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The effect of the Committee on Climate Change's proposed carbon budgets on fuel poverty

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Executive Summary

The Committee on Climate Change (CCC) has a remit to consider the effect of any proposed carbon budgets on levels of fuel poverty. The CCC have commissioned the Building Research Establishment (BRE) to carry out analysis to estimate this effect for each of the nations in the UK (England, Scotland, Wales and Northern Ireland). The methodology and results of this analysis are presented below.

A household is considered to be in fuel poverty if it is required to spend more than 10% of its income on household fuel in order to meet a defined heating regime. In England, the national level of fuel poverty is monitored using data from the English House Condition Survey (EHCS). The latest available EHCS dataset from 2006 show there to be 2.4 million households in fuel poverty in England. Similar surveys are used to calculate fuel poverty levels in Scotland, Wales and Northern Ireland.

Fuel poverty is calculated using detailed information on the amount of energy consumed by the household in order to meet a defined heating regime, the price paid for each fuel and household income.

BRE have used EHCS data to estimate the effect of the proposed carbon budgets on levels of fuel poverty in England. Numerous fuel price, income and energy efficiency scenarios have been examined.

The fuel price scenarios are:

- Baseline (i.e. without any change in fuel prices resulting from the carbon budgets)
- Fuel price changes accounting for the effects of a carbon price and renewable electricity
- Fuel price changes accounting for the effects of a carbon price, renewable electricity and renewable heat
- Fuel price changes accounting for the effects of a carbon price, renewable electricity, renewable heat and uplift from a post-2011 Supplier Obligation

The fuel price scenarios have been applied for both 'central' and 'high-high' projected fossil fuel prices to 2012, 2017 and 2022.

The energy efficiency scenarios are:

- Reference (i.e. without any abatement energy efficiency measures)
- Non-targeted abatement (i.e. with additional energy efficiency measures applied in a random manner)
- Targeted abatement (i.e. with additional energy efficiency measures applied in a targeted manner)

Incomes have been inflated in line with HM Treasury estimates provided to BRE by the CCC.

Results for Scotland, Wales and Northern Ireland have then been produced by applying scaling factors for each nation onto the England results.

BRE have also produced estimates of the cost of removing all households in England which have been made fuel poor by the carbon budgets back out of fuel poverty, and the costs of returning any household placed deeper into fuel poverty by the carbon budgets to their original proportional fuel spend.

The results show that the abatement energy efficiency measures act to reduce the level of fuel poverty by up to 10%. However, the abatement measures on their own are insufficient to reduce the level of fuel poverty back to their likely ‘baseline’ levels (i.e. the level without any fuel price uplift resulting from the carbon budgets).

The cost of compensating all households in England directly (through reduced fuel bills) ranges from around £400 million (at 2006 prices) under the central fossil fuel price scenario to around £800 million under the high-high fossil fuel price scenario.

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1. Introduction

The Climate Change Bill requires the Committee on Climate Change (CCC) to take into account 'social circumstances, and in particular the impact of the decision on carbon budgets for fuel poverty'. A household is considered to be in fuel poverty if it spends more than 10% of its income on all household fuel use, in order to meet a defined heating regime.

This report presents the methodology and results of analysis carried out by BRE in order to estimate the effect of the proposed carbon budgets on fuel poverty to 2012, 2017 and 2022. The primary analysis is of the effect in England, with results for Scotland, Wales and Northern Ireland derived from this estimate.

The analysis has been carried out using data from the 2006 English House Condition Survey (EHCS). Previous to this analysis, BRE has produced estimates for the CCC of the range of energy efficiency measures that will be taken up across the national housing stock in the future *[1]*. This work is a key input to the model. The results of this earlier analysis have been combined with the CCC's estimates of the effect of carbon budgets on fossil fuel prices, and their suggested abatement measures, to enable us to estimate the effect on fuel poverty to 2012, 2017 and 2022.

This report is primarily an account of the methodology used in the production of the estimates. The results are discussed in a policy context in the 2008 inaugural report of the CCC.

The report begins with an introduction to the overall methodology used in the production of national annual estimates of fuel poverty in England. There then follows an overview of how the specific CCC improvement modelling has been carried out, including a description of the scaling methodology used to produce the fuel poverty estimates for the other nations in the UK. Finally, the full results are presented together with a brief discussion on interpretation of the results in the context of the methodology employed.

2. Estimating fuel poverty

A household is defined as being fuel poor if it is required to spend more than 10% of its income on all household fuel use, in order to meet a defined heating regime. Fuel poor households are considered to be at greater risk of ill health and death as a result of inadequately heated homes, in turn caused by the high cost of fuel relative to their income.

Full details of the annual calculation method for fuel poverty statistics in England can be found in the online fuel poverty methodology documentation *[2]*. This methodology is summarised below.

The number of households in fuel poverty in England is calculated annually by BRE on behalf of the Department of Energy and Climate Change (DECC). This analysis uses data from the English House Condition Survey (EHCS). The EHCS provides information on the changing condition and composition of the housing stock and the characteristics of households living in different types of dwelling. The latest results from the EHCS show that in 2006 approximately 2.4 million households in England were fuel poor.

Originally carried out every five years until 2001, the EHCS now operates on a continuous format in which approximately 8,000 dwellings are surveyed each year. Published analyses, including for the monitoring of fuel poverty in England, use two years' datasets combined to give a sample size of around 16,000 dwellings/households.

Comprehensive data about the housing stock and occupants are collected in two main components of the EHCS: the 'physical' and 'interview' surveys. The physical survey is undertaken by trained surveyors and collects comprehensive information about the key physical attributes of the dwelling. The interview survey includes responses obtained from the Household Reference Person (HRP) or their partner about the occupants of the dwelling.

The EHCS dataset is collected using a complex clustered stratified sampling frame. In order to account for this, and any bias caused by survey non-response, a set of weights (grossing factors) are applied to the survey analysis. These weights scale the sample to the national totals and act to remove any bias.

To calculate households that are fuel poor, household level information on fuel costs (a combination of fuel prices and energy consumption) and incomes are required.

For each case on the EHCS, a 'fuel poverty ratio' is calculated. This calculation has three components – energy prices (unit and standing charges), fuel consumption and income. The equation takes the following form:

$$\text{Fuel poverty ratio} = \frac{\sum(\text{Unit Fuel Price} \times \text{Fuel Consumption}) + \sum \text{Standing Charge}}{\text{Income}}$$

[Equation 1]

Where for each household the following applies:

- The unit fuel price (£/GJ) is applied to each fuel type
- Fuel consumption (GJ) is the energy use for each fuel type
- Standing charges (£) are applied where applicable for each fuel type
- Income (£) is the annual income of the whole household
- For every household all applicable use and cost values are summed for each fuel type.

If the fuel poverty ratio is greater than 0.1 (i.e. a household spends more than 10% of their income on fuel) then the household is considered to be fuel poor.

Energy consumption

The amount of fuel consumed to provide the energy needs of each household is required as one of the components of the fuel poverty calculation.

Under the fuel poverty definition, the energy required to heat and power a home includes energy for:

- Space heating - E_S (GJ).
- Water heating - E_W (GJ).
- Lights and appliances - $E_{L\&A}$ (GJ).
- Cooking - E_C (GJ).

The BRE Domestic Energy Model (BREDEM) *[3]* is used to predict the energy use of a household where:

Total household fuel consumption = $E_S + E_W + E_{L\&A} + E_C$.

