, the scenario has a net positive impact equivalent to 0.27 percentage points in the level of GVA in 2027 compared to the baseline. This increase in GVA is higher compared to all other investment scenarios.

The net macroeconomic effects are similar in the two energy efficiency sub-scenarios, as the total monetary value of the investment is the same in both. However, employment is slightly higher in the capped sub-scenario, driven by the increased cost-effectiveness of the investment as described above. The capped sub-scenario generates higher total household savings, and these result in higher consumer expenditure and therefore higher employment (particularly in consumer services), which outweighs the fewer utilities jobs in this sub-scenario. The net difference between the two sub-scenarios is 800 jobs, while there is a negligible difference in GVA in percentage terms (less than 0.02% of the baseline in 2027).

Table 1: Summary of long-term modelling results

	EE_SC (capped)	EE_SC (uncapped)	G0_SC	GK0_SC	I0_SC
Annual fiscal stimulus (£m 2013 prices)	341	341	341	341	341
Total homes treated ('000s)	823.5	611.5	n/a	n/a	n/a
Annual jobs created ('000s FTE)	8.9	8	6.5	4.5	4.3
Scottish GVA impact (%)	0.27	0.26	0.2	0.19	0.15
Annual energy bill saving per household treated (£ 2013 prices)	505	552	n/a	n/a	n/a

Conclusion

This analysis shows that the macroeconomic case for investment in energy efficiency measures in fuel poor households is strong, particularly if it is targeted at cost-effective investments. Such an investment programme would deliver social, economic and environmental benefits beyond those that would be expected from the alternative investment scenarios considered in this study.

1. Introduction

This study has been commissioned by Consumer Futures to understand the potential for recycling of carbon taxes to upgrade the energy performance of fuel poverty homes in Scotland, and the wider macroeconomic benefits that this investment would have for the Scottish economy. It follows on from a similar UK-wide study commissioned by Consumer Futures in 2012 that demonstrated that investing money in household energy efficiency delivers greater economic, environmental and social benefits than other kinds of major Government investment.

The Scottish Government has set a target to eliminate fuel poverty as far as is reasonably practicable by 2016 and has maintained its commitment to public funding of energy efficiency and fuel poverty schemes through the Home Energy Efficiency Programmes for Scotland (HEEPS). However, rising fuel prices are pushing an increasing number of households into fuel poverty. Fuel poor homes also tend to have lower energy efficiency performance on average. The average Scottish home currently has a SAP[3] score of 61 (mid-range EPC rating of Band D) while the average fuel poor home has a SAP score of 56 (on the boundary of EPC Bands E and D). This study has estimated the number of fuel poor households in 2016 and the level of investment that will be required to bring them out of fuel poverty.

The recycling of revenues from the EU Emissions Trading Scheme and the Carbon Price Floor mechanism into energy efficiency measures has the scope to provide significant funding for properties suffering from fuel poverty and to provide wider stimulation for the economy. This study has projected Scotland's share of carbon revenues out to the end of the fourth carbon budget period in 2027 and evaluated the impact that these revenues could have on funding energy efficiency in Scotland's fuel poor homes.

Investing in fuel poor households in Scotland has the scope to stimulate the wider economy through energy efficiency measures boosting the construction industry and through providing householders with greater purchasing power (due to reduced energy expenditure). This study has assessed the economic impact of investing in the energy efficiency of Scottish households, and compared this impact with alternative forms of investment, using Cambridge Econometrics' MDM-E3 model for the UK.

To summarise, the study assesses three main aspects:

1. The scale of investment required to bring all households out of fuel poverty in 2016 through installing energy efficiency measures;
2. The projected revenues for the UK government from carbon taxes between now and 2027, the end of the fourth carbon budget, and an estimate of Scotland's pro-rata share;
3. The macroeconomic benefits for Scotland of recycling their share of carbon tax revenues to improve the energy performance of fuel poor homes.

[3] Standard Assessment Procedure

2. Fuel poverty analysis

2.1 Overview

Fuel poverty in Scotland is currently defined as the situation faced by households when they need to spend more than 10% of their income to heat the home to an adequate level and meet other energy needs. The Scottish Government decided not to follow the UK Government in adopting the Hills[4] recommendations in 2012 for a new definition of fuel poverty based on a Low Income High Costs (LIHC) framework. However, the Scottish Fuel Poverty Forum is currently in the process of reviewing the definition in Scotland.

To assess whether a household is fuel poor or not, the amount that they spend on fuel is calculated according to an approved methodology, rather than being taken from their actual bills. The methodology requires rooms to be heated to a specific temperature (21°C in living room and 18°C in the rest of the house[5]) and according to a pre-defined heating regime (9 hours during weekdays[6] and 16 hours on weekends) during the heating season. This is because in reality fuel poor households tend to under-heat their properties, which means that their actual bills may not be an accurate representation of the level they would need to spend to achieve an adequate level of comfort.

There are three main aspects affecting whether or not a household is fuel poor.

- **Energy prices**: As fuel prices go up, households have to spend an increasing amount of their income on heating their homes and other energy uses. Therefore, the higher the fuel prices, the higher the number of households that will fall into fuel poverty.
- **Energy consumption**: This in turn is dependent on the characteristics of the property that the household occupies. Properties that are poorly insulated or those with old inefficient boilers will have a higher level of fuel consumption compared to well insulated properties.
- **Household income**: Lower income households are at most risk of fuel poverty. However, where household incomes do not rise proportionate to increase in energy prices, more and more households will be driven into fuel poverty, unless specific measures are taken to bring down the fuel consumption.

The number of fuel poor households in 2016 was estimated by projecting predicted rises in fuel price and household incomes over the next 3 years, and incorporating the estimated reduction in energy consumption from current policy instruments. The current Scottish definition of fuel poverty was used for this modelling. Further, technical and financial modelling was then carried out to assess the level of investment required to improve the energy performance of fuel poor homes so that their modelled energy spend does not exceed 10% of the household income. This fuel poverty analysis in turn provided the relevant inputs for the macro-economic modelling and consisted of the following key steps that are detailed further in the subsequent sections:

- Estimating number of fuel poor households in 2016
- Modelling investment required to alleviate fuel poverty in these households
- Calculating the energy bill and CO_2 savings associated with these energy efficiency measures.

[4] Hills Fuel Poverty Review – Getting the Measure of Fuel Poverty, March 2012
[5] 23° C in the living room and 18° C in other rooms for elderly and infirm households
[6] 16 hours out of 24 for the elderly and infirm households during weekdays

2.2 Approach to modelling

2.2.1 Estimating number of fuel poor households in 2016

For the analysis, Scotland's housing stock was classified into archetypes based on dwelling type (e.g. detached, semi-detached, terrace, flat), wall construction and heating fuel. The most predominant typologies are gas-heated cavity-wall semi-detached, terraced properties and flats. This is followed by gas-heated solid wall flats and electric heated solid wall flats. The top ten archetypes do not include solid fuel or oil heated properties. For each archetype, sub-archetypes were defined to cover a range of starting energy efficiency performance levels or SAP scores. The distribution of each archetype and sub-archetype in the 2009-2011 Scottish Housing Condition Survey (SHCS) dataset has been used as the basis to extrapolate the dwelling level results to the wider housing stock.

The SHCS is a sample of approximately 9,700 Scottish households with detailed information on property energy performance, energy bills and household income. To estimate 2016 levels of fuel poverty in Scotland, household incomes and fuel bills in the 2009-2011 SHCS were projected forwards to 2016 levels. Projections of fuel price increases were taken from DECC's Updated Energy & Emissions Projections[7] and the proportional increase of 30% up to 2016 applied to the energy costs faced by households in the 2009-2011 SHCS. Household incomes were projected using the Office for Budget Responsibility's forecasts[8] which forecast a 4% increase in average household income between 2010 and 2016. Allowance has been made in the calculations for improvements to the energy efficiency of the housing stock in 2016 compared with 2009-2011 levels and the impact this may have on average household energy consumption. This projection of the impact of improvements to the energy efficiency of the stock has been based on two elements; firstly, the general downward trend in energy consumption patterns of an average UK household (driven by end-of-life or otherwise replacement of products with more efficient products e.g. boilers, energy efficient lighting and appliances) and, secondly, the specific impact of Scottish Government policies and investment programmes on energy consumption in Scottish households.

