Distributional impacts of UK Climate Change Policies

Final report to eaga Charitable Trust

June, 2010

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Acknowledgments

In the preparation of this report a number of organisations and individuals provided helpful advice, comments and information. The team would particularly like to thank the following: Ofgem for the provision of the Ipsos Mori survey data on domestic energy customers' attitudes and behaviours in Great Britain's energy supply market; DECC for their support in reviewing the report and enabling the use of the underlying assumptions; and Derek Lickorish, Chair of the Fuel Poverty Advisory Group, for his early comments on the methodological approach.

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Executive Summary

Introduction

The Low Carbon Transition Plan (LCTP)[1] sets out the Government's proposed policies for delivering on its renewable energy and carbon-related targets. The delivery of the policies listed in the Plan will see some benefits to the UK housing stock, in the form of insulation and renewable energy measures, but all policies will incur significant financial cost.

eaga Charitable Trust appointed the Centre for Sustainable Energy (CSE) and the Association for the Conservation of Energy (ACE) to examine how the costs and benefits of the UK's renewable energy policies may distribute amongst the domestic sector.

The study aims to:

- Determine the scale of sustainable energy deployment required to meet the UK's EU renewables target of 15% by 2020 and the proportions to be supplied through renewable heat, power and energy conservation in relation to the residential sector;
- Identify the range and size of technologies required and their potential to supply energy to UK households;
- Determine the cost of achieving the UK climate change and renewable energy targets with particular focus on the distributional impacts of cost recovery through consumer bills and income taxation;
- Explore the wider implications for social justice in the context of climate change mitigation policies.

Analytical approach

The study uses CSE's 'Distributional Impacts Model for Policy and Strategic Analysis' – 'DIMPSA'. This model is based on a dataset of household energy consumption, developed from the UK Expenditure and Food Survey (EFS, 2004/05 - 2007), with additional variables modelled from the English House Condition Survey (EHCS, 2006) and Ipsos MORI/Ofgem survey of energy consumer market behaviour (see section 2.3 and Annex I).

The costs and (where applicable) benefits (in the form of insulation and renewable energy measures) of the following policies have been modelled:

1. EU Emissions Trading Scheme
2. Carbon Emissions Reduction Target (CERT)
3. Proposed Supplier Obligation after CERT
4. Community Energy Saving Programme (CESP)
5. Renewables Obligation
6. Feed-in tariffs (FIT)
7. Renewable Heat Incentive (RHI)

[1] HM Government, (2009). The UK Low Carbon Transition Plan. National strategy for climate and energy. www.decc.gov.uk/Media/viewfile.ashx?FilePath=White%20Papers\UK%20Low%20Carbon%20Transition%20Plan%20WP09\1_20090724153238_e_@@_lowcarbontransitionplan.pdf&filetype=4

8. Smart meters
9. Product policies

A series of look-up tables and algorithms provide the means for:

1. Modelling the allocation of insulation and renewable energy measures under each of the relevant policies and the associated benefits in reduced fuel bills or FIT/RHI revenues;
2. Distributing the costs of each policy.

For the first stage, the allocation of measures (insulation and renewables) has been modelled using a simple 'exogenous input' method. This approach forces the model to allocate measures at a given rate defined by the user and according to pre-determined household suitability and policy criteria.

In defining the individual policy cost pass-through to domestic consumers, the same assumptions have been applied as those used in the LCTP, with the exception of the RHI and FIT, for which more up-to-date figures were available from DECC based on their latest impact assessments.

Three scenarios of policy cost recovery are modelled: the first two assume costs are recovered through consumer bills, and the other models cost recovery via income taxation. The cost recovery through bills includes two scenarios: one of an equal 'spread-even' cost distribution; and the second a commercial reality 'supplier' cost distribution (see Annex II).

The model of income taxation is based on taxation thresholds and associated rates concurrent with historical trends for income tax (i.e. the 1980s onwards). The taxation required to fund climate change policies is based on the relative difference between the survey reported income tax payment projected to 2009, and the subsequent additional revenue and baseline scenarios modelled.

The impact on consumer energy bills resulting from the modelling are presented in terms of the counterfactual bill. This is the energy bill in 2020 without any of the LCTP policies, but taking account of fuel price rises. The fuel price rise assumptions used in this report match those used by the fuel prices team in DECC, in the distributional impacts analysis discussed in the LCTP Analytical Annex (Chapter 5)[2]. The non-metered fuel price rise assumptions have been taken from the WWF '*How Low?*' report[3].

Results

Distribution of measures

The results of the policy modelling show that nearly two thirds (65%) of households receive at least one measure, with 60% receiving insulation (including cavity wall, solid wall, loft

[2] HM Government, (2009). Analytical Annex. The UK Low Carbon Transition Plan. www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx

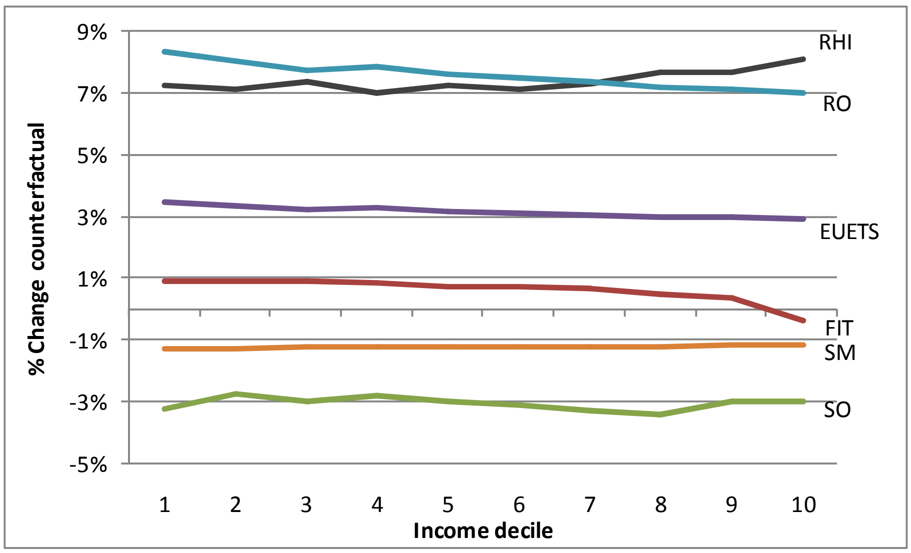
[3] WWF, (2008). How Low? Achieving optimal carbon savings from the UK's existing housing stock. http://assets.wwf.org.uk/downloads/how_low_report.pdf

virgin or top-up). One in ten households gets a renewable heat technology, and 3% renewable power.

Individual policy impact

Analysis of individual policy impact (Figure A) shows that the RHI and RO result in the greatest increase in household energy bills: without the insulation measures available from other policies, which protect households from price rises, the RHI and RO result in an average increase of 7.5% on the counterfactual bill. However, the RHI does appear slightly progressive in nature, resulting in a greater percentage increase for the higher income households. This is related to the distribution of different heating fuels: lower income households rely to a greater extent on electricity for heating and therefore receive less of the policy cost pass-through of the RHI (which is expected not to be recovered through electricity bills).

Figure A: Impact of individual policies on the counterfactual energy bill by income decile



Combined policy impact

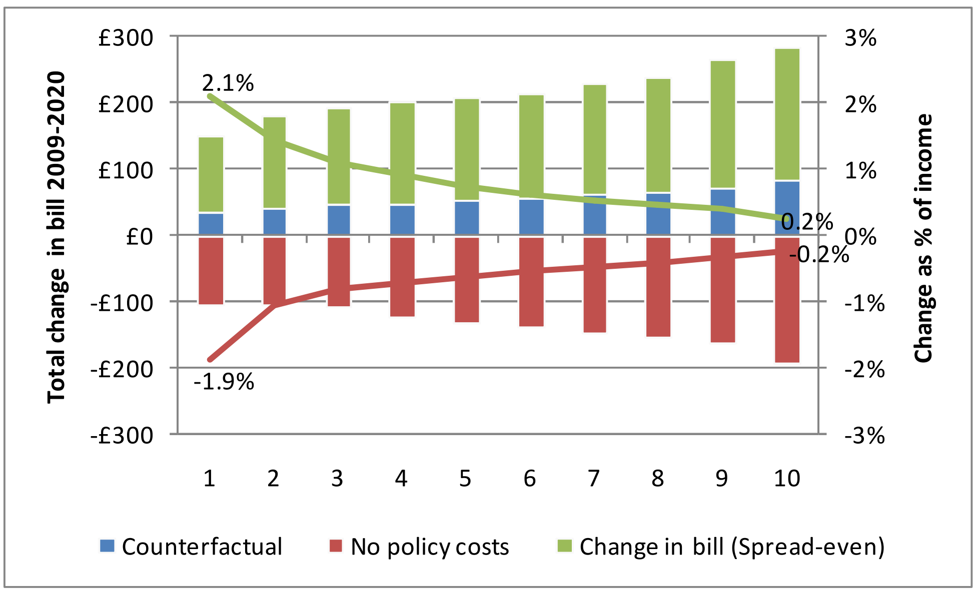
Analysis of all the LCTP policies combined, shows that if policy costs are recovered through consumer energy bills this results in an average increase in household energy bill of £103 in 2020 (table D). This is an increase of 8.5% on the counterfactual. Recovering policy costs through income taxation on the other hand sees the average household energy bill decrease by £193 (16% below the counterfactual), with households benefiting from policy measures (insulation and renewable), but not paying the cost through bills. However, under this cost recovery scenario, annual household income falls by an average of £309. Therefore, under the income taxation scenario the average household is £116 'net' worse off, compared to £103 under the 'spread even' scenario (so called because it assumes energy suppliers recover costs evenly across its customer base, rather than loading them more onto certain types of customer (see Section 2.6).

Table D. Impact of LCTP policies on energy bills through the two cost recovery scenarios

	No policy, no measures (Counterfactual)	Spread even scenario	Income tax scenario
Total bill 2009	£1,154	£1,154	£1,154
Total bill 2020	£1,211	£1,314	£1,018
Total change in bill	£57	£160	-£136
Difference: total bill ‘20 & counterfactual ‘20	-	£103	-£193
% Change in bill counterfactual	-	8.5%	-16.0%
Change as a % of income	-	0.6%	-1.5%
Change as a % of income in 2020	-	0.5%	-1.3%
Change in annual household income	-	-	-£309

The spread-even cost recovery through bills scenario results in greater absolute increase in bill for the higher income deciles, but this increase represents a smaller percentage change, and smaller proportion of household income, than for the lower income households (Figure B).

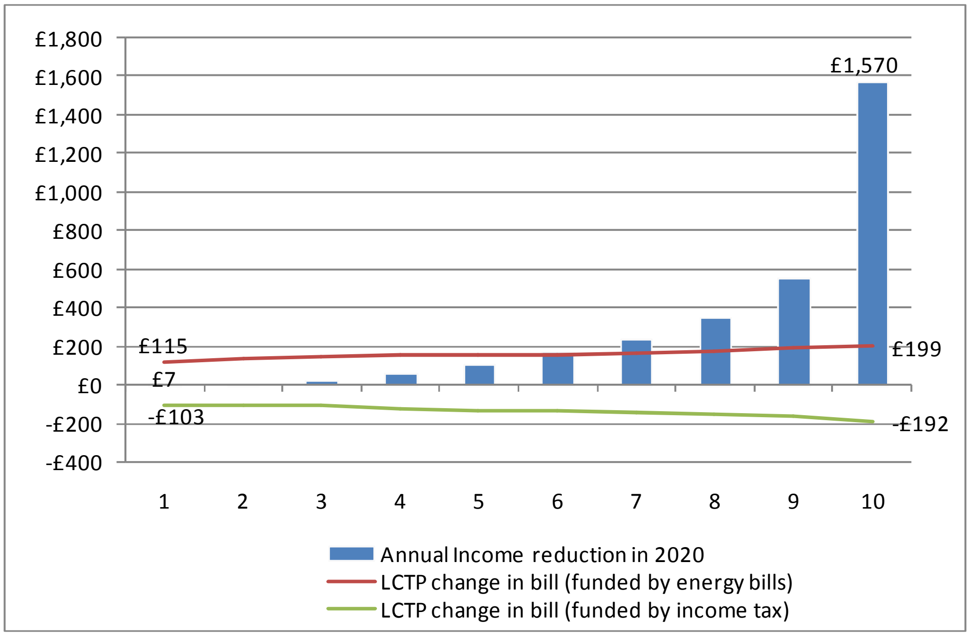
Figure B. Change in household energy bill and change as a proportion of income



Impact of income taxation cost recovery

Taking account of the decrease in energy bill and decrease in household income under the taxation scenario, the lowest income households (decile 1) have on average a net surplus of £96 (i.e. the decrease in energy bill exceeds the decrease in household income), compared to the highest income decile with an average net deficit of £1,378 (Figure C).

Figure C. Reduction in household income and change in energy bills under the two scenarios



The spread-even cost recovery scenario results in some households (22% of the dataset) 'winning' – that is experiencing a decrease in energy bill – whilst some are made extremely worse off.

Applying CHAID ('Chi squared automatic interaction detector' see Annex I for details) to the modelling results helps to identify the key defining characteristics of these 'winning' and 'losing' households, by creating 'nodes' – or clusters. The results show that all 'winning' nodes receive 100% cavity wall insulation – i.e. households that currently have uninsulated cavities but receive this measure under one of the relevant policies stand to gain: the benefits of insulation act as a buffer against future fuel price rises. The winning nodes also receive above average renewable heat technologies and, for 3 out of the 4 winning clusters, power technologies. However, there is evidence of renewables in some of 'losing' households as well, suggesting insulation is the key factor in making a household better off.

Alternative tariff solutions

There are alternative methods for recovering policy costs from consumer's energy bills, which have not been modelled as part of the study. The introduction of a 'protected block' tariff represents one possible approach.

A protected block tariff would require regulatory backing to specify that energy suppliers only recover policy costs above a certain threshold for both gas and electricity. For example, the first 2,000kWhs would not be subject to the additional costs of climate change policies but these would be loaded on consumption in excess of this. The remaining units could be subject to either uniform cost pass through or they could escalate, in a similar manner to a rising block tariff, with the unit cost increasing with consumption.

Whilst this approach has not been modelled in detail for this study, high level analysis of consumption patterns suggests:

i. Lower income households generally consume less energy and as such would stand to benefit from lower fuel bills.
ii. A relatively small number of low income households have high levels of energy consumption and would be at risk from the higher priced bands.
iii. A higher proportion of low income households heat their home with electricity and could also therefore be made worse off under the block tariff.
iv. High consumption low income households could be exempt from the block tariff, to eliminate the risks identified in (ii) and (iii) above, if they meet certain qualifying criteria, for example, linked to income and / or off-peak electricity tariffs.
v. Fuel poor households are on average less efficient which means they theoretically need more energy to heat their homes. A protected block tariff could therefore both increase fuel poverty (in the official sense of the definition) and simultaneously make people better off
vi. The tariff should not place an undue burden on energy suppliers. For example, the obligation could be split between suppliers based on the consumption of the households they supply rather than the total numbers of customers.

Conclusions and recommendations

This study has modelled the potential distributional impacts of UK climate change policies, as set out in the Government's Low Carbon Transition Plan. It explores and compares the impacts of recovering policy costs through consumer bills and via income taxation.

The use of energy bills to recover the cost of climate change policies appears more regressive than the alternative use of income taxation. These approaches both require the population to pay for a variety of measures from which they may or may not benefit. The 'winners' see an overall reduction in their energy bills under either scenario, with the income taxation route benefiting those on lower incomes.

However, current and future Governments are unlikely to use income taxation to fund these measures unless an alternative revenue stream can be found for the country's huge structural deficit. If energy bills are the principal route for the recovery of climate change policy costs then the delivery of the LCTP and the HEMS – or its successor with the new Government – must be designed to be as fair as possible. The HEMS and the LCTP's delivery must therefore:

1. Ensure no fuel is unduly burdened by climate change policy costs.

Electricity prices are set to increase by over 4p/kWh by 2020 which is more than any other fuel. Whilst this increase relative to today's costs may be proportionally lower than that experienced by gas consumers, those heating their homes with electricity will face significantly higher energy bills. Such households are concentrated in the lower income deciles.

2. Ensure expenditure on measures is linked to the householder.

The HEMS provides further details on the Government's proposals for low interest loans and the possibility of mandatory standards for rented housing. The use of loans and regulation provides the potential to remove the link between policy costs and energy bills. For example, low interest loans will link the cost of measures and their repayments to the property and as such remove the need to place a delivery obligation on the energy suppliers. However, low interest loans will not be appropriate for all householders, particularly those on low incomes that currently under heat their homes and as such will not generate the necessary financial savings to make the loan repayments. The delivery of measures to low income households will therefore require grants and subsidies; the analysis undertaken in this study would suggest this would be most fairly funded from income taxation.

3. Design tariffs that penalise high consumers and control energy supplier cost pass through strategies.

The recovery of the costs of climate change policies should penalise those consumers that pollute most. If energy bills are to be the primary cost recovery mechanism then tariffs should be structured to favour those who pollute least and energy suppliers should not be left to recover these policy costs as they see fit to meet their own commercial objectives, rather than to serve wider societal objectives such as reduced inequalities. The report has identified a 'protected block' tariff as a potential solution to this problem. The implementation of this tariff would have its own set of distributional impacts i.e. potentially unduly impacting on low income households using electricity to heat their homes. The tariff would therefore need to be structured to account for different payment methods, (e.g. economy 7), and customer types (e.g. households in receipt of certain means tested benefits with low incomes).

List of abbreviations

ACE	Association for the Conservation of Energy
bn	Billion
CCGT	Combined cycle gas turbine
CERT	Carbon Emissions Reduction Target
CESP	Community Energy Saving Programme
CH	Central heating
CHP	Combined heat and power
CLG	Department of Communities and Local Government
CSE	Centre for Sustainable Energy
DECC	Department of Energy and Climate Change
DIMPSA	Distributional Impacts Model for Policy and Strategic Analysis
EFS	Expenditure and Food Survey
EHCS	English House Condition Survey
EUETS	European Union emissions trading scheme
FIT	Feed-in tariff
FP	Fuel poverty
GWh	Gigawatt hours
HEMS	Household Energy Management Strategy
IGCC	Integrated gasification combined cycle
IMF	International Monetary Fund
LCTP	Low Carbon Transition Plan
NPV	Net present value
RHI	Renewable heat incentive
RO	Renewables Obligation
SM	Smart metering
SO	Supplier Obligation

1. Background to the study

The Government has stated its commitment to delivering the UK share of the EU target of sourcing 20% of energy (i.e. electricity, heat and transport fuels) from renewable sources by 2020. The EU's draft Renewables Directive proposes a UK target of 15%. At present only 2% of the UK's energy comes from renewables (approximately 5% of UK electricity is generated from renewable sources)[4]. It is therefore clear that the Government must facilitate a huge increase in the deployment of renewable energy if it is to meet the EU target. The recently published UK Renewable Energy Strategy suggests that meeting the UK's target will require investment in the order of £100bn[5] and create up to half a million jobs by 2020.

In addition to the increased targets for renewables the Government has been set ambitious targets to reduce carbon emissions by 31%[6] by 2020 and 80%[7] by 2050. The Low Carbon Transition Plan brings together the Government's proposed renewables and carbon related policies, producing a national strategy to deliver its climate and energy related targets. The delivery of the household based policies listed in this plan will also require a significant increase in expenditure i.e. an estimated £25 to £29bn[8]. For example, the plan estimates an investment of £3.2bn in the delivery of CERT which is itself smaller in scale than the supplier obligation (2012 onwards).

In addition to the driver of climate change, energy security is increasingly becoming a motivation for the deployment of new capacity and demand reduction. The analysis of energy bills in 2020 therefore includes an assumed increase in prices as a result of infrastructure investment, global trends for energy prices and global demand for energy. It is also important to recognise the need to retrofit the housing stock in the context of energy security: insulating our homes and switching to renewable sources of energy will in part protect us from a reduction in UK gas supply and electricity[9] generating capacity.

eaga Charitable Trust appointed the Centre for Sustainable Energy (CSE) and the Association for the Conservation of Energy (ACE) to examine the distributional impacts of UK renewable energy targets. In particular the study aims to:

- Determine the scale of sustainable energy deployment required to meet the UK's EU renewables target of 15% by 2020 and the proportions to be supplied through renewable heat, power and energy conservation in relation to the residential sector;
- Identify the range and size of technologies required and their potential to supply energy to UK households;

[4] DECC, (2009). Digest of United Kingdom energy statistics, 2009. *Renewable sources data used to indicate progress under the EU Renewables Directive 2008 (Table 7.7, p.209)* www.decc.gov.uk/en/content/cms/statistics/publications/dukes/dukes.aspx

[5] HM Government, (2009). The UK Renewable Energy Strategy 2009.

[6] Committee on Climate Change, (2008). Building a low-carbon economy – the UK's contribution to tackling climate change. www.theccc.org.uk/pdf/TSO-ClimateChange.pdf

[7] Climate Change Act, 2008.

[8] HM Government, (2009). The UK Low Carbon Transition Plan: Analytical Annex.

[9] Several nuclear plants are due for decommissioning and coal plants may face reduced operation from proposed legislation.

- Determine the cost of achieving the UK climate change targets and renewables targets and the associated impact on low income households i.e. the number of households who would directly benefit from a technology and the additional cost to the consumer through taxation or increased energy bills;
- Explore the wider implications for social justice in the context of climate change mitigation policies.

2. Analytical Approach

2.1. Determining the deployment required to meet the UK's energy requirements

The evidence presented in the Government's Low Carbon Transition Plan (LCTP) and Renewable Energy Strategy (July 2009) was reviewed to develop a clear indication of the policies that the Government envisage in the delivery of their 2020 and 2050 targets. The team has therefore summarised the costs and benefits associated with:

- The Government's LCTP assessment of investment and deployment required to reduce emissions and achieve renewables targets in the domestic sector i.e. retrofitting the existing housing stock
- The Government's LCTP assessment of investment and deployment required to meet our energy generation targets for renewables and the associated impact on domestic consumers.

The review and analysis has therefore focussed on the following policies:

1. EU Emissions Trading Scheme – carbon
2. Carbon Emissions Reduction Target (CERT) – carbon and micro renewables
3. Proposed Supplier Obligation after CERT – carbon and micro renewables
4. Community Energy Saving Programme (CESP) – carbon and micro renewables
5. Renewables Obligation – carbon and large scale renewables
6. Feed-in tariffs (FIT) – carbon and micro to large scale renewables
7. Renewable Heat Incentive (RHI) – carbon and micro scale renewables
8. Smart meters – carbon
9. Product policies – carbon

The results provide an overview of the total policy costs and the overall scale of deployment associated with the delivery of climate change and renewable energy targets. The team has also performed a review of the research community's own assessment of what is required to achieve the Government's 2020 and 2050 targets. The overall costs and impacts are then compared to enable some sensitivity analysis to determine the range of bill or income tax increases required to fund these scenarios.

The results do not include the impacts associated with Carbon Capture Storage (CCS) as the costs associated with this research and demonstration technology are as yet unknown. The research review provides an overview of the potential range of cost implications based on previous research. The future implementation of CCS should provide more up to date information for modelling its distributional impacts at a later date.

2.2. Wider implications for social justice

The King Baudouin Foundation[10] is currently conducting a collaborative scoping study to examine the relationship between climate change mitigation polices and social justice in Europe. The Foundation produced a discussion paper to help generate debate at a project workshop[11]. To help thinking about the links between climate change mitigation policies and social justice, an evaluation scheme was developed by the Université Libre de Bruxelles[12]. Annex IV contains a direct quotation from the discussion paper outlining the evaluation scheme's design as a tool to explore potential conflicts and synergies.

The team have applied the evaluation scheme to the proposed LCTP climate change policies and the alternative scenario proposed in the companion publication. It is important to note that the social justice implications may be different if the policies themselves were funded by taxation. If funded by income taxation then it could be argued they are being paid for progressively by citizens, rather than regressively through energy bills by consumers.