Total household energy use includes energy for space and water heating (to meet defined standards) and energy for lights, appliances and cooking. The amount of energy required to heat a dwelling will depend on the building specification such as insulation levels, heating systems and the geographical location of the dwelling. A household's demand for energy will depend on the number of people within the household and the habits of these individuals (which are estimated using BREDEM algorithms). Energy consumption is independent of household income. Information from the EHCS is used to provide details about both dwellings and households.

Fuel prices

The price each household pays for its fuel depends on four main factors:

- The household's location within England (fuel prices vary regionally)
- The choice of supplier
- The choice of tariff
- The method of payment where relevant (i.e. payment by direct debit, credit etc).

Information on the exact tariff, or the supplier, is not collected in the EHCS. The survey *does* however collect information on the geographical location of each case and on the method of payment (for metered fuels). This allows the application of an average fuel price for each region and method of payment.

The prices themselves come for the majority of fuels come from DECC (metered fuels) or a series of reports called the Sutherland Tables (non-metered fuels). DECC provides average annual prices (April to

March) for gas, standard electricity and off-peak (Economy 7) electricity. These prices are split by the electricity supply regions/gas distribution zones and three methods of payment; direct debit, standard credit and pre-payment.

The prices paid for the majority of non-metered fuels (with the exception of wood) are taken from the Sutherland Tables. These are independently produced reports which provide the average prices paid for fuels, split into four broad geographical regions. The prices of wood, communal heating, Economy 10 and Economy 24 electricity are based on the price published in the SAP 2005 specification *[4]*.

By combining the information on method of payment, geographical location and the fuel prices themselves, we are able to calculate a fuel price for each different fuel, that is specific to each household.

Incomes

In modelling incomes for fuel poverty, two definitions have been adopted:

- “Basic income” excludes income related directly to housing.
- “Full income”, used for targets, includes income related directly to housing (i.e. Housing Benefit, Income Support for Mortgage Interest, Mortgage Payment Protection Insurance, Council Tax Benefit and the payment of council tax).

For both definitions it is the income, net of income tax and national insurance, of the whole household. That is the income of the Household Reference Person (HRP) and any partner, plus any other adult member.

The EHCS collects detailed information about the income of the HRP and any partner from different sources (wages, pensions, benefits, savings and investments and other sources e.g. rent from property). Respondents are asked separately about each source and which, if any, State benefits they receive. This information is collated and modelled to produce total net income for the primary benefit unit (HRP and any partner/spouse). Less detailed information is collected from the respondent (who is always in the primary benefit unit) about the income of any additional benefit units in the household. The EHCS also collects information on housing and council tax benefit, council tax bands, Income Support for Mortgage Interest (ISMI) and Mortgage Payment Protection Insurance (MPPI).

There are three major steps involved in modelling household incomes for fuel poverty. First, the Primary Benefit Unit (PBU) Income is calculated for the HRP and partner in each household. Next, the fuel poverty Basic income is modelled for each household and from this, the fuel poverty full income is modelled. For the purpose of this analysis, the level of fuel poverty under the ‘full income’ definition has been used.

Fuel poverty estimates in Scotland, Wales and Northern Ireland.

National fuel poverty estimates for Scotland, Wales and Northern Ireland follow broadly the same methodology. However, there are some differences in the details of the definition between nations. This should be recognised when interpreting the results presented here. The reductions in fuel poverty estimated for Scotland, Wales and Northern Ireland (presented in section 5 of this report) are based on the analysis of English fuel poverty. Different results might be produced were the process to be repeated incorporating greater use of each nation’s data and methodology directly.

3. Producing estimates of the effect of the carbon budgets in England

BRE has produced a scenario model which simulates the effects of the carbon budgets and the CCC's suggested abatement measures on the levels of fuel poverty in 2012, 2017 and 2022.

The primary outputs of the model are estimates of fuel poverty in England. A set of scaling factors are then applied to these results in order to produce estimates of fuel poverty for Scotland, Wales and Northern Ireland.

The BRE model takes into account numerous factors including:

- Changing fuel prices as a result of the carbon budgets
- Changing household incomes
- The effect of energy efficiency improvements in the period to 2012, 2017 and 2022
- Changing population demographics
- The effect of new-build housing

Secondary outputs of the modelling process are estimates of the costs of compensating households by directly reducing fuel bills for households placed into fuel poverty through the carbon budgets, and for those households whose fuel poverty status has become worse.

Analysis of the 2006 EHCS has shown that ~2.4 million households in England are fuel poor. The simulation of the effect of the carbon budgets for England uses this dataset (and this level of fuel poverty) as the base position. The combined effect of all relevant factors should be considered relative to this figure.

Simulating the effect of fuel price changes

The effect of fuel price changes has been included in the modelling by inflating the prices used in the base data by the fuel price scenarios presented to BRE by the CCC. Four different fuel price scenarios, to three different end dates, have been examined.

The scenarios are:

- Baseline (i.e. without any change in fuel prices resulting from the carbon budgets)
- Fuel price changes accounting for the effects of a carbon price and renewable electricity
- Fuel price changes accounting for the effects of a carbon price, renewable electricity and renewable heat
- Fuel price changes accounting for the effects of a carbon price, renewable electricity, renewable heat and uplift from a post-2011 Supplier Obligation

All fuel price scenarios have been projected to 2012, 2017 and 2022.

The details of these scenarios are outlined in full in Appendix A of this report.

The fuel price changes are split into four different fuel price inflation categories: mains gas, electricity, fuel oil and solid fuel. All types of fuels included on the EHCS have been have been inflated in line one of these. The assignment of fuels to fuel price category is shown in Table 1 below. It is important to recognise that because two fuels are assigned to the same category, each of the fuels is <u>*not*</u> assigned an identical price. Each base price used in the calculation is inflated by the same percentage (as shown in Appendix A).

Fuel Price Inflation Category	*Fuels Included*
Mains gas	Mains gas, communal heating
Electricity	Standard electricity, off-peak electricity (all tariffs)
Fuel Oil	Fuel oil, bulk LPG, bottled gas
Solid Fuel	House coal, anthracite, wood & smokeless fuel

Table 1: The assignment of individual fuels to fuel price categories

Fuel prices used in the base position take into account the region and method of payment of the household (see section 2). The modelling to 2012, 2017 and 2022 does not include any change to methods of payment of households, the differential in prices between different methods of payment, or the differential between supply regions.

The base EHCS dataset covers the two-year period April 2005 – March 2007. The fuel prices in the base position are annual prices for either 2005 or 2006 (depending on the date the dwelling was surveyed). The fuel price inflation takes this into account when applying the required fuel price changes.

Simulating the effect of income changes

EHCS fuel poverty 'full income' (see section 2) has been inflated to 2012, 2017 and 2022 in line with the scenarios shown in Appendix B. These scenarios are based upon HM Treasury estimates of disposable household income growth in the UK, and have been provided to BRE by the CCC.

It has been assumed that all types of income, in all types of households and income brackets, rise at the same rate.

Simulating the effect of energy efficiency changes

The effect of energy efficiency is calculated by simulating the installation of a finite number of energy efficiency improvements into the housing stock. The base data for each improved case is adjusted to include the details of the improvement that has been applied and the fuel poverty ratio (see section 2) of each case is recalculated. As it is not possible to determine exactly which households in the future will be improved, this process is repeated several times, with improvements applied at random, and an average result calculated.

