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Cheaper, Greener and More Efficient: Rationalising UK Carbon Prices*

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Abstract

Current UK energy use policies, which primarily aim to reduce carbon emissions, provide abatement incentives that vary by user and fuel, creating inefficiency. Distributional concerns are often given as a justification for the lower carbon price faced by households, but there is little rationale for carbon prices associated with the use of gas to be lower than those for electricity. We consider reforms that raise carbon prices faced by households and reduce the variation in carbon prices across gas and electricity use, improving the efficiency of emissions reduction. We show that the revenue raised from these reforms can be recycled in a way that ameliorates some of the distributional concerns. Whilst such recycling is not able to protect all poorer households, existing policy also makes distributional trade-offs, but does so in an opaque and inefficient way.

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JEL classification numbers: H21, H23.

Policy points

- Reducing greenhouse gas emissions is a costly process. A uniform carbon price should form a central part of policy aimed at reducing emissions at the lowest economic cost. Current policy does not reflect this, and instead provides inefficient incentives for abatement. Reforms to policy should be considered to reduce the costs of achieving emissions reductions targets.
- Poorer households spend a greater proportion of their budget on energy than richer households. This has contributed to a policy landscape where households face lower carbon prices than businesses, providing weak incentives to reduce emissions arising from domestic energy use. Gas is also undertaxed relative to electricity. Carbon price variation could be reduced by extending full-rate VAT to domestic energy use and introducing a tax on domestic gas.
- Revenues raised from the reforms could be returned to all households through lump-sum transfers to mitigate much of the negative distributional impacts of the energy price rises. However, such compensation would not prevent some poorer households substantially losing as a result of significant within-decile variation in energy expenditures.
- A compensation package can be designed to better protect poorer households from the energy price rises. This is achieved through increasing the generosity of existing benefits and tax credits. However, this imposes a trade-off for policymakers as such a package (for a given cost) would impose larger losses on richer households. The redistributive objectives of policymakers therefore have an important role in deciding which type of compensation package is implemented.

I. Introduction

The UK is a world leader in policies to tackle climate change. The landmark 2008 Climate Change Act commits the UK government to reducing greenhouse gas (GHG) emissions by 80 per cent of their 1990 levels by 2050. However, as a result of legitimate desires to reduce the burden of energy costs on poor households, policy has evolved in such a way that households have remained relatively sheltered from policies that increase energy prices. Households therefore face much lower carbon prices on electricity and gas use than businesses. Carbon prices on domestic use of gas and of electricity also differ considerably.

This means that households face lower incentives to reduce energy consumption (particularly gas usage) than businesses, and hence that reducing GHG emissions may be more costly than it needs to be. A uniform carbon price – which would mean that all users and all fuels are taxed similarly – would help to reduce emissions more efficiently, as those with the lowest marginal cost would be the first to reduce their emissions. However, a reform that raised energy prices in this way would be regressive, with increased energy prices affecting poorer households more than richer households (as a proportion of income or expenditure).

In this paper, we model a reform to the current policy landscape that would rationalise carbon prices across users and fuels and we illustrate the distributional implications of such a reform. The paper adds to the existing literature in this area by modelling a reform that not only rationalises carbon prices, but does so at a level consistent with meeting current carbon emissions reductions targets. We also design two packages to compensate households for the cost-of-living increases arising from the energy price reforms, with differing distributional implications. In each case, the total cost of the compensation package is set to be at least revenue-neutral to the government, as we take into account overall behavioural responses to the increased prices.

By extending the full rate of VAT to all household energy use (from the current reduced rate of 5 per cent to the full rate of 20 per cent) and introducing a new tax on domestic gas use, we can approximately equalise carbon prices across fuels within the domestic sector and deliver a carbon price close to that faced by businesses on electricity use. We estimate that this would lead to a 14 per cent increase in electricity prices and a 34 per cent increase in gas prices. Such a reform could reduce carbon dioxide emissions by around 8 million tonnes in the short run (equivalent to 7 per cent of emissions from households) and 22 million tonnes (18 per cent of household emissions) in the long run.

However, this policy alone would have large and regressive effects on household budgets. On average, household spending would need to rise by 1.5 per cent to enable consumption of the same amount of energy, but for households in the bottom expenditure decile this increase would be as high as 3.8 per cent (whilst being only 0.8 per cent for those in the top decile). In addition, therefore, we use a microsimulation model of the UK tax and benefit system to design two compensation packages. First, we model the effects of a lump-sum compensation package. Second, we model a strongly targeted compensation package that attempts to minimise the proportion of the poorest 30 per cent of households who lose from the reform. The different packages may be more or less appealing to policymakers depending on their redistributive objectives.

We find that both compensation packages can, on average, ameliorate many of the distributional effects associated with the reform. Lump-sum compensation of £2.15 per individual results in an average loss of £0.86 per week as a result of the combined reform. This masks substantial within-decile variation, with 24 per cent of the poorest tenth of households losing more than £1 per week and 56 per cent gaining more than this amount. The second compensation package significantly reduces these losses for the poorest households, reducing the losers to 13.5 per cent of households, while 74 per cent gain more than £1 per week.

Our results highlight that whilst distributional concerns about increasing carbon prices are well founded, this does not in itself provide a rationale for subsidising household use of electricity and gas that produces carbon emissions. Existing policy levers can be manipulated to, on average, compensate households in ways that are consistent with different distributional preferences. However, there is significant within-decile heterogeneity in energy use, and so any compensation package is likely to leave some losers even amongst groups that policymakers most wish to protect.

In a context where carbon prices are set to rise in order to meet urgent climate objectives, policy will necessarily increase costs to households. Some policies, such as a household gas tax, have direct costs to households. Their distributional effect is easily measured and, if desired, compensation packages using the revenue raised can be designed. Other policies, which raise costs for businesses, will be passed on to households in higher prices, lower wages or lower dividends. These policies also have distributional effects, but such effects are opaque. Rather than trying to hide the cost of climate change policy by focusing on charges on businesses, carbon reduction policy should aim to maximise efficiency, and other policy tools should be used to ameliorate distributional concerns.

The rest of the paper is structured as follows. Section II briefly reviews other relevant literature and discusses in more detail what this paper adds. Section III summarises the broad policy landscape in the UK. Section IV details our carbon price reform and sets out two potential compensation packages that could be implemented to mitigate its distributional consequences. Section V outlines the data and the microsimulation methods used in our analysis. Section VI presents the distributional effects of the reform with and without these compensation packages, and shows the proportions and types of households that significantly gain or lose from the combined reforms. Section VII concludes.

II. Literature review

This paper adds to an existing literature related to different reforms to energy use policies in the UK. Johnson, McKay and Smith (1990) examined the distributional impact of extending the standard rate of VAT (then 15 per cent) to domestic energy. They found that households could be compensated on average using a lump-sum compensation package. However, a more targeted package was required to avoid significant within-decile variation among poorer households.

Crawford, Smith and Webb (1993) conducted a similar exercise when estimating the impact of the introduction of a VAT rate of 17.5 per cent on domestic energy use. They found that the automatic indexation of the existing benefit system would have provided significant compensation for poorer households following the increase in inflation as a result of the reform. However, these measures would fail to compensate poor households who spend a relatively large share of their expenditure on energy. Additional measures would be required to compensate these households.

Dresner and Ekins (2006) evaluated whether 13 distinct compensation packages, based on changes to existing means-tested and pension-age benefits, could be used to compensate poor households for the introduction of a household carbon tax. All reforms were progressive on average, but a large number of households in the poorest income decile would still significantly lose from the reforms in each case (19–48 per cent of households in the lowest income decile). This was due to large variation in the expenditure on energy across households within this decile, which was largely driven by heterogeneous standards of energy efficiency in the housing stock. The authors suggested that support should be targeted towards low-income households in order to provide incentives for the installation of energy efficiency measures in their homes.

Preston et al. (2013) modelled the effects of a number of reform packages introduced in 2017–18. One package included the introduction of a carbon tax on domestic gas (and other, non-metered fuels) at the same rate as an existing policy, the carbon price floor. This was accompanied by an extension of the full rate of VAT (at 20 per cent) to domestic energy use. The estimated revenues of £6.8 billion per year were fully recycled to compensate for the reforms, with 72 per cent of households in the bottom 30 per cent of the income distribution gaining from the reform.

