



A Major Green Fiscal Reform for the UK: Results for the Economy, Employment and the Environment

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About the Green Fiscal Commission

The Green Fiscal Commission is an independent body and is not affiliated to any political party or government. Its membership includes experts from business, leading academics, senior MPs from all three main UK political parties, three members of the House of Lords, and representatives from consumer and environmental organisations.

The Commission's aim is to assess the social, environmental and economic implications of a substantial green tax shift, such that 15-20 per cent of tax revenues come from environmental taxes. The Commission has reviewed and collated the existing evidence on the implications of a green tax shift as well as conducting new research. The results from this work have been placed in the public domain to stimulate debate and, we hope, action on this agenda.

This briefing is one in a series of briefings intended to cover the main issues associated with green fiscal reform. Other briefings have already been published on topics ranging from 'Public Opinion on a Green Tax Shift' to 'How Effective are Green Taxes?'. These are available on the Green Fiscal Commission website: www.greenfiscalcommission.org.uk

'A Major Green Fiscal Reform for the UK' was written by Paul Ekins on the basis of a modelling report supplied by Philip Summerton, Chris Thoung and other colleagues from Cambridge Econometrics.

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A Major Green Fiscal Reform for the UK: Results for the Economy, Employment and the Environment



Summary

This Briefing reports the results of a major modelling exercise to gain insights into the possible economic and environmental effects of a large-scale green fiscal reform (GFR) in the UK.

GFR involves a shift in the target of taxation away from labour or firms towards pollution or the use of natural resources, in such a way that overall tax revenues are unchanged. It is hoped that such a tax shift will deliver environmental improvements while having a neutral or positive effect on the economy. The modelling was set up to explore the extent to which this would be the case.

Such modelling projects different scenarios into the future and compares their outcomes. The scenarios in this case had medium, low and high fossil fuel prices without a tax shift (the 'baseline' scenarios); medium and low prices with a tax shift (the GFR or S-scenarios); and the same prices with a tax shift but with 10 per cent of the extra tax revenues spent on environmental investments (the 'eco-innovation' or E-scenarios).

The baseline with a high oil price reduces UK carbon emissions, although not enough to meet the 2020 target, but also reduces 2020 GDP by 6.3 per cent compared with the medium-price scenario.

The headline environmental result from the GFR scenarios is that the UK meets its 34 per cent greenhouse gas (GHG) emissions reduction targets for 2020, whereas the baselines miss them by a large margin. On the economy, the baseline GDPs are reduced in the GFR scenarios by 0.6 to 0.7 per cent by 2020, a reduction in the economic growth rate of around 0.07 percentage points (i.e. from around 2.6 per cent per year to 2.53 per cent per year). The reduced cost of labour in the GFR scenarios results in about 455,000 extra jobs by 2020.

In the E scenarios 10 per cent of the environmental tax revenues are invested in making homes more energy efficient, in fuel-efficient cars and in offshore wind electricity. This increases the generation of electricity from renewables to 26-29 per cent by 2020 (up to double the share in the baselines); the more efficient cars reduce carbon emissions from road transport by around 5 per cent; and the greater efficiency of homes reduces their carbon emissions by around 9 per cent. Overall, the E1 and E2 scenarios reduce carbon emissions a further 3.5 per cent and 7.3 per cent below the already low levels in S1 and S2 respectively, indicating the environmental effectiveness of such investment.

GFR emerges from this modelling exercise as a policy instrument that can reduce GHG emissions enough to meet the stretching government targets for 2020, with practically no cost to the economy overall, and with an increase in employment. There is no other single policy that can achieve this.

Introduction

An important intention of the work of the Green Fiscal Commission was to generate insights into the economic and environmental implications of a large green fiscal reform (GFR) in the UK.

GFR involves shifting the target of taxation away from labour (incomes taxes, or National Insurance Contributions) or business enterprise (taxes on profits) towards taxes on pollution or the use of natural resources. It is hoped that such a tax shift will reduce pollution and increase resource efficiency, and, by reducing disincentives to use labour or make profits, have a broadly positive effect on the economy.

Those GFRs that have been introduced to date have been quite small, usually involving the shift of only a few per cent of tax revenues. However, even these have been estimated to have had significant positive environmental and economic effects, increasing energy efficiency and reducing emissions, and increasing employment. This provided the rationale for seeking to understand the wider implications of a much larger GFR.

Between 1999 and 2007 the proportion of revenues from environmental taxes in total tax revenues in the UK fell from 9.4 to 7.4 per cent. In other words recent years have seen a negative GFR. The Green Fiscal Commission (GFC) was keen to undertake work to increase understanding of what might be the results if, instead, the proportion of tax revenues to come from environmental taxes were to increase significantly, say to 15-20 per cent of tax revenues by 2020. This Briefing reports on the results of this work.

Evaluating a Green Fiscal Reform

A GFR involves relatively large increases in environmental taxes, balanced by a reduction in other taxes, such that tax revenues overall remain largely unchanged. Such a tax shift can be expected to have a large impact on both the environment (which is the major purpose of the tax shift), and the economy, with different economic sectors being affected in very different ways.

To generate any kind of detailed insights into these effects requires the use of an economic model that simulates the many interactions between different sectors in the economy. The Green Fiscal Commission commissioned Cambridge Econometrics (CE) to undertake this work, using its model of the UK economy called MDM-E3 (multi-sectoral dynamic model of the economy, energy and the environment). This model has been developed and improved over many years, and has often been used in simulations of this kind.

This is not the place to go into a detailed exposition of the model, which is described in Cambridge Econometrics' detailed report of this work, which will be made available in due course in the book of the GFC's work. Briefly, it is a highly disaggregated econometric model in which the key relationships in the economy are estimated on the basis of past data, and scenarios are projected into the future on the basis of these relationships and a number of assumptions about key variables such as economic growth, energy prices and government policies. The total model consists of the main economic model, and sub-models of the energy system and, within it, the electricity system. In addition to its results for the economy and energy demand, the model estimates air emissions from the use of energy and industrial processes, of which the most important are the six greenhouse gases covered by the Kyoto Protocol, the main one of which is carbon dioxide (CO₂) emissions resulting from the combustion of fossil fuels.

The basic modelling approach to generating insights into the impacts of a GFR is, first, to generate one or more projections of the future that shows how the economy, energy demand and emissions might develop in the absence of a GFR. These are called the Baseline projections. The various elements of the GFR are then imposed, singly or together, and the results of the projections with the GFR are compared with the results of the Baseline(s). These various projections are called scenarios. The next section describes the rationale for and nature of the Baseline and GFR scenarios that were produced for this work.

Scenarios

GFR works by using taxes to raise the prices of energy and other resources, or taxing pollution, and reducing other taxes. However, energy prices often change without GFR through the operation of world energy markets. A major purpose of this modelling was to generate insights into any differences between the impacts of energy price increases due to world markets, and those due to GFR. This entailed the modelling of three Baselines, with different assumed fossil fuel prices – medium (B1), low (B2) and high (B3). The GFR scenarios (S) were compared against these Baselines. In a variant of the GFR scenarios, not all the revenues from the environmental taxes were used to reduce other taxes. Ten per cent of these revenues were instead used to boost the environmental effects of the taxes, by investing in household energy efficiency, fuel-efficient cars and renewable energy sources. Because other taxes had not been reduced by the full amount of the environmental tax increases, this means that in these 'eco-innovation' (E) scenarios overall tax revenues, and public spending, were higher than in the other scenarios.

The main assumptions for Baseline B1 are now described in more detail, followed by the detailed specification of the other scenarios.

Main Assumptions for Baseline B1

The Baseline scenario (B1) for this study was the August 2008 projection from CE's UK Energy and the Environment report. This baseline economic forecast builds on and is consistent with the industrial and regional economic forecasts published by CE in its regular forecast publications *Industry and the British Economy* and *Regional Economic Prospects*, respectively. The baseline forecast provides a disaggregated projection of economic, energy and environmental developments to 2020.

The fact that baseline economic projections in June 2008 did not predict the scale of the economic downturn that occurred in late 2008 and early 2009 will not materially affect the results of the analysis of the differences between the Baseline and GFR scenarios, since the focus is on a comparison of the scenarios to the baseline projections (which

would have been similarly affected by the downturn) over the period to 2020, rather than their absolute levels of GDP and other economic variables.

In respect of energy prices, it will be remembered that in July 2008 oil futures prices reached highs of over \$145 per barrel. In the period to 2010 it was assumed in Baseline B1 that oil prices would decline moderately from the highs of 2008, but would remain high at over \$110 per barrel in nominal terms. Over 2010-20, real oil prices were then assumed to rise at a long-term trend of two per cent per annum, reaching \$170 per barrel in nominal terms in 2020, as global dependence on OPEC supplies increases and non-OPEC production falls, and the demand for oil is led by developing countries, China and India in particular. Gas prices, while lower, rise from 2010 with oil prices. Coal prices stay broadly constant in real terms to 2020.