2.3. Modelling distributional impacts – overview of 'DIMPSA'

Microsoft SQL Server Express 2008 provides the platform for the 'Distributional Impacts Model for Policy and Strategic Analysis' – DIMPSA – (see figure 1 below). DIMPSA is built upon a series of algorithms designed to model the impact and benefits of policy delivery. These algorithms have been stored in the SQL database that underpins DIMPSA as a series of look-up tables which store the technological performance assumptions of home energy improvements; and a set of annotated queries that underpin the calculations.

DIMPSA builds upon CSE's previous Expenditure and Food Survey based work for Defra on personal carbon trading[13] and more recent work for DECC on policy scenario distributional impacts. There is currently no nationally representative survey that captures all the information required to undertake an analysis of the social and geographic distributional impacts of climate change policies in the UK. The English House Condition Survey (EHCS), managed by the Department for Communities and Local Government, captures very useful information on housing condition and heating systems, but it does not record actual expenditure on, or consumption of, household and transport fuels or energy services.

The UK Expenditure and Food Survey (EFS) undertaken by the Office for National Statistics, upon which the model is based, lacks some of the detailed housing condition data contained in the EHCS and the devolved nations own Housing Condition Surveys, but does record expenditure on a wide range of items. For the purpose of distributional impacts analysis we have therefore modelled a number of additional variables in the EFS which enable us to determine:

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[10] www.kbs-frb.be

[11] Held in Brussels between 18-19 November 2009, http://kbf.syncsphere.com/news/Social_impact_of_EU_policy_responses_to_climate_change_debated_in_Brussels

[12] Schiellerup, P., Chiavari, J., Bauler, T., Grancagnolo, M., (2009). Climate change mitigation policies and social justice in Europe: An exploration of potential conflicts and synergies. Published by the King Baudoin Foundation.

[13] Thumim, J. and White, V. (2008). Distributional impacts of Personal Carbon Trading. A report by CSE to the Department for Environment, Food and Rural Affairs. Defra, London. www.defra.gov.uk/environment/climatechange/uk/individual/carbontrading/pdf/pct-distributional-impacts.pdf

- **Who benefits:** based on the opportunity to install measures, utilising the EHCS to derive information on wall type and loft insulation (see Annex I for further discussion)
- **Who pays:** likely patterns of the way in which energy suppliers load costs on different customer types, based on supplier switching behaviour identified from Ofgem's consumer market behaviour survey (conducted by Ipsos Mori).

The model therefore includes a number of imputed variables which enable the identification of who benefits and who pays within DIMPSA (see Annex I for further details). The imputed variables include:

- **Wall type** as defined by the English House Condition Survey: the wall type variable is used to help identify the opportunity for cavity wall insulation, solid wall insulation and suitability for renewables, e.g. the wall type flag restricts the deployment of Ground Source Heat Pumps to properties with insulated cavity walls only.

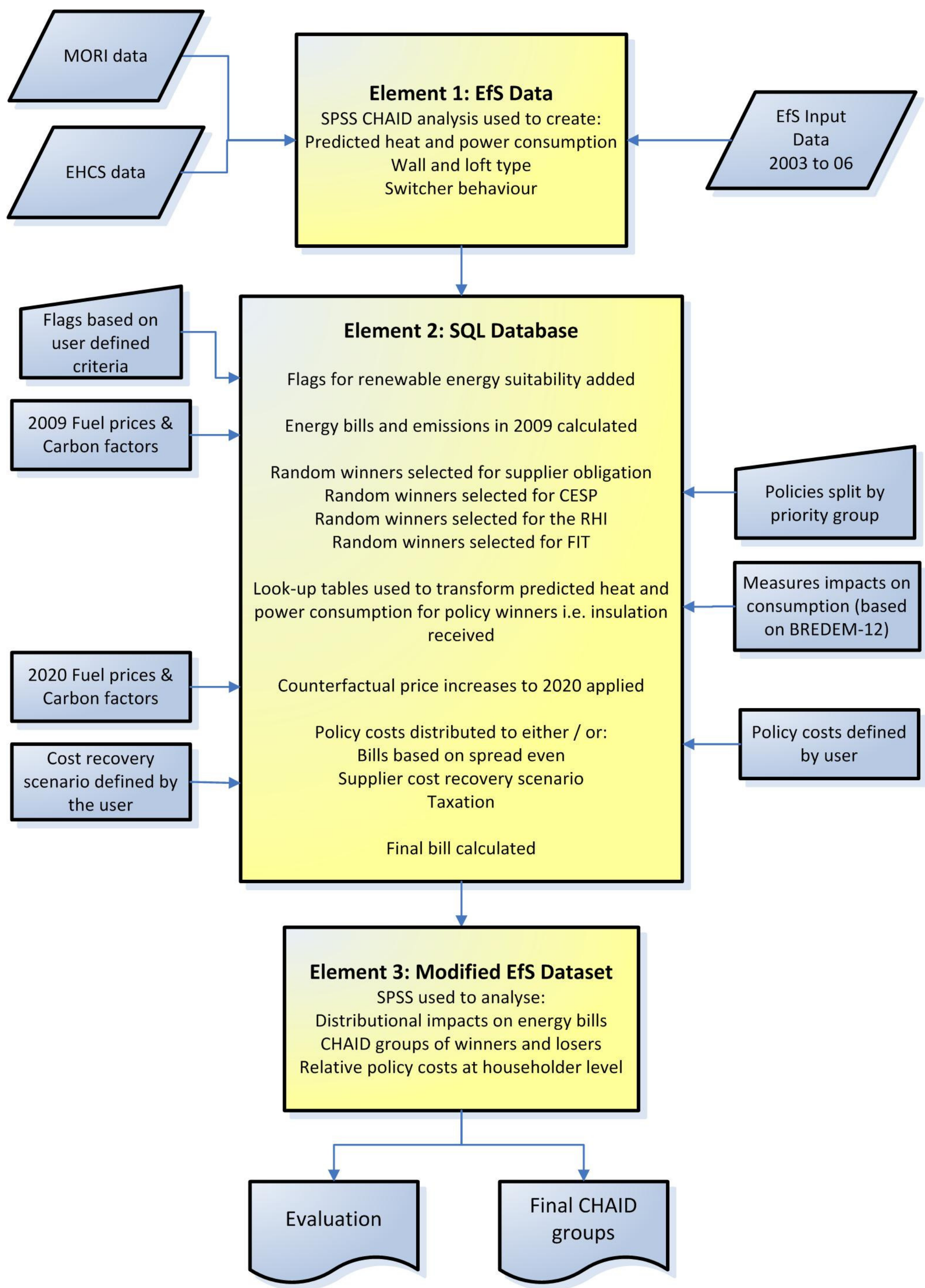
- **Loft insulation opportunity** as defined by the English House Condition Survey: the loft insulation variable defines the opportunity to insulate the loft and the proportional saving to be assigned to winning cases. The variable defines the household as having no loft, a virgin loft, a top up opportunity or insulated already.

- **Communal heating** as defined by the English House Condition Survey: the community heating variable defines the property as accessing heat from both district heating or combined heat and power. DIMPSA then selects these cases as appropriate for fuel switching as supported by the supplier obligation[14] i.e. switching the source fuel from gas to biomass.

- **Propensity to switch energy supplier** as defined by the Ipsos Mori survey for Ofgem: the switcher flag defines a household's propensity to switch as "never switched" and "switched more than once". The commercial reality supplier cost recovery scenario applies an additional level of costs to households that never switch to reflect the present tariff differential (see Annex II for a more detailed discussion).

[14] As defined by the LCTP Impact Assessment

Figure 1. DIMPSA Model Diagram



2.4. Data health warnings

The DIMPSA model is based on EFS data on energy expenditure. The expenditure data is converted to fuel consumption using fuel price look-ups and this figure is then used to produce a modelled total for heat and power consumption (see Annex I for further details). The team has not sought to reconcile the modelled UK totals for fuel consumption with those published in the UK Digest of Energy Statistics (DUKES). The DUKES figures contain some consumption from Small and Medium Sized Enterprises (SMEs) and are also weather corrected, where as the EFS data is based on non weather corrected energy expenditure. The totals are relatively similar with the exception of mains gas with an EFS total of 340 GWhs compared to a three year DUKES average of 399 GWhs[15]. It would be a relatively simple process to inflate or deflate the EFS totals to the DUKES figures, but this represents further modelling of a model and as such we have used the unadjusted EFS figures.

The Government Household Energy Management Strategy (HEMS)[16] was published in March 2010, having previously been consulted on as the Household Energy Saving Strategy. The HEMS provides a more specific household level focus to the policies discussed in the LCTP. The strategy provides more detail on the approach taken to the local delivery of measures, with a suggestion that social housing and solid wall insulation may play a larger role in the Supplier Obligation. However, the overall policy costs are unlikely to differ significantly from the policies analysed in the production of this report.

The HEMS also outlines plans for a Pay as You Save (PAYS) loans model and possible mandatory standards for rented accommodation and social housing. The PAYS model would decouple the financing of measures from the energy bill and as such represents a less regressive policy. However, the measures supported by PAYS are unlikely to reduce the costs associated with the UK's existing climate change policies i.e. the policies themselves will proceed at their present cost. The team is currently working to develop a system to include a loans scheme in the DIMPSA. However this will require an estimation of energy need relative to actual energy consumption, which is limited in the Expenditure and Food Survey dataset that underpins DIMPSA. The EFS contains limited information on the property and, as discussed in section 7.1, the distributions of consumption and energy need range significantly, which means it is difficult to determine if a low energy consumption house is also a cold one.

The team acknowledge that a more sophisticated approach is required to develop a dataset which synthesises information on UK household condition, energy need and actual energy consumption more fully. CSE is currently working with the University of Bristol Townsend Centre and the University of Oxford Environmental Change Institute to deliver a Joseph Rowntree Foundation funded project looking at the social Impacts of climate change policies. The study will look at the broader context of emissions i.e. domestic, public transportation and personal travel (car use and aviation). In doing so, it will create a UK wide dataset showing the distribution of emissions, with an England subset that contains energy

[15] 2006 UK total for gas supply from DUKES

[16] HM Government, (2010). Warm Homes, Greener Homes: A strategy for Household Energy Management. www.decc.gov.uk/media/viewfile.ashx?filepath=what%20we%20do/supporting%20consumers/household%20energy%20management/1_20100331101157_e_@@_warmhomesgreenerhomeshemstrategy.pdf&filetype=4

consumption and energy need data. The team hope to use this dataset to model the potential benefits and impacts of PAYS in the future and develop DIMPSA's functionality.

2.5. Policy scenario – Low Carbon Transition Plan

The study has examined the distributional impacts and costs associated with the Government's Low Carbon Transition Plan. A companion report will also be produced examining the impacts and costs associated with an alternative approach to retrofitting the housing stock.

CSE worked with the Department for Energy and Climate Change (DECC) to help them analyse the distributional impacts of climate change policies on the energy bills of UK consumers for the LCTP[17]. The team has therefore used the same assumptions to model the distributional impacts associated with the LCTP policies analysed in this study. To ensure a fair comparison with our second publication we will use the same assumptions for the costs of 'global' policies[18]:

- EU Emissions Trading Scheme
- Smart Meters
- UK Product Policy (assumed zero cost impact)
- Renewables Obligation and the extended 32% target[19]

2.6. Cost recovery mechanisms

2.6.1 Private and public expenditure

This study does not question the degree to which emissions cuts are needed. Rather, it is concerned with how they can be achieved in the fairest way possible. The costs of climate change policies are met through:

- Private expenditure, recovered through increased market prices – in particular energy bills
- Public expenditure, recovered through taxation (e.g. income, environmental)

Neither means of meeting the required expenditure is inherently 'better' than the other. Regardless of whether households are paying for climate change policies in their capacity as private consumers or as citizens (that is to say taxpayers[20]), what matters is whether objectives can be met subject to achieving a 'fair' outcome. In drawing up this definition of consumer interests, care should also be taken to be clear about those interests which are generally 'for the public' and those which are much more specifically about the role of householders and businesses as bill-paying energy consumers.

While this distinction can seem a little erudite (since energy consumers – or at least domestic consumers - are also citizens), it is an important one to make. This is because of:

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[17] Chapter 5: Annex for the UK Low Carbon Transition Plan (page 73-75)
[18] Global policies impact upon all households.
[19] The EU's Renewables Directive has set a UK target of 15.4% for energy from renewable sources by 2015. The relatively low level of generation from renewables, in particular heat, has led to an extended renewables obligation target.
[20] In this instance income taxation which is more progressive than general taxation.

(a) the increasing use of energy bills as the mechanism for recovering the cost of policies to achieve sustainable energy objectives, and; (b) the inherently regressive nature of this approach (because energy bills tend to represent a far higher proportion of household income for low income consumers than for higher income consumers).

To assist with making this distinction, we have outlined below some possible criteria to determine whether it is reasonable for energy consumers to pay the costs of achieving sustainable energy goals through their energy bills (via levies or regulatory obligations) or for citizens as taxpayers to carry (or share) the costs.

Taxpayers should carry the principal burden of cost when:

- the principal beneficiaries are future generations (e.g. new technology development)
- the costs to be met are the result of the failure of previous generations to pay real costs (e.g. the nuclear decommissioning legacy, coal mining subsidence and health impacts)
- if the impact on energy costs is highly and unduly regressive
- if the problem being addressed is largely non-energy in cause (e.g. fuel poverty)

Energy consumers (or more specifically energy bill payers) should carry the cost of:

- their fair share of the costs of energy supply and distribution and maintaining a specified standard of energy 'reliability'
- ensuring that all consumers have equal opportunities to exploit the benefits of competition and regulatory obligations
- the environmental damage caused by their energy use (and/or cost of avoiding the damage)

In reality a blend of funding mechanisms may be a fairer way of delivering those policies contained in the LCTP. For example, taxation could pay for the elements of policies aimed at reducing fuel poverty, and energy bills pay for those associated with offsetting the environmental damage associated with consumers' activities. However, analysing the implications of funding a set of policies from a combination of taxation and / or energy bills would significantly increase the number of scenarios required. The study has therefore sought to compare the impacts of the so called 'polluter pays' energy bills approach and the citizen pays principle via income taxation.

2.6.2 Modelled cost recovery mechanisms

The analysis of cost recovery from energy bills has itself been split into two distinct methods, the spread even and supplier cost recovery scenario. Energy suppliers can take a variety of approaches to recovering policy costs from their customer base. CSE has examined this in previous work for Defra[21], highlighting some of the commercial drivers that are likely to shape the distribution of policy costs.

[21] Roberts, S., White, V., Preston, I. and Thumim, J. (2007). Assessing the social impacts of a supplier obligation. Report to Defra, Centre for Sustainable Energy, Bristol.

The DIMPSA model therefore examines the impacts of two scenarios for cost recovery through energy bills.

Scenario 1: **'SPREAD EVEN'** - Costs are recovered evenly across the customer base in direct proportion to household expenditure on fuel (in which there would still be some distributional impacts between households on different payment methods)

Scenario 2: **'COMMERCIAL REALITY'** (or 'supplier' cost recovery) - Costs are recovered according to commercial drivers, favouring a disproportionate loading of costs on customers with no record of switching suppliers (i.e. still with British Gas or the supplier which now owns their previously 'regional' electricity supplier) and customers not considered 'desirable' within the market context created, in part, by these policies (see Annex II for further discussion)

It is important to recognise there are other methods of raising funds for environmental measures, such as the recently proposed French Carbon Tax. The DIMPSA model could be adapted to calculate the distributional impacts associated with a carbon tax; however, the study has limited its scope to the use of energy bills and income taxation. The report therefore includes a third scenario:

Scenario 3: **INCOME TAXATION** - Costs are recovered through income taxation as an alternative to energy bills.

This report has been published at a time when the UK faces an unprecedented squeeze on public finances. The Chancellors Pre-Budget Report forecast that public debt would reach £178bn in 2009/10, or 12.6% of GDP. The Institute of Fiscal Studies has estimated the total cuts required by 2013-14 at £35.7bn[22]. Readers of this report may therefore dismiss income tax as a route for revenue generation. This dismissal must be considered in the context of the alternative route that is energy bills i.e. either way the consumer or the citizen pays.

It is important to note that the DIMPSA based model of income tax is relatively simplistic, applying changes from a modelled set of income tax scenarios to the reported EFS income taxation payments. The results in this report therefore provide a reflection of the scale of changes required to raise revenue from the personal income tax thresholds and also the overall distribution of these changes.

The income taxation model would need to be upgraded further to allow for the fact there is some under-reporting of income in the highest decile, and the higher income deciles submit tax returns and claim additional tax allowances i.e. pay a lower amount in tax. The DIMPSA model of income tax could therefore be improved by adopting the approach used by other taxation models[23] and the Department for Work and Pensions - which uses data from the Survey of Personal Incomes in order to attempt to correct for the under-reporting of incomes, in their Households Below Average Income (HBAI) series.

[22] Institute of Fiscal Studies, Public Spending, December Briefing, 2009
[23] TAXBEN www.ifs.org.uk/publications/572; EUROMOD www.iser.essex.ac.uk/research/euromod

2.6.3 Alternative mechanisms for funding climate change policies

The public deficit could also be funded in a number of additional ways with many calling for a new fiscal mechanism that applies the 'polluter pays' principle to the financial sector i.e. the financial sector was the primary cause of the problem and should therefore help pay for it. The application of a Tobin Tax[24] (as originally proposed by the US economist in the 1970s) has been briefly discussed here as one possible financial mechanism.

Tobin Tax proposed a small levy on financial transactions as a way of reducing the risk associated with speculative transactions. As early as 2004, the Belgian Ministry of Finance proposed the introduction of an EU[25] wide financial transaction tax as a way of reducing the perceived risk associated with financial markets. At the last G20 Summit[26], world leaders tasked the IMF with drawing up an implementation plan for a Financial Transaction Tax (FTT), as one of a number of proposals to ensure the contribution of the financial sector both to the cost of bank bailouts and to the recovery from the global economic crisis.

The proposal for a FTT has received widespread support from European, US and African leaders and leading economists. For example, 350 prominent economists from all over the world wrote to the leaders of the G20 calling on them to implement the FTT on the banks "as a matter of urgency"[27]. The preliminary estimates suggest a FTT, applied globally, could raise billions every year. Experts suggest that at an average rate of 0.05%, annual revenues could be as much as $400bn (£250bn), with approximately £8bn in the UK[28]. In March of this year, Members of the European Parliament voted strongly in favour of a resolution on "making financial transactions taxes work"[29]. The resolution calls upon the European Commission to explore options for implementing a FTT.

The main argument against a FTT is the associated potential for "tax incidence" i.e. the burden of this new tax is moved to other areas. It is likely that small transactions such as exchanging money to go on holiday or sending remittances abroad may be affected by the FTT; however, the distributional impacts are likely to be minimal compared to the alternative burden on taxation and public services. Furthermore, institutions such as hedge funds that speculate rather than invest will pay the highest proportion of a FTT.

In the UK, the campaign for a FTT – dubbed the 'Robin Hood Tax' – has been gathering momentum in recent months[29]. The Robin Hood Tax would not be levied on banks' transactions with their High Street customers, but would only apply to transactions between financial institutions, with different rates applied to different types of transaction. The campaign is calling for half the proceeds to be spent domestically and for the rest to be split equally between poverty reduction and tackling climate change. Whilst international

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[24] http://en.wikipedia.org/wiki/Tobin_tax
[25] ECB (2004). Opinion of the European Central Bank (CON/2004/34)
[26] G20 Pittsburgh, September 2009
[27] Independent Newspaper, Open Letter to the G20, 15th February 2010
[28] Schulmeister (2009), Stephan Schulmeister (2009), Institut für Wirtschaftsforschung (WIFO), A General Financial Transaction Tax: A Short Cut of the Pros, the Cons and a Proposal; and Baker et al (2009), Centre for Economic and Policy Research, The Potential Revenue from Financial Transactions Taxe, www.cepr.net/documents/publications/ftt-revenue-2009-12.pdf
[29] http://robinhoodtax.org.uk/

agreement on implementing a FTT would be preferable, supporters of the Robin Hood Tax do not see this as a barrier to action within the UK.

2.7. Assessing distributional impacts

This study assesses the distributional impacts of UK climate change policies on consumers, by modelling changes to consumer bills and incomes that result from the installation of measures and the recovery of policy costs via three different scenarios. The headline results from the modelling process are reported in terms of and relative to the 'counterfactual bill'; and change as a proportion of household income. These are defined below.

'Counterfactual Bill'

The 'counterfactual' energy bill (or 'Total bill without measures') is a means to assess how much more energy consumers will be paying in 2020 as a result of climate change policies. It represents the 'no additional climate change policies' energy bill, but does take into account non-climate change policy-related fuel price rises to 2020.

Change as a proportion of the energy bill

The percentage change relative to the counterfactual bill ('% change counterfactual') represents the total bill in 2020 (following the application of measures and policy costs, 'Total Bill 2020') minus the counterfactual bill ('Total Bill 2020 without measures'), divided by the counterfactual bill:

$$\%\ \text{change counterfactual} = \frac{(\text{Total Bill 2020} - \text{Total Bill 2020 without measures})}{\text{Total Bill 2020 without measures}}$$

The resulting figure shows how much climate change policies add to consumer bills in 2020, as a proportion of these bills if no policies were implemented. It provides the best indication of relative change, as the counterfactual bill accounts for non-policy related price rises between 2009 and 2020. For example, the gas price is likely to increase significantly during this period as a result of improvements to the distribution network; therefore simply analysing the percentage change relative to the bill in 2009 wouldn't allow the user to account for this trend.

For the 'supplier cost recovery' ('commercial reality') and income tax scenarios the same overall calculation is used to determine the percentage change counterfactual; however, the respective total bills in 2020 are used to replace 'Total Bill 2020' in the above equation (i.e. it would read 'Total Bill 2020 for the supplier cost recovery model' and 'Total Bill 2020 when income tax is used to fund policies').

Change as a proportion of household income

The proportional change relative to the counterfactual bill provides a useful indication of 'winners', who see a decrease in their fuel bills, and 'losers', who see an increase; however, we must also analyse the extent of this change relative to a householders income ('% change Income') to obtain a greater insight of distributional impacts.

$$\%\ \text{change Income} = \frac{(\text{Total Bill 2020} - \text{Total Bill 2020 without measures})}{\text{Annual income 2009}}$$

Reduction in income – total change in income tax paid

DIMPSA has been modified to include a model of UK income taxation. The taxation model uses the data contained in the Expenditure and Food Survey to predict the current level of revenue generated from income tax and the potential for additional revenue in the future. Annex IV contains a detailed description of the model used to determine changes in income tax.

The model allows the user to specify two scenarios for income tax in 2020. The first represents a business as usual scenario (i.e. based on historic changes in income tax thresholds) and the second scenario to capture a higher amount of revenue. The annual reduction in income in 2020 therefore represents the difference between these scenarios:

Annual Income reduction 2020 = Income tax in 2020 Sc2 - Income tax in 2020 Sc1

3. Research Review Findings

3.1. DECC Low Carbon Transition Plan

A partial distributional impact assessment was carried out by CSE for the development of the Government's Low Carbon Transition Plan. It is important to note that the research discussed in the results section of this report uses updated costs for the RHI and FIT and therefore differs from the LCTP analysis discussed below.

Table 1 below summarises the energy bill implications of the Plan in 2020 compared to the 'counterfactual' bill – that is the bill in 2020 without the LCTP's policies[30]. This table represents the average household fuel bill, based on DECC's central fossil fuel price assumption of $80 a barrel of oil in 2020. The green shading provides a reminder of which policies' impact on bills have been assessed distributionally in this study.

Table 1. Energy bill implications in 2020 (published in the LCTP)

	Gas (£)	Electricity (£)	Total (£)	Across households (£ m)[31]
'Counterfactual' bill	771	577	1348	40,440
Additional cost as a result of individual LCTP policies				
EU ETS	0	55	55	1,650
CERT	-22	-38	-60	-1,800
CESP	0	-1	-1	-30
Supplier Obligation	-24	-21	-45	-1,350
Feed-In Tariff	0	14	14	420
Renewable Heat Incentive	179	0	179	5,370
Smart meter rollout	-14	-15	29	-870
Product Policy	16	-77	-61	-1,830
Extended RO	0	64	64	1,920
CCS demonstration	0	14	14	420
Better billing	-2	-2	-4	-120
Cumulative	**133**	**-7**	**126**	**3,780**
Total bill with LCTP	**904**	**570**	**1474**	**44,220**

As can be seen from the table, household fuel bills are projected by the Government to increase by £126 as a result of these policies, a 9% increase. However, this masks considerable variation between policies and fuels. Many policies are projected to result in a net decrease in the average energy bill, though these are outweighed. Most notable is the difference in impact on gas and electricity bills, with the latter actually projected to decrease marginally on average, and the former projected to increase by a considerable 17% -

[30] This is assumed by the LCTP to include the cost of policies up to and including the 2007 Energy White Paper.
[31] Thirty million UK households assumed in 2020, based on CLG projections.

predominantly as a result of the Renewable Heat Incentive. Figure 2 below charts the impact of individual policies on the 2020 fuel bill, ranked in order of ascending cost.