The present paper adds to this literature in a number of ways. First, we model a new reform that is distinct from the existing literature outlined above. Importantly, we model a reform that rationalises carbon prices in the UK, removing their variation across fuels and greatly reducing differences between domestic and business users. We also aim to equalise carbon prices at a level consistent with meeting current carbon emissions reductions targets. The Department of Energy & Climate Change (DECC) publishes annual non-traded carbon prices consistent with achieving these targets. In our reforms, we equalise prices at £59, the shadow price of non-traded carbon in 2013.[1] This is the carbon price that needed to be charged in 2013 for carbon emissions that are not covered by the EU Emissions Trading System for the UK to be in line to meet its targets based on the 2008 Climate Change Act.

These important goals distinguish our work from previous studies. Johnson, McKay and Smith (1990) and Crawford, Smith and Webb (1993) both considered an extension of the full rate of VAT to domestic energy, but did not focus on the environmental effects of this reform. Preston et al. (2013) also

[1]Department of Energy & Climate Change and HM Treasury, 2013.

considered similar instruments (a gas tax and the extension of full-rate VAT) but did not consider the resulting carbon prices after the reform. As a result, there was still variation in prices between users, and these prices remained well below the level targeted by DECC.

Second, we examine the effects of two very different compensation packages – lump-sum compensation and targeted compensation delivered through the existing tax and benefit system. Past work has typically focused on one or the other, but has not directly compared the effects of each in an explicit way. For example, Crawford, Smith and Webb (1993) examined the impact of lump-sum compensation, without detailed modelling of a targeted package. In contrast, Dresner and Ekins (2006) and Preston et al. (2013) did not model this first stage to provide a benchmark comparison.

We also include the effect of 'automatic compensation' in our targeted compensation package. Many UK benefits and tax credits are uprated in line with inflation; hence reforms that increase inflation will also lead to benefits and tax credits rising in nominal terms (albeit not sufficiently to fully compensate individuals for the price rises, as energy is only one of a bundle of goods that are used to calculate inflation rates).

Finally, in contrast to existing work, we take into account adjustments to household energy consumption in response to the price change when considering the levels of revenues raised by the reforms. This reduces the revenues raised relative to a static estimate. We therefore examine compensation packages that do not fully exhaust the static revenues. If such packages can be used to adequately compensate households for the reform, remaining revenues raised in the short term can be used for alternative purposes. Examples include temporary cuts in marginal tax rates elsewhere or investing in wider energy efficiency measures.

The results presented in this paper are topical and important for the current debate on energy use policies. The reforms that we present look very different from the policies put forth by politicians in recent years. In fact, recent policy changes have been aimed at reducing the short-term impacts of energy policy on household bills.[2] This creates a situation that is further from the 'first-best' scenario of uniform carbon prices, which would provide the most efficient reduction of globally damaging carbon emissions. Furthermore, historical attempts to extend full-rate VAT to domestic energy have met with

[2]For example, policy announcements made in the 2013 Autumn Statement (temporarily) reduced effective carbon prices for domestic energy use by reducing the size of the Energy Company Obligation and moving the Warm Home Discount Scheme away from a bill-based system to a tax-funded system. For more details, see Stoye (2013). More recent policy announcements have begun to discuss reductions in energy (and hence implicitly carbon) taxes for businesses – for example, the announcement in the 2015 July Budget of a plan 'to develop a simple, fair and more efficient energy environment for business that minimises administrative burdens and improves incentives for business to invest and grow'. However, no offsetting increase to carbon taxes for households was proposed, suggesting that the carbon reduction targets will not be achieved.

considerable opposition.[3] Introducing such a policy is therefore a difficult and sensitive operation.

However, it is extremely important to note that under the latest estimates by DECC, the cost of planned policies will lead to large increases in domestic energy prices in the near future. In particular, policies aimed at the promotion of electricity from renewable sources, such as the Renewables Obligation and Contract for Difference feed-in tariffs, will cause sharp rises in electricity prices. In 2013, energy use policies are estimated to have increased the unit price (£/MWh) of electricity by 17 per cent. This is forecast to rise to 33 per cent by 2020 and 41 per cent by 2030.[4] Under current plans, these price increases will occur without any explicit compensation package to protect low-income households. This paper presents a representative reform that shows it is possible to reform energy policies in such a way that the UK can more efficiently meet emissions targets, while mitigating many of the distributional concerns attached to policy reform in this area.

III. Institutional background

Energy use and climate change policy in the UK has a number of objectives.[5] Some policies aim to reduce GHG emissions through increasing the cost of energy use, whilst others aim to reduce emissions indirectly, by correcting for a range of market failures in the production of renewable technologies and the installation of energy efficiency measures in the home. Both types of policies have an impact on energy prices, either explicitly by design or implicitly as a result of firms recouping the costs associated with these policies by passing on the increased costs to consumers and firms in the form of higher energy bills.

Energy is an economic necessity, with poorer households spending a larger share of their budget on energy than richer households. As a result, policies that increase energy prices will have the greatest effect on the poorest households as a proportion of their total income or spending. A desire to shelter these households has led to a deliberate attempt to minimise the direct cost imposed by policy on energy use. Of particular importance is the VAT treatment of domestic energy use, with domestic gas and electricity taxed at a reduced VAT rate of 5 per cent (relative to a full rate of 20 per cent). We further discuss this policy, and its implications, in Section IV.

[3]Attempts were previously made in 1993 by the then Chancellor Norman Lamont to impose full-rate VAT on domestic energy use. Ultimately, this policy proved unsuccessful and domestic energy, previously exempt from VAT, became subject to the reduced VAT rate of only 5 per cent.

[4]Department of Energy & Climate Change, 2013a.

[5]Existing policies can be classified into four groups based upon the primary aim of the policy. See Table A1 in Appendix A online for details on the objectives, revenues and costs associated with energy policies in place in the UK in 2013–14. Note that some policies produce revenues for the exchequer, while others incur costs. The costs of some policies are recouped by energy companies through increases in domestic bills. See Advani et al. (2013a) for further details of specific policies.

Given the ambitious targets that the UK has set to reduce emissions over the coming decades, policy should be designed to achieve these reductions at least cost. The central plank of such a policy should include a uniform carbon price faced by all users.[6] This would provide consistent incentives across different users and ensure that reduction efforts are efficiently divided across users. Similarly, carbon prices should not vary across fuels, in order to avoid users switching from higher-taxed to lower-taxed (but equally polluting) fuels.

To further illustrate this important concept, consider the following simple example. We assume that the government wishes to reduce carbon emissions by a given amount. Businesses and households both consume energy, which produces emissions. We also assume that businesses initially face a lower marginal cost of abatement. If the government sets a uniform carbon price, each user will reduce emissions to the point where the marginal cost of abatement is equal to this price. This means that emissions reductions are shared optimally across the different users, with firms accounting for a larger share of the reduction (given the relatively cheaper reductions available to them).

However, if the government sets a lower price for households (perhaps due to distributional concerns), these households will face weaker incentives to reduce emissions and will therefore achieve lower levels of abatement. Given that the emissions target does not change, firms will now face a higher carbon tax rate and account for a greater share of emissions reductions. However, these additional reductions will be achieved at a cost above the one that households previously incurred for the same level of abatement. The same level of emissions reduction is therefore achieved at a higher total cost than is the case with a uniform price. This example naturally extends to differences in prices across fuels.[7]

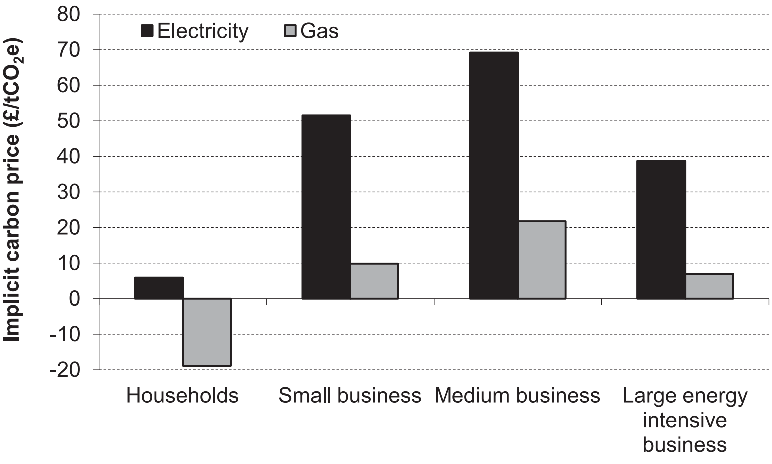
A multitude of current energy use and climate change policies have an impact on the price of electricity and gas faced by consumers of energy. Policies primarily aimed at reducing emissions have explicit carbon prices. However, policies with other objectives can also affect the prices that consumers pay. For example, the costs of policies aimed at supporting the development of renewable technologies (such as the Renewables Obligation and Contract for Difference feed-in tariffs)[8] are generally recouped through the price of electricity paid by households and firms. These policies therefore have ‘implicit’ carbon prices.