Data published by the Committee on Climate Change[9] has been used for the first element. These projections suggest an average UK household reduction in electricity consumption of 11% and an average UK household reduction in gas consumption of 3.2%.

Information on the impact of Scottish Government policies has been taken from the Scottish Fuel Poverty Forum's May 2012 review of the Scottish Government Fuel Poverty Strategy[10]. This review outlines estimated funding levels for fuel poverty and energy efficiency up to 2015. It identifies a total of £585 million of funding between 2012 and 2015 for energy efficiency measures targeted at households at risk of fuel poverty. This funding total includes an estimate of the amount of ECO funding allocated to Scottish homes, although the value of this now in fact is likely to fall due to the reductions in ECO expenditure announced by the UK Government in December 2013.

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[7] Updated Energy & Emissions Projections, DECC September 2013 https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2013

[8] Office of Budget Responsibility - Economic and fiscal outlook charts and tables - March 2013 (http://budgetresponsibility.independent.gov.uk/category/topics/economic-forecasts/)

[9] Committee on Climate Change (2011) Household energy bills – impacts of carbon budgets

[10] Scottish Government's Fuel Poverty Forum: Review of the Scottish Government's Fuel Poverty Strategy http://www.scotland.gov.uk/Topics/Built-Environment/Housing/warmhomes/fuelpoverty/ScottishFuelPovertyForum/SFPFinterimreportmay012

2.2.2 Modelling investment required to alleviate fuel poverty in these households

To estimate the level of investment required to take households out of fuel poverty, a ‘Target SAP rating’ was calculated for each dwelling in the SHCS data. The ‘Target SAP’ is defined as the minimum SAP score a dwelling needs to achieve to avoid the current household living in fuel poverty, up to a maximum SAP score of 81 corresponding to an EPC rating of ‘B’. This has been calculated by working out the amount of money that a household can spend on energy bills without falling into fuel poverty, based on the projected 2016 fuel prices and household incomes.

Technical energy efficiency modelling of key Scottish housing archetypes has been used to generate ‘cost curves’ based on the capital costs of energy efficiency measures and the relative improvement they make to the SAP score. These cost curves include the core costs (the capital cost and installation cost) for each energy efficiency measure but do not include the costs of administering, targeting and marketing an energy efficiency programme.

The measures modelled vary with archetype, and include cavity insulation, loft insulation, solid wall insulation, floor insulation, hot water cylinder jacket, primary pipework insulation, low energy lighting, draught-proofing, double/ triple glazing, heating controls, high efficiency boilers for gas heated properties, heat pumps for electric heated properties, and advanced airtightness package with MVHR (Mechanical Ventilation with Heat Recovery). The sequence of measures has been optimised to ensure that the most cost-effective measures are installed first; although some consideration has also been given to the hassle factor of installing a measure.

The cost curves are based on average costs for each energy efficiency measure in each archetype. The costs are taken from a number of different sources across the UK including social housing retrofit programmes and private housing schemes and from the EST (Energy Saving Trust) Housing Energy Model[11]. The cost data in the EST Housing Model are total installed costs and were put together based on discussions with trade associations, manufacturers and installers. These costs have been adjusted for Scotland by applying correction factors taken from data published by the Royal Institute of Chartered Surveyors[12] on correction factors for UK regional variations. The house archetype categorisation does not include location (i.e. rural or urban) or heritage status (e.g. tenement or modern construction) and therefore these average costs are not differentiated into urban/ rural or heritage/ non-heritage.

The energy efficiency cost curves were then applied to each fuel poor household in the SHCS data, taking into account its projected starting SAP score in 2016 (based on the expected reduction in energy consumption by 2016 due to current polices ad programmes) and its target SAP score (calculated to ensure less than 10% of income is spent on energy), to work out the level of investment required to take the household out of fuel poverty.

[11] EST Housing Energy Model assumptions: www.energysavingtrust.org.uk/uk/Publications2/Local-authorities/Strategy-development/The-Energy-Saving-Trust-Housing-Energy-Model-assumptions

[12] BICs, The Greener Homes Price Guide - Organising and Budgeting for Energy Efficiency and Reducing Your Carbon Footprint, 2008

2.2.3 Calculating the energy bill and carbon savings associated with these energy efficiency measures

The energy bill savings that would be associated with improving the projected starting SAP score in 2016 to the target SAP score for each archetype was then calculated to identify the benefit to the householders. The impact of 'comfort take' on these energy bill savings has been incorporated into the analysis with the assumption that 40% of predicted energy savings would not be realised and are in fact taken as thermal comfort improvements in the home. This 40% figure is taken from UK Government assumptions used in CESP evaluations. The energy bill savings were converted into carbon savings using appropriate Government fuel carbon factors.[13]

The SHCS archetype analysis has been aggregated up to the total Scottish housing stock using appropriate weighting factors to provide:

- Total and average cost of fuel poverty alleviation per household
- Average energy bill reduction per household
- Average CO_2 savings per household

2.3 Investment required to address fuel poverty in 2016

2.3.1 Number of households in fuel poverty by 2016

The analysis of the SHCS 2009-2011 dataset suggests that 654,000 households were in fuel poverty in Scotland in 2010 (as the middle year of the dataset) which equates to 28% of Scotland's housing stock (there are around 2.4 million homes in Scotland). The modelling indicates that the number of fuel poor households will increase to approximately 945,000 by 2016 – about 40% of all households as illustrated in Figure 1. This increase is driven by the projected increases in energy prices which are pushing more and more households into fuel poverty. Energy prices are projected to increase by 30% between 2011 and 2016 whereas average household income is projected to increase by only 4%.

