

(Mis)understanding Climate Policy

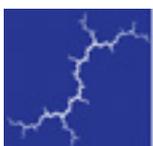
The role of economic modelling

Prepared for Friends of the Earth (England, Wales & Northern Ireland) and WWF-UK

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April 2014



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Energy Economics, Inc.

Contents

Executive Summary	1
Recommendations	3
Inside the HMRC CGE Model	5
Crowding Out or Pulling In?	8
Pricing Pollution	11
Cooperation and Leadership in a Divided World	16
Appendix: Data Sources and Calculations	19

This report was commissioned by Friends of the Earth (England, Wales & Northern Ireland) and WWF-UK.

Thanks to:

Cambridge Econometrics, Julian Morgan (Green Alliance) and Dimitri Zenghelis (LSE) for giving their time to peer review this report.

Additional thanks to:

Simon Bullock, Leo Hickman, Nick Molho, Guy Shrubsole and Emma Scott.

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Executive Summary

Economic models often speak with an authoritative-sounding voice in policy debates, providing precise quantitative estimates of the impacts of our collective choices. It is important, therefore, to be clear about what is included, and what is omitted, in such a model and its projections.

The HM Revenue and Customs (HMRC) CGE model, a “computable general equilibrium” (CGE) model, was developed for HMRC to use in analysing changes in tax policies. Recently it has been applied to climate policy, specifically producing a widely quoted headline number for the economic impacts of the fourth carbon budget.

Climate policy raises some of the most important and complex issues in public life today. It involves ethical choices, international cooperation, development and deployment of new technologies, interaction with other environmental problems – and economic calculations and tradeoffs concerning costs. A model such as HMRC CGE cannot address this full range of vital concerns.

Climate policy raises some of the most important and complex issues in public life today.

A look inside the HMRC CGE model shows that it rests on numerous simplifying assumptions. Some of these assumptions deviate far from the facts of real-world economic life. Any model simplifies reality, but the simplifications and omissions in HMRC CGE have a clear effect on the results and strongly undermine its ability to guide policy: some of the major assumptions predispose the model to reporting that any environmental or social initiative is unrealistically expensive.

- The model is not designed to calculate employment benefits of public policies. Instead, it assumes that everyone already has a job, implying there are no possible employment benefits for any policy.
- The model is not designed to evaluate non-market health and environmental benefits. In effect, it quantifies only the policy costs, a one-sided measure that cannot determine whether a policy is worthwhile. It thereby assumes that health and environmental benefits do not have any economic value, and that GDP is the sole measure of wellbeing.
- The model is not designed to understand interactions with the rest of the world. It assumes that international transactions are static, with no changes, imbalances, or negotiations ever involved. By focusing on a single national economy in isolation, HMRC CGE misses the all-important international dimension of the climate problem.

In each of these areas, better approaches are available – and lead to different answers.

- As long as there is significant unemployment, the job creation benefits of public policies can and should be calculated. Models that take this approach frequently find substantial employment benefits for active climate and environmental policies.
- The health effects of fossil fuel combustion are too large to ignore. Values for these health effects, published in other studies, would imply that the benefits of emission reduction often outweigh the costs – echoing results found by leading American economists analysing U.S. data.
- Climate policy is the ultimate international issue, and cannot be sensibly considered without its global context. On the one hand, solutions to this completely global problem will require international cooperation. On the other hand, early innovation and deployment of new technologies will create a first-mover advantage for countries that take the lead.

Even a revised and improved economic model would be only one of many inputs into climate policy decisions. The obligation to address climate change transcends simple calculation – and the opportunity to build a sustainable, clean energy economy requires new and innovative approaches to modeling and analysis.

