A ‘green and fair’ tax system in Scotland: Distributional impacts and impacts on rural poverty of a carbon tax in Scotland

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Glossary

Affordable Warmth Scheme – Affordable Warmth is offered to households in Scotland that are vulnerable to fuel poverty as defined by the UK Government's affordable warmth group. They must be the homeowner or the tenant of a private sector landlord and must be in receipt of qualifying benefits. Affordable Warmth energy efficiency measures are installed and paid for by the energy companies through the Energy Company Obligation (ECO).

Boiler Scrappage Scheme – A scheme that offered a rebate of £400 on the replacement of eligible boilers. The scheme closed in Scotland in 2013.

Carbon Capture and Storage (CCS) – Technology attempting to prevent the release of large quantities of CO_2 into the atmosphere from fossil fuel use in power generation and other industries by capturing CO_2, transporting it and ultimately, pumping it into underground geologic formations to securely store it away from the atmosphere.

Carbon price – The cost of emitting a ton of carbon dioxide or its equivalent under a carbon tax or an emissions trading system.

Carbon Price Floor (CPF) – The carbon price set by the EU ETS has not been certain or high enough to encourage sufficient investment in low-carbon electricity generation in the UK. The CPF is a pricing mechanism that has been created to set a minimum price for carbon emissions in the traded EU ETS market for carbon from the electricity generation sector.

Energy Assistance Scheme (EAS) – The Scottish Government funds measures under the Energy Assistance Scheme. It offers grants for up to £4,000 worth of work (or sometimes up to £6,500) for eligible households.

Energy Company Obligation (ECO) – The Energy Act 2011 Amends existing powers in the Gas Act 1986, Electricity Act 1989 and the Utilities Act 2000 to enable the Secretary of State to create a new Energy Company Obligation to take over from the previous obligations to reduce carbon emissions which expired at the end of 2012, and to work alongside the Green Deal finance offer by targeting appropriate measures at those households which are likely to need additional support, in particular those containing vulnerable people on low incomes and those in hard to treat housing.

Equivalised income – The income that a household needs to attain a given standard of living will depend on its size and composition. For example, a couple with dependent children will need a higher income than a single person with no children to attain the same material living standards. Equivalised income adjusts a household's income for size and composition so that the incomes of all households can look at on a comparable basis.

EU Emissions Trading Scheme (ETS) – The European Union greenhouse gas emissions trading scheme began in 2005, and covers carbon dioxide emissions from six sectors of heavy industry, including electricity generation, steel-making, cement-making, pulp and paper, and glass. Companies covered by the scheme may emit only a certain quota of carbon dioxide each year, and are issued with carbon permits for every tonne of the quota. They can trade these permits with each other. In successive phases of the scheme, the quota is reduced so that the overall emissions fall.

Feed-in tariff (FIT) – A feed-in tariff (FIT) scheme offers guaranteed cash payments to homeowners, business and organisations such as schools and community groups that generate their own electricity through small-scale green energy installations such as solar photovoltaic (PV) panels or wind turbines. It guarantees a minimum payment for all electricity generated by the system, as well as an additional payment for the unused electricity produced that can be exported to the grid, known as the Generation tariff and Export tariff respectively. The level of payment depends on the technology and whether it is being fitted to an existing home, or installed as part of a new build. In the UK, future payments are guaranteed for the next 20 years for solar and wind turbine-generated power and are linked to inflation. Solar installations registered before 1 August 2012 will receive the payment for 25 years.

Green Deal – A UK government scheme to tie low interest loans, issued by Green Deal Providers for energy efficiency improvements to the energy bills of the properties the upgrades are performed on. These debts would then be passed on to new occupiers when they take over the payment of the bills. Green Deal works in conjunction with the Energy Company Obligation (ECO).

Home Energy Efficiency Programmes for Scotland (HEEPS) – Offers various types and levels of assistance to help make homes warmer and more energy efficient. Energy suppliers fund measures under the Affordable Warmth Scheme (AWS) and the Scottish Government funds measures under the Energy Assistance Scheme.

Living Costs and Food Survey (LCF) – The Living Costs and Food Survey (LCF) is a survey by the Office of National Statistics that collects information on household expenditure, food consumption and income that reflects household budgets across the country. In April 2001 the Family Expenditure Survey (1961-2001) and the National Food Survey (1974-2000) were combined to form the Expenditure and Food Survey (EFS). From January 2008, the EFS became known as the Living Costs and Food Survey (LCF), a module of the Integrated Household Survey (IHS). The survey includes 12,000 households a year.

Pension Credit – A means-tested benefit aimed at the poorest retired people. It has two elements: Guarantee Credit is an income-based benefit which is paid if the income of the applicant and partner (plus a notional income from savings) is below a certain level. The minimum age for claiming is rising in line with the increase in women's retirement age. It is currently just over 60, but by April 2020 the minimum age for claiming will be 65. When the applicant or partner reaches 65 then the second element, Savings Credit, is also payable. Savings Credit is designed to "reward" people who saved for their pension during their working life. It therefore provides additional benefit to retired people who are not well off, but do have savings or a personal pension, and may not qualify for the full Guarantee Credit.

Product Policy – A policy measure aimed at influencing the design of a product so as to reduce its impact on the environment. In this context, it usually refers to tightening regulatory standards for the energy or water consumption of household appliances and electronic devices.

Renewable Heat Incentive (RHI) – A payment system for the generation of heat from renewable energy sources. The RHI operates in a similar manner to the feed-in tariff system. In the first phase, starting in November 2011, payments are paid to owners who install renewable heat generation equipment in non-domestic buildings. The RHI was extended to domestic buildings from April 2014.

Through the RHI, generators of renewable heat are paid for hot water and heat which they generate and use themselves. The RHI tariff depends on which renewable heat systems are used and the scale of generation. The annual subsidy will last for 20 years.

Renewables Obligation (RO) – A policy designed to encourage generation of electricity from eligible renewable sources in the United Kingdom. The RO places an obligation on licensed electricity suppliers in the United Kingdom to source an increasing proportion of electricity from renewable sources.

Smart meter – A smart meter is usually an electrical meter that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes. Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting. Such an advanced metering infrastructure (AMI) differs from traditional automatic meter reading (AMR) in that it enables two-way communications with the meter.

Universal Credit – A new welfare benefit in the United Kingdom that will replace all the main means-tested benefits and tax credits for working-age people except for Council Tax Benefit. The Government plans to introduce Universal Credit over the period to 2017/18

Warm Home Discount Scheme – A scheme which helps some older people with energy costs. Energy companies give those eligible a discount on their bill (£140 in 2014/15). People are eligible if they are aged under 80 and receiving only the Guarantee Credit element of Pension Credit (no Savings Credit) and people aged 80 or over who are receiving the Guarantee Credit element of Pension Credit (even if they receive Savings Credit as well). Some other older people are eligible, but the rules vary depending on which energy supplier they are with.

Executive Summary

Introduction

This paper looks at how a green tax like a carbon tax can be introduced to promote the desired environmental outcomes (in this case carbon savings) while protecting those least able to pay or able to change their behaviours to reduce their tax exposure. Specifically it examines how to design a revenue-neutral carbon tax on household energy use and private road transport in Scotland, with a focus on safeguards to protect low-income households. This study is illustrative of the way in which a green tax needs to interact with the wider benefit and tax system to balance environmental and social concerns.

Methodology

The study uses two models that are both based on the Living Cost and Food (LCF) Survey, namely:

- The Centre for Sustainable Energy's (CSE) Distributional Impacts Model for Policy Scenario Analysis (DIMPSA) to model the energy consumption and expenditure of UK households
- The Institute for Fiscal Studies' (IFS) model TAXBEN to calculate the effect of changes in taxes and benefits.

The modelling in this study looks forward to 2017/18 and takes into account the effects on household energy consumption and road transport emissions of existing policies and, as far as possible, future policies that are already planned. That date was chosen because 2017/18 is when Universal Credit is planned to come fully into force.

For the level of the carbon tax, the team have used the published traded and non-traded carbon prices for Government appraisal as a benchmark.[1] The prices contain three thresholds low, central and high. In the light of the conclusions of the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report,[2] and the clear urgency for action, the team opted to model the high carbon price scenario in this study. Two different values were applied, to allow for the fact that emissions associated electricity generation are already traded. Therefore, the carbon tax was charged at £21 per tonne of carbon dioxide for electricity (the expected price in 2017 at the time of modelling) and £94 per tonne for all remaining fuels (including road transport fuels). These values were applied to the household and road transport emissions totals in 2017 to determine the amount paid by each household and the total amount of revenue raised.

Taxing domestic sector carbon emissions in Scotland in 2017

Analysis of the average annual carbon tax paid on household fuels and road transport (petrol and diesel) by equivalised annual income decile in 2017 is shown below. There appears a clear correlation between income and carbon tax paid, with the richest 10% of households paying almost £200, whilst the poorest 10% of households pays £80 a year on average. However, whilst richer households pay more, this represents a smaller proportion of their household income compared to lower income households.

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[1] Values for Traded and Non-traded sectors: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal (tables 1-20, table 3)
[2] IPCC, 2014. "Impacts, Adaptation and Climate Change" http://www.ipcc.ch/report/ar5/wg2/

There is also a notable difference in the proportion of total carbon tax paid on household fuels and road transport across income groups. For the lowest income households, consumption of energy in the home accounts for 74% of the total carbon tax paid (£59 a year on average for household emissions, compared to £21 for road transport emissions), whilst the highest income group pay proportionally less carbon tax on household fuels (£103, or 54% of their total average annual carbon tax, Figure ES 1). This pattern reflects (amongst other factors) vehicle ownership, which is higher amongst higher income households.

Figure ES 1. Average annual carbon tax paid in 2017 by equivalised annual income decile

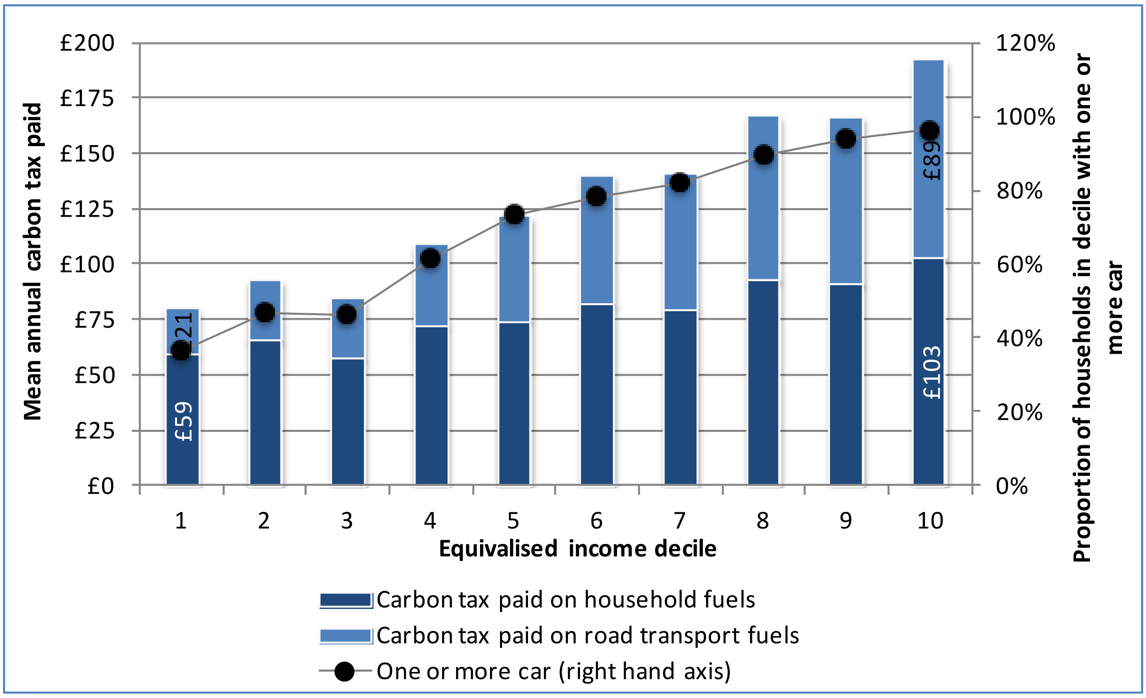


Figure ES 2 below shows the average annual carbon tax paid by geographical area ("rurality"). Households in the less urban areas appear to pay relatively more tax on average on energy consumed in the home; this is likely to reflect the nature of dwellings (a higher proportion of older, less energy efficient properties in rural areas and reliance on more carbon intensive heating fuels due to lack of mains gas network).

Looking at the average carbon tax paid on road transport emissions suggests that – perhaps contrary to expected results - households in the more remote areas do not pay the highest annual carbon tax on average compared to other areas. This is linked to the lower levels of car ownership in the very remote areas.

The average carbon tax paid on road transport fuels appears to increase from "large urban areas" to "accessible" areas, but reduce when comparing those in remote (which includes "very remote") areas. This suggests that other factors - beyond physical location of the property – have a stronger influence over vehicle fuel use (and therefore carbon tax paid on road transport emissions) (e.g. location of employer and the types of employment available and / or having the financial and physical capacity to travel long distances).

Figure ES 2. Average annual carbon tax paid in 2017 by urban/rural identifier

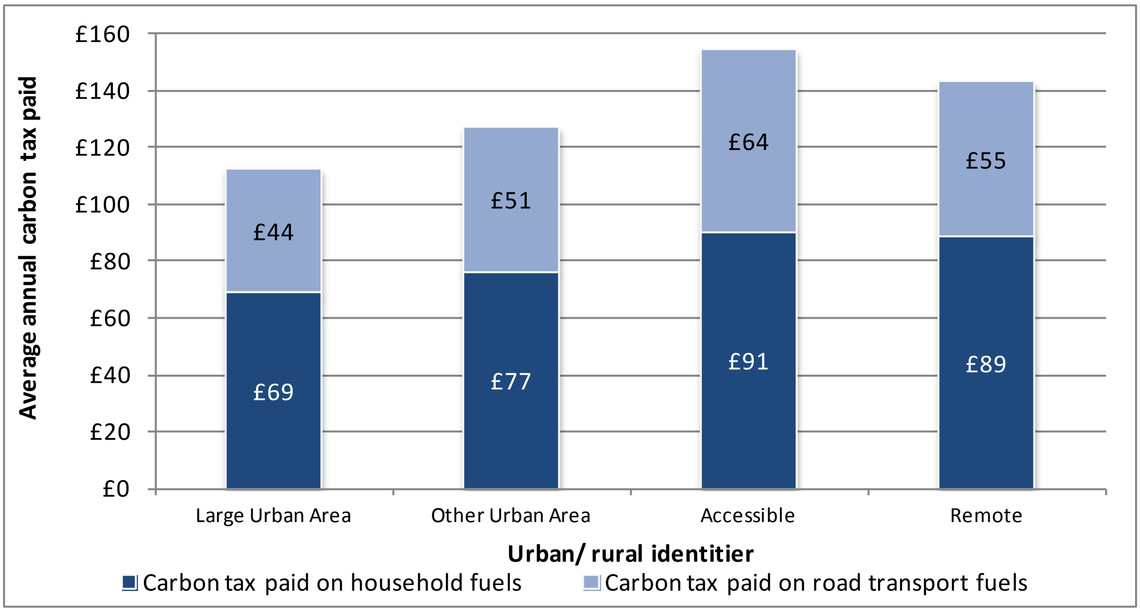
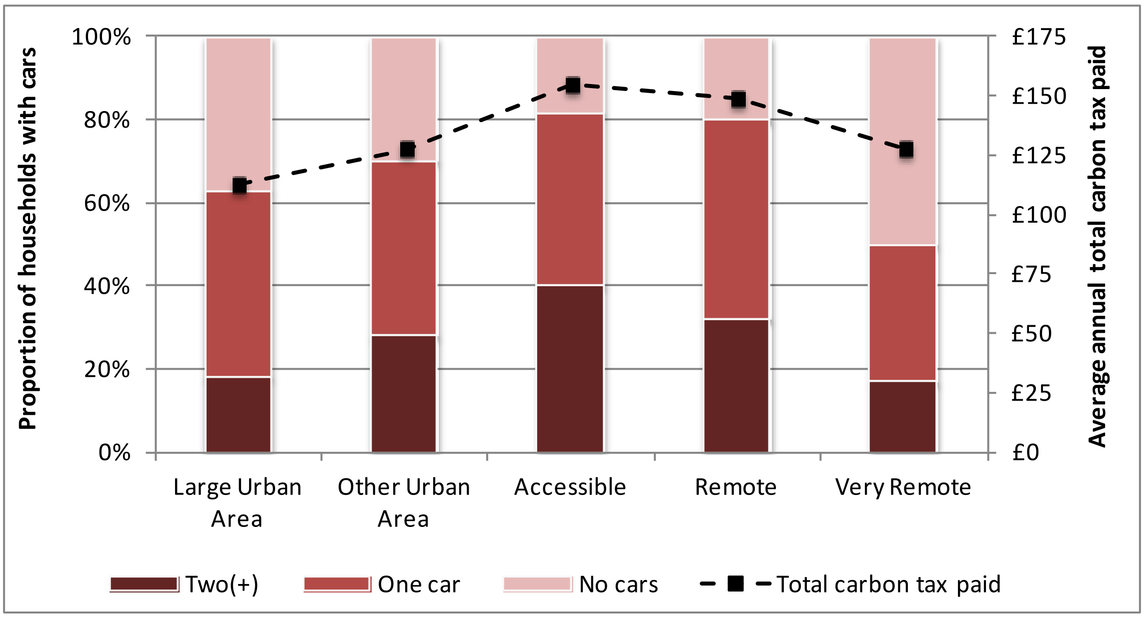


Figure ES 3 provides further insight into these underlying factors: it shows that both income and vehicle ownership is greatest in households in "accessible" areas (where 80% of households have a vehicle, half of whom have 2 or more vehicles); and lowest – income notably so – in the more remote areas.

Figure ES 3. Number of cars in household and average total carbon tax paid in 2017 by urban/rural identifier



Tax and benefit compensation packages

The IFS TAXBEN model was used to simulate a compensation package to recycle the revenue raised from the carbon tax in Scotland back to households. The aim of this modelling is to demonstrate how low income households can be protected from the adverse impacts of a carbon tax.

The compensation mechanism can be designed in different ways and for the purposes of this study we have limited ourselves to changes in benefits and pensions and applied three criteria in the design of the compensating changes:

1. Revenue neutrality – the revenue from the carbon tax and the increase in benefits are equal. On average, households are no better or worse off than before the introduction of the tax.

2. No particular household type is favoured over any other.

3. The number of low-income losers from the tax is minimised.

The compensation package involves changes to Universal Credit, in particular increasing the basic amounts of Universal Credit that different family types get and lowering the rate at which it is withdrawn as incomes rise. [3] To compensate low-income pensioners for the carbon tax in much the same way, Pension Credit amounts are also increased. The details are given in Table ES 1 below, with all figures in nominal terms in 2017–18. The compensation package gives a total of £300 million to households in Scotland in 2017–18, which is the same aggregate amount that the carbon tax in Scotland, as modelled in this study, would raise.

Table ES 1. Details of compensation package

Annual increase in	
Pension Credit for singles	£300
Pension Credit for couples	£500
Universal Credit for singles without children	£300
Universal Credit for lone parents	£200
Universal Credit for couples without children	£700
Universal Credit for couples with children	£300
Universal Credit taper rate	-2ppt (from 65% to 63%)
Total cost of package	**£0.3 billion**

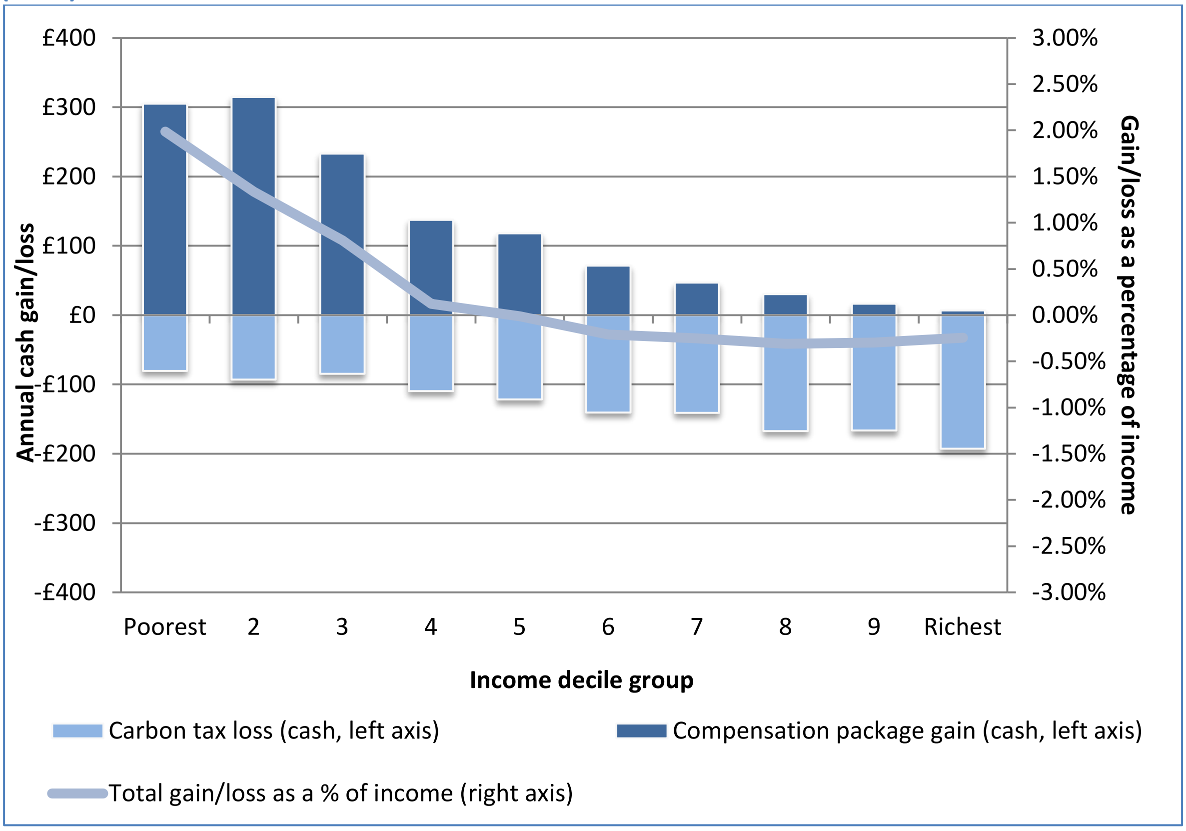
Figure ES 4 shows average carbon tax amounts and average gains from the compensation package for households in each decile group of the Scottish income distribution (left axis), along with the combined net gain or loss as a percentage of income (right axis).

Increases in Universal Credit and Pension Credit that recycle the revenue raised by the carbon tax easily compensate lower-income households, on average. Each of the bottom three Scottish income

[3] The taper rate is the rate at which Universal Credit will be withdrawn for each additional pound of income. For example, a taper rate of 65% means that for an additional pound of income, UC will be reduced by 65p, so the claimant will keep 35% of any additional income.

decile groups gains on average from the combined carbon tax and compensation package, with average net gains of about 2% of income (£310 per year) in the bottom decile and about 0.8% of income (£230 per year) in the third. The net effect on the fourth and fifth decile groups is close to zero, on average. Revenue neutrality implies that these gains are balanced by average losses in higher-income households, although as a percentage of income these losses are much smaller than the gains to lower-income households.

Figure ES 4. Distributional impact of carbon tax and associated compensation package in Scotland (2017)



Notes and sources: Notes: Income decile groups are derived by dividing all households in Scotland into 10 equal-sized groups according to income adjusted for household size using the McClements equivalence scale. Decile group 1 contains the poorest tenth of the population, decile group 2 the second poorest, and so on up to decile group 10, which contains the richest tenth.

