2050 Vision

How can the UK play its part in avoiding dangerous climate change?

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Executive summary

Institute for Public Policy Research

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About the authors

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Executive summary

In 2000, the UK Government adopted a recommendation from the Royal Commission on Environmental Pollution that the UK should cut its carbon emissions by 60 per cent from 1990 levels by 2050. The Government now proposes to make this goal legally binding, by writing it into the draft Climate Change Bill.

However, climate science has moved on substantially since 2000, and now suggests that countries like the UK should be aiming to make carbon dioxide emissions reductions of *at least* 80 per cent from 1990 levels by 2050, if we are to avoid a 2°C global warming above pre-industrial levels – a threshold beyond which there is a sharp increase in the expected impacts of climate change.

As a result, a number of voices are now calling for the Government to go beyond the 60 per cent target, to adopt a long-term carbon emissions reduction goal of 80 per cent in the Climate Change Bill. In a speech in September 2007, Prime Minister Gordon Brown opened the door to a review of long-term emissions reductions objectives, saying that one of the first tasks of the proposed Climate Change Committee would be to revisit the targets in the Bill.

But is an 80 per cent reduction in UK emissions even remotely possible? How would we generate electricity? How would industry manage? Would we need nuclear power? Would we all have to stop flying and give up our game consoles and gadgets? How would we heat our homes? What would fuel our cars and lorries? And above all, what would it all cost and can we afford it?

There is currently no rigorous assessment of the feasibility and costs of reaching an 80 per cent carbon emissions reduction in the UK, a gap that this study aims to fill. In partnership with WWF-UK and the Royal Society for the Protection of Birds (RSPB), ippr commissioned modelling work following two approaches that produce technology scenarios and cost estimates for achieving carbon emissions reductions of this order.

While in practice some of this reduction might be met through purchase of credits from abroad, here we look at the limiting case where all the reductions are made within the UK, in order to explore feasibility and costs under the most demanding scenario. We also explore some of the policies that will be needed to transform our energy and transport systems.

It is important to clarify the nature of the approach taken here. The Stern Review of 2006 produced a full cost-benefit analysis of action to tackle climate change, and came to the conclusion that benefits exceeded costs for stabilising greenhouse gas concentrations in the range of 450 to 550 parts per million (ppm) CO_2 equivalent – giving a very high chance of exceeding 2°C warming above pre-industrial levels.

Such an approach is beyond the scope of this report. Rather, here we take the 2°C target as a given, and effectively explore costs of action at the lower end of the range presented in the Stern Review (and beyond).

Modelling an illustrative emissions reduction trajectory

We have adopted an illustrative emissions reduction trajectory of :

- a 30 per cent reduction in carbon emissions from 1990 levels by 2020

- a 60 per cent reduction by 2030, and
- an 80 per cent reduction by 2050.

Our study includes emissions from international aviation, which are not covered by the Government's 60 per cent target, but which over time will form an important element of emissions ascribable to the UK.

Both of our commissioned modelling approaches have been developed by authoritative sources. One – a model developed by Professor Dennis Anderson at Imperial College, London – was used in the Stern Review. The other – the MARKAL-MACRO model – has been used by the UK Government in the production of White Papers on energy.

It is important to emphasise that the approaches used here are not forecasting models. They are not used to try to predict the future energy system of the UK in 50 years' time. Instead they offer ways of exploring the trade-offs and tipping points between different combinations of fuels and energy technologies over time, and the cost and emissions implications of these different options.

Some assumptions about technologies and energy demand were applied to both modelling exercises. Due to concerns about the potentially negative social and environmental impacts of excessive biomass production, a WWF international study of sustainable biomass potential was used as a basis for placing a limit on bioenergy imports. Because of questions about waste management and the costs of insurance, as well as public acceptability, the study also looks at the option of excluding new nuclear build. Finally, the future growth of aviation demand in the baseline is assumed to be no higher than efficiency gains, effectively keeping emissions from (and energy use in) aviation constant from 2010 onwards.