Recommendations

Careful modeling of costs can be one useful input into a policy process, but the limitations of the HMRC model currently reduces its relevance and reliability. Therefore we recommend that:

- 1. The UK government should not use the output of HMRC's CGE model in its current form as the primary evidence base for decision making on climate policy.**
- 2. The government should be transparent about its climate policy modelling.**
 - Complete analyses and model outputs, rather than just headline numerical results, should be released for public review and discussion. HMRC should release a public, interactive version of its model online.
 - Any changes to the model made for environmental analyses should be described in public documents (we have found references to such changes, but no documentation of them).
- 3. Past HMRC CGE analyses should be compared to actual economic outcomes, to allow validation of model relationships.**
- 4. The model should be changed to include more realistic assumptions on employment.**
 - HMRC CGE should be run without the assumption of automatic full employment, to allow estimation of employment impacts.
 - HMRC CGE results should be compared to those from other models that calculate employment resulting from climate policies.
- 5. Externality (pollutant) prices should be included in HMRC CGE analyses.**
 - One or more sets of published prices for pollutant impacts, and values for non-traded sector carbon emissions, should be incorporated, in order to compare estimated GDP changes to these partial estimates of environmental impacts.
- 6. The model should be extended to include a representation of economic relations between the UK and the rest of the world.**



Inside the HMRC CGE Model

The HMRC CGE model has played an important role in recent debate on UK climate policy. In particular results from the model are thought to have been influential in decision making in the review, currently underway, of the fourth carbon budget.

It is important, therefore, to understand what is included, and what is omitted, in the model framework. Relatively little information on the HMRC CGE model in general is available in the public domain; its schematics are not made public for people to explore themselves; and virtually nothing has been released on specifically what assumptions are made about climate policy in particular. No tests or calibration of the model against real economic data have been reported; instead, the model has been justified by comparison to other economic models and theories.

The principal benefits of many climate and environmental policies cannot be incorporated in a HMRC CGE analysis.

A technical description of the model, however, has been released.¹ CGE is an abbreviation for “computable general equilibrium,” a type of model often used by economists. CGE models are designed to capture the interactions between different markets and sectors, enabling analysis of how a policy change in one area ripples through the rest of the economy. In order to focus on these interactions, CGE models make a series of simplifying assumptions, some of them deviating far from the facts of real-world economic life. HMRC are not alone in this regard: many of the features and limitations of the HMRC model are typical of the broad category of CGE models.

The assumptions that shape the HMRC CGE model include the following:

- Full employment is assumed to occur automatically, with or without new government policies. This implies that no policy can ever cause a measurable increase or decrease in employment. In other words, for every worker hired by a new policy initiative, some existing employer must lose an employee, since all potential workers already have jobs. Section 2 discusses the implications of this frequently unrealistic assumption.
- The model estimates impacts on GDP (gross domestic product, the monetary value of all goods and services produced in the country) and on market incomes. Other important outcomes such as health and environmental impacts are ignored, unless they result in economic costs or benefits with price tags attached.² For lack of meaningful prices, basic values such as protection of human life, health, biodiversity, and the existence of unique habitats and landscapes are omitted. As a result, the principal benefits of many climate and environmental policies cannot be incorporated in a HMRC CGE analysis. A partial adjustment for this limitation is presented in Section 3.

¹ HMRC, “HMRC’s CGE model documentation,” December 2013.

² Although some sources suggest that an environmental module has been added to the model, no documentation for this module seems to be available.

- The rest of the world is invisible. There is no foreign investment, either inward or outward. Foreign trade is always in balance, with exports equal to imports in value. Technology transfers, innovations spreading from one country to another, and international environmental impacts – such as climate change – are ruled out by design. Section 4 addresses this problem, as it affects climate policy.
- Other sources of real-world economic complexity have been removed from the model by assumption, including
 - There is no monetary system or financial institutions
 - In the absence of new policies, economic growth is assumed to occur at a fixed, constant rate
 - All households are perfectly rational, continually updating their complex, multi-stage calculations about lifetime consumption and investment plans
 - The future is certain and predictable; financial, environmental, and other risks can be ignored

HMRC’s own modelers offer a candid picture of the model’s limitations (from which this account is derived). It is not a forecast of year-to-year changes in the economy. Rather, it produces two pictures of the economy, one with and the other without a proposed new policy. Comparison of the two images allows an assessment of policy impacts.³

HMRC originally developed the CGE model to estimate the impact of tax changes. Under its many simplifying assumptions, it can estimate the effects of a new tax policy on GDP, and on the incomes received by subgroups of the population. It is worth noting that the model is estimating the impact of taxes in an economy just like the UK except for the absence of unemployment, foreign investment, foreign trade fluctuations, environmental externalities, and financial markets, and the presence of superhuman calculators in every household.