The Baseline B1 only includes 'firm' government policies up to June 2008; that is, policies that were already in operation or those that had been planned and definitely confirmed. The UK environmental policies modelled in the baseline scenario include the Renewables Obligation (RO), the Renewable Transport Fuel Obligation (RTFO), the Climate Change Levy (CCL), and the UK's membership of the EU Emissions Trading Scheme (EU ETS). It is also assumed that the Carbon Reduction Commitment and the Carbon Emission Reduction Target will dampen fuel demand from commercial and household users respectively. The EU ETS has an impact on fuel prices as it is assumed that the cost of emissions allowances is passed through to fuel users. In the Baseline B1, the EU ETS price is assumed to be €25/tCO₂ in 2008, the first year of Phase 2, and thereafter to grow between 2 and 2.5 per cent per annum, reaching €32/tCO₂ in 2020. This means that the emissions reductions induced by the EU ETS at this level are already in the Baseline B1.

Baselines B2 and B3

The Baselines B2 and B3 have the same assumptions as B1, except for the oil and other fossil fuel prices. In B2, a low oil price baseline to simulate technical progress in



fossil-fuel production from unconventional sources and/or reductions in demand from carbon emissions reductions. The oil price is the same as in B1 until 2010, when it falls smoothly to \$70 per barrel (in nominal terms) by 2020. B3, in contrast, is a high oil price baseline to simulate an unstable world economy/energy market – the oil price is the same as in B1 until 2010, after which wholesale oil and gas prices were increased above B1 to leave

end user gas and petrol prices equal to those in the central green fiscal reform scenario (S1, described below). This leads to an oil price in 2020 of around \$500 per barrel in nominal terms. In each case the prices of other fossil fuels (coal and gas) were adjusted so as to be consistent with the oil prices used.

Chart 1 shows the oil prices over the projection period for the different Baselines.

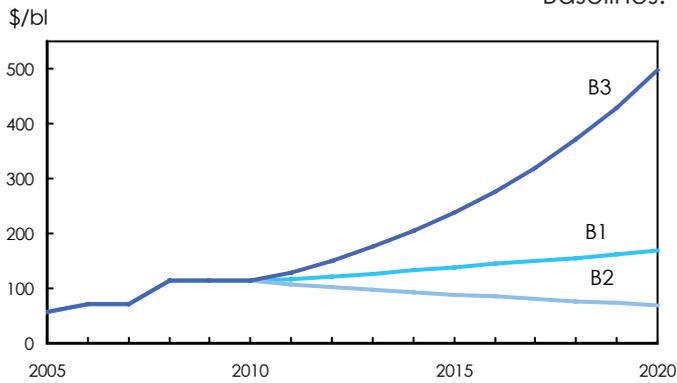


Chart 1: Oil Price Assumptions in the Baselines

Source(s) : BERR, Cambridge Econometrics.

The GFR Scenarios, S1 and S2

Two green fiscal reform scenarios were modelled, S1 starting from the Baseline B1, and S2 starting from the Baseline B2, but with the same target end fuel user prices as S1. Because the market prices of fossil fuels were lower in B2/S2, the GFR had to be larger (i.e. the taxes had to be higher) in order to reach the same end fuel user prices, generating more revenue that could then be used to lower other taxes.

- a purchase tax on new vehicle purchases averaging £300 in 2010 and rising by £300 each year, reaching £3,300 in 2020,
- a tax on the business use of water, beginning in 2010 at 10 per cent of the average water price in that year and increasing by 10 per cent per annum to 2020,
- an aggregates levy escalator of 10 per cent per annum beginning in 2010.

The green taxes and other measures for S1 were specified as follows:

- a substantial increase in CCL rates, by 25 per cent per annum, beginning in 2010,
- a household energy tax at the level of the aforementioned increased CCL rates over the period 2010-20,
- a Fuel Duty Escalator of 10 per cent per annum during the 2010-20 period,
- auctioning of EU ETS permits: 100 per cent auctioning for power generation during 2013-20 and 20 per cent of all other permits in 2013 increasing linearly to 100 per cent in 2020,
- the inclusion of aviation in the EU ETS beginning in 2013, and a tightening of the EU ETS cap to reflect the greater commitment in the S-scenarios to reduce carbon emissions,

In both S1 and S2 environmental tax revenues from industry are recycled through a reduction in employers' National Insurance Contributions (NICs) while revenues raised from households are returned via lower income taxes.

Also, in both S1 and S2, the cap on the EU ETS was tightened (i.e. the number of emission allowances was reduced), as a complement to the high taxes being levied on the untraded sectors, so that the traded sectors (i.e. those in the EU ETS) made some contribution to the 2020 emission targets.



The Eco-innovation Scenarios, E1 and E2

Two 'eco-innovation' scenarios were modelled, E1 and E2, allocating 10 per cent of the green-tax revenues levied in S1 and S2 respectively to the three following measures in roughly equal amounts (instead of using this money to reduce other taxes, as in S1 and S2):

- **offshore wind:** funds were allocated to subsidise this technology, making it competitive with respect to gas-fired new build; this was converted to an annual increase in capacity,
- **hybrid vehicles:** subsidies (of £3,000 per vehicle) were provided covering the additional production cost of a full hybrid vehicle, thus increasing the number of hybrid vehicles manufactured and bought in the UK,
- **retrofitting of the UK housing stock:** this portion of the revenues was given to households to pay for the installation of insulation measures in houses currently lacking them; loft insulation is installed first and once all houses have this, houses are then retrofitted with cavity wall insulation. Once all houses have this too, remaining funds are allocated to the offshore wind and hybrid vehicles investment streams.

These measures should not be taken to be prescriptive in any way; they were selected to give an idea as to the carbon reduction potential of green investment.

Because S2 has higher green taxes, as explained above, the scenario E2 has a much larger amount of investment into these eco-innovation measures, because the scale of the S2 green fiscal reform is greater.

Results of the Baselines

Results of Baseline B1

In B1 less than 5 per cent of the total tax revenue comes from environmental taxes by 2020. The Renewables Obligation (RO) target (as of 2008) of 20 per cent of electricity to be generated from renewable sources by 2020 is not met in the baseline; in 2020 RO generation is forecast to be 16 per cent of electricity sales.

Carbon intensity and primary-energy intensity were forecast to decline over the forecast period, continuing the recent trend. A major factor in this has been and will be the shift in the UK's electricity generation mix away from coal and towards gas and renewables. This is being driven by a fall in the price of gas relative to coal, and by policies such as the EU's Large Combustion Plant Directive, which will lead to the closure of a number of coal-fired power stations, and the UK's membership of the EU ETS, which is further raising the price of coal relative to other fuels. Also, the UK is encouraging the development of renewables generation through policies such as the RO. In addition, the fall in carbon and energy intensity is being driven by the decline in the share of manufacturing in UK GDP, and the rise of services and information technology.

Carbon emissions tend to track trends in energy demand. The increase in electricity demand over 2000-05 led to a rise in emissions from coal and gas-fired power stations, so that total carbon emissions rose by around ¼ per cent per annum over 2000-05. Carbon emissions from coal were forecast to fall by around 4 per cent per annum over 2005-10, and then by 2½ per cent per annum over 2010-15, before accelerating to a fall of 4¾ per cent per annum over 2015-20. Some of the fall over 2010-2020 was offset by increases in emissions from gas for power generation, so that total emissions were forecast to decline by around 1½ per cent per annum over 2005-10, but then to stabilise over 2010-15, before falling slowly by around ¼ per cent per annum thereafter.

Carbon emissions from road transport fuels were forecast to decline by around ¼ per cent per annum over 2005-10, largely as a result of the impact of the Renewable Transport Fuel Obligation (RTFO), although there is an associated ¼ per cent per annum rise in energy use forecast in road transport over this period. Over the long term (2010-20), road transport emissions were forecast to rise by around ¼ per cent per annum.

In 2020 total carbon emissions are forecast to be 500.1 mtCO₂, 15 per cent below the level in 1990, compared to a mandatory target adopted by the Government in April 2009 of a 29 per cent reduction in carbon emissions by that date.

Comparing the Baselines B1, B2 and B3

Table 1 shows the effect on end-user energy prices of the different baseline assumptions about market energy prices shown in Chart 1. By 2020, the real domestic gas price in B3 is 5.64 p/kWh compared with 3.23 p/kWh in B1 and just 2.30 p/kWh in B2. Even clearer is the impact of high oil prices on petrol prices: in B3, for example, petrol prices

reach 190 p/l in real terms compared to 110 p/l in B1, while they fall to 80 p/l in B2. Domestic electricity prices also increase significantly in the high fossil fuel price scenario, with real domestic electricity prices reaching 41 p/kWh in 2020 in the B3 scenario. The electricity prices in B3 are contrasted below with the electricity prices in S1 and S2 to show the effects of the green fiscal reform compared with those of increased world market fossil fuel prices.