Figure 1: Projected number of fuel poor households in Scotland in 2016

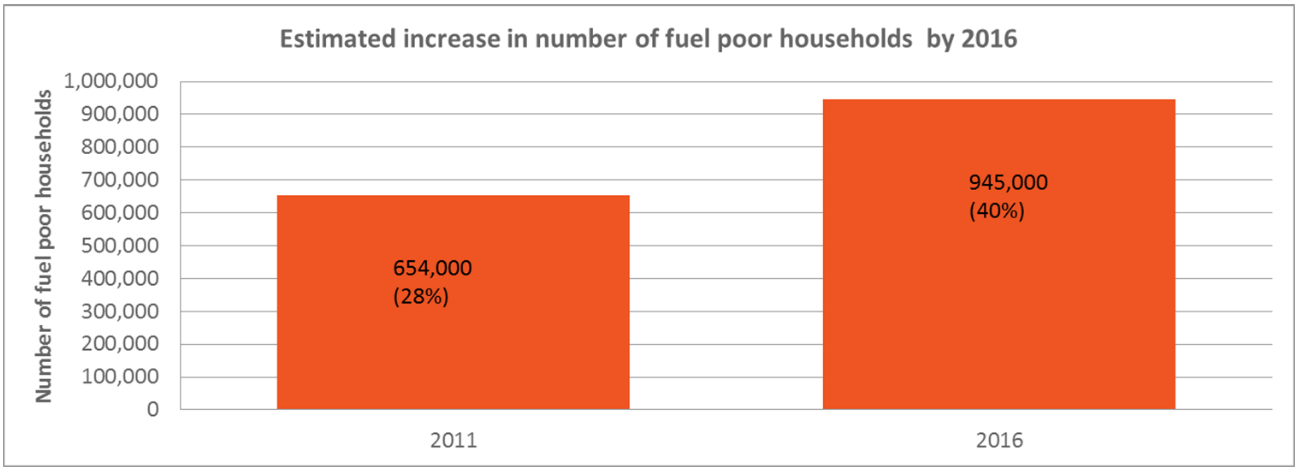
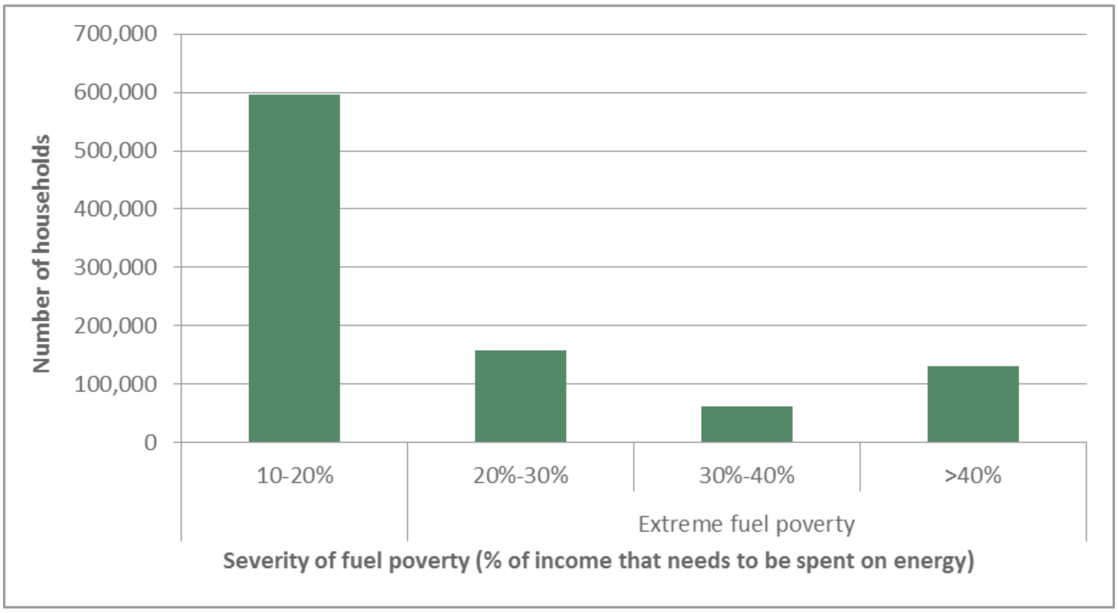


Figure 2 illustrates the severity of fuel poverty across fuel poor households in Scotland in 2016. The modelling indicates that approximately 600,000 households will live in 'fuel poverty' or 'severe fuel

[13] Updated Energy & Emissions Projections, DECC September 2013 https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2013

poverty', which the Scottish Government defines as those needing to spend between 10% -12% or 13% - 20% respectively of their income on energy. Approximately 350,000 households will live in 'extreme fuel poverty', those households needing to spend 20% or more of their income on energy. Of these households, approximately 130,000 would need to spend more than 40% of their income on energy in order to provide adequate thermal comfort in their home.

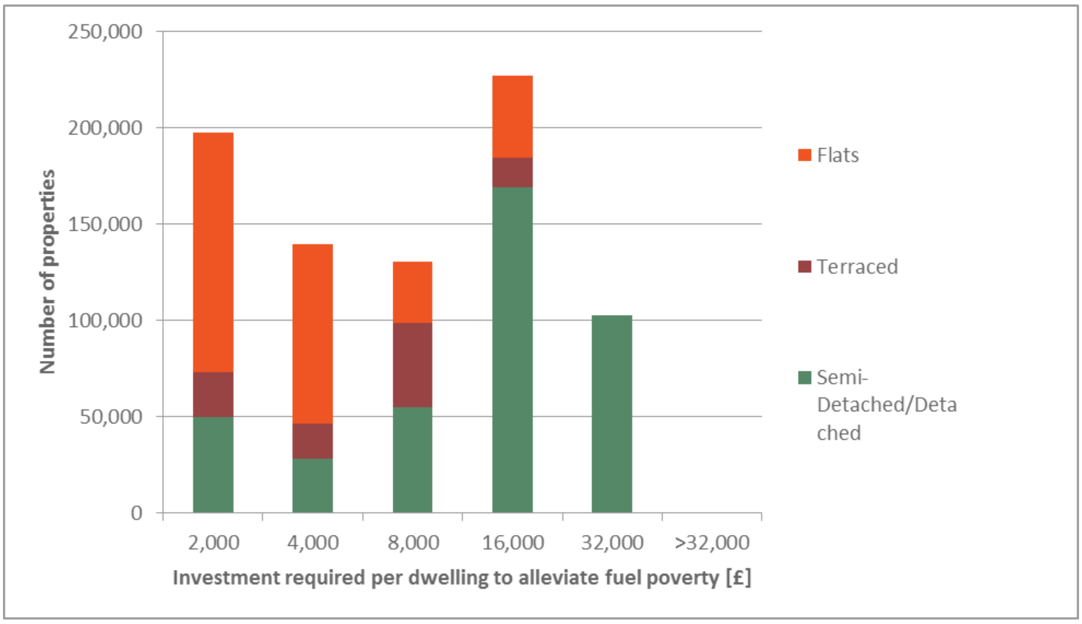
Figure 2: Severity of fuel poverty in 2016



2.3.2 Cost of upgrading fuel poor homes

Figure 3 provides a breakdown of fuel poor households by house type and level of investment required to take them out of fuel poverty. Approximately 50% or 480,000 of fuel poor homes are semi-detached and detached homes, with 13% terraced housing and 37% flats.

Figure 3: Breakdown of fuel poor households in 2016 by house type and by level of investment required



The spread of energy efficiency investment cost per property to alleviate fuel poverty ranges from £300 right up to almost £32,000. The total investment cost of alleviating fuel poverty in 2016 across 945,000 Scottish households is £7.4 billion at an average cost of £7,800 per property, but this covers core installation costs only and fuel poverty programme delivery costs would be additional.

Figure 4 provides a breakdown of fuel poor households by starting EPC score as well as by the level of investment required to take them out of fuel poverty. It illustrates that there is a wide spread of starting EPC scores across all brackets of investment cost, although there are a larger proportion of homes with a starting EPC score of E,F & G in the more expensive investment brackets.

Figure 4: Breakdown of fuel poor households in 2016 by level of investment required and EPC score

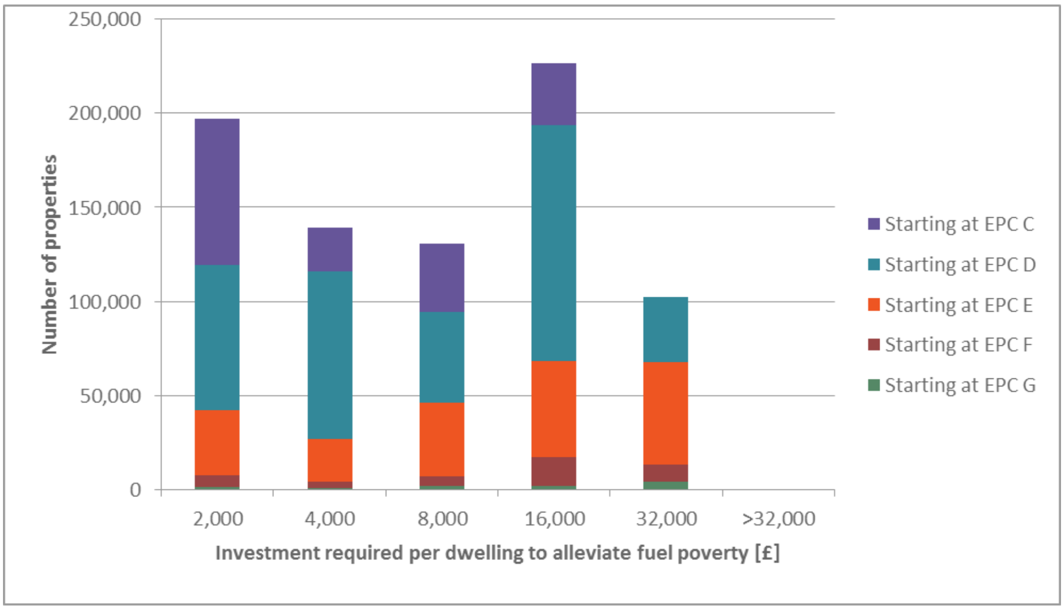


Table 2 provides three illustrative example retrofit packages and associated installation costs to provide an indication of the types of retrofit package that fall into the cost brackets outlined above. The specific measures required for a particular fuel poor household, and therefore the specific capital cost, will depend on property type, the starting energy efficiency performance of the property and household income.