Source: Authors' calculations using DIMPSA and TAXBEN run on the 2006-2010 Living Costs and Food Surveys.

Of course, Figure ES 4 masks variation within each income decile. For example, the near-zero net gains in the fourth and fifth deciles aggregate the losses of some households together with the gains of other households. To identify "winners" and "losers", we apply a better or worse off threshold of greater than £1 per week respectively. We include a 'broadly unaffected' category for those households who gain or lose by less than £1 per week (£52 per year) as a result of the combined carbon tax and compensation package (see Box ES1 for full details).

Box ES1. Defining winners and losers

Overall gain or loss = Compensation package gain – Carbon tax

'Winners' = overall gain of at least £52 per year
'Broadly unaffected' = overall gain or loss less than £52 per year
'Losers' = overall loss of at least £52 per year

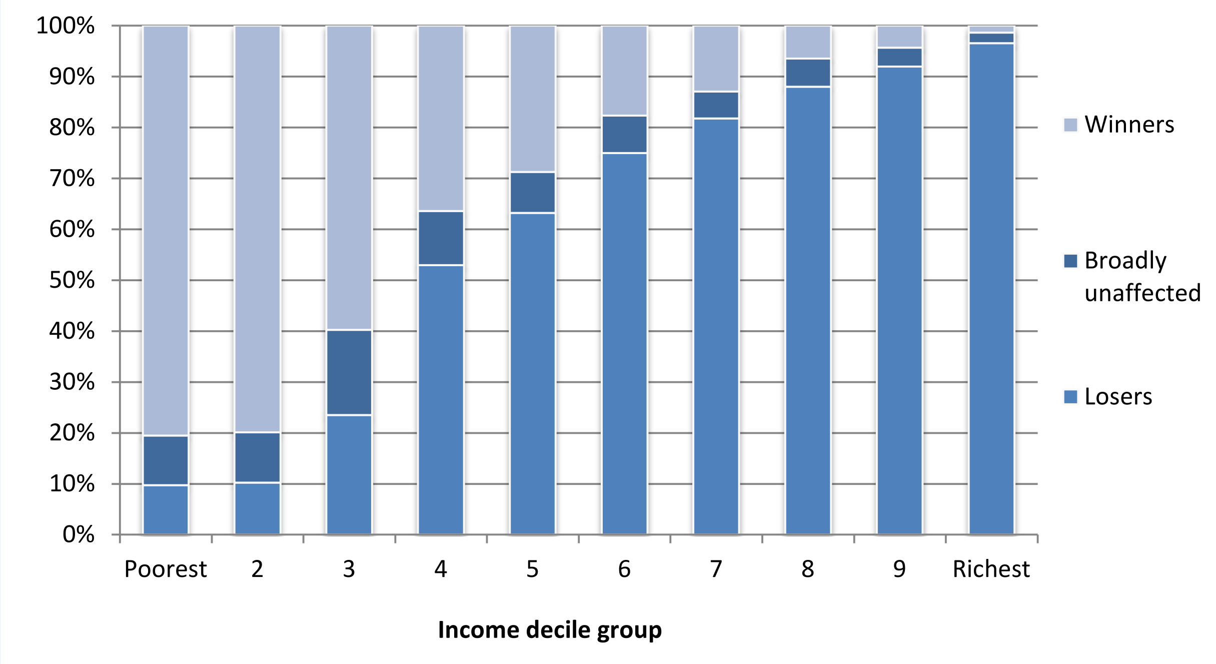
Overall a third of households are better off as a result of the combined effects of the carbon tax and its compensation package in 2017 in Scotland (Table ES 2), whilst 59% are worse off and 8% 'broadly unaffected'.

Table ES 2. Winners and losers under carbon tax and benefits package in Scotland (2017)

	Count (000s)	%	Mean 'net gain'
Loser	1,383	59%	-£160
Broadly unaffected	184	8%	-£18
Winner	764	33%	£289

Figure ES 5 shows the proportion of households in each income decile group that gains or loses from the combined effects of the carbon tax and its compensation package. This shows that most low-income households in Scotland gain overall from the combined carbon tax and compensation package, and most high-income households lose. This is unsurprising given the results shown in Figure ES 4 and given that the compensation packages are deliberately skewed towards lower-income households. The compensation packages do not eliminate low-income losers entirely. Some low-income households are not entitled to means-tested benefits (e.g. because they have significant amounts of capital or because they are students) or are particularly high users of carbon, and they will be particularly difficult to compensate by these means. Nevertheless, about 90% of households in the first and second income deciles and almost 80% of households in the third income decile are compensated, or more-than-compensated, for the carbon tax that they would have to pay.

Figure ES 5. Winners and losers by income decile from carbon tax and associated compensation package in Scotland (2017)



Notes and Sources: as for Figure 5.1.

Figure ES 6 explores this effect in more detail, showing the average net/gain loss for winning and losing households (the broadly unaffected group is omitted here hence the bars do not add up to 100%) by income quintile and the overall average net gain/loss for the group (quintile) as a whole (this information is shown by income quintile rather than the deciles used previously due to small sample sizes associated with this detailed level of analysis).

As we saw previously, the majority of low income households appear better off under the carbon tax/benefit system modelled here, with 80% of the lowest income quintile experiencing a net benefit – "winning" – and by a convincing margin of around £300 a year on average (Figure ES 6).

The proportion of households "winning" decreases as income levels increase: less than a quarter (23%) of income quintile 3 are winning, although by a similar amount as quintile 1 (£300 a year on average), whilst only 3% of the top income quintile are better off overall and by less than half that of the lowest income group.

There appears less variation in the average net loss of households made worse off, which ranges from £129 for the 10% of losing households in quintile 1, to £180 for the 94% of losing households in quintile 5.

Overall, the average net impact of the carbon tax and benefits system modelled here is net benefit of around £220 for the lowest income quintile and a net loss of around £170 for the top income quintile.

Figure ES 6. Proportion of winners and losers (left axis) and mean net gain (for winners), loss (for losers) and overall average (right axis) by equivalised household income quintile

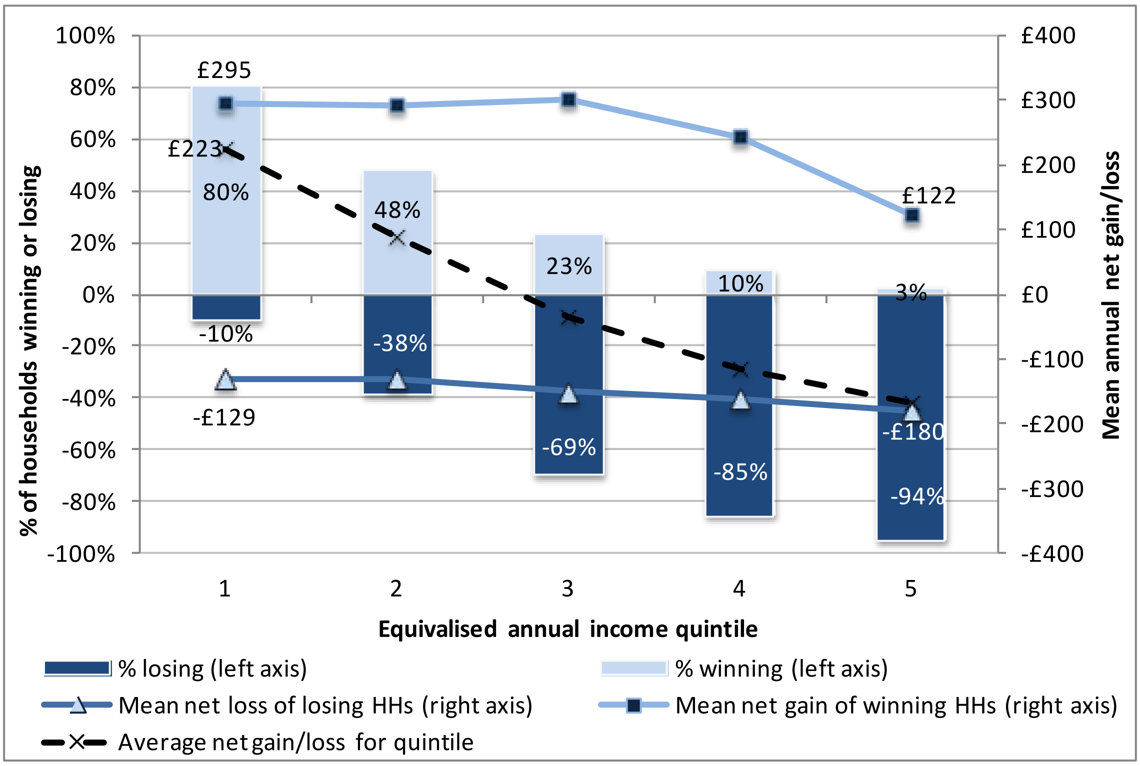


Figure ES 7 shows the same information as Figure ES 6 above but split by geographical area. This shows that households living in "accessible" areas are losing the most (64% of households made worse off by around £180 a year on average) but only marginally so compared to all other areas. This apparent lack of variation in overall impact of the carbon tax and benefits system modelled here across different settlement types in Scotland suggests there are interacting factors driving this effect, for example related to physical property characteristics, vehicle ownership and income.

Figure ES 7. Proportion of winners and losers (left axis) and mean net gain (for winners), loss (for losers) and overall average (right axis) by urban/rural identifier

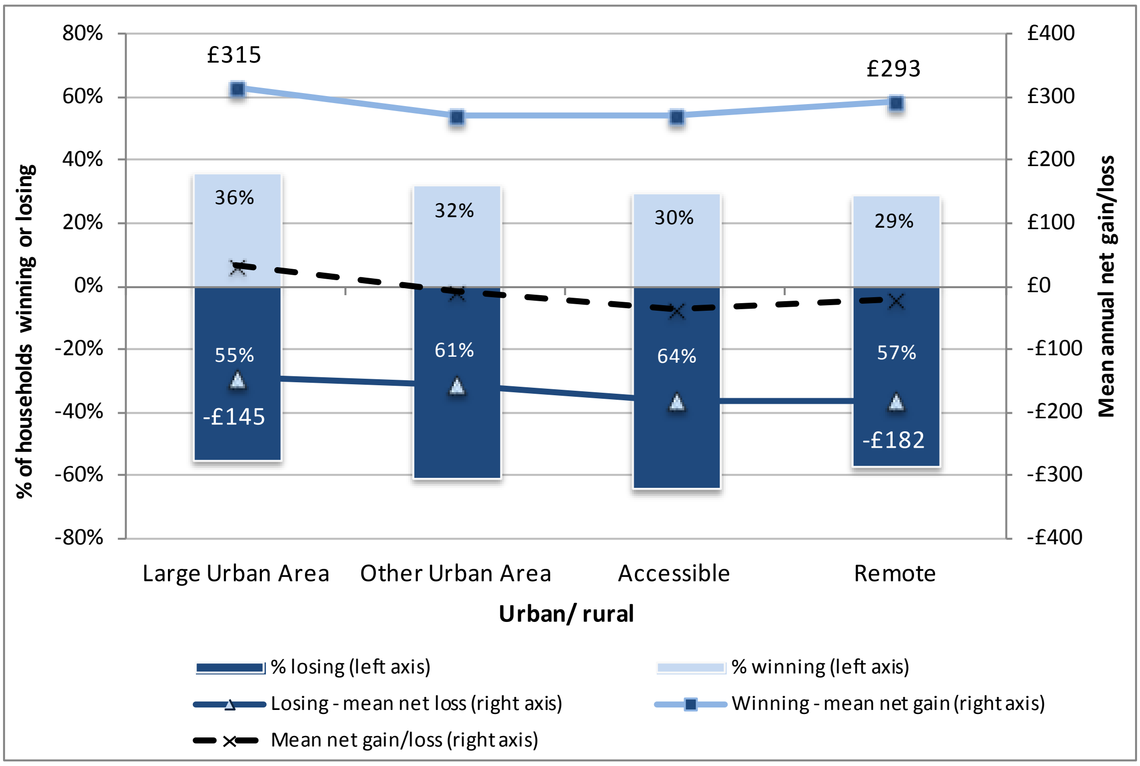


Table ES 3. Compensation received and carbon tax paid by area

	% of HHs eligible for compensation	Mean compensation	Total carbon tax paid	Net impact
Large Urban Area	70%	£145	£113	£32
Other Urban Area	67%	£118	£127	-£9
Accessible	67%	£118	£154	-£37
Remote	67%	£122	£143	-£21

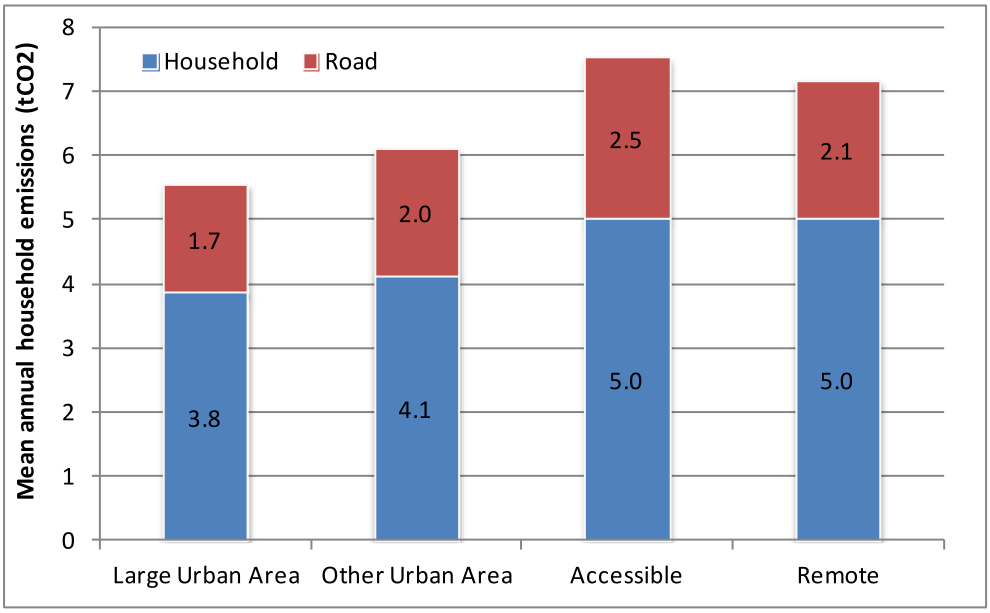
Discussion and Conclusions

Statistical analysis (Chi-squared Automatic Interaction Detector (CHAID)) was used to further explore the key defining characteristics of 'winning' and 'losing' households. The results showed that the revenue from a carbon tax could be used to compensate low-income households in Scotland for the carbon tax payments they would have to make, in a way that leaves them better off on average and with a large majority having gained from the combined package overall.

The CHAID analysis provides a richer understanding of the socio-economic groupings of the 'winners' and 'losers', with wealthy couples in larger rural dwellings and high vehicle ownership bearing some of the highest tax burdens and un(der)employed couples and families in rented urban flats benefiting the most from the compensatory changes in the benefit system.

The spatial dimension of the distributional impact of the carbon tax and compensation package is complex. Whilst households in remote areas (representing around 7% of households in Scotland) have slightly higher household and road transport emissions on average than their urban counterparts (around 1.3 times higher) and therefore pay more in the way of carbon tax on average (as illustrated in Figure ES 2, page 9), the proportional make-up of emissions appears roughly similar across all areas (with road transport emissions accounting for around 30%, rising to 33% in "accessible" areas) and there appears little spatial variation in the proportion of winners and losers, nor indeed in the amount by which they win or lose (Figure ES 7). More detailed analysis of the data suggests this reflects the variation in household occupancy, incomes, dwelling types, etc that interact to affect the overall average impact we see across different settlement types.

Figure ES 8. Average annual household and road transport emissions by rural/ urban indicator



The compensation package does appear sufficiently designed to ensure any low-income rural households are protected from the impact of the carbon tax, whilst wealthy rural dwellers pay towards the cost of their high emitting lifestyle. This result should be caveated however with the assumptions inherent in the modeling.

Firstly, TAXBEN assumes full take-up of means-tested benefits, whilst in practice there is some non-take up of benefits and the take-up rate of the new Universal Credit will be crucial in determining how important a factor this will be in the future. Existing means-tested benefits and tax credits for those of working age already have relatively high rates of take-up, often in excess of 90%, at least for those on lower incomes.[4] The government hopes that Universal Credit will have a higher take-up rate as it is a single benefit that families can continue claiming whether they are in or out of work. However, Pension Credit has a lower rate of take-up, particularly among pensioners with small

[4] See http://www.hmrc.gov.uk/statistics/fin-takeup-stats/cwtc-take-up.pdf and https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/222915/tkup_full_report_0910.pdf

amounts of private income.[5] It is therefore likely that more low-income pensioners would lose out from the carbon tax and compensation package than we estimate here.

Furthermore, research has shown there may be a rural/urban divide associated with accessing benefit entitlements. For example: *"In rural areas, single pensioners have few opportunities to increase their income. Poor access to information and advice about benefits and entitlements is likely to mean that many people do not receive their full benefits"* (Scottish Government, 2009).[6] The results presented here may therefore underestimate the number of low-income rural households who would be worse off under the carbon tax and compensation package. Therefore any programme of carbon taxation would need to be complemented by support services promoting access to these benefits. The most successful fuel poverty programmes provide both energy efficiency measures and benefits advice for similar reasons.

Secondly, the analysis does not take account of individuals changing their labour market or other behaviours in response to the reforms. The introduction of the carbon tax and increases in the basic amounts of means-tested benefits would both tend to weaken the incentives for individuals to do paid work, though this is offset at least partly by the reduction in the rate at which Universal Credit is withdrawn as incomes rise. As with any change to tax and benefit policy, a government wishing to introduce a compensation package for a carbon tax would in practice have to balance distributional goals against other objectives it may have, such as work incentive objectives.

This study has not modelled any behavioral response to the impact of the introduction of a carbon tax on energy used in the home and private road transport fuels. Behavioural change to reduce energy consumed in the home may be more difficult for some households, and/or pose a potential risk to health and well-being, particularly in low income households (i.e. a choice to limit heating to avoid/reduce the carbon tax could result in a cold and damp living environment). The data used in the modelling and analysis in this study is limited in detail on physical property characteristics, hence we do not know the extent to which households may be under-heating and cold (fuel poor); or being wasteful/inefficient with their energy use; and/or living in poorly insulated housing. The latter presents an opportunity for households to reduce their carbon emissions and the impact of a carbon tax, and improve their living environment. A financial support mechanism as modelled in this study should therefore be accompanied by a programme to support the installation of energy efficiency and low carbon measures for low income households, with additional incentives and mechanisms in place to encourage uptake amongst the able to pay.

Whilst (as with any change to tax and benefit policy) a government wishing to introduce a compensation package for a carbon tax would in practice have to balance distributional goals against other objectives it may have, this research has shown that a carbon tax on household energy and private road transport use in Scotland can be implemented in such a way that, through appropriate recycling of the tax revenues, most lower-income households could be protected.

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[5] According to DWP analysis, between 62% and 68% of pensioners entitled to Pension Credit claimed their entitlements in 2009–10, with between 20% and 27% of the total cash entitlement not being claimed. See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/222915/tkup_full_report_0910.pdf

[6] Scottish Government, 2009. The Experience of Rural Poverty in Scotland. Qualitative Research with Organisations Working with People Experiencing Poverty in Rural Areas. Report by EKOS Ltd on behalf of the Scottish Government

1 Introduction

1.1 Project Rationale

This paper looks at how a green tax like a carbon tax can be introduced to promote the desired environmental outcomes (in this case carbon emission reductions) while protecting those least able to pay or able to change their behaviours to reduce their tax exposure. Specifically, it examines how to design a revenue-neutral carbon tax on household energy use and private road transport in Scotland, with a focus on safeguards to protect low-income households. This study is illustrative of the way in which a green tax needs to interact with the wider benefit and tax system to balance environmental and social concerns.

There are two principal ways of reducing carbon emissions from the household sector. One is to increase the energy efficiency of homes, so that people can keep warm using less energy. The UK and Scottish Governments have had policies in this area for a number of years, such that the average energy efficiency of homes has indeed increased.

The other principal way of achieving cuts in carbon emissions (from all sectors) is to use public policy to put a price on carbon – indeed, carbon pricing is widely recognised to be essential for the transition to a low-carbon society – and this, and the implications for low-income households, provide the main focus for this project.

The Scottish Government has a target to reduce emissions of carbon dioxide (CO_2) and other greenhouse gases that contribute to climate change by 80% from 1990 levels by 2050. It has an interim target to reduce emissions by 42% by 2020. In 2013, the Low Carbon Scotland report set out the following objectives for the household and transport sectors[7]:

- A largely decarbonised electricity generation sector by 2030, using renewable sources for electricity generation with other electricity generation from fossil-fuelled plants utilising carbon capture and storage;
- A largely decarbonised heat sector by 2050 with significant progress by 2030 through a combination of reduced demand and energy efficiency, together with a massive increase in the use of renewable or low carbon heating;
- Almost complete decarbonisation of road transport by 2050, with significant progress by 2030 through wholesale adoption of electric cars and vans, as well as significant shift towards public transport and active travel, and significant decarbonisation of rail;
- A step-change in provision of energy efficient homes to 2030 through retrofit of existing housing and improved building regulations for new build homes

ClimateXChange commissioned this project to review the distributional impacts in Scotland of a carbon tax and draw some conclusions about what would constitute a 'green and fair' taxation system that would tax greenhouse gas emissions whilst avoiding regressive effects. The project team previously conducted research for the Joseph Rowntree Foundation (JRF) which looked at the issues for the UK.[8] This project has gone beyond that by looking specifically at the effects in Scotland and by looking in more detail at the effects in rural areas.

[7] http://www.scotland.gov.uk/Publications/2013/06/6387/3
[8] http://www.jrf.org.uk/publications/carbon-tax

At the level of the European Union (EU) carbon pricing is achieved through the EU Emissions Trading Scheme (EU ETS), and the UK Government has supplemented this with a number of other taxes related to energy or carbon emissions, including the Climate Change Levy and the carbon price floor (CPF).

The CPF is a policy instrument intended to ensure that electricity generators face a minimum price for the carbon contained in any fossil fuels that they burn, to encourage them to use and invest in low-carbon technologies. The CPF is made up of the price of the permits in the EU ETS, plus a carbon tax on the fossil fuel inputs to power generation. In addition to giving an incentive to power generators to use low-carbon technologies, this carbon price will be passed through to the electricity prices faced by consumers, in theory therefore also providing an incentive to them to buy more efficient appliances and generally use less electricity, reducing further the emissions and other damaging environmental effects from power generation. The intention was that the CPF would increase each year from 2013 at a rate to ensure that the overall price of carbon for the fuels burned in power stations rose annually until 2020. It was planned that the rate would be £21 per tonne of carbon dioxide in 2016/17, but in Budget 2014, the UK Government announced that it would be capped at £18 per tonne from 2016/17 to 2019/20.[9] However, this taxation of the carbon inputs to electricity is not matched by the taxation of carbon-based fuels used by households, mainly natural gas for heating.

1.2 Report structure

The methodology used to model the effects of the proposed carbon tax and compensation package are presented in Chapter 2.

The research has utilised the Centre for Sustainable Energy's (CSE) DIMPSA[10] model in combination with the Institute for Fiscal Studies' (IFS) TAXBEN model of the tax and benefits system, both of which run on a comprehensive dataset representative of households in the UK.

DIMPSA is used to simulate the impacts of existing Government energy and climate change policies on household energy bills in 2017 (the year chosen for analysis) and simulate the carbon tax on household energy use and private road transport. The results from this modelling are presented in Chapter 3 and Chapter 4 respectively.