The explicit and implicit carbon prices created by each policy can be combined to form the effective carbon prices faced by different users when using different fuels. Figure 1 shows the implicit carbon prices faced by households and businesses of different sizes when using gas and electricity

[6]Mirrlees et al., 2011.
[7]For a more detailed discussion, see Advani et al. (2013a).
[8]See Table A1 in Appendix A online for further details.

FIGURE 1

Implicit carbon prices (£/tCO_2e), by end user and metered fuel type, 2013–14



Source: Figure 6.4 of Advani et al. (2013a).

in 2013.[9] There is considerable variation in current prices, both across fuels and across users.

This variation is driven by two main features of current policy. First, the VAT treatment of domestic energy use has a significant effect on the carbon price faced by households. Domestic energy use is subject to a reduced rate of 5 per cent, in comparison with the 20 per cent full rate of VAT levied on most other goods and services. This acts as an effective carbon subsidy of £53 per tonne of carbon dioxide equivalents (tCO_2e) for electricity and £32/tCO_2e for gas use in 2013.[10] Without this subsidy, carbon prices for households would be similar to those for businesses. As well as the poor incentives created from the perspective of carbon pricing, the differential rate of VAT creates welfare losses by distorting consumer choices.[11]

Second, gas is currently undertaxed relative to electricity. A variety of policies increase the price of domestic electricity, in many cases as a side effect of some other policy goal. In contrast, there are currently no policies in place

[9]For more details on the policies that create these prices, see Advani et al. (2013a).

[10]See Advani et al. (2013a). The subsidy is larger for electricity than for gas because the subsidy is proportional to the price of the fuel. One megawatt-hour (MWh) of energy from electricity is more expensive than the same amount of energy produced using gas, and this difference in price remains even after taking into account the greater carbon content of a unit of electricity.

[11]Mirrlees et al., 2011.

that directly tax domestic gas use,[12] and relatively few for businesses. This has resulted in a lower carbon price on gas for all users, and a negative price for households once the reduced rate of VAT is taken into account, effectively subsidising gas consumption.[13] In Section IV, we set out two potential reforms to household policy that reduce this variation.

Variation in carbon prices (across both users and fuels) exists not only in the UK, but also in a wider international context. Vivid Economics (2012) examined the range of effective carbon prices in a number of European countries and found significant variation within all locations. Similarly, the OECD (2013) estimated effective carbon prices for all OECD countries, distinguishing between energy used for transport, heating and processing, and electricity generation. It found large variation in prices, both across and within countries.

OECD (2013) also indicated that the nature of this variation differs across countries. For example, Denmark and Norway levy much higher carbon prices on energy used for residential purposes than on industrial uses. This is in contrast to the variation noted in the UK in Figure 1, where concerns over distributional impacts have resulted in lower domestic carbon prices. However, the principle of carbon price equalisation and its likely distributional effects apply across many countries.

IV. Our reforms

1. Carbon price reform

We model two reforms to carbon prices in order to reduce the variation in carbon prices faced by different users, and across electricity and gas. The reforms are:

- an increase in the rate of VAT on domestic fuel (electricity, gas and other fuel) from 5 per cent to 20 per cent;
- a new tax on domestic gas of 0.8p per kilowatt-hour (kWh). Since VAT is applied to the tax-inclusive price, we assume the total cost to households is 0.96p/kWh.

The first reform raises the carbon price for household electricity to be more similar to that faced by small and medium firms. We then impose a gas tax of the correct size to approximately equalise carbon prices across domestic gas and electricity use.

[12]The only positive carbon prices for domestic gas are incurred by the costs of policies that provide bill support and that support energy efficiency measures, which are recouped through both gas and electricity prices.

[13]The reduced rate of VAT makes direct consumption of energy cheaper than the cost of energy ‘embedded’ in purchased products.

TABLE 1

The impact of the reforms on domestic energy prices, 2013–14

	Pre-reform unit price (p/kWh, estimate)	*Effect of 20% VAT rate (p/kWh)*	*Effect of gas tax (p/kWh) including VAT*	*Post-reform unit price (p/kWh)*	*Change in unit price (%)*	*Pre-reform carbon price (£/tCO$_2$e)*	*Post-reform carbon price (£/tCO$_2$e)*
Electricity	15.60	2.23	0.00	17.83	14.3%	5.92	58.65
Gas	4.83	0.69	0.96	6.47	34.0%	–18.92	56.05

Note and source: Pre-reform unit prices are 2012 figures from Department of Energy & Climate Change (2012a for electricity; 2012b for gas) uprated to 2013 values using the year-on-year electricity and gas RPI inflation rates at April 2013. Pre-reform carbon prices are taken from Advani et al. (2013a); the post-reform prices are the estimates from Advani et al. (2013a) excluding the carbon subsidy from reduced-rate VAT and adding an additional £43.28/tCO$_2$e to gas from the 0.8p/kWh tax rate based on Department for Environment, Food & Rural Affairs and Department of Energy & Climate Change (2012) estimates that a MWh of gas generates 0.18483tCO$_2$e. Figures are rounded to two decimal places (one decimal place for the percentage price change).

Together these reforms achieve a domestic carbon price of close to £59/tCO$_2$e. This figure is DECC's central estimate of the shadow price for non-traded carbon in 2013.[14] In other words, emissions not covered by the EU Emissions Trading System need to be priced at this level in 2013 in order to be consistent with meeting UK domestic emissions reductions targets.

Although equalisation of carbon prices improves the efficiency of carbon reduction, such reforms are not currently being discussed either in the UK or internationally. However, the cost of carbon required to meet emissions reduction targets will soon begin rising rapidly, both in the UK and elsewhere. As these costs rise, the efficiency costs of protecting certain groups will grow rapidly, and so we expect greater pressure towards equalisation of carbon prices in the future.

It is also important to note that households will still face many of these costs indirectly regardless of current policies aimed to shelter them. This is because firms will pass on many of the higher costs of production (arising from increased energy costs) in the form of higher prices for goods and services. In this way, households will still face higher prices as a result of energy prices, but not face the correct incentives to decrease energy consumption at the margin.

Table 1 shows the pre- and post-reform energy and carbon prices if the reforms had been introduced in 2013–14.

Total revenue raised – and the amount by which emissions are reduced – by imposing these changes will depend on households' behavioural responses to the higher prices they face. If households do not change the quantity of

[14]Department of Energy & Climate Change and HM Treasury, 2013.

energy they consume, we estimate that the reform will raise £8.2 billion each year. Using a short-term price elasticity for energy use of –0.3 and a long-term elasticity of –0.8,[15] we estimate that behavioural responses would reduce annual revenue to £7.5 billion in the short term and £6.4 billion in the long term. We use a conservative estimate of £7.2 billion when we model the compensation packages below, which allows for slightly more than the expected short-run response; additional revenues could be used either to conduct further compensation or towards other government priorities.[16]

Using the same price elasticities, we estimate that this reform would reduce emissions by around 8 million tCO_2e per year in the short term, equivalent to 7 per cent of emissions from households, and 22 million tCO_2e per year in the long term, equivalent to 18 per cent of emissions from households.[17] At current carbon values, this long-term saving would be worth £1 billion, rising to £1.2 billion at 2020 carbon values.[18]

2. Compensation packages

We model two reforms that directly address the distributional consequences of a substantial rise in energy prices. We consider two opposing cases for how the revenues raised by the reforms could be used to compensate households for the increase in energy prices. The distributional objectives of policymakers will play an important role in choosing the precise mechanism used in practice, which may fall somewhere between the examples we illustrate. Our first package returns the revenue through lump-sum transfers, while the second explicitly targets compensation on the bottom three expenditure deciles by

[15] Espey and Espey, 2004.

[16] There are a number of other reasons to err on the cautious side when deciding how much revenue to commit to redistribution through adjustment in benefit rates. For example, we do not measure variation in price elasticity. Since it is likely that richer households have a higher price elasticity for energy, as well as being larger consumers of energy, this would imply that actual revenue raised might be lower than we estimate.