Table 1: Final User Energy Prices and Fuel Duty for Different Baselines

	2007	2020		
2003 prices		B1	B2	B3
Domestic Gas (p/kWh)	3.17	3.23	2.30	5.64
Domestic Electricity (p/kWh)	10.37	17.50	12.81	40.85
Petrol (p/l)	84.6	109.9	79.3	190.1
Diesel (p/l)	91.4	121.6	83.9	221.1
Nominal prices				
Fuel duty (p/l) / % annual growth	50.4	78.3 / 3.6	75.8 / 3.3	91.2 / 5.2

Source(s): CE, DUKES and DECC.

In all the baselines and scenarios, the fuel duty is 50.4 p/l in 2007 (accounting for more than half the final price faced by consumers). Differences in the paths of the tax in the three baselines can be explained entirely by the different paths of inflation, as the Fuel Duty Escalator is index-linked; the tax is highest in 2020 in B3, having grown by some 5.2 per cent per annum over 2010-20, to more than 91.2 p/l. Because oil prices are growing so strongly in B3, the share of the tax in the final price falls over the projection period, to 26.2 per cent. Lower inflation in other baselines is reflected in lower growth in

fuel duty. In B1, fuel duty increases by 3.6 per cent per annum over 2010-20, reaching 78.3 p/l in nominal terms by 2020. Growth in the tax in B2 is somewhat lower averaging 3.3 per cent per annum in the same period, increasing to 75.8 p/l in nominal terms by 2020. Fuel duty is relatively stable as a share of the price faced by final users in B1 in 2020 and rises in B2.

Higher world market prices for energy reduce UK GDP. Chart 2 shows GDP by component under the three baselines, with B3 showing the lowest GDP.

£2003bn

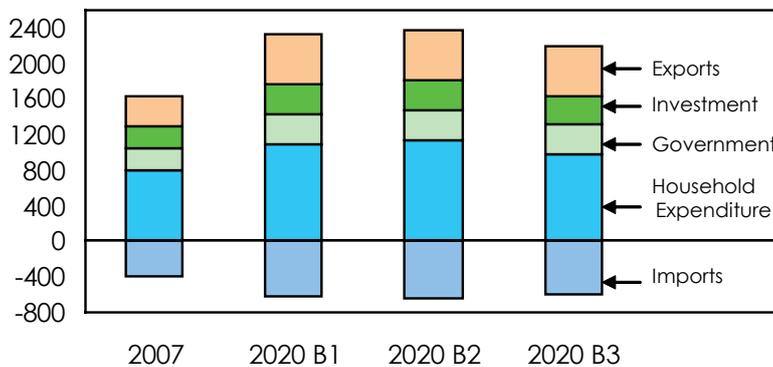


Chart 2: GDP by Component in 2020 in the Baselines

Source(s) : ONS, Cambridge Econometrics.



It can be seen that the various fossil fuel price assumptions have a strong impact on the economy. The considerably higher fossil fuel prices in B3 cause a substantial fall in GDP of 6.3 per cent by 2020 compared to B1. The average growth rate for GDP in the period 2010 to 2020 is 2.6 per cent per annum in B1 compared to just 1.9 per cent per annum in B3. In other words, the high fossil fuel prices modelled lead to average GDP growth to be 0.7 percentage points lower over the period 2010 to 2020. Conversely, in B2 fossil fuel prices are slightly lower than the baseline and so there is a 1.8 per cent increase in GDP by 2020 (equivalent to 2.8 per cent per annum growth in the period 2010 to 2020).

The increase in fossil fuel prices in B3 has the largest effect on real household expenditure, as wage inflation fails to keep pace with the significant price inflation. Moreover, the increase in the price of fossil fuels means that there is greater leakage from the UK economy as the revenues from the high fossil fuel prices are captured by fossil fuel producers abroad (rather than by the UK government under green fiscal reform). As real incomes are lower in B3, imports are reduced.

The impact of the higher energy prices differs across sectors. Those sectors facing the highest energy costs are more affected by the impact of the higher fossil fuel prices; typically manufacturing is more affected than services. Energy suppliers are also similarly affected. As industrial output is reduced as a result of the higher fossil fuel prices in B3 there is also a reduction in employment. In B3, higher fossil fuel prices cause some 82,000 job losses by 2020, again quite

different to the impact of the green fiscal reform.

Final energy demand is considerably reduced in B3 compared with B1 and B2, and this translates into a fall in CO₂ emissions.

It is important to distinguish throughout this Briefing between UK territorial emissions, i.e. those actually emitted due to activities in the UK, which are said to be accounted on an IPCC basis, and those which are counted towards UK commitments under the Kyoto Protocol (here called 'Kyoto emissions', or emissions calculated on a 'net carbon account' basis). Kyoto emissions take account of emissions permit trades through the EU ETS, and may be more or less than UK territorial emissions, depending on whether the UK is a seller or buyer of EU ETS permits.

In this Briefing, CO₂ emissions are normally reported on a territorial (IPCC) basis, to relate them to the economic activities by which they are produced. GHG emissions are normally given as Kyoto emissions to take account of the permit trades that are relevant to whether or not the UK achieves its emissions targets, and this is also true of CO₂ emissions when they are being assessed against targets.

As shown in Chart 3, in 2020 total carbon emissions in B1 are forecast to be 497 mtCO₂ on an IPCC basis (15.7 per cent below the level in 1990). However, on a Kyoto basis 2020 carbon emissions are 501 mtCO₂, compared to the target adopted by the Government in April 2009 of a 29 per cent reduction in carbon emissions by 2020.

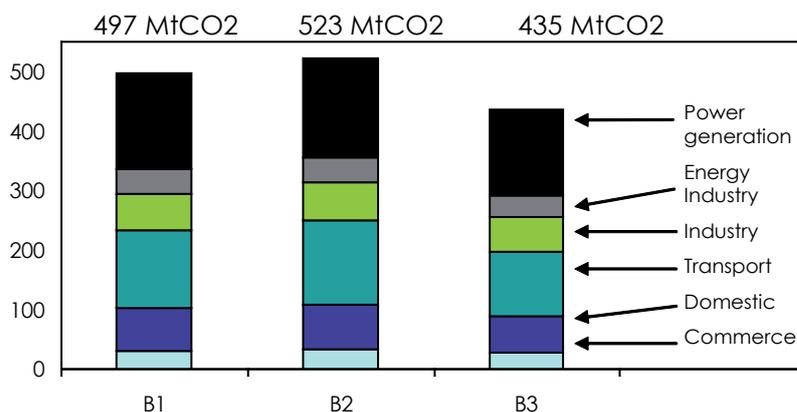


Chart 3: CO₂ Emissions (IPCC) in 2020 in the Baselines

Note(s) : Total CO₂ emissions, by the IPCC definition, are reported above each column.

Source(s) : NAEI and Cambridge Econometrics.

The total number of permits within the EU ETS is unchanged by world market energy prices, and is the same in all the baselines. In baseline B1 emissions reductions under EU ETS contribute to the 21.5 per cent reduction on the 1990 level by 2020. In B2 the lower fossil fuel prices reduce this to a 19.1 per cent reduction. In baseline B3 the high fossil fuel prices impact heavily on power generation, but even so are insufficient to push GHG emissions down to the 34 per cent

reduction goal by 2020, as shown in Chart 4. Although actual UK territorial GHG emissions are reduced by over 30 per cent, in baseline B3 the UK becomes a net exporter of EU ETS permits to other European countries and so the reduction in 'Kyoto GHG emissions' is only 26.7 per cent. Table 3 at the end of this Briefing gives a full comparison of both CO₂ and GHG emissions, calculated on both a territorial (IPCC) and Kyoto basis.

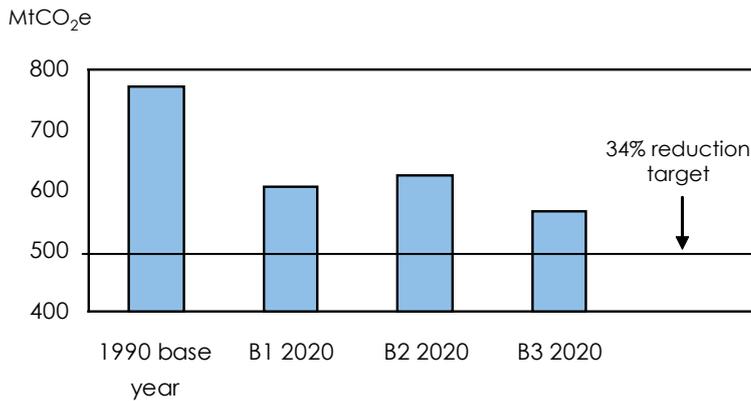


Chart 4: GHG Emissions (Kyoto) in 2020 in the Baselines

Source(s) : NAEI and Cambridge Econometrics.

The main conclusion of this comparison between the baselines is that higher world market fossil fuel prices reduce UK economic growth as well as carbon emissions. It will be seen that green fiscal reform can deliver a greater reduction in carbon emissions without damaging the economy.