In addition to encouraging people to reduce their energy use and emissions, the carbon tax raises revenues, which can be used to compensate households for the extra cost associated with a carbon tax. The compensation mechanism, modelled using TAXBEN, is described in detail in Chapter 5, with an overview of the distributional effects after the compensation package has been applied.

DIMPSA is then used again to identify the key defining characteristics of the main groups of 'winning' (better-off overall) and 'losing' (worse off overall) households. The results of this analysis are given in Chapters 6 and 7.

Chapter 8 discusses the implications of the carbon tax and its compensation mechanisms for different household types and, finally, Chapter 9 draws conclusions about a 'green and fair' carbon tax system for Scotland.

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[9] http://www.hmrc.gov.uk/climate-change-levy/carbon-pf.htm
[10] 'Distributional Impacts Model for Policy Scenario Analysis'

2 Policy and carbon taxation modelling: method

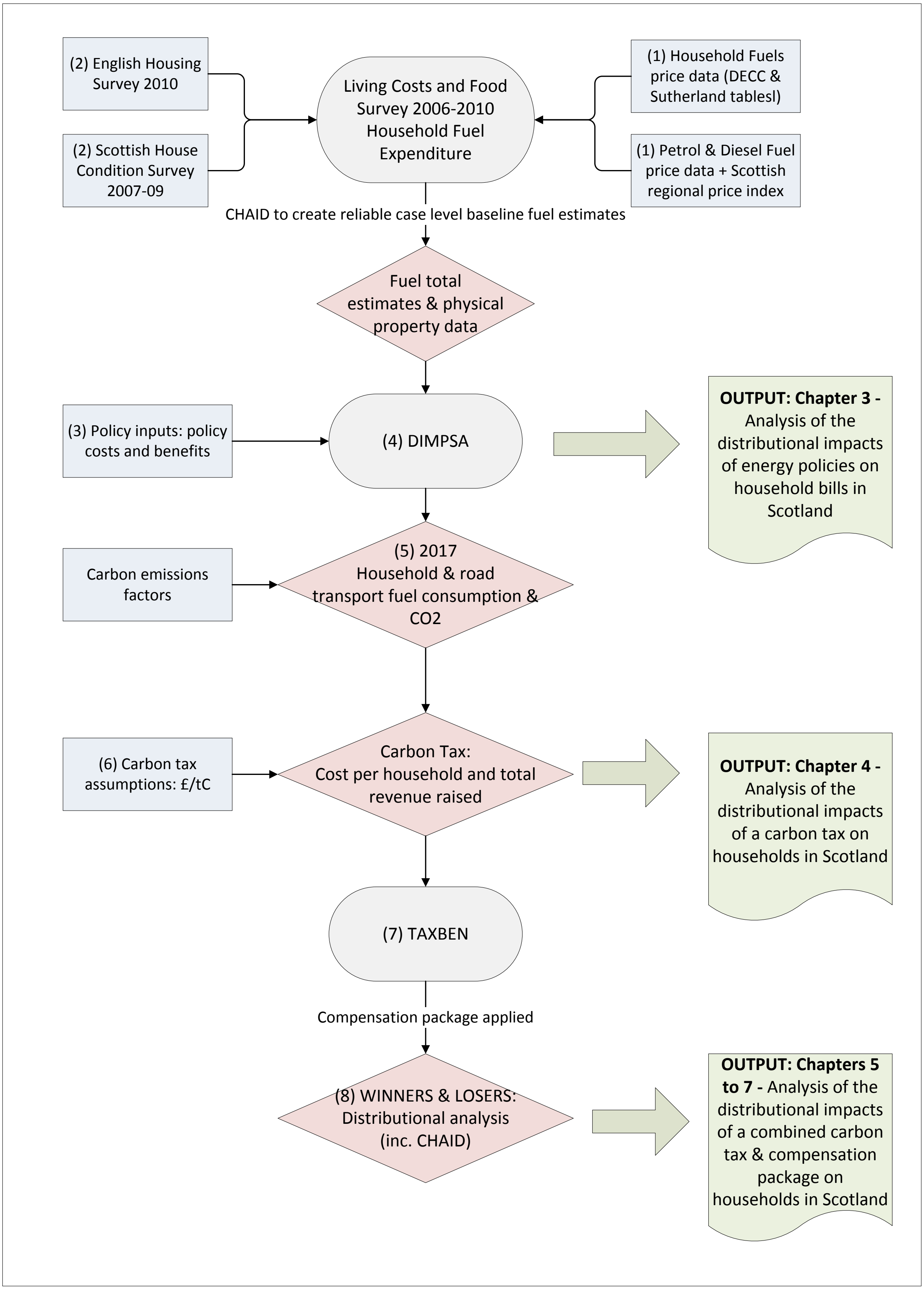
2.1 Overall methodology

This chapter explains the methods underpinning the research exploring the potential impact of a carbon tax in Scotland. The study uses two models that are both based on the Living Cost and Food (LCF) Survey, namely:

- DIMPSA – CSE's 'Distributional Impacts Model for Policy Scenario Analysis'
- TAXBEN – IFS's model of the tax and benefits system

Figure 2.1 below shows the overall methodology for the study. The key stages are labelled (1 to 7) and described in more detail below.

Figure 2.1. Research methodology diagram



(1) Deriving fuel consumption estimates from Living Cost and Food Survey expenditure data

The dataset underpinning the DIMPSA and TAXBEN model is based the socio-demographically representative sample of UK households surveyed in the ONS Living Costs and Food Survey (LCF).

Data from five LCF surveys have been combined (years 2006, 2007, 2008, 2009 and 2010), generating a sample size of over 29,700 cases (for the UK as whole, 9% of which are in Scotland). The LCF is a rolling annual survey that records data on all personnel and household expenditure, including on household fuels (electricity, gas and all non-metered fuels) and petrol and diesel. Household energy consumption (kWh) and petrol and diesel usage (litres) estimates are derived from the survey expenditure data using time (month and year), location (country and English region) and (for mains gas and electricity) method of payment-specific fuel price information. The sources of fuel prices used in this study are shown below. To allow for petrol and diesel fuel price differentials across Scotland, additional research was undertaken to generate inflation factors to apply to prices for rural areas. See Annex I for further details.

Table 2.1. Sources of fuel price data used in converting LCF survey expenditure data to consumption

Fuel	Price information source
Mains gas and electricity	DECC domestic energy price statistics[11]
Non-metered fuels	Sutherland tables
Petrol and Diesel	The AA website for 2006 to 2007[12] Provided directly to the project team by Experian Catalist for 2008 onwards[13]

Due to the nature of the LCF survey, the distribution of expenditure- and therefore the derived energy consumption values – cannot be considered accurate. Data at the individual case level should not therefore be used, but average (mean) estimates derived from sufficiently large samples of cases can be. Further modelling is therefore undertaken to assign estimated consumption values for heat and power (kWh) and petrol and diesel (litres) to every case in the LCF survey data (using CHAID – see below for explanation). This produces in a compressed distribution, and a reliable estimate of baseline fuel consumption for every household in the dataset, whilst maintaining the original mean value for the dataset as a whole.

The resulting DIMPSA dataset therefore includes:

- Extensive socio-demographic data (as collected by the ONS LCF survey), including household income, household composition (including number of adults and children and householder age), employment status, tenure, property type and size (no. of rooms/bedrooms), rurality and welfare benefits received.
- Modelled annual household energy and road transport fuel consumption, derived from actual stated expenditure.

(2) Modelling physical property variables in the LCF

As described above, the modelling for this study is based on the Living Costs and Food (LCF) survey dataset. The LCF does not include detailed information on physical household characteristics,

[11] https://www.gov.uk/government/statistical-data-sets/annual-domestic-energy-price-statistics Table QEP 2.2.3 for electricity and QEP 2.3.3 for gas.
[12] http://www.theaa.com/motoring_advice/fuel/
[13] Fuel price data is available on the AA website in pdf format. Experian Catalist Fuel Price Archive provided this data in spreadsheet format for the purpose of this research.

beyond built form, which are important in modelling the impact of energy policies. Data from the 2010/11 English Housing Survey (EHS) and 2007-09 Scottish House Condition Survey was therefore used by CSE to generate a predictive models (using CHAID) to identify wall types/insulation, loft insulation levels and heating system age/communal heating in the LCF dataset.

(3) UK Energy policy inputs

DIMPSA simulates the impact of both the costs and benefits to domestic consumers of UK energy and climate change policies. The former is represented in DIMPSA as an additional cost on the household electricity and/or gas bill on a p/kWh basis or cost per customer, depending on the nature of the policy. Benefits include physical measures (energy efficiency, heating and low carbon measures) and fiscal benefits, such as the Warm Homes Discount.

For the purpose of this study the input settings for UK energy policies in DIMPSA were reviewed and updated to ensure that all relevant policies were included. This included adding policies specific to Scotland (the Energy Assistance Scheme).[14] Policies modelled within DIMPSA (as applied in this study) are shown in Box 2.1. The Glossary provides further explanation of these policies.

Box 2.1. Policies modelling in DIMPSA as part of this study

- Carbon Emissions Reduction Target (CERT)
- Feed-in tariff (FIT) and Renewable Heat Incentive (RHI)
- Smart meters
- Warm Home Discount
- EU Emissions Trading Scheme (ETS)
- Renewables Obligation (RO)
- Carbon Capture and Storage (CCS)
- Product Policy
- Energy Company Obligation[15] (ECO) and Green Deal[16]
- Carbon Price Floor (CPF)
- Boiler Scrappage Scheme (Scotland only)
- Home Energy Efficiency Programme (Scotland only)
- Energy Assistance Scheme (Scotland only)

[14] The Expert Commission on Energy Regulation, an independent expert commission of industry and consumer experts and academics, set up by the Scottish Government to provide evidence on improvements to the Scotland's stewardship of electricity and gas regulation in an independent Scotland recommended its recent report (July 2014) maintaining a single electricity and gas market covering the whole of GB should Scotland become independent. http://www.scotland.gov.uk/Resource/0045/00455402.pdf

[15] In Scotland future ECO costs are assumed to be raised from public finances as mentioned in Scotland's referendum on 18 September 2014 is a choice between two futures, Chapter 8 - http://www.scotland.gov.uk/Publications/2013/11/9348/12

[16] The installation rates for the ECO reflect actual activity rather than the Government Impact Assessment i.e. as performed in previous studies using DIMPSA. For more details see CSE's Independent Evaluation of the ECO for Energy UK.

(4) Simulating the costs and benefits of energy policies using DIMPSA

DIMPSA has been developed by CSE, through close working with the Department of Energy and Climate Change (DECC)[17]. For the purpose of this study, policies are simulated to derive estimates of household fuel bills and consumption in 2017. This includes simulating the deployment of measures, assumed energy efficiency savings (e.g. through Products Policy) and fuel prices. The year 2017 was chosen to align with the anticipated date by which the UK reforms to benefits should be complete (N.B. this study is unable to comment on the overall shape of the benefits system in an independent Scotland).

DIMPSA models the impact of policy costs passed through to domestic customers according to which sectors the policy affects. For instance, FITs apply to both domestic and non-domestic customers; the costs of this policy are therefore split between these two customer groups based on the total annual consumption (kWh). In addition, policy costs are distributed based on the fuel types covered by the policy, i.e. electricity, gas, oil, coal or liquid petroleum gas (LPG). The total policy costs to distribute domestically are then divided between the relevant fuels according to the weighted number of consumers using each fuel.

In modelling the expected benefits of energy policies, DIMPSA identifies types of households in the LCF dataset that may be suitable for the different energy efficiency measures and sustainable energy technologies. A number of standard criteria are applied in the model to constrain the application of measures. Variables used in these criteria include: tenure; built form; central heating type; number of rooms; occupants; age of household representative; rurality; and wall type. For example, the model will apply solid wall insulation to households with un-insulated solid walls only and biomass boilers are constrained to households in non-urban areas.

Policy measures are, in some instances, also targeted at specific groups, consistent with policy design. For example, FIT measures are targeted at a group identified as “early adopters” of technology, based on some specific household characteristics. ECO measures are targeted at groups that are identified as low-income/vulnerable households. Further detail about the modelling of policies is DIMPSA is included in Box 2.2.

The results from modelling the impact of energy and climate change policies on household bills were analysed to show the likely distributional impact across households in Scotland (Chapter 3).

[17] DECC uses DIMPSA for its own modelling and analysis of policy impacts. For example see: DECC (March 2013) ‘Estimated impacts of energy and climate change policies on energy prices and bills’.

Box 2.2. Modelling policy costs and benefits in DIMPSA

DIMPSA simulates the installation of measures across households in the UK housing stock. The levels of energy savings associated with different measures are estimated based on the year and household characteristics and are adjusted for comfort taking. For any heat consumption reduction measure (such as gas condensing boilers, renewable heat pump or insulation measures) the savings are adjusted in the model to allow for comfort taking (for example, applying a rate of 15% to be consistent with the assumptions on comfort taking used in the Green Deal Impact Assessment). The Energy Assistance Scheme and Boiler Scrappage Scheme target measures at households in Scotland based on the eligibility criteria and data on installed measures[18].

Product Policy improves the energy efficiency of appliances and other products that use energy by tightening the standards they must meet. Savings are applied in each year based on the number of large and small appliances the household has (with the savings associated with lighting distributed according to the number of rooms). Smart Meter savings are based on a constant percentage reduction consistent with the roll-out profile in the Smart Meters Impact Assessment.

The installation of FIT measures will include some level of tariff payment. That is, the installation of a small-scale generator (for example, solar panels) reduces household consumption of electricity from the grid but also provides a payment on top. There is also an additional payment for any surplus electricity fed back into the grid. Depending on the type of measure, household and year a corresponding tariff payment is estimated. Tariff payments from the grid to households taking up FIT measures are netted off the final bill.

The Warm Home Discount (WHD) provides a rebate on bills for certain vulnerable households (£130 per household in 2012/13). The discounts are targeted at three specific groups of vulnerable consumers: a 'legacy group' who will continue to receive support, including social tariffs, similar to that under the previous voluntary agreement between energy suppliers and the government; a 'core group' of low-income and vulnerable households; and a wider 'broader group'. Each group has specific characteristics consistent with criteria for vulnerable households[19]. The level of rebate is specified for each group and subtracted from the final bill.

(5) Estimating household carbon emissions in 2017

Once the policies have been applied to the households the final energy consumption totals are used to determine household energy bill and emissions in 2017. The latter uses the DECC/Defra carbon emission factors[20]. The emissions factors for road transport were adjusted to reflect projected improvements to fleet efficiency. The Committee on Climate Change provided CSE with its latest projections for tail pipe emissions factors to 2030 (excluding electric vehicles) for this purpose.

The output from stages 1 to 4 is a comprehensive UK-wide dataset of estimate household fuel and petrol and diesel consumption and associated emissions in 2017.

[18] http://www.energysavingtrust.org.uk/scotland/Take-action/Home-Energy-Scotland/Home-Energy-Efficiency-Programmes-for-Scotland/Programme-statistics

[19] These were developed through CSE's work with DECC, in conjunction with DECC's Fuel Poverty team.

[20] http://www.ukconversionfactorscarbonsmart.co.uk/

(6) Applying a carbon price

The team used the published traded and non-traded carbon prices for Government appraisal as a benchmark.[21] The prices contain three thresholds low, central and high.

The Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report[22] assesses the current state of climate change science and concludes that scientists are 95% certain that humans are causing extra warming which has led to snow and ice melting and sea levels rising. The report finds that climate change is already contributing to problems like flooding, disruption to farming and food supply and species migration and extinction.

The report calls for further efforts to limit emissions by 'mitigating' climate change. Beyond 2°C of warming, the report concludes that the effects of climate change will be much more unpredictable and harder to adapt to, nations have agreed. Global emissions have grown faster in recent years and will continue to do so; unless further action is taken then we are likely to take the planet beyond a two-degree temperature rise.

In light of these conclusions and the clear urgency for action, the team opted to model the high carbon price scenario in this study. Two different values were applied, to allow for the fact that emissions associated electricity generation are already traded. Therefore, the carbon tax was charged at £21 per tonne of carbon dioxide for electricity[23] and £94 per tonne for all remaining fuels. These values were applied to the household and road transport emissions totals in 2017 to determine the amount paid by each household and the total amount of revenue raised. The results were analysed to show the distributional impacts of carbon tax on households in Scotland (Chapter 4).

(7) Simulating tax and benefits with TAXBEN

This study uses the IFS' tax and benefit microsimulation model, TAXBEN, to model compensation packages which recycle the revenue raised by the carbon tax back to households in Scotland. TAXBEN calculates households' tax liabilities and benefit entitlements under different tax and benefit policies. The input to the model is information on households' demographic characteristics, gross incomes, expenditures and entitlement to non means-tested benefits from large-scale household surveys. The output is the calculation of each household's direct and indirect tax liabilities and entitlements to benefits and tax credits, given a specified tax and benefit system. A detailed description of the model was given in Giles and McCrae (1995)[24] and the main features of the model remain the same. TAXBEN is set up to run on various UK household surveys, including the 2006 to 2010 Living Cost and Food (LCF) survey dataset used by the DIMPSA model.

DIMPSA supplied TAXBEN with the additional tax liabilities for each household in the LCF data as a result of the carbon tax. TAXBEN was then used to design appropriate compensation packages for the same sample of households, using information on each household's pre-tax income and other

[21] Values for Traded and Non-traded sectors: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal (tables 1-20, table 3)
[22] IPCC, 2014. "Impacts, Adaptation and Climate Change" http://www.ipcc.ch/report/ar5/wg2/
[23] This was consistent with the expected price per tonne in 2017 at the time of the modelling.
[24] C. Giles and J. McCrae (1995), 'TAXBEN: The IFS microsimulation tax and benefit model', IFS Working Paper, http://www.ifs.org.uk/wps/wp1995.pdf.

relevant characteristics recorded to calculate how much they would gain from the compensation package. Combining this information with the simulated carbon tax liabilities for each household calculated by DIMPSA makes it possible to calculate whether each household in the LCF dataset gains or losses overall, and by how much, from the combined effect of the carbon tax and the compensation package. The aim of the research team in constructing the compensation package was to minimise the number of 'low-income losers' in Scotland from the combined impact of the carbon tax and compensation package.

The analysis takes into account all tax and benefit changes already announced for future implementation up to and including Budget 2014. The team modelled the carbon tax and compensation package as happening in 2017–18. By this time the rollout of the government's new Universal Credit, which will replace most existing means-tested benefits and tax credits for those of working age, will be nearly complete.[25]

(8) Analysis of results

The results from TAXBEN of redistributing the total revenue raised from the carbon taxation policy to households were analysed in detail to explore the likely distributional impacts across households in Scotland (Chapter 5 and 6). The analysis includes identification of 'winners' and 'losers' (households deemed better/worse off overall as a result of the combined impact of the tax and compensation package). In addition, detailed statistical analysis was undertaken to identify the key defining characteristics of groups of winners and losers, using CHAID (Chapter 7).

[25] The current plan is that all new benefit claimants will be in the Universal Credit system by April 2017, and for most existing benefit claimants to be rolled onto Universal Credit during 2016 and 2017 (the timetable for this latter stage of the roll-out has not been precisely specified). Thus there will still be a small number of families claiming the current set of means-tested benefits and tax credits during the 2017–18 fiscal year. We ignore this for the purposes of our analysis, assuming that Universal Credit is fully in place. We are considering long-term rather than transitory changes to the tax and benefit system, so it is more informative to model impacts under Universal Credit than under the system that it will replace.

3 Impact of policies on household energy bills

3.1 Overall impact of Government policies

The impact of Government energy policies on the 2017 household energy bill (under the 'central policy scenario,' i.e. standard DECC assumptions which includes products policy[26]) is an average net decrease of £23 for households in Scotland, or 2%, compared to the expected bill in 2017 without policies (Table 3.1). (See Box 3.1 for a discussion around how these results compare with DECC's own assessment of the impact of Government policies on household energy bills).

Table 3.1. Impact of DECC policies on average household energy bills in Scotland (and UK for comparison)

	Scotland			*UK*		
	2013	2017	2020	*2013*	*2017*	*2020*
Bill without policies	£1,210	£1,287	£1,276	*£974*	*£1,297*	*£1,284*
Bill with policies	£1,262	£1,264	£1,196	*£1,064*	*£1,263*	*£1,196*
Impact of policies	£52	-£23	-£80	*£90*	*-£33*	*-£88*
Impact of policies %	4%	-2%	-6%	*9%*	*-3%*	*-7%*

Box 3.1. Assessing energy policy impacts on bills: same models, different results

DECC's latest estimates of the impact of energy and climate change policies on consumer energy prices and bills (which also uses CSE's DIMPSA tool) shows a net average saving of £166 to the average consumer bill in 2020 (NB this is for the UK as a whole)[27]. Despite using the same DIMPSA tool, the estimated impacts of policies on bills presented here appear quite different. This is due to different assumptions applied in relation to the starting point or baseline. For example, DECC's analysis includes savings from the Energy Efficiency Commitment (which started in 2002) and all of CERT. It also includes savings from building regulations, namely boiler replacement, which came into effect in 2002. The modelling and analysis carried out for this report only includes the impact of measures from policies from 2010 onwards. This therefore reduces the savings on bills from CERT and boiler replacement. The overall net impact remains negative (i.e. a saving) however, largely due to assumptions around improvements in product efficiency reducing household electricity demand.

3.2 Distributional impacts of Government policies

By household income

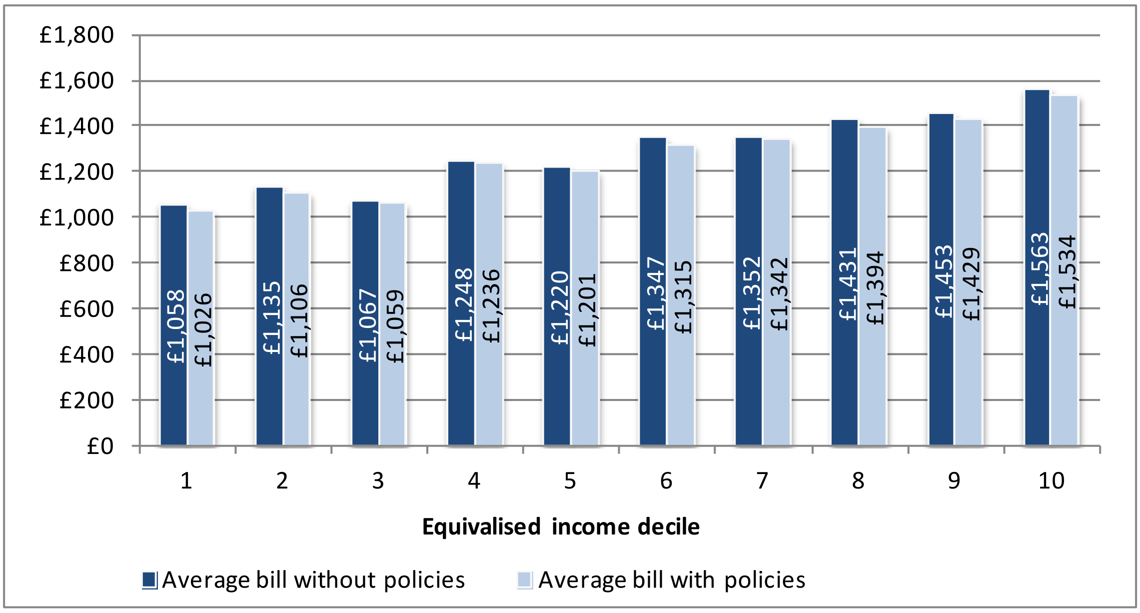
The analysis below shows the impact of policy on average household energy bills in 2017 by equivalised disposable household income decile. This shows that the average household energy bill appears lower for all income groups as a result of Government policies. The poorest 10% of households see a saving of £32 on average compared to the expected bill in the absence of Government policies, whilst the richest 10% of households see an average saving of some £29 (Figure 3.1). Whilst the average impact of policies on household bills in 2017 appears broadly similar across all income groups, this average masks a wide within-decile distribution, whereby some

[26] The policy assumptions presented here are designed to match as closely as possible DECC's latest policy analysis.