The Anderson model has a probabilistic treatment of costs and other variables. For many emerging technologies, such as coal with carbon capture and storage[1] or hydrogen fuel cell vehicles, we do not know for certain what costs will be, so the model assumes a range of possible costs, with each cost within that range assigned a probability. The results, in terms of future portfolios of technologies, and costs, are then produced through multiple runs of the model, and are expressed in terms of a probability distribution. The results reported here are the average values.

The MARKAL-MACRO model has a different approach. Rather than a range of possible costs for each technology, the model works with a single estimate. Uncertainties about the future are explored through sensitivity analyses, for example with different assumptions about oil prices, or learning rates for new technologies. With the exception of the assumptions mentioned above about biomass, nuclear and aviation emissions, the analysis here employs the same assumptions as used by the Government in calibrating the model for the 2007 Energy White Paper. However, for technical reasons, we imposed additional storage costs on intermittent renewables above 25 per cent of the total electricity generation threshold.

Technology scenarios

Both models imply that an 80 per cent reduction in carbon emissions would be feasible with technologies known about today, but would be very challenging to achieve, and would require urgent and radical changes in policy.

1. Carbon capture and storage, or CCS, is a technology in which the carbon dioxide from fossil fuels can be extracted before, during or after combustion, and then stored underground, typically in depleted oil or gas fields.

In both models, to meet the rapid emissions reduction requirements in the period to 2030, the electricity sector decarbonises first and to the greatest extent. Wind (especially offshore wind) and carbon capture and storage (CCS) play a major role in both models, because they are the cheapest ways of reducing emissions in the short to medium term.

At the moment, wind generates around 3 terrawatt hours (TWh) of electricity a year, less than 1 per cent of UK supply. According to the MARKAL-MACRO model, that would have to increase to 20 TWh by 2020, requiring 6 gigawatts (GW) of installed capacity (for comparison, the planned London Array in the Thames Estuary has a capacity of 1 GW). This is within the range of Round 2 of offshore wind-farm development (5.4–7.2 GW). However, by 2030 capacity would have to rise to 33 GW, and to some 48 GW by 2050.

In the Anderson model, where electricity takes up most of the decarbonisation strain until 2025, the rate of investment would have to be even faster. According to our calculations based on the Anderson model, up to 20 GW of wind power may be needed by as soon as 2015. However, this is of the same order as estimates of what can be achieved from the wind power industry.

The models also call for a very rapid deployment of CCS technologies by as early as 2020, to cover around 5.5 GW of fossil-fuel capacity, equivalent to 11 medium-sized power stations. By 2050, between 50 and 110 power stations of this size would need to have CCS. Currently there are plans for just one demonstration plant by the middle of the next decade.

The MARKAL-MACRO model seeks out the lowest cost solutions, and may well underestimate the contribution of decentralised renewables such as solar power. These play a greater role in the Anderson model, where the average portfolio also includes some of what is known as 'domestic combined heat and power' (the simultaneous generation of heat and electricity from a single unit in the home).

Road transport also sees a major restructuring, first with a move to much greater efficiency in car engines, and by the widespread introduction of electric hybrid drives in vans and buses. Biodiesel use (especially second-generation biodiesel) begins to take off from 2010 across all vehicle classes, and by 2030 conventional diesel has been largely phased out.

However, there are limits to the use of first-generation biofuels, especially in cars. In the MARKAL-MACRO model only around 1 million tonnes of oil equivalent (Mtoe) (around 4 per cent of current use) of biofuel is used in the car fleet, rising to 4 Mtoe in 2050. The most important fuel source for cars by 2050 (providing about 70 per cent of energy) is so-called second-generation Fischer-Tropsch diesel, produced from biomass. It should be noted that despite the tight carbon constraint, the model does allow for an increase in mileage, with the distance covered by vehicles some 50 per cent more in 2050 than in 2005. The fleet of heavy-goods vehicles converts to hydrogen (mainly from electrolysis using zero-carbon electricity) by 2030. Rail switches over entirely from diesel (which currently accounts for 60 per cent of energy use in rail) to electricity.

The sector that decarbonises least is aviation. Despite this, in the MARKAL-MACRO model the number of air passenger kilometres travelled still increases by around 30 per cent between 2000 and 2050.