Figure 2. Impact of individual policies on the 2020 fuel bill from the published LCTP

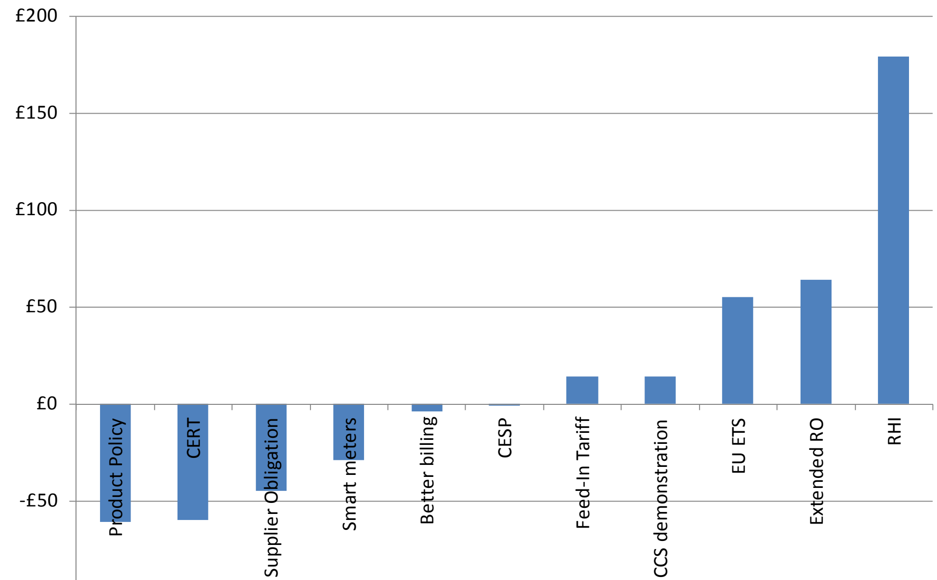


Figure 2 illustrates the importance of the distributional impact assessment approach. The average overall increase in fuel bills overshadows differences between individual policies and fuels. For example, if individual households do not benefit from the Renewable Heat Incentive in 2020, then the other policies may (if they themselves benefit from CERT, the Supplier Obligation etc.) protect them from the policy costs associated with the RHI. Figure 3 below (taken from LCTP Analytical Annex, 2009) presents future fuel bills as a percentage of income across income deciles.

Whilst Figure 3 highlights the overall regressive nature of funding climate change policies from energy bills, there is also considerable variation across the income deciles between those who take up sustainable energy measures and those who do not – as Figure 4 below shows. In the case of those who receive measures, the variation across income deciles in terms of fuel bills as a percentage of income is smaller, and hence less regressive.

Figure 3. Increase in energy bills in 2020 by income deciles

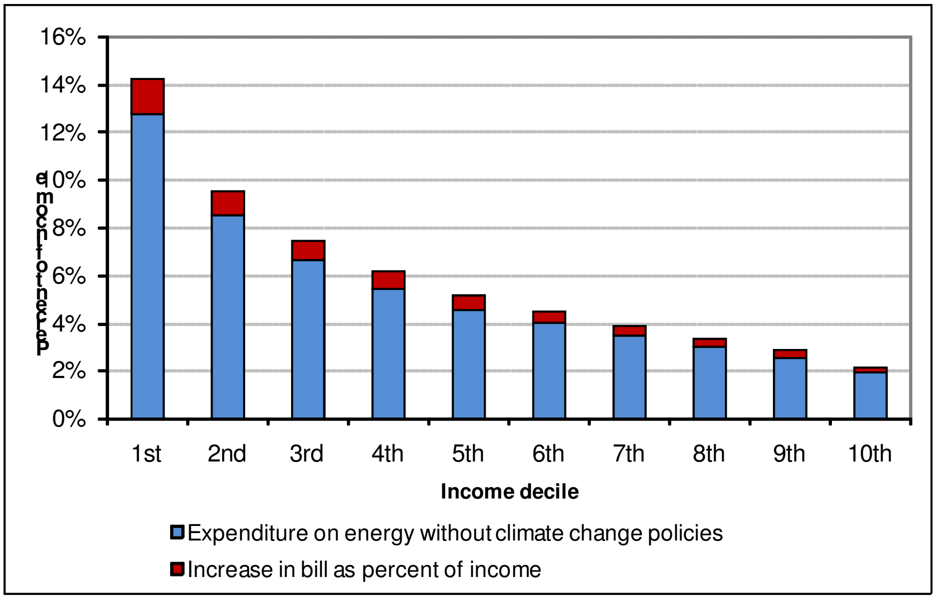
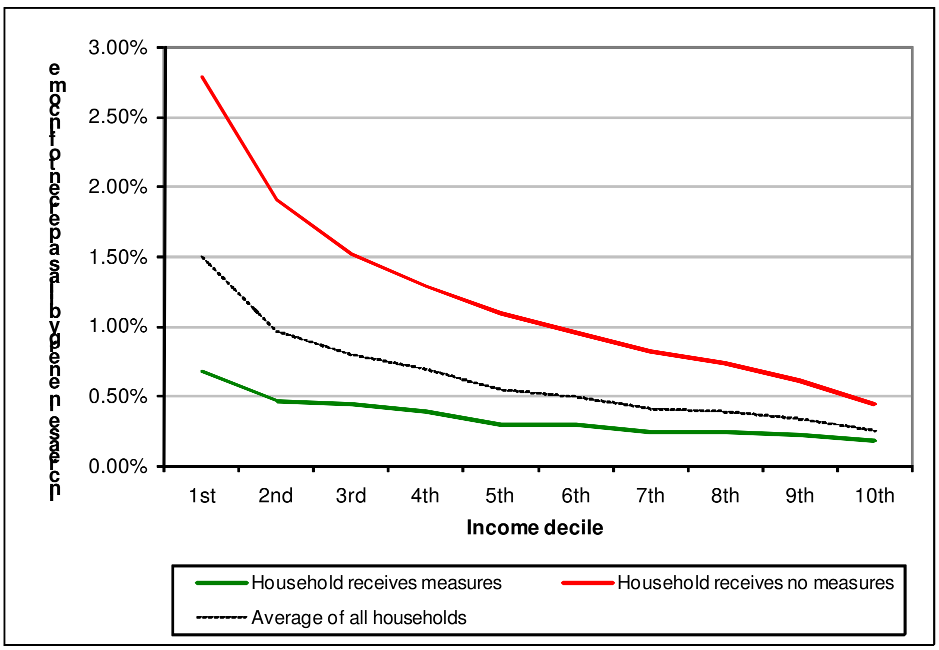


Figure 4. Impact of climate change policies for household that take up measures



3.2. Ofgem – Project Discovery

In early 2009, Ofgem launched a consultation process to begin to frame the debate around what needs to be achieved for the UK to ensure it has secure and sustainable energy supplies over the next 10-15 years. They employed scenario analysis as a vehicle to understand what investment in energy infrastructure might be needed to meet these objectives, taking into account effects on the competitiveness of UK businesses and the impacts on consumers' bills. Ofgem received feedback from stakeholders on their initial publication in late 2009, and published their revised scenario analysis in February 2010 – which is the focus of the brief review here.

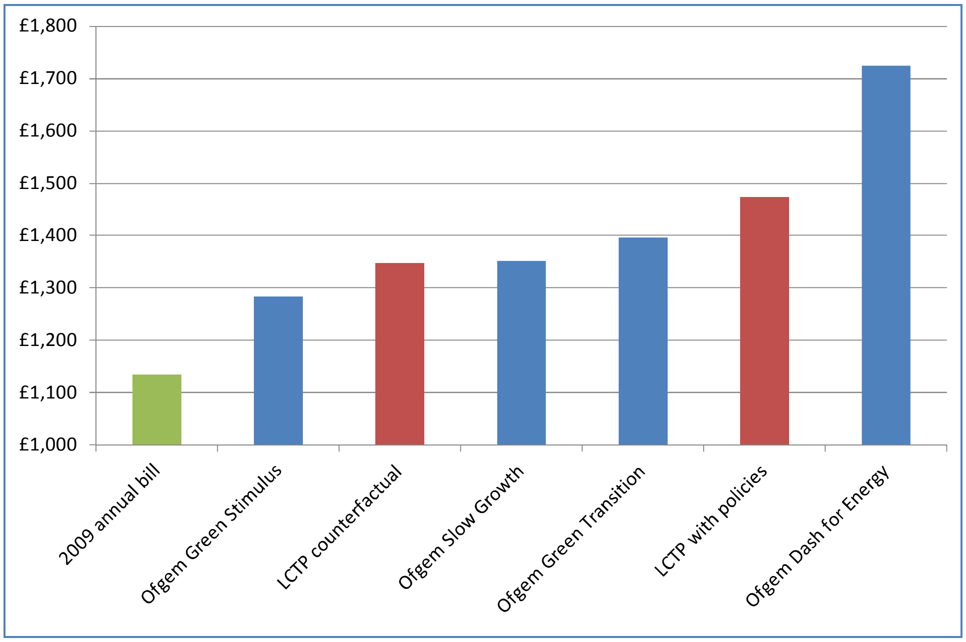
Four scenarios to 2020 were developed, which are summarised below:

Green Transition	Green Stimulus
• There is rapid economic recovery and significant new investment globally • A global agreement on tackling climate change is reached • Energy efficiency measures are effective • New nuclear and CCS demonstration projects come on-line before 2020 • Gas prices are moderate, carbon prices are high, and coal prices are relatively low as demand is suppressed by the high carbon prices • GB gas demand falls but electricity demand grows on the back of wider deployment of heat pumps and electric vehicles	• There is a slow recovery from recession and restricted availability of finance • A global agreement on tackling climate change is reached and governments implement 'green stimulus' measures • Energy demand falls globally in the near term • Fuel prices are relatively low • The combination of relatively high carbon prices and direct government support to nuclear, CCS and large scale renewables promote rapid decarbonisation of the generation sector
⇨ **Domestic bills up by 23%** ⇨ **Carbon down by 33%** ⇨ **£194 billion investment required**	⇨ **Domestic bills up by 13%** ⇨ **Carbon down by 46%** ⇨ **£190 billion investment required**
Dash for Energy	**Slow Growth**
• Global economies bounce back strongly • Security of supply concerns prevail over environmental concerns: there is no global agreement on tackling climate change • Gas supply is tight and fuel prices are high • Investment is forthcoming but not always timely • Significant expansion of CCGT generation capacity • Planning and supply chain constraints prevent new nuclear plant becoming operational before 2020 • Planning delays push back storage investment	• Impact of recession and credit crisis continues • Low levels of investment • Low commodity and carbon prices, reducing incentives for renewables, nuclear and CCS • Generation build is dominated by CCGTs • Energy efficiency measures have limited impact but demand is low initially due to slow economic growth
⇨ **Domestic bills up by 52%** ⇨ **Carbon down by 14%** ⇨ **£110 billion investment required**	⇨ **Domestic bills up by 19%** ⇨ **Carbon down by 19%** ⇨ **£95 billion investment required**

The 'Green Transition' scenario is (inherently) most in keeping with the Low Carbon Transition Plan in terms of carbon savings achieved. The domestic bill increases cited by Ofgem, however, relate to the average bill in 2009 (which both Ofgem and the LCTP cite as

£1,135), not a 2020 'counterfactual' bill. Caution should be applied in making a comparison with the LCTP's predictions regarding domestic bill increases, but on this basis, Figure 5 shows how the scenarios compare with the LCTP's average 2020 fuel bills with and without policies.

Figure 5. Average household energy bill in 2020 under the different policy scenarios



Comparing the 'Green Stimulus' and 'Green Transition' scenarios with the LCTP's 'with policy' fuel bill for 2020, Ofgem appear to be assuming smaller increases in bills as a result of climate change policies, or are taking account of factors that lower the non-climate change policy related components of the bill. What is important to note is that the two scenarios which imply less CO_2 reduction ('Slow Growth' and 'Dash for Energy') actually result in higher average bills than the LCTP's counterfactual bill. This appears to suggest that the realistic alternatives to effective emissions reductions are at least as likely to increase bills as significantly as the 'green' scenarios, and are likely to carry with them a wholly different set of distributional implications. Ofgem acknowledge the importance of taking potential distributional impacts into account, but have not undertaken any analysis at that level so far.

3.3. Implications of Carbon Capture and Storage

The potential costs of Carbon Capture and Storage (CCS) to electricity generation are difficult to accurately forecast due to a range of technical, structural and economic factors. Some examples include:

- Different carbon dioxide capture technologies (e.g. post-combustion capture, pre-combustion capture and oxyfuel combustion);
- Fuel and generating technology (i.e. coal or gas, IGCC or NGCC);
- Future timescales for commercial development;
- Variation in geographical location of potential storage in relation to carbon dioxide production;

- Future costs of coal;
- Payback rates from enhanced oil recovery using captured CO_2;
- The future cost of carbon in emissions trading markets.

The UK Carbon Capture and Storage Consortium[32] acknowledge that for any cost estimate to be accurate, the project cost predictions must be site-specific and time-specific. In their interim report they mention that "*no mechanism exists in the current UK market explicitly to relate electricity price to total generation costs".* Nevertheless, since 2006 a number of studies have attempted to calculate the cost of electricity generation using CCS. Table 2 below shows some figures for coal fired in an integrated gasification combined cycle (IGCC) power station. The figures illustrate two main points: firstly, the degree of uncertainty as shown by the significant range in potential costs. Secondly, these results suggest that in the next ten years the cost of capturing CO_2 will at least double the cost of generating electricity without CCS.

Table 2. Predicted costs of electricity generation in a coal IGCC power station

Study	Year of study	Projected year of cost	Cost of elec from coal without CCS (p/kWh)	Cost of elec from coal without CCS (p/kWh)	% Increase
Viebahn[33]	2009	2020	n/a	6.2[34]	-
Anderson[35]	2007	2005-2015 levelised	2.6	4.8	85 %
UKCCSC[21]	2006	-	2.73	4.13	51 %
Committee on Climate Change[36]	2008	2020	4.9	6.3 – 11.0	29 – 124 %
Frontier Economics[37]	2008	2020	4.5	6.5 – 7.5	44 – 67 %

Despite growing optimism for CCS and its ability to make a significant contribution to a low carbon future, the technology is still in its initial demonstration phase, and its total capacity and future is as yet unproven. Combined with the cost uncertainties outlined, modelling this policy measure is currently extremely difficult. As the technology and policy develop in the coming years a clearer picture may evolve and modelling CCS may become a more feasible operation.

[32] Gibbins, J., Haszeldine, S., Holloway, S., Pearce, J., Oakey, J., Reiner, D. and Turley, C. (2006). Interim results from the UK Carbon Capture and Storage Consortium project. http://nora.nerc.ac.uk/1540/1/P01_03_05.pdf
[33] Viebahn, P., Fischedick, M., Nitsch, J., (2009). Ecological, economic, and structural comparison of renewable energy technologies (RE) with carbon capture and storage (CCS) – an integrated approach. IOP Conf. Series: Earth and Environmental Science 6.
[34] Using an averaged exchange rate for 2009 of 1.12 EUR to 1.00 GBP
[35] Anderson, D. (2007). Electricity Generation Costs and Investment Decisions: A Review Working Paper, February 2007. Imperial College Centre for Energy Policy and Technology
[36] Committee on Climate Change, (2008). Building a low-carbon economy – the UK's contribution to tackling climate change. www.theccc.org.uk/pdf/TSO-ClimateChange.pdf
[37] Frontier Economics, (2009). Alternative policies for promoting low carbon innovation. Report for the Department of Energy and Climate Change.

3.4. Additional policy costs for the residential sector in 2020

The report has discussed the cost implications of CCS and its potential to increase energy bills further. However, it is also worth mentioning two additional areas of climate change policy which will both have distributional impacts but have not been captured in this study:

Nuclear Power: The costs of funding nuclear power are as yet unclear; the market may be able to deliver nuclear power at no additional cost to the consumer. However, the costs may be passed on to energy bills with a further impact of taxation to fund the disposal and management of waste.

Road Transport: The costs of road transport are also likely to increase as the targets for the renewable content of fuel increase over time, thus increasing the prices of petrol and diesel with further distributional consequences.

3.5. Matrices of social justice

The evaluation scheme, developed by the Université Libre de Bruxelles[38], as part of the work of the King Baudouin Foundation[39] on the relationship between climate change mitigation polices and social justice in Europe, was applied to the policies under consideration in this study.

The policies are assessed against four main dimensions of social justice as follows:

- *Distributional justice:* social and economic inequalities derived from a different distribution of primary goods between different income groups;
- *Fair access:* the ability of vulnerable groups to access social and economic goods and their capacity to transform them into well-being;
- *Intra- and inter-generational justice:* the opportunity for people outside the developed world as well as future generations to live valuable lives; and
- *Environmental justice:* the distribution of the costs (and the opportunities) of climate change mitigation policies, as well as of environmental quality.

Annex IV contains a direct quotation from the discussion paper outlining details of evaluation scheme's design and application.

[38] Schiellerup, P., Chiavari, J., Bauler, T., Grancagnolo, M., (2009). Climate change mitigation policies and social justice in Europe: An exploration of potential conflicts and synergies. Published by the King Baudoin Foundation.
[39] www.kbs-frb.be

CERT

(The assessment of CERT below also applies to future Supplier Obligation and CESP)

Distributional justice	
Price of essential goods	Negative: increases the price of energy
Cost of domestic energy services	Beneficiaries will experience a reduction in their energy costs/warmer homes, but non-beneficiaries' energy costs will increase
Transport costs	n/a
Employment effects	Positive, due to demand for installers
Labour market transition / restructuring	Uncertain – potentially no effect, or potentially positive with the development of supply chains for measures
Fair access	
Health	Positive: reduces the number of people living in cold, damp homes (assuming benefits reach them)
Consumer access to information	Weakly positive if any effect – where information about energy efficiency is given with measures
Citizenship	Probably no effect, although by taking up a measure a householder may feel they are 'doing their bit'
Gender equality, non-discrimination, equal treatment	Weakly positive: with a Priority Group CERT can reduce the energy bills of low-income households and/or improve their standard of living and comfort within the home
Environmental justice	
Distribution of climate policy cost	Negative, because there are low income households who can't get measures (e.g. solid walls, some low income groups) and who will pay the cost of the policy disproportionately
Distribution of environmental quality	Potential to favour certain areas of easy-to-treat/reach housing
Companies' environmental responsibility	Energy companies are forced to provide measures – therefore they are being more environmentally responsible and the number of measures is linked to the number of customers of the energy company.
Intra- and inter-generational justice	
Sustainability of public finances	Policy is paid for by consumers so no impact on public debt
Inter-generational ecological debt	All environmental policies should have a positive impact on this. Could be an issue with carbon reductions being lower than anticipated and comfort-taking.

Renewables Obligation

Distributional justice	
Price of essential goods	Negative: Increases the price of electricity
Cost of domestic energy services	Negative: Increases the price of electricity
Transport costs	No impact
Employment effects	Positive impact on renewables industry
Labour market transition / restructuring	No impact
Fair access	
Health	Increase in renewable energy leads to a decrease in fossil fuel and nuclear power, both of which could have negative health effects. Probably a weak positive effect as there is a need to have some fossil fuel reserve to back up wind power, and use of biomass creates emissions to air which could be harmful to health.
Consumer access to information	No effect
Citizenship	No effect
Gender equality, non-discrimination, equal treatment	No effect
Environmental justice	
Distribution of climate policy cost	Weakly negative – cost of electricity increases – richer households use more electricity in general, but can absorb the cost better. Low income households that use electricity for heating get a higher proportion of the cost.
Distribution of environmental quality	No effect
Companies' environmental responsibility	Energy companies forced to be greener, as with CERT
Intra- and inter-generational justice	
Sustainability of public finances	No impact – paid for by consumers
Inter-generational ecological debt	Positive – reduced CO_2

EU Emissions Trading Scheme (EUETS)

Distributional justice	
Price of essential goods	Negative: Increases the price of electricity
Cost of domestic energy services	Negative: Increases the price of electricity
Transport costs	No impact
Employment effects	Positive impact on commercial suppliers of energy efficiency technologies and some renewables companies involved in co-firing
Labour market transition / restructuring	No impact
Fair access	
Health	Improved efficiency at plants responsible for large scale emissions may deliver local health benefits to citizens, although the overall national impact will be negligible.
Consumer access to information	No effect
Citizenship	No effect
Gender equality, non-discrimination, equal treatment	No effect
Environmental justice	
Distribution of climate policy cost	Negative – cost of electricity increases – again richer households use more electricity in general, but can absorb the cost better. Low income households that use electricity for heating get a higher proportion of the cost.
Distribution of environmental quality	Little effect, although local environmental quality is likely to improve where emissions are being mitigated.
Companies' environmental responsibility	Business responsible for large scale emissions and companies generating power from fossil fuels will theoretically be forced to take action; however, the success of the trading scheme itself is a function of the amount of permits issued and the price they then trade at.
Intra- and inter-generational justice	
Sustainability of public finances	No impact – paid for by consumers
Inter-generational ecological debt	Positive – reduced CO_2

Feed-in Tariffs

Distributional justice	
Price of essential goods	Negative – paid for through energy bills so energy prices have to rise.
Cost of domestic energy services	Negative - depending on the level of the FIT, some households' bills will fall but others will rise to pay for it
Transport costs	None
Employment effects	Positive – employment for installers
Labour market transition / restructuring	Positive – stimulates and develops market for micro-renewables
Fair access	
Health	Positive if it displaces fossil fuel power.
Consumer access to information	Positive - This will be important for the policy to work properly so assume that it will be included
Citizenship	Positive – people are able to do more to reduce their carbon emissions
Gender equality, non-discrimination, equal treatment	Depends on details of the policy – better educated, higher income households are more likely to take advantage of the policy, especially if it requires taking out a loan. However there may be offers to help lower income households.
Environmental justice	
Distribution of climate policy cost	Negative
Distribution of environmental quality	No effect
Companies' environmental responsibility	Positive, because companies can also install and claim the FIT
Intra- and inter-generational justice	
Sustainability of public finances	No impact
Inter-generational ecological debt	Positive – reduced carbon emissions

Renewable Heat Incentive

Distributional justice	
Price of essential goods	Negative – paid for through energy bills so energy prices have to rise.
Cost of domestic energy services	Negative - depending on the level of the RHI, some households' bills will fall but others will rise to pay for it
Transport costs	None
Employment effects	Positive – employment for installers
Labour market transition / restructuring	Positive – stimulates and develops market for micro-renewables
Fair access	
Health	Potential positive impact if results in warmer homes. Increase in biomass could lead to decline in local air quality.
Consumer access to information	Positive - This will be important for the policy to work properly so assume that it will be included
Citizenship	Positive – people are able to do more to reduce their carbon emissions
Gender equality, non-discrimination, equal treatment	Depends on details of the policy – better educated, higher income households are more likely to take advantage of the policy, especially if it requires taking out a loan. However there may be offers to help lower income families.
Environmental justice	
Distribution of climate policy cost	Negative
Distribution of environmental quality	No effect
Companies' environmental responsibility	Positive, because companies can also install and claim the RHI
Intra- and inter-generational justice	
Sustainability of public finances	No impact
Inter-generational ecological debt	Positive – reduced carbon emissions

Domestic smart meters

Distributional justice	
Price of essential goods	Could be positive or negative at the individual household level. Energy prices will need to go up to fund the installation, but this is mostly due to a one-off cost (although smart meters will eventually need to be replaced), and they provide the opportunity for households to monitor and reduce their energy use. Fuel poor households may have less scope to reduce their energy consumption, but smart meters may also provide them with opportunities to access cheaper energy at off-peak times.
Cost of domestic energy services	As above
Transport costs	N/a
Employment effects	Employment created for installers
Labour market transition / restructuring	Several thousand meter readers are likely to lose their jobs as a result of the smart meter role out. Conversely new jobs will be created in design and manufacturing which may or may not be based in this country.
Fair access	
Health	None
Consumer access to information	Positive: access to better information about when and how they use energy, and how to save money by shifting consumption to different times
Citizenship	Positive: households see more clearly what their contribution to climate change is in terms of the amount of energy used
Gender equality, non-discrimination, equal treatment	No effect provided roll-out undertaken in accordance with anti-discrimination laws
Environmental justice	
Distribution of climate policy cost	Potentially negative, for households that have less flexibility to reduce / shift their consumption
Distribution of environmental quality	None
Companies' environmental responsibility	None
Intra- and inter-generational justice	
Sustainability of public finances	None – financed through energy bills
Inter-generational ecological debt	Positive – assuming consumption reduced

4. Low Carbon Transition Plan assumptions

This section sets out the assumptions underlying the analysis of the Government's Low Carbon Transition Plan.