[27] DECC (2013), *Estimated impacts of energy and climate change policies on energy prices and bills*

households appear more substantially better off, whilst others stand to lose, as discussed further below.

Figure 3.1. Average household energy bills in 2017 by equivalised disposable income decile



Impact of policy benefits - households that do and do not receive support

The impact of Government policies on any one household is dependent on whether the household benefits 'directly' from any of the policies, and indeed if this benefit sufficiently outweighs the amount the household pays towards policy costs. Direct benefits may be in the form of measures, e.g. insulation or heating, or financial support, e.g. Warm Homes Discount. When analysing the distributional impacts of Government policies on household energy bills it is therefore useful to differentiate in absolute terms between households that do and do not receive any direct benefit.

Table 3.2 below shows the number and proportion of households that do and do not benefit directly from Government policies in Scotland, by equivalised income decile and overall. Overall around one third (31%) of households in Scotland benefit directly and as a result see a saving of over £230 compared to the 'no policy' 2017 household energy bill. However, the majority of households appear to not receive any direct policy benefits and instead see an average increase in their 2017 household energy bill, of £71 compared to the 'no policy' scenario.

This finding highlights the wide distributional policy impact that is masked when looking at the overall effect across all households in Scotland. Whilst overall households in Scotland appear better off as a result of Government policies (by £23 on average - Table 3.1), it is the minority that benefit directly and experience a large net reduction, whilst the majority pay towards the cost of policy without experiencing any direct benefit and as a result see an increase in their household energy bill in 2017 (of £71 on average).

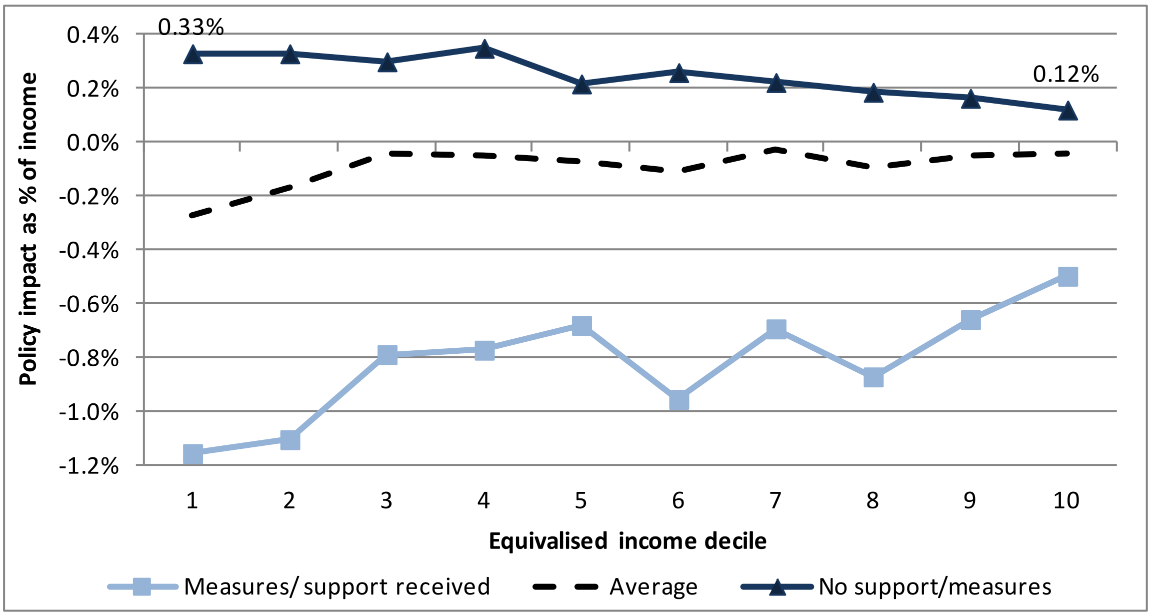
Across income deciles, the lower income groups appear more likely to benefit directly from policies than the higher income groups. However, whilst 12% more households in the lowest income group benefit compared to the proportion in the highest income group, the average net saving experienced by the latter is higher – by some £217, or 150%.

Table 3.2. The distribution of winners and losers by equivalised income decile and overall (2017)

Decile	Households not receiving policy benefits (measures/ £ support)		Households receiving policy benefits (measures/ £ support)		*Overall average impact for Decile*
	% of decile	Average bill impact	% of decile	Average bill impact	
1	61%	£39	39%	-£145	*-£32*
2	65%	£56	35%	-£187	*-£29*
3	69%	£60	31%	-£159	*-£9*
4	64%	£80	36%	-£176	*-£12*
5	68%	£58	32%	-£180	*-£19*
6	70%	£79	30%	-£290	*-£32*
7	73%	£78	27%	-£241	*-£10*
8	74%	£76	26%	-£353	*-£37*
9	74%	£82	26%	-£323	*-£24*
10	73%	£93	27%	-£362	*-£29*
Overall	69%	£71	*31%*	*-£232*	*-£23*

Figure 3.2 shows the same data as in Table 3.2 but with the bill impact represented as a percentage of income for each decile. The overall average impact of policies on household bills in 2017 (compared to a 'no policy' scenario) appears less than 0.3% of household (equivalised) income in 2017, across all income groups. The impact for households not receiving any direct policy benefit represents a higher proportion of income for the lowest income group, but this is less than 0.4% of 2017 household income.

Figure 3.2. Impact of policies on 2017 household energy bill as a proportion of equivalised household income, by decile and those who do and do not receive policy benefits



4 Taxing domestic sector carbon emissions in Scotland in 2017

4.1 Overall impact

The level of revenue raised from applying a tax on emissions resulting from the consumption of energy in the home and petrol and diesel usage in Scotland in 2017 is shown below.

The amount any one household pays in carbon tax is directly related to its energy/fuel usage. This in turn is related to the impact of Government energy policies discussed in the previous chapter. Households benefiting directly from policies through energy efficiency/heating measures that result in a reduction in their energy consumption stand to pay relatively less in carbon tax compared to a scenario without these benefits.

Table 4.1 below shows the impact of Government policies and assumed improvements in vehicle efficiencies (to 2017) reduce household and road transport emissions by some 1 $MtCO_2$ and 0.5MtC02 respectively (compared to the baseline year). Average annual household emissions in 2017 in Scotland are around 6.4tCO2; this translates into average annual carbon tax of £130, with the consumption of energy in the home accounting for 60%.

In total, a carbon tax on household emissions and petrol and diesel (domestic level use only) in Scotland raises some £302.2 million in 2017.

Table 4.1. Household and road transport emissions and carbon tax revenue in Scotland

	Sum	Mean (per household)
Baseline year Household emissions	11.0 $MtCO_2$	4.72 tCO_2
Baseline year Road transport emissions	5.41 M tCO_2	2.32 tCO_2
Household emissions 2017 with policy applied	10.0 $MtCO_2$	4.30 tCO_2
Road transport 2017 with policy applied	4.91 $MtCO_2$	2.10 tCO_2
Carbon tax paid on household fuels	£181.9m	£78
Carbon tax paid on road transport fuels	£120.4m	£52
Total carbon tax paid	£302.2m	£130

Notes: the baseline year is a 'synthetic' year represented by the Living Costs and Food Survey datasets spanning 2006-2010.

4.2 Distributional impact

As with the analysis of the impact of Government policies on household energy bills, the average carbon tax paid by households in Scotland (£130 in 2017) masks significant variation across different household types.

Analysis of the average annual carbon tax paid on household fuels and road transport (petrol and diesel) by equivalised annual income decile in 2017 is shown below. There appears a clear correlation between income and carbon tax paid, with the richest 10% of households paying almost £200, whilst the poorest 10% of households pays £80 a year on average.

However, there is a notable difference in the proportion of total carbon paid on household fuels and road transport across income groups. For the lowest income households, consumption of energy in the home accounts for 74% of the total carbon tax paid (£59 a year on average for household emissions, compared to £21 for road transport emissions), whilst the highest income group pay proportionally less carbon tax on household fuels (£103, or 54% of their total average annual carbon tax). This pattern reflects (amongst other factors) vehicle ownership, which is higher amongst higher income households (Figure 4.2).

Figure 4.1. Average annual carbon tax paid in 2017 by equivalised annual income decile

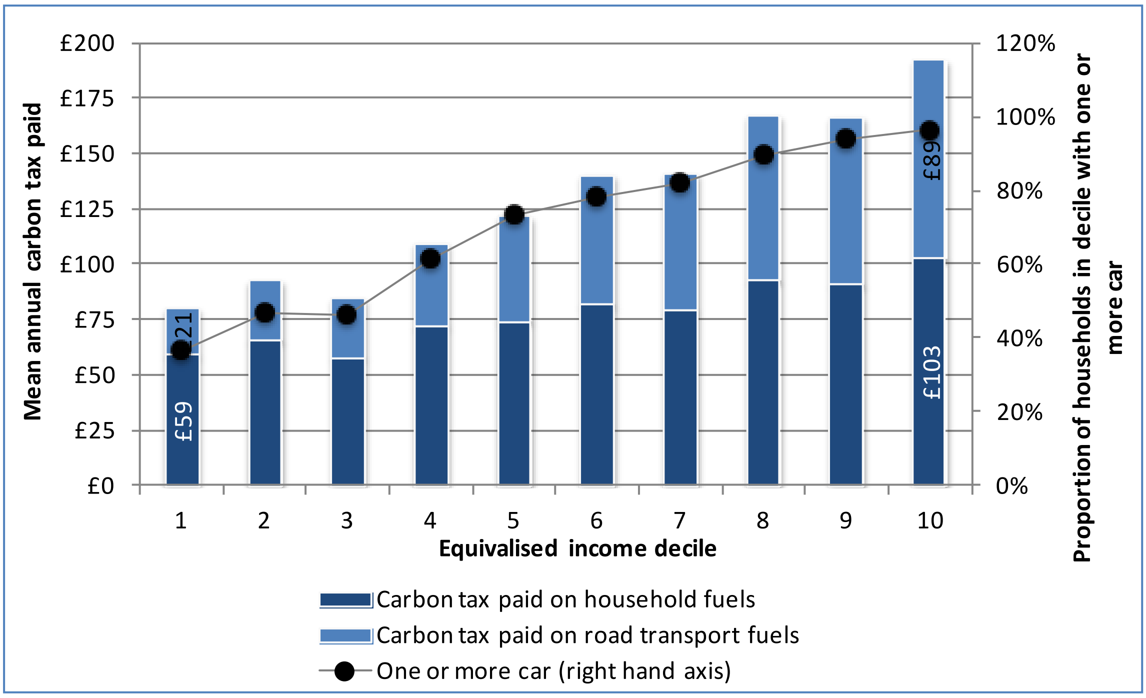


Figure 4.2. Car ownership in Scotland households by income decile

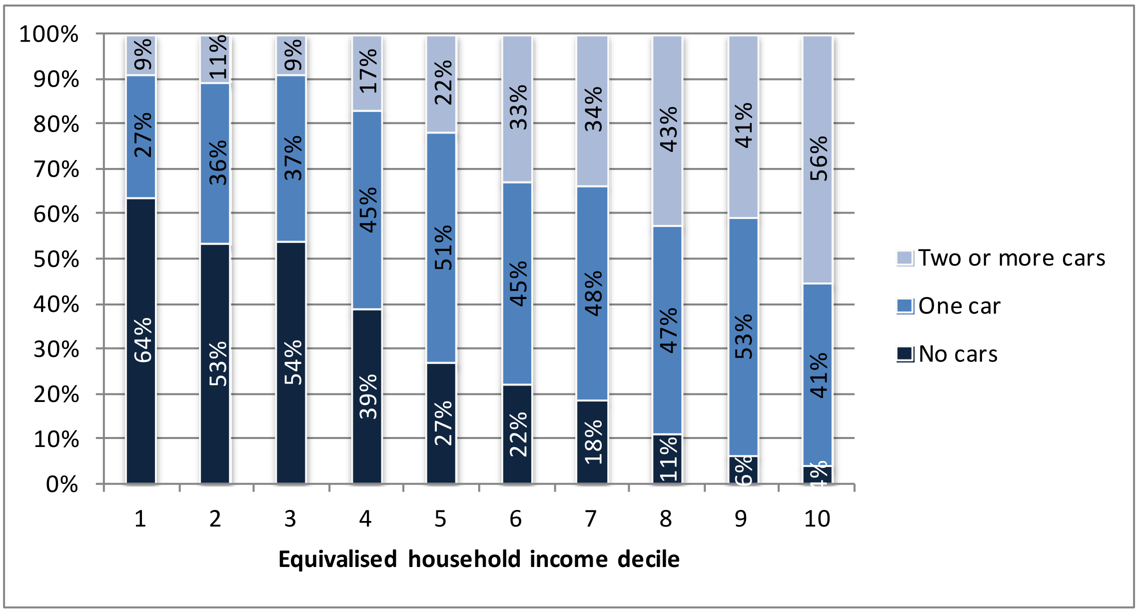


Figure 4.3 below shows the average annual carbon tax paid by different household types. This again suggests there is less divergence in tax paid on energy consumed in the home compared to vehicle emissions. A multi-person household pays around double the carbon tax of a single person household on household fuels (around £100 compared to £50 respectively), but 3 to 6.5 times that in carbon tax on road transport emissions (depending on whether the single person is over or under 60). This reflects the 'economies of scale' of energy consumption in the home compared to vehicle

usage in multiple occupancy houses. There will also be interacting income effects underlying the patterns seen in Figure 4.3 (e.g. single adult households likely to be on a lower income which generally translates into lower energy consumption).

Figure 4.3. Average annual carbon tax paid in 2017 by household composition

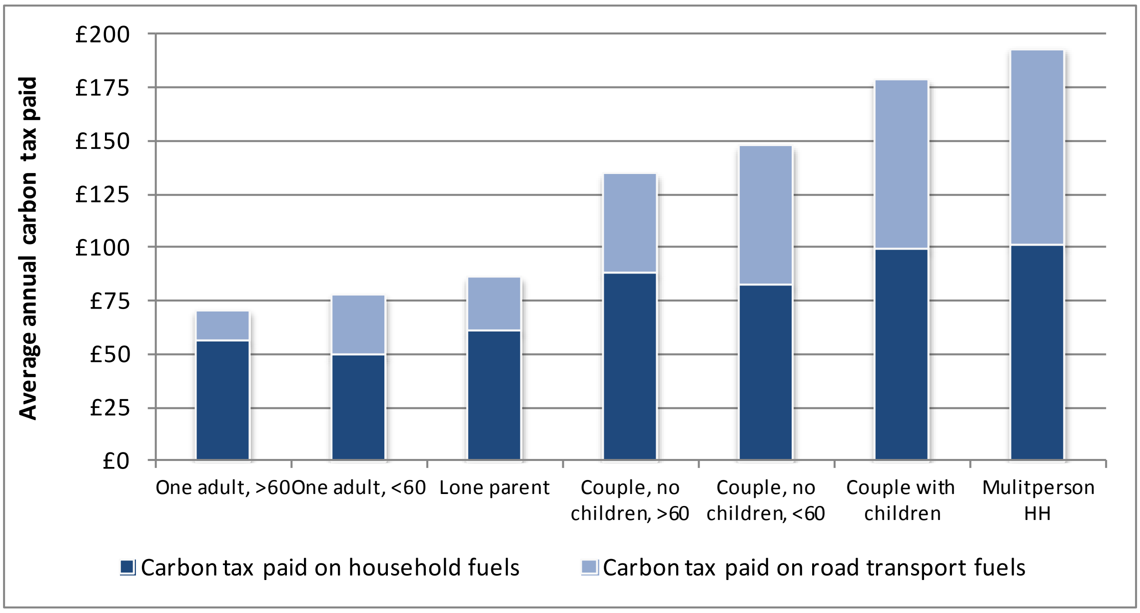


Figure 4.4 below shows the average annual carbon tax paid by geographical area ("rurality"). Households in the less urban areas appear to pay relatively more tax on average on energy consumed in the home; this is likely to reflect the nature of dwellings (more older, less energy efficient properties in rural areas and reliance on more carbon intensive heating fuels due to lack of mains gas network).

Looking at the average carbon tax paid on road transport emissions suggests that – perhaps contrary to expected results - households in the more remote areas do not pay the highest annual carbon tax on average compared to other areas.

The average carbon tax paid on road transport fuels appears to increase from "large urban areas" to "accessible" areas, but reduce when comparing those in remote (which includes "very remote") areas. This suggests that other factors - beyond physical location of the property – have a stronger influence over vehicle fuel use (and therefore carbon tax paid on road transport emissions) (e.g. location of employer and the types of employment available and / or having the financial and physical capacity to travel long distances).

Figure 4.4 provides further insight into these underlying factors: it shows that both income and vehicle ownership is greatest in households in "accessible" areas (where 80% of households have a vehicle, half of whom have 2 or more vehicles); and lowest – income notably so – in the more remote areas.

Figure 4.4. Average annual carbon tax paid in 2017 by urban/rural identifier

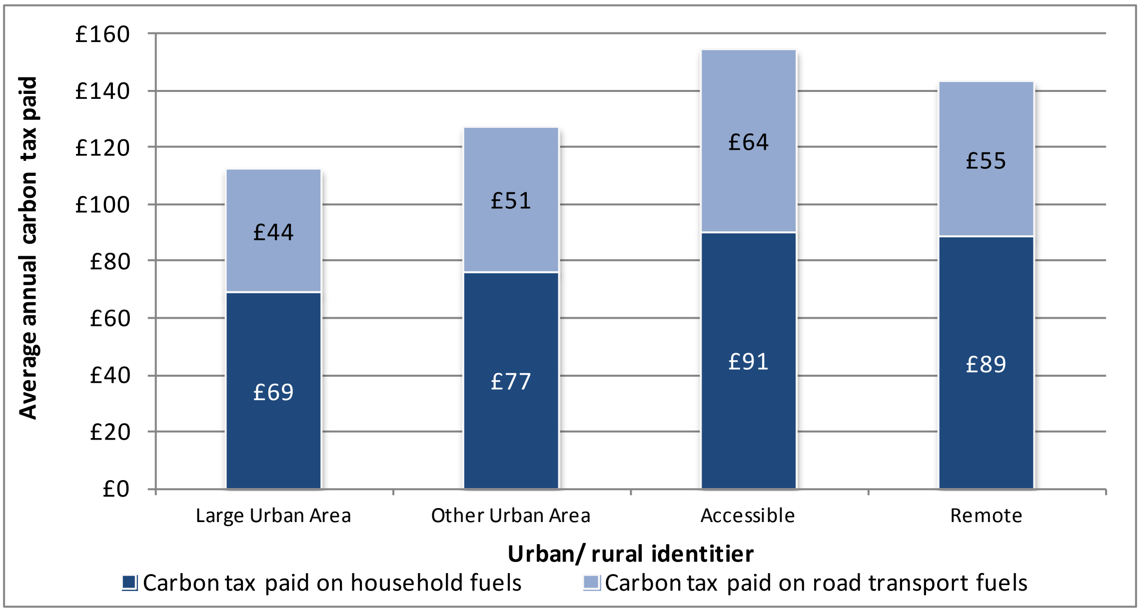
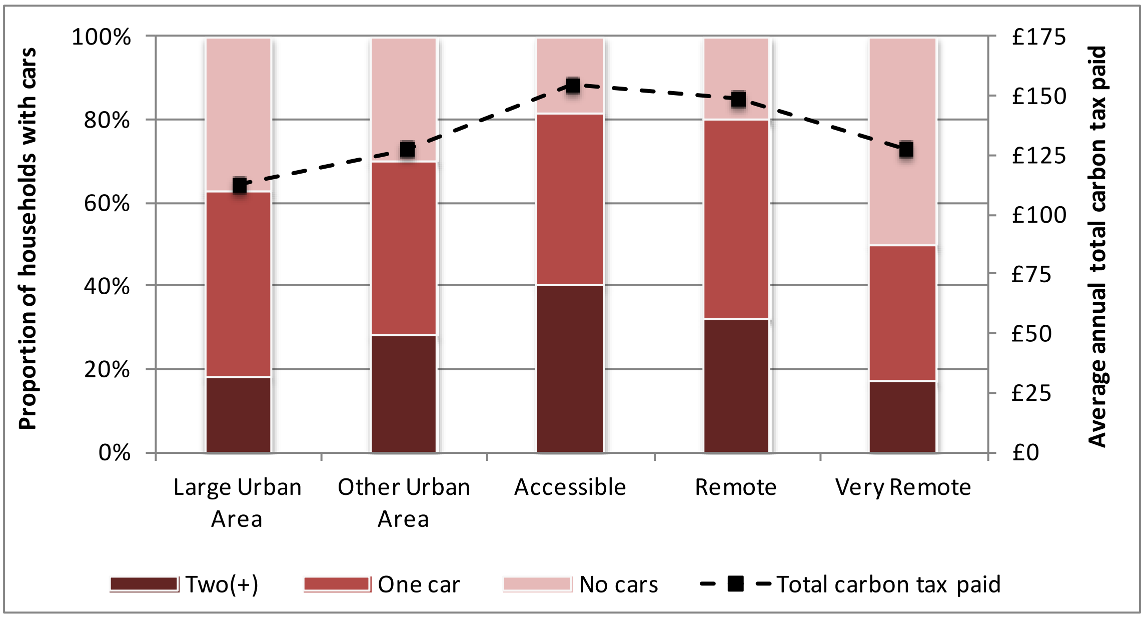


Figure 4.5. Number of cars in household and average total carbon tax paid in 2017 by urban/rural identifier



5 Tax and benefit compensation packages

As described in the methodology section of this report, the IFS TAXBEN model is used to simulate a scenario of compensation packages to recycle the revenue raised from the carbon tax in Scotland back to households. The aim of this modelling is demonstrate the potential to protect low income households from the adverse impacts of a carbon tax.

In the proceeding analysis, financial values from the data have been uprated to 2017–18 prices. Most importantly, earnings levels in the data have been uprated using actual earnings growth up to the present and the Office for Budget Responsibility (OBR) forecast of earnings growth up to 2017–18.

5.1 TAXBEN scenario

The final compensation packages involve changes to Universal Credit, in particular increasing the basic amounts of Universal Credit that different family types get and lowering the rate at which it is withdrawn as incomes rise. [28] To compensate low-income pensioners for the carbon tax in much the same way, Pension Credit amounts are also increased. The details are given in Table 5.1 below, with all figures in nominal terms in 2017–18. The compensation package gives a total of £300 million to households in Scotland in 2017–18, which is the same aggregate amount that the carbon tax in Scotland, as modelled in this study, would raise.

Table 5.1. Details of compensation package

Annual increase in	
Pension Credit for singles	£300
Pension Credit for couples	£500
Universal Credit for singles without children	£300
Universal Credit for lone parents	£200
Universal Credit for couples without children	£700
Universal Credit for couples with children	£300
Universal Credit taper rate	-2ppt (from 65% to 63%)
Total cost of package	**£0.3 billion**

It is important to note that these compensation packages are intended to be illustrative: the aim of the research team was to minimise the number of low-income losers in a way that did not favour one particular household type over another (so we do not particularly favour pensioners or lone-parent households, for example). A government that wished to introduce a carbon tax would have its own distributional objectives: the analysis here is simply intended to show that the introduction of a carbon tax need not disproportionately impact on low-income households if combined with an appropriate compensation package.