Results of the GFR Scenarios

Here the GFR scenarios S1 and S2 are compared with their respective baselines B1 and B2, with the results for B3 (which was constructed to have the same end-user fuel prices as S1 and S2) also included for comparison.

Effects on Tax Revenues

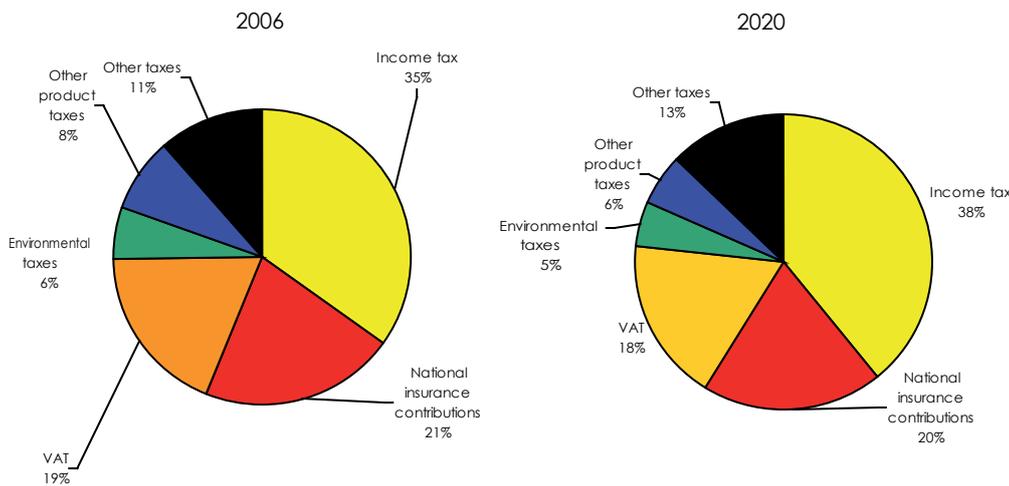
Charts 5 and 6 show the scale of the GFR S1 in terms of the shift in the source of tax revenues. In the B1 baseline, tax revenues rise to £875 billion in 2020. Almost 5 per cent of these revenues are accounted for by environmental taxes (£43 billion). Chart 5 shows that the composition of the sources of tax revenues does not change substantially over the course of this particular scenario.

After the GFR, tax revenues in 2020 are slightly higher in S1, standing at £888 billion. This is because taxes are nominal and prices are higher than in B1. By design, the share of environmental taxes in these revenues is higher, at almost 15 per cent (£132 billion). The increase in the share of environmental taxes leads to a corresponding decrease in the share of National Insurance contributions and income tax. This is, of course, to be expected given the specification of the GFR scenarios. Chart 6 shows that in the GFR scenario S1 revenues from income tax are reduced by about 10 per cent, and from National Insurance contributions by about a third, compared to B1.

In S2 (not shown) the share of environmental taxes in all tax revenues in 2020 reaches 17.6 per cent (£155.8 billion). The amount of revenue raised does not differ much between B1 and S1, and B2 and S2, indicating that the tax base arising from GFR over the projection period is stable.

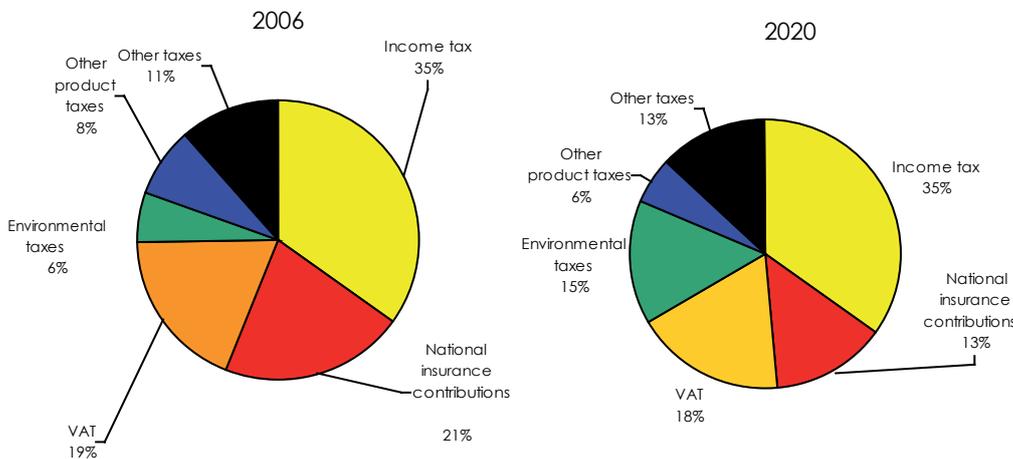


**Chart 5:
Composition of Tax
Revenues in B1**



Source(s) : ONS and Cambridge Econometrics.

**Chart 6:
Composition of Tax
Revenues in S1**



Source(s) : ONS and Cambridge Econometrics.

Effects on Tax Rates and Fuel Prices

Table 2 shows final user energy prices and fuel duty for the GFR scenarios and the baselines.

The rate of increase in fuel taxes is markedly higher in the scenarios in which a GFR has been modelled in order to curb demand for road transport fuels; double-digit average growth is seen in all these scenarios and the taxes in 2020 all exceed 200 p/l. In S1 the fuel duty increases by just over 13 per cent per annum over 2010-20, reaching around 205 p/l in 2020 in nominal terms. The tax accounts for around 58 per cent of the final price in 2020 in this scenario. In order for the fuel prices to match in the low fossil

fuel price in B2, fuel duties must be raised more aggressively. Fuel duty growth in S2 therefore averages 14.5 per cent per annum over 2010-20. The tax in 2020 is thus higher in this scenario, reaching approximately 236p/l in nominal terms, and the share of the tax in 2020 increases to 68 per cent.

An energy tax was raised on households in S1 that was in line with the substantial increase in CCL rates also modelled as part of the GFR. The tax on gas faced by households starts at 0.22 p/kWh in 2010, accounting for 4.7 per cent of the final price, and rises to 2.53 p/kWh in 2020 (almost 25 per cent of the nominal final price of 10.3 p/kWh [6.54 p/kWh in real terms]). In order for the domestic gas prices to be equalised in S2, it was

Table 2: Final User Energy Prices and Fuel Duty in the GFR Scenarios

	2007	2020				
		B1	B2	B3	S1	S2
2003 prices						
Domestic Gas (p/kWh)	3.17	3.23	2.30	5.64	6.54	6.76
Domestic Electricity (p/kWh)	10.37	17.50	12.81	40.85	23.40	20.55
Petrol (p/l)	84.6	109.9	79.3	190.1	220.6	228.0
Diesel (p/l)	91.4	121.6	83.9	221.1	230.6	230.4
Nominal prices						
Fuel duty (p/l / % annual growth)	50.4	78.3 / 3.6	75.8 / 3.3	91.2 / 5.2	205 / 13	236 / 14.5

Note(s): Final user prices for domestic gas and petrol in B3, S1 and S2 have been equalized in nominal terms but inflation differs across scenarios, so that the real prices vary.

Source(s): CE, DUKES and DECC

necessary to raise this domestic energy tax at a higher rate over 2010-20. In S2, the tax on gas rises to 3.32 p/kWh in order for the end-user price in 2020 to reach the same nominal price as in S1 (6.76 p/kWh in real terms). As discussed above, in B3 the wholesale price of gas was increased by assumption to reach the same (nominal) end-user price as in the GFR scenarios.

In S1 in 2020, £87.2 billion (in nominal terms) is available for recycling. Some 62 per cent of this revenue was used to reduce employers' National Insurance contributions and the remainder was recycled into a reduction in income tax. The reduction in income tax implies a reduction in the standard rate of tax from 20 per cent in B1 in 2020 to just over 18 per cent in S1. Over 2010-20 a total of £410.8 billion is recycled.

Table 2 shows that the end-user prices for the two fuels mentioned, while equal in nominal terms, diverge slightly in real terms due to different rates of inflation between scenarios as a result of higher fossil fuel prices or the green fiscal reform. In contrast, in B3 the electricity price is substantially increased over those in S1 and S2, because electricity, included in the EU ETS, is far more affected by world market price increases than by the GFR.

In S2, the amount of funds available for recycling reaches almost £110 billion (nominal) with the split between reductions in social security contributions and income tax broadly similar between S2 and S1. The implied income tax rate in S2 in 2020 falls to 17.5 per cent. A total of £496.8 billion is recycled over 2010-20 in S2.