There are three energy efficiency scenarios for each of the three target dates. The three energy efficiency scenarios are:

- a 'reference energy efficiency scenario',
- a 'randomly assigned abatement energy efficiency scenario'
- a 'targeted abatement energy efficiency scenario'

The reference scenario is a policy scenario which includes all measures announced and funded before the Energy White Paper in 2007 *[5]*. It is derived from the number of measures predicted as part of Marginal Abatement Cost (MAC) curves work carried out for the CCC by BRE *[1]*. The measures applied in the reference scenario are listed in Appendix C. Of particular relevance is that the reference scenario includes measures installed through the Carbon Emissions Reduction Target 2008-2011 (CERT), but excludes any measures installed through a post-2011 equivalent (known as the post-2011 Supplier Obligation). In this analysis, CERT measures have been installed with reference to the CERT 'illustrative mix of measures' *[6]* and have been targeted accordingly using the CERT priority group split (see Appendix D) which can be approximated using EHCS interview survey data. In the reference scenario none of the post-2011 measures have been targeted at any particular group. The reference scenario also includes significant installations, over and above CERT, due to take up of energy efficiency measures without policy beyond 2006 levels. For example, the reference scenario assumes that there is significant take-up of cavity wall insulation and loft insulation measures, to the extent that over half of households without these measures in 2006 have taken them up by 2022. This is an important factor in reducing fuel poverty from 3.5 million households in 2006 to 2.1 million in 2022 in the central fossil fuel price reference scenario (see Table 2).

The abatement scenario extends the reference scenario to include additional installations in the period to 2022. It includes additional energy efficiency measures, over and above the reference scenario, consistent with those assumed to be implemented in the CCC's (Extended Ambition) abatement scenario. The number of additional installations have been provided by the CCC and are listed in Appendix C. The additional installations (over and above the reference scenarios) have either been applied at random, or targeted using a 50% priority group split (using the CERT priority group definition). A 50% priority group has been chosen as initial sensitivity analysis showed that this level of targetting offered a significant advantage over a 40% priority group target, particularly under the 'high-high' fuel price scenarios.

The modelling of each scenario requires a set of 'control totals' which specify the overall number of measures to be installed. These are specific to each energy efficiency scenario. Each control total is derived from the remaining potential tables shown in Appendix C. These tables show the number of households in each year, for the UK, which have not been fitted with the relevant energy efficiency measures.

The effect of the most significant energy efficiency improvements has been analysed. These measures are:

a) Cavity wall insulation
b) Loft insulation
c) Hot water cylinder insulation
d) Gas boiler upgrades
e) Solid wall insulation
f) Heat pumps
g) Solar water heating
h) Biomass boiler installations
i) Double glazing

Many of the measures are installed in combination. Where a dwelling requires any of the mainstream insulation measures (a – c above) all are installed together. Similarly, all mainstream insulation measures required in a dwelling are installed in combination with solid wall insulation (the assumption being that it is reasonable to assume that any mainstream measures will have been installed ahead of or at the same time as solid wall insulation).

The modelling proceeds in the following way:

- A data record (case) on the EHCS is selected at random for improvement
- Any required measures are installed as long as the total number of installations as specified in the appropriate 'control total' has not been reached (i.e. where there is still remaining potential)

- The post-improvement fuel poverty ratio for that case is calculated using the new fuel costs
- Another case is selected for improvement

The different measures are installed in turn until each of the control totals has been reached. Because of the random nature of the selection process repeated runs of the model are required in order to achieve convergence around an average value for the number of households removed from fuel poverty.

In this modelling no assumptions have been made about changing levels of energy use (for example for lights and appliances) in the future. The current versions of the energy use algorithms used in fuel poverty modelling have been used throughout. The energy algorithms used in the calculation of fuel poverty have previously been updated alongside changes to BREDEM (the current version is the 2001 specification). Lights and appliance use is generally recognised to be a rising component of household consumption, and any future BREDEM changes are likely to recognise this. However, the increasing efficiency of lighting and appliances may act to reverse this trend and it is difficult to predict exactly the nature of any future usage.

Accounting for demographic changes

The extended horizon of the modelling required for this work makes it sensible to consider what effect projected changes to the population will have on the number of fuel poor households. One example is that with an ageing population, as is the case in the UK, in the future there will be more households on fixed incomes that may find it harder to meet their heating and fuel costs. The chosen methodology to account for this effect is to alter the weights (grossing factors) used within the EHCS to allow the results from the sample survey to be expressed in terms of the total number of households in each target year.

Projections of change in the demographics of the population and of the number and type of different households are available from Office of National Statistics and Department for Communities and Local Government respectively that cover the three target years of interest to this project.

The original (2006) weights are constructed for each EHCS dataset and are calculated so that when they are applied, the sample matches the national totals and any bias is removed. To take into account the changes to 2012, 2017 and 2022 appropriate alternative weights have be applied to the base EHCS 2006 dataset to reflect the expected number of households in the three years specified. Information on projected household composition characteristics and on ages of individuals has been used in constructing the weights for each year.

Accounting for new build dwellings

A consequence of the adjustments to the weights is to increase the number of dwellings in each of the dwelling-age categories as the number of households increases; something that could not happen in reality (as it would imply that more dwellings had been built in the past). It is necessary to recognise this by changing the characteristics of certain cases so that they in effect switch from being an 'old' property (in any construction date category older than 2007 onwards) to a modern new build property. These 'new build dummies' take the energy characteristics of a modern dwelling (likely to be of high energy efficiency) and so will have very low fuel costs compared to the older dwellings that they have replaced. This in turn means that the household occupying the new dwelling is unlikely to be fuel poor.

The new-build adjustment is made by converting a (random) selection of cases in each dwelling age band to 'new build dummies' to ensure that the number of (non new-build) households in each age band is returned to the 2006 position. This acts to remove the problem of too many dwellings in the older age bands.

Once the new build dummies are identified the next step is to establish their fuel poverty status. It is a complex process to attempt to establish the likelihood of households being fuel poor in new dwellings. There will be a greatly reduced likelihood of a household living in a highly energy-efficient modern dwelling living in fuel poverty, although it is possible if household income is low and fuel prices high enough.

To take account of this we set the proportion of fuel poor households living in the new-build dummies equal to the proportion of households living in a dwelling with a SAP rating greater than 65 that are fuel poor under each of the relevant fuel price and income scenarios. This threshold has been chosen because all newly built homes are likely to achieve at least this SAP score. This proportion of new build dwellings which are assumed to be fuel poor is in the region of 2-6% for the 'central' fuel price scenarios, rising to 9-21% for the 'high-high' fuel price scenarios. Building regulations require that homes built after 2010 should have very low fuel cost and, and after 2016 should be close to zero fuel cost, so these estimates are likely to somewhat overstate the number of fuel poor households in new build homes.

Calculation of compensation costs

An additional output of this project is to estimate the cost of compensation (in terms of reduced fuel bills) for households which either:

a) become fuel poor as a result of applying the carbon budgets, or

b) would already have been fuel poor (under the baseline fuel price scenarios) but have been placed deeper into fuel poverty by the effect of the carbon budgets.

In the case of a) we would like to know the reduction in fuel bills required to remove the household from fuel poverty (i.e. to reduce the fuel poverty ratio to 0.099). In the case of b) we would like to know the reduction in fuel bills required to return the fuel poverty ratio to that *before* the additional fuel price rises resulting from the carbon budgets.