[28] The taper rate is the rate at which Universal Credit will be withdrawn for each additional pound of income. For example, a taper rate of 65% means that for an additional pound of income, UC will be reduced by 65p, so the claimant will keep 35% of any additional income.

5.2 Modelling benefits: health warning

It is important to bear two caveats in mind. First, TAXBEN assumes full take-up of means-tested benefits. In practice there is some non-take up of benefits, which will act to produce more low-income losers in reality than we estimate here. Clearly, the take-up rate of the new Universal Credit will be crucial in determining how important a factor this will be. Existing means-tested benefits and tax credits for those of working age already have relatively high rates of take-up, often in excess of 90%, at least for those on lower incomes.[29] The government hopes that Universal Credit will have a higher take-up rate as it is a single benefit that families can continue claiming whether they are in or out of work. However, Pension Credit has a lower rate of take-up, particularly among pensioners with small amounts of private income.[30] It is therefore likely that more low-income pensioners would lose out from the carbon tax and compensation package than we estimate here. Therefore any programme of carbon taxation would need to be complimented by support services promoting access to these benefits. The most successful fuel poverty programmes provide both energy efficiency measures and benefits advice for similar reasons.

Secondly, the analysis does not take account of individuals changing their labour market or other behaviours in response to the reforms. The introduction of the carbon tax and increases in the basic amounts of means-tested benefits would both tend to weaken the incentives for individuals to do paid work, though this is offset at least partly by the reduction in the rate at which Universal Credit is withdrawn as incomes rise. As with any change to tax and benefit policy, a government wishing to introduce a compensation package for a carbon tax would in practice have to balance distributional goals against other objectives it may have, such as work incentive objectives.

5.3 Overview of distributional impacts

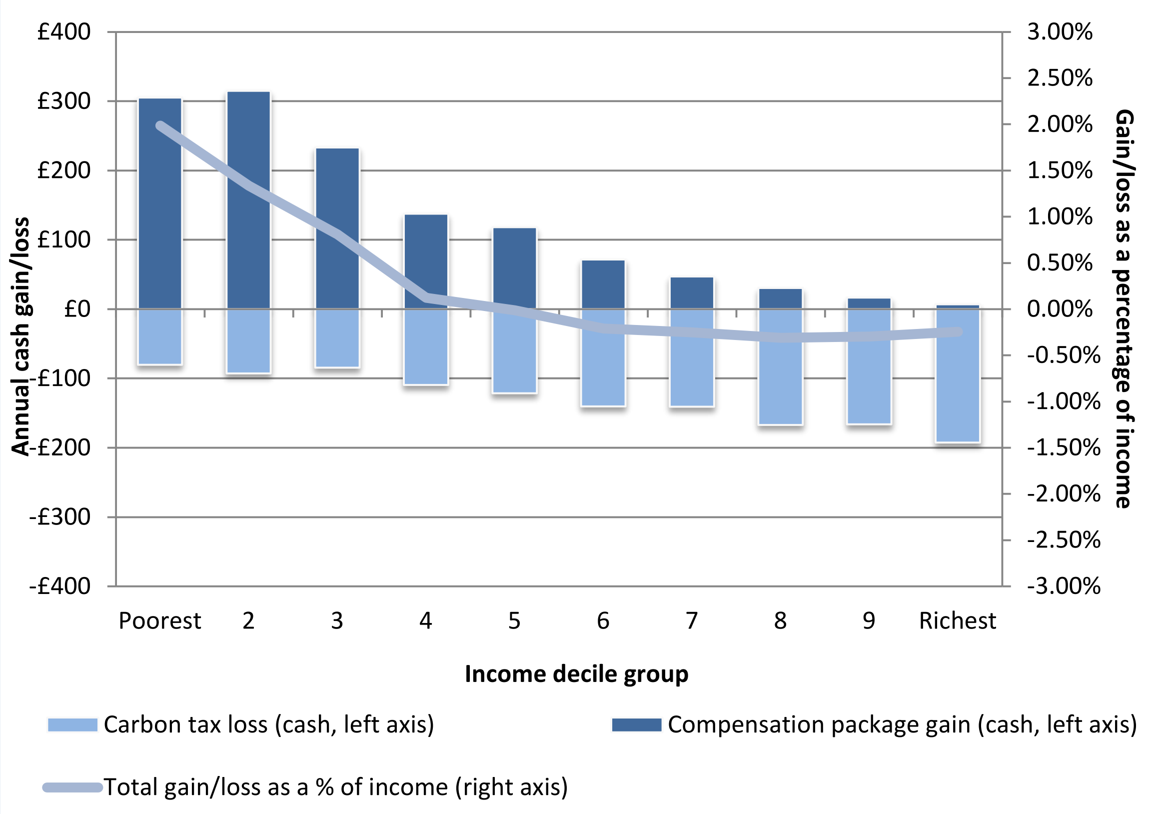
Figure 5.1 shows average carbon tax amounts and average gains from the compensation package for households in each decile group of the Scottish income distribution (left axis), along with the combined gain or loss as a percentage of income (right axis).

Increases in Universal Credit and Pension Credit that recycle the revenue raised by the carbon tax easily compensate lower-income households, on average. Each of the bottom three Scottish income decile groups gains on average from the combined carbon tax and compensation package, with average net gains of about 2% of income (£310 per year) in the bottom decile and about 0.8% of income (£230 per year) in the third. The net effect on the fourth and fifth decile groups is close to zero, on average. Revenue neutrality implies that these gains are balanced by average losses in higher-income households, although as a percentage of income these losses are much smaller than the gains to lower-income households.

[29] See http://www.hmrc.gov.uk/statistics/fin-takeup-stats/cwtc-take-up.pdf and https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/222915/tkup_full_report_0910.pdf.

[30] According to DWP analysis, between 62% and 68% of pensioners entitled to Pension Credit claimed their entitlements in 2009–10, with between 20% and 27% of the total cash entitlement not being claimed. See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/222915/tkup_full_report_0910.pdf.

Figure 5.1. Distributional impact of carbon tax and associated compensation package in Scotland (2017)



Notes and sources: Notes: Income decile groups are derived by dividing all households in Scotland into 10 equal-sized groups according to income adjusted for household size using the McClements equivalence scale. Decile group 1 contains the poorest tenth of the population, decile group 2 the second poorest, and so on up to decile group 10, which contains the richest tenth.

Source: Authors' calculations using DIMPSA and TAXBEN run on the 2006-2010 Living Costs and Food Surveys.

5.4 "Winners" and "losers"

Of course, Figure 5.1 masks variation within each income decile. For example, the near-zero net gains in the fourth and fifth deciles aggregate the losses of some households together with the gains of other households. To identify "winners" and "losers", we apply a better or worse off threshold of greater than £1 per week respectively. We include a 'broadly unaffected' category for those households who gain or lose by less than £1 per week (£52 per year) as a result of the combined carbon tax and compensation package (see Box 5.1 for full details).

Box 5.1. Defining winners and losers

Overall gain or loss = Compensation package gain – Carbon tax

'Winners' = overall gain of at least £52 per year
'Broadly unaffected' = overall gain or loss less than £52 per year
'Losers' = overall loss of at least £52 per year

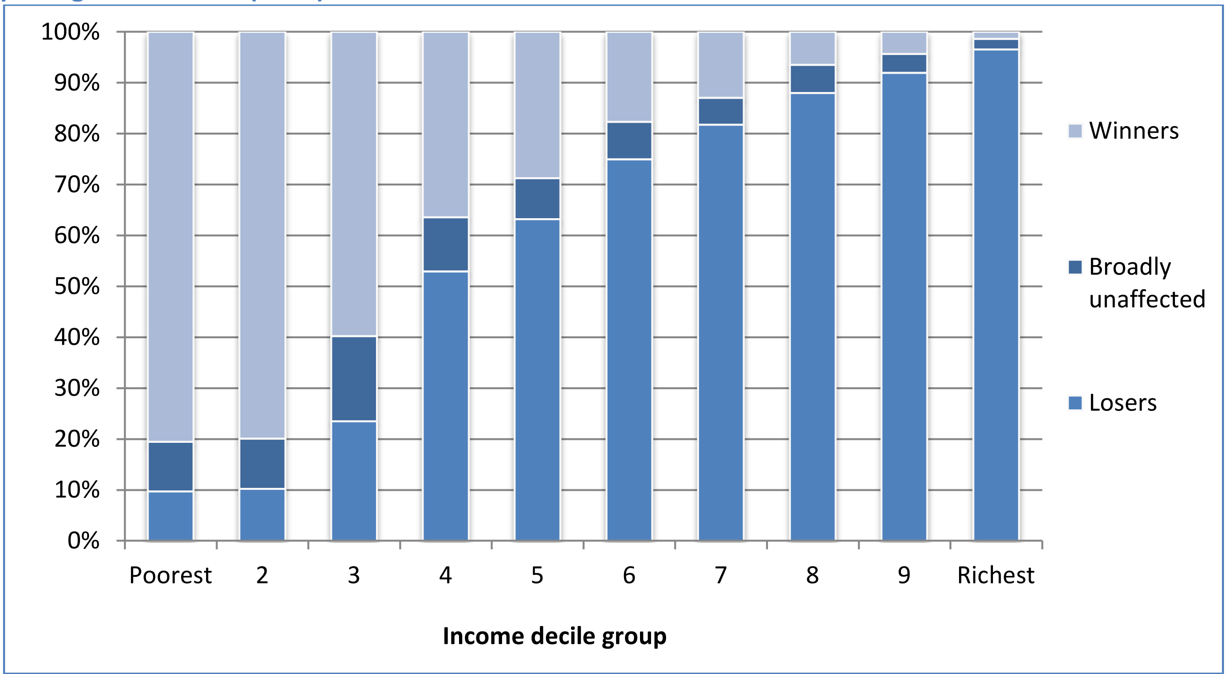
Overall a third of households are better off as a result of the combined effects of the carbon tax and its compensation package in 2017 in Scotland (Table 5.2), whilst 59% are worse off and 8% 'broadly unaffected'.

Table 5.2. Winners and losers under carbon tax and benefits package in Scotland (2017)

	Count (000s)	%	Mean 'net gain'
Loser	1,383	59%	-£160
Broadly unaffected	184	8%	-£18
Winner	764	33%	£289

Figure 5.2 shows the proportion of households in each income decile group that gains or losses from the combined effects of the carbon tax and its compensation package. This shows that most low-income households in Scotland gain overall from the combined carbon tax and compensation package, and most high-income households lose. This is unsurprising given the results shown in Figure 5.1 and given that the compensation packages are deliberately skewed towards lower-income households. The compensation packages do not eliminate low-income losers entirely. Some low-income households are not entitled to means-tested benefits (e.g. because they have significant amounts of capital or because they are students) or are particularly high users of carbon, and they will be particularly difficult to compensate by these means. Nevertheless, about 90% of households in the first and second income deciles and almost 80% of households in the third income decile are compensated, or more-than-compensated, for the carbon tax that they would have to pay.

Figure 5.2. Winners and losers by income decile from carbon tax and associated compensation package in Scotland (2017)



Notes and Sources: as for Figure 5.1.

5.5 Conclusion

This chapter has shown that the revenue from a carbon tax could be used to compensate low-income households in Scotland for the carbon tax payments they would have to make, in a way that leaves them better off on average and with a large majority having gained from the combined package overall.

The minority of low-income households in Scotland that would lose out overall are on the whole not entitled to means-tested benefits. In some cases this is because they have considerable savings or other assets which mean they are not entitled to Universal Credit, which in some cases will be because they have a low income only temporarily. In others cases, losing households contain students who are generally not entitled to benefits.

The next chapter discusses the characteristics of the winners and losers from the carbon taxes in more detail.

6 Distributional impacts of combined carbon tax and benefits compensation

This chapter presents a more detailed analysis of the combined impact of a carbon tax and benefits compensation package on households in Scotland in 2017.

6.1 Distribution of winners and losers by socio-demographics

As described in the previous chapter, households are categorised as 'winners', 'losers' or 'broadly unaffected' according to the net impact ("overall gain") of the carbon tax and compensation packages (refer to Box 5.1). We saw that overall some 8% of households fall into the 'broadly unaffected' category and the majority of low-income households are better off or broadly unaffected (Figure 5.2, page 38), being sufficiently compensated through changes to the benefits system for the carbon tax that they would have to pay.

Figure 6.1 explores this effect in more detail, showing the average net/gain loss for winning and losing households (the broadly unaffected group is omitted here hence the bars do not add up to 100%) by income quintile and the overall average net gain/loss for the group (quintile) as a whole (this information is shown by income quintile rather than the deciles used previously due to small sample sizes associated with this detailed level of analysis).

As we saw previously, the majority of low income households appear better off under the carbon tax/benefit system modelled here, with 80% of the lowest income quintile experiencing a net benefit – "winning" – and by a convincing margin of around £300 a year on average (Figure 6.1).

The proportion of households "winning" decreases as income levels increase: less than a quarter (23%) of income quintile 3 are winning, although by a similar amount as quintile 1 (£300 a year on average), whilst only 3% of the top income quintile are better off overall and by less than half that of the lowest income group.

There appears less variation in the average net loss of households made worse off, which ranges from £129 for the 10% of losing households in quintile 1, to £180 for the 94% of losing households in quintile 5.

Overall, the average net impact of the carbon tax and benefits system modelled here is net benefit of around £220 for the lowest income quintile and a net loss of around £170 for the top income quintile.

Figure 6.1. Proportion of winners and losers (left axis) and mean net gain (for winners), loss (for losers) and overall average (right axis) by equivalised household income quintile

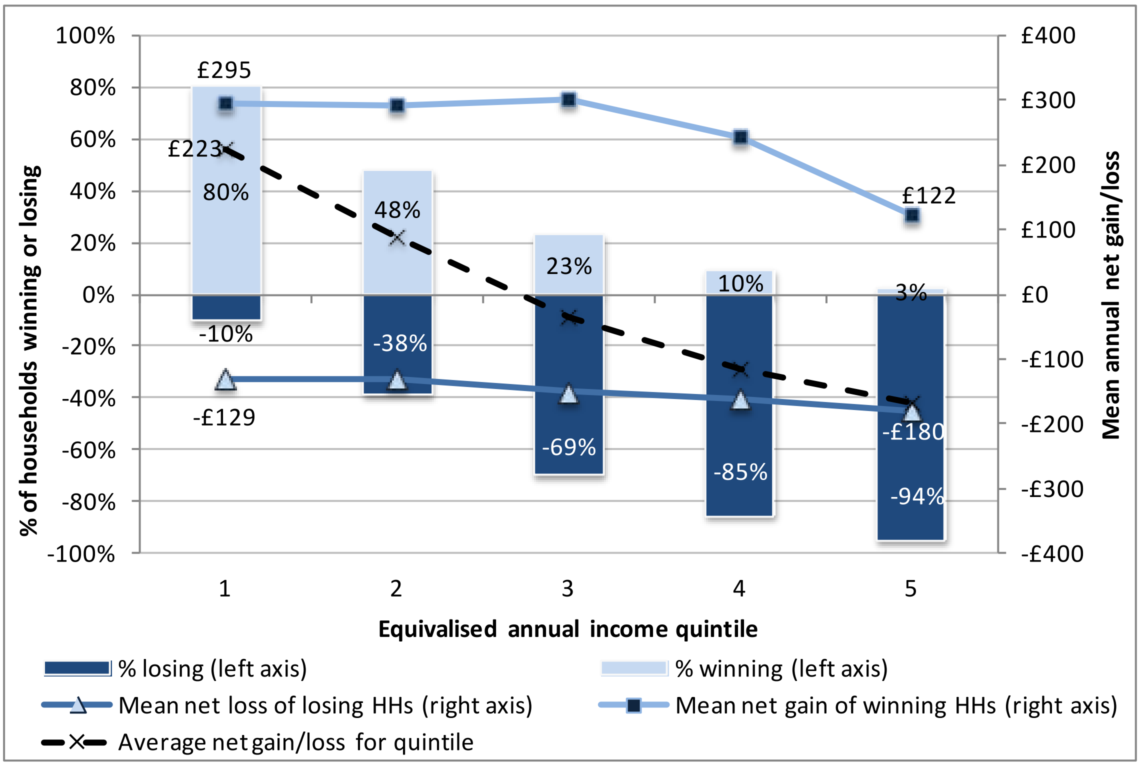


Figure 6.2 shows the same information as Figure 6.1 above but split by geographical area. This shows that households living in "accessible" areas are losing the most (64% of households made worse off by around £180 a year on average) but only marginally so compared to all other areas. This apparent lack of variation in overall impact of the carbon tax and benefits system modelled here across different settlement types in Scotland suggests there are interacting factors driving this effect, for example related to physical property characteristics, vehicle ownership and income. Analysis presented in section 4.2 explored the distribution of carbon tax paid on household fuels and road transport), incomes and car use by settlement type. This showed both income and car use to be lower in the most rural areas, but tax paid on household fuels higher compared to urban areas (refer to Figure 4.4 and Figure 4.5). Table 6.1 shows that whilst the proportion of households receiving compensation is fairly consistent across different settlement types, the average level of compensation received is lower in the more remote areas, whilst average carbon tax paid by households in these areas is higher, and hence the net effect is a loss on average of around £20 a year.

Figure 6.2. Proportion of winners and losers (left axis) and mean net gain (for winners), loss (for losers) and overall average (right axis) by urban/rural identifier

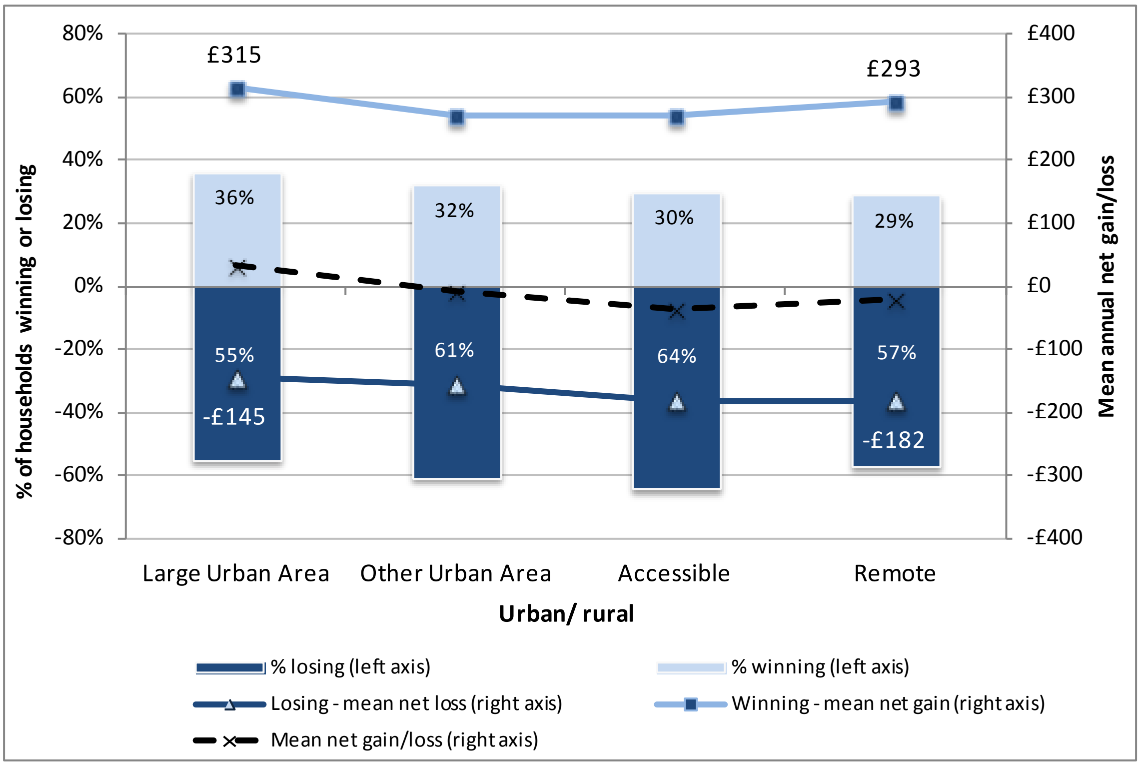


Table 6.1. Compensation received and carbon tax paid by area

	% of HHs eligible for compensation	Mean compensation	Total carbon tax paid	Net impact
Large Urban Area	70%	£145	£113	£32
Other Urban Area	67%	£118	£127	-£9
Accessible	67%	£118	£154	-£37
Remote	67%	£122	£143	-£21

Heating fuel is another factor that is likely to be influencing the pattern we see across settlement types. Figure 6.3 shows that the majority (78%) of households reliant on oil for heating (some 123,000 households in Scotland, 40% of whom are in remote areas) are worse off and by nearly £240 a year. This relates to the carbon intensity of the fuel and most likely reflects a number of interacting effects such as dwelling type, income and so on.

Electrically heated properties (some 353,000 in Scotland, 37% of whom are in large urban areas) appear most likely to gain, with 46% winning by around £300 a year. Low-income households are more likely to use electricity to heat their home so this effect appears progressive (Figure 6.4). Lower levels of car usage in these households and access to compensation via improved benefits is the underlying driver for this trend i.e. rather than the impact of energy efficiency measures in electrically heated homes.