Table 2: Three example retrofit packages and associated installation cost

House archetype	Energy efficiency measures	Cost
Cavity walled, terrace house with gas heating	Cavity wall insulation, insulated pipes, foam insulated DHW cylinder, heating controls, double glazing, draught proofing	£4,000
Solid walled, terrace house with gas heating	Insulated pipes, heating controls, draught proofing, internal wall insulation, insulated doors, advanced air-tightness, triple glazing	£13,000
Cavity walled, semi-detached house with electric heating	Cavity wall insulation, insulated pipes, loft insulation, insulated doors, floor insulation, advanced air-tightness, triple glazing, air source heat pump	£23,000

Figure 5 provides a breakdown of the total level of investment required to alleviate fuel poverty by scale of investment required per property. The total number of properties is on the left axis and is represented by the green bars whereas the total investment required to upgrade those properties is on the right axis and is represented by the burgundy bars. This demonstrates that although 25% of fuel poor households require £2k or less of funding to remove them from fuel poverty, it would only take 3% of the total investment cost to do so. Conversely, although only 13% of fuel poor households require large funding levels of between £16k and £32k to remove them from fuel poverty, this activity would require 34% of the total investment cost. This demonstrates that addressing the more expensive-to-treat homes would require a disproportionately large share of the overall budget.

Figure 5: Spread of investment required to alleviate fuel poverty

Table 3 compares the average SAP score, average energy bill, and average income for households with an investment cost of less than £2,000 with those households with an investment cost of more than £16,000. This illustrates that the 100,000 households with very high energy efficiency refurbishment costs typically have very low SAP scores, high energy bills and low incomes.

Table 3: Impact of poor energy performance, high energy bills and low income on the cost of eliminating fuel poverty

Level of energy efficiency investment required	Up to £2,000	Over £16,000
Average income within these homes	£14,585	£10,422
Average energy bills for these homes	£1,514	£3,271
Average SAP score of these homes	67	53

2.3.3 Energy bill savings and carbon reductions

As outlined above, the total cost of alleviating fuel poverty in 2016 across 945,000 Scottish households is £7.4 billion at an average cost of £7,800 per property. Such an investment would deliver total carbon savings across fuel poor households of 1.5 million tonnes CO_2 per annum. The average fuel bill saving per fuel poor household would be £552 and the average carbon saving per fuel poor household would be 1.6t/CO_2, as summarised in Table 4. As indicated previously , the impact of a 40% 'comfort take' has been incorporated within these energy bill and carbon savings.

Table 4: Energy bill and carbon savings associated with alleviating fuel poverty in Scotland in 2016

Total carbon savings across fuel poor stock	1.5 million tonnes CO_2 per annum
Average CO_2 savings per fuel poor home	1.6 tonnes CO_2 per annum
Average fuel bill savings per fuel poor home	£552

3. Quantifying Scotland’s share of carbon tax revenues and comparison with cost of alleviating 2016 fuel poverty levels

3.1 Deriving Scotland’s share of carbon tax revenues

There are a number of potential approaches to deriving Scotland’s share of carbon tax revenues. The carbon revenues could potentially be allocated through three main alternative ways:

- On a proportional basis based on Scotland’s population
- Based on relevant emissions arising in Scotland (i.e. EU ETS captured emissions arising in Scotland)
- On a proportional basis based on the severity/ incidence of fuel poverty in Scotland (compared to the rest of the UK)

There are pros and cons to each of these approaches, but it was felt that allocating revenues on a pro rata population basis was the most straight-forward, simplest and least contentious approach. The second option of calculating carbon revenues related to power and industrial sector emissions arising within Scotland has the downside of constituting a somewhat artificial approach as the whole UK population consumes electricity regardless of the location of the power plant. The third option of allocating revenues according to the incidence of fuel poverty may well have provided a more generous allocation to Scotland since the climate is colder than the UK average and it has higher fuel poverty levels. However, it was decided this option would be more politically contentious.

3.2 Approach to carbon modelling

Verco’s CaR (“Carbon Revenue”) model has been used to calculate carbon tax receipts. It projects UK government revenue arising from UK and European carbon initiatives. The analysis modelled two sources of carbon revenue; auctioning of carbon allowances under the EU Emission Trading Scheme (EU ETS) - a regional cap and trade initiative - and the Carbon Price Floor (CPF) mechanism, which sets a minimum cost for carbon.

The EU Emissions Trading System (EUETS) was initiated on 1st January 2005 as a direct function of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). It puts a cap on the carbon dioxide (CO_2) emitted by nearly 11,000 energy-intensive operators throughout the 27 Member States of the EU and has created a market for carbon allowances (i.e. the “European carbon market” which currently accounts for over 80% of the value of traded greenhouse gas allowances/credits in the world market).

The carbon price floor mechanism came into force 1st April 2013 and introduced a minimum cost of carbon for large electricity producers. The price floor applied is based on the cost of carbon under the EUETS. A support rate is set on top of the cost for an allowance. The “tax inclusive carbon price” will ensure that carbon is always priced above a minimum legislated level. The Government set the carbon price floor in the 2011 Budget with the price beginning at £16/tCO_2 in 2013 and rising by £2/tCO_2 per annum until 2020. From 2020 to 2030 the price will increase by £4/tCO_2 per annum.

The carbon tax revenues were calculated through four stages:

3.2.1 Projection of emissions

Emission trends were taken from the Department of Energy and Climate Change and Committee on Climate Change, which show annual growth or decline in the power sector and the industrial sector. These emission trends were applied to available data from the European Union Transaction Log on the number of allowances in the EU ETS to provide forward projections on likely emissions for the sectors covered by the EU ETS.

3.2.2 Projection of allocation of free allowances by sector

Free allocations are specified in the Modified UK National Implementation Measures for Phase III of the EU Emissions Trading System publication by DECC. It was also assumed that phase 4 (2020 – 2027) will not be subject to radical change in terms of present proposals for allowance auctioning (specifically with regards to sectors prone to carbon leakage) and in terms of sectors covered.

3.2.3 Carbon price under the EU ETS

Publicly available UK EU ETS auction data was used to provide a reference of historical prices and DECC published data on carbon price forecasts was used for the future modelling. DECC's medium price projections were used in the modelling of future revenues.