The cost of compensation is calculated by manipulating Equation 1, which is restated in a simpler form as Equation 2 below.

$$\text{FPR} = \frac{\text{Fuel Costs}}{\text{Income}}$$ [Equation 2]

As we know the fuel poverty ratio for each case prior to the carbon budget fuel price scenario, we are able to determine the fuel cost adjustment required. This adjustment is stated as 'y' in Equations 3 and 4:

$$Y = \text{Fuel Costs - 0.099 * Income} \quad \text{(For those entering fuel poverty)}$$ [Equation 3]

$$Y = \text{Fuel Costs - (Original FPR) * Income} \quad \text{(For those already in fuel poverty)}$$ [Equation 4]

4. Estimating the effect in Scotland, Wales and Northern Ireland

Estimates of the effect of the carbon budgets in Scotland, Wales and Northern Ireland have also been produced. These have been produced in a two stage process:

1) Estimation of the effect of fuel price changes in each nation (without any improvement in energy efficiency)

2) Estimation of the effect of energy efficiency.

For Wales and Northern Ireland only we have also taken account of demographic changes to 2012, 2017 and 2022. This was not possible for Scotland, as explained later in this section.

Stage 1) has been produced by inflating the base fuel poverty data directly for Wales and Northern Ireland (i.e. using the same methodology as for England), and use of Scottish Government estimates of the effect of fuel price rises for Scotland. This approach has been taken to allow for the differences in the fuel poverty methodology used in Scotland.

Stage 2) has been produced with reference to the effect of energy efficiency in England in different types of dwellings, and applying this effect to the different mix of dwellings in Scotland, Wales and Northern Ireland. The details of this process are outlined below.

Application of fuel price and income scenarios

The Scottish Government publish a tool which enables the user to estimate the effect of fuel price rises on the level of fuel poverty in Scotland (approximately 8,000 households become fuel poor for each percentage point rise in all fuels *[7]*). Using the inverse relationship between fuel costs and income, we can also incorporate income changes into this estimate. We have been able to use this tool to calculate the effect of the fuel price and income scenarios on the level of fuel poverty in Scotland.

The Wales and Northern Ireland base datasets have been inflated directly using the same method as used for England, using the equivalent of the EHCS for these nations. Using the base data in this way has the advantage that we are able to incorporate the effect of demographic changes in Wales and Northern Ireland with reference to specific demographic scenarios for these nations (using the same methodology as England).

The inclusion of the effect of demographic changes has not been possible for Scotland due to the different approach taken. As a piece of supplementary analysis, however, the possible underestimation in the final level of fuel poverty as a result has been estimated. This has been carried out by examining the effect of the fuel price rises in England, but without any demographic adjustments. This reveals that in England the inclusion of demographics may lead to a rise in fuel poverty of up to 17%. This is as a result of the increasing number and changes to the type of households as predicted in 2012, 2017 and 2022. The results of this analysis are shown in Appendix E. Although the predictions of demographic change in Scotland are different to England, this may indicate the level of any underestimate as a result of this methodological difference.

Estimation of the effect of energy efficiency

The effect of implementing energy efficiency in Scotland, Wales and Northern Ireland is estimated by applying scaling factors to the effect of energy efficiency improvements in reducing the number of households in fuel poverty in England.

From the England analysis, we are able to identify the characteristics of households which have been removed from fuel poverty as a result of energy efficiency improvements. Of particular interest to us are the energy efficiency characteristics of the dwellings occupied by those households which have been removed from fuel poverty. We have concentrated on four of the most important energy efficiency dwelling attributes: main heating fuel, main heating type, wall type and loft insulation.

The England modelling outputs the number of households removed from fuel poverty with each of these different characteristics. For example, the model outputs that *x*-number of households removed from fuel poverty use mains gas for their main heating, *y*-number of households use electricity for main heating and so on for all heating fuels. Similarly, the model outputs the number of households removed from fuel poverty with uninsulated cavity walls, insulated cavity walls and solid walls. Further outputs include details on the type of heating system (central heating, storage radiators etc) and loft insulation thickness.

BRE have also analysed the energy efficiency characteristics of the housing stock in each nation in the UK, using data from each of the national house condition surveys (2004 data for each nation to assist comparability). By using these splits we are able to scale the results from England to estimate the effect in Scotland, Wales and Northern Ireland.

The first step in this process is to adjust the outputs for England to match those of the other nations. This is done by applying a factor based on the ratio of occurrence of each characteristic. For example, we can compare the relative occurrence of each type of wall in England and Northern Ireland as below:

We know (from direct analysis of house condition data) that in England 42% of dwellings have unfilled cavity walls, 27% of dwellings have filled cavity walls and 31% of dwellings have 'other' (primarily solid) walls. We also know that in Northern Ireland, only 17% of dwellings have unfilled cavity walls, compared to 63% filled cavity walls and 20% other wall types. Northern Ireland therefore has less than half the proportion of unfilled cavities than England (the ratio is equal to 17/42), over double the proportion of filled cavity walls (63/27) and around two-thirds (20/31) the proportion of other wall types.

The number of households removed from fuel poverty, as output by the England model, can then be adjusted to match the proportions of unfilled cavity walls / filled cavity walls / other walls as Northern Ireland. Similar splits are calculated for the other key energy efficiency dwelling attributes (i.e. loft insulation type, main heating type and main heating fuel). In effect this simulates the possible effect in England if it was to have the same (wall type, loft insulation, heating type and heating fuel) characteristics as Northern Ireland. This gives us estimates for the proportion of households in England that would be removed from fuel poverty if England's housing stock looked similar to Northern Ireland's. This proportion is then applied to the number of fuel poor households in Northern Ireland to estimate the number of households removed from fuel poverty in Northern Ireland due to energy efficiency.

The scaling factor approach is a mechanism of attempting to account for differences in the potential for energy efficiency improvements in each of the nations. It is important to recognise, however, that this approach is an approximation of the effect in each of the nations and the results should be treated as such.

Among the most important assumptions to recognise are:

- An assumed linear nature of the effect of fuel price rises in Scotland (an additional 8,000 households has been assumed for all scenarios).
- It is also assumed that the four characteristics of dwellings (main fuel type, main heating type, wall type and loft insulation thickness) are important indicators of the effect of energy efficiency on fuel poverty.
- No attempt has been made to account for the non-linear distribution of households either side of the 10% fuel poverty line (the position in the fuel poverty distribution) which will be different for each of the nations
- The nations have been compared using 2004 house condition survey data. Some characteristics of the housing stock may have changed in the intervening years
- The effect of any gas network extension has not been included in the modelling.

It would be a valuable exercise to compare the results of this scaling approach to results derived directly from modelling of each nation's house condition data, although this has not been possible in the course of this analysis. Without this analysis it is very difficult to estimate the quantity or direction of any uncertainty associated with the scaling approach (with the exception of the demographic effect for Scotland). The methodology of the approach itself, however, does not appear to have any obvious directional bias.

5. Results

The final results of the modelling, for all nations, are shown in Tables 2 to 5 and in Figures 1 to 6 below. The results show that the abatement energy efficiency measures act to reduce the level of fuel poverty by up to 10%. However, the abatement measures on their own are insufficient to reduce the level of fuel poverty back to their likely ‘baseline’ levels (i.e. the level without any fuel price uplift resulting from the carbon budgets).

These results are discussed in a policy context in the 2008 inaugural report of the CCC, however, it is also worthwhile discussing a few of the key results here where they relate directly to the methodology employed.

It can be seen that for each of the different scenarios there is a reduction in fuel poverty as a result of the additional abatement measures installed. This is unsurprising, and reveals the effect energy efficiency can have in alleviating fuel poverty. Of particular note is the pattern seen in targetting of measures through the CERT priority group. For 2012 and 2017 it can be seen that the application of targetting achieves a significant increase in the number of households removed from fuel poverty. For 2022, the effect of targetting is greatly reduced to close to zero. This can be readily explained by the overall number of measures which have been installed in the period to 2022. By this date, under the abatement scenarios, the point of ‘saturation’ has been reached for the main measures of cavity wall insulation and loft insulation. At this point all potential for these measures has been exhausted and targetting of these measures loses any significance (see Appendix C for details of the number of measures installed to each end date).