Figure 6.3. Proportion of winners and losers (left axis) and mean net gain (for winners), loss (for losers) and overall average (right axis) by main heating fuel

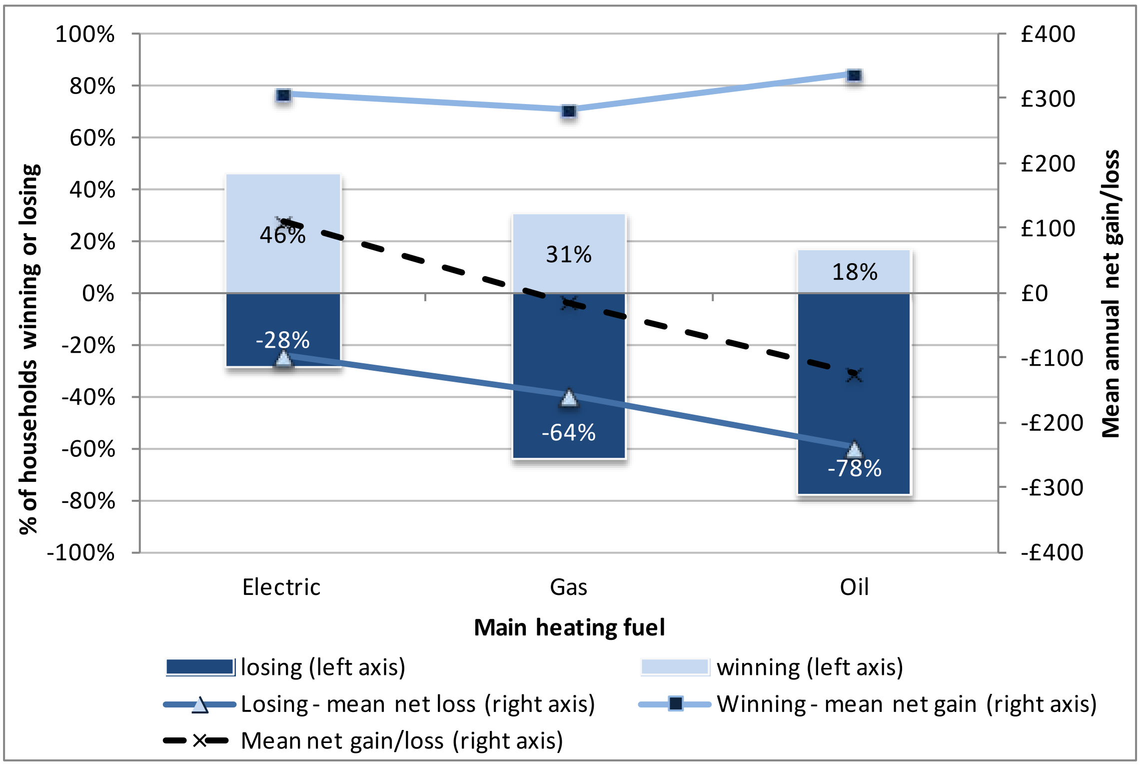


Figure 6.4. Proportion of households using each heating fuel by income quintile

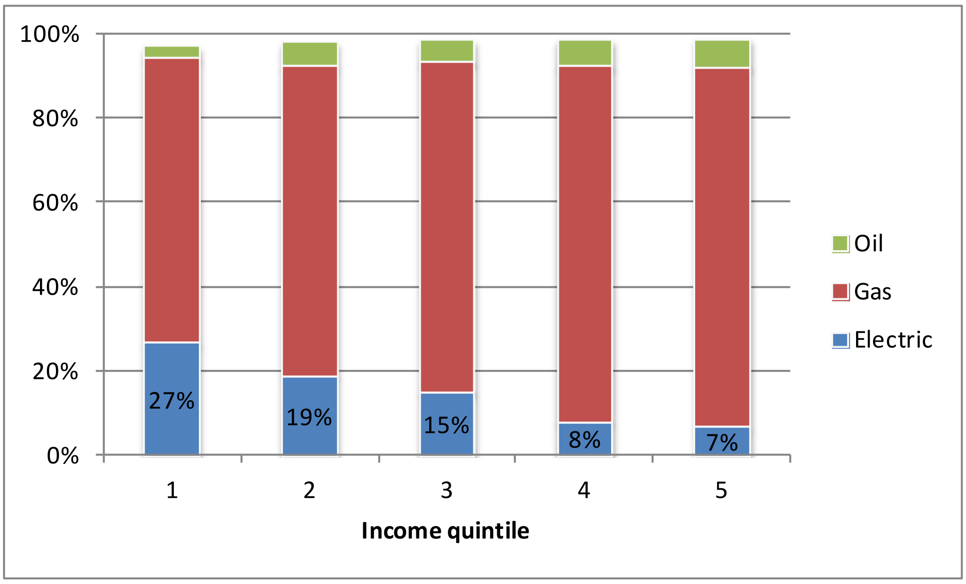
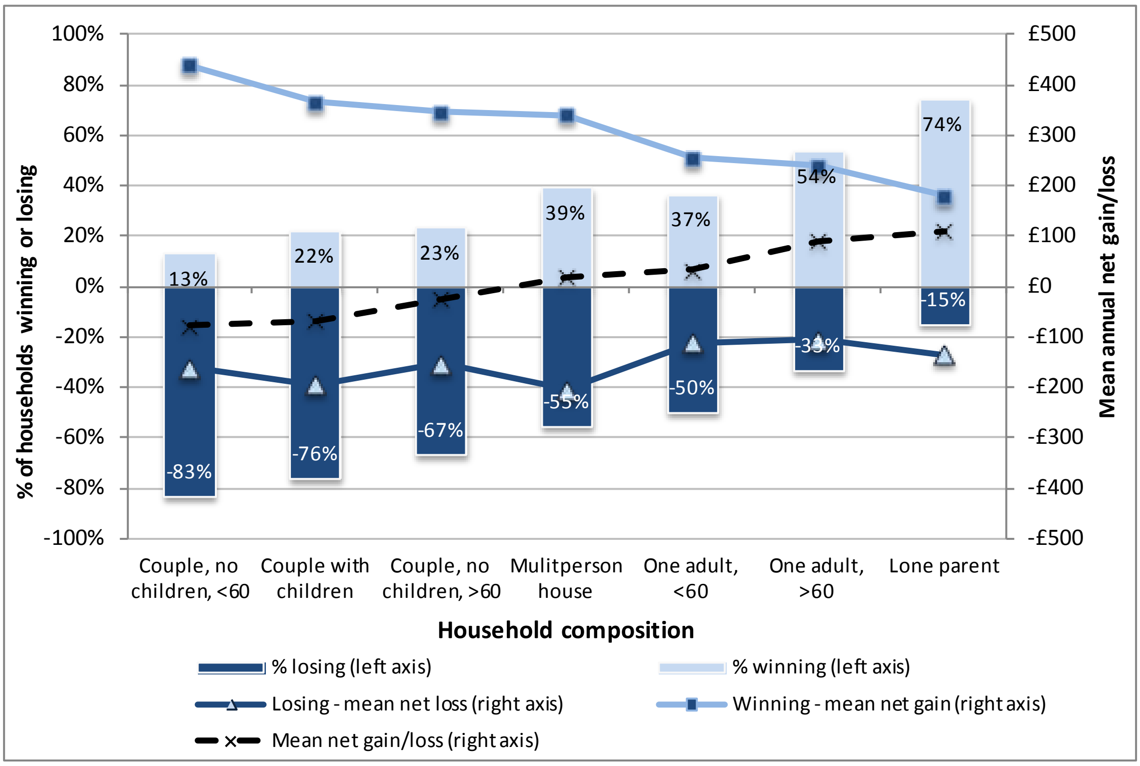


Figure 6.5 shows the proportion of winners and losers by household composition. Lone parents appear to most likely to be better off overall under the carbon tax and benefit system modelled here, with 74% of this group “winning” by around £180 a year on average. Couples under the age of 60 with no children appear most likely to make a loss, with 83% losing by around £160 a year on average. Whilst only 13% of this group are “winning”, they do so by over £400 a year. This pattern is consistent across all the household types: the less likely they are to be winners, the greater the value of any potential gain appears to be. This result should be interpreted with some caution however as the sample sizes are small. Overall the results do suggest that multiperson households;

single adult households (both over and under 60) and lone parents should all be better off on average whilst couples (with and without children, over and under 60) appear worse off on average, but by less than £80 a year (dashed line on Figure 6.5 below). This pattern reflects the design of the TAXBEN compensation package, which is more likely to apply to single persons over 60 and lone parents.

Figure 6.5. Proportion of winners and losers (left axis) and mean net gain (for winners), loss (for losers) and overall average (right axis) by household composition



7 Detailed characterisation of 'Winners' and 'Losers'

Analysis presented in the previous chapter showed the average annual net gain/loss and proportion of households 'winning' and 'losing' by different socio-demographic characteristics. This provides some indication of the likely distributional impact of the carbon tax and compensation package modelled in this study. This section presents some more detailed analysis to further explore and identify key defining characteristics of 'winning' and 'losing' groups of households using 'CHAID'.

CHAID (Chi-squared Automatic Interaction Detector) 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 net gain/loss in 2017. This results in clusters – or 'nodes'- of cases with similar defining characteristics and to which a predicted value for the dependent variable is assigned.

This method facilitates grouping of households based on the relationship between certain household characteristics and the estimated net gain/loss of the carbon tax and compensation package.

CHAID analysis therefore has the advantage that it enables more detailed scrutiny of the socio-demographics of winning and losing households, whilst maintaining a sufficient number of cases to give reliable estimates of values.

7.1 Results from CHAID analysis

CHAID is an exploratory research method and several different approaches were trialled before identifying a model considered to be most useful in analysing the outputs for this research. ClimateXChange is particularly interested in the differential impacts across urban and rural areas of Scotland. The model was therefore forced to use an urban/rural indicator to first split the data[31]. Whilst this slightly reduced the model fit (the accuracy with which CHAID identifies winning/losing households), it provides a useful means of analysing the potential spatial impacts in more detail.

The dependent variable in the model was annual net gain/loss of the combined carbon tax and compensation package on households in 2017. Predictor variables selected by the model (i.e. variables which CHAID identified as having a statistically significant difference with respect to the dependent variable) are shown in Box 7.1.

Box 7.1. Variables selected as predictors in the CHAID model on small carbon tax without transport scenario outputs

- Urban/ rural indicator*
- Tenure
- Economic position of HRP[32]
- Number of adults in household
- Household income decile
- Number of vehicles in household
- Household composition
- Number of children in household
- Dwelling type

Notes: * forced model to split on urban/rural first

[31] A two-fold classification was used whereby urban includes 'large urban areas' and 'other urban areas' with all remaining areas classed as rural. Models were run using a more detailed classification to categorise remote areas separately but this resulted in a poor model, with outputs of limited use (e.g. only one node was identified as remote, with no further breakdown; it therefore included a mix of winners and losers and different household types).

[32] HRP refers to the 'Household Reference Person', defined, as noted earlier, as the householder with the highest income (or the oldest of two or more householders with the same income).

Based on the net/gain loss predicted by the CHAID model, this gives an estimated 47% of households to be worse off overall (i.e. a predicted net loss of greater than £52 a year); 35% to be better off; and 19% to be 'broadly unaffected' (Table 7.1). This compares to 59%, 8% and 33% respectively in the actual observed data. Overall the model correctly classifies 71% of cases (Table 7.2).

Table 7.1. Estimated number of winning and losing households based on CHIAD modelled net gain/loss

	Count of households	Percent
Losers	1,086,991	47%
Broadly unaffected	435,908	19%
Winners	809,144	35%
Total	*2,332,043*	*100%*

Table 7.2. Results of CHAID on small carbon tax without transport scenario outputs

		Predicted			
		Loser	Broadly unaffected	Winner	*Percent Correct*
Observed	Loser	982,826	266,897	133,660	71%
	Broadly unaffected	46,786	61,710	75,719	33%
	Winner	57,379	107,300	599,766	78%
	Overall Percentage	47%	19%	35%	71%

A total of 14 different 'nodes' were identified by the CHAID model, five of which are predicted to be losing; three broadly unaffected; and six winning, as shown in Figure 7.1, Figure 7.2 and Table 7.3 below. Figure 7.1 and Figure 7.2 show the average income (equivalised) and emissions (from energy used in the home and petrol and diesel) for each node respectively. This shows that in general, lower income and lower emissions are typical of the winning nodes, whilst the losing nodes appear richer and higher emitters. This is not surprising given the targeting of the compensation package at low income households (and that low income households typically consume less in the first place).

It is also interesting to note the average proportional split between household and road transport (petrol and diesel) emissions for each node: road transport accounts for nearly half the total annual average emissions for some of the richer, 'losing' nodes, whilst two of the losing nodes appear to use almost no petrol and diesel (i.e. these are non-driving households). This has implications for the potential for households to avoid the carbon tax through behavioural change (e.g. driving less), or improving the energy efficiency of their home. This level of modelling is beyond the scope of this study, but is discussed again briefly in the concluding chapter.

Figure 7.1. Average income and estimated net gain/loss by CHAID node

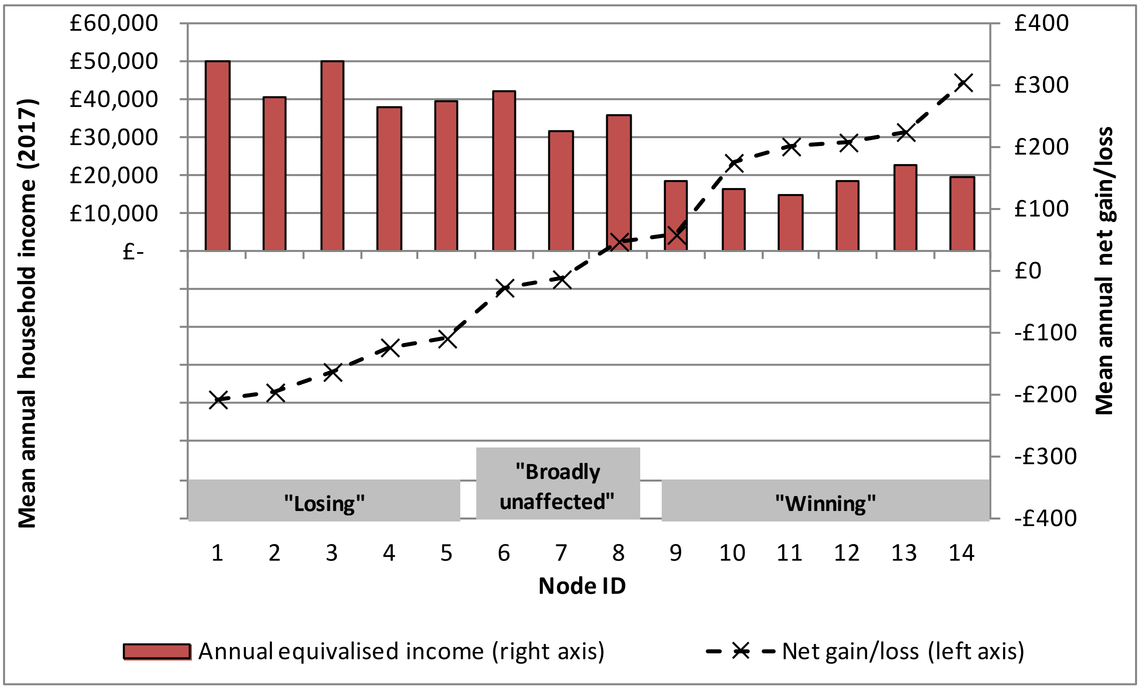


Figure 7.2. Average annual emissions and estimated net gain/loss by CHAID node

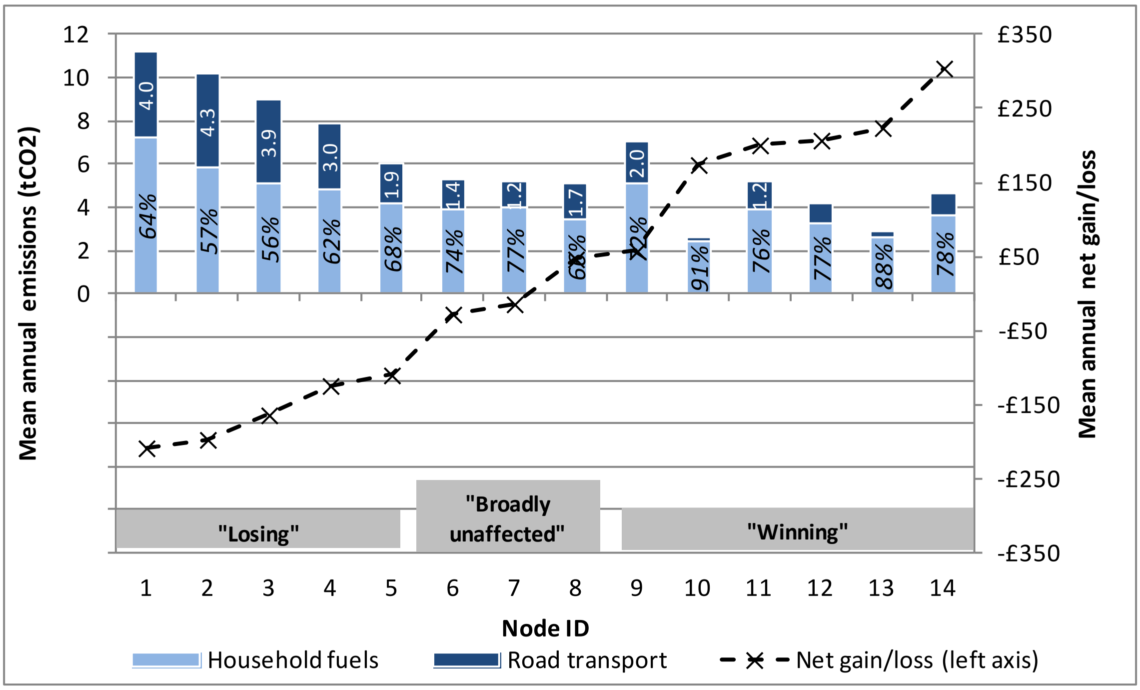


Table 7.3 also shows the actual proportion of winning and losing households in each node based on the underlying dataset[33]; whether the node is in urban or rural areas and the average income of all households in the node.

[33] This is based on the actual household-level dataset net gain/loss, as opposed to the net gain/loss as predicted by CHAID, which is essentially equal to the mean net gain/loss for all households in the node and

Four nodes represent households in rural areas (where rural includes all areas except large and other urban). Two of the rural nodes are predicted to be worse off overall under the carbon tax and compensation package modelled here; indeed the group with the greatest average predicted net loss is a rural node (node 1). However, these appear to be relatively high income households.

Cross-tabulating the nodes created in the CHAID analysis with additional socio-demographic variables in the LCF dataset provides further insight into the underlying drivers for 'winning' and 'losing' under the carbon taxation and compensation package modelled in this study. The results of this detailed node-by-node analysis are shown in the tables that follow and summarised below.

Table 7.3. Summary of nodes identified by CHAID

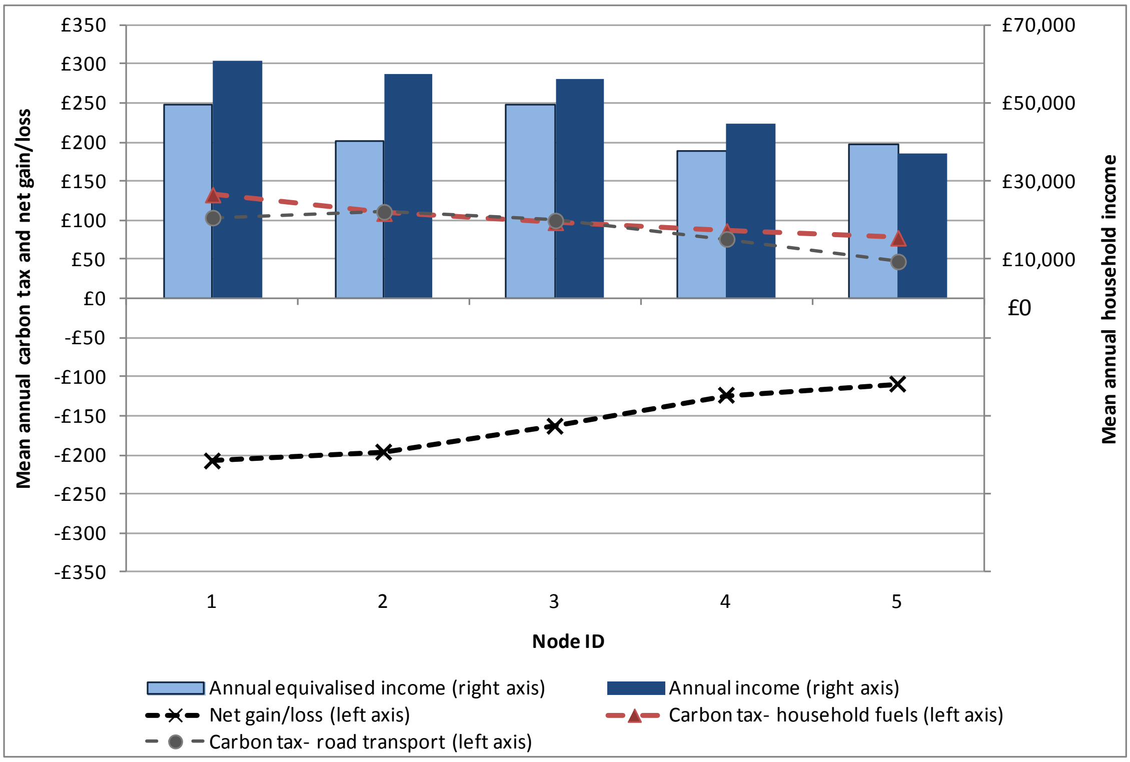
Node		Count of HHs	% of HHs	Predicted net gain/ loss	Predicted winning/losing status			Actual winning/ losing status			Urban or rural?	Mean income
					Losing	Broadly unaffected	Winning	Losing	Broadly unaffected	Winning		
Predicted losing	1	167,072	7%	-£208	100%	0%	0%	92%	2%	6%	rural	£60,663
	2	129,858	6%	-£197	100%	0%	0%	93%	3%	4%	urban	£57,231
	3	196,748	8%	-£164	100%	0%	0%	91%	1%	8%	urban	£56,234
	4	156,034	7%	-£124	100%	0%	0%	88%	3%	9%	rural	£44,819
	5	437,278	19%	-£110	100%	0%	0%	89%	7%	3%	urban	£37,215
Unaffected	6	116,779	5%	-£28	0%	100%	0%	67%	9%	24%	rural	£26,559
	7	177,921	8%	-£14	0%	100%	0%	57%	16%	26%	urban	£27,779
	8	141,208	6%	£47	0%	100%	0%	62%	16%	23%	urban	£36,399
Predicted winning	9	151,609	7%	£58	0%	0%	100%	41%	15%	44%	urban	£19,014
	10	135,658	6%	£174	0%	0%	100%	4%	7%	89%	urban	£11,964
	11	137,044	6%	£201	0%	0%	100%	14%	12%	74%	urban	£14,592
	12	121,277	5%	£207	0%	0%	100%	12%	11%	77%	rural	£15,935
	13	127,554	5%	£224	0%	0%	100%	6%	4%	90%	urban	£14,667
	14	136,003	6%	£304	0%	0%	100%	18%	6%	76%	urban	£23,881
Total		2,332,043	100%	-£2	47%	19%	35%	59%	8%	33%		£33,721

7.1.1 Summary of 'losing' nodes

Five nodes are predicted by CHAID to be worse off overall under the carbon tax and compensation package modelled. These generally consist of households with high household and/or road transport emissions, who are working full time and higher income, hence less likely to be eligible for compensation.

therefore has a wide distribution. The percentages shown in the table above therefore provide an indication of predictive accuracy of the model for each node.

Figure 7.3. Key statistics for nodes identified as worse off on average by CHAID



Node 1: Greatest losing node – Wealthy working couples in more rural areas with oil heating and large houses (-£208)

The top 'losing' node is in non-urban, but accessible areas. Dwellings are predominantly larger and detached and being in more rural areas, a higher than average proportion use oil to heat their home (hence higher still household carbon emissions). This group of households has very high household and road transport (petrol and diesel) emissions; and being high income, in employment and under pension age, these households are unlikely to qualify for any compensation. Whilst worse off by over £200 a year, this represents less than 0.5% of their average annual household income. However, there may be limited capacity for these households to reduce their emissions (and therefore the amount they pay in carbon tax) due to being in rural areas and therefore lack access to mains gas and a greater need to drive due to lower and poorer provision of public transport.

Node 2: Wealthy working families in smaller urban areas with very high car use (-£197)

The second highest set of losing households (with an average net loss only very marginally less than the previous node) has the highest average road transport emissions of all nodes identified (4.3 tCO_2 per year – see Figure 7.2). These households are marginally better off than the previous node due to lower household emissions, being in slightly smaller dwellings (though still larger than average) and in urban areas hence with mains gas. These households all have children and live in smaller ('other urban') urban areas. The high transport emissions may reflect a commuting lifestyle (both driving to work and driving children to school), but being in urban areas driving may be avoidable to some extent (depending on the level of public transport provision in these areas).

Node 3: Higher income "empty-nesters" in urban areas with high vehicle ownership (-£164)

This group consists of couples who have a car each and are either in full time employment or in/nearing retirement. There are no dependent children, but the demographic suggests some households may have grown up 'children' still living at home. They are predominantly in smaller urban settlements ('other urban') and have mains gas heating.

Node 4: Higher income couples/families in accessible areas, mains gas or electric heating, high vehicle use (-£124)
This group is in non-urban but predominantly accessible areas, which correlates with higher vehicle use. These households are predicted to have a lower net loss than previous nodes, which can be explained by the presence of mains-gas or electric heating and slightly smaller houses (hence lower household carbon emissions). The demographic suggests these households consist of families (either with dependent children or adult off-spring still living at home).

Node 5: Owner-occupying, working, city dwellers, with one car and no children (-£110)
This group represents 19% of all households in Scotland. It is characteristic of full-time employed professional couples without children, who own their city flat or terraced house (with a mortgage) and have a car. These households are predicted to be worse off but by less than £2 a week. They have higher than average income but around average emissions – hence pay average rates in carbon tax but higher income means they are unlikely to qualify for the compensation package, so appear worse off overall.