4.1. Fuel price assumptions

Table 3 below shows the fuel price rises assumptions used in this report. The counterfactual changes (i.e. changes in fuel costs without any policy implementation) match those used by the fuel prices team in DECC for the distributional impacts analysis discussed in the LCTP Analytical Annex (Chapter 5)[40]. The non metered fuel assumptions have been taken from the WWF 'How Low?' report[41]. Ofgem has recently published its research examining the future trajectories for energy prices under four scenarios (see section 3.2 for details). The price rises used in this report are broadly comparable with Ofgem's 'Green Transition' scenario.

Table 3: Counterfactual fuel price increases in 2020

Fuel	Counterfactual price increase
Electricity	17.1%
Gas	18.5%
Solid Fuel	18.1%
Oil	9.1%
LPG	9.1%
Biomass	0.0%

4.2. Policy cost assumptions

Table 4 below shows the cost of policies passed through to consumers. These are estimated costs passed through to domestic energy bills, extrapolated from total costs which could be passed on to both domestic and business consumers, as is the case for RHI and FIT. The assumption used is that the costs on domestic sector will be in line with estimated domestic sector consumption as a proportion on total consumption for gas (with respect to RHI) and electricity (with respect to FIT).

The 'rump' and 'non-rump' refer the 'commercial reality' cost recovery scenario modelled in this study, whereby a proportion of the total cost (the non-rump) is spread disproportionately amongst consumers, according to payment method and market switching behaviour – see Annex II for details.

[40] HM Government, (2009). Analytical Annex. The UK Low Carbon Transition Plan. www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx
[41] WWF, (2008). How Low? Achieving optimal carbon savings from the UK's existing housing stock. http://assets.wwf.org.uk/downloads/how_low_report.pdf

The policy cost assumptions used in this study match those used in the LCTP with the exception of Feed-in Tariffs and the Renewable Heat Incentive. The costs for these clean energy cash-back policies have been based upon the most recent Impact Assessments which accompany the relevant Government consultations. The total policy costs of £7.351bn used in the DIMPSA analysis for this study cover the seven modelled climate change policies. The total policy costs for Smart Meters, the EU ETS and Renewables Obligation (RO) have not been specifically detailed in the table below as they have not been published elsewhere, and in the case of smart meters the cost represents those passed to consumers i.e. the costs less the benefits to suppliers. The analysis discussed here therefore matches the most recent Government analysis with the exception of the Supplier Obligation which will be consulted on in more detail prior to its implementation.

Table 4. Total policy costs passed through to consumers

	Policy	Total cost[42]	Total Cost 'Rump'	Total Cost 'Non Rump'
3	Electricity FIT[43]	£227m	£181m	£46m
4	RHI[44]	£2,320m	£1,856m	£464m
5	Supplier obligation	£1,814m	£1,451m	£363m
7	CESP	£*	£	£

* CESP has no cost in 2020, as costs already reclaimed

It is also important to note that the study has assumed the RHI costs are recovered by gas bills and those of non metered fuels i.e. oil, coal and LPG. The cost recovery mechanism for the RHI is still uncertain and under consultation (see the Budget 2010[45] page 113 para 7.25). The RHI could alternatively be recouped solely from gas bills which would in turn have a different set of distributional impacts i.e. further impacting on gas consumers. The policy would also miss an opportunity to begin regulating an un-regulated market (as suggested by the recent Energy and Climate Change Select Committee report on Fuel Poverty) if costs are recovered in this way.

The model of cost recovery via income taxation is based on the thresholds and settings shown in Table 5 below. The income bands used to set taxation thresholds and the associated rates are based on historical trends for income taxation i.e. the 1980s onwards. The income taxation model itself could be recalibrated to raise income taxation at different rates, different bands and additional bands i.e. retaining the current 50% income taxation rate and upper band. The team ran the income tax model repeatedly using a range of income bands and rates, including the bands used in countries like Norway. The analysis demonstrated the relative importance of the middle band of income taxation in raising revenue i.e. the rate applied to incomes between band 1 and 2. If a Government were to try and raise the additional revenue required for climate

[42] HM Government, (2009). The UK Low Carbon Transition Plan. National strategy for climate and energy.
[43] FIT Impact Assessment Accompanying Government Response www.decc.gov.uk/en/content/cms/consultations/elec_financial/elec_financial.aspx
[44] RHI Impact Assessment www.decc.gov.uk/en/content/cms/consultations/rhi/rhi.aspx
[45] www.hm-treasury.gov.uk/d/budget2010_complete.pdf

change policies from the upper band of income taxation alone, then the rate would be exceptionally high and thus unacceptable to the voting public.

Table 5. Income tax rules in 2020

Tax settings	2020 baseline[46]	2020 additional revenue
Band 1	£3,355	£3,355
Band 2	£52,000	£52,000
Start rate	0.1	0.1
Middle rate	0.22	0.232
Top rate	0.40	0.46
DIMPSA total	£142,795,213,361	£152,104,071,585
EFS total	£119,510,996,032	£127,198,663,488

The study has not sought to reconcile the incomes reported in the EFS with figures provided by more robust surveys of income, such as the Annual Survey of Hours and Earnings and data held by HMRC and HM Treasury. The incomes and taxation payments reported by the highest income deciles of the EFS typically under-estimate the figures reported nationally. To reconcile these, the team therefore would need to access sensitive data held by HMRC for the households captured by the survey.

The totals shown in Table 5 above are therefore based on the EFS reported gross incomes and income taxation payments. The taxation required to fund climate change policies is based on the relative difference between the survey reported income tax payment projected to 2009, and the subsequent additional revenue and baseline scenarios i.e. £127bn and £119bn.

If DIMPSA's tax module calculated the income tax payment from the survey reported income (albeit too low for some high earners), the actual level of taxation raised from income tax would be higher than the sum total for the survey years and the teams projected total for 2009. Therefore, in addition to the under reporting of incomes there is also some under reporting of income tax payments. The actual directly modelled income taxation payments in 2020 are therefore shown in Table 5 above for comparison i.e. £152bn and £142bn respectively.

Table 6 below shows the relative cost pass through for each fuel by policy under the spread even cost recovery scenario. Electricity is subject to the highest cost pass through of 4.25p/kWh with gas being the second at 1.07p/kWh. The non metered fuels are subject to a relatively minor but politically significant pass through of 0.54 to 0.74 p/kWh. The RHI may eventually be set as a levy on the suppliers of heating fuels; however, the team has applied the spread even scenario to enable a realistic interpretation of this eventuality.

[46] Assumes an overall growth in incomes of 2% pa to 2020 for both scenarios

Table 6. Extra unit cost for the spread even scenario in 2020

Fuel	EUETS	RO& RO32	Elec FIT	RHI	SO	SM	CESP	Total Extra
Electricity	£0.0082	£0.0198	£0.0023		£0.0107	£0.0016		£0.0425
Gas				£0.0075	£0.0028	£0.0004		£0.0107
Oil				£0.0054				£0.0054
Coal				£0.0103				£0.0103
LPG				£0.0074				£0.0074
Biomass								£0

The higher increase in electricity costs has significant implications for low income consumers and fuel poor households. Table 7 below shows the distribution of household heating fuels by income deciles in the EFS. Approximately 22% of households in the bottom three income deciles use electricity to heat their homes, these households will therefore be subject to a significant increase in their heating bill unless they install an efficient heating technology, insulation and / or switch to a new fuel. The study provides some alternative tariff solutions to the application of climate change policy costs at the end of this report e.g. low income consumers on economy 7 and eligible for social tariffs could be protected from a proportion of these costs.

Table 7. EFS primary heating fuel by income deciles

Income deciles	Gas	Electric	Oil	Solid fuel	Other gas	Wood	% Electricity
1	1,668,493	661,435	91,928	38,737	22,501	1,323	27%
2	1,781,993	520,015	118,866	37,211	25,941	948	21%
3	1,849,810	435,604	131,302	36,780	27,582	3,623	18%
4	1,871,875	437,486	126,147	25,846	22,449	298	18%
5	1,955,112	333,654	145,937	30,045	20,223	-	13%
6	1,995,020	283,727	154,218	29,097	20,066	1,901	11%
7	2,008,154	254,633	173,539	30,781	16,554	1,320	10%
8	2,090,772	171,224	172,396	20,989	24,381	4,823	7%
9	2,106,686	156,667	177,732	16,152	26,135	1,245	6%
10	2,084,501	127,811	221,720	12,936	34,587	2,833	5%

4.3. Uptake assumptions

The uptake of energy efficiency measures can be modelled by two methods:

- Exogenous input – where the model is forced to take up technologies at a given rate defined by the user.
- Endogenous uptake – where internal algorithms dictate how individual measures are taken up by different house types. This category includes choice based uptake, where

the behaviour of different consumers with respect to energy purchases is explicitly simulated.

The impact assessments that accompany the main measures based policies have been produced by several consultants, namely NERA, Element Energy and BRE. These impact assessments are themselves based on the EHCS which contains more detailed data on the property and thus the suitability of technologies and the associated rate of return on investment. The impact assessments typically combine the outputs of a SAP or BREDEM based energy model with economic drivers, such as income, fuel prices and technology life span. For example, the FIT impact assessment produced by Element Energy uses a LOGIT based economic assessment of technology suitability, coupled with the required policy projections for take up and investment to determine the take up of measures.

Being based on the EFS, the DIMPSA model contains relatively limited data on the household itself (see Data Health Warnings, section 2.4, for further discussion). The model therefore uses a relatively simple exogenous process to determine the take up of measures, namely:

1. Cases (households) in the dataset are first flagged to determine their suitability for technologies. The overall suitability is dependent upon a number of factors, namely tenure, built-form, central heating type, number of rooms, occupancy, wall type and rurality. For example, a Ground Source Heat Pump (GSHP) would not be suitable in a flat and take up (at present) is un-likely in the private rented sector.

2. Once the constraints have been set the model must choose the most appropriate technology for the property. The model therefore uses least cost to decide on the most appropriate heating technology. If the property data in the EFS were improved then this choice could be based on NPV. It is important to note that this choice only occurs for the space heating technology; a property can still also install solar water heating, Photovoltaics (PV) and / or small scale wind.

3. The total number of technologies associated with each policy is then placed in a spreadsheet, and where possible separated by the appropriate targeting method e.g. priority group for CERT and the Supplier Obligation, the bottom income decile for CESP and currently the non priority group for RHI and FIT.

4. The database then uses a stored procedure to load these measures and settings into the database and randomly assigns them to cases (households), based suitability and the total number of installations possible i.e. the database stops when it reaches the total required.

5. Results

5.1. Distribution of measures

The table below shows the proportion of households in the model receiving measures for those policies that result in the installation of measures and therefore provide direct benefits. This shows that over 60% of households receive insulation measures, compared to 9.5% and 3.1% receiving heat and power technologies respectively. Overall nearly two thirds of all households receive a measure of sorts under the four policies. However, it is important to note that these results assume a high level of penetration for lofts and cavities which may be challenging without the mandatory standards outlined in the Household Energy Management Strategy.

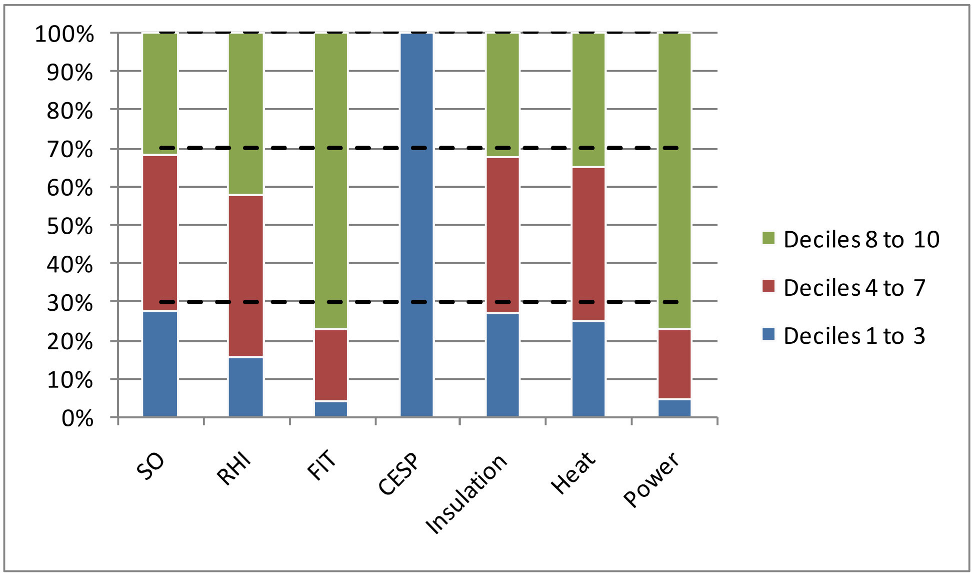
Table 8. Proportion (%) of households receiving measures

<table>
<tr><th colspan="2">Measure</th><th>SO</th><th>CESP</th><th>RHI</th><th>FIT</th><th colspan="2">Total</th></tr>
<tr><td rowspan="4">INSULATION</td><td>Cavity wall insulation</td><td>28.0</td><td>.0</td><td>-</td><td>-</td><td>28.0</td><td rowspan="4">60.1</td></tr>
<tr><td>Loft insulation top up</td><td>34.2</td><td>.2</td><td>-</td><td>-</td><td>34.4</td></tr>
<tr><td>Loft insulation full</td><td>8.1</td><td>.0</td><td>-</td><td>-</td><td>8.1</td></tr>
<tr><td>Solid wall insulation</td><td>3.4</td><td>.2</td><td>-</td><td>-</td><td>3.6</td></tr>
<tr><td rowspan="6">HEAT</td><td>Biomass</td><td>.0</td><td>0</td><td>0.1</td><td>-</td><td>0.1</td><td rowspan="6">9.5</td></tr>
<tr><td>GSHP</td><td>.2</td><td>.0</td><td>1.7</td><td>-</td><td>2.0</td></tr>
<tr><td>ASHP</td><td>2.4</td><td>.0</td><td>1.2</td><td>-</td><td>3.6</td></tr>
<tr><td>Solar water heating</td><td>.8</td><td>.0</td><td>3.9</td><td>-</td><td>4.7</td></tr>
<tr><td>Community biomass</td><td>.1</td><td>0</td><td>0</td><td>-</td><td>0.1</td></tr>
<tr><td>Micro-CHP</td><td>.0</td><td>.0</td><td></td><td>.1</td><td>0.2</td></tr>
<tr><td rowspan="3">POWER</td><td>PV</td><td>.0</td><td>0</td><td>-</td><td>2.8</td><td>2.8</td><td rowspan="3">3.1</td></tr>
<tr><td>Micro-wind</td><td>0</td><td>0</td><td>-</td><td>.0</td><td>0.0</td></tr>
<tr><td>Wind</td><td>0</td><td>0</td><td>-</td><td>.1</td><td>0.1</td></tr>
<tr><td colspan="2">Total</td><td>61.7</td><td>0.4</td><td>6.7</td><td>3.0</td><td colspan="2">64.8</td></tr>
</table>

Figure 6 below shows the distribution of policies and measures by income deciles (2009 disposable household income). The dashed lines show where the distribution would lie if measures were distributed equally amongst the deciles. As a result of policy and model assumptions, the RHI and FIT are skewed towards the higher income deciles (it is assumed the measures are taken up by the non-priority group). Whilst the priority group provides a good overall match with lower income households, there are some low income households that don't qualify for support. The modelling has therefore resulted in a small amount of take up of FIT and the RHI in the bottom three deciles. The RHI take up is higher in the lower income deciles than that for FIT as smaller properties were deemed suitable for ASHP under the RHI, where as PV and small scale wind under FIT require larger houses and weren't applicable to flats.

CESP on the other hand is only applicable to the lower income deciles (decile one only) and the Supplier Obligation is fairly evenly distributed across the deciles (i.e. across 'priority group' and 'able to pay'). This results in the insulation and heat measures being fairly evenly distributed amongst the deciles, whereas power technologies mirror the distribution of FIT.

Figure 6. Distribution of policies and measures by income deciles group



5.2. Individual policy impact

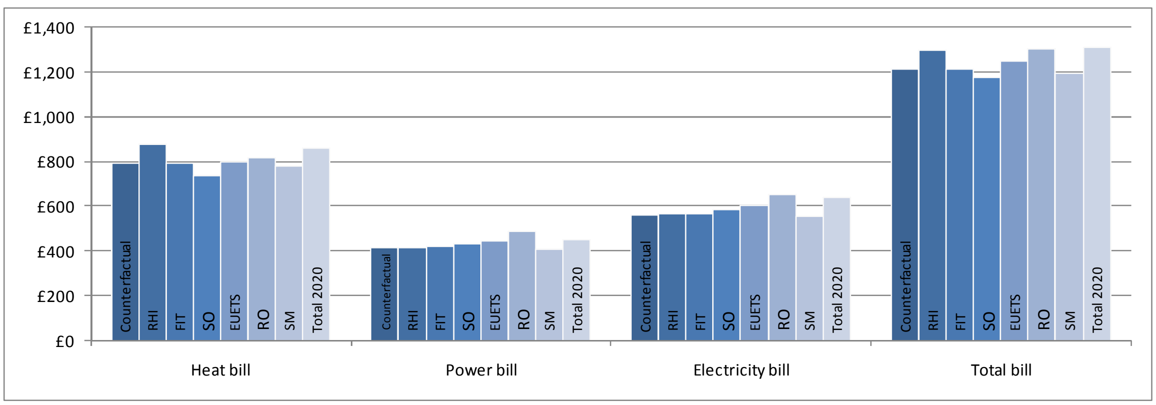
Overall results

The model has examined the impact associated with the policy cost pass through and the benefits i.e. measures installed for each policy. The impact of each policy in isolation on household fuel bills in 2020 is shown below (Table 9, Figure 7). As this illustrates, the cost of the RHI and the RO on their own potentially increase bills to the same extent as all policies combined. The impact of the measures under the Supplier Obligation and Smart Metering, on the other hand, counteract the impact of price rises in 2020, hence the negative percentage change in bill under these policies (alone) relative to the counterfactual. There is evidence of an impact of FIT on heat bills due to properties that use electricity to heat the home.

Table 9. Household energy bills in 2020 under each policy scenario

	2009	2020 Counter-factual	RHI	FIT	SO	EUETS	RO	SM	All policies 2020
Heat bill	£722	£792	£881	£795	£742	£802	£816	£784	£860
Power bill	£432	£419	£418	£422	£433	£447	£487	£412	£454
Electricity bill	£582	£565	£572	£571	£586	£603	£657	£556	£643
Total bill	£1,154	£1,211	£1,299	£1,217	£1,175	£1,249	£1,303	£1,196	£1,314
Total change	-	£57	£145	£63	£21	£95	£149	£42	£160
% change counterfactual	-	-	7.4%	0.6%	-3.1%	3.1%	7.6%	-1.2%	8.1%

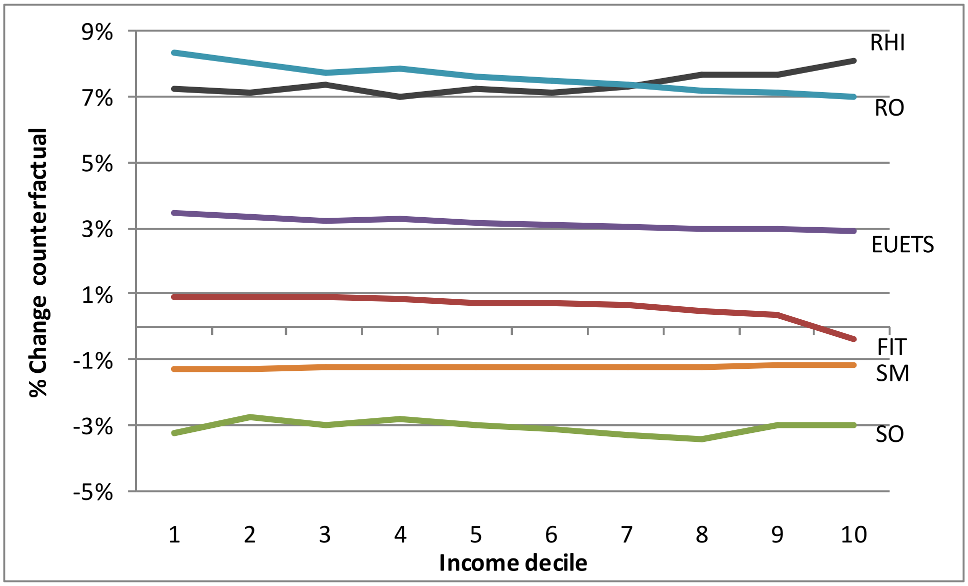
Figure 7. The impact of individual policies on household fuel bills in 2020



Impact by income deciles

Figure 8 below shows the percentage change in bill under each individual policy (relative to the counterfactual) by income deciles. The policies generally demonstrate a higher proportional change for lower income deciles, with the RHI appearing to be slightly progressive in nature i.e. with a higher change in bill for the higher income deciles. FIT on the other hand appears regressive in nature, increasing bills for lower income deciles, and decreasing them for the highest income decile. These phenomena relate to the heating fuels through which the policy costs are recovered, as discussed in section 4.2 above, and the resulting change in bills by heating fuel (discussed below).

Figure 8. Percentage change in bill by income deciles



Impact by heating fuel

The impact of individual policies on household energy bills by heating fuel is shown below. This shows that under the RHI, households that use electricity for heating experience a decrease in fuel bill in 2020 (relative to the counterfactual). This helps to explain the apparent progressive nature of the RHI, as shown in the graph above: a much greater proportion of low income household use electricity to heat their home (31% in income decile 1), compared to the higher income deciles (5% in income decile 10) (Figure 10). As the RHI does not recover costs through electricity these households therefore appear better off under this policy alone.

The RHI and SO may result in a change in heating fuel. The numbers shown in brackets in Table 10 show the percentage change in household bill by heating fuel after policy implementation.