There are numerous challenges in attempting any forward scenario modelling such as this. When interpreting the results it is essential that the underlying assumptions are understood. This analysis has attempted to take some account of changes to the number and type of households to 2012, 2017 and 2022 (although this has not been possible for Scotland). No account, however, has been made to account for changing patterns of use to these dates. Fuel poverty is monitored against a ‘standard’ for energy usage. This standard is a combination of a defined heating regime and BREDEM algorithms which track average usage for lights, appliances and hot-water. In the future it is possible that usage will change, and the fuel poverty standard will be altered. This analysis does not account for this possibility.

It is also possible that the scenarios set for income and fuel prices will be changed as a result of economic or other effects. This analysis should be considered as indicative for these scenarios only. Any revised circumstances affecting fuel prices and incomes will themselves require a revision to these fuel poverty projections.

		Central Fossil Fuel Prices								
		Baseline Fuel Prices	Carbon Price and Renewable Electricity			Carbon Price, Renewable Electricity and Renewable Heat			Carbon Price, Renewable Electricity, Renewable Heat and Supplier Obligation	
Nation	Year	Reference Scenario	Reference Scenario	Non Targeted Abatement	Targeted Abatement	Reference Scenario	Non Targeted Abatement	Targeted Abatement	Reference Scenario	Targeted Abatement
England	2012	2,372	2,640	2,556	2,521	2,711	2,627	2,589	3,104	2,965
	2017	1,864	2,295	2,156	2,116	2,770	2,601	2,560	3,150	2,911
	2022	1,581	2,040	1,850	1,835	2,948	2,668	2,667	3,320	3,013
Scotland	2012	405	431	422	416	437	427	421	474	457
	2017	334	370	353	346	418	398	392	456	428
	2022	287	329	302	300	422	389	389	454	419
Wales	2012	186	212	205	203	219	212	209	255	243
	2017	146	182	170	167	236	221	217	270	249
	2022	129	170	153	152	261	234	234	297	267
Northern Ireland	2012	171	185	180	177	189	183	180	199	193
	2017	141	157	146	143	183	170	167	198	185
	2022	124	143	124	123	191	167	167	204	185
UK	2012	*3,134*	*3,468*	*3,363*	*3,317*	*3,556*	*3,449*	*3,399*	*4,032*	*3,858*
	2017	*2,485*	*3,004*	*2,825*	*2,772*	*3,607*	*3,390*	*3,336*	*4,074*	*3,773*
	2022	*2,121*	*2,682*	*2,429*	*2,410*	*3,822*	*3,458*	*3,457*	*4,275*	*3,884*

Table 2: Projected levels of fuel poverty in each nation (1000s of households) under central fossil fuel price scenarios to 2012, 2017 and 2022. UK figures are the sum of the results for each nation.

		High-High Fossil Fuel Prices								
		Baseline Fuel Prices	Carbon Price and Renewable Electricity			Carbon Price, Renewable Electricity and Renewable Heat			Carbon Price, Renewable Electricity, Renewable Heat and Supplier Obligation	
Nation	Year	Reference Scenario	Reference Scenario	Non Targeted Abatement	Targeted Abatement	Reference Scenario	Non Targeted Abatement	Targeted Abatement	Reference Scenario	Targeted Abatement
England	2012	4,989	5,921	5,784	5,739	5,947	5,810	5,765	6,405	6,215
	2017	5,293	6,559	6,285	6,244	6,979	6,704	6,667	7,429	7,111
	2022	4,420	5,923	5,552	5,546	6,816	6,404	6,400	7,251	6,831
Scotland	2012	654	737	726	721	740	728	723	778	761
	2017	623	751	727	722	784	760	756	822	793
	2022	529	666	630	630	732	694	693	766	727
Wales	2012	413	482	471	467	483	472	468	513	497
	2017	424	536	513	509	560	537	534	597	570
	2022	365	493	459	459	556	520	519	587	550
Northern Ireland	2012	308	351	343	340	352	344	341	362	352
	2017	309	363	346	344	378	360	359	389	372
	2022	266	336	309	308	366	336	336	377	350
UK	*2012*	*6,364*	*7,491*	*7,324*	*7,267*	*7,522*	*7,354*	*7,297*	*8,058*	*7,825*
	2017	*6,649*	*8,209*	*7,871*	*7,819*	*8,701*	*8,361*	*8,316*	*9,237*	*8,846*
	2022	*5,580*	*7,418*	*6,950*	*6,943*	*8,470*	*7,954*	*7,948*	*8,981*	*8,458*

Table 3: Projected levels of fuel poverty in each nation (1000s of households) under high-high fossil fuel price scenarios to 2012, 2017 and 2022. UK figures are the sum of the results for each nation.

		Central Fossil Fuel Prices						
		Carbon Price and Renewable Electricity			Carbon Price, Renewable Electricity and Renewable Heat			Carbon Price, Renewable Electricity, Renewable Heat and Supplier Obligation
		Reference Scenario	Non Targeted Abatement	Targeted Abatement	Reference Scenario	Non Targeted Abatement	Targeted Abatement	Targeted Abatement
England	2012	94.5	87.2	85.4	114.6	105.6	103.3	217.1
	2017	118.5	94.3	92.9	267.7	216.4	211.6	304.8
	2022	131.2	88.8	85.6	411.0	297.8	292.1	393.4
UK	*2012*	*113.2*	*104.4*	*102.3*	*137.2*	*126.5*	*123.7*	*260.0*
	2017	*141.9*	*112.9*	*111.3*	*320.6*	*259.2*	*253.4*	*365.0*
	2022	*157.1*	*106.3*	*102.5*	*492.2*	*356.6*	*349.8*	*471.1*

Table 4: Compensation costs for England (2006 million £s) under central fossil fuel price scenarios. UK figures have been derived from the England totals by multiplying by 1/0.835 (a factor which accounts for the proportion of all UK households in England).

		High-High Fossil Fuel Prices						
		Carbon Price and Renewable Electricity			Carbon Price, Renewable Electricity and Renewable Heat			Carbon Price, Renewable Electricity, Renewable Heat and Supplier Obligation
		Reference Scenario	Non Targeted Abatement	Targeted Abatement	Reference Scenario	Non Targeted Abatement	Targeted Abatement	Targeted Abatement
England	2012	444.5	416.2	407.1	459.5	430.0	420.5	643.2
	2017	516.3	420.7	415.5	715.3	580.8	572.1	755.7
	2022	504.4	361.6	355.6	861.4	617.7	611.5	776.7
UK	*2012*	*532.3*	*498.4*	*487.5*	*550.3*	*515.0*	*503.6*	*770.3*
	2017	*618.3*	*503.8*	*497.6*	*856.6*	*695.6*	*685.1*	*905.0*
	2022	*604.1*	*433.1*	*425.9*	*1,031.6*	*739.8*	*732.3*	*930.2*

Table 5: Compensation costs for England (2006 million £s) under high-high fossil fuel price scenarios. UK figures have been derived from the England totals by multiplying by 1/0.835 (a factor which accounts for the proportion of all UK households in England).