7.1.2 Summary of 'broadly unaffected' nodes

Three nodes are identified by the CHAID model to be 'broadly unaffected' on average (with a predicted annual net/gain loss of between +/-£52 a year). These groups have slightly lower than average emissions (for both household fuels and road transport) and average income. They appear worse off overall by almost exactly the amount they pay in carbon tax, which suggests they are not eligible for any compensation.

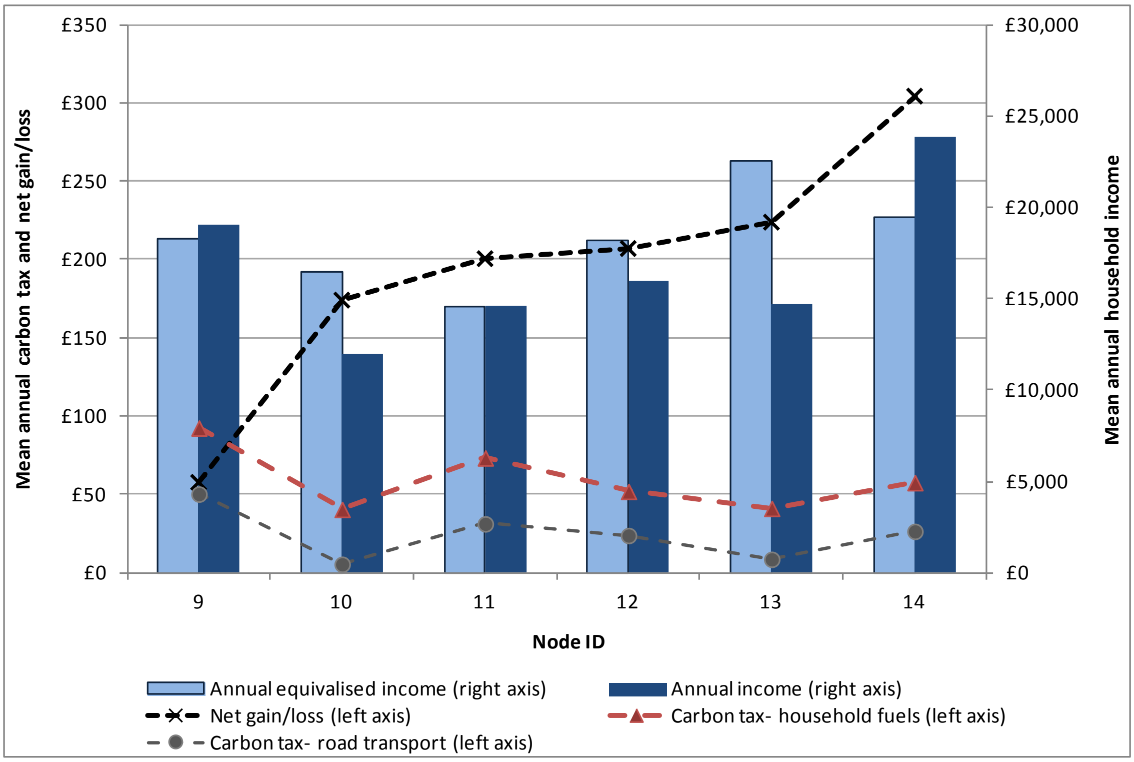
Node 6 represents one of the more remote groups of households, with 24% being in remote or very remote areas (compared to a 7% average across Scotland as whole). There also appears an element of under-occupancy in this group, which consists of only single adult households, around one third of whom live in detached dwellings and/or have three or more bedrooms.

7.1.3 Summary of 'winning' nodes

Six nodes were identified by CHAID as being, on average, better off overall under the carbon tax and compensation package modelled here.

In terms of the low-income and/or rural households, the compensation package appears sufficiently large and well-targeted to protect potentially vulnerable groups from the adverse impacts of a carbon tax.

Figure 7.4. Key statistics for nodes identified as better off on average by CHAID



Node 14: Top-winning node – Young out-of-work couples or families (+£304)

Being out-of-work, in rented accommodation and predominantly car-less households, this group appears neither asset-rich nor financially robust. These households live in urban areas (mostly in 'large urban centres') and are therefore not vulnerable to the issues of isolation and access to services associated with living in more rural areas of Scotland. However, a third do have dependent children at home and may therefore be considered an at-risk group. This is not the lowest emitting nor poorest group of households but their low-income status combined with higher occupancy rates (no single adult households) means these households receive higher levels of compensation (refer to Table 5.1, page 35 for details of the compensation package) which appears to more than off-set what they pay in the carbon tax.

Node 15: Low income single elderly in small social rented flats with mains gas or electric heating (+£224)

This group of households are again urban dwellers, living in small, (social) rented flats, without a car. Unlike Node 14, this group appears low income due to being retired or in part-time employment only. The demographic is notably older: nearly two-fifths are aged 75 or over, hence this could also be considered a vulnerable group. Their very low household emissions (due to property size, tenure – social housing being typically more energy efficient than private sector dwellings) and heating fuel – mains gas or electric), and very low road transport emissions (being in urban centres and predominantly car-less households), combined with low-income and pensioner status mean this group is receiving compensation sufficient to more than off-set what they pay in carbon tax.

Node 12: Rural electrically-heated, low income single adults, non-drivers (+£207)

This represents a low income, low emitting group of single adults (mixed ages), in small, (mainly social) rented houses and flats with very low private vehicle use despite over a quarter being in “remote” or “very remote” areas. This represents a potentially vulnerable group, being low-income (some with children) and in more isolated areas, hence with limited access to services and lack of mains gas. However, the compensation package appears to off-set the adverse impacts of a carbon tax in these circumstances (and with sufficient excess that should these households be under-heating at present they could potentially afford to increase their energy use in the home and still avoid being worse off overall).

Node 11: Low-income, retired and elderly owner-occupiers in urban flats or houses (+£201)

Whilst potentially vulnerable, being elderly and low-income, over half own their (mainly 3-bed) home outright so may be considered asset rich. They live in urban centres (over half in ‘large urban areas’ hence should have good access to services) and have mains gas heating. Their lower than average household and road transport appear more than off-set by eligibility for compensation. Whilst the average emissions of this node are consistent with their living circumstances (small, gas-heated properties in urban areas) they may also reflect a constrained income (properties are average sized, but household emissions are lower than average). Furthermore, being elderly, the heating needs of these households may be greater than average. It is therefore reassuring that this group appears better off (and by more than £200 a year); if these households are under-heating to any extent at present, this additional source of income could facilitate an increase in energy use in the home whilst still being no worse off financially as a result of the carbon tax.

Node 10: Lowest emitters - Low income, out-of-work single adults and lone parents in social rented flats in urban centres (+£174)

This is our lowest emitting group of households with household emissions almost half the national average and almost non-existent road transport emissions (87% of these households are without a car). Being out-of-work single adults, some with children at home, this represents a potentially vulnerable group. However, they live in social-rented accommodation (which has typically higher standards of energy efficiency than private sector housing) and are in urban areas (hence not physically isolated). A combination of low income status and very low emissions sees these households better off overall under the carbon tax and compensation package modelled here.

Node 9: Lower income retired households in rural, off-gas houses (+£58)

This group of households is predicted to be better off on average by the CHAID model, but only marginally so (at +£58 a year on average). It is slightly mixed group of households in terms of demographics with some couples, some single adults, some in full-time employment, but retired and elderly households feature strongly. Being low income (although some potentially asset-rich, owning their home outright), in rural areas, with over a third in ‘remote’ or ‘very remote’ areas this group may be considered vulnerable. Higher reliance on oil for heating may be a factor limiting the extent to which they ‘win’. Detailed physical property and fuel poverty characteristics are unknown, but if these households are under-heating at present and cold, the extent to which they benefit from the compensation package may be insufficient to improve their situation (i.e. enable them to increase their use of heating and/or make improvements to their home).

8 Discussion: Implications of a carbon tax in Scotland for different household types

The CHAID analysis presented in the previous chapter has provided a more detailed picture of the characteristics of winning and losing households under the Scotland carbon tax and compensation package modelled in this study. It is interesting to note the pattern around occupancy characteristics: the losing nodes are all predominantly couple or multi-adult households; whilst two of the winning nodes consist entirely of single adult households, with a third group being predominantly single adult households. However, the 'top' winning node contains only 2(+) adult households (Table 8.1).

Table 8.1. Predominant number of adults in household for each node

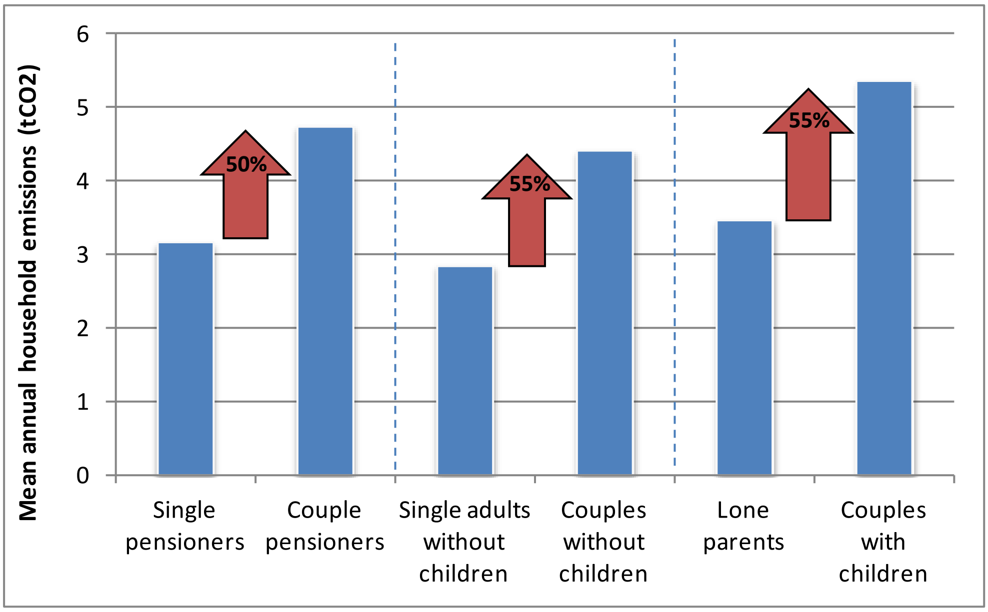
	Node ID	(Predominant) Number of adults in household	Count of households	Mean net gain/loss
Losing	1	2+	167,072	-£208
	2	2+	129,858	-£197
	3	2+	196,748	-£164
	4	2+	156,034	-£124
	5	2	437,278	-£110
	6	all single	116,779	-£28
	7	mainly single	177,921	-£14
	8	mixed	141,208	£47
Winning	9	mainly couples	151,609	£58
	10	all single	135,658	£174
	11	mainly couples	137,044	£201
	12	mainly single	121,277	£207
	13	all single	127,554	£224
	14	all 2+	136,003	£304

This effect is (at least in part) a factor of the approach taken in modelling the carbon tax and compensation package. The carbon tax system is modelled on a household level basis; that is, all emissions from energy consumption in the home and petrol and diesel use are 'pooled' and it is assumed that the carbon tax is paid at a household level (i.e. no one occupant bears a greater share). Similarly all the analysis presented here is at the household level.

The compensation package on the other hand is awarded on a family level, with couples receiving a higher rate than single people (e.g. single adult receives £300; two adults £500 – see Table 5.1, page 35). This means that a household overall could benefit twice from the compensation package (for example, house shares containing more than one compensation-eligible 'single' adult; grown-up children living in the family home; etc).

The compensation package is designed to minimise the number of low-income losing households without favouring any particular demographic group. Therefore, as we might expect, the compensation package design is broadly consistent with the average increase in household (not including road transport) emissions associated with additional adults in the household (see Figure 4.3, page 33, illustrated more explicitly below). However, it is not perfectly aligned: eligible couple pensioners see an annual increase in Pension Credit 67% greater than eligible single pensioners (£500 compared to £300 respectively); whilst retired couples over 60 have average household emissions only 50% greater than single pensioner households; and eligible couples without children stand to receive more than twice the amount received by eligible single people without children despite their emissions being only 55% higher on average. It is likely that this last difference arises because single people without children are more likely to live with other people who are not part of their immediate family: in this case, households containing multiple single childless adults will potentially benefit from the compensation package several times over, but will not face a similarly higher carbon tax liability.[34] By contrast, couples without children tend not to live with any other adults, meaning that they will face a similar carbon tax liability alone and hence require a greater degree of compensation. However, the broad pattern of impact of the combined carbon tax and compensation package, as is shown by the distributional impact across income deciles, is that lower-income households gain and wealthier households lose; as couples tend to be better-off than single people this fits with the results from the CHAID analysis.

Figure 8.1. Average annual emissions from the consumption of energy in the home by household composition



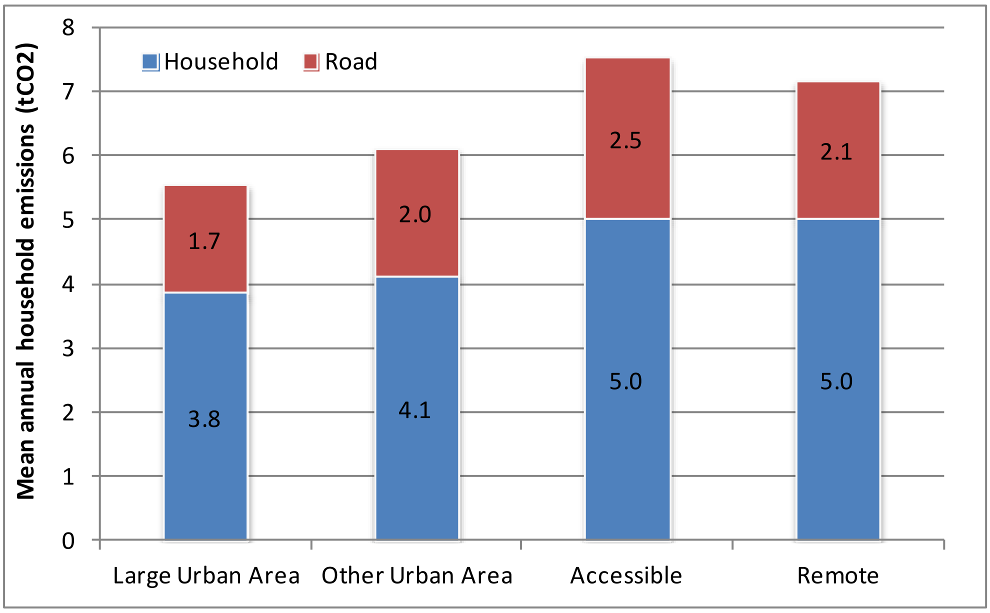
The spatial dimension of the distributional impact of the carbon tax and compensation package is complex. Whilst households in remote areas (representing around 7% of households in Scotland) have slightly higher household and road transport emissions on average than their urban counterparts (around 1.3 times higher), the proportional make-up of emissions appears roughly similar across all areas (with road transport emissions accounting for around 30%, rising to 33% in "accessible" areas) and there appears little spatial variation in the proportion of winners and losers,

[34] This is because the bulk of the carbon tax is a tax on domestic fuel use. As domestic fuel use does not increase proportionally with household size, larger households will generally pay less carbon tax on a per-person basis.

nor indeed in the amount by which they win or lose. More detailed analysis of the data suggests this reflects the variation in household occupancy, incomes, dwelling types, etc that interact to affect the overall average impact we see across different settlement types.

The compensation package does appear sufficiently designed to ensure any low-income rural households are protected from the impact of the carbon tax, whilst wealthy rural dwellers pay towards the cost of their high emitting lifestyle. This result should be caveated however with the assumptions inherent in the modeling, with assumed full take-up of benefits. Previous research has shown there may be a rural/urban divide associated with accessing benefit entitlements. For example: *"In rural areas, single pensioners have few opportunities to increase their income. Poor access to information and advice about benefits and entitlements is likely to mean that many people do not receive their full benefits"* (Scottish Government, 2009[35]). The results presented here may therefore underestimate the number of low-income rural households who would be worse off under the carbon tax and compensation package.

Figure 8.2. Average annual household and road transport emissions by rural/ urban indicator



[35] Scottish Government, 2009. The Experience of Rural Poverty in Scotland. Qualitative Research with Organisations Working with People Experiencing Poverty in Rural Areas. Report by EKOS Ltd on behalf of the Scottish Government.

9 Conclusions: A 'green and fair' carbon tax system in Scotland

The distributional impact across income deciles shows that most low-income households in Scotland can be protected from income losses caused by a carbon tax. This is unsurprising given that the compensation packages are deliberately skewed towards lower-income households and low income households typically consume (emit) less in the first place. The analysis shows that overall around one third of households in Scotland appear better off as a result of the combined effects of the carbon tax and its compensation package in 2017, whilst 59% are worse off and 8% 'broadly unaffected'.

The compensation package modelled in this study is intended to be illustrative: the aim was to minimise the number of low-income losers in a way that did not favour one particular household type over another (so we do not particularly favour pensioners or lone-parent households, for example). A government looking to introduce a carbon tax would have its own distributional objectives. Whilst acknowledging the assumptions imbedded within the DIMPSA and TAXBEN models (e.g. full take-up of means-tested benefits assumed), the analysis presented here does demonstrate that the introduction of a carbon tax need not disproportionately impact on low-income, vulnerable or isolated (rural) households in Scotland, if combined with an appropriate compensation package. For low income households in remote areas, low car use and adequate compensation, protected them from the impacts of a carbon tax. However, the extent to which this compounds a lack of existing access to road transport is unclear i.e. if this compounds an existing problem.

The analysis does not take account of individuals changing their labour market or other behaviours (including reducing energy consumption through reduced heating use; installing energy efficiency measures; or driving less) in response to the reforms. Households that appear worse off under the system modelled in this study typically have higher road transport emissions (actual and relatively speaking – i.e. emissions from use of petrol and diesel account for a higher proportion of their total emissions). Whilst beyond the scope of this study, this raises an important point in considering the implications and potential for households to avoid a carbon tax through behaviour change. For example, if a household has the option of switching to use public transport or avoid driving altogether, without any detrimental impact on their lifestyle, they could effectively avoid (or at least reduce) the impact of this element of the carbon tax.

Behavioural change to reduce energy consumed in the home may be more difficult, and/or pose a potential risk to health and well-being, particularly in low income households (i.e. a choice to limit heating to avoid/reduce the carbon tax could result in a cold and damp living environment). The data used in the modelling and analysis in this study is limited in detail on physical property characteristics, hence we do not know the extent to which households may be under-heating and cold (fuel poor); or being wasteful/inefficient with their energy use; and/or living in poorly insulated housing. The latter presents an opportunity for households to reduce their carbon emissions and the impact of a carbon tax, and improve their living environment. A financial support mechanism as modelled in this study should therefore be accompanied by a programme to support the installation of energy efficiency and low carbon measures for low income households, with additional incentives and mechanisms in place to encourage uptake amongst the able to pay.

Whilst (as with any change to tax and benefit policy) a government wishing to introduce a compensation package for a carbon tax would in practice have to balance distributional goals against other objectives it may have, such as work incentive objective, this research has shown that a carbon tax on household energy and private road transport use in Scotland can be implemented in such a way that, through appropriate recycling of the tax revenues, most lower-income households could be made better off rather than worse off.

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Annex I- Modelling petrol and diesel consumption using the Living Costs and Food Survey (2006-2010)

Summary of approach

Average petrol and diesel unit prices by month, year and region were collated from the AA website for 2006 to 2007[36] and provided directly to the project team by Experian Catalist for 2008 onwards[37].

The fuel unit price data was used to create look-up tables for converting Living Costs and Food (LCF) survey household expenditure data on petrol and diesel to annual fuel consumption [(total annual expenditure (in £) / average unit price (£/litre)].

Adjusting fuel prices in Scotland

The fuel prices obtained from AA/Experian give an average unit price for each of the nine English regions, Wales, Northern Ireland and Scotland. However, petrol and diesel prices vary substantially throughout Scotland. Given the approach applied in this study for deriving fuel consumption from expenditure data (i.e. expenditure on fuel / unit price = litres consumed), using an average unit cost for Scotland is likely to result in an overestimate of fuel consumption in more rural areas (where the price of fuel is notably higher).

The team therefore explored the potential to adjust the average fuel prices for petrol and diesel in Scotland to reflect this urban-rural differential.

The Scotland rural-urban classification system includes an 'accessibility' parameter in addition to the 'urban/rural' categorisation (see Annex Table 1).

Annex Table 1. Scottish Government 8 fold Urban Rural Classification[38]

1 Large Urban Areas	Settlements of over 125,000 people.
2 Other Urban Areas	Settlements of 10,000 to 125,000 people.
3 Accessible small Towns	Settlements of between 3,000 and 10,000 people and within 30 minutes drive of a settlement of 10,000 or more.
4 Remote Small Towns	Settlements of between 3,000 and 10,000 people and with a drive time of over 30 minutes to a settlement of 10,000 or more.
5 Very Remote Small Towns	Settlements of between 3,000 and 10,000 people and with a drive time of over 60 minutes to a settlement of 10,000 or more.
6 Accessible Rural	Areas with a population of less than 3,000 people, and within a 30 minute drive time of a settlement of 10,000 or more.
7 Remote Rural	Areas with a population of less than 3,000 people, and with a drive time of over 30 minutes to a settlement of 10,000 or more.
8 Very Remote Rural	Areas with a population of less than 3,000 people, and with a drive time of over 60 minutes to a settlement of 10,000 or more.

Analysis by the Highlands and Islands Enterprise (HIE) of urban-rural fuel prices in Scotland using the 2003 Rural Scotland Price Survey (RSPS) presents a number of different indices for fuel costs for

[36] http://www.theaa.com/motoring_advice/fuel/
[37] Fuel price data is available on the AA website in pdf format. Experian Catalist Fuel Price Archive provided this data in spreadsheet format for the purpose of this research.
[38] Source: http://www.scotland.gov.uk/Topics/Statistics/About/Methodology/UrbanRuralClassification

different areas and urban/rural classifications (Annex Table 2). Based on research by the Hutton Institute, accessibility was deemed more relevant than the urban-rural aspect of the classification system in the context of petrol and diesel fuel price differentials. The 'Remote-Accessible' index of fuel prices, (column 2 of Annex Table 2 below "*All areas Remote-accessible index*"[39]) was therefore selected as the basis for creating an inflation factor for adjusting the average petrol and diesel prices for 'accessible' and 'remote' areas of Scotland.

Annex Table 2. Rural-urban indices for selected items relating to home heating and motoring fuel costs (Source: Hutton Institute paper, 2013)

	All areas Rural-urban index	All areas Remote-Accessible index	HIE Rural-urban index	SE Rural-urban index
Housing				
Water rates and other charges	1.026	1.022	1.036	1.013
Household goods and Services				
Coal	0.992	0.982	0.950	1.035
Domestic heating oil	1.074	1.066	1.115	1.026
Electricity tariff	1.000	1.000	1.000	1.000
Gas tariff	1.000	1.000	1.000	1.000
Motoring				
Unleaded petrol	1.069	1.068	1.103	1.021
Diesel	1.063	1.069	1.099	1.017

Source: 2003 Rural Scotland Price Survey.

Allowing for 'very remote' areas

The index provided by the HIE research differentiates between 'accessible' and 'remote' only. Fuel prices in 'very remote rural' areas are likely to higher again (these are mainly located in the Highland and Islands region). The team therefore explored the potential to create an additional inflation factor for 'very remote rural' areas.