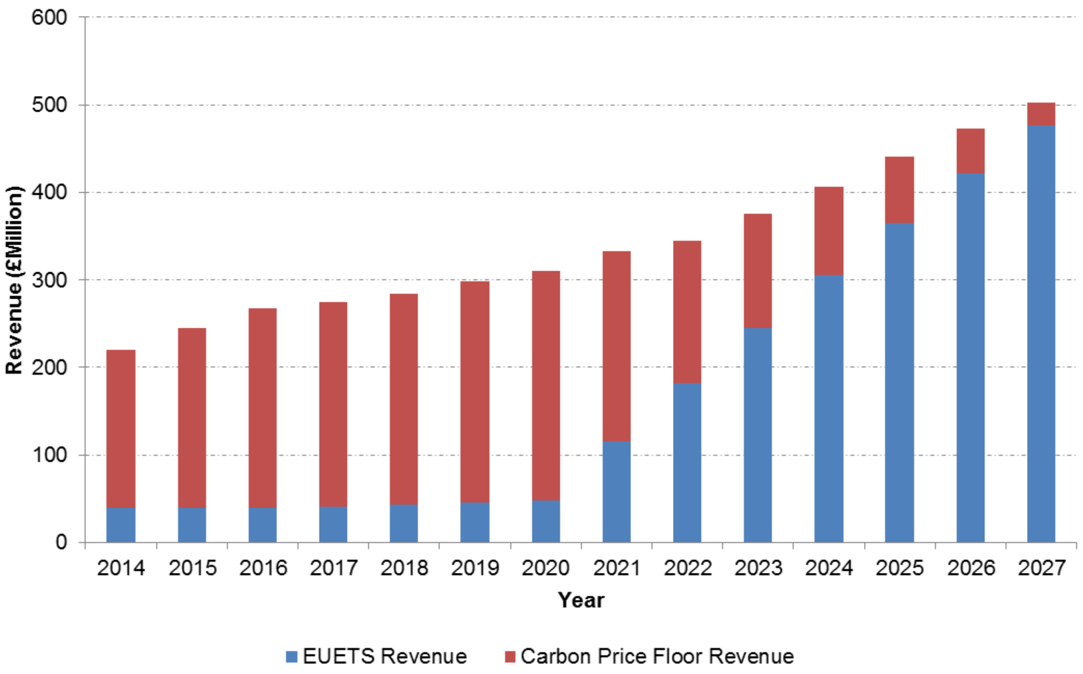
3.2.4 Carbon price under the price floor mechanism

As outlined above, Government set the carbon price floor in the 2011 Budget at £16/tCO_2 in 2013, rising by £2/tCO_2 per annum until 2020 and £4/tCO_2 per annum from 2020 to 2030.

3.3 Quantifying carbon tax revenues for Scotland

Scotland's share of UK carbon taxes was calculated on a pro-rata population basis, which equates to 8% of the UK total. The total combined revenue for the EU ETS and carbon price floor mechanism, between 2014 and 2027, is projected to be £4.8 billion. Figure 6 shows the annual contributions from the EU ETS and the carbon price floor which shows that the EU ETS is expected to continue to perform fairly poorly over the next seven to eight years with the carbon price floor picking up the slack during that period. Later in the 2020s, the EU ETS carbon prices are expected to pick-up and provide a greater contribution to carbon revenues. Over the full period the two mechanisms contribute similar amounts to the cumulative £4.8 billion.

Figure 6: Scotland's Carbon Revenue forecast for 2014 to 2027



3.4 Comparison with fuel poverty funding requirements

3.4.1 Allocating carbon revenues to fuel poor households

The cumulative carbon revenues of £4.8 billion by 2027 are not large enough to cover the full cost of £7.4 billion required to alleviate fuel poverty across all households estimated to be in fuel poverty in 2016. Only 612,000 properties, 65% of all fuel poor properties, would benefit from energy efficiency measures (and energy bill savings) if the full £4.8 billion of carbon revenues were allocated for fuel poverty alleviation. The average energy efficiency investment per property is £7,800 and the average energy bill saving per property is £552, as outlined in Table 5.

Table 5: Allocating available Carbon Revenues to fuel poor households in Scotland

Total no. of homes that can be addressed through allocating carbon revenues	612,000
Number of homes that can't be addressed	333,000
Average level of investment required per home	£7,800
Total carbon savings across fuel poor stock	0.98 million tonnes CO_2 per annum
Average fuel bill savings per fuel poor home	£552
Average CO_2 savings per fuel poor home	1.6 tonnes CO_2 per annum

3.4.2 Allocating carbon revenues to fuel poor households with a funding cap of £10k per property

As discussed in Section 2.3.2, the level of energy efficiency funding required per property to alleviate fuel poverty ranges from under £1,000 to almost £32,000. Although this is the range of investment required to remove different households from fuel poverty, there are diminishing returns in terms of the energy savings associated with increasingly higher levels of expenditure. The analysis therefore investigated capping the level of energy efficiency investment per property at £10,000 to evaluate the impact on the number of fuel poor properties that could potentially benefit from measures.

The total level of investment required to upgrade all fuel poor homes reduces to £5.5 billion with a £10,000 cap, which is £0.7 billion more than the amount likely to be available from carbon revenues. The total number of homes that could receive energy efficiency measures increases to 824,000 properties, 87% of the total number of fuel poor properties. The average energy efficiency investment per property is reduced to £5,800 and the average energy bill saving per property becomes £505, as outlined in Table 6.

Although 824,000 households receive energy efficiency works (compared to 612,000 households without the cap), not all of these households are fully removed from fuel poverty, since 327,000 properties require investment exceeding £10k to eliminate fuel poverty. The application of a £10k funding cap eliminates fuel poverty for 539,000 households whilst also providing support to 285,000 additional households. The severity of fuel poverty for these households is reduced with a number of households potentially transferred from the 'extreme fuel poor' category into the 'fuel poor' category.

Table 6: Allocating available Carbon Revenues to fuel poor households in Scotland, with a £10k funding cap per property

Total no. of homes that can be addressed through allocating Carbon Revenues capped at £10k per property	824,000
No. of homes alleviated from fuel poverty	539,000
Average level of investment required per home	£5,800
Total carbon savings across fuel poor stock	1.2 million tonnes CO_2 per annum
Average fuel bill savings per fuel poor home	£505
Average CO_2 savings per fuel poor home	1.5 tonnes CO_2 per annum

4. Macroeconomic modelling of the impact of energy efficiency investment

4.1 Overview

This analysis assesses the macro-economic impact of investing in energy efficiency upgrades to fuel poor households in Scotland. We also compare this with the impact of providing an equivalent stimulus in the Scottish economy using alternative ways. The work involved:

- Developing a set of alternative investment scenarios representing an equivalent amount of fiscal stimulus in different forms
- Assessing the economic impact of investing in energy efficiency of Scottish fuel poor homes and alternative investment scenarios using the MDM-E3 model for the UK. The Scottish input-output tables were also used to better capture the flows in Scotland.

This is discussed below in detail.

4.2 Approach to economic modelling

A baseline scenario was set to compare alternative investment scenarios on a neutral basis. The baseline scenario was constructed using the latest data from Office of National Statistics (ONS) to 2012. For the years over 2013-2018, the latest economic projections for all components of final expenditure, income, employment, wages and inflation were obtained from Office of Budgetary Responsibility (OBR)[14]. These OBR growth rates were applied to the historical data to obtain a series of consistent projections to 2018. For later years, where no official projections were available, Cambridge Econometrics' updated forecast was used to 2030. Energy demand projections and end-user domestic prices for gas and electricity were derived from the most-up-to-date central projections from DECC over 2013-2030 (updated in September 2013)[15].

A set of scenarios (described in detail in Section 4.2.1) were developed using the following inputs from the fuel poverty analysis:

- The amount invested in domestic energy efficiency measures is the estimated available funding from the EU ETS auction and carbon floor price revenues. This investment in efficiency measures amounts to £314m every year beginning in 2014 to 2027
- The net energy savings after comfort take[16] were broken down by fuel type (ie gas and electricity) and applied to the economic model
- The alternative investment scenarios were developed by investing an equivalent amount, £314m, in a number of potential different programmes, namely government expenditure, capital spending by government or an income transfer to consumers (see Section 4.2.1 below for further details of each scenario)

4.2.1 Scenario analysis of the economic impacts of alternative investment policies

The scenario analysis provides a comparison of the four alternative investment scenarios for spending EU ETS and carbon price floor revenues, against the baseline. The main investment scenarios and their macro-economic impacts quantified using MDM-E3 are briefly described below:

[14] OBR's latest economic projections released in November 2013 were used
[15] https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2013
[16] Comfort take means the proportion of savings not realised as carbon savings as households can heat homes for longer period or at a higher temperature

- Energy Efficiency (EE_SC) - This scenario shows the impact of investing in improving the homes of fuel poor households in Scotland to a cap of £10,000 or less. The energy savings resulting from the associated investment had two broad impacts in the energy efficiency scenario as shown below:

- Demand side stimulus (see
-
-

Figure 4-1) - An increase in investment in energy efficiency measures in Scottish housing drives demand for the construction sector as installers of the measures. This leads to higher production and jobs, also having supply chain effects through construction's increased demand for inputs such as metals and minerals. An increase in overall employment will increase income and stimulate consumer expenditure. Higher spending feeds back into further production to meet greater demand resulting in more jobs due to the multiplier effect.