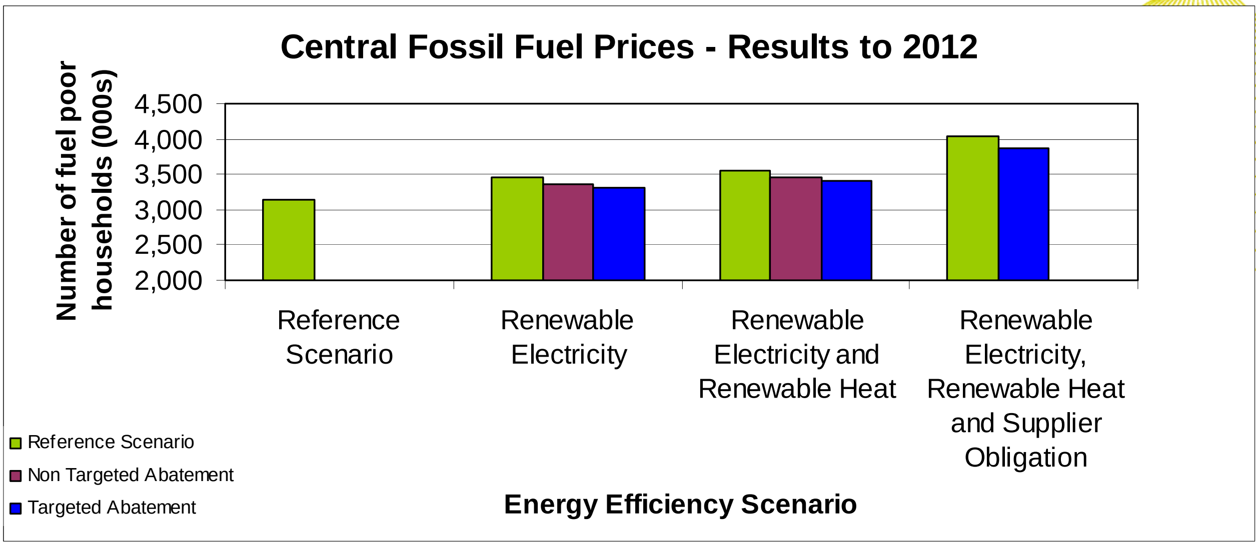

Figure 1: Results for UK for central fossil fuel prices to 2012

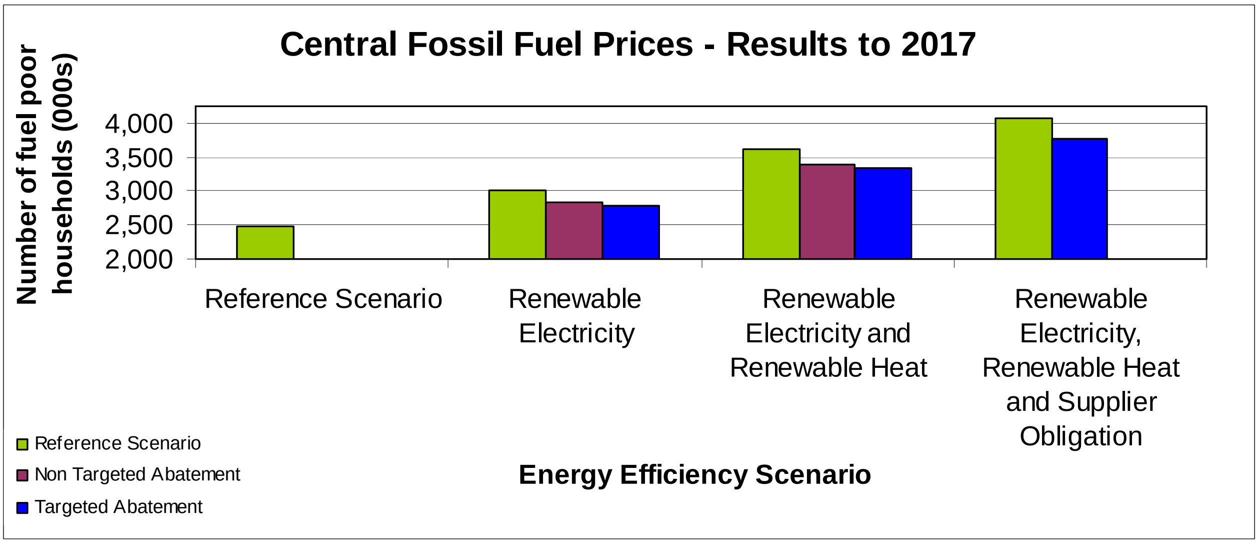

Figure 2: Results for UK for central fossil fuel prices to 2017

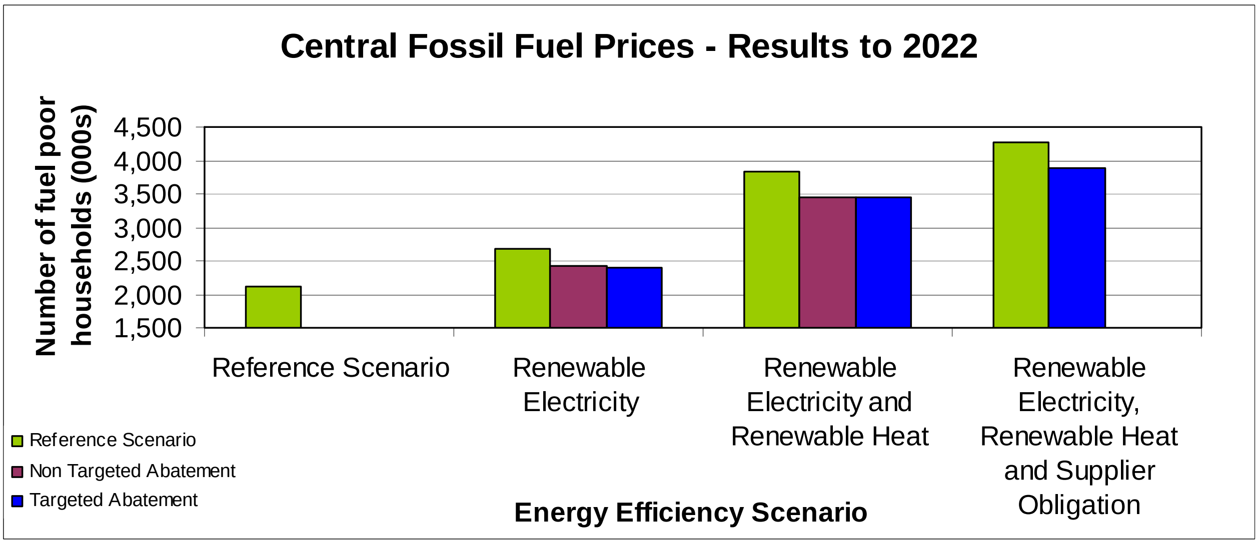

Figure 3: Results for UK for central fossil fuel prices to 2022

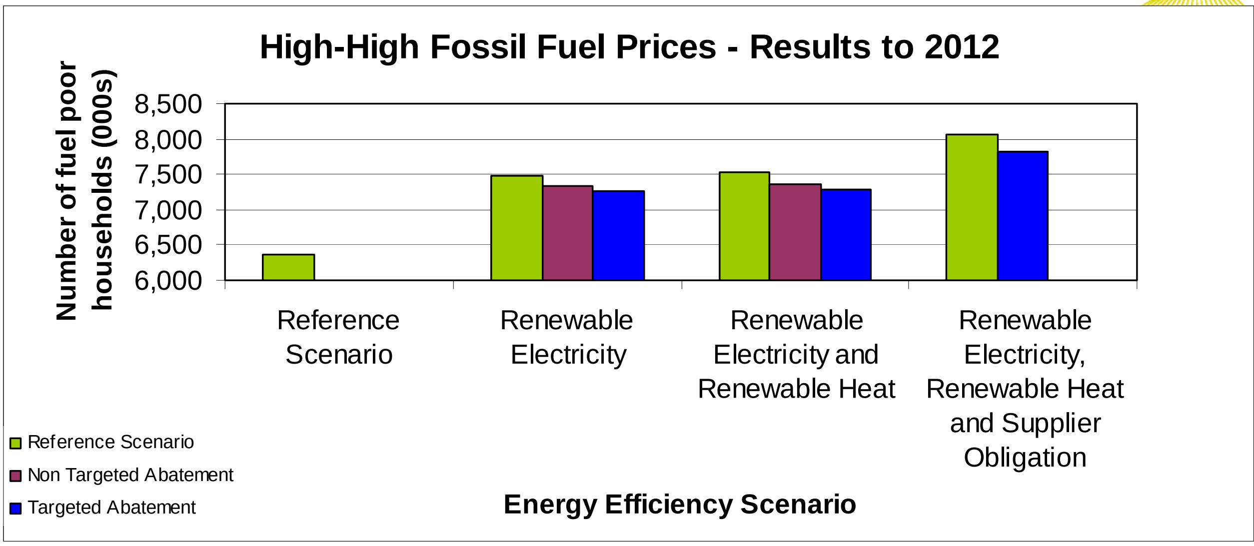

Figure 4: Results of analysis for UK for High-High Fossil fuel price to 2012

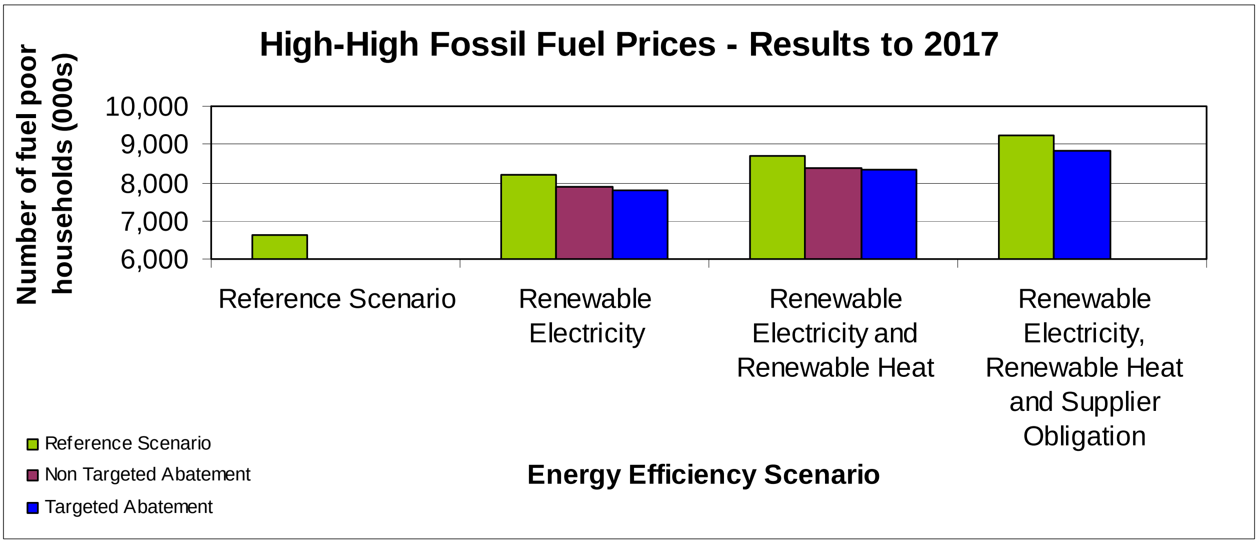

Figure 5: Results of analysis for UK High-High fossil fuel price to 2017

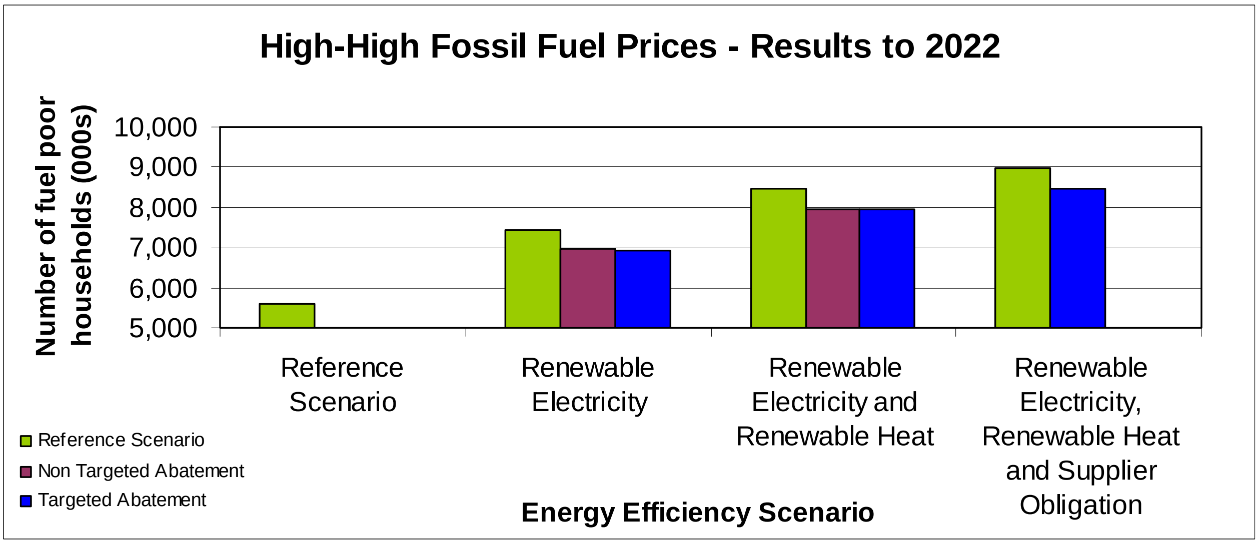

Figure 6: Results of analysis for UK for High-High fossil fuel price to 2022

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Appendix A – Fuel price scenarios

For Central fossil fuel price assumptions					
	2005	**2006**	**2012**	**2017**	**2022**
Baseline Scenario					
Electricity price (p/kWh)	9.15	10.57	11.43	11.76	11.98
Gas price (p/kWh)	2.41	3.10	3.02	3.07	3.12
Oil price (p/kWh)	2.85	3.36	3.46	3.54	3.63
Coal/solid fuel price (p/kWh)	2.75	2.77	2.52	2.48	2.49
With carbon price and renewable electricity					