Cost estimates

The costs of reducing carbon dioxide emissions in the UK by 80 per cent from 1990 levels by 2050 on the assumptions above would be 2.1 per cent of GDP per year by 2050, according to the Anderson model, and 2.8 per cent according to the MARKAL-MACRO model.

By comparison, a 60 per cent reduction under the same assumptions would cost around 1 per cent of GDP. The estimated costs of a 60 per cent reduction in the 2007 Energy White Paper, not including international aviation emissions and without constraints on biofuels and without building new nuclear installations, are in the range 0.3–1.5 per cent of GDP per year by 2050.

These are significant costs, as can be seen if they are expressed in absolute terms, amounting to between £50 billion and £70 billion at 2007 prices. This is roughly what is currently spent each year on the NHS. However, even with the deep carbon emissions reduction in the models, the UK economy would still be expected to grow to around 2.5 times its current size by 2050. The deep emissions reduction scenario is not an anti-growth scenario.

It should also be noted that neither of these models includes interactions with the wider global economy. Some of these include risks for energy-intensive, and therefore carbon-intensive, industries that are exposed to international competition, and these may need extra support in decarbonising if production and jobs are not to be moved abroad.

However, there are also huge potential opportunities for UK companies in the global markets for low-carbon and high-efficiency technology and services. For electricity alone, the International Energy Agency estimates that cumulative global investment in low-carbon electricity technologies could be worth US$13 trillion by 2050. Deep decarbonisation could give UK firms a larger domestic market on which to build an export base, particularly in areas such as offshore wind and carbon capture and storage.

The cost estimates above are averages. Subject to different assumptions about technology costs, demand growth, oil and gas prices, and energy efficiency policies, they could range from under 1 per cent to above 3.5 per cent of GDP. Increasing energy efficiency is what makes the most difference to costs, especially in the short term.

Anderson analyses the costs of achieving the 80 per cent emissions reduction trajectory with and without new nuclear installations. The cost difference is small but significant in 2025 (at some 0.4 per cent of GDP per year), but insignificant by 2050, as the cost of alternative technologies has come down.

The costs of action also need to be placed against the costs of inaction, which will fall on both households and businesses. The Stern Review estimates the global costs of unmitigated climate change at between 5 and 20 per cent permanent average reduction in consumption. The net costs of doing nothing to prevent climate change (over mitigated climate change) in the UK are not fully known. However, estimates of potential flood damage, making up part of those costs, are very large by 2080, in the region of £40 billion a year in 2005 prices.

Beyond fossil fuel prices, the modelled costs of making deep cuts are reduced substantially by speeding up progress towards more efficient use of energy. Policies that bring down the expected future costs of low-carbon technologies through accelerated deployment and R&D would also help.

Policies of low-cost measures that drive towards greater energy efficiency and innovation in low-carbon technologies are therefore central to getting the UK onto an emissions reduction trajectory that is consistent with avoiding dangerous climate change.

Targets and the credibility of international leadership

The scientific imperative for an 80 per cent target is strong. The modelling presented in this report also suggests that achieving such a target, while challenging, is technologically feasible and in the same range of costs as a 60 per cent target.

However, there are questions about the desirability of adopting an 80 per cent target for the UK in the absence of an international agreement for tackling climate change post-2012. The point is often made that UK emissions are only 2 per cent of global emissions, so whatever the UK does in terms of emissions reductions will only have a marginal impact on global climate change.

Against this is the view that international collective action is itself more likely to emerge if countries such as the UK demonstrate leadership (demonstrating such leadership is one of the explicit objectives of the Climate Change Bill). To explore this argument, we explored the nature of UK leadership on climate change through a series of interviews with influential stakeholders in governments, academia and civil society from 13 countries around the world (including the US, China, India, France and Germany).

Setting ambitious long-term targets was identified as an element of leadership, particularly within the EU, where the UK is already a key actor in shaping European policy. However, there was also an emphasis on medium-term targets and concern about setting unachievable goals – if these are not met, even in the short term, the UK will rapidly lose credibility.