Supply side impact of installing energy efficiency measures (see Figure 4-2) - Households receiving the investment will be able to reduce the amount spent on energy resulting in lower energy bills. As a result of this reduction in fuel bills they will have higher disposable income to spend on other products, which are less reliant on imports. Lower demand for gas, which is largely imported, will reduce leakage from the Scottish economy.

- Government spending (G0_SC) - This scenario shows the impact of investing an equivalent amount by the government on health care, education and other related social sectors. An increase in government spending will stimulate the government services related sectors and its supply chain resulting in increase in jobs in the Scottish economy.

- Government investment (GK0_SC) - Under this scenario, the same amount of investment is instead invested by government in capital spending infrastructure projects such as roads, hospitals, etc. in Scotland. This will provide an impetus to the construction sectors and its supply chain (particularly manufacturing sectors) also generating more jobs in the Scottish economy.

- Income transfers (I0_SC) - Transferring the same amount of investment to consumers would stimulate consumer expenditure leading to a rise in consumer related services such as retail, food and beverage services, financial services, etc. This in-turn stimulates output creating more jobs.

Figure 4-1: Demand-side stimulus: The Impact of Energy Efficiency Investment

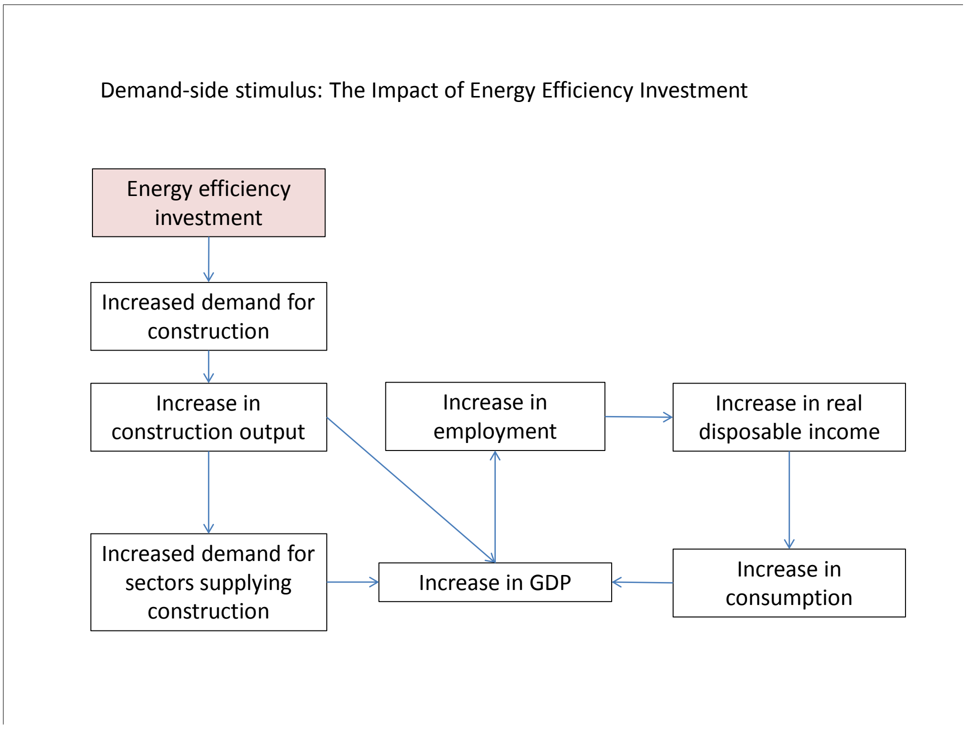
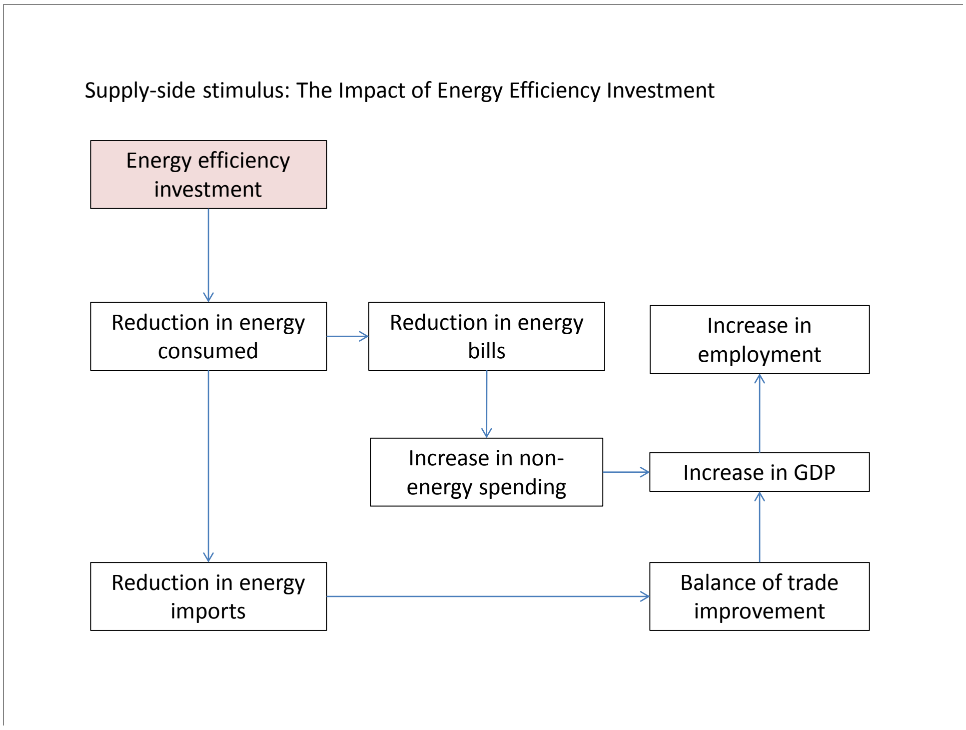


Figure 4-2: Supply side stimulus: The impact of Energy Efficiency Investment



4.3 Macro-economic benefits of energy efficiency investment in fuel poor households

4.3.1 Key findings

Since all the scenarios model an injection of spending into the economy, they all have positive impacts. The important comparison is therefore the relative impact of each scenario against the baseline, and not an absolute comparison against the baseline. The key findings are set out below:

- Of the scenarios modelled, the energy efficiency investment scenario (EE-SC) has the largest impact on GVA relative to the baseline. This is because, in addition to the positive impact of the investment stimulus there is a reduction in Scotland's net imports through a shift away from imported gas, and towards domestically produced goods and services demanded by consumers.
- All scenarios resulted in an increase in GVA versus the baseline (since the scenarios are not fiscally neutral). The investment scenarios (GK0-SC and EE-SC) resulted in increased output from the construction sector and associated supply chains, while the government expenditure scenario (G0-SC) saw an increase in government services and the income transfer scenario (I0-SC) boosted consumer expenditure.
- The energy efficiency investment scenario leads to a reduction in household energy bills. In total around 800,000 households benefit from energy efficiency measures by 2027, with an average reduction in fuel bills of £505 in treated households after direct rebound effects.

- Around 8,900 extra jobs are created in the EE-SC relative to the baseline, over 2,000 more than in the government spending scenario and 4,000 more than the government investment scenarios.

4.3.2 Results of the energy efficiency investment scenario

The scenario in which revenues are invested in energy efficiency measures in fuel poor homes gives the largest increase in GVA relative to the baseline. While all scenarios include the same level of investment or stimulus, there are two distinct effects contained within the energy efficiency scenario, which results in larger increase in GVA than in the alternatives.