[17] Emissions reductions are calculated in the following way. First, we calculate total baseline domestic use of electricity and gas by taking an annual average between 2009 and 2011 (Department of Energy & Climate Change, 2012c). This yields baseline levels of 116.3 million MWh of electricity use and 338.4 million MWh of gas use. Second, we calculate the reduction in the total domestic use of electricity and gas by applying the price elasticities to the baseline levels. Third, we convert this reduction into an annual emissions reduction using conversion rates of 0.368tCO_2/MWh for electricity (Department of Energy & Climate Change, 2012c) and 0.185tCO_2/MWh for gas (Department for Environment, Food & Rural Affairs and Department of Energy & Climate Change, 2012). Finally, we estimate the sum of these reductions as a proportion of total domestic emissions in 2011, which were 124.2 million tCO_2e (Department of Energy & Climate Change, 2013b). To see how the estimated emissions reductions change with the price elasticities, see table 6.5 of Advani et al. (2013b).

[18] Emissions reductions from gas are valued at the non-traded carbon price of £59/tCO_2e in 2013 and £66/tCO_2e in 2020; reductions from electricity are valued at the traded price of £3/tCO_2e in 2013, rising to £5/tCO_2e by 2020 (Department of Energy & Climate Change and HM Treasury, 2013).

adjusting the generosity of existing benefits.[19] In both cases, the total package costs around £7.2 billion.

We first model the effects of a lump-sum compensation package, redistributing £7.2 billion as equal payments to each individual in the population. These payments are estimated to be £2.15 per person per week. This is equivalent to £5.47 per household on average. Such a compensation package is in general progressive, with equal transfers representing a larger proportion of total income or expenditure for poorer households than for richer households. However, poor households with relatively large budget shares for energy will still suffer significant losses as a result of the reform. Policymakers with stronger redistributive objectives may therefore wish to target compensation towards poorer households.

The second compensation package explicitly targets compensation towards poorer households on means-tested benefits. We create the package in two stages. First, we take into account the 'automatic' compensation that arises through the uprating of existing tax and benefit thresholds as a result of energy price increases. These price rises will cause a one-off increase in inflation, which in turn should result in an increase in tax thresholds and mean that a variety of means-tested benefits and tax credits are uprated at a higher rate than would occur in the absence of the reform.

Using the weights for household energy from the 2013 consumer prices index (CPI), we estimate that the reforms would lead to a one-off increase in inflation of 1.2 percentage points. The 'automatic' part of this compensation package therefore includes a 1.2 per cent rise in tax thresholds, tax credits, excise duty rates and means-tested benefit rates. This is estimated to cost £2.6 billion.[20]

We then build in additional compensation measures. As noted above, our aim with these compensation measures is to minimise the share of net losers in the bottom three expenditure deciles; this is one way to represent a strong preference against losses at the bottom of the expenditure distribution. Within this group, certain household types are over-represented (relative to the rest of the expenditure distribution). For example, 43 per cent of households in the bottom three deciles contain individuals of pensionable age, compared with

[19]Until 2013, the definition of fuel poverty was a need for a household to spend more than 10 per cent of its after-housing budget on fuel. On average across 2009 and 2010, households in the bottom four deciles spent 15.5 per cent, 12.6 per cent, 11.1 per cent and 9.3 per cent (first to fourth deciles respectively) of their non-housing budget on fuel (calculated from the 2009 and 2010 LCF data, which we also use for our distributional analysis, and equivalising using the modified OECD scale). We therefore focus on attempting to 'protect' the bottom three deciles, where the average household is fuel poor.

[20]Note that this includes an increase in the basic state pension – which is subject to a 'triple lock' (rising by the highest of growth in prices, growth in earnings and 2.5 per cent) – since at the moment price inflation is greater than earnings growth. Of course, that may not always hold; if the inflation rate were at least 1.2 percentage points lower than earnings growth, then the reform would not lead to any additional rise in pensions. This would save around £420 million of the projected cost.

26 per cent in all other expenditure deciles. Also, fewer of them contain full-time employed individuals (19.6 per cent, compared with 51.8 per cent in other deciles) and more contain unemployed individuals (6.2 per cent compared with 1.6 per cent). Our proposed reforms therefore adjust existing benefits for which the households most commonly found in these deciles are eligible. In particular, we increase a number of existing benefits and tax credits that are targeted at poorer pensioners, low-income working people without children, families with children and those with longer-term sickness and disabilities.[21] These measures cost an additional £4.6 billion above the automatic compensation. This results in a total cost of £7.2 billion for the second compensation package.[22]

There are many ways that one could structure these compensation measures and achieve the same annual cost. We considered a large number of policy combinations to try to achieve our aim of minimising losses in the bottom three deciles whilst keeping within the remaining budget. The combination in Appendix B (available online) best met our criterion, but if one had a different objective then some alternative package would likely meet those needs better. Our packages should be considered as illustrative examples of what could be achieved, based on policymakers' potential objectives.

V. Data and methods

1. Living Costs and Food Survey

Our analysis is based upon data from the Living Costs and Food Survey (LCF). The LCF is an annual cross-sectional survey containing information from approximately 6,000 households in each year. Data are available between 1974 and 2011. The survey contains information on household income and a wide range of socio-economic characteristics. In addition, all adult respondents complete a diary over a two-week period detailing all expenditures. We use the expenditure information, combined with demographic characteristics, to estimate how different types of household are affected by our proposed energy price reforms.[23] Combining this with the information on incomes, we are able to calculate tax payments and benefit receipt, which we then use to study the distributional effects of different compensation packages.

[21]Table B1 in Appendix B online details the particular reforms and provides additional information on the relevant benefits and tax credits.

[22]Note that we consider broad increases in a range of means-tested benefits that exist in the 2013–14 system as a way to try to compensate poorer households more generally rather than increasing a single specific benefit. Over the next few years, the system will be simplified by the roll-out of universal credit, which will reduce the number of parameters of the system that need to be changed to try to compensate poorer households.

[23]Unfortunately, the LCF does not contain information on energy consumption, only expenditure. We therefore use average regional prices by payment method as a proxy for the energy prices faced by households.

Energy expenditures are recorded separately by fuel type. We convert all expenditures to a weekly average, and break these down into spending on electricity, gas and non-metered fuels (heating oil, coal, etc.). The different payment methods that are used to purchase different fuels lead to some artificial variation in household-level energy spending as observed in the data due to seasonality effects and the infrequency of purchases. Advani et al. (2013b) discuss these details in greater depth and describe the procedures that we use to adjust the data in light of these concerns.

We construct a measure of overall living standards based on non-housing expenditure, which we use in our distributional analysis. This is equivalised using the after-housing-costs (AHC) modified OECD equivalence scale, with childless couples as the reference household. We use expenditure (as opposed to income) as a measure for overall living standards. This is because cross-sectional reporting of income is volatile, particularly for some groups such as students and pensioners, and may not accurately reflect living standards if an individual can borrow against future incomes or draw on past savings. Expenditure is therefore a better measure of lifetime living standards, as it should not be subject to these short-term changes as a result of consumption smoothing.[24] Housing is excluded from expenditure for two reasons. First, the use of AHC expenditure is consistent with the income measures proposed by the 2012 Fuel Poverty Review,[25] which have been adopted to officially define fuel poverty since 2013. Second, housing costs are generally difficult to change in the short run and therefore higher expenditure on housing costs – for example, increases in rents – do not necessarily imply higher living standards.

Our analysis uses pooled data from the 2009 and 2010 surveys.[26] Households that are resident in Northern Ireland are excluded due to significant

[24] Brewer and O'Dea, 2012.

[25] Hills, 2012.

[26] We use data from 2009 and 2010 as these were the latest available at the time of writing. These data are taken from a recessionary period and therefore may represent exceptional household expenditure behaviour. If the expenditure share of energy changed significantly during this period, there may be concerns that the analysis would overestimate (or underestimate) the impact of our modelled reforms. For example, if the budget share increased during the period, the analysis would overestimate the change in total expenditure required to compensate households for the subsequent increases in energy prices. There is little evidence of large changes in budget shares over this period. The energy expenditure share remained relatively constant between 2009 and 2011 (see figure 3.8 of Advani et al. (2013b)), and this is consistent across the expenditure distribution. This share is also consistent with historical levels. What is noticeable is the long-run trend in increasing budget share in the years prior to this period. Between 2000 and 2011, energy prices increased by 134 per cent relative to other goods. Over the same period, average household energy consumption fell by roughly 10 per cent. However, price increases slowed dramatically after 2008, with relative prices falling between 2009 and 2010. It is therefore unclear whether this trend has changed due to the recession or as a result of falls in energy prices.