In this context, the adoption of an 80 per cent target by the UK, along with credible policies for getting on to a path towards that target, would send a strong signal to at least some parts of the international community that the UK is committed to action consistent with avoiding dangerous climate change. This signal would come at a crucial time as international negotiations gather pace on the target for cutting carbon emissions after 2012.

Such a target for the UK will also be more consistent than a 60 per cent target with any future international agreement that aims to minimise the risk of exceeding a 2°C warming. If such a global agreement is reached, it is almost certain that a 60 per cent target written into UK legislation will have to be changed.

Overall, an 80 per cent long-term target and supporting medium-term policies and targets are therefore best understood not as unilateral gestures, but rather as a means towards a multilateral goal, and as about making the UK 'climate-treaty ready'.

Finally, there are likely to be positive spin-offs from a far-reaching decarbonisation for the UK, in the form of improved energy security.

Policy recommendations

Targets

The Government should propose adopting a target of reducing carbon dioxide emissions by at least 80 per cent by 2050 from 1990 levels, with appropriate intermediate targets. However, this proposal should be open to full public debate, part of which will take place through scrutiny and discussion of the draft Climate Change Bill.

The proposed Committee on Climate Change should determine the degree to which the purchase of credits from abroad should be made (and hence the ambition of domestic policies). To be able to take all the relevant factors into consideration, the committee should have expertise and experience in international climate negotiations represented within it.

Low-carbon electricity

Both models suggest that the electricity sector should decarbonise first and most extensively in the medium term (while also indicating the importance of making a start on transport). The extent will depend on how much effort is taken up by the transport sector, but getting onto the path towards an 80 per cent reduction will almost certainly require major investments in low- and zero-carbon power.

Given the longevity of power plant, and the time scales for decarbonising electricity, this is a short-term policy issue. To help the UK avoid building new power stations that generate high-carbon, coal-fired electricity, the Government should immediately start to develop a framework for investment in carbon capture and storage (CCS), anticipating the successful demonstration of the technology early in the next decade and setting a target for CCS compliance.

Innovation in low-carbon technologies

The role of low-carbon technologies is crucial. If technologies such as offshore wind, hydrogen storage and carbon capture and storage are not developed and commercialised, then the only way to radically reduce emissions would be through a much reduced use of energy and by having a smaller economy. Such a vision is likely to be politically unattainable.

More resources should be given to support research on low-carbon technologies. Government should increase annual support from a planned £60 million per year to at least £100 million a year by 2010. Further expansion could be funded out of revenue from energy companies purchasing certificates to meet their targets for renewable electricity under the Renewables Obligation. The new Energy Technologies Institute should focus principally on research, rather than development, with an appropriately open intellectual property regime.

The Renewable Transport Fuel Obligation, which requires fuel suppliers to ensure that 5 per cent of the fuel they sell comes from renewable sources by 2010, should be extended to 2020 and banded, to give incentive to the development of second-generation biofuels.

Government should continue to press for long-term targets for emissions from new cars across the EU, with a goal of vehicles having zero emissions by 2030. This approach should be extended to aviation. Government should propose a long-term mandatory carbon emissions standard for aircraft that land at EU airports, and consider adopting a standard for UK airports.

Systems of certification for product standards should be amended to provide a low-cost rapid 'innovation assessment' for new low-carbon technologies, especially for business-to-business markets.

The Government should work at the EU level to provide a framework for investment in road transport refuelling stations, help avoid incompatibility between countries or even regions within countries.

Speeding up progress towards energy efficiency

In both models presented in this study, speeding up the rate of change at which we move towards more efficient use of energy will lower the costs of reducing emissions. The cost reductions would be substantial, of the order of one-third. These effects are far larger than the differences that would be made by ruling out a new generation of nuclear power stations.

Government should place a greater focus on approaches informed by behavioural psychology in designing interventions to speed up the introduction of energy efficient behaviour and new products in the household sector. In the commercial and retail sector interventions should focus more on regulation and corporate social responsibility as the key drivers of behaviour.

There is also a need to keep energy efficiency a priority in the minds of the public. There is a tendency to talk about energy efficiency, but rapidly move on to solutions that focus on supply, including nuclear power. For electricity in particular, the more that demand-side efficiency and management solutions are brought into use, the less the gap in generation on the supply-side. In terms of short-term strategy, government should ensure that energy efficiency and conservation is the priority for energy policy.