Any model must make simplifying assumptions; the question is whether the assumptions would be expected to distort the results. This report does not address the appropriateness of the model when used for its original purpose of tax modeling. When HMRC CGE is used to model the costs of climate policy, however, the particular assumptions that shape the model lead to a number of fundamental problems. In the next three sections, we examine three key sources of bias and incompleteness in HMRC CGE climate analyses.

³ “HMRC’s CGE Model Documentation,” p.4.



Crowding Out or Pulling In?

Among the many simplifying assumptions in the HMRC CGE model, one stands out as a pervasive source of bias: the idea that all unemployment is voluntary, so that everyone who wants a job can get one. This assumption of full employment applies both before and after a policy change, implying that it is impossible for a policy to increase or decrease total employment. HMRC are not alone in this assumption; most (but not all) of the broad category of CGE models make the same assumption, in order to simplify calculations and to ensure consistency with other economic models and theories. Yet “other economists do the same thing” is not a good excuse for an assumption that could distort the results of the analysis.

In this modeled world, any change can only make things worse. Starting from the top of the mountain, there is nowhere to go but down.

The impacts of any new policy look lopsided through a CGE lens, where it appears that everyone who wants work has already found it. Starting from this vantage point of full employment, any proposed new initiative – whether a highway, hospital or environmental program – is inevitably competing with existing employers. New programs can succeed only by “crowding out” existing, profitable enterprises, competing with them for workers and for investment capital. Since competitive markets, in this modeled world, are already employing everyone who wants to work, in enterprises that produce exactly what consumers want to buy, any change can only make things worse. Starting from the top of the mountain, there is nowhere to go but down.

The HMRC CGE analysis of the costs of climate policy suffers from exactly this defect. It estimates the costs that would be incurred if carbon constraints were forced onto a full-employment version of the UK economy, crowding out enough existing activity to obtain the needed labour and other resources. Any economic benefits of putting people to work in emission-reducing activities would have to be balanced against the (usually greater) costs of removing them from their former employment. The result is not at all specific to climate policy: in the modeled economy of full-employment UK, any new initiative crowds out existing, profitable activity, leading to net economic costs.

In the real world, it is unfortunately clear that full employment is not a guaranteed, permanent state of affairs. When starting from any point below the “top of the mountain” (i.e., less than full employment), job creation is a crucial benefit of new policies. Under such conditions, climate policy competes, at least in part, with the dole rather than with existing businesses; it is pulling workers into the labour force, rather than crowding profitable businesses out.⁴ The economic benefits of newly created jobs include not only the personal gain for those who are hired, but also a reduction in government costs for unemployment payments and other services, and an increase in taxes

⁴ Some energy-sector jobs will be intentionally replaced with new “green jobs,” e.g. if coal plants are replaced by wind turbines. The new measures required for climate policy will create more jobs than they replace; hence the question is whether the net increase in employment is achieved by crowding out other businesses, or by reducing or preventing unemployment.

paid by the newly employed workers. As those workers spend their wages, additional new jobs are created in other sectors. This was the basic insight of John Maynard Keynes, writing about economics in the context of the 1930s depression. Amid the lingering effects of the worst economic slump since the 1930s, that insight cannot be ignored.

It is possible that unemployment will be of limited importance by 2023-2027, the years of the fourth carbon budget. If the economy has fully recovered, and no new recession has occurred, then perhaps the full employment assumption of HMRC CGE will be appropriate for those years. It is also possible, however, that a decade of stagnation will leave the economy still weak by that time – or that a vigorous near-term recovery will be followed by another slump, recreating the problem of unemployment in the mid-2020s. In the face of this macroeconomic uncertainty, relying on a model that assumes unvarying full employment amounts to ignoring one of the most important real-world problems of economic policy.