Electricity price (p/kWh)	9.15	10.57	12.67	13.88	14.88
Gas price (p/kWh)	2.41	3.10	3.02	3.07	3.12
Oil price (p/kWh)	2.85	3.36	3.46	3.54	3.63
Coal/solid fuel price (p/kWh)	2.75	2.77	2.52	2.48	2.49
With carbon price, renewable electricity price and gas price uplift (due to renewable heat)					
Electricity price (p/kWh)	9.15	10.57	12.67	13.88	14.88
Gas price (p/kWh)	2.41	3.10	3.07	3.48	3.98
Oil price (p/kWh)	2.85	3.36	3.51	4.02	4.63
Coal/solid fuel price (p/kWh)	2.75	2.77	2.56	2.81	3.18
With carbon price, renewable electricity price and gas price uplift (due to renewable heat) & Supplier Obligation contribution					
Electricity price (p/kWh)	9.15	10.57	13.27	14.48	15.48
Gas price (p/kWh)	2.41	3.10	3.27	3.68	4.18
Oil price (p/kWh)	2.85	3.36	3.51	4.02	4.63
Coal/solid fuel price (p/kWh)	2.75	2.77	2.56	2.81	3.18

Table A1: Central Fuel Price Scenarios to 2012, 2017 and 2022 (2007 real terms prices). All prices provided by the CCC, from DECC energy modelling based on CCC assumptions (with additional CCC assumptions for renewable heat and Supplier Obligation price increases).