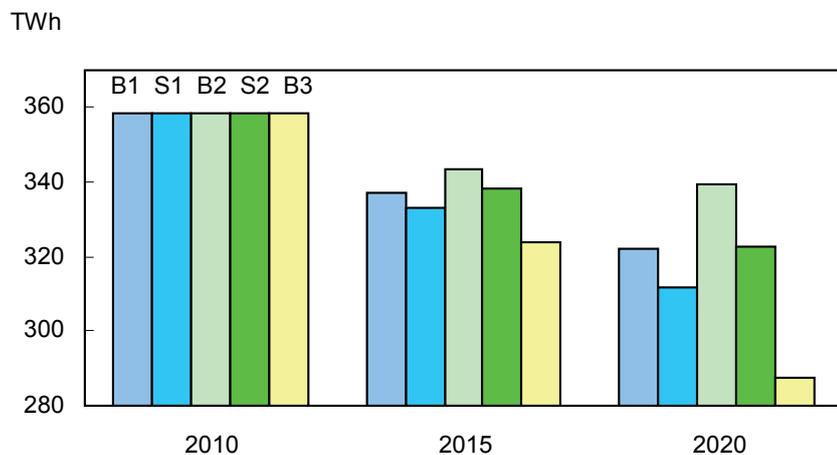


Chart 7: Total Energy Demand from Industry

Source(s) : DECC and Cambridge Econometrics.

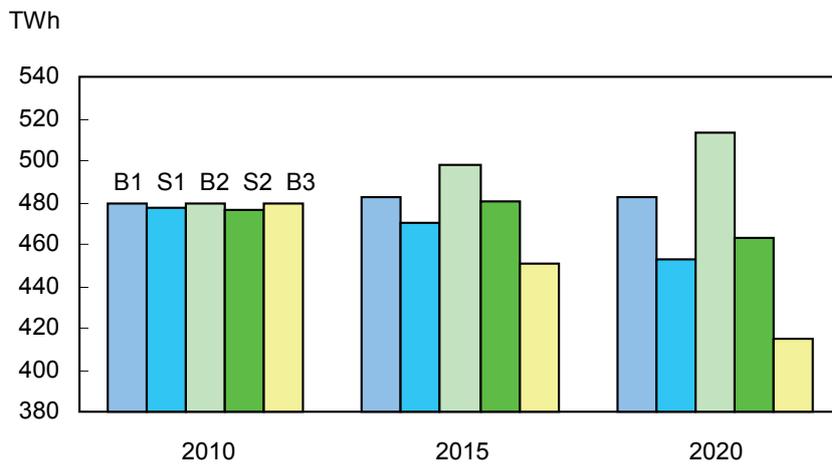


Chart 8: Total Energy Demand from Households

Source(s) : DECC and Cambridge Econometrics.

The Effect of GFR on Energy Demand by Industry and Households

GFR reduces energy demand from industry and households, as shown in Charts 7 and 8. In B1, energy demand from Industry falls by 1.1 per cent per annum over 2010-20 (see Chart 7). Energy demand falls faster in S1 over the same period, averaging -1.4 per cent per annum owing to the substantially higher energy taxation imposed. Industrial energy demand is 3.3 per cent lower in S1 than in B1. In absolute terms, the largest reductions in energy demand are in Other Industry followed by Chemicals (in which the largest percentage reductions are seen compared to the baseline).

Industrial energy demand falls at a much slower rate in B2, by 0.5 per cent per annum over 2010-20, and the effect of the environmental taxation is to increase this rate of decline to 1 per cent per annum. In S2, industrial energy demand is 4.9 per cent lower than in B2 in 2020. The largest reductions in industrial energy demand by fuel, as a result of a GFR, come from the fossil fuels coal and gas, with the share of fossil fuels in the fuel mix reduced. The consequent emissions reduction between B1 and S1 is thus larger than the reduction in energy demand. Emissions of CO₂ from Industry in 2020 are 4 per cent lower in S1 than in B1 (whereas the demand reduction is 3.3 per cent). The reduction in energy demand is greater between B2 and S2 than between B1 and S1 owing to the heavier taxation imposed and the switch from gas to electricity is more pronounced. Emissions from Industry are reduced by 5.7 per cent compared to an energy demand reduction of 4.9 per cent.

Chart 8 compares energy demand from households between the scenarios. In contrast to the slight growth in energy demand projected in B1, household energy demand falls under a GFR in which households face energy taxes of the level of the increased CCL, by 0.5 per cent per annum over 2010-20. In S1 the nominal price of gas faced by households increases by 8.4 per cent per annum over 2010-20 and in 2020 is double the price in B1. While consumers' expenditure across all categories is 1.2 per cent lower in S1 in 2020 than in B1, spending on energy is around 8.2 per cent lower. The largest percentage reductions in expenditure are on gas and coal. Electricity's share of expenditure increases under GFR. Emissions from households in 2020 are 6.7 per cent lower in S1 than in B1 (compared to a reduction in energy demand of 6.3 per cent) and 10.4 per cent lower in S2 compared to B2 (the corresponding reduction in energy demand is 9.8 per cent).

Effect of GFR on Energy Demand by Transport

The inclusion of a transport sub-model in MDM-E3 has allowed for more detailed results in the road transport sector. In the B1 and B2 baselines, demand for road transport (as expressed in passenger kilometres) increases by 0.5 and 1 per cent per annum over the period 2010 to 2020, respectively; lower oil prices lead to lower road fuel prices (the main variable cost of road travel) and thus more travel demand. In contrast, road travel demand falls in S1 and S2, by 1.3 and

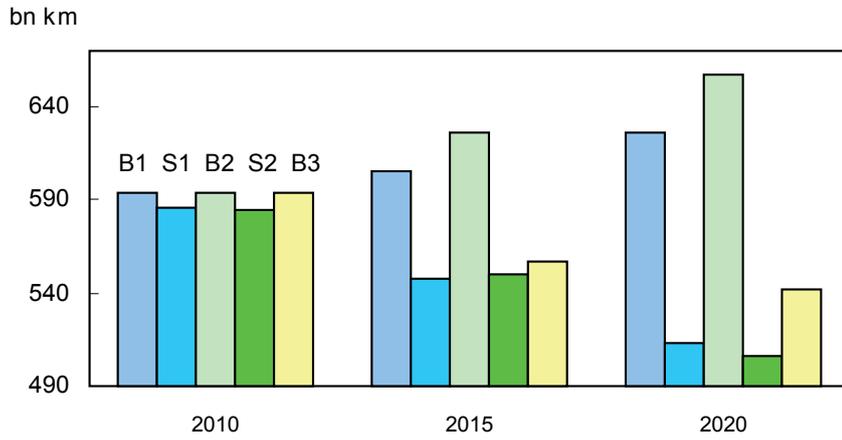


Chart 9: Demand for Road Transport

Note(s) : Figures shown are passenger kilometres.

Source(s) : DfT and Cambridge Econometrics

1.4 per cent per annum over the same period, respectively (the results are similar because the road fuel prices have been equalised between these two scenarios). In 2020, demand for road travel in S1 is 18.1 per cent lower than in B1 and 23.1 per cent lower in S2 compared to B2 (see Chart 9). The vehicle purchase taxes imposed in the GFR scenarios serve to reduce the incentive to buy new vehicles, as evidenced by a vehicle stock in 2020 that is 2.7 per cent lower in S1 than in B1 (2.4 per cent lower in S2 compared to B2).

By 2020, by curbing the demand for road transport, GFR has also curbed road fuel demand substantially, by 21.3 per cent in S1 and 27.6 per cent in S2 when compared to their respective baselines (see Chart 10). This result arises from the much higher fuel prices faced by users from the Fuel Duty Escalator imposed (the weighted average of petrol and diesel prices in 2020 in S1 is almost double that of B1). Road fuel prices in B1 grow by 3.7 per cent per annum over 2010-20 compared to 10.2 per cent per annum in S1 with the price of petrol growing somewhat faster than the price of diesel.

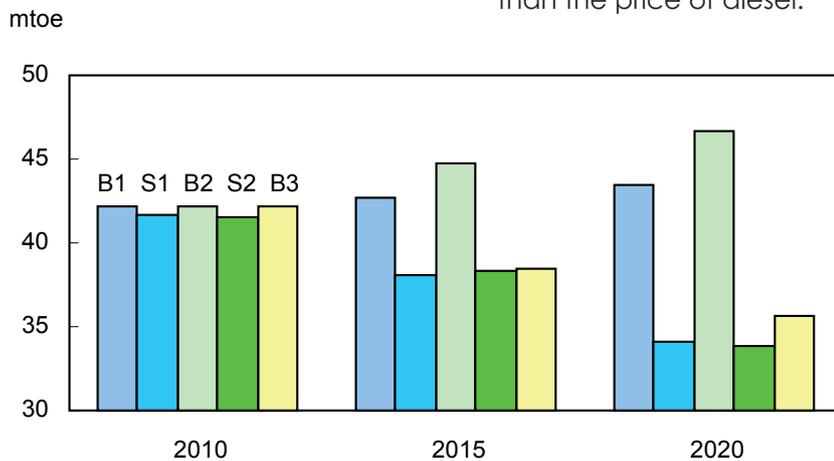


Chart 10: Total Energy Demand from Road Transport

Source(s) : DECC and Cambridge Econometrics.