The first effect is that of an increase in investment. As in the government investment scenario, this leads to an increase in GVA in the construction sector (the direct impact) and a boost to sectors which form part of the supply chain for construction (the indirect impact). These increases are linked to increases in employment, and therefore aggregate wages across the economy. The increase in total household income from additional people in employment results in increased consumer expenditure (the multiplier effect) and therefore additional positive GVA impacts.

The second effect is the energy saving in each treated household. The improved energy efficiency results in reduced demand for, and household expenditure on, energy (allowing for comfort take). This has two impacts; it reduces GVA in the import-supplied utilities sector (expenditure on which largely leaked out of the Scottish economy to foreign energy providers), and simultaneously increases household disposable income, which is spent in the domestic economy, boosting consumer-focused sectors (particularly services) such as retailing and hotels & catering. Household demand for gas is met by both domestic production and imports, and the MDM-E3 model treats imports of gas as ‘topping up’ domestic production to meet demand – therefore a reduction in demand results only in a reduction in imports of gas, and not in a reduction in demand for domestically-produced gas. This also serves to reduce the vulnerability of the Scottish economy to volatility in gas prices going forwards.

In the short term, the boost to construction has the largest impact; in 2015 and 2020 construction GVA is almost 2% higher than in the baseline and there are an additional 3.4 thousand jobs (see Table 4.1). However, as the number of households that have received treatment accumulates over time the reduction in household energy expenditure has an increasingly large negative impact on utilities GVA, while increases GVA in services and (to a lesser extent) manufacturing. By the end of the forecast period in 2027 the number of additional jobs generated in services, at 3.8 thousand, is greater than those created in construction by the continued investment (see Table 4.2).

Reduced energy demand results in a £160m decrease of gas imports by 2027 (the last year modelled), cumulatively exceeding £1.1bn over the entire period. In effect, the average annual household fuel bill is reduced by £176 in 2027 (£505 per treated household per year).

Comfort taking is included in the analysis and this serves to dampen the economic results. However, it is important to consider that direct comfort taking in the form of warmer homes further improves the standards of living in these fuel poor homes, despite worsening the perceived effectiveness of the measures in economic terms.

Table 4-1 GVA in the energy efficiency scenario, % difference from baseline

	2015	2020	2027

Manufacturing	0.19	0.24	0.29
Utilities	-0.31	-1.22	-2.34
Construction	1.98	1.83	1.7
Services	0.08	0.15	0.22
Total	0.23	0.25	0.27
Note(s): The table shows main broad sectors only			

Table 4-2 Employment in the energy efficiency scenario, 000s difference from baseline

	2015	2020	2027
Manufacturing	0.5	0.6	0.7
Utilities	-0.1	-0.5	-1.0
Construction	3.4	3.4	3.3
Services	1.2	2.4	3.8
Total	5.5	7.2	8.9
Note(s): The table shows main broad sectors only			

4.3.3 Capped versus uncapped energy efficiency funding

As outlined above, the analysis included two options for energy efficiency investment; unconditional investment where the funds per household are not limited (the ‘uncapped’ scenario), and a limit on investment per household of £10,000 (the ‘capped’ scenario). When selecting households that receive resources for energy efficiency improvements, it is important to consider cost effectiveness. For example, if investment in excess of £10,000 results in savings of £500 annually, the investment is not viable on micro-economic grounds, although it might be considered if it leads to other social and environmental goals being met. To consider the macroeconomic aspects of the cost-effectiveness of the investment, we model two different variants of the EE-SC scenario.

While the uncapped scenario allows for 611,500 homes to receive energy efficiency measures, limiting the resources per household results in a 35% increase in the number of households receiving measures. Even though the average energy savings decrease, the overall increase in the number of homes receiving energy efficiency measures results in an increase in total energy savings of 25% (£318m to £396).

Table 4-3 Treated households under the uncapped and capped scenarios

	Uncapped	Capped
Treated households ('000s)	611.5	823.5
Total savings of all households	£318m	£396m

The capped scenario therefore offers a more efficient form of investment, leads to higher overall savings and significantly more homes being treated. While the cap does not allow some treated homes to be brought out of fuel poverty, treatment is still provided and their energy bills are reduced.

The net macroeconomic effects are similar in the two scenarios, as the total monetary value of the investment is the same in both. However, employment is slightly higher in the capped scenario, driven by the increased cost-effectiveness of the investment as described above. The capped scenario generates higher total household savings, and these result in higher consumer expenditure and therefore higher employment (particularly in consumer services), which outweighs the fewer utilities jobs in this scenario. The net difference between the scenarios is 800 jobs, while there is a negligible difference in GVA in percentage terms (less than 0.02% of the baseline in 2027).

4.3.4 The impact of improved energy efficiency on health

Investment in energy efficiency measures in fuel poor households is expected to have positive heath benefits and also likely to reduce NHS spending on cold-related illnesses. However, the impact of energy efficiency savings on wellbeing and health outcomes has not been quantified as part of this study due to the inherent difficulty in measuring these variables.

Literature review carried out as part of the UK wide study commissioned by Consumer Futures[17] showed that published estimates on the costs to NHS of cold homes vary considerably, with some studies focussing on specific geographies or tenures. The review also indicated that there a lack of robust data and methodologies to establish a firm link between fuel poverty and the resulting costs to the NHS, as was echoed by John Hills[18] in the fuel poverty review published in 2012. The review suggested that the cost of fuel poverty in the UK to the NHS is likely to be in the region of £600m to £1bn per annum and even this is likely to be a conservative estimate. This would equate to cost of between £48m - £80m per annum for Scotland, using population as the basis of working out an indicative share of the burden on NHS. Whilst not providing a definitive figure, this does give a rough indication of the size of the problem and the potential benefits of investing in energy efficiency upgrades in fuel poor homes in terms of avoided health spending.

4.3.5 Comparison with the alternative investment scenarios

In terms of GDP, GVA, employment or income, we see the EE-SC has the greatest positive impact of all the scenarios modelled. This is due to its highest efficiency as resources are better targeted compared to the other scenarios.

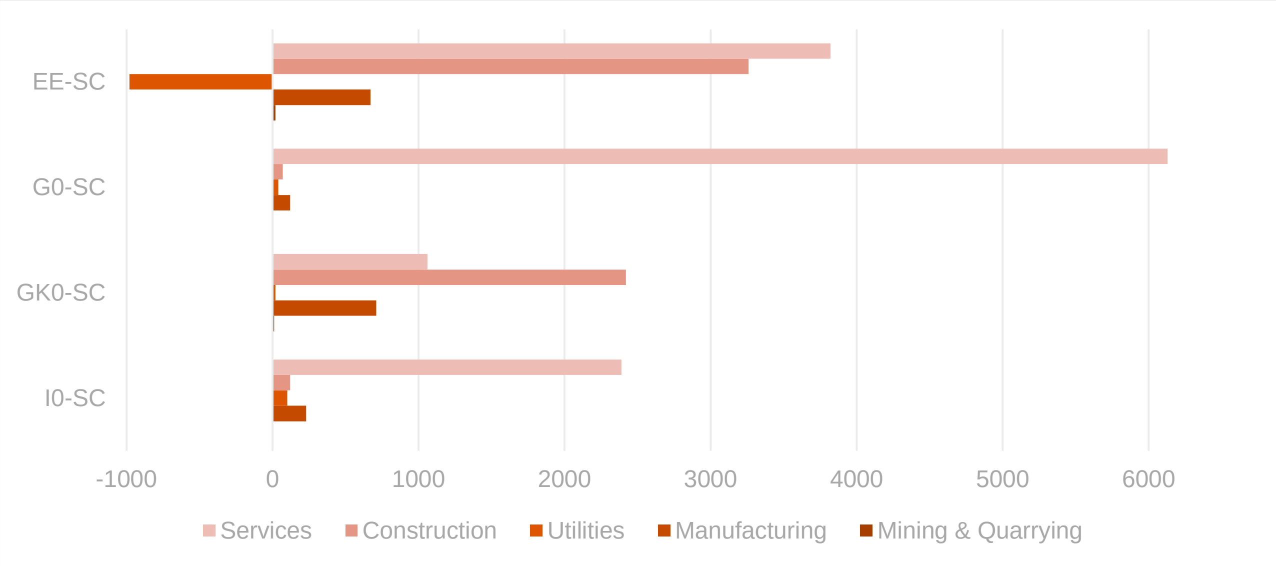
Both G0-SC and GK0-SC, where funds are used in general government spending and government investment, respectively, result in a smaller marginal benefit to the economy than EE-SC, as the additional amount spent is minor in comparison to existing public expenditures. I0-SC, where the carbon tax revenue is used for direct income transfers, gives the smallest returns as funds are spent by consumers on a number of low-productivity sectors. It is notable, however, that much of the existing policy aimed at reducing fuel poverty in the UK, such as the Winter Fuel Payment, are distributed using this mechanism.