Table 10. Percentage change in total household energy bill by heating fuel before policy (and after)

Policy	Elect.	Gas	Oil	Solid fuel	Other gas	Biomass
RHI	-2.8% (-4.6%)	9.1% (9.9%)	7.2% (7.3%)	11.7% (12.0%)	5.8% (6.6%)	0.0% (-7.5%)
FIT	1.9%	0.4%	0.5%	0.9%	0.4%	0.7%
SO	-4.3% (-3.7%)	-2.6% (-2.7%)	-4.7% (-4.9%)	-5.6% (-5.5%)	-7.3% (-6.3%)	-2.5% (-12.4%)
EUETS	6.6%	2.6%	2.4%	3.0%	1.8%	2.6%
RO	16.0%	6.3%	5.8%	7.3%	4.4%	6.3%
SM	-1.6%	-1.3%	-0.6%	-0.7%	-0.4%	-0.6%

Figure 9. Percentage change in total household energy bill by heating fuel (before policy)

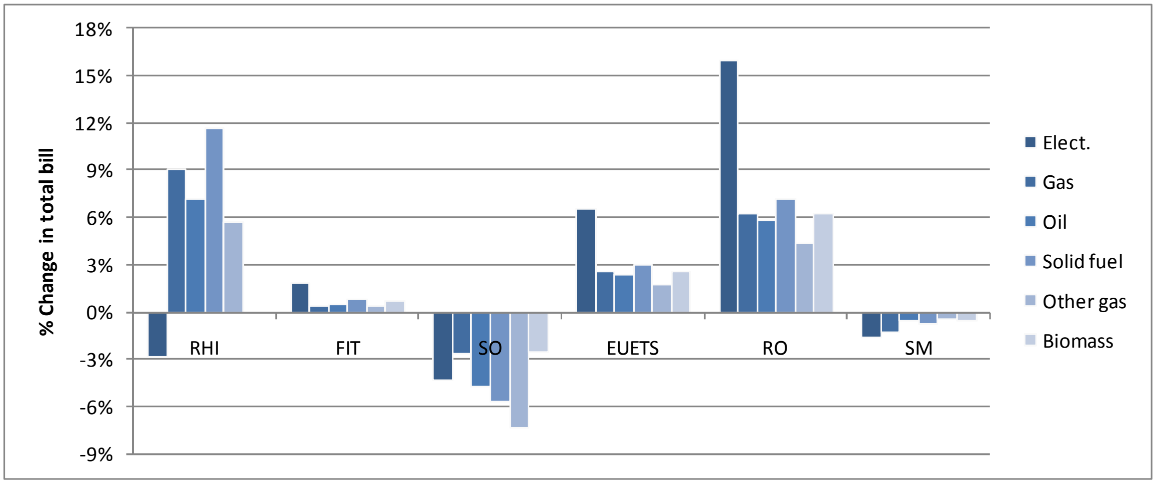
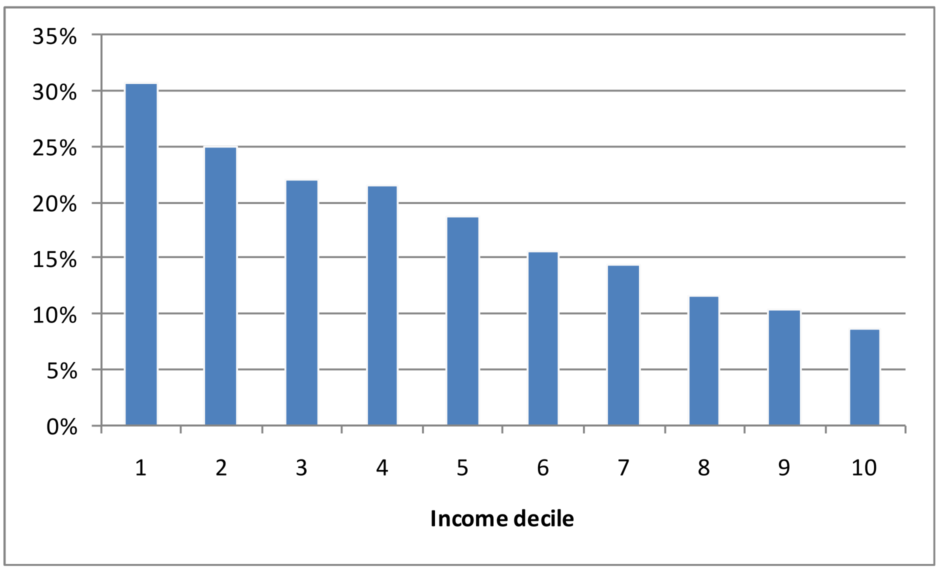


Figure 10. Percentage of households in each income decile using electricity to heat their home



5.3. Results for all policy scenarios combined

Overall impact

The table below shows the headline results of the impact on household energy bills of all policy scenarios combined. Figures represent the mean for the whole dataset.

Table 11. Summary of mean results for all scenarios

	No policy, no measures (Counterfactual)	Measures, but no policy costs	Spread even scenario	Supplier cost recovery	Income tax scenario
Total bill 2009	£1,154	£1,154	£1,154	£1,154	£1,154
Total bill 2020	£1,211	£1,018	£1,314	£1,314	£1,018
Total change in bill	£57	-£136	£160	£160	-£136
Difference: total bill '20 & counterfactual '20	-	-£193	£103	£103	-£193
% Change in bill counterfactual	-	-16.0%	8.5%	8.6%	-16.0%
Change as a % of income	-	-	0.6%	0.6%	-1.5%
Change as a % of income in 2020	-	-	0.5%	0.5%	-1.3%

The 'no policy, no measures' column shows the impact of fuel price changes only (from 2009 to 2020) on household energy bills, with absolutely no policies or measures implemented. This shows that bills are expected to increase by an average of £57 by 2020. This is the 'counterfactual' bill, to which other scenarios are compared (shown by '% change in bill counterfactual' in the table). It is important to note that other agencies and studies have outlined alternative scenarios for the counterfactual fuel costs, meaning this value could therefore vary accordingly. However, the additional policy costs themselves would still need to be recovered at a similar scale to that shown above.

The second data column in the table above shows the effect of implementing policy measures, such as insulation and renewables, but without transferring the cost of these policies to consumers' bills. Under this scenario the average household could see a fall in energy bill of £136 from 2009 to 2020, which is nearly £200 below the counterfactual bill (i.e. the impact of measures do, on average, outweigh the impact of price rises over the period).

However, if the cost of these policies is recovered through consumer bills (under the 'spread even' scenario), the household energy bill shows an average increase of over £160 by 2020; this is 8.5% higher than the counterfactual bill in 2020, or rather, policy costs add just over £100 on average to consumer bills in 2020. The 'spread even' and 'supplier cost recovery' scenario show very similar results at this high level.

The final column shows the impact of recovering policy costs through income taxation. Without the costs being transferred to bills, but with households still benefiting from measures, the average household bill shows a decrease of £136 in 2020 (this is effectually the same as the 'measures, but no policy costs' column). This is 16% lower than the counterfactual bill. The impact of this cost recovery scenario on household income in 2020 is discussed later.

Overall winners and losers

The above headline results can be broken down by 'winning' and 'losing' households, whereby a household is described as winning if it experiences a decrease in household fuel bill (2009-2020).

The results, shown below, give an indication of the distribution of changes to bills. Under the two cost recovery through consumer bills scenarios, 78% of all households experience an increase in household energy bill, the average increase being £226, or 14% above the counterfactual bill in 2020. This increase represents 1% of household income in 2020. For the 22% that experience a decrease in bills, the average decrease is just over £70, or 11% lower than the counterfactual bill.

The income taxation approach shows a converse result, with no households experiencing an increase in energy bill (% relative to the counterfactual). (This is the result of households experiencing benefits from measures decreasing bills, which offset price rises, whilst they pay for these benefits elsewhere, i.e. through income tax). The results shown below for the income taxation scenario therefore repeat those shown above with the average change in bill being -£136 under this scenario.

However, whilst the income taxation scenario sees an average decrease in energy bill, households also experience an average reduction in income of £309 in 2020, as a result of this cost recovery scenario. This is just over 1% of modelled income in 2020.

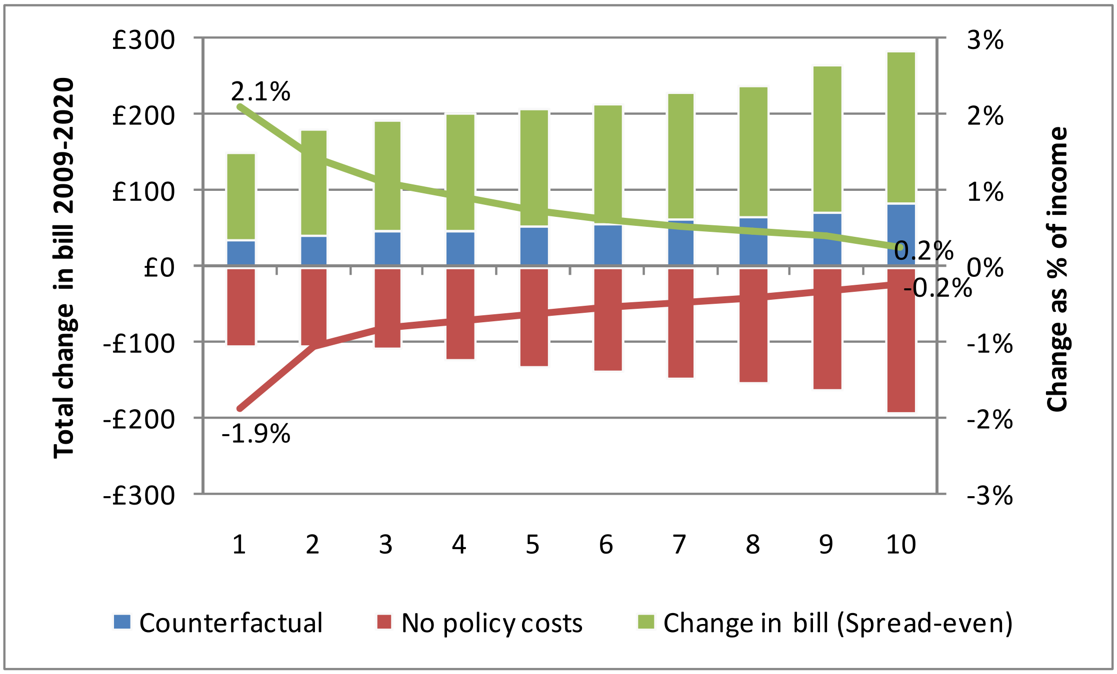
Table 12. Proportion of households 'winning' and 'losing' and mean change in bill (2009-2020) under each cost recovery scenario

	Spread even		Supplier cost recovery		Income taxation	
	Losing	**Winning**	**Losing**	**Winning**	**Losing**	**Winning**
% of households	78%	22%	77%	23%	0%	100%
Total bill 2020	£1,383	£1,076	£1,375	£1,107	.	£1,018
Change in bill	£226	-£71	£229	-£71	.	-£136
% change in bill counterfactual	14%	-11%	15%	-11%	.	-16%
Change as % of income 2009	1.2%	-1.6%	1.3%	-1.5%	.	-1.5%
Change as % of income 2020	1.0%	-1.3%	1.0%	-1.2%	.	-1.3%

Impact by income deciles

The bars on Figure 11 below show the average change in household energy bill from 2009 to 2020 with no measures or policy costs (the counterfactual); with measures but no policy costs passed on; and under the 'spread-even' cost recovery scenario, by disposable income deciles. This shows the total change in bill relative to the counterfactual under the spread-even scenario is higher for the upper income deciles. However, the lines show the reverse is true when looking at change in bill as a percentage of income. This shows that the change in bill for the lower income deciles represents a higher proportion of household income, compared to the higher income deciles.

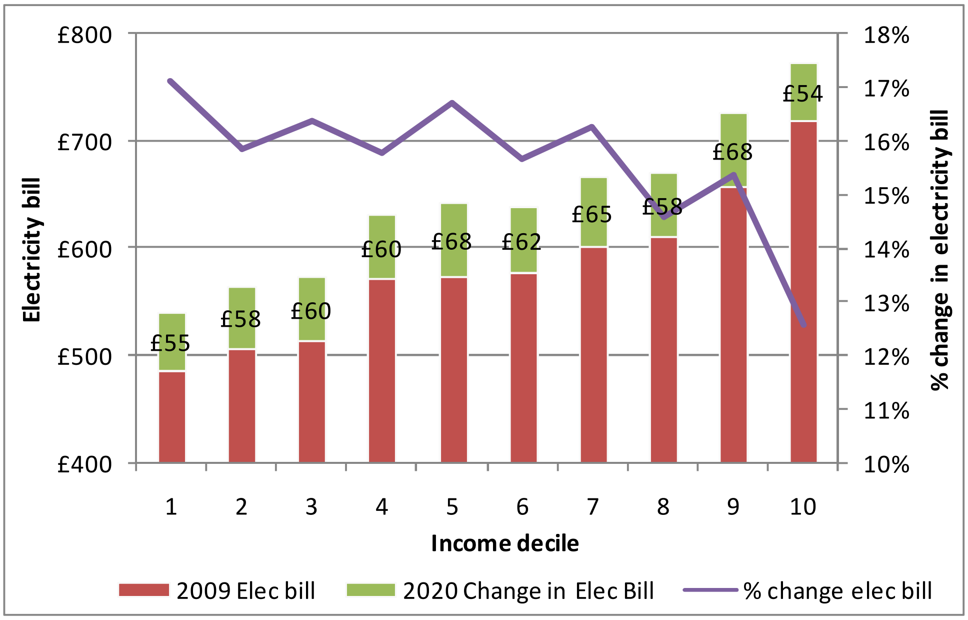
Figure 11. Total change in energy bill and change as a proportion of income



Impact on electricity bills by income decile

Figure 12 below shows the impact of all policies under the spread-even cost recovery scenario on electricity bills alone. Unlike the results above that show a lower absolute increase in total bill for the lower income deciles in 2020, when looking at electricity bill alone the same pattern is not so evident: lower income deciles experience a very similar absolute increase in electricity bill as the high income deciles. As before, this increase represents a higher percentage change in bill for the lower deciles. This relates to the greater reliance on electricity for heating in the lower deciles, as discussed above (section 5.2).

Figure 12. Electricity bill in 2009 and 2020, and percentage change in electricity bill (counterfactual) by income deciles



Impact by household heating fuel

The table below shows the modelled change in household energy bill by 'final' heating fuel (i.e. after policy intervention).

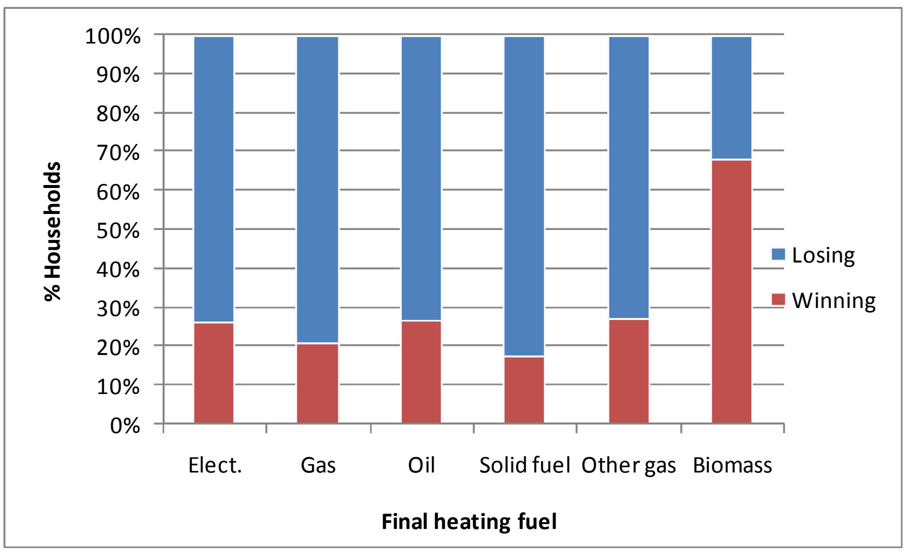
Table 13. Impact on household energy bill by heating fuel (after policy)

	Elect.	Gas	Oil	Solid fuel	Other gas	Biomass
Total bill 2009	£1,188	£1,118	£1,455	£921	£1,649	£1,489
Total bill 2020 no policy costs, no measures (counterfactual)	£1,177	£1,190	£1,519	£994	£1,741	£1,520
Total bill 2020 no policy costs	£943	£1,008	£1,318	£840	£1,528	£1,164
Total bill 2020 spread even	£1,273	£1,300	£1,586	£1,078	£1,774	£1,304
Change in bill no policy costs, no measures (counterfactual)	-£11	£72	£64	£73	£92	£31
Change in bill 2009-2020 no policy costs	-£245	-£110	-£137	-£81	-£121	-£324
Change in bill 2009-2020 spread even	£85	£182	£130	£157	£125	-£184
Difference: Total bill 2020 – counterfactual 2020	£96	£109	£66	£84	£32	-£215
% change in bill counterfactual spread even	6.8%	9.4%	4.4%	8.3%	1.5%	-13.5%

Without any measures and policy costs, (the counterfactual) gas bills are expected to rise by an average of £72 in 2020, whereas electricity bills see a fall of £11 on average. This decrease is the result of the 2020 counterfactual bill representing the change relative to a 2009 price that excludes existing policy costs. The costs in 2009 are first reduced as the cost component of the EUETS, RO and CERT are removed; the price is then increased to 2020 to allow for non climate change related costs (i.e. the blue proportion of the bill). The existing EUETS, CERT and SO impacts on our energy bills are higher than the relative increase associated with global oil price projections, infrastructure investment etc, therefore suggesting a decrease in energy bill when these costs are themselves removed.

Under the 'spread even' cost recovery scenario, households on gas see the greatest increase in their energy bill, with an average increase of £182, or 9% compared to the counterfactual. Households that use biomass for heating in 2020 appear the best off in terms of change in energy bill under the modelled cost-recovery scenario. This is the only heating group that actually see an average decrease in annual energy bill under the spread-even cost recovery scenario, of over £200 compared to the counterfactual.

Figure 13. Proportion of households winning and losing by heating fuel

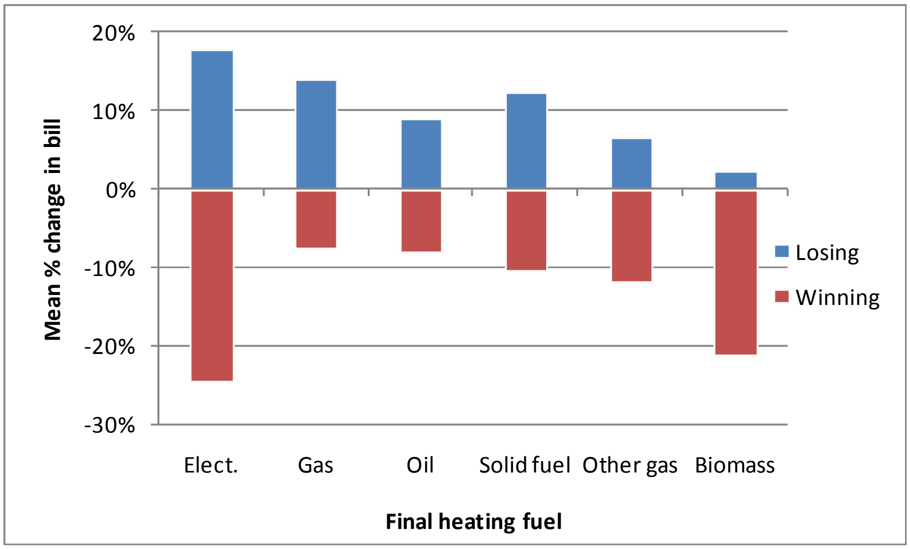


The graphs above and below show the proportion of winners and losers under the spread-even cost recovery scenario by (final) heat fuel (Figure 13) and their mean percentage change in bill relative to the counterfactual (Figure 14). Over 60% of households that use biomass for heating in 2020 experience a modelled decrease in energy bill (i.e. are described as 'winning') compared to less than 30% in all other heating groups. However, Figure 14 shows that of those households that do experience a decrease in energy bill, it is those that use electricity for heating in 2020 that see the greatest average decrease, at around 25% below the counterfactual. These households predominantly receive either an ASHP or a GSHP with an assumed coefficient of performance of 2.5 and 3.25 respectively[47] i.e. high enough to result in a decrease in bill regardless of fuel switching. Similarly, the average reduction in bills of those who have biomass

[47] As defined by the assumptions that underpin the CERT and Supplier Obligation impact assessments

heating is 21%, whilst the 30% who see an increase in bills will only experience an average price rise of ~2%.

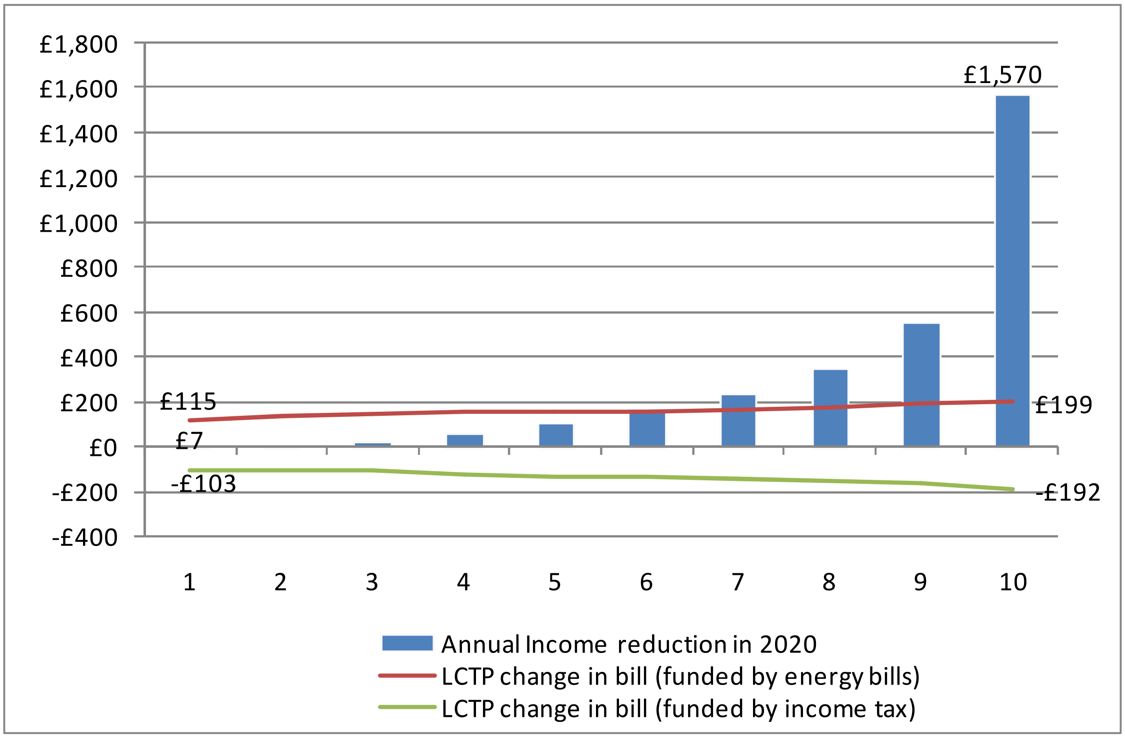
Figure 14. Average change in bill, by final heating fuel



5.4. Impact of income tax cost recovery scenario

The graph below shows the impact of the income taxation scenario on household income in 2020 (bars) alongside the percentage change in bill (lines). This shows that the reduction in household income is significantly lower for the lower income deciles (just £7 for income decile 1) whereas the impact on household income for decile 10 is much more significant, with an average decrease of over £1,570 a year.

Figure 15. Annual income reduction as a result of additional taxation vs. total change in energy bill



The change in bills and incomes under the income tax cost recovery scenario, and mean disposable income in 2020 by decile, is provided in Table 14 and Figure 16 below.