TABLE 2

Summary statistics, by expenditure decile

£ per week

	All households	*By non-housing expenditure decile* Poorest 10%	Fifth decile	Richest 10%
Total income	507	283	465	874
Total non-housing expenditure	434	98	338	1,127
Spending on domestic energy	26	16	26	35
of which:				
Electricity	*12*	*8*	*12*	*15*
Gas	*12*	*8*	*12*	*16*
Other fuel	*2*	*0*	*1*	*5*

Note: Deciles are equivalised using the AHC modified OECD scale. The table excludes Northern Ireland. Numbers may not sum due to rounding.
Source: Authors' calculations from the IFS tax and benefit model, TAXBEN, using 2009 and 2010 Living Costs and Food Survey.

differences in the energy use profile between these households and those in the rest of the UK. We also exclude from our analysis all households that report any negative component of energy expenditure (i.e. negative expenditure on electricity, gas or non-metered fuels).[27] The total remaining sample size is 10,276 households.

Table 2 presents summary statistics. It shows average total income and expenditure for the first, fifth and tenth deciles of the expenditure distribution. It also details average spending on each type of energy. Weekly energy expenditure for households in the top expenditure decile (£35) is more than double energy expenditure in the bottom decile (£16). However, this accounts for a much smaller proportion of total expenditure, with households in the top decile spending 3.1 per cent of their total expenditure on energy, compared with 16.1 per cent for households in the bottom decile. This suggests that reforms that increase the cost of energy will have a larger impact in cash terms on richer households, but will have a much smaller effect as a percentage of expenditure.

2. Simulating the carbon price reform and modelling the compensation packages

We simulate the carbon price reform and model the compensation packages in the following way. First, we model the VAT reform by increasing prices

[27]Negative expenditure can occur when households receive a rebate on their fuel bill or when expenditures are reported erroneously. This covers a very small proportion of the British sample: 0.6 per cent in 2009 and 2010.

for electricity and gas by 14.29 per cent. All household fuel expenditures are uprated to April 2013 prices using the appropriate retail prices index (RPI) subindices.[28] Under the assumption of no behavioural response (see below for discussion of this assumption), the VAT reform represents an increase of 14.29 per cent in real fuel expenditure for each household.

We model the gas tax (after 20 per cent VAT is applied) to minimise the difference between carbon prices across the two fuels. As the gas tax is applied as an additional charge per kWh, we need to estimate the quantity of gas consumed by each household. We use Department of Energy & Climate Change (2012a) estimates of the average tariffs (fixed and marginal cost) by year, region and payment method and apply these prices to the adjusted gas expenditure figures to back out an estimate of household consumption.[29] Where this gives a very low (or even negative) estimate of consumption, we instead use Department of Energy & Climate Change (2012b) estimates of the average per-kWh price by year, region and payment method.

We take the costs of each policy and apply household weights to approximate the aggregate costs to all households in each year. In order to be consistent throughout our microsimulation modelling, we assume that there is no behavioural response to the energy price changes (i.e. households continue to consume the same quantity of energy at the new prices). We do this for two reasons. First, we are unable to relax the assumption of no behavioural response in our modelling of taxes and benefits, and it would seem inconsistent to allow our modelled households to adjust some economic quantities and not others. Second, we do not have data on price elasticities of energy across the distribution of expenditure, which are critical when trying to understand the distributional effect of the reforms. Making this choice does, however, introduce some inconsistency in our analysis, since in our compensation package we choose to only use the revenue *after* we account for the reduction in energy demand. The cost of this is that we are likely to overstate the losses or welfare costs to households. Nevertheless, it is likely that elasticities are lower in the bottom deciles – the groups we are focusing on – and therefore we are more likely to capture costs accurately for these households.

[28]Similar results would be obtained using the CPI, with energy inflation between the beginning of 2009–10 and the beginning of 2013–14 identical (18.14 per cent) in the two indices.

[29]It is important to note that we do not have any data on the actual tariffs that individual households face. It is not clear whether our method overestimates or underestimates the quantity consumed at different points in the distribution. Poorer households are less likely to switch to cheaper tariffs, which might lead us to overestimate their consumption. On the other hand, social tariffs reduce the cost for some households – about 1 million, or 4 per cent, of households received these in 2011–12 (Ofgem, 2012) – which might lead us to underestimate consumption. It is not clear overall which effect dominates, but the main result is likely to be larger within-decile heterogeneity in energy consumption than we currently measure.

Second, we use the IFS tax and benefit model (TAXBEN)[30] to create a compensation package for the price-based energy reforms. We use TAXBEN to estimate the gains to each household from increases in various means-tested benefits and compare these with the estimated losses from the energy tax reforms. This gives a net impact for each household, allowing us to look at the overall distributional impact of the energy tax and compensation package reforms taken together.

We assume no behaviour change (in terms of earnings or employment status, for example) by households following the compensation package. TAXBEN calculates each household's eligibility for means-tested benefits (as opposed to actual receipt) and assumes these are fully taken up. Some people do not take up the full range of benefits to which they are entitled, and as a result more people may lose out from the overall package of reforms than is captured by the modelling.

VI. Results

1. Distributional effects of carbon price reforms

We first examine the distributional effect of the proposed energy price reforms as if they were introduced in 2013–14 without any compensation. Figure 2 shows the additional amount, as a percentage of total non-housing expenditure, that a household would need to spend to purchase the same quantity of fuel that it purchased prior to the reform, across the expenditure distribution.[31] The effects of the extension of full-rate VAT and the introduction of a gas tax are shown separately.

The reform is clearly regressive when we rank households on an expenditure basis, with poorer households losing a greater share of total expenditure than richer households as a result of the reform. The poorest tenth of households lose 3.7 per cent of total expenditure on average, while the richest tenth lose 0.8 per cent.[32] Overall, households lose 1.5 per cent of total expenditure on average as a result of the reform.

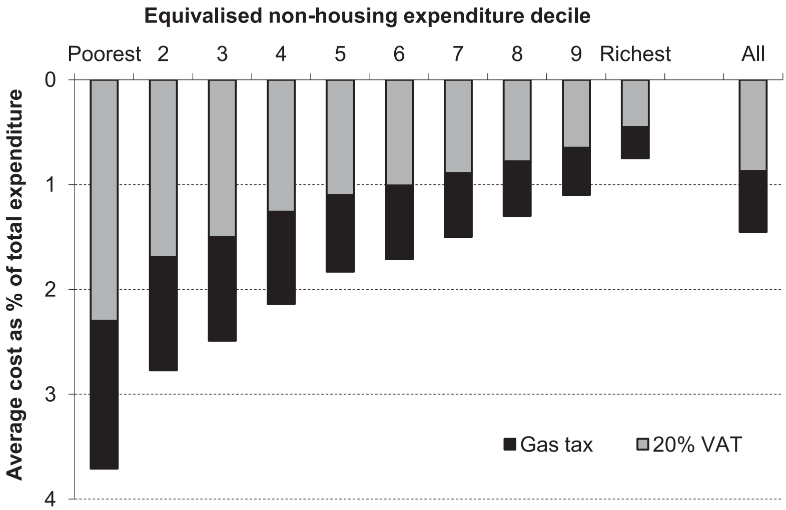
[30]See Giles and McCrae (1995) for details of TAXBEN; although that is now an outdated summary, the broad methodology is very similar. Tax liabilities and benefit entitlements are calculated for the 2009 and 2010 LCF samples (with financial variables uprated to 2013–14 values) based on observed pre-tax income, expenditure behaviour and self-reported entitlement to disability benefits. Tax liabilities and benefit entitlements can also be calculated under hypothetical alternative tax and benefit systems and the gain or loss from the reforms can be estimated for each household in the data; the overall cost of the tax and benefit changes can be calculated using the weights provided with the survey data.

[31]We can also examine variation across the income distribution; our results change little when using income instead of expenditure. Full results are available in Advani et al. (2013b).

[32]Richer households lose a greater amount in cash terms as a result of the reform. However, since energy expenditure accounts for a larger share of the budget amongst poorer households, these households are more affected as a share of expenditure.

FIGURE 2

Average cost (relative to total spending) of energy price reforms, by expenditure decile



Note: Deciles are equivalised using the AHC modified OECD scale. Figures are weighted for survey non-response. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

2. Distributional effects of a lump-sum compensation package

We now examine the extent to which our lump-sum compensation package mitigates the distributional effects observed in Section VI.1. We summarise the impact of the combined reform in three ways. In each case, results are presented across the expenditure distribution.[33]

First, following the approach of Mirrlees et al. (2011), we examine whether households are compensated for the cost-of-living increase arising from the reform. If prices rise by 1 per cent, real purchasing power is maintained by a 1 per cent increase in household income. We therefore compare the percentage increase in the cost of living and the percentage increase in income provided by the compensation package.