The reduction in demand for road fuel is greater under GFR than is implied by the reduction in demand for road travel because of a more efficient vehicle stock under GFR. In 2020 the UK vehicle stock is 2.4 per cent more fuel efficient in S1 compared to B1 and 3.3 per cent more efficient in S2 compared to B2, as consumers buy more efficient vehicles. Carbon emissions in 2020 from road transport are 21.8 per cent lower in S1 (than B1) and 28.2 per cent lower in S2 (than B2).

GFR also brings about a marked reduction in the growth of international aviation, due to a higher price for air travel, as shown in Chart 11. Spending on air travel is lower in S1 by £4.3 billion in 2020. Demand for jet fuel still grows in S1 to 2020 but the average growth rate is 1.1 percentage points lower (2.1 compared to 3.2 per cent per annum). As a result, demand for aviation fuel in 2020 is 9.8 per cent lower in S1 than in B1.

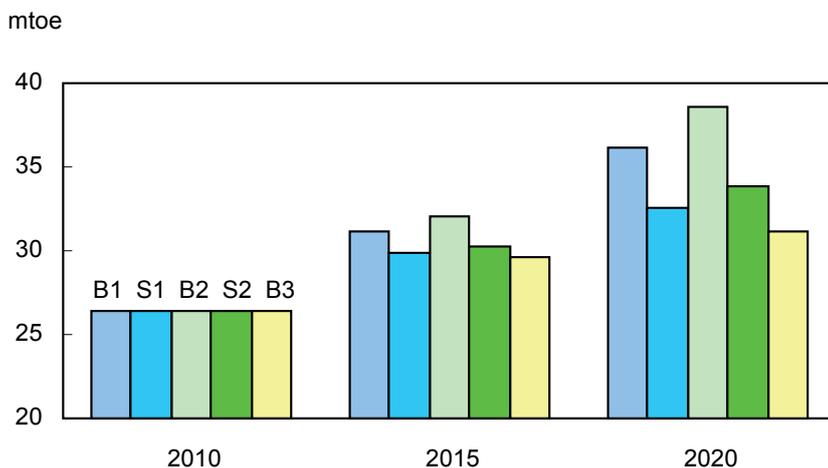


Chart 11:
Total Energy Demand from International Aviation

Source(s) : DECC, NAEI and Cambridge Econometrics.

A larger reduction in the growth in energy demand is seen in S2 compared to B2 (1.4 percentage points) and in 2020 the demand for aviation fuel is 12.4 per cent lower in S2 than in the corresponding baseline.

generation fall by 0.7 per cent per annum over 2010-20. Power generators are affected by world market fossil fuel prices, so that emissions from power generation are considerably lower in the high world market fossil fuel price baseline B3

Effect on the Power Generation Sector

Over 2010-20, in all three baselines, emissions from power generation fall, even though demand for electricity rises over the same period. This is the result of switching to more gas-fired generation (away from coal) and the increasing penetration of electricity sourced from renewables (see Chart 12). In B1 emissions from power

generation fall by 0.7 per cent per annum over 2010-20. Power generators are affected by world market fossil fuel prices, so that emissions from power generation are considerably lower in the high world market fossil fuel price baseline B3

In the GFR taxes are not levied directly on the power sector, as this is in the EU ETS, and the decline in emissions with GFR (S1, S2) is more rapid than in the baselines (B1, B2) largely as a result of a reduction in electricity demand. CO₂ emissions from this sector in 2020 are 4.5 per cent lower in S1 than B1 while demand for electricity from final users is 3.3 per cent lower as a result of the higher energy taxes they face under GFR.

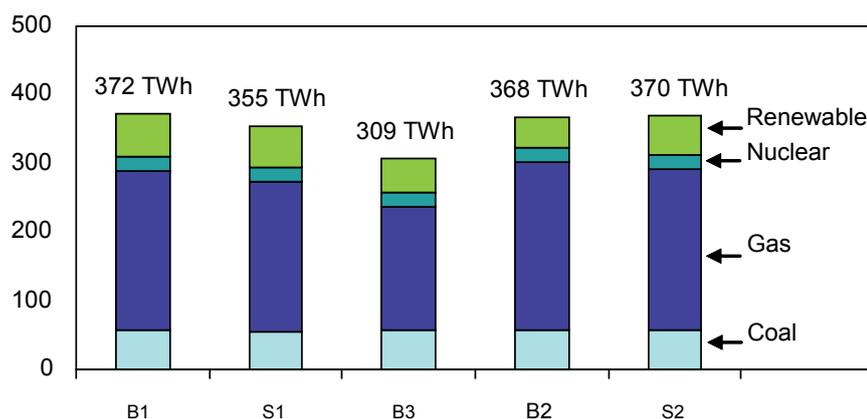


Chart 12:
Electricity Generation Mix in 2020

Note(s) : Total generation from main fuel sources is reported above each column.

Source(s) : BERR, Cambridge Econometrics.

Two other factors contribute to the reduction in emissions in S1 over the baseline:

- the EU ETS allowance price is higher in S1 to simulate the likely effects of the inclusion of aviation in the scheme. This makes it more costly for power generators to produce electricity by burning fossil fuels. By 2020 burning coal is 8.6 per cent more costly for power generators in S1 than in B1 while for gas the cost increase is 2.9 per cent.
- the way in which power generators typically meet demand, by bringing the stations with the cheapest running costs online first; conversely, they will tend to take the most expensive sources offline first in response to decreases in demand. These tend to be the fossil-fuel powered stations.

Effect on CO₂ emissions

Chart 13 shows that CO₂ emissions in the B1 baseline fall by 0.3 per cent per annum over 2010-20 to 497.1 MtCO₂, largely because of the rising fossil fuel prices. The emissions reductions in this run are driven by the non-EU ETS sectors, specifically Commerce, Households and non-traded industry. Emissions from Road Transport increase in B1 over the projection period.

The non-EU ETS sectors continue to drive the emissions reductions in S1, with a substantial reduction in emissions coming from Road Transport as a result of the purchase and fuel taxes. Total emissions over 2010-20 fall by 1.2 per cent per annum in S1 to 451.7 MtCO₂.

MtCO₂

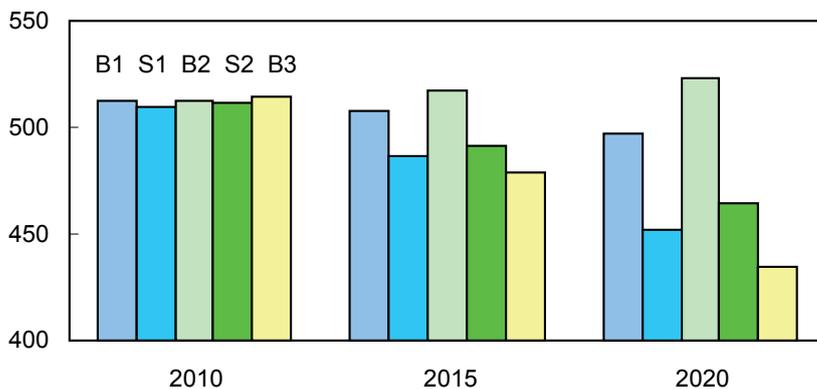


Chart 13: Total UK CO₂ Emissions (IPCC)

Note(s) : CO₂ emissions have been reported on an IPCC basis.
Source(s) : NAEI and Cambridge Econometrics.

UK territorial (IPCC) emissions in B2 rise by 0.2 per cent per annum over 2010-20 because fossil fuel prices are much lower. A substantial reduction in emissions is seen with GFR once again driven by a marked reduction in emissions from Road Transport.

In B1 in 2020, CO₂ emissions as measured on a Kyoto-basis stand at 501.1 MtCO₂, a 15.0 per cent reduction on the 1990 level. Emissions of GHGs on the same basis stand at 606.4 MtCO₂e, a 21.5 per cent reduction on the 1990 level. In the baseline, without additional measures, the 34 per cent target for GHG emissions reductions by 2020 (and the implied target of a 29 per cent reduction in CO₂ emissions) is not achieved.

By contrast, the GHG and CO₂ emissions-reduction targets are met in S1 as a result of GFR. With both calculated on a Kyoto basis, CO₂ emissions fall to 403.1 MtCO₂ in S1, a reduction of 31.6 per cent and GHG emissions fall to 506.9 MtCO₂e, a reduction of 34.4 per cent (see Chart 14). Of the 99.5 MtCO₂e reduction in GHG emissions (on the Kyoto basis) in S1 on B1, 46.9 MtCO₂e (47 per cent) comes from reductions in emissions from the non-traded sector, of which the majority is accounted for by reductions in CO₂ (45.4 MtCO₂). The remaining 52.6 MtCO₂e reduction (all of it carbon) is effected through the purchase of additional emissions allowances through the EU ETS. The purchase of these additional allowances contrasts with B1, in which only a small number of allowances (4 MtCO₂) are sold, in aggregate.