For High-High fossil fuel price assumptions					
	2005	**2006**	**2012**	**2017**	**2022**
Baseline Scenario					
Electricity price (p/kWh)	9.15	10.57	14.93	16.69	16.70
Gas price (p/kWh)	2.41	3.10	4.23	4.76	4.76
Oil price (p/kWh)	2.85	3.36	5.51	6.41	6.41
Coal/solid fuel price (p/kWh)	2.75	2.77	2.90	2.97	2.97
With carbon price and renewable electricity					
Electricity price (p/kWh)	9.15	10.57	17.98	20.97	22.04
Gas price (p/kWh)	2.41	3.10	4.23	4.76	4.76
Oil price (p/kWh)	2.85	3.36	5.51	6.41	6.41
Coal/solid fuel price (p/kWh)	2.75	2.77	2.90	2.97	2.97
With carbon price, renewable electricity price and gas price uplift (due to renewable heat)					
Electricity price (p/kWh)	9.15	10.57	17.98	20.97	22.04
Gas price (p/kWh)	2.41	3.10	4.24	5.03	5.36
Oil price (p/kWh)	2.85	3.36	5.53	6.77	7.21
Coal/solid fuel price (p/kWh)	2.75	2.77	2.91	3.13	3.34
With carbon price, renewable electricity price and gas price uplift (due to renewable heat) & Supplier Obligation contribution					
Electricity price (p/kWh)	9.15	10.57	18.58	21.57	22.64
Gas price (p/kWh)	2.41	3.10	4.44	5.23	5.56
Oil price (p/kWh)	2.85	3.36	5.53	6.77	7.21
Coal/solid fuel price (p/kWh)	2.75	2.77	2.91	3.13	3.34

Table A2: High-High Fuel Price Scenarios to 2012, 2017 and 2022 (2007 real terms prices). All prices provided by the CCC, from DECC energy modelling based on CCC assumptions (with additional CCC assumptions for renewable heat and Supplier Obligation price increases).

Appendix B – Income scenarios

All Scenarios	**2005**	**2006**	**2012**	**2017**	**2022**
Household income (Index 2005 = 1)	1.00	1.01	1.07	1.16	1.24

Table B1: Income scenarios (real terms).

Appendix C – Energy efficiency scenarios

Listed in tables C1 and C2 are the remaining potential for the main measures as identified for the reference and abatement scenarios. These figures are for the UK. In the scenario modelling for England, these figures have been adjusted downwards by applying factors based on the remaining potential for each measure in England (obtained from direct analysis of EHCS data).

	Remaining potential (millions of homes)		
	2012	**2017**	**2022**
Pre76 cavity wall insulation	3.36	3.36	3.36
76-83 cavity wall insulation	0.45	0.45	0.45
Post '83 cavity wall insulation	0.43	0.43	0.43
Solid wall insulation	7.55	7.45	7.37
Loft insulation 0 - 270mm	0.44	0.00	0.00
Loft insulation 25 - 270mm	0.05	0.05	0.05
Loft insulation 50 - 270mm	0.55	0.55	0.55
Loft insulation 75 - 270mm	2.02	2.02	2.02
Loft insulation 100 - 270mm	4.01	4.01	4.01
Glazing - single to new	4.71	3.05	1.88
A-rated condensing boiler	11.65	7.27	3.99
Uninsulated cylinder to high performance	0.75	0.33	0.11
Modestly insulated cyl to high performance	3.87	2.54	1.37
Solar water heating	18.70	18.48	18.19
Glazing - single to future double	4.71	3.05	1.88
Residential biomass (off gas grid)	4.37	4.35	4.32
Heat pumps (off gas grid)	9.17	9.17	9.16

Table C1: The remaining potential for the key measures as applied in the reference scenario

	Remaining potential (millions of homes)		
	2012	**2017**	**2022**
Pre76 cavity wall insulation	2.38	1.21	0.00
76-83 cavity wall insulation	0.32	0.16	0.00
Post '83 cavity wall insulation	0.30	0.15	0.00
Solid wall insulation	7.32	7.00	6.63
Loft insulation 0 - 270mm	0.31	0.00	0.00
Loft insulation 25 - 270mm	0.04	0.02	0.00
Loft insulation 50 - 270mm	0.39	0.20	0.00
Loft insulation 75 - 270mm	1.43	0.73	0.00
Loft insulation 100 - 270mm	2.97	1.69	0.40
Glazing - single to new	4.19	2.25	1.13
A-rated condensing boiler	10.95	6.33	3.19
Uninsulated cylinder to high performance	0.67	0.24	0.07
Modestly insulated cyl to high performance	3.87	2.54	1.37
Solar water heating	18.70	18.48	18.19
Glazing - single to future double	4.52	2.80	1.63
Residential biomass (off gas grid)	4.37	4.35	4.32
Heat pumps (off gas grid)	9.17	9.17	9.16

Table C2: The remaining potential for the key measures as applied in the abatement scenario

Appendix D – CERT priority group

Under CERT, 40% of the target savings must be obtained in the priority group. The priority group includes households containing someone aged 70 or over, and households in receipt of one or more of the following benefits:

- Council tax benefit
- Income support
- Housing benefit
- Jobseekers allowance (income based)
- Attendance allowance
- Disability living allowance
- Disablement pension which includes a constant attendance allowance
- War disablement pension (with mobility supplement or constant attendance allowance)
- Child tax credit (where the consumer's relevant income is £15,592 or less)
- Working tax credit (where the consumer's relevant income is £15,592 or less)
- State pension credit

All of these qualifying benefits have been modelled in this analysis, with the exception of disablement pension with a constant attendance allowance. Information on this benefit is not collected on the EHCS.

Appendix E – The effect of including demographic changes in England

A sensitivity analysis has been carried out to examine the effect of including demographic change in the modelling. The level of fuel poverty before any energy efficiency improvements has been examined using the original grossing factors and without any adjustments for new build dwellings. The inclusion of demographics has resulted in an increase in the level of fuel poverty under these scenarios. The size of this increase is shown in Tables E1 and E2 below.

Central Fossil Fuel Prices				
	Baseline Fuel Prices	**Renewable Electricity**	**Renewable Electricity and Renewable Heat**	**Renewable Electricity, Renewable Heat and Supplier Obligation**
2012	11.55%	11.09%	10.98%	11.00%
2017	13.88%	14.38%	13.14%	12.58%
2022	16.90%	16.00%	13.42%	13.62%

Table E1: Estimate of the effect of inclusion of demographics on the level of fuel poverty (before energy efficiency improvements) for each of the central fossil fuel price scenarios.

High-High Fossil Fuel Prices				
	Baseline Fuel Prices	**Renewable Electricity**	**Renewable Electricity and Renewable Heat**	**Renewable Electricity, Renewable Heat and Supplier Obligation**
2012	11.55%	11.09%	10.98%	11.00%
2017	13.88%	14.38%	13.14%	12.58%
2022	16.90%	16.00%	13.42%	13.62%

Table E2: Estimate of the effect of inclusion of demographics on the level of fuel poverty (before energy efficiency improvements) for each of the high-high fossil fuel price scenarios.