In terms of employment, we can see different drivers of change across the scenarios. In EE-SC and GK0-SC, construction plays a major role as investment in that sector is an important driver in these two scenarios. There is a drop in employment in utilities in the EE-SC scenario due to the decrease in energy demand as homes become more energy efficient. Jobs in services in EE-SC, GK0-SC and I0-SC are mainly as a result of higher household expenditure (therefore affecting sectors such as retail or advertising), whereas G0-SC boosts public sector jobs, e.g. in education or health. New jobs in manufacturing are due to supply chain effects from construction, so we see higher increases in EE-SC

[17] Jobs, Growth and Warmer Homes - Evaluating the Economic Stimulus of Investing in Energy Efficiency Measures in Fuel Poor Homes, 2012
[18] J. Hills, Getting the measure of fuel poverty – Final report of the Fuel Poverty Review, *March 2012.*

and GK0-SC compared to the other two scenarios. Although the GVA impacts are similar across the G0-SC and GK0-SC scenarios, we observe differing employment impacts, reflecting different productivity levels across sectors. Construction, which is boosted in the G0-SC scenario, requires fewer additional workers to generate additional output than in the lower productivity service sector which is affected in G0-SC. See Figure 4.3 for an overview.

Figure 4-3 New jobs in 2027 (by sector)



GVA changes (Table 4.3) show similar trends to the employment figures. A noticeable drop in value added in utilities in EE-SC, due to the energy savings, is more than outweighed by increases in other sectors, notably construction. No other scenario features a decrease in GVA in any of the sectors. A summary of various other metrics is presented in Table 4.4. We see the drop in gas imports and decrease in average fuel bills, both unique to EE-SC, as well as other relevant indicators.

Table 4-3 GVA in 2027, % difference from baseline

	EE-SC	G0-SC	GK0-SC	I0-SC
Mining & Quarrying	-0.12	0	0.06	0.01
Manufacturing	0.29	0.06	0.28	0.11
Utilities	-2.34	0.08	0.05	0.21
Construction	1.7	0.06	1.26	0.08
Services	0.22	0.29	0.07	0.14
Total	0.27	0.2	0.19	0.15

Table 4-4 Comparison of indicators in 2027, difference from baseline

	EE-SC	G0-SC	GK0-SC	I0-SC
GVA (%)	0.27	0.20	0.19	0.15
Gas imports (%)	-1.60	0.01	0.01	0.01
Employment ('000s)	8.9	6.5	4.5	4.3
Average annual fuel bill savings per household (£2013)	155.8	-0.1	0.0	0.0

5. Conclusions

The level of political ambition for energy efficiency, and the impact of current domestic sector energy efficiency policy, need to be urgently reviewed within Scotland (and the rest of the UK). Energy price rises are pushing more and more households into fuel poverty and highlighting the current adequacy of the building stock in terms of keeping people warm. As this analysis has shown, even though the Scottish Government continues to invest resources in energy efficiency programmes to address fuel poverty, the level of activity falls far short of what is needed, and it is highly unlikely that the target to eliminate fuel poverty by 2016 will be met.

Improving the energy performance of Scotland's homes up to a standard that eliminates fuel poverty in 2016 is estimated to cost a total of £7.4 billion. Although the recycling of carbon taxes from EU ETS and the carbon price floor into domestic energy efficiency over the period up to the 4th Carbon budget would not cover this total cost, it offers a potential revenue stream that could massively reduce projected levels of fuel poverty over the coming years.

Clearly, all the scenarios are positive for the economy because the modelling does not consider the impact of raising the revenue, instead it compares scenarios that have the same quantity of fiscal stimulus. The results show the macroeconomic case for investing in energy efficiency in fuel poor households is strong. Investing Scotland's share of carbon revenues of around £4.8 billion (over the period up to the 4th Carbon budget) in domestic energy efficiency would deliver greater social, economic and environmental benefits than would be delivered by spending the same amount on typical Government investment programmes or transferring the income directly to households.

6. Appendices

6.1 Appendix 1 – data sources

Analysis	Data source
Fuel poverty analysis	
Housing stock data, incomes, identification of fuel poor households	• SHCS 2009 - 2011
Projecting household income	• Office of Budget Responsibility income projections for the UK
Projecting energy demand/ SAP score	• Scottish Fuel Poverty Forum's May 2012 review of the Scottish Government Fuel Poverty Strategy – overview of Scottish energy efficiency budgets 2012 to March 2015 • Committee on Climate Change (2011) Household energy bills – impacts of carbon budgets (for general market trends)
Projecting energy prices/ fuel bills	• DECC 2012 Valuation of Energy Use and Greenhouse Gas Emissions
Carbon factor/ savings	• DECC 2012 Valuation of Energy Use and Greenhouse Gas Emissions
Comfort take	• 40% comfort take assumptions from DECC evaluation of CESP programmes
Projecting carbon tax revenues	• DECC and Committee on Climate Change emission trends • Number of allowances - European Commission Climate Action website, European Union Transaction Log • Allocation of free allowances - DECC 2012 Modified UK National Implementation Measures for Phase III of the EU Emissions Trading System • EUETS auction data on prices • DECC carbon price forecasts
Scotland's share of carbon tax revenues	• Pro rata basis, based on UK and Scotland populations
Macroeconomic modelling	
Baseline macroeconomic view	• Office of Budgetary Responsibility projections for the UK in the medium-term
Data for key indicators: • GVA and Wages • Employment • Unemployment	• ONS Supply and Use Tables • ONS Workforce Jobs and Business Register and Employment Survey (BRES) • NOMIS • United Kingdom National Accounts, The Blue Book

• Incomes	

6.2 Appendix 2 - MDM-E3 Model Description

The macroeconomic analysis is based on Cambridge Econometrics' (CE's) model of the UK energy-environment-economy (E3) system, MDM-E3. CE applies MDM-E3 for both scenario analysis and as part of CE's regular energy-economy-emissions forecasting service. It is well-suited for the analysis:

- The model covers the entire UK economy, identifying 87 economic sectors (and 45 explicitly within each of the regions and nations of the UK) and recognising the interdependencies between them (i.e. supply chains); this representation is fully consistent with official UK economic statistics.
- The model has a full representation of the energy system, both in physical flows of energy and monetary terms, with two-way linkages with the economy.
- The model contains behavioural equations to explain final energy demand for more than 20 final energy users.
- The model includes a representation of the UK's power sector by generating technology to explain changes in electricity supply.
- Energy-related emissions are projected as a consequence of energy use.
- The model is a dynamic model, with its behavioural parameters estimated on official UK data. Such a specification allows for non-equilibrium outcomes and path dependency, e.g. the possibility of sustained levels of unemployment in the medium-to-long term, which is a feature of CE's latest economic forecasts

MDM-E3 is used regularly to assess the relationships between economic development and the energy system and, conversely, the impact of energy and carbon reduction policies on the economy.