Second, we examine the effect of the reform in cash terms by looking at how net household spending changes as a result of the increase in energy costs and the additional income from the compensation package.

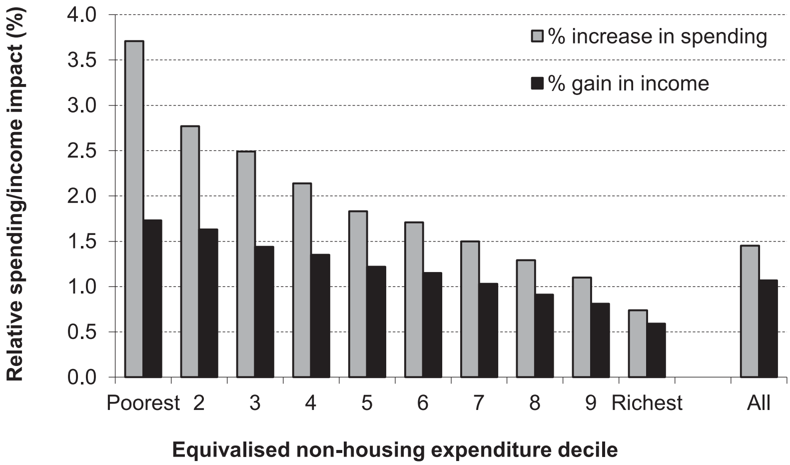
Third, we show how the impact of the reforms varies across households with broadly similar living standards. We categorise households into 'winners' and 'losers' from the reform within expenditure deciles. We classify households

[33]Results across the income distribution can be found in Advani et al. (2013b).

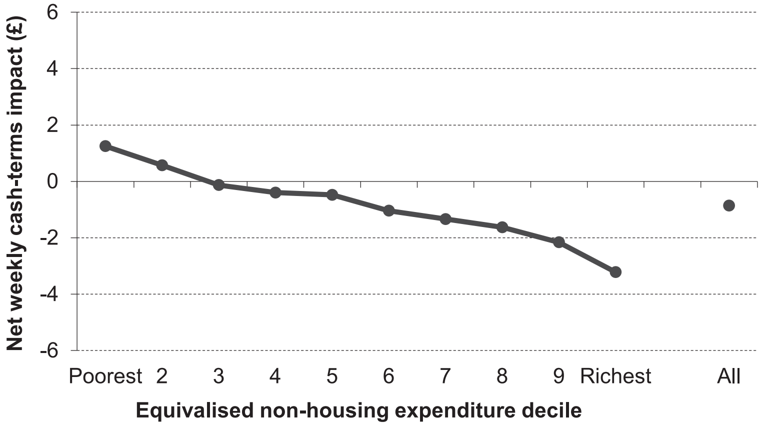
FIGURE 3

Average impact of energy price reforms with lump-sum compensation, by expenditure decile

A. As a percentage of income/expenditure



B. In net weekly cash terms (£)



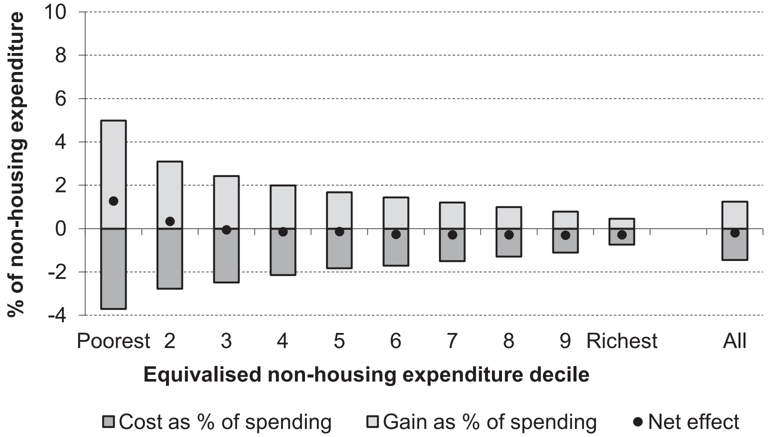
Note: Deciles are equivalised using the AHC modified OECD scale. Figures are weighted for survey non-response. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

as 'winners' if they gain more than £1 per week, while households are 'losers' if they lose more than £1 per week. The remaining households are classified as broadly unaffected.

Figure 3 shows the mean within-decile effect of the energy price reforms

FIGURE 4

Average net impact (relative to total spending) of the reform with a lump-sum compensation package, by expenditure decile



Note: Deciles are equivalised using the AHC modified OECD scale. Figures are weighted for survey non-response. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

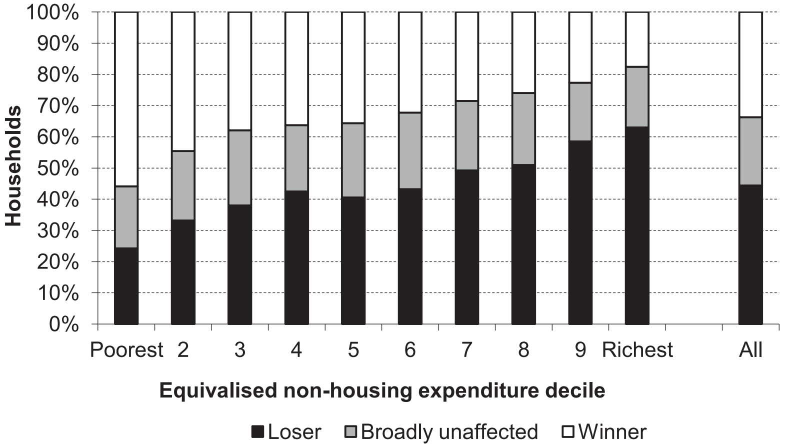
once the lump-sum compensation is included. Panel A shows the effects on the cost of living and the mean income gain, while Panel B shows the net cash gain or loss per week.

When we rank households by spending, the compensation package fails to fully compensate any decile on average for the cost-of-living increases arising from the energy price rises: Panel A of Figure 3 shows that the percentage increase in spending exceeds the percentage gain in income, on average, for each decile. However, Panel B shows that households in the bottom two expenditure deciles gain on average in cash terms. This is because income typically exceeds expenditure, so the income gains are more than enough to offset in cash terms the larger percentage losses incurred because of rising energy prices.

Figure 4 shows the average net impact (relative to total spending) of the combined package. This shows the average gain, loss and net effect in cash terms as a percentage of spending across the spending distribution. By this measure, the reform is progressive at the bottom of the distribution. Net cash gains for the poorest decile are worth 1.3 per cent of total non-housing spending. Those in the second expenditure decile gain 0.3 per cent of spending on average. The effects on the remaining deciles are broadly similar, with losses ranging from 0.1 to 0.3 per cent.

FIGURE 5

Percentage of 'winners' and 'losers' from the reform with a lump-sum compensation package, by expenditure decile



Note: Deciles are equivalised using the AHC modified OECD scale. Figures are weighted for survey non-response. 'Winners' are those who gain at least £1 per week from the overall reform package. 'Losers' are those who lose at least £1 per week. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

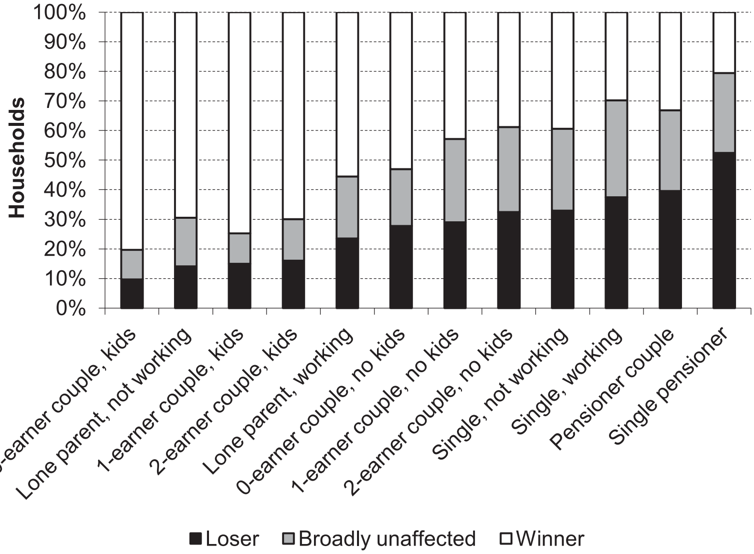
When we instead rank households by income, the reform is broadly neutral. In the bottom half of the distribution, households gain or lose no more than 0.1 per cent of expenditure on average, whilst losses in the upper half of the distribution are between 0.2 and 0.3 per cent.