The pace and ambition of change should also be stepped up. Policies to speed up energy efficiency, especially an obligation on energy suppliers, should be brought forward and adopted more quickly than is currently planned. The earlier measures are introduced, the more effective they will be in lowering costs.

Policies to help the vulnerable

Low-income households will face difficulties in meeting the higher costs associated with cutting carbon envisaged in the models. 'Carbon poverty' will replace fuel poverty as a major social policy problem and political issue.

Tackling carbon poverty will require the same range of policies as those dedicated to addressing fuel poverty. There will need to be a mix of well-targeted programmes to improve the energy performance of the housing of low-income households, direct payments for winter fuel (and possibly in future, fuel payments in summer, for cooling). Most important of all will be to raise the incomes of the most vulnerable households through targeted benefit and tax credit measures.

In addition, new approaches, such as requiring energy suppliers to adopt social tariffs or step-up tariffs, or bulk-buying of energy at a discount for low-income households by government, should also be considered.

Policies for energy-intensive industries

Some energy-intensive industries (especially those open to international competition) will also have concerns about the impacts of tighter carbon constraints and higher pricing, with the fear that production and jobs will move to other countries. In fact, relatively few industries in the UK are both energy-intensive and exposed to a high degree of international competition. Aluminium, iron and steel are likely to be the most affected.

Global sectoral agreements are often seen as the best way of reducing emissions in energy-intensive industries open to high levels of international competition. However, sectoral agreements will be easier to negotiate in some sectors than others.

In the absence of successful global sector-specific agreements, government should work with companies with energy-inefficient plant to reduce their carbon footprint by reaching industry best-practice levels. Taxes on imports could also be considered.

Conclusions

Climate science suggests that for the world to have a good chance of avoiding dangerous climate change, the UK needs to reduce its carbon emissions by *at least* 80 per cent by 2050 from 1990 levels.

The models presented here suggest that achieving these emissions reductions through domestic action alone is technologically feasible, based on a combination of increased energy efficiency and investment in technologies known about today. This is the case even if new nuclear power stations are ruled out.

However, the scenarios are highly challenging, and would require radical, almost immediate changes in policy, and investment in the electricity sector in particular.

The costs of achieving an 80 per cent emissions reduction, at an estimated 2–3 per cent of GDP per year by 2050, are larger than the estimated costs of achieving a 60 per cent target, but are of roughly the same order.

In addition to being necessary, technologically feasible and affordable, a more ambitious emissions reduction target, along with credible policies, would also be desirable in terms of demonstrating UK leadership on climate change, and so helping to make a global agreement more likely. Energy security – making sure the UK does not rely too much on other countries for its energy supplies – would also be improved.

The models offered here do not present the only ways of reducing UK carbon emissions by 80 per cent by 2050 from 1990 levels. Inevitably, for example, they cannot anticipate future technologies. However, these two models do incorporate a large amount of what we know about current technologies, and they investigate both plausible and lowest cost paths to that aim.

Achieving an 80 per cent reduction in carbon emissions in the UK in this timeframe would be a massive undertaking. The scale of the challenge should not be underestimated. Such a reduction would represent a total transformation of the ways we use energy in our homes, in business and in transport. The technologies we use to generate (and in many cases, use) energy would have to change completely within the space of the next few decades.

However, the technological challenges are probably not as great as the policy challenges. We already have many of the technologies that these models suggest would be needed, and some of them are already being brought into use on a significant scale. Others are at an emerging stage but are relatively well developed. But both the models suggest that the pace of investment in these technologies will need to increase both urgently and radically.

Underlying the policy challenges are the economic and political challenges. According to our costing exercises, the overall economic implications of decarbonisation would not be enormous in terms of impacts on long-term growth. This makes sense, since energy makes up only a relatively small part of the economy. Nevertheless, the economic costs would be large enough to have political significance. In the short term, there are likely to be winners and losers, and thought needs to be given to supporting the latter groups. The kind of policy changes involved would require major support, and a prerequisite for radical change would be the building of a solid mandate from the public.