What would the costs of climate policy look like, in a framework that recognized the reality of significant unemployment? One well-known model that adopts this approach is E3MG (soon to be replaced by E3ME Global), developed by Terry Barker and colleagues at the Cambridge Centre for Climate Change Mitigation Research (4CMR) and Cambridge Econometrics. Analyses with E3MG have found that more stringent climate targets – including goals far more ambitious than the fourth carbon budget – may stimulate growth and increase GDP, by providing more employment and accelerating the development and adoption of new technologies. While models relying on CGE-style full employment assumptions do not find this result, there are at least 14 models, cited in the fourth (2007) report from the Intergovernmental Panel on Climate Change (IPCC), that find net economic benefits from mitigation scenarios compared to baseline assumptions.⁵ The fact that HMRC CGE does not report such benefits is an input assumption, not a result.

As noted earlier, any model makes simplifying assumptions; the question is whether those assumptions distort the results. HMRC CGE is not necessarily wrong to simplify some aspects of reality in attempting to create a useful analytical tool. It turns out, however, that one of the unrealistic simplifications – the assumption of full employment both with and without a new policy initiative – is one likely cause of the HMRC CGE finding of substantial net costs to climate policy. In an alternative modeling framework that allows the realistic possibility of involuntary unemployment, the effort to meet stringent climate targets can stimulate employment, technological progress, and growth, improving economic performance over a baseline with no new climate policy.

⁵ See Terry Barker and S. Serban Scricieiu, "Modeling Low Climate Stabilization with E3MG: Towards a 'New Economics' Approach to Simulating Energy-Environment-Economy System Dynamics," *Energy Journal* 31(2010) special issue, 137-164. On the 14 models cited by IPCC, see note 14, p.153. See also Terry Barker, S. Serban Scricieiu and Tim Foxon, "Achieving the G8 50% Target: Modelling Induced and Accelerated Technological Change Using the Macro-econometric model E3MG," *Climate Policy* 8(2008), S30-S45.



Pricing Pollution

The HMRC CGE model, by design, focuses on projections of GDP and incomes, and says little or nothing about non-market impacts. The model was designed to analyse changes in tax policies, an area where the important consequences may consist primarily of changes in monetary incomes and expenditures. In contrast, changes in climate and environmental policies, like infrastructure projects and other public goods, have impacts that cannot be fully measured in a market framework.

Analysis of social and environmental policy, and of infrastructure spending, in a model such as HMRC CGE can capture the policy costs but not the resulting benefits. If we know how much a policy costs, how do we decide whether its non-market benefits are worth the price? The cost of building and maintaining roads could be estimated, and might turn out to be a large number. This would not prove that highways are an unaffordable expense, because so many households and businesses own and use motor vehicles. Flood protection is expensive, but the expense may seem worthwhile to those who have recently been flooded. Hospitals are expensive, but almost everyone will need them at some point in life. HMRC CGE analyses estimating the costs of highways, flood protection, or hospitals would be incomplete, providing only one side of the balance. The same is true for climate and environmental policies.

Announcement of the projected costs alone creates a misleading impression of pure costs with no benefits, logically comparable to highways that are never traveled or hospitals that never help a patient. An environmental policy that never improved the environment would indeed be pointless and expensive. But that does not describe any actual proposals, for the fourth carbon budget or others that we are aware of. To restore a sense of balance to the analysis, some method of accounting for environmental benefits is needed.

Announcement of the projected costs alone creates a misleading impression of pure costs with no benefits

To address this problem, attempts have been made to create surrogate prices for pollutants, based on the health and environmental damages that they cause. These surrogate prices are subject to considerable uncertainty; as we will see in a moment, there is more than one set of such prices. They provide only a partial, necessarily incomplete measure of the value of protecting life and nature. Inclusion of these prices does not transform GDP into a correct, all-purpose measure of human and ecological welfare. Nonetheless, inclusion of these prices, representing a partial attempt to monetize environmental impacts, has a dramatic effect on the economics of climate and energy policies. In particular, inclusion of these prices can reverse the results of the HMRC CGE analysis of climate policies.