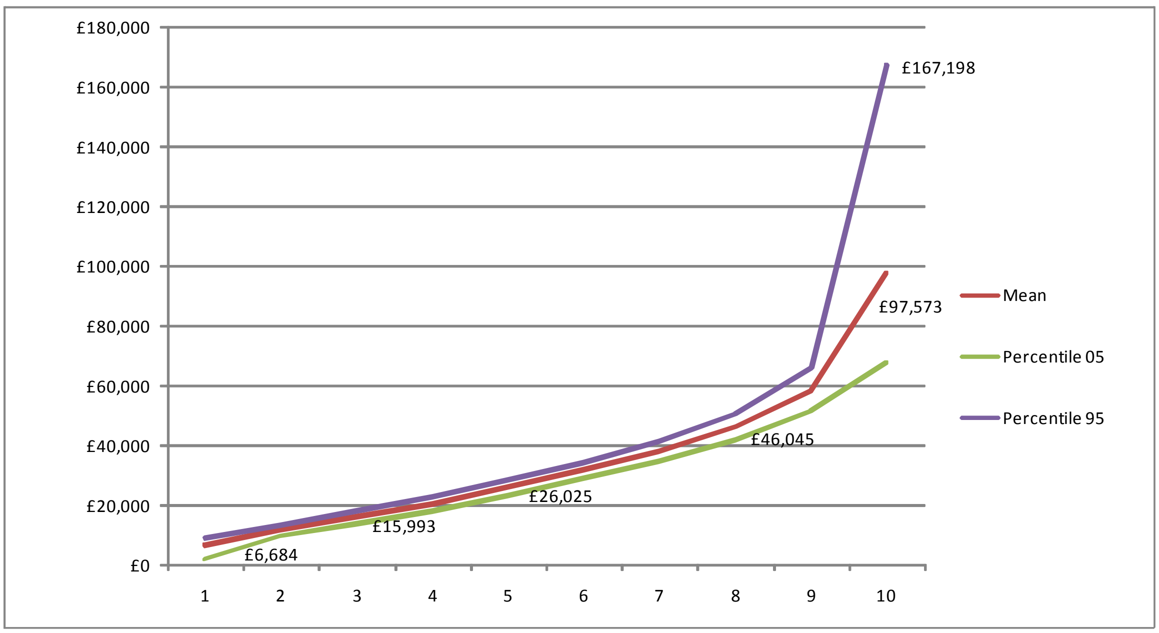
As noted above, in this cost recovery scenario, the lowest income decile sees an average reduction in bills of £103 whilst seeing annual income reduce by £7 or 0.1%. At the top income decile, bills are reduced by £192 whilst disposable income is reduced by £1,570 or 1.6% of their total disposable income.

Therefore, under the income taxation scenario decile 1 would see an overall increase in 'disposable' income of £96 on average whilst decile 10 would see an average reduction of £1,378 (Table 14 below). The recovery of costs via income tax therefore has significant benefits to fuel poor households in 2020, who would stand to benefit from an overall positive change in disposable income, whilst middle income deciles see little change in 'disposable' income and all upper deciles see a net decrease.

Table 14. Change in incomes and bills in 2020 by income decile, under the income taxation scenario

Income deciles	Annual Income reduction in 2020	LCTP change in energy bill 2020	Change in bill as % of income 2020 less income tax	Net change in “disposable” income
1	-£7	-£103	-6.6%	£96
2	-£10	-£103	-1.2%	£93
3	-£20	-£108	-1.0%	£88
4	-£57	-£123	-0.8%	£66
5	-£109	-£133	-0.7%	£24
6	-£171	-£138	-0.6%	-£33
7	-£242	-£147	-0.6%	-£95
8	-£353	-£154	-0.5%	-£199
9	-£555	-£161	-0.4%	-£394
10	-£1,570	-£192	-0.3%	-£1,378

Figure 16. Distributions of incomes by deciles in 2020



6. Analysis of distributional impacts within income deciles

The broad analysis of the impact of the different policy cost recover scenarios by income deciles or household characteristics fails to provide an overview of the fundamental drivers for those households' 'losing' (where a household may be described as 'losing' if it experiences an increase in its energy bill, and all other households may be considered as 'winning' (whether they see a decrease or no change in their bill)).

The process of chi-squared automatic interaction detector (CHAID) can be used to assist in identifying the key defining characteristics of these groups of households. CHAID is a classification method which seeks to identify optimal splits in categorical 'predictor' variables with respect to their influence upon a single dependent variable – in this case percentage change in household energy bill as a result of policy implementation (i.e. relative to the counterfactual bill). CHAID results in clusters – or 'nodes'- of cases with similar defining characteristics and to which a predicted value for the dependent variable is assigned.

Running CHAID on the EFS dataset and creating these nodes has the advantage that it enables more detailed analysis of the socio-demographics of 'winning' and 'losing' households, whilst maintaining a sufficient number of cases (set at 200 cases in the normally weighted dataset) to give a reliable prediction of the mean of the dependent variable i.e. the percentage change in the counterfactual bill.

6.1. The CHAID model for the spread-even scenario

CHAID was applied to the EFS dataset to further explore the relationship between household change in bill and socio-demographic factors, under the spread-even cost recovery scenario[48]. CHAID creates clusters of households ('nodes') based on 'predictor' variables that have a significant relationship with the dependent variable – in this case percentage change in household bills relative to the counterfactual. CHAID then assigns a 'predicted value' for the dependent variable to each node created, equal to the mean for all households in that cluster.

The CHAID model resulted in 36 clusters, defined according to the predictor variables listed below.

[48] The supplier cost recovery scenario has not been analysed in depth here as the overall results do not differ significantly from that of the spread-even scenario: running CHAID on the supplier cost recovery results gives additional nodes to include a group of non switcher 'sticky' households that tend to lose out further. The income tax results have not been examined as all households tend to benefit.

Table 15. Predictor variables selected by the CHAID model

• Wall type	• Dwelling type
• Loft insulation	• Electricity method of payment
• Priority Group	• Government Office Region
• Heat method of payment	• Heating fuel
• Tenure	• Age of HRP
• Number of rooms	• Switcher flag

Figure 17 below shows the distribution of these clusters, with the predicted percentage change in bill on the x-axis and number of households in the cluster on the y-axis. As the histogram demonstrates, only four of the clusters created through CHAID, totalling 4.1 million households (17%), have a predicted decrease in their household energy bill; six clusters have a predicted increase of less than 5% (1.9 million households, 8%) and five (4.9 million households, 20%) see an increase in energy bill of more than 15%.

Figure 18 shows the proportion of households in each node that receive insulation, heat and power technologies (NB the x-axis is not to scale). The dashed lines show the average for the whole dataset. As this shows, the ‘winning’ nodes all receive 100% insulation and some heat and power technologies.

Figure 17. Distribution of household clusters created through CHAID

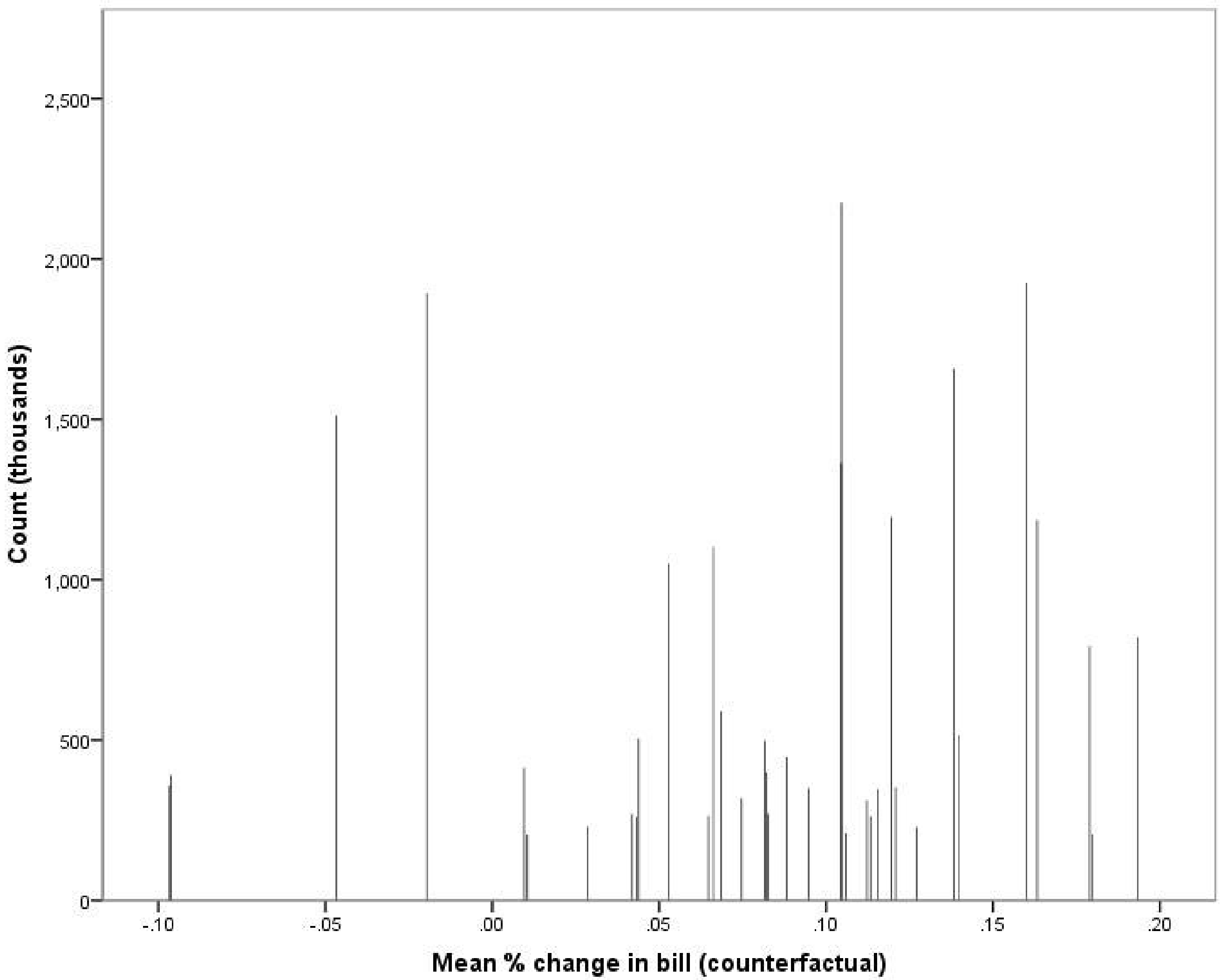
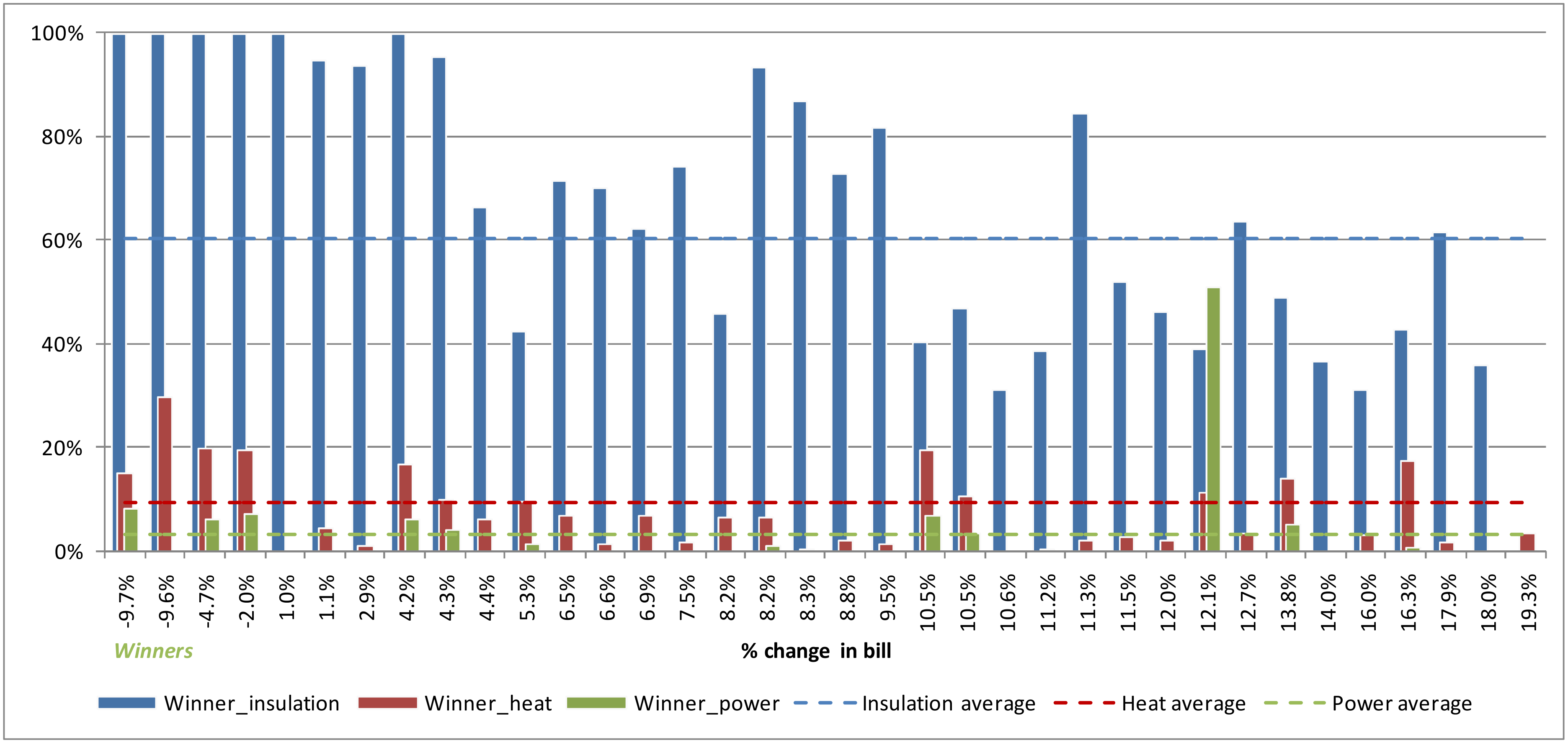


Figure 18. Proportion of households in each node receiving insulation, heat and power technologies (x-axis not to scale)



6.2. Characterising winners and losers

Cross-tabulating the nodes created in the CHAID analysis with socio-demographic variables helps to identify the underlying drivers for 'winning' and 'losing'. The discussion below identifies and characterises groups of nodes with the most extreme predicted percentage changes in household bill.

Common themes for the winning nodes

The 'winning' 4.1 million households (17% of the UK) identified by the CHAID model benefit from the receipt of measures (in isolation or combination), such that every single household in the 'winning' nodes gets a form of insulation (cavity or loft), with some complimented with renewable heat and power technologies. The lower income deciles are under-represented.

Cold to cosy houses (1 node) – 9.7% reduction, 356,000 households or 1.4%

- Households receive a 100% rate for both cavity wall insulation and virgin loft insulation
- In addition, 15% get heat and 9% get power technologies including biomass, solar water heating, ground source heat pumps and PV.
- The majority of households are home owners, in the higher income deciles (56% in deciles 7-10), living in houses
- Heating fuel mirrors the overall average, with around 74% and 16% using gas and electricity respectively – the impact of insulation protects these households from price rises

Insulated, green-heated flats (1 node) – 9.6% reduction, 389,986 households or 1.6%

- Households receive a 100% rate for cavity wall insulation
- 41% of households receive top up loft insulation
- 30% of households receive a renewable heat technology (with air source heat pumps being the dominant type)
- Households use electricity for heating
- A large proportion (40%) of this node are flats
- Properties tend to be smaller in size
- Middle income bands dominate slightly (49% in deciles 4-7)

Sticky insulated green houses (1 node) – 4.7% reduction, 1.5 million households or 6%

- Households receive a 100% rate cavity wall insulation
- 44% of households receive top-up loft insulation
- 20% and 6% of households in this node receive heat and power technologies respectively (twice the overall average rate)
- Being 'non-switchers', households in this node pay by standard credit for their electricity and (where applicable) gas;
- They use gas or oil to heat their homes and live in larger detached or semi-detached houses
- Over 50% are aged between 45 and 64, working full time or self-employed

- A higher income node (44% in deciles 8 to 10)

Comfortable gas insulators (1 node) – 2% reduction, 1.9 million households or 8%

- Very similar to the above, but fewer renewables and no oil:
- Households receive a 100% rate cavity wall insulation
- 44% of households receive top-up loft insulation
- 100% of households use gas to heat the home (before policy) and pay by direct debit
- 10% of this node get solar water heating and 7% PV
- The vast majority are couples, who own their home (with a mortgage), in larger detached or semi-detached houses, working full-time
- The highest income of all winning nodes (49% in deciles 8 to 10)

Common themes for the extreme 'losing' nodes (greater than 15% increase)

Five of the nodes have an average increase in bill of over 15%. These 4.9 million (20% of the UK) 'losing' households tend to live in insulated homes with gas for heating.

Fully insulated retired (1 node) -19% increase, 820,000 households or 3.3%

- All of the households already had insulated cavity walls and lofts
- Only 4% of households receive any measures (air source heat pumps and solar water)
- 100% Priority Group
- Properties are mainly owned outright or LA/HA tenants and retired (56% over 65)
- Gas or electric heaters, paying by direct debit

Middle-income electric private renters (1 node) -18% increase, 204,000 households or 0.8%

- All of the households already had insulated cavity walls
- 46% required top-up loft insulation; 36% receive it
- Non-switchers paying by standard credit or prepayment meters, with electric heating
- 100% private rented, mostly small flats and young people (56% under 35)
- 100% Non-Priority Group

Partially insulated gas heaters (1 node) - 18% increase, 792,000 households or 3.2%

- All of the households already had insulated cavity walls
- 100% of households required top-up loft insulation; 62% receive it
- 100% Priority Group (elderly – 49% over 65)
- 100% direct debit for heating, with evidence of switching
- Owner occupiers (own outright), larger detached and semi-detached houses
- Gas heaters

High income gas heaters (1 node) - 16% increase, 1.2 million households or 5%

- All of the households already had insulated cavity walls
- 59% required top-up loft-insulation; 43% receive it
- Do get some heat technologies – ground source heat pumps and solar water (4 and 10%)

- 100% direct debit
- Owner occupiers (own with mortgage), larger detached and semi-detached houses
- Gas heaters
- Higher income, full-time employment, without children
- 100% non-PG

Social housing, low income elderly (1 node) - 16% increase, 1.9 million households or 8%

- All of the households already had insulated cavity walls
- 47% required top-up loft-insulation; 31% receive it
- 100% Priority Group
- Local Authority/ Housing Association tenants
- Standard credit and prepayment meter users
- Gas and electric heaters (79%/21%)
- Elderly, low income, single adult households

7. Alternative tariff solutions – a protected block tariff

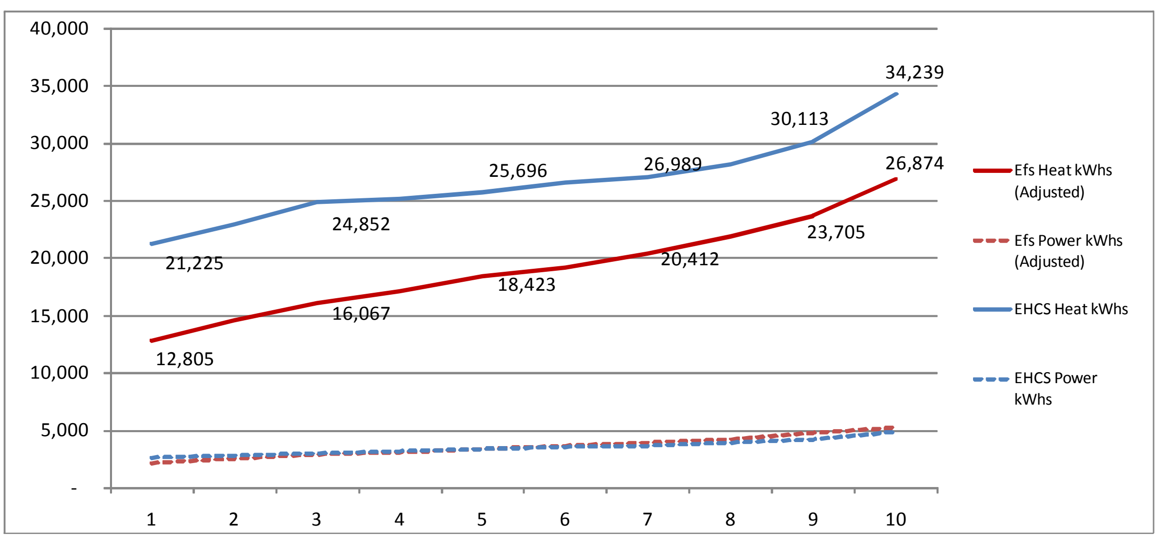
There are alternative methods for recovering policy costs from consumer's energy bills. The introduction of a 'protected block' tariff represents one possible approach. The tariff would require regulatory backing to specify that energy suppliers only recover policy costs above a certain threshold for both gas and electricity. For example, the first 2,000kWhs would not be subject to the additional costs of climate change policies with the remainder being subject to the additional costs discussed previously.

The team has not yet performed the modelling work required to discover the optimum cut off point for the protected block and the cost impacts associated with the remaining kWhs or units of a consumer's energy bill. The remaining units could be subject to either uniform cost pass through or they could escalate i.e. similar to a rising block tariff with the cost increasing with consumption. However, we have performed some initial analysis to discuss the potential advantages and disadvantages of this approach:

- Lower income households generally consume less energy and as such would stand to benefit from lower fuel bills
- A relatively small number of low income households have high levels of energy consumption
- A higher proportion of low income households heat their home with electricity, thus potentially making a group of low income households worse off
- Fuel poor households are on average less efficient which means they theoretically need more energy to heat their homes. A protected block tariff could therefore both increase fuel poverty and simultaneously make people better off
- The tariff should not place an undue burden on energy suppliers

7.1. Lower income households consume less

Figure 19. DUKES Adjusted EFS Consumption vs. EHCS Energy Need by Income Deciles

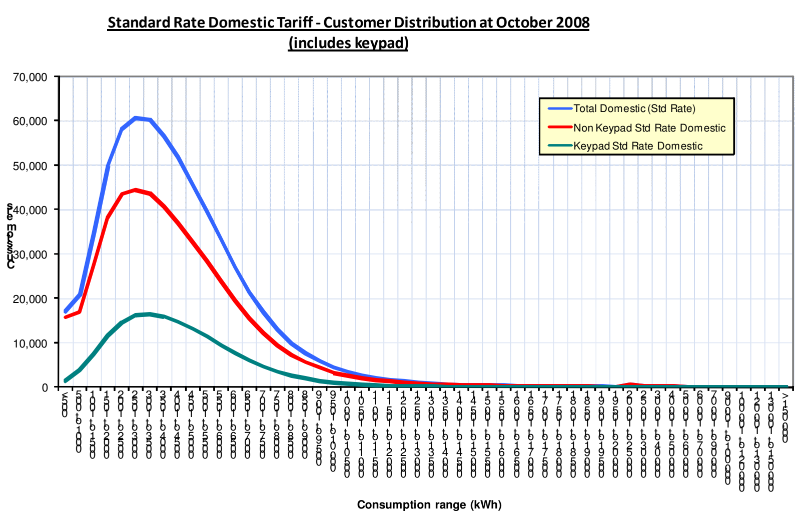


The graph above shows average consumption and energy need for both heat and power. The figures for energy need have been derived from the 2007 EHCS and assume a standard heating regime[49]. The figures for energy consumption are derived from the EFS. The EFS totals for gas and electricity have been adjusted to ensure the summary statistics match the total supply figures published in the UK Digest of Energy Statistics. The graph shows a significant gap between actual energy consumption and theoretical energy need i.e. suggesting the majority of people do not heat their homes to 21^{o}C. Furthermore, the chart also shows a relatively clear correlation between low incomes and low energy consumptions. The protected block tariff approach could therefore help protect low income consumers, as 'consumption level' appears to be a reasonable proxy for poverty.

In Brenda Boardman's book 'Fixing Fuel Poverty'[50], the author has suggested a protected block tariff i.e. putting the extra costs of climate change policies that impact upon electricity onto the 37% of high users only. The proposal draws on the work of the Northern Ireland Energy Regulator who recently examined the potential for a 'rising block tariff' in the report 'Orphans in the Energy Storm'[51].

In Northern Ireland, the average electricity consumption per household is 4,200kWh, with a long tail of demand created by high users (see figure below). McIldoon has proposed, as one permutation, that the 28% of householders using less than 2,500kWh per annum would pay a reduced rate for their electricity. The next group of householders (35%) using up to 4,500kWh pa would end up paying roughly the same rate as they currently do, as a result of a lower rate for the first 2,500kWh offset by a higher rate for the next 2,000kWh. The 37% of households in the remaining long tail of consumers would be paying a higher amount than at present. As a result, consumers 'are paying less for consumption that is essential for civilised existence and more for electricity that is optional'.