Data was collected from the 'whatgas' website[40] for: (i) very remote small towns; (ii) very remote rural areas; and (iii) urban areas[41]. The weighted average fuel price in very remote small towns and very remote rural areas was then compared with the weighted average fuel price in urban areas to derive price inflation factors (see Annex Table 3).

Annex Table 3. Fuel price inflators derived from analysis of 'whatgas' fuel prices

	Petrol inflator	Diesel inflator
Very remote small town	1.059	1.033
Very remote rural	1.114	1.081

[39] Source: James Hutton Institute, 2013. '*Rural-urban differentials in home heating costs and transport fuel costs in Scotland*'
[40] www.whatgas.com
[41] For the 7 cities in Scotland.

The results of this analysis showed that for ‘**very remote small towns**’ the price inflator derived using whatgas data for petrol (1.059) does not vary substantially from that based on the 2003 RSPS analysis (1.068 (Annex Table 2)); thus the RSPS value was deemed sufficient to use here.

For diesel prices, there were many unreported values for very remote small towns in the ‘whatgas’ data, so the resulting price inflator was deemed unreliable and again the RSPS value was selected instead.

For ‘**very remote rural areas’**, analysis of ‘whatgas’ data showed considerable differences in fuel prices compared to the urban average (1.114 and 1.081 for petrol and diesel respectively), similar to those derived from the 2003 RSPS HIE rural-urban index (1.103 for petrol and 1.099 for diesel (table 2)).

A combination of the RSPS 2003 analysis and the more recent ‘whatgas’ data analysis was therefore used to derive a final set of indices for adjusting petrol and diesel prices to allow for rural-urban differentials in Scotland (Annex Table 4).

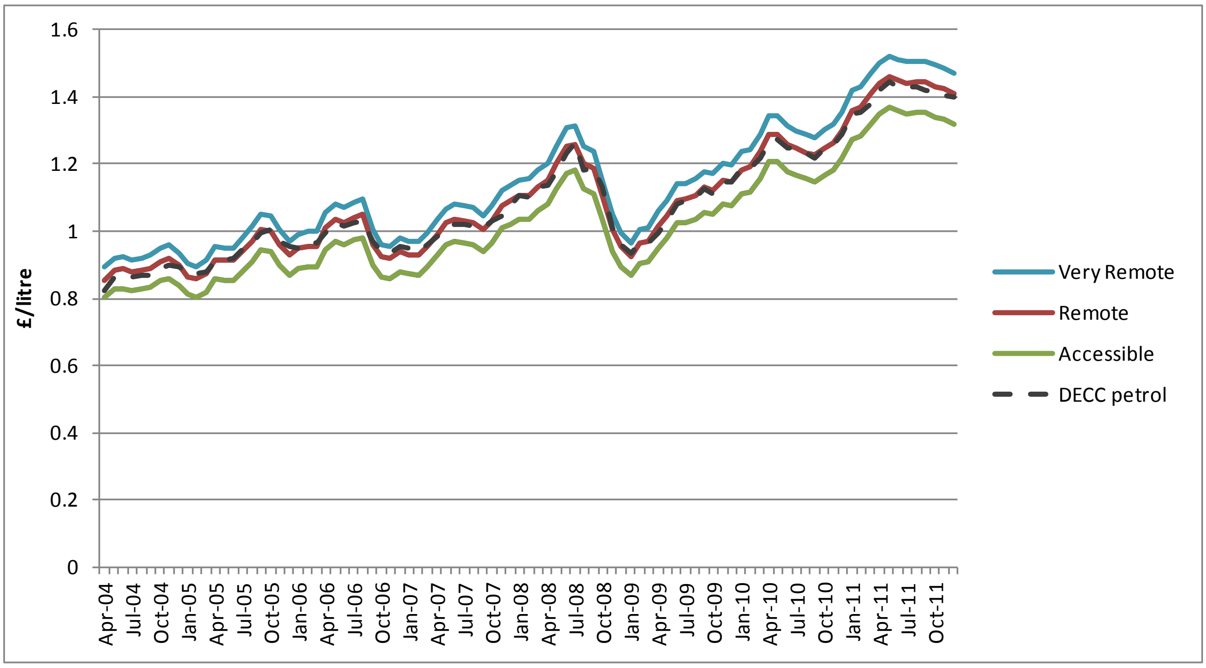
Annex Table 4. Fuel price inflators for 8-fold rural-urban classification in Scotland

	Petrol inflator	Diesel inflator
Large Urban Area	1	1
Other Urban Area	1	1
Accessible Small Town	1	1
Remote Small Town	1.068	1.069
Very Remote Small Town	1.068	1.069
Accessible Rural	1	1
Remote Rural	1.068	1.069
Very Remote Rural	1.114	1.081

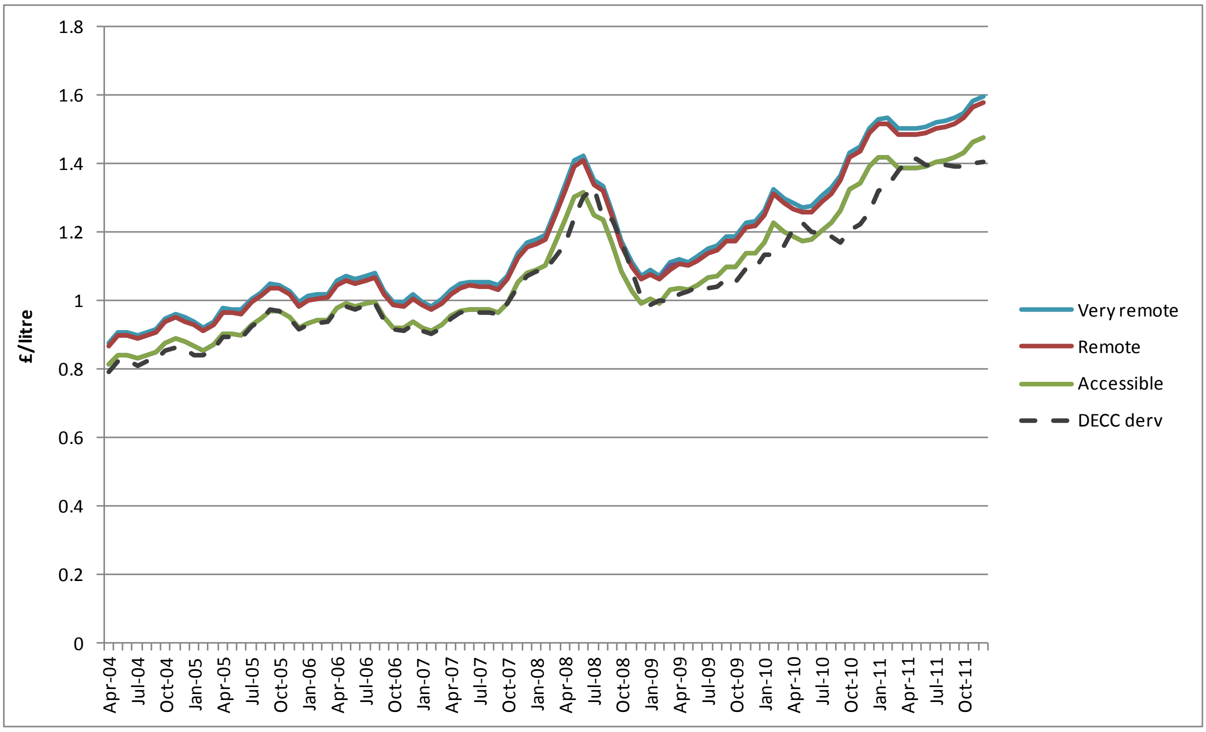
Results – fuel prices

The average unit prices resulting from applying the rural-urban inflators to the average unit price of petrol and diesel in Scotland (as supplied by AA/Experian) is illustrated below. These represent the final unit prices applied in deriving petrol and diesel consumption from household expenditure provided in the Living Costs and Food survey dataset.

Annex Figure 1. Scotland petrol unit prices



Annex Figure 2. Scotland diesel unit prices



Annex II – summary of node characteristics

Node 1, losing: Wealthier, working couples in larger "rural" dwellings with high vehicle ownership Working age, full-time employed couples, some with children, in non-urban but accessible areas
Count & percentage of HHs in node: 167,072 (7%)
Predicted annual net gain/loss: -£208
Actual proportion losing | broadly unaffected | winning: 92% | 2% | 6%
Mean annual household emissions: 7.2 tCO_2
Mean annual road transport emissions: 4.0tCO_2
Mean annual household disposable income (& equivalised income): £60,663 (£49,740)
Key characteristics: **Wealthier** households – mainly (60%) top income quintile 5 **Larger** (mainly 4 or more bedrooms) **detached** (95%) dwellings **High vehicle** ownership (74% with two or more vehicles) **Non-urban** but "**accessible**" areas: 48% accessible rural; 32% accessible small town Lower gas connectivity (58%), higher reliance on **oil** (28%) **Owner occupiers**, two fifths (41%) of whom own outright No single adult households: mainly **working age** (53% aged 25-54) **couples**, under 60 Mainly in **full time employment,** some **retired** (17%) Some **families**: one third (31%) with children **Why worse off**: Very high household and road transport emissions; not eligible for compensation

Node 2, losing: Higher income families, in smaller urban areas with mains gas and high vehicle use Working families with very high car use (commuters?)
Count & percentage of HHs in node: 129,858 (6%)
Predicted annual net gain/loss: -£197
Actual proportion losing | broadly unaffected | winning: 93% | 3% | 4%
Mean annual household emissions: 5.8 tCO_2
Mean annual road transport emissions: 4.3 tCO_2
Mean annual household disposable income (& equivalised income): £57,231 (£40,425)
Key characteristics: **Higher income** households – mainly (53%) income quintile 5 Mainly **3-4 bed** detached or semi-detached houses **All have 2 or more vehicles** **Urban areas** (56% 'other urban areas[42]') **Mains gas** heated **Owner occupiers**, with a mortgage Families (all have children) **Working age** (77% aged 35-54) **couples** In **full time employment** Some **families**: one third (31%) with children **Why worse off**: High household and very high road transport emissions; not eligible for compensation. Marginally better off than node 1 due to mains-gas heating and slightly smaller dwellings (hence lower household carbon emissions). Younger demographic living in smaller urban centres ("hard working families")

[42] 'Other urban areas are defined as settlements of 10,000 to 125,000 people.

Node 3, losing: Higher income 'empty-nesters', in urban areas with high vehicle ownership Couples, without dependent children, in full time employment or in/nearing retirement with a car each
Count & percentage of HHs in node: 196,748 (8%)
Predicted annual net gain/loss: £164
Actual proportion losing | broadly unaffected | winning: 91% | 1% | 8%
Mean annual household emissions: 5.1tCO_2
Mean annual road transport emissions: 3.9tCO_2
Mean annual household disposable income (& equivalised income): £56,234 (£49,634)
Key characteristics: **Higher income** households – mainly (55%) income quintile 5 **Mid-larger** (74% 3 or more bed) **detached/semi-detached** (66%) dwellings **All have at least 2 vehicles** **Urban** with mains gas heating **Owner occupiers**, a third (35%) of whom own outright Mix of **working age** (45% aged 45-59) & over 60 **couples**, but mainly still working No dependent children, but demographic suggests some adult offspring still living at home **Why worse off**: High household and high road transport emissions; not eligible for compensation. Marginally better off than nodes 1 and 2 due to mains-gas heating and slightly smaller houses (hence lower household carbon emissions). Slightly older demographic ("empty nesters")

Node 4, losing: Better off couples/families in accessible areas, mains gas or electric heating, high vehicle use Working families or couples (some still with adult off-spring at home) in accessible towns or accessible rural
Count & percentage of HHs in node: 156,034 (7%)
Predicted annual net gain/loss: -£124
Actual proportion losing | broadly unaffected | winning: 88% | 3% | 9%
Mean annual household emissions: 4.9 tCO_2
Mean annual road transport emissions: 3.0 tCO_2
Mean annual household disposable income (& equivalised income): £44,819, (£37,792)
Key characteristics: **Mid-higher income** households – mainly (47%) income quintile 4 **Mid-sized** (50% 3-bed) **semis** **High vehicle ownership** (46% with one, 47% two or more cars) **Rural** but **accessible** (46% accessible small towns, 37% accessible rural) Largely mains gas heating (74%), some electric (15%) **Owner occupiers**, a third (30%) of whom own outright All couples, mainly working age (64% aged 35-59) and in full time employment Around one third (30%) with dependent children at home **Why worse off**: High household and high road transport emissions; not eligible for compensation. Lower net loss than previous nodes due to mains-gas or electric heating and slightly smaller houses (hence lower household carbon emissions). Demographic suggests families (either with dependent children or adult off-spring still living at home).

Node 5, losing: Young professional city dwellers, who own their home and one car
****19% of households in Scotland in this group****
Smaller urban flats or terraced houses in large urban centres occupied by working couples without children

Count & percentage of HHs in node: 437,278(19%)

Predicted annual net gain/loss: -£110

Actual proportion: losing | broadly unaffected | winning: 89% | 7% | 3%

Mean annual household emissions: 4.2 tCO_2

Mean annual road transport emissions: 1.9 tCO_2

Mean annual household disposable income (& equivalised income): £, (£)

Key characteristics:
Urban areas, with **mains gas** heating
Owner occupiers mainly with mortgage but 30% own outright
Mainly **younger** (48% under-44), **couples** (73%) in **full time employment** (68%)
Mainly **1-car** households (87%)
Mix of purpose-built flats (32%) and terraced houses (28%), small-medium sized (42% 2-bed, 36% 3-bed)

Why worse off:
Predicted to be worse off but by less than £2 a week
Higher than average income but around average emissions – hence pay average rates in carbon tax but higher income means unlikely to qualify for compensation package so worse off overall.

Node 6, broadly unaffected: Rural older single adults and one-car households
Some underoccupying being single adults in 3(-plus) bed detached houses

Count & percentage of HHs in node: 116,779 (5%)

Predicted annual net gain/loss: -£28

Actual proportion losing | broadly unaffected | winning: 67% | 9% | 24%

Mean annual household emissions: 3.9 tCO_2

Mean annual road transport emissions: 1.4 tCO_2

Mean annual household disposable income (& equivalised income): £26,559 (£42,152)

Key characteristics:
Middle income on unequivalised scale, but higher (32% top quintile) on equivalised, due to all being **single adult** households.
Older occupants (40% over 65, 25% over 75); 45% retired, but 41% still in full time employment.
Some may be considered asset rich (36% own their home outright); but 21% are in social housing and 14% private rented.
Mix of dwelling types – 37% detached and 34% 3 or more bedrooms suggest some **underoccupancy** (being all single adult households).
Non-urban areas (38% accessible small town and accessible **rural**; 13% remote rural, 4% very remote). Hence, 25% electrically heated, and 18% oil (though still 54% on gas).
Mainly one car households.

Why broadly unaffected:
Model predicted this group to be 'broadly unaffected' but 67% are technically worse off.
Household and road transport emissions are below average. Though not low-income (& hence lower eligibility for compensation), a potentially vulnerable group, being older, single adults in less urban areas.

Node 7, broadly unaffected: Owner-occupying retired single adults in city houses
Count & percentage of HHs in node: 177,921 (8%)
Predicted annual net gain/loss: -£14
Actual proportion losing | broadly unaffected | winning: 57% | 16% | 26%
Mean annual household emissions: 4.0 tCO_2
Mean annual road transport emissions: 1.2 tCO_2
Mean annual household disposable income (& equivalised income): £27,779 (£31,719)
Key characteristics: **Middle income** households but all owner-occupiers and 67% owning their home outright (and therefore may be considered asset rich) Mixed demographic: either single adult households (66% one adult over 60; 21% a lone parent) or multiple-occupancy households (3 or more adults, 23%); retired (64%) or working, 13% part-time. Small to medium sized dwellings (38% 2-bed, 39% 3-bed) Mix of dwelling types: semi-detached (30%) or terraced (27%) houses or purpose-built flats (28%) Lower vehicle ownership (39% without a car; no households with more than one vehicle) In large **urban** (52%) or other urban areas, with mains-gas heating **Why broadly unaffected**: Lower than average household and road transport emissions and some eligibility for compensation suggests these households are only marginally affected by a carbon tax.

Node 8, broadly unaffected: Young, working couples or single adult city-dwellers, in small, rented purpose-built flats Small dwellings and urban setting mean lower household and road transport emissions
Count & percentage of HHs in node: 141,208 (6%)
Predicted annual net gain/loss: £47
Actual proportion losing | broadly unaffected | winning: 62% | 16% | 23%
Mean annual household emissions: 3.4 tCO_2
Mean annual road transport emissions: 1.7 tCO_2
Mean annual household disposable income (& equivalised income): £36,399 (£35,908)
Key characteristics: Mid-higher income renters: 43% social housing; 54% private renters In small (27% 1-bed, 46% 2-bed) purpose-built flats (65%) In large urban areas (57%) with mains gas heating Younger demographic (47% under 35) of couples (34%), single adults (25%) or HMOs (17%) All households have HRP in full-time employment Mix of drivers and non-drivers (42% without a vehicle) **Why broadly unaffected**: Model predicted this group of households to be better off on average but marginally so. Whilst 62% are actually classed as losing, they are unlikely to be substantially worse off as have lower than average emissions.

Node 9, winning: Lower income retired households in rural, off-gas houses Mix of retired couples and single adult households, with above average household emissions due to oil heating
Count & percentage of HHs in node: 151,609 (7%)
Predicted annual net gain/loss: £58
Actual proportion losing | broadly unaffected | winning: 41% | 15% | 44%
Mean annual household emissions: 5.1 tCO_2
Mean annual road transport emissions: 2.0 tCO_2
Mean annual household disposable income (& equivalised income): £19,014 (£18,301)
Key characteristics: Lower income (all lowest four deciles on equivalised income scale) Mix of couples (30%) and single adults (22%) but mainly older (43% over 64, 24% 75 or over) Medium-sized (2-4 bed) detached (35%) and semi-detached (30%) In non-urban areas: 35% accessible rural, 30% accessible small towns, 24% remote hence greater reliance on oil (21%) or electricity for heating (17%) Slightly higher than average vehicle ownership (45% with one car, 32% with 2 or more) **Why winning**: Average road transport emissions (despite being non-urban) but above average household emissions due to being off-mains gas. Eligibility for compensation means this group is just about better off on average, but represents a potentially vulnerable group of older, rural householders.

Node 10, winning: Low income, out-of-work single adults and lone parents in social rented flats in urban centres Very low household and road transport emissions, but eligible for compensation due to low-income status
Count & percentage of HHs in node: 135,658 (6%)
Predicted annual net gain/loss: £174
Actual proportion losing | broadly unaffected | winning: 4% | 7% | 89%
Mean annual household emissions: 2.4 tCO_2
Mean annual road transport emissions: 0.2 tCO_2
Mean annual household disposable income (& equivalised income): £11,694 (£16,499)
Key characteristics: Low income (80% quintile 1) All single adults (hence difference in non-equivalised and equivalised income), a third of whom have dependent children at home (hence lone parents) Socially rented (84%) small (82% 2 or fewer bedrooms), purpose-built (77%) flats with mains gas (75%) or electric heating (24%) in urban centres (58% large urban areas) Car-less (87%) **Why winning**: Lowest emitting group on average: Very low household emissions (due to dwelling type, size, tenure (social housing likely to have higher energy efficiency rating) and heating fuel (mains gas or electric) and predominantly car-less households so very low road transport emissions, combined with eligibility for compensation means these households are better off on average under the carbon tax and benefits system modelled here.

Node 11, winning: Low-income, retired and elderly owner-occupiers in urban flats or houses Medim-sized properties with mains gas; urban areas and some use of car still
Count & percentage of HHs in node: 137,044 (6%)
Predicted annual net gain/loss: £201
Actual proportion losing | broadly unaffected | winning: 14% |12% |74%
Mean annual household emissions: 3.9 tCO_2
Mean annual road transport emissions: 1.2 tCO_2
Mean annual household disposable income (& equivalised income): £14,592 (£14,546)
Key characteristics: Low income (100% bottom income quintile on equivalised income), but owner occupiers, 55% of whom own their home outright so may be considered asset rich Medium-sized (41% 3-bed) purpose-built flats or terraced houses with mains gas heating in urban areas Mix of couples and single adults but predominantly retired and older (24% 75 or older) Around half with a car in the household **Why broadly unaffected**: Lower than average household and road transport emissions and eligible for compensation.

Node 12, winning: Non-urban (some remote), electrically-heated, low income single adults non-drivers Low income, low emitters, in small houses and flats with very low private vehicle use despite rurality
Count & percentage of HHs in node: 121,277 (5%)
Predicted annual net gain/loss: £207
Actual proportion losing | broadly unaffected | winning: 12% | 11% | 77%
Mean annual household emissions: 3.2 tCO_2
Mean annual road transport emissions: 0.9 tCO_2
Mean annual household disposable income (& equivalised income): £15,935 (£18,191)
Key characteristics: Low income (56% bottom (unequivalised) income quintile Social (70%) or private (22%) rented in non-urban areas (37% accessible rural 36% accessible small towns; 20% remote, 8% very remote) Small (71% 1-2 bed), mix of houses (32% terraced, 25% semi) and flats (27%) Electrically-heated (34%) or mains gas (47%) Mainly single adults (60% one-adult households) retired (39%) or not working (28%) Some lone parents (14%) Over half (55%) without a car in the household **Why broadly unaffected**: Non-driving (despite living in non-urban areas) and small properties a high proportion of which are social housing (likely higher energy efficiency) so low emissions and low income status means eligible for compensation

Node 13, winning: Low income single elderly in small social rented flats with mains gas or electric heating Urban dwellers, without a car and very small properties; low income due to retired or part-time working status
Count & percentage of HHs in node: 127,554 (5%)
Predicted annual net gain/loss: £224
Actual proportion losing | broadly unaffected | winning: 6% | 4% |90 %
Mean annual household emissions: 2.6 tCO_2
Mean annual road transport emissions: 0.3tCO_2
Mean annual household disposable income (& equivalised income): £14,667 (£22,522)
Key characteristics: Very low unequivalised income (64% quintile 1; all single adults, mainly without children hence higher equivalised income) Small (50% 2-bed, 35% 1-bed), social-rented (85%), purpose-built flats (62%) with mains gas (70%) or electric heating Car-less (81%) in urban areas (58% 'other urban'). Single adults, mainly retired (70%) and elderly (39% 75 or over) though some with children at home hence lone parents (14%) and some part-time working (30%) **Why winning**: Very low household (due to property size, tenure and heating fuel), and road transport emissions (urban centres and car-less households), combined with (low-income) high eligibility for compensation.

Node 14, top winning: Younger, out-of-work or part-time employed couples or familes in urban rented flats Social or privately rented couples or families in urban areas with mains gas or electric heating
Count & percentage of HHs in node: 136,003 (6%)
Predicted annual net gain/loss: £304
Actual proportion losing | broadly unaffected | winning: 18% | 6% | 76%
Mean annual household emissions: 3.6 tCO_2
Mean annual road transport emissions: 1.0 tCO_2
Mean annual household disposable income (& equivalised income): £23,881 (£19,475)
Key characteristics: Low to average income (51% in bottom income quintile on equivalised scale) Very young demographic (22% under 25) No single adult households: couples (80%) or HMOs (20%), where the HRP is not working (44%) or in part-time employment (25%). Some families (34% have dependent children in the household) Small-medium sized (43% 2-bed, 38% 3-bed), social (69%) or privately renting (26%) purpose-built flats (60%) or terraced houses (26%) Mainly non-drivers (56% without a car) in urban centres (62% large urban areas) **Why winning**: Not the lowest emitting nor lowest income group of households but very young couples or families, out-of-work or only part-time employed, hence low-income status combined with higher occupancy rates (i.e. not single adult households) means these households receive more compensation.