Many attempts have been made to assign values to the leading air pollutants emitted by power plants and motor vehicles. In the U.S. context, three prominent economists, writing in a leading journal, have estimated that coal-burning power plants have negative value added – that is, the value of their

health damages exceeds the monetary value they add to the economy – when conventional American values for health effects are applied. Most of the health damage from coal combustion consists of deaths caused by sulphur emissions.⁶ The study found that coal-burning power plants had negative value added even without any price on carbon emissions; gas-burning power plants had negative value added with a carbon price of less than £5 per tonne of CO₂.⁷

“

Solid waste combustion, sewage treatment, stone quarrying, marinas, and oil and coal-fired power plants have air pollution damages larger than their value added. The largest industrial contributor to external costs is coal-fired electric generation, whose damages range from 0.8 to 5.6 times value added.

”

Nicholas Z. Muller, Robert Mendelsohn, and William Nordhaus, “Environmental Accounting for Pollution in the United States Economy,” *American Economic Review*, 2011. (The range of estimates for coal plants reflects sensitivity analyses on damage estimates.)

Monetary valuations of the health damages of key air pollutants for the UK are available in a study performed for DEFRA,⁸ and in a European Environment Agency (EEA) report that calculates country-specific values for all EU nations for 2010 and 2020.⁹ The estimated emissions associated with alternative scenarios are presented in DECC’s “Impact Assessment” for the fourth carbon budget.¹⁰

A widely reported calculation from the HMRC CGE analysis shows that achieving a target of 50 percent reduction below 1990 carbon emission levels by 2027 would decrease GDP by £0.7 billion more than the less demanding alternative of a 46 percent reduction. That estimate is subject to the criticisms discussed in the previous section; but in this section we will put aside those criticisms and work with the £0.7 billion estimate. It should be recognized that this is a small fraction of GDP, arguably within the margin of error for a forecast more than a decade in the future.¹¹

The more stringent target reduces other power plant and motor vehicle emissions as well as carbon emissions. This raises the possibility that the increased value of avoided health damages could outweigh the projected impact on GDP of the 50 percent reduction budget, paralleling the results of the American study.

⁶ Nicholas Z. Muller, Robert Mendelsohn, and William Nordhaus, “Environmental Accounting for Pollution in the United States Economy,” *American Economic Review* 101 (2011), 1649-1675.

⁷ *Ibid.*, Table 5, shows the ratio of “gross external damages,” with and without a carbon price, to value added. The study used a carbon price of US\$27/tonne C, which is equivalent to US\$7.40/tonne CO₂, or £4.40/tonne CO₂ at recent exchange rates.

⁸ AEA Energy & Environment, “Optimising Delivery of Carbon Reduction Targets: Integrating Air Quality Benefits Using the UK MARKAL Model,” report to DEFRA, November 2008.

⁹ “Revealing the Costs of Air Pollution from Industrial Facilities in Europe,” EEA Technical Report 15, 2011.

¹⁰ DECC, “Impact Assessment of Fourth Carbon Budget Level,” 16 May 2011.

¹¹ The fourth carbon budget has been described as costing 0.2 percent more of GDP than the first three carbon budgets (Sam Thomas, “UK Government analysis of energy efficiency policies: cost benefits analysis, headline metrics and macroeconomic impacts,” 25 January 2013). Economic forecasts are not generally accurate to within 0.2 percent in predicting GDP more than 10 years in the future.

In addition, as government analyses have acknowledged but not emphasized, even a very modest estimate of the economic value of a reduction in carbon emissions – as a proxy for climate damages potentially avoided, as part of global effort – could convert the net ‘cost’ to a net benefit.¹²

In order to estimate a range of possible values for health damages, we calculated the difference between the 46 percent and 50 percent reduction scenarios in three categories of air emissions: nitrogen (NO_x), sulphur (SO₂), and particulates (PM-10).¹³ These emissions could be priced at the DEFRA study values, or at the EEA low or high values for 2020. Table 1 shows, under the assumptions used in those studies, the monetary equivalent of the reduction in emissions. As seen in Table 1, the reduction in these three categories of emissions is worth more than half of the estimated £700 million cost of the more stringent carbon target using the DEFRA values, or more than twice the cost at EEA low values. At EEA high values, the reduction in these three pollutants is worth more than six times the cost estimated by HMRC CGE. As in the U.S. study described above, reductions in sulphur emissions are the most important component of these benefits. Details on the calculation are provided in the appendix.