Figure 20. Distribution of electricity consumption in Northern Ireland (McIldoon 2008)



[49] For the modelling of fuel poverty the demand temperature of all dwellings within the primary zone is assumed to be 21ºC, the secondary zone is assumed to be heated to 18ºC and the temperature of the unheated zone relates to the external temperature and therefore varies depending on the local climatic conditions.
[50] Boardman, B. 2010. Fixing Fuel Poverty.
[51] McIldoon, D., 2008. Northern Ireland electricity consumers – orphans in the energy storm. www.uregni.gov.uk/uploads/publications/McIldoon_Review_051208.pdf

7.2. Low income, high energy consumption households

The protected block tariff would benefit low users of energy and conversely penalise high users. The 2004 Dresner and Ekins discussion paper examining the social impacts of environmental taxation explored the variation of energy use and emissions between and amongst deciles for both the 1996 EHCS and the 2001 EFS[52]. The study identified a large range for both energy need and consumption across income deciles suggesting that some low income households could also consume high amounts of energy.

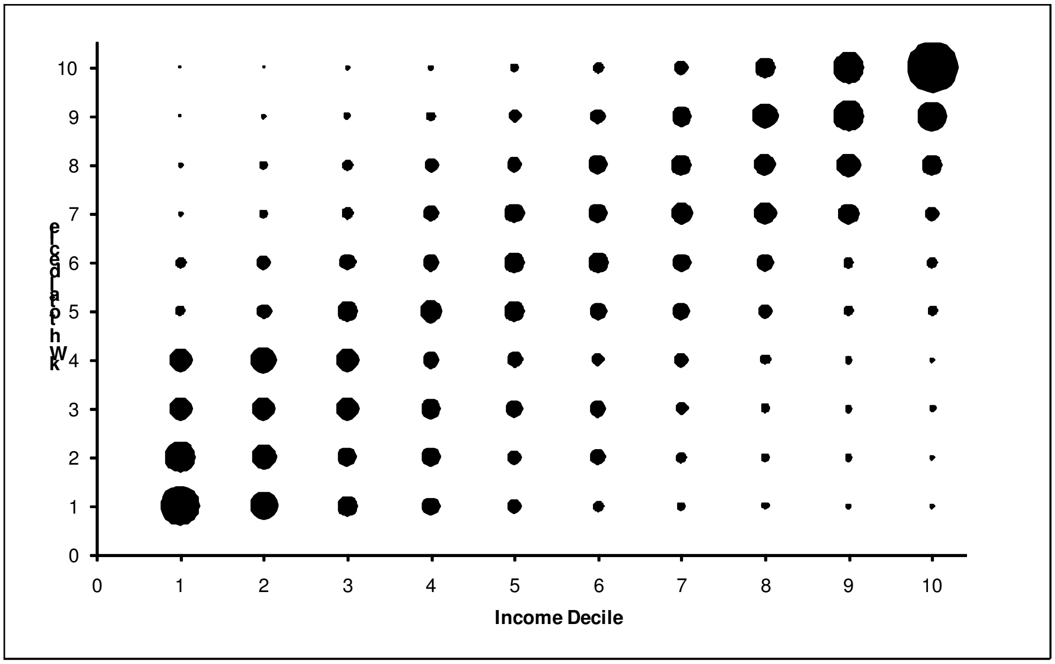
Figure 21 below shows the overall distribution of consumption by income deciles, based on CSE's 2004-2007 EFS dataset (see Annex I – Modelling dataset for details). The width of the bubbles represents the total count of households. This suggests that whilst the majority of low income households will be better off, the protected block tariff is likely to impact heavily on the households in the top left hand corner i.e. income deciles 1 to 3 and energy consumption deciles 8 to 10. The EFS contains relatively limited data on the property itself and it is therefore difficult to ascertain the extent to which this group of households are:

- Living in a poorly insulated and / or inefficiently heated home
- Living in a well insulated home with poor energy behaviour
- Living in a well insulated home with higher than average energy needs e.g. due to illness
- Living in a large home and under heating that property

The characteristics of this group of high consumption and low income homes therefore need to be better understood if a protected block tariff is likely to be applicable. At the time of writing CSE is undertaking some research for Ofgem to further explore the nature of the low income, high consuming households.

[52] Ekins, P, Dresner, S., 2004. Green taxes and charges, Joseph Rowntree Foundation.

Figure 21. Distribution of energy consumption by income decile based on the EFS



7.3. Low income electric heating households

As discussed in section 4.2 and 5.2 a higher proportion of low income households use electricity to heat their homes (approximately 1.5 million households (see Figure 10, p.48)). The relationship between the thermal efficiency and the current energy consumption is particularly important for this group i.e. those with high energy need are likely to become colder as a result of the additional policy costs. To deal with high consumption low income households the study proposes a safety net through exemption. In this instance, low income households with higher consumption could seek exemption if they meet certain qualifying criteria e.g. linked to income and / or off-peak electricity tariffs.

7.4. Fuel poverty and a 'protected block' tariff

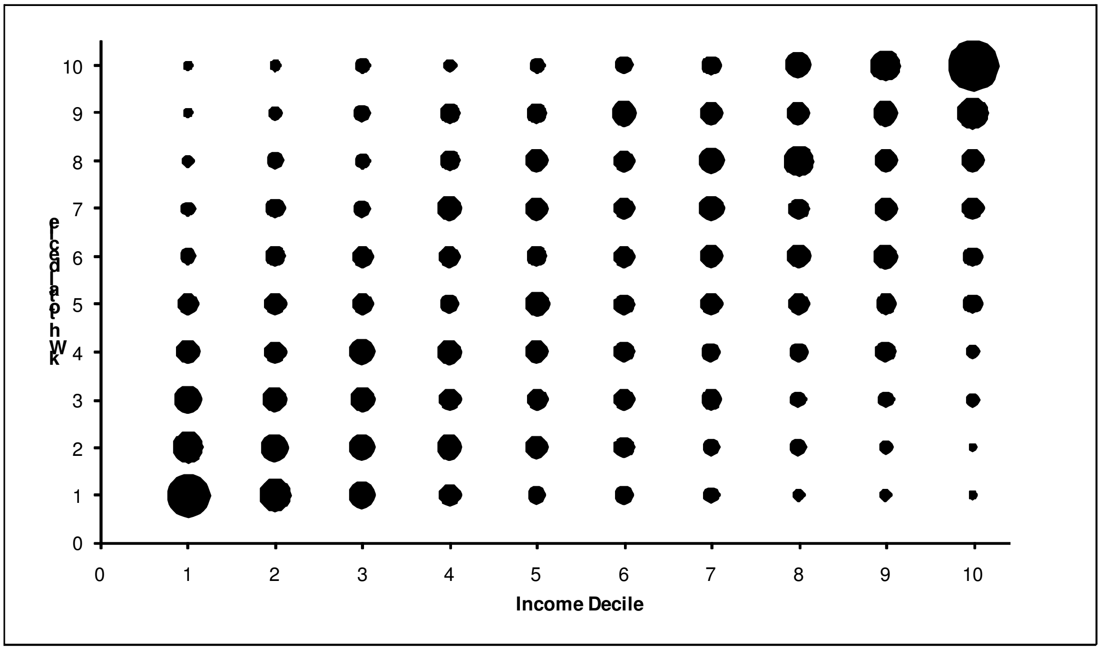
The extent to which a 'protected block' or 'rising block' tariff can help fuel poor households depends on there being a strong correlation between fuel poverty and having a low energy requirement. The available evidence and modelling suggests that fuel poor households actually have higher energy requirements than non-fuel poor households (due to a combination of thermally inefficient houses and patterns of energy use - Table 16).

Figure 22 shows the relationship between energy need and income, which is less defined than that for consumption (Figure 21).

Table 16. 2006 EHCS Mean Energy Need (kWh) for Fuel Poor and Non Fuel Poor households

Fuel Poverty status	Space heating	Water heating	Lights and appliances	Cooking	Total
Not in FP full definition	22,604	4,696	2,900	793	30,993
In FP full definition	30,925	4,180	2,462	680	38,247

Figure 22. Distribution of energy need by income decile based on the EHCS



Based on this analysis of energy need, the protected block tariff would therefore impact upon a larger group of low income households (those in the top left hand corner of Figure 22). As discussed below the fuel poverty statistics are based on the modelled energy requirement rather than actual expenditure which will be constrained by poorer households choosing to prioritise other expenditure. It is therefore possible that the official numbers of fuel poverty would increase. However, given the overall trend of energy consumption it is likely that the actual experience of energy poverty could be considerably better since households which currently under-heat their homes can buy more of the cheaper, policy-cost-free fuel for the same spend.

The current survey data does not allow us to determine how much energy fuel poor households actually consume (although the proposed EHS Energy Follow-Up Survey should help clarify this); however, as discussed above the evidence suggests they use much less than the modelled requirement. The proposed 'rising block' approach could therefore exacerbate the theory of fuel poverty, whilst potentially improving the lives of people i.e. making them warmer but possibly more fuel poor by definition. There therefore appears to be a 'Catch 22' situation for the delivery of our fuel poverty targets and the real experience of 'energy poverty' i.e. the households' experiences based on actual spend and the energy service gained in return. This represents a serious challenge to the development of tariff based solutions, which requires politicians to admit our fuel poverty targets are unlikely to ever be met and therefore switch emphasis to improving lives rather than delivering a theoretical target.

7.5. Potential interactions with the energy market

The energy suppliers may themselves raise legitimate concerns that the onus of a protected block tariff falls unduly on them. For example, if an energy supplier had a large base of low consumption households then they would have a smaller amount of high consumption householders across which to spread the costs. In this instance energy suppliers may argue that the costs themselves need to be reconciled to enable a fair distribution of costs amongst suppliers i.e. not distorting the market unfairly. The obligation could therefore be first split between suppliers based on the consumption of the households they supply rather than the total numbers of customers.

8. Conclusions: Funding a fair low carbon future

8.1. Income taxation vs. energy bills

This study has modelled the potential distributional impacts of UK climate change policies, as set out in the Government's Low Carbon Transition Plan. It uses the model (the 'Distributional Impacts Model for Policy and Strategic Analysis' - 'DIMPSA') developed by CSE in its work with the Department of Energy and Climate Change (DECC). For consistency, the assumptions underlying the LCTP and the analysis for DECC (that is for fuel price rises and policy cost pass through to domestic sector) have been applied here.

The model enables policy measures (insulation and micro-renewables) to be distributed amongst all households in the dataset according to a set of qualifying assumptions. The policy costs are then applied according to three different scenarios of cost recovery. Two assume costs are recovered through consumer bills, and explore the impact of a 'spread-even' distribution of costs and a 'commercial reality' supplier cost recovery approach, whereby certain households pay disproportionately. The final scenario explores the potential impacts of recovering policy costs through income taxation.

The results of the policy modelling show that nearly two thirds (65%) of households receive at least one measure, with 60% receiving insulation (including cavity wall, solid wall, loft virgin or top-up).One in ten households get a renewable heat technology, and 3% renewable power.

Analysis of individual policy impact shows that the RHI and RO result in the greatest increase in household energy bills: without the insulation measures available from other policies, which protect households from price rises, the RHI and RO result in an average increase of 7.5% on the counterfactual bill. However, the RHI does appear slightly progressive in nature, resulting in greater percentage increase for the higher income households. This is related to the distribution of different heating fuels: lower income households rely to a greater extent on electricity for heating and therefore receive less of the policy cost pass-through of the RHI (which is not recovered through electricity bills).

Analysis of all the LCTP policies combined, shows that if policy costs are recovered through consumer energy bills this results in an average increase of £103 in 2020. This is an increase of 8.5% on the counterfactual i.e. above the increase in energy prices associated with infrastructure investment and wholesale costs. Recovering policy costs through income taxation on the other hand sees the average household energy bill decrease by £193 (16% below the counterfactual), as a result of households benefiting from policy measures (insulation and renewable). However, under this cost recovery scenario, annual household income falls by an average of £309. Therefore, under the income taxation scenario the average household is £173 worse off. Whilst this is greater than the average impact of recovering policy costs through bills, the impact is distributed much more progressively.

The spread-even cost recovery scenario results in greater absolute increase in bill for the higher income deciles, but this increase represents a smaller percentage change, and smaller proportion of household income, than for the lower income households. Conversely, taking account of the decrease in energy bill and decrease in household income under the taxation scenario, lower income households have on average a net surplus of £96 (i.e. the decrease in energy bill exceeds the decrease in household income), compared to the highest income decile with an average net deficit of £1,378.

The spread-even cost recovery scenario results in some households (22% of the dataset) 'winning' – that is experiencing a decrease in energy bill – whilst some are made extremely worse off. Applying CHAID to the modelling results helps to identify the key defining characteristics of these 'winning' and 'losing' households, by creating 'nodes' – or clusters. The results show that all 'winning' nodes receive 100% cavity wall insulation – i.e. households that currently have uninsulated cavities but receive this measure under one of relevant policies stand to gain: the benefits of insulation act as a buffer against future fuel price rises. The winning nodes also receive above average renewable heat technologies and, for 3 out of the 4 winning clusters, power technologies. However, there is evidence of renewables in some of 'losing' households as well, suggesting insulation is the key factor in making a household better off.

The results for this study are generated by DIMPSA, which is based on Expenditure and Food Survey (EFS) data. The resulting dataset provides accurate energy consumption figures at the mean level, but lacks detailed information on housing characteristics, which is important in modelling the impact of insulation and renewable measures. The team acknowledge the weaknesses of the model and further research is underway to develop the dataset to include EHCS energy need and household characteristics data and transportation data.

8.2. Large scale retrofit vs. a disaggregated policy approach

The EFS dataset has enabled the team to explore the distributional impacts associated with climate change policies. However, the dataset doesn't provide sufficient cases to spatially represent these distributional impacts alongside the potential to minimise these through local area based approaches. The HEMS places an increased emphasis on the need to use local partnership to deliver better targeting and uptake of measures. In the future, DECC's Non-domestic Energy Efficiency Data Frameworks (NEED) data[53] could be used to analyse distributional impacts. DECC is developing a pilot NEED database to gather and where appropriate incorporate information from existing databases for the entire building stock.

8.3. Recommendations for the delivery of the LCTP and HEMS

The use of energy bills to recover the cost of climate change policies is more regressive than the alternative use of income taxation. These approaches both require the population to pay for a variety of measures which they may or may not benefit from. The winners see an overall reduction in their energy bills under either scenario with income taxation benefiting those on lower incomes. However, current and future Governments are unlikely to use income taxation to fund these measures unless an alternative revenue stream can be found for the country's huge structural deficit. If energy bills are the principal route for the recovery of climate change policy costs then the delivery of the LCTP and the

[53] DECC 2009, Non-domestic Energy Efficiency Data Framework
www.defra.gov.uk/environment/climatechange/uk/energy/energyservices/documents/need-report090129.pdf

HEMS – or its successor with the new Government - must be designed to be as fair as possible. The HEMS and the LCTP's delivery must therefore:

1. Ensure no fuel is unduly burdened by climate change policy costs.

Electricity prices are set to increase by over 4p/kWh by 2020 which is more than any other fuel. Whilst this increase relative to today's costs may be proportionally lower than that experienced by gas consumers, those heating their homes with electricity will face significantly higher energy bills. Furthermore, the 2010 Energy Bill contained the primary legislation required to fund Carbon Capture Storage (CCS) from energy bills. The commercial viability of CCS has not been proven and as such the use of energy bills to fund an unproven technology seems unfair (see section 2.6 for discussion).

2. Expenditure on measures is linked to the householder.

The HEMS provides further details on the Government's proposals for low interest loans and the possibility of mandatory standards for rented housing. The use of loans and regulation provide the potential to remove the link between policy costs and the energy bills. For example, low interest loans will link the cost of measures and their repayments to the property and as such remove the need to place a delivery obligation on the energy suppliers. However, low interest loans will not be appropriate for all householders; particularly those on low incomes that currently under heat their homes and as such will not generate the necessary financial savings to make the loan repayments. The delivery of measures to low income households will therefore require grants and subsidies which the analysis here would suggest would most fairly be funded from income taxation.

3. Design tariffs that penalise high consumers and control energy supplier cost pass through strategies.

The recovery of the costs of climate change policies should penalise those consumers that pollute most. If energy bills are to be the primary cost recovery mechanism then our tariffs should be structured to favour those who pollute least and energy suppliers should not be left to recover these policy costs as they see fit to meet their own commercial objectives rather than to serve wider societal objectives such as reduced inequalities. The report has identified a 'protected block' tariff as a potential solution to this problem. The implementation of this tariff would have its own set of distributional impacts i.e. potentially unduly impacting on low income households using electricity to heat their homes. The tariff would therefore need to be structured to account for different payment methods, (e.g. economy 7), and customer types (e.g. households in receipt of certain means tested benefits with low incomes).

Annex I – Modelling datasets

Expenditure and Food Survey

The Distributional Impacts Model for Policy and Strategic Analysis (DIMPSA) is based on the Expenditure and Food Survey (EFS). For the purpose of the modelling, four EFS datasets, spanning 3.5 years (financial years 2004/05, 2005/05 and calendar years 2006 and 2007), have been combined, increasing the sample size to over 20,000 cases.

The EFS uses interview and diary-based methods to collect information on a range of personal and household expenditure, including household fuels. Time- and location-specific fuel price information was used to convert survey expenditure data on all household fuels into consumption.

To improve the accuracy of modelling policy impacts a number of additional variables have been modelled in the EFS dataset, namely:

- **Propensity to switch energy supplier** as defined by the Ipsos Mori survey for Ofgem
- **Wall type** as defined by the English House Condition Survey
- **Loft insulation opportunity** as defined by the English House Condition Survey
- **Communal heating** as defined by the English House Condition Survey

Propensity to switch flag from the Ipsos MORI survey

The team has developed two scenarios for the potential pass through of policy costs to UK energy consumers (see section 2.6 and Annex II). The 'commercial reality' supplier cost recovery scenario assumes costs are recovered according to commercial drivers, favouring a disproportionate loading of costs on customers with no record of switching suppliers (i.e. still with British Gas or the supplier which now owns their previously 'regional' electricity supplier) and customers not considered 'desirable' within the market context created, in part, by these policies.

In order to model propensity to switch supplier, CSE performed detailed analysis on a survey of domestic energy customers' attitudes and behaviours in Great Britain's energy supply market, conducted by Ipsos MORI, on behalf of Ofgem, in 2008[54]. The survey involved face-to-face interviews with 2,024 customers located throughout Great Britain and is weighted to provide a representative sample of domestic energy customers, based on variables of sex, age, social group and working status. (Although it should be noted that Ipsos MORI acknowledge that the survey actually over-represents direct debit customers and under-represents standard credit customers).

The survey results provide socio-demographic information in addition to information on consumer switching behaviour (number of times customer has switched supplier, for gas and electricity separately). The survey dataset has been used to build a predictive model of switching behaviour that could be used to identify customers who are more likely to switch energy supplier in the EFS dataset.

[54] Ipsos MORI, (2008). Customer Engagement Survey. Report prepared for Ofgem, 29 August 2008. *Internal report.*

To do this, firstly a variable was created in the MORI dataset, using the responses to various MORI survey questions, which classifies a customer as a 'switcher' (customer has switched energy supplier more than once) or a 'non-switcher' (customer has switched energy supplier only once, or never). This is the dependent variable in the model.

Socio-demographic variables common to both the MORI and EFS datasets were harmonised, such that categories are identically defined. These variables are the predictor variables in the model and were also used to confirm that the two datasets were suitably comparable.

Using these variables in the MORI dataset, chi-squared automatic interaction detector (CHAID) was used to generate classification rules for identifying whether a customer is likely to be a 'switcher'. The rules generated by CHAID are then run on the EFS dataset to create a 'switcher' variable. This resulted in 22% of households in the EFS being identified as 'switchers', which is suitably comparable with the actual results in the MORI survey, which identifies 28% of customers as 'switchers', as shown in the tables below. The socio-demographic characteristics of 'switchers' identified in the two datasets were also compared to ensure similarity.

Annex Table 1: Frequency of 'switchers'

	MORI survey results (actual)		CHAID predictions on MORI dataset		CHAID predictions on EFS dataset	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Non-switcher	1,465	72.4	1,503	74.3	19,236	78.1
Switcher	559	27.6	521	25.7	5,397	21.9
Total	2,024	100.0	2,024	100.0	24,633	100.0

These results are comparable with Ofgem's categorisation of consumer groups, which classifies 17% of the population as 'proactive' (consumers who have either switched on their own or regularly check prices).

Wall, loft and communal heating flags from the EHCS analysis

The EFS does not include detailed information on physical household characteristics, beyond built form, which are important in modelling the impact of energy policies. Data from the 2006 English House Condition Survey (EHCS) was therefore used to generate a predictive model to identify wall type, loft insulation levels and heating system age/communal heating in the EFS.

These variables were first created in the EHCS dataset using EHCS survey data. Socio-demographic variables common to both the EHCS and EFS, which could be used as predictor variables in the model, were harmonised such that categories were identically defined. These could also be used to verify the comparability of the two datasets, although comparability is restricted to some extent as the EHCS is a survey of households of England and Wales only, whereas the EFS is UK wide (hence the difference in totals in the tables below).

Three separate CHAID models were then used to generate rules identifying the most likely wall type, loft insulation level and heating system age/communal heating (respectively), according to the set of (harmonised) socio-demographic variables. The rules for each of these three models were then run on the EFS, creating new variables identifying the most likely wall type, loft insulation level and heating system age for every household in the EFS dataset. The results of this process are shown below. The figures show that the CHAID models provide a very high level of accuracy in the proportions of households classified into each category for the variables in the EHCS. Accuracy remains high when predicting the proportions in the EFS as well.

Annex Table 2: Wall type

	EHCS survey results (actual)		CHAID predictions on EHCS dataset		CHAID predictions on EFS dataset	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Cavity with insulation	6,477,207	30.5	6,472,353	30.5	7,770,930	31.5
Cavity un-insulated	8,215,537	38.7	8,245,673	38.9	9,406,734	38.2
Other	6,528,063	30.8	6,502,781	30.6	7,455,409	30.3
Total	21,220,807	100.0	21,220,807	100.0	24,633,073	100.0

Annex Table 3: Loft insulation

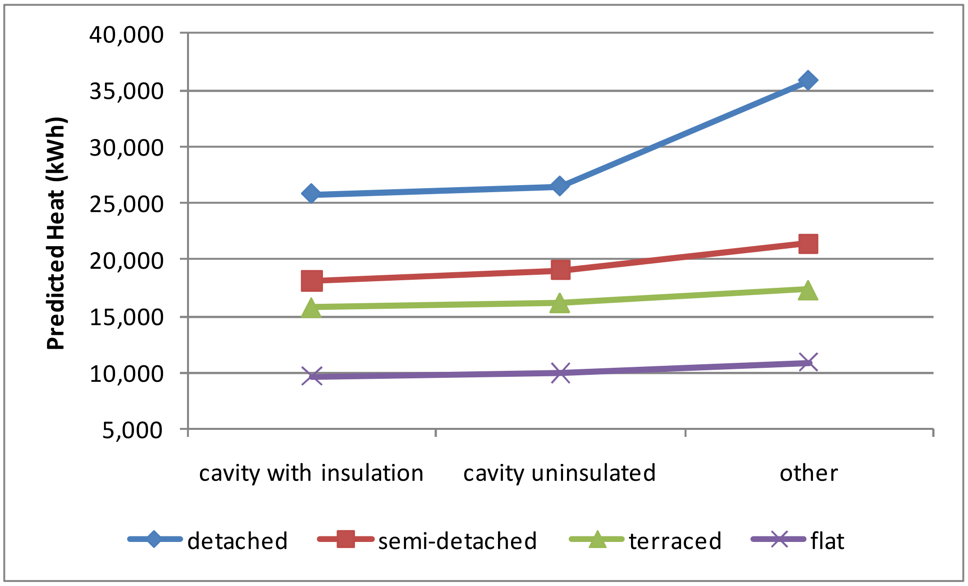
	EHCS survey results (actual)		CHAID predictions on EHCS dataset		CHAID predictions on EFS dataset	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
No loft	2,234,700	10.5	2,240,686	10.6	2,392,574	9.7
Virgin	1,376,100	6.5	1,360,670	6.4	2,132,760	8.7
Top-up	11,346,787	53.5	11,331,378	53.4	12,344,113	50.1
No opportunity	6,263,220	29.5	6,288,073	29.6	7,751,923	31.5
Total	21,220,807	100.0	21,220,807	100.0	24,621	100.0

Annex Table 4: Boiler age/ Communal heating

	EHCS survey results (actual)		CHAID predictions on EHCS dataset		CHAID predictions on EFS dataset	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
less than 3 years	4,415,847	20.81	4,392,117	20.70	4,925,467	20.00
3-12 years	7,725,105	36.40	7,715,788	36.36	8,496,413	34.49
more than 12 years	6,195,775	29.20	6,213,857	29.28	6,832,290	27.74
No boiler	2,560,697	12.07	2,577,808	12.15	4,194,205	17.03
Communal	323,383	1.52	321,237	1.51	184,698	0.75
Total	21,220,807	100.00	21,220,807	100.00	24,633,073	100.00

Cross-tabulation of predicted wall type, loft insulation and heating system in the EFS with built form and heat consumption provide a further 'sense check' and reassurance that households have been classified appropriately. This is illustrated in the figure below for wall and dwelling type.