In general, the lump-sum compensation package appears to do a reasonable job of mitigating the distributional impacts of the reforms. This is particularly true (on average) in the lowest three deciles of the expenditure distribution, which might be considered most at risk from such reforms. However, simply examining the average effects of the reform may conceal substantial within-decile variation and therefore may not reflect the extent to which poorer households lose from the reform. Figure 5 shows the within-decile impact, classifying winners and losers on the basis of whether net gains or losses exceed £1 per week.

When we rank households on an expenditure basis, we see that the difference between richer and poorer households is quite pronounced. In the poorest decile, 56 per cent of households gain from the reform. This compares with 18 per cent of the richest decile being winners. However, even amongst poorer households, the number of losers is relatively large, averaging 32 per cent

FIGURE 6

Percentage of 'winners' and 'losers' in bottom three expenditure deciles from the reform with a lump-sum compensation package, by household type



Note: Figures are weighted for survey non-response. 'Winners' are those who gain at least £1 per week from the overall reform package. 'Losers' are those who lose at least £1 per week. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

in the bottom three deciles.[34] This suggests that, although on average the compensation package can mitigate many of the negative distributional effects of the energy price reforms, a significant proportion of poor families are still made worse off by the combined reform.

The effects of the reform differ not only across the expenditure distribution but also across household types. This is the case even when considering only the bottom three deciles of the expenditure distribution, where households on average gain from the reform. Figure 6 divides households in the bottom three expenditure deciles into 12 demographic types and shows the proportion of winners and losers in each from the combined package. A majority of non-working couples and of households with children gain from the reform, while a majority of single-pensioner households lose. Other single-person households, couples without children and pensioner couples divide approximately evenly between winners and losers.

[34]When we rank households on an income basis, the proportions of winners and losers are relatively similar across deciles up to the sixth decile. They are also relatively high, both averaging around 37 per cent in the bottom three deciles.

3. Distributional effects of a targeted compensation package

The lump-sum compensation package does substantially reduce the average loss as a result of the energy price reform. However, the within-decile differences may raise concerns that poorer households may still suffer significant losses. We now examine the extent to which our targeted compensation package can reduce the proportion of poorer households that lose and compare this with the results in the previous subsection.

The first step in our targeted compensation package is to uprate tax and benefit thresholds by inflation. Since energy makes up a significant share of household budgets, the rise in VAT on domestic energy and the new gas tax are large enough to generate a substantial increase in the price level. Using the CPI, we estimate that the reforms would lead to a one-off increase in inflation of 1.2 percentage points. The effect of this is to increase by 1.2 per cent all tax credit and benefit rates (at an estimated cost of £2.6 billion). By itself, this 'automatic' compensation does little to compensate households for increased energy costs, offsetting only 16 per cent of the increased expenditure for the poorest decile and less than 30 per cent even for the richest decile.[35] Additional compensation is therefore required to compensate households for the reform.

Figure 7 shows the mean impact of the energy price reforms after the complete targeted compensation package is implemented – including both the uprating of tax and benefit thresholds due to inflation and the adjustments to benefits described in Appendix B – and distinguishes between different points across the expenditure distribution. Panel A shows the effects on the cost of living and the mean income gain, while Panel B shows the net cash gain or loss per week.

The targeted compensation package provides significantly greater compensation for households in the bottom half of the expenditure distribution than the lump-sum compensation package. Households in deciles 1 to 4 experience a positive net cash effect on average, while losses are greater in deciles 5 to 10.

Figure 8 shows the average net impact (relative to total spending) of the targeted package. When households are ranked on an expenditure basis, the net effect of the full compensation package is strongly progressive in the bottom half of the distribution, with average gains in the bottom four deciles. In the top half of the distribution, the effect is relatively neutral, with average losses varying between 0.5 per cent and 0.7 per cent of spending.[36]

[35]Households that spend more on energy than the average household will experience an inflation rate greater than the 1.2 per cent increase received in benefits, and will therefore not be fully compensated for the changes. This group tends to disproportionately include poorer households, as they spend the largest share of their budgets on energy, and so the reform will remain regressive.

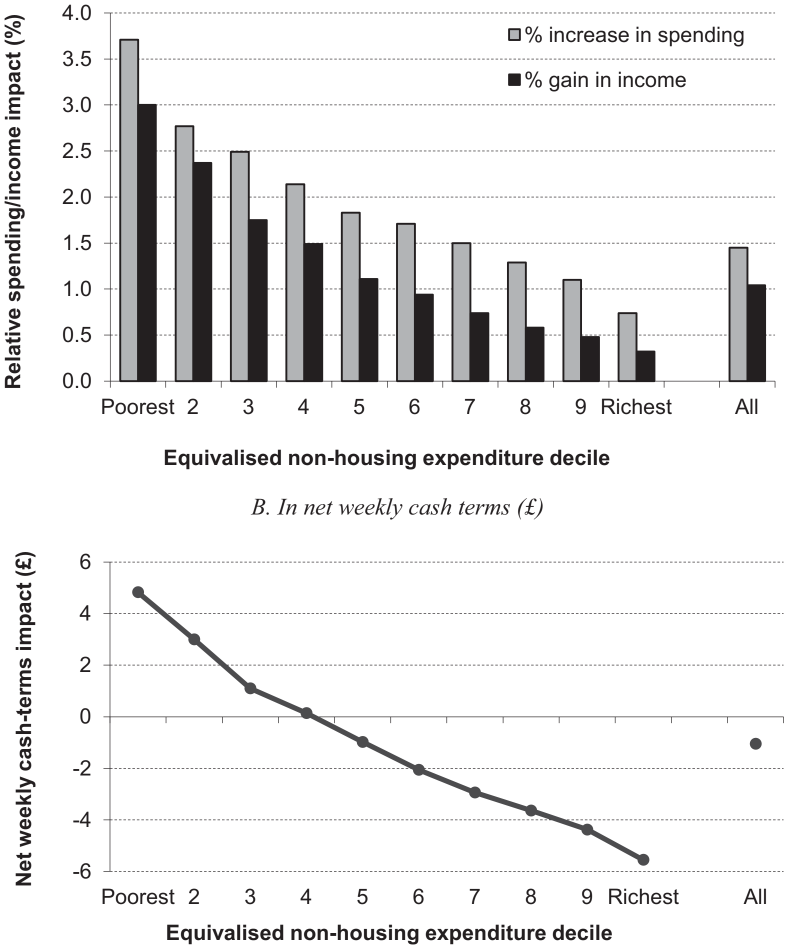
[36]A similar pattern can be observed on an income basis, although the average net gains relative to income are smaller at the bottom of the distribution. However, they remain greater than in the lump-sum compensation case. Results across the income distribution can be found in Advani et al. (2013b).

FIGURE 7

Average impact of energy price reforms with targeted compensation package, by expenditure decile

A. As a percentage of income/expenditure

B. In net weekly cash terms (£)

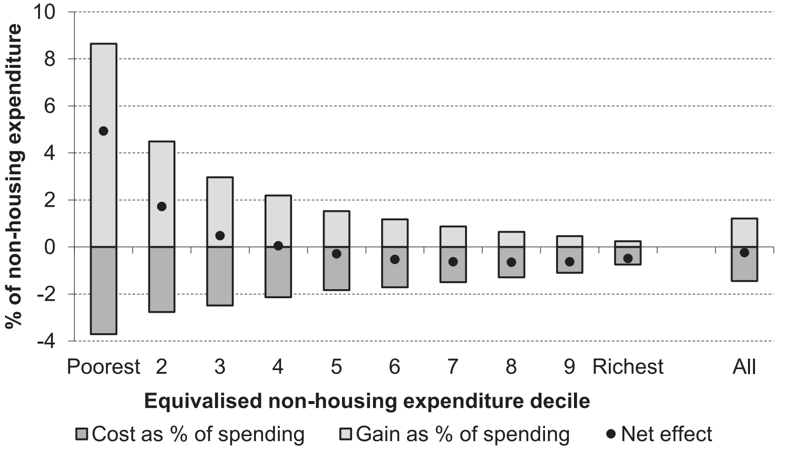


Note: Deciles are equivalised using the AHC modified OECD scale. Figures are weighted for survey non-response. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

These results show that poorer households are, on average, better compensated by the targeted compensation package. We now examine the extent to which the additional compensation reduces the number of net losers in poorer spending groups. Figure 9 shows the within-decile impact, as before