Table 1

Values of selected emission reductions in fourth carbon budget: 50 percent vs. 46 percent carbon reduction targets

Valuation method	DEFRA (million £)	EEA - Low (million £)	EE - High (million £)
NO _x	75	370	1,027
SO ₂	227	1,186	3,309
PM-10	88	95	265
Total	390	1,651	4,601

These are differences between values of 2023-2027 emissions under the 50 percent reduction vs. 46 percent reduction scenarios for the fourth carbon budget, using three different valuations of emissions.

See appendix for details.

Other analyses have also estimated substantial values for the health impacts of air pollution. A recent analysis of the health damages caused by coalplants across Europe estimated annual damages in the UK at £1.1 – 3.1 billion (€1.3 – 3.7 billion).¹⁴

¹² “The total net present lifetime **cost** of the current policy package is estimated at £9 billion (excluding the value of GHG emissions savings in the non-traded sector). Including the value of GHG savings in the non-traded sector results in the package delivering a net **benefit**, on central estimates, of £45 billion.” - December 2011 Carbon Plan, Annex B, p.151 (emphasis added).

¹³ The choice of these pollutants, including the use of PM-10 rather than PM-2.5, was based on the availability of estimates in the DEFRA report.

¹⁴ HEAL (Health and Environment Alliance, “The unpaid health bill: How coal power plants make us sick,” 2013, Table 3, p.25, The HEAL report uses similar data sources to the EEA report cited above. Note that the HEAL damage estimates in the text are annual values for all coal plant emissions, while Table 1 presents 5-year totals for reduction in total emissions from all sources due to a change in fourth carbon budget scenarios. Hence the numbers are not directly comparable.

Zero does not seem like a good guess at the magnitude of the costs imposed by air pollution.

The calculations in Table 1 are far from complete valuations of environmental impacts of these scenarios. Among other omissions, they do not include any valuation of carbon emissions, except for the price of EU ETS allowances. That is, both scenarios in the HMRC CGE analysis include the cost of allowances required for traded sectors covered by the EU ETS (electricity generation and heavy industry), but do not include any valuation of carbon emissions from non-traded sectors (the rest of the economy).

The 50 percent target leads to a reduction in non-traded sector carbon emissions of 102 million tonnes of CO₂ compared to the 46 percent target.¹⁵ So valuing avoided CO₂ emissions in the non-traded sectors at only £7 per tonne would offset the £700 million monetary cost of the more stringent target, even without including any of the health benefits discussed above. Alternatively, the £700 million cost could be offset by the DEFRA valuations of sulphur, nitrogen, and particulates plus a non-traded CO₂ valuation of about £3 per tonne. Of course, £7 per tonne, let alone £3, is far below many projected carbon prices and valuations for the 2020s.

It is difficult to put a definitive financial valuation on avoided air pollution; as we have seen, there is more than one set of proposed valuations. This again emphasizes the importance of the assumptions used in the model. Zero, however, does not seem like a good guess at the magnitude of the costs imposed by air pollution. Yet zero is the value used by HMRC CGE for sulphur, nitrogen, particulates, and non-traded-sector CO₂ emissions. With the inclusion of published values for local air pollutants, and a low or even zero value for non-traded carbon emissions, the headline conclusion of the HMRC CGE analysis of climate policy would be reversed: more stringent climate policy would create health benefits worth more than the increased monetary costs of the policy.

¹⁵ Like other statistics presented here on the difference between these two targets, this is a total for the years 2023-2027.



Cooperation and Leadership in a Divided World

Another potential objection to the costs of climate policy looks beyond the details to the inherent limitations of unilateral action in a divided world. Why spend anything to reduce domestic emissions, if the rest of the world might not follow suit?

Part of the answer can be found in the two preceding sections. The jobs created by climate policy and the health and environmental benefits of reduced emissions are local benefits from local policies; they will make the UK a healthier, more pleasant and more prosperous country, regardless of actions taken elsewhere. Another part of the answer involves the global nature of the problem, the need for leadership, and the benefits of innovation.

In the face of a global externality, where we all are the cause of each other's problems, the only hope lies in forging international cooperation around a common solution.