Annex Figure 1: Predicted heat load by dwelling and wall type



Annex II – Distributing policy measures and costs

Selecting the households to receive policy measures

CERT, CESP, the RHI and FIT result in the installation of insulation and/or micro renewable measures in consumers' homes. To identify which households in the EFS dataset receive measures under these policies, the sql database creates a set of 'opportunity flags' for each EFS case. The opportunity for wall and loft insulation is based on the EHCS modelling discussed in Annex I. The model currently uses the following variables to constrain the application of renewable energy measures:

- Tenure
- Built form
- Central heating type
- Number of rooms
- Occupants
- Age of household representative
- Rurality (derived)
- Wall type

Following the identification of opportunity for measures the model then identifies cases that match the Governments funding criteria, namely:

- CERT and the Supplier Obligation – priority group or non priority group
- CESP – the bottom income decile (based on disposable income)
- RHI and FIT – the non priority group

The sql database then performs a set of queries for each policy selecting households to receive each of the relevant measures. The database records cases receiving measures to stop duplication i.e. if a case receives loft insulation under the supplier obligation it will not receive it under CESP. The model then transforms the energy consumption of the household based on the measures received.

Distributing policy costs

The DIMPSA model examines the impacts of three scenarios for policy cost recovery. The first two scenarios for cost recovery via energy bills are discussed here with more specific discussion on the model of income taxation in Annex III.

Scenario 1: SPREAD EVEN: Costs are recovered evenly across the customer base in direct proportion to household expenditure on fuel (in which there would still be some distributional impacts between households on different payment methods)

Scenario 2: COMMERCIAL REALITY: (Referred to as 'supplier' cost recovery in the main text) Costs are recovered according to commercial drivers, favouring a disproportionate loading of costs on customers with no record of switching suppliers (i.e. still with British Gas or the supplier which now owns their previously 'regional' electricity supplier) and customers not considered 'desirable' within the market context created, in part, by these policies

Scenario 3: INCOME TAXATION: Costs are recovered through income taxation as an alternative to energy bills.

Energy bill cost recovery

The total policy costs to be passed through to customers are dependent upon two key factors:

- The customer types covered i.e. domestic, commercial or both
- Fuel types covered i.e. electricity, gas, oil, coal or LPG

The Renewables Obligation (RO32) and the Renewable Heat Incentive (RHI) will apply to both domestic and commercial customers. The costs will therefore be split between these two customer groups based on their total annual consumption.

The total policy costs to distribute domestically are then divided between the relevant fuels according to the weighted number of consumers using each fuel. Table 5 below shows the fuels that may be covered by each policy.

Annex Table 5: Fuels covered by policies

Policyc	Policy	Fuels covered
1	EU ETS	Electricity
2	RO32	Electricity
3	FIT	Electricity
4	RHI	Gas, oil, LPG and coal
5	Supplier obligation	Electricity, gas
6	Smart Meters	Electricity, gas
7	CESP	Electricity, gas

Suppliers spread costs evenly – 'Spread even'

If the costs are spread evenly the model assumes that the total policy cost apportioned to each fuel (see Table 4, p.40) is divided by the sum total of households using the relevant fuels. The model then sums the increase for each fuel accounting for the policies that apply to them. This additional unit cost is then applied to each case for the relevant final heating fuel and power usage i.e. if you have oil heating your costs will increase due to the RHI and your power costs will increase due to the EU ETS, RO32, FIT, Supplier obligation and Smart Meters.

Suppliers distribute costs by attractiveness and stickiness – 'commercial reality'

CSE has developed a model to predict the distributional impacts associated with energy supplier's own business models i.e. their internal pricing mechanisms. This cost recovery model is based on the following assumptions:

- Energy suppliers will tend to load costs on to customers who are loyal (i.e. not 'switchers') and with less attractive payment methods (i.e. not direct debit)
- All competitive pricing activity is focused on direct debit 'switchers' (Ofgem's 'proactive' consumers[55])

The team discussed these assumptions (plus detail on cost splits shown in Annex Table 7) with the regulator and a high profile former energy supplier operational manager. The team then performed a review of current cost comparison websites based on former incumbent supplier / non incumbent supplier and medium usage to verify the overall cost differentials shown in Annex Table 6. This therefore shows one interpretation of how energy suppliers split their customer base into four overall categories.

A consumer's loyalty is defined by their propensity to switch; those that have switched more than once are defined as 'switchers'; and those that have switched once or never are therefore defined as non switchers. Energy suppliers still have relatively limited data on their consumers, they can therefore only load costs through their existing tariff structures. The overall attractiveness of a customer is therefore defined by payment type with attractive customers being those on direct debit i.e. a lower cost to serve and a more assured source of revenue.

The cost load flags[56] used to determine the differentials in costs are as follows:

- Cost load flag 0 – Non-switcher unattractive
- Cost load flag 1 – Switcher unattractive
- Cost load flag 2 – Non-switcher attractive
- Cost load flag 3 – Switcher attractive

The 'commercial reality' cost recovery scenario first assumes that a proportion of the costs are assigned to all households equally. The team has called this the 'rump' and assumed that 80% of costs are spread evenly using the methodology outlined above. The remaining costs are the 'non rump' and these are split according to the cost load flag i.e. 0, 1, 2 or 3 (see section 4.2 for further discussion).

[55] Ofgem, (2009). Energy Supplier Probe.
[56] The propensity to switch is based upon our analysis of Ofgem's Mori data (see Annex I) and electricity and gas method of payment as recorded by the EFS.

Annex Table 6. Theoretical 'commercial reality' approach to cost recovery through consumer bills (based on EFS customer profile)

	OTHER PAYMENT METHODS	FULLY DIRECT DEBIT
Switched more than once	**Switcher unattractive (1)** • 4.1 % of total customer base • Strategy: defensive • **100%** of 'equal share' • Impact on bills if £280 is equal share = £280	**Switcher attractive (3)** • 17.8 % of total customer base • Strategy: aggressive • 80% of 'equal share' • Impact on bills if £280 is equal share = £224
Switched once or never	**Non-switcher unattractive (0)** • 59.1% of total customer base • Strategy: excess cost-recovery • 108% of equal share • Impact on bills if £280 is equal share = £301	**Non-switcher attractive (2)** • 19 % of total customer base • Strategy: defensive • 95% of equal share • Impact on bills if £280 is equal share = £266

The impacts on bills shown in Annex Table 6 represent the theoretical numbers used to test our assumptions. However, the differentials between cost load flags shown are designed to match the current market for energy supply i.e. the difference in bill for an attractive switcher and an unattractive non-switcher is on average £80 per year, based on the EFS dataset.

The 'commercial reality' scenario first assumes that a proportion of the total policy costs to be recovered are assigned to all households equally. The team has called this the 'rump' and assumed that 80% of costs are spread evenly using the methodology outlined above. The remaining costs are the 'non rump'. Annex Table 7 shows how these are then split according to the cost load flag i.e. a higher proportion is loaded onto the stickier and less attractive customers.

Annex Table 7: Customer base and distribution of policy costs by cost load flag in 2009

Cost load flag	Count (households)	Percentage of customer base	Percentage of 'non rump'
0	11,351,831	45.7%	60.6%
1	800,004	3.2%	0.45%
2	7,003,240	28.2%	27.5%
3	5,690,689	22.9%	11.5%

It is important to note that the percentage of customers in each cost load flag varies between Annex Table 6 and Annex Table 7. The model assumes householders who install a heat pump and change heating fuel to electricity, then choose to pay by direct debit.

DECC has given CSE permission to use the assumptions that underpin our work for Government on the Low Carbon Transition Plan in this study. Annex Table 8 shows by cost load flag:

- The average final bill in 2009 before measures or the impacts of policy costs
- The average final bill in 2020 including the impact of policy costs and measures (spread evenly)
- The average final bill in 2020 including the impact of policy costs and measures with the inclusion of 'commercial reality' pricing structures

Annex Table 8: Projected 2020 changes in bills under the different cost recovery scenarios

Cost load flag	Description	Count (Households)	Average Total Household Energy Bill			Average supplier cost differential
			2009	2020 Spread even	2020 Supplier cost recovery	
0	Non-switcher, non-DD	11,351,831	£1,099	£1,245	£1,271	£25.27
1	Switcher, non-DD	800,004	£1,021	£1,171	£1,157	-£14.60
2	Non-switcher, fully DD	7,003,240	£1,127	£1,282	£1,280	-£1.89
3	Switcher, fully DD	5,690,689	£1,317	£1,511	£1,465	-£46.03

The average supplier cost differential in 2020 as a result of the commercial reality scenario ranges from +£25.27 to -£46.03. The overall difference between the least attractive sticky customers and the so-called 'proactive consumers' mirrors that experienced in 2009 i.e. the current level of tariff differentiation. The team has assumed that the present situation will not become more acute for non-switchers on prepayment meters or standard credit i.e. the cost differential will not diverge further. However, the team has assumed a slight improvement in the tariff offering for switchers using less attractive payment methods, hence a slightly higher average bill reduction for cost load flag 1 vs. 3.

Future tariff development

The current proposals for mandatory social tariffs suggest that the Government plan to provide a higher degree of regulation in the future. The team have identified the following factors which may impact on the future cost differential:

- The smart meter roll-out will provide suppliers with an opportunity to offer more varied and responsive tariffs; however, these tariffs may be more complicated and thus more opaque.
- The cheque clearance system may be obsolete making standard credit less viable for many consumers.
- Prepayment is likely to be retained in a 'pay as you go' format that mirrors mobile technology and other utilities; however, suppliers are likely to pass on costs associated with payment through third parties.
- 'Pay as you go' may be redefined as attractive depending on the customer's method of pre-payment and potential use of paperless billing.

Annex III: Cost recovery from income taxation

DIMPSA has been modified to include a model of UK Income Taxation. The taxation model uses the data contained in the Expenditure and Food Survey (EFS) to predict the current level of revenue generated from income tax and the potential for additional revenue in the future.

The EFS is a diary based survey that's designed to provide statistically representative data on commodities expenditure for the UK. Researchers typically use this data in combination with the reported income and demographic data to analyse social trends and the distributional impacts of expenditure.

The income taxation model uses detailed EFS data on income from earnings, investments, pensions and benefits. The collection of income data is particularly difficult given the complexity and sensitivity of the information. For example, respondents may know their overall level of income without a detailed knowledge of the level of tax or national insurance they pay. In addition, respondents may also misreport this information due to concerns about the sharing of data with other parties.

The key variables used in the prediction of income tax include:

- Number of adults
- Number of children
- Age and sex of household reference person (hrp)
- Employment status of hrp
- Age of oldest person in the household
- Gross household income
- Disposable household income
- Main household income source i.e. wage, self employed, benefits etc.
- Main household income value
- Estimated hrp income
- Self employed tax household
- Income tax from employer
- Income tax less refunds
- Total benefits
- Total benefits from pensions (taxable)
- Income from annuities and pensions
- Taxation on pensions
- Income from investments

The team has compared the level of income taxation reported in the EFS 2004-07 (income tax less refunds) with that reported in the 2006 Budget. The 2006 Budget estimated total income tax revenue of

136bn[57] compared to the EFS three year average of £114bn. It is therefore important to note that the data reported in the EFS underestimates the receipt of revenue from income tax.

Modelling income tax in the survey year

The model first calculates income tax in the survey year based on the income tax thresholds and rates at that time[58]. The model performs the following calculations:

- The gross income is first split into two – the main hrp's income and a second partner income (where the household size is larger than 1 and the gross income less benefits exceeds the hrp income)
- These incomes are then assigned their HMRC tax allowances based on the given survey year and the respondents ages
- Once the allowances have been set the tax rates are applied to the taxable earnings
- The two values for income tax are then combined to give an overall value for household income tax payments

The model provides predicted income tax revenue of £136bn i.e. the calculated income tax rather than the reported EFS survey income tax value. The predicted value is significantly closer to the 2006 Budget estimate of £136bn than the actual value given by the survey. The model could therefore potentially ignore the reported survey value and instead use a value predicted by the model. The team has chosen not to do this as:

- It is typically good practice to retain the survey values rather than substitute your own modelled values;
- The model uses the survey reported disposable income values to analyse the distributional impacts of climate change polices. The survey reported disposable income is derived from the gross income less taxation, and as such this may also then need to be adjusted to reflect the under reporting of taxation.

Modelling current income tax

The income tax model uses a similar approach to that employed when predicting changes in future income levels. These are typically calculated using an inflation factor based on more inherently accurate datasets. For example, the Annual Survey of Hours and Earnings (ASHE) provide a detailed breakdown of income changes by sex and income deciles. The change in income between the survey year (EFS) and the present year[59] (2008) in ASHE data would be used to calculate an inflation factor for incomes, up-rating them to the present year. The model therefore calculates income tax in 2009 as follows:

- The incomes are up-rated from 2008 to 2009 using the projections for national income levels provided by the 2009 Budget[60];

[57] www.hm-treasury.gov.uk/d/bud06_chc_247.pdf. Revenue raised confirmed as £135bn in the 2007 Budget.
[58] www.hmrc.gov.uk/rates/it.htm
[59] ASHE data is available up until 2008
[60] Table 1.4 of www.hm-treasury.gov.uk/d/Budget2009/bud09_econfinances_968.pdf

- These incomes are then assigned their HMRC tax allowances based on the 2009 tax thresholds and the respondents ages;
- Once the allowances have been set, the 2009 tax rates are applied to the taxable earnings;
- The two values for income tax (hrp and partner) are then combined to give an overall predicted value for household income tax in 2009;
- The estimated value of income tax in 2009 is then divided by the value predicted for the survey year to calculate an inflation factor. This factor is then applied to the survey reported income tax value to generate a 2009 total.
- There are a number of cases that pay income tax in 2009 but wouldn't have been required to in the survey year i.e. changes to their income or tax allowances have changed their income tax status. In these incidences the modelled value of income tax in 2009 is assigned to the case.

Modelling future income tax

The modelling of income tax in 2020 requires the user to establish two tax scenarios. Annex Table 9 shows the tax allowances and rates for the baseline scenario and an additional revenue scenario. The baseline thresholds are based on Government income projections and the historical changes to income tax bands in the last decade.

Annex Table 9: Tax allowances and rates

Tax settings	2020 baseline	2020 additional revenue
Band 1	£3,355	£3,355
Band 2	£52,000	£52,000
Start rate	0.1	0.1
Middle rate	0.22	0.232
Top rate	0.40	0.46
DIMPSA total	£142,795,213,361	£152,104,071,585
EFS total	£119,510,996,032	£127,198,663,488

The model calculates income tax revenue in 2020 as follows:

- First the gross incomes are up-rated from 2009 to 2020 using an inflation factor supplied by DECC and Treasury;
- These incomes are then assigned the tax allowances shown in Annex Table 9 for each scenario;
- Once the allowances have been set the scenario tax rates are applied to the taxable earnings;
- The two values for income tax (hrp and partner) are then combined to give an overall predicted value for household income tax in 2020 under each scenario;
- The estimated value of income tax in 2020 is then divided by the value predicted for the survey year to calculate an inflation factor for each scenario. This factor is then applied to the survey reported income tax value to generate a 2020 total.

- There are a number of cases that pay income tax in 2020 but wouldn't have been required to in the survey year. In these incidences the modelled value of income tax in 2020 is assigned to the case.

The model then compares the two values for income tax revenue in 2020 to determine the additional revenue generated. This is then compared to the total climate change policy costs to determine:

- If the total policy cost is met, then the additional income tax payment is subtracted from the household income (both gross and disposable).
- If the total policy cost isn't met, then the total revenue raised is taken from the policy costs with the remainder being distributed to energy bills. The additional income tax payment is also subtracted from the household income (both gross and disposable). In this instance the team adjusted the income tax bands until sufficient revenue was produced.

Annex IV: The social justice evaluation scheme

The evaluation scheme applied in section 3.5 (p.32) of this report was broadly informed by a capabilities approach to thinking about human welfare, as developed by Amartya Sen and others from the 1980s onwards (Sen, 2009[61]). Such a perspective encourages us to pay attention to people's real opportunity for living a life they value and thus has a broader scope than, say, income. More specifically, the evaluation scheme draws on existing European Commission Impact Assessment Guidelines[62], a review of indicators for socio-economic security, social cohesion and social inclusion (Van der Maesen and Walker, 2005)[63], as well as specific studies in the realm of environmental justice (Pye et al., 2008[64]).

Four main dimensions of social justice were identified:

- *Distributional justice:* social and economic inequalities derived from a different distribution of primary goods between different income groups;
- *Fair access:* the ability of vulnerable groups to access social and economic goods and their capacity to transform them into well-being;
- *Intra- and inter-generational justice:* the opportunity for people outside the developed world as well as future generations to live valuable lives; and
- *Environmental justice:* the distribution of the costs (and the opportunities) of climate change mitigation policies, as well as of environmental quality.

In the present context, we are concerned with the links between climate change mitigation and social justice *in Europe* and so the North-South dimension is outside our scope.

Based on the literature and a bottom-up sociological analysis of those domains of daily life likely to be affected by climate change mitigation policies, an initial long list of fifty indicators was developed. This was then reduced to a more manageable set of 14 indicators. Whilst this list cannot be comprehensive, it at least provides a starting point for thinking systematically about the links between social justice and climate change mitigation policies. Box 1 below, shows the indicators grouped according to the dimensions of social justice outlined above.

Section 3.5 of this report sets out the results of using this set of indicators to explore the links between UK climate change policies and social justice. Due to the short timescale of this project, the analysis is necessarily superficial and only a selection of indicators is discussed for each policy measure. Moreover, we have not been able to take account of the fact that policy measures can be deployed alone or in combination with others, and this will of course influence the way in which they impact on social justice.

[61] Sen, A (2009). The Idea of Justice. Allen Lane, London.
[62] European Commission, (2009). Impact Assessment Guidelines, SEC (2009)92, 15.01.2009.
[63] Van der Maesen, L.J.G. and Walker, A.C., (2005). Indicators of social quality: Outcomes of the European Scientific Network, *European Journal of Social quality*, Vol. 5, Issue 1-2, pp8-24.
[64] Pye, S., Skinner, I., Meyer-Ohlendorf, N., Leipprand, A., Lucas, K. and Salmons, R. (2008). Addressing the social dimensions of environmental policy. A study on the linkages between environmental and social sustainability in Europe, for the European Commission - DG Employment, Social Affairs and Equal Opportunities, Brussels.

Box 1: Definition of social justice indicators (King Baudouin Foundation)

Distributional justice

Social and economic inequalities derived from a different distribution of primary goods between different income groups.

Price of essential goods: Does this climate change policy measure increase (negative impact, -) or decrease (positive impact, +) the price of essential goods such as food, drink or clothing? ***Implications for social justice***: Low-income groups use a greater proportion of their income on such essential goods compared to medium- and high-income households. An increase in the price of essential goods, for example, as a consequence of higher energy prices is therefore likely to affect low-income groups more.

Cost of domestic energy services: Does this climate policy measure increase (-) or decrease (+) heating and electricity costs? Does it increase maintenance costs or require the purchase of new devices? ***Implications for social justice***: Increases in heating and electricity costs have a significant impact on the capacity of households to access adequate energy services in the home. Refurbishment, the installation of solar panels or the installation of new energy-efficient equipment all require investment that low-income households are less able to afford without compensation measures.

Transport costs: Does this climate policy measure increase (-) or decrease (+) transport costs? ***Implications for social justice***: Higher daily transport costs as a consequence of e.g. fuel taxes, road pricing, increased cost of parking, will have a negative effect on low-income households, unless there are opportunities for a modal shift to e.g. public transport, cycling or walking.

Employment effects: Does this climate policy measure result in an overall increase (+) or reduction (-) in employment? ***Implications for social justice***: Impacts on employment arise mainly from the economic impact of climate policies, which can be highly uneven between sectors and individual forms, reflecting their competitive market changes, the availability of government support etc. The availability of employment is a key aspect of social justice.

Labour market transition/restructuring: Does this climate policy measure promote labour market transition? Does it provide adequate compensation measures for workers who lose their jobs (+) or not (-)? ***Implications for social justice***: Labour market transitions may have negative consequences for low-skilled workers, because they might lose a job in a sector in which they are skilled but fail to secure employment in a new sector that requires other specific skills.

Fair access

The ability of vulnerable groups to access social and economic goods and their capacity to transform them into well-being.

Health: Does this climate policy measure improve (+) or worsen (-) public health? How are these effects distributed? ***Implications for social justice***: Some policy measures, such as those directed at improving the housing stock or promoting a modal shift to cycling and walking can have significant co-benefits in terms of public health.

Consumer access to information: Does this climate policy measure provide easy access to reliable consumer information (+) or not (-)? ***Implications for social justice***: Adequate information is essential to be able to make informed choices. It is also essential to be able to benefit from support mechanisms for energy efficiency or renewable energy installations.

Citizenship: Does this climate policy measure promote more (+) or less (-) citizen participation in economic, social, civic and political activities? Is the citizen more (+) or less (-) aware of climate change issues? ***Implications for social justice***: The ability to participate in the economic, social, civic and political life of society is a useful indicator of social inclusion. It contributes to raising awareness and citizens' responsibility regarding social and environmental issues.

Gender equality, non-discrimination, equal treatment: Does this climate policy measure increase (+) or decrease (-) social equity, with regard to gender, disability, migrants, low-income households? ***Implications for social justice***: Social equity means that people have equal capacity to access social and economic goods, regardless of their social and economic background.

Environmental justice

Distribution of climate policy costs: Are the costs of these climate policy measures, including taxes, levies and grants, fairly (+) or unfairly (-) distributed among social groups? Do they imply higher costs for low-income households expressed as a share of their income? ***Implications for social justice:*** Besides the logic of 'the polluter pays', social justice should also take into account a fair distribution of costs among citizens and avoid regressive impacts, which weigh more on low income and other vulnerable groups.

Distribution of environmental quality: Does this climate policy measure improve (+) or worsen (-) the geographical distribution of environmental damage/improvement across nations, regions, local communities? Does it benefit/affect more rural or urban areas? ***Implications for social justice***: Environmental justice theories highlight the connection between environmental degradation and the standard of living. Poor people are more likely to live in low-quality environments than medium- and high-income households due, for instance, to lower housing costs.

Corporate environmental responsibility: Do these climate policy measures imply more (+) or less (-) corporate responsibility for the environmental consequences of their actions?

Implications for social justice: If companies have greater legal obligations regarding their environmental footprint, this can improve their sense of responsibility and their willingness to act. It can also increase access to justice for ordinary citizens in terms of their capacity to take action against companies regarding their quality of life (see point 7, citizenship).

Intra- and inter-generational justice

The opportunity for people outside the developed world as well as future generations to live valuable lives.

Sustainability of public finance: How do these climate policy measures affect the overall level of public debt, upwards (-) or downwards (+)? ***Implications for social justice***: A long-term expansive budgetary policy in support of a climate change mitigation policy may not be sustainable for public finances and, in certain Member States, it may affect the social protection and health systems if it drains resources from them. Public debt entails inter-generational costs, transferred to the next generations. Present generations have the responsibility not to worsen the conditions of future generations through untenable economic policies.

Inter-generational ecological debt: Are these climate policy measures environmentally effective? Is their overall impact, both on the climate and other ecological concerns such as natural resource consumption, generally positive (+) or negative (-)? Are there negative effects that will be transmitted to future generations? ***Implications for social justice:*** As with public finance, the current generation has the responsibility to safeguard the environment without incurring the creation of unreasonable ecological debts that will weigh upon future generations.