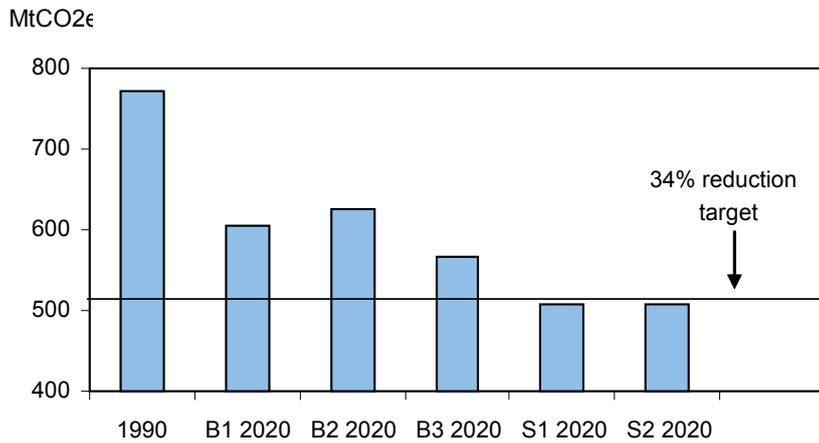


Chart 14: GHG Emissions (Kyoto) in 2020

Source(s) : NAEI, Cambridge Econometric

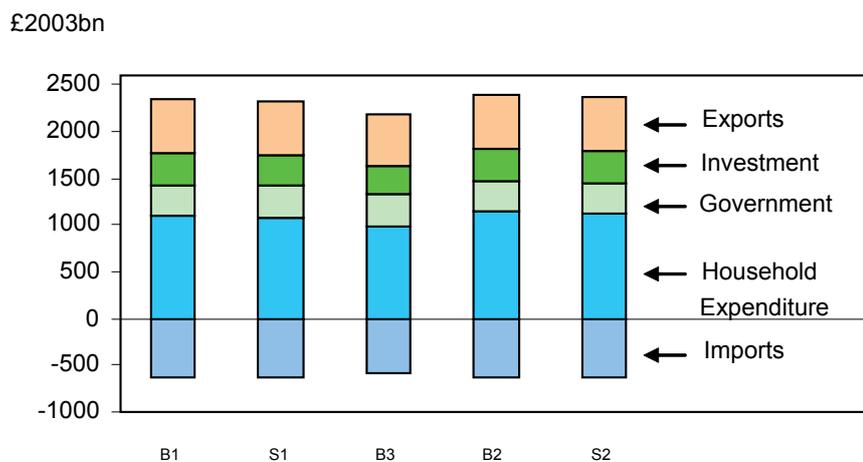


Chart 15: GDP by Component in 2020

Source(s) : ONS, Cambridge Econometrics.

GFR has a similar effect in a world of low fossil fuel prices. Again calculated on a Kyoto basis, CO₂ emissions in B2 in 2020 total 518.3 MtCO₂ (a 12.3 per cent reduction from 1990) compared to 404.9 MtCO₂ (a reduction of 31.3 per cent) in S2. The GHG emissions-reduction target is also met in S2 with a fall of 34.1 per cent (GHG emissions total 508.9 MtCO₂e in 2020) compared to a 19.1 per cent reduction in B2 (emissions of 624.4 MtCO₂e).

The Economic Effects of GFR

GDP in 2020 is 0.6 per cent lower in S1 and 0.7 per cent lower in S2 compared to their respective baselines (see Chart 15). This can, at least in part, be attributed to a reduction in the UK's price competitiveness as it is assumed that no additional policy effort is made internationally. The competitiveness effect is mitigated somewhat by the recycling of tax revenues back to firms through lower social security contributions, lowering their labour costs.

Thus the GDP impact of the GFR (compared to the baselines) is negative, but small. The reduction in GDP is larger in S2 (because the tax shift is larger) but average growth over 2010-20 in this scenario compared to its baseline (B2) is little more than 0.07 percentage points less each year (i.e. the annual economic growth rate falls from around 2.6 per cent to 2.53 per cent). This is well within the margin of measurement error associated with official statisticians' estimates of historical economic growth, so that the effect of GFR on GDP growth would be imperceptible.

The impact on GDP of high world market energy prices, as illustrated in B3, is substantial; 6.3 per cent lower in 2020 when compared to B1. High world market fossil fuel prices raise the cost of primary energy to UK power generators and, in turn, the energy prices faced by industry and consumers. Unlike GFR, the economic rent from higher energy prices to industry is not captured by the UK government and available for recycling. Instead, it is international oil and gas producers that benefit.

Unsurprisingly, the reductions in income taxes and employers' National Insurance contributions lead to a reduction in labour costs and thus an increase in UK employment, of 1.3 to 1.7 per cent in 2020 depending on the fossil fuel prices assumed (and the consequent GFR modelled). The effect is greater in the case of low fossil fuel prices because the size of the tax shift is greater and thus a much larger sum of money is available for recycling into reduced employers' National Insurance contributions.

Chart 16 shows that employment in all broad sectors rises as a result of GFR because employers' labour costs are reduced from lower National Insurance contributions. By 2020 GFR has created 455,000 new jobs when S1 is compared to B1 with the majority in financial, other business and public services because they are typically more labour intensive than the manufacturing sectors. Employment in services suffers most in B3 compared to B1.

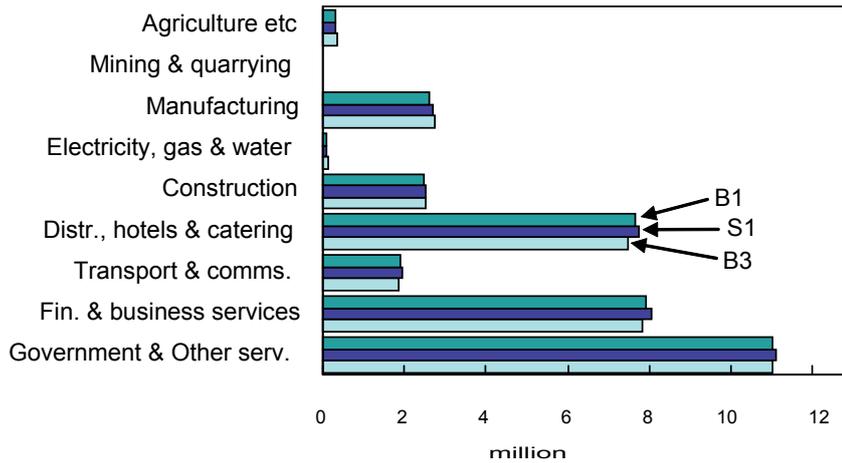


Chart 16: Employment by Sector in 2020

Source(s) : ONS, Cambridge Econometrics.

Results of the Eco-Innovation Scenarios

Renewable Electricity

Here the effects of GFR and eco-innovation investment in scenarios E1 and E2 are compared to the results from the two standard GFR scenario projections S1 and S2. The qualitative results are broadly the same between E1 when compared to S1 and E2 when compared to S2. The size of the change is typically larger in E2 owing to a greater tax shift in the S2 scenario and consequently a larger amount of funds is made available for investment in eco-innovation. In 2020, £7.1 billion (in 2003 prices) is invested in eco-innovation measures in E2 (10 per cent of the tax revenue in that year) compared to £5.5 billion (in 2003 prices) in E1.

As already noted, the eco-innovation spending was split by subsidising three measures: renewable power generation (offshore wind), cavity wall and loft insulation, and hybrid cars. In the case of cavity wall insulation and

loft insulation, retrofitting is completed before the end of the projection period (around 2019); all possible lofts and cavity walls in the UK have been fully insulated. The 'spare' funding has then been used to subsidise additional offshore wind capacity and hybrids. There is therefore considerable investment in offshore wind and hybrid vehicles towards the end of the modelling period. In the E2 scenario this occurs even earlier and so there is even more funding made available.

In scenario E1 21.6 GW of offshore wind capacity is built by 2020 compared to just 3.6 GW in S1. As the eco-innovation spending is greater in E2 a total 29.3 GW of offshore wind capacity is built by 2020 compared to just 0.3 GW in S2. Furthermore, as electricity demand is reduced as a result of the green fiscal reform, the Renewables Obligation target (as of 2008) for 20 per cent of electricity sales to be met by renewable generation, in 2020, is exceeded in both E2 (28.5 per cent) and E1 (25.5 per cent) compared to S2 (14.1 per cent) and S1 (16.1 per cent). Chart 17 shows the share of electricity generated by each major fuel source, illustrating the impact of the eco-innovation investment on boosting



renewable energy in the power sector. However, the UK's target of 15 per cent of final energy demand coming from renewables is still not met in the E1 (6.8 per cent) and E2 (7.2 per cent) scenarios but does increase from 4.7 and 4.4 per cent in S1 and S2 respectively.