Climate change is an entirely global externality: greenhouse gases from every country mix in the atmosphere and affect the climate in every country. China, the largest current emitter, accounts for less than 30 percent of global emissions today; the United States, the leader in cumulative emissions, accounts for less than 30 percent of total emissions since 1850. No other country accounts for as much as 10 percent of either current or cumulative emissions. Regardless of which measure is used (despite media attention to current emissions, climate change is actually driven by cumulative emissions), more than 70 percent of climate change for China and the U.S., and more than 90 percent in all other countries, is caused by “foreign” emissions.¹⁶ In short, everyone on the planet faces a problem that is overwhelmingly caused by other countries. The UK, with less than 2 percent of current and 6 percent of cumulative emissions, is in very good company in this respect.

In the face of a global externality, where we all are the cause of each other's problems, the only hope lies in forging international cooperation around a common solution. The route to that cooperation is complex and not yet entirely clear, as veterans of global climate conferences know all too well. It seems appropriate for higher-income countries to take the lead in climate initiatives, as the UK and Europe in general have often done.

Yet other countries are also taking action. China has emerged as a leading investor in clean energy, installing more than 23 GW of renewable capacity in 2012 alone (one-quarter of the world total for the year).¹⁷ Brazil and Mexico have adopted ambitious national climate legislation; Mexico's law calls for 50 percent reduction in carbon emissions, and 50 percent non-fossil fuel electricity generation, by 2050.¹⁸ The United States, despite a near-total

¹⁶ In addition, purchases of imports in the UK and other high-income countries are responsible for some of the emissions in exporting countries; adjusting for this would change the numbers but not the general point made here.

¹⁷ Pew Environmental Initiatives, “Who's Winning the Clean Energy Race? 2012 Edition”

absence of explicit national climate policies, has regulated other emissions from coal plants strictly enough to cause a shift away from coal and a significant overall reduction in carbon emissions.

China and other emerging economies, which account for a large and increasing share of emissions, will not continue to take action to protect the climate if higher-income countries start to hold back and complain about the costs. We are all in this together – and given the global nature of the problem, we are all nervously looking over each other’s shoulders to be sure that no one else is shirking their responsibilities.

Europe has long played a leading role in the pursuit of global climate solutions. And the UK, in particular, has played a crucial part in reshaping the economic understanding of climate change. The Stern Review offered a new way of thinking about catastrophic climate risks and intergenerational obligations, and posed a powerful, much-needed challenge to “analysis as usual” among American and other economists. A succession of government policies have creatively addressed the social cost of carbon, the shadow price of carbon, and the use of marginal abatement cost analysis to rationalize and advance climate mitigation. Americans advocating more vigorous climate policies and better climate economics, as the authors of this report can attest, have often pointed to the UK as an example of how to do it right.

Climate policy leadership is not only the right thing to do; it can be a source of innovation and comparative advantage in the world economy.

Climate policy leadership is not only the right thing to do; it can be a source of innovation and comparative advantage in the world economy. The transition to renewable energy and sustainable economies will require the development and deployment of many new technologies. The “first mover advantage,” which accrues to the countries that take the lead in these technologies, may shape the global economy of the 21st century. Denmark’s early leadership in wind turbine production is a recent example; there is room for many more technology leaders in the years ahead.

These international economic benefits of innovation and technological leadership are yet another category that is omitted by the HMRC CGE model. The single-country focus of the model, eliminating interactions with the rest of the world by design, makes it blind to the factors that can strengthen the position of the UK in the global economy.

¹⁸ Juan Carlos de Obeso, “Mexico’s Climate Change Law”



Appendix: Data Sources and Calculations

This appendix documents the data sources and explains the calculations used to construct Table 1 and related results in Section 3. Our calculations, drawing on a report for DEFRA,¹⁹ begin with the estimated difference in carbon emissions in the years 2023-2027 under the fourth carbon budget with its 50 percent reduction (the “33/80” scenario), versus the alternate 46 percent reduction (baseline) scenario. That difference is a total of 157 million tonnes of carbon dioxide.