FIGURE 8

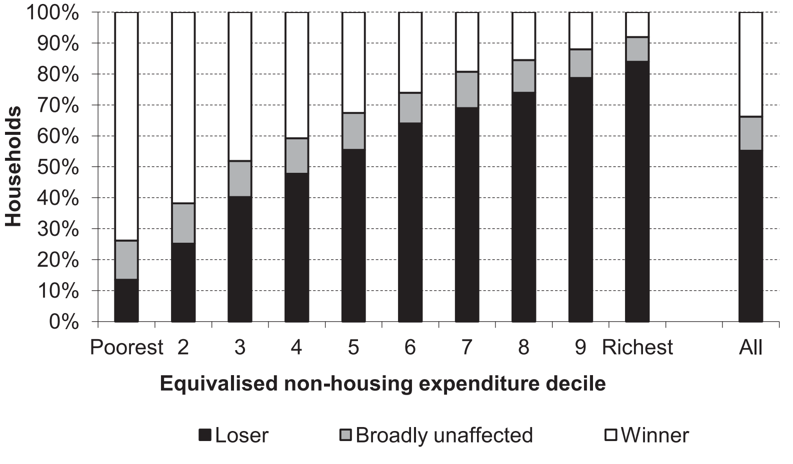
Average net impact (relative to total spending) of the reform with a targeted compensation package, by expenditure decile



Note: Deciles are equivalised using the AHC modified OECD scale. Figures are weighted for survey non-response. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

FIGURE 9

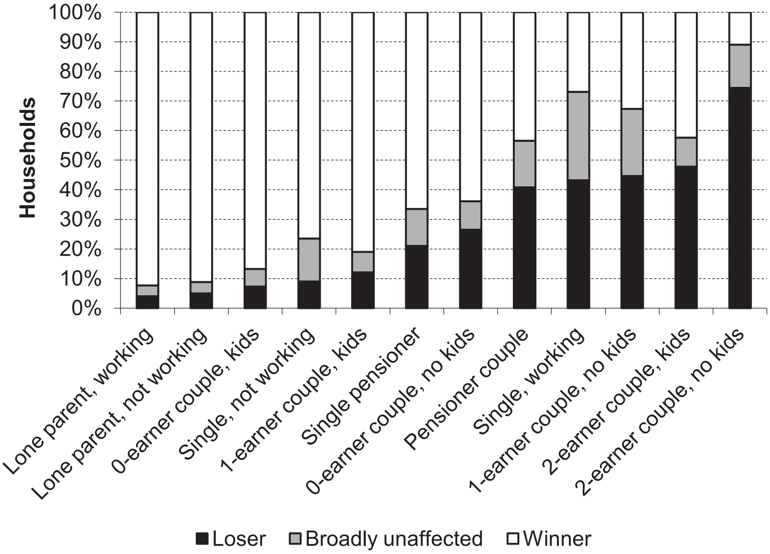
Percentage of 'winners' and 'losers' from the reform with a targeted compensation package, by expenditure decile



Note: Deciles are equivalised using the AHC modified OECD scale. Figures are weighted for survey non-response. 'Winners' are those who gain at least £1 per week from the overall reform package. 'Losers' are those who lose at least £1 per week. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

FIGURE 10

Percentage of 'winners' and 'losers' in bottom three expenditure deciles from the reform with a targeted compensation package, by household type



Note: Figures are weighted for survey non-response. 'Winners' are those who gain at least £1 per week from the overall reform package. 'Losers' are those who lose at least £1 per week. The figure excludes Northern Ireland.
Source: Authors' calculations from TAXBEN using 2009 and 2010 Living Costs and Food Survey.

classifying winners and losers on the basis of whether net gains or losses exceed £1 per week.

Looking across the entire distribution, the proportion of households that lose more than £1 per week is larger under the targeted compensation package (55 per cent) than under the lump-sum compensation package (44 per cent), while the numbers of households that gain more than £1 per week are the same, at 34 per cent.

However, the proportion of losers in the poorest and second deciles is substantially reduced when the targeted measures are introduced, despite starting from a relatively low base under the lump-sum compensation package (from 29 per cent down to 19 per cent). Under the targeted package, 74 per cent of households in the poorest decile gain more than £1 a week, while 14 per cent lose more than this amount. Again there is a steady rise in losers as expenditure increases, with 84 per cent of households in the richest decile classified as 'losers'.

Figure 10 shows the proportion of winners and losers in the bottom three expenditure deciles from the combined package, by demographic type. Now a majority of zero-earner couples, single-earner couples with children, and households with children and only one adult gain from the reform. Two-earner couples are the only group in which a majority lose.

Relative to the lump-sum compensation package, a greater proportion of workless singles, lone parents and pensioners are classified as 'winners' as a result of the reform. Substantially fewer two-earner couples, and single-earner couples without children, gain under the more targeted reform. This is due to relatively large increases in pension credit and child tax credit as part of the targeted package. Households that are eligible for these are therefore more likely to be classified as 'winners' under this reform, while couples of working age without children are less likely to be.

VII. Conclusions

Whilst the UK has some of the most ambitious carbon emissions reductions targets in the world, current policies make emissions reductions needlessly expensive. In particular, the variation in carbon prices across users and across fuels creates inefficient abatement incentives, not encouraging households to do much direct emissions reduction and discouraging electricity use much more than gas use.

Distributional concerns are often used as a justification for reducing carbon prices for households. The cause of this concern is clear: the poorest tenth of households spend 16 per cent of their non-housing budget on energy, whilst the richest tenth spend only 3 per cent of their budget on energy. However, if emissions reductions targets are to be met, then not encouraging households to directly reduce emissions forces carbon savings to be made elsewhere. These reductions are likely to be more costly and, in any case, their cost will inevitably feed through to households in some opaque way. As energy costs rise as a result of policy, firms are likely to pass through the increased costs of production to households in the form of price increases for the goods and services that they purchase. In this way, households will still face increased costs, while emissions continue to be reduced in an economically inefficient way.

In this paper, we show how one can directly provide households with incentives to reduce emissions, and reduce the costs of abatement, by creating more equal carbon prices across both fuels and users. We do this through levying the full rate of VAT on both electricity and gas, and additionally creating a gas tax. We estimate that this would raise around £8.2 billion initially, although as households adjust their consumption in the short run we estimate that the revenue raised will fall to nearer £7.5 billion. Such reductions in spending would reduce carbon emissions by more than 8 million tCO_2e, around 7 per cent of total household emissions.

We then use the revenues raised by these reforms to provide some compensation to households. At one extreme we do this through a lump-sum rebate to each individual, whilst at the other extreme we focus compensation on the poorest three expenditure deciles. We show that although it is not possible to 'protect' all low-expenditure households from the effects of higher energy costs, most of these households can be (at least partially) compensated. Households that still lose as a result of the reform typically have extremely high energy expenditures, and other policies such as free or subsidised energy efficiency measures are likely to be a more effective way to provide support than the current blanket subsidy to energy bills.

It is important to bear in mind a number of limitations when considering our findings. First, since individual price data are not available in household surveys, we use aggregate measures which vary only by region and payment method in any period. This is likely to understate the variation in energy consumption, and will affect our estimates of energy consumption for each household. This will have consequences for our estimates of the expenditure impacts as a result of the price reforms, although the direction of this effect across the expenditure distribution is not clear. Second, we also use a common price elasticity, since detailed data allowing estimation of elasticities by decile are not available. It is likely that the price elasticity is lower for poor households than for rich households. This would reduce the revenue raised and increase the carbon reduction arising from the carbon price reform, as richer households spend more on energy and will reduce consumption by more. Finally, we do not allow for behavioural responses in our microsimulation (although we do account for them in the reduced revenue received from lower energy consumption). This is unlikely to have a large impact on estimated costs to poorer households, as they are likely to be relatively price inelastic. However, it may result in an overstatement of the costs of the reform for richer households. As a result, the estimated losses due to the reform would be reduced for households in the upper expenditure deciles.

Although reforms that explicitly increase domestic energy prices would be unpopular, it is important to remember that policy as currently planned is also projected to drive large increases in energy prices in the near future. In particular, the introduction of policies aimed at promoting the production of electricity from renewable sources (such as the Renewables Obligation and Contract for Difference feed-in tariffs) will have significant upward pressure on electricity prices. Such policies will make households worse off and will not provide explicit compensation to mitigate this, while also causing further divergence between the effective carbon prices levied on gas and electricity. A similar reform to one demonstrated in this paper, which improves efficiency through equalising carbon prices across fuels and users, while also reducing the distributional impacts on households through the use of a targeted compensation package, would provide a fairer and more efficient option.

Supporting information

Additional supporting information may be found in the online version of this paper on the publisher's website:

• Appendices A and B

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