The result of the eco-innovation spending on offshore wind is to reduce power generation emissions by 11.1 MtCO₂ in E1 compared to S1 and by 32.6 MtCO₂ in E2 compared to S2, a reduction of 20 per cent. This sizeable difference occurs for two reasons, first the funding available is larger in E2 and second because the domestic retrofitting is completed at an earlier stage, more funding is made available to offshore wind earlier.

Hybrid Vehicles

In E1, funds made available to subsidise the additional production cost of hybrid vehicles over cars with conventional internal combustion engines are sufficient to increase the share of hybrid vehicles in

the UK vehicle stock to 25.5 per cent. The number of vehicles on the road in E1 in 2020 is much the same as in S1 and most of the substitution is away from petrol-driven cars (as opposed to diesel-engined ones). The impact on carbon emissions from spending on hybrids is modest for a number of reasons:

- in both the S1 and S2 scenarios the fuel efficiency of new petrol and diesel cars increases by approximately 20 per cent, by 2020, and so the impact of switching to hybrids is diminished,
- hybrid vehicles still require petrol, although substantially less,
- emissions from cars do not account for all of the emissions arising from road transport in S1 in 2020.

Direct emissions from road transport, fall from 93.9 MtCO₂ in 2020 in S1 compared to 89.5 mtCO₂ in E1, a reduction of 4.7 per cent. In E2 the 2020 emissions reduction is 4.4 mtCO₂ when compared to S2, with road transport emissions in E2 projected to be 88.4 mtCO₂ in 2020.

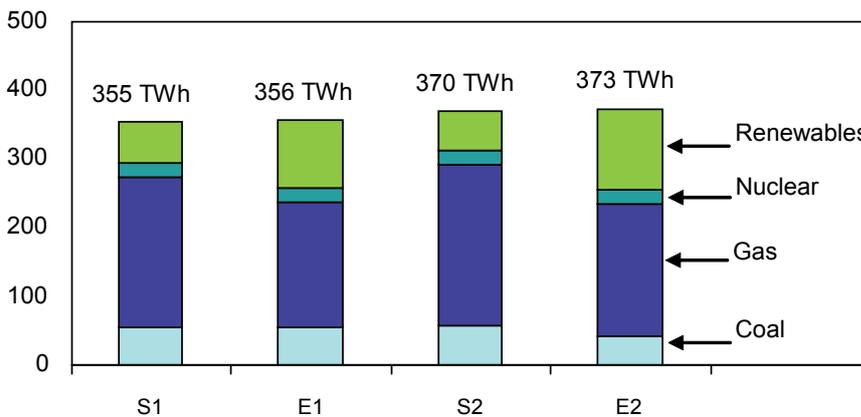


Chart 17: Electricity Generation Mix in 2020 in Eco-innovation Scenarios

Note(s) : Total generation from main fuel sources is reported above each column.

Source(s) : DECC, Cambridge Econometrics

Insulating Housing

In E1, the entire housing stock can be retro-fitted with loft insulation (7.4m houses were estimated from the English Housing Condition Survey to be without it) and cavity wall insulation (10.7m) by 2020. There was in fact revenue left over following the retro-fitting programme which was split evenly between the other measures as discussed. In the E1 scenario the reduction in gas demand from the eco-innovation measures when they are applied on top of the GFR (i.e. when E1 is compared against S1) is around 10 per

cent. Total emissions from households in E1 in 2020 are 8.7 per cent (5.5 mtCO₂) lower when compared to S1.

The economic impacts of E1 and E2 are small. When comparing the eco-innovation scenarios against S1 and S2 there is very little impact on employment and GDP, even by sector.

Conclusions

Table 3 brings together the major results for CO₂ emissions for all the scenarios in 2020, with the 1990 emissions given for comparison. It shows both CO₂ and GHG emissions, calculated on both the territorial (IPCC) and Kyoto bases (which were the same in 1990, as there was no emissions trading then).

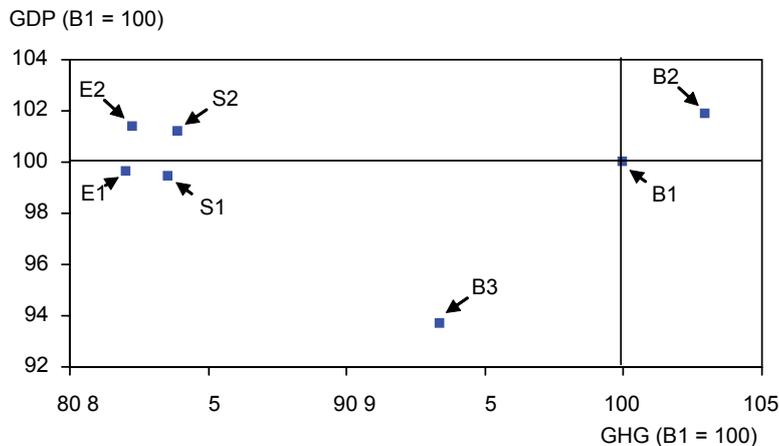
It is clear that the S and E scenarios all meet the 2020 CO₂ reduction target of a 29 per cent, and a 34 per cent cut in GHGs, by 2020 on a Kyoto basis (which is the basis on which the targets are calculated), when all the baselines do not.

The other striking thing about the table is the extent of the extra emission cuts achieved in the E scenarios. Spending only 10 per cent of the extra tax revenues on green investments results in a further reduction in CO₂ emissions from 1990's level of 3.5 per cent from S1 to E1, and 7.3 per cent from S2 to E2 (both on an IPCC basis), compared with a 7.7 per cent reduction for S1 (from B1) and a 17.3 per cent reduction in S2 (from B2). In this way, the environmental spending greatly enhances the environmental impact of the GFR.

Table 3: Results for CO₂ Emissions for All the Scenarios

	2020							
	CO2				GHG			
	IPCC		Kyoto		IPCC		Kyoto	
	Levels mtCO ₂	Below 1990, per cent	Levels mtCO ₂	Below 1990, per cent	Levels mtCO ₂	Below 1990, per cent	Levels mtCO ₂	Below 1990, per cent
1990	589.4	0	589.4	0	772.2	0	772.2	0
B1	497.1	-15.7	501.1	-15.0	602.4	-22.0	606.4	-21.5
B2	523.4	-11.2	518.3	-12.1	629.5	-18.5	624.4	-19.1
B3	435.0	-26.2	463.0	-21.4	538.2	-30.3	566.2	-26.7
S1	451.7	-23.4	403.1	-31.6	555.4	-28.1	506.9	-34.4
S2	464.4	-21.2	404.9	-31.3	568.4	-26.4	508.9	-34.1
E1	430.8	-26.9	393.9	-33.2	534.3	-30.8	497.4	-35.6
E2	421.6	-28.5	395.4	-32.9	525.2	-32.0	499.0	-35.4

Chart 18 shows a comparison of indexed GDP and GHG emissions, calculated on a Kyoto basis, for all of the seven scenarios.



**Chart 18:
Comparison of
GDP and GHG
Emissions in
2020 across All
Scenarios**

Note(s) : GHG figures have been calculated on a net carbon account basis in MtCO₂e.

Source(s) : ONS, NAEI, Cambridge Econometrics.



The key points from this modelling analysis are:

- High world market fossil fuel prices reduce GHG emissions, but at high cost to the economy. The main reason for this is that they cause financial resources to flow from an energy-importing country (like the UK) to energy exporting countries. Countries would therefore do well to reduce their vulnerability to high world market fossil fuel prices by becoming more energy efficient. One way of doing that is through GFR.
- GFR also reduces GHG emissions, but at effectively no cost to the economy and with increased employment. Because the extra taxes in the GFR implemented here are largely focused on the non-EU ETS sectors, the GHG emission reductions come from these sectors, which can be difficult to achieve with other instruments.
- Using some of the tax revenues from a GFR to invest in eco-innovation can further reduce GHG emissions without adverse consequences for the economy. It may also develop new economic sectors with export potential (as, for example, Denmark and Germany have found with investments in wind energy), but that is outside the scope of this modelling.

Because energy use tends to increase with income, and because of the rebound effect, the promotion of energy efficiency by itself (i.e. without increasing energy prices at the same time) is most unlikely to reduce GHG emissions to the extent now required by the UK Government. This leaves GFR as the preferred policy instrument to meet the UK's GHG emission reduction targets. Other policy instruments may be used to reinforce GFR, or increase the response to the shift in relative prices which it brings about. But seeking to rely wholly on other instruments, without the pervasive price-based influence of GFR, will make the policy outcome both more uncertain and more costly.

These results from a single modelling exercise from a single class of models are clearly not definitive. Different models have different strengths and limitations, and further work from different perspectives would be desirable to get more insights into the likely results of a GFR on this scale. But the model used was designed precisely to look at such issues as GFR and has a good track record in such analysis. Moreover, the results are theoretically plausible and internally consistent. In the absence of evidence to the contrary, they suggest that GFR is a very attractive policy indeed.



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