We then calculated the difference between baseline and 33/80 scenario emissions of three other pollutants, NO_x, SO₂, and PM-10, as well as CO₂, in 2050. We assumed that the 2050 ratio of the reduction in each of the other pollutants to the reduction in CO₂ also applied to the 157 million tonnes of CO₂ in 2023-2027, i.e. the difference in carbon reduction between the two scenarios for the fourth carbon budget.²⁰ Under these assumptions, the difference in emissions of the three pollutants is shown in Table A1.

Table A1	Pollutant	Difference (thousand tonnes)
Selected emissions, 2023-2027: Difference under 50% vs. 46% reduction versions of fourth carbon budget	NO _x	59
	SO ₂	111
	PM-10	4
	CO ₂ , of which	157,000
	traded sectors	55,000
	non-traded sectors	102,000

Source: See text for explanation and sources

That is, Table A1 presents our best estimate of the reduction in the selected emissions that result from the increased stringency of the 50 percent scenario versus the 46 percent scenario.

The text (in Section 3) also refers to valuations of the CO₂ emissions coming from the non-traded sectors. Based on the December 2011 Carbon Plan, Annex B, we determined that the non-traded sectors are projected to account for 65 percent of carbon emissions in 2023-27.

The reductions in (non-carbon) pollutants shown in Table A1 will result in health benefits, such as reduced mortality and morbidity. We found three sets of valuations for these reductions in emissions.

¹⁹ See note 10. Where needed, we digitized graphs in this report using the Dagra software. For information on Dagra see: www.blueleafsoftware.com/Products/Dagra/

²⁰ For NO_x and SO₂, the ratios to CO₂ emissions were virtually identical for 2025 and 2050; for PM-10 the uneven timing assumed in the 33/80 scenario made it difficult to derive a useful 2025 ratio.

One set of values for the first three pollutants is derived from the same DEFRA report. It did not report numerical values, but provided graphs showing the total value of emission reduction. We measured the reported value of the reduction in each pollutant in 2050 and compared it to the volume of emission reduction. This yielded a price for each pollutant in 2050, which we adjusted back to 2025, based on the report’s apparent assumption that prices rise by 2 percent per year.²¹

Two other sets of values are provided in the EEA report cited in the text.²² EEA presents values by country for several pollutants, for both 2010 and 2020; we used the 2020 values since that year is closer to the fourth carbon budget period. We did not adjust these values for possible changes between 2020 and 2023-2027. Since the EEA values for pollutants rose significantly from 2010 through 2020, it is possible that their values for 2023-2027 would be even higher.

For each year, country, and pollutant, EEA presents a high and a low value, based on different methods of valuation of mortality that are advocated by environmental economists; there is no consensus about which is superior. EEA’s high values are based on assigning a value to lives lost to pollution (or equivalently, a value for deaths avoided by pollution reduction), the so-called “value of a statistical life” (VSL) method. The low values are based on assigning a value to each year of life lost to pollution, or saved by pollution reduction, the “value of life-year” (VOLY) method. In one table, presenting data for a different pollutant (ozone), EEA mentions use of a €2,080,000 value per life and a €54,000 value per life-year; it is unclear whether these values apply to all pollutants.

The three sets of values per tonne for NO_x, SO₂ and PM-10, converted from euros to pounds, are presented in Table A2. These values, when multiplied by the emission reductions in Table A1, yield the health impact estimates presented in the text in Table 1.

Table A2	DEFRA 2025	EEA 2020 Low (VOLY)	EEA 2020 High (VSL)
Three valuations of selected emissions, 2020-2025	(£/tonne)	(£/tonne)	(£/tonne)
	NO _x	1,263	17,346
	SO ₂	2,056	29,930
	PM-10	20,654	61,993

Source: See text for explanation and sources

²¹ As explained in note 19, we digitized the graphs using Dagra, using the difference between baseline and “33/80” scenario values. The price for PM-10 could be calculated from the graphs for 2050 but not 2025. We determined from the NO_x and SO₂ graphs that the report assumed 2 percent annual growth in prices between 2025 and 2050, and used this growth rate to calculate the PM-10 price for 2025.

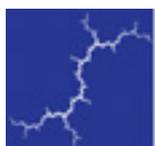
²² See note 11.



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