Oxera

Agenda

Advancing economics in business

Plugging the carbon productivity gap

Productivity trends are used to explain the changing structure of the economy and to compare the UK's performance against its peers. When the same concept is applied to energy, and ultimately to carbon, it becomes a clear measure of progress towards achieving long-term greenhouse gas emission targets. The results for the UK electricity sector suggest that, if the government's existing targets are to be met, the current policy programme will have to be expanded, at a cost of several billions, during the next 10–15 years

Trouble ahead

When 166 nations signed the United Nations Framework Convention on Climate Change (UNFCCC) during 1992–93, they made a commitment to 'stabilise greenhouse gas concentrations' in the atmosphere. This was crystallised in the Kyoto Protocol, which absorbed diplomatic effort for the best part of ten years between its drafting and its ratification earlier this year. Other policy initiatives have arisen alongside in the form of the UK's Climate Change Programme, introduced in 2000, and the EU Emissions Trading Scheme (ETS), which commenced in January.

Barely two years ago, the UK government adopted an ambitious new position—the pursuit of a 60% reduction in greenhouse gas emissions by 2050. It may seem a distant goal, but it is already finding traction. The UK Climate Change Programme's 10–20-year time horizon covers one-third to one-half of the period to 2050.[1] Although hardly an election issue, after the election, ministers will have the opportunity to build momentum within the G8 and within Europe. A robust domestic programme would help. As the analysis below shows, that means tough decisions ahead.

Discussing the release of the latest UK greenhouse gas emissions statistics, Elliot Morley, Environment Minister, stated:

> We are committed to our national targets. We shall succeed in our response to climate change. We cannot afford to fail.[2]

Yet, while CO_2 emissions fell 5.6% between 1990 and 2003,[3] if levels continue to fall at this rate, the government's 2050 long-term target would not be met, as the analysis below shows.

Consider three facts.

- First, the UK economy is expected to create gross added value of around £1,100 billion in 2005.[4] As it has done for many years, the economy is likely to continue to grow in real terms. The Treasury forecasts real growth of around 2.5% per annum for the next five years, and the economy is expected to double in size over the next 30 years.

- Second, at present, the UK generates greenhouse gases equivalent to around 150m tonnes of carbon.[5] If the productivity of energy use continues to grow in line with the productivity of the factors of labour and capital within the economy, emissions of greenhouse gases will remain static, but not fall, while the economy doubles in size.

- Third, at the government's semi-official valuation of £70 of damage caused per additional tonne of carbon released, the value destroyed by these emissions each year is £10 billion, or around 1% of gross value added. In the economy as a whole, the carbon price would have limited impact.

There are various aspects to the problem. First, a group of government advisers, assembled within the Royal Commission on Environmental Pollution, recommended that the UK's greenhouse gas emissions should be reduced by 60% by 2050,[6] and the government agreed. This translates into an absolute reduction of 1.92% per annum.[7] Furthermore, the rate at which carbon productivity (ie, the amount of carbon emitted per unit of GDP) would have to improve to achieve this target is 4.2% per annum, if economic growth is a steady 2.25%.[8] Finally, energy is used by people and machines, so energy productivity is most probably linked to labour and capital productivity, and these grow typically at around 2% per annum—a full 2% less than the carbon target.

Hence the problem is ultimately a question of how much of the 60% target will be delivered through general productivity improvements, and how much (the remainder) will be delivered by switching away from carbon-emitting energy—switching that will either be born of serendipity or, more likely, induced by policy.

Table 1 Carbon productivity per unit of carbon, 1970–2000 (CAGR, %)

	Industry GDP	Service sector output	Whole economy
Headline	3.7	2.7	3.0
Underlying (excluding dash for gas)	3.0	1.8	2.1

Source: Inter-departmental Analysts Group (2002), 'Long-term Reductions in Greenhouse Gas Emissions in the UK'.

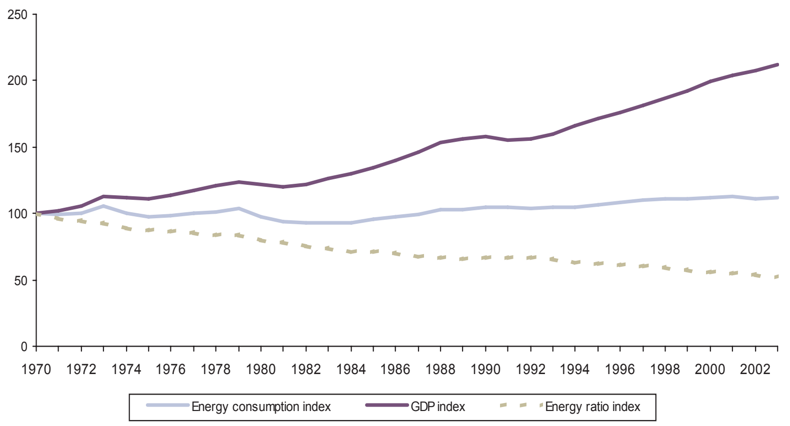
The productivity gap

Total factor productivity is the ratio of output, measured as value added, to input, measured as capital and labour. It shows how many pounds of value are created for every pound of input. The trends in total factor productivity vary across the economy. Some sectors have improved rapidly—for example, utilities, transport and communication; others, such as construction and manufacturing, improve more slowly. There seems to be a pattern of energy-intensive sectors exhibiting slow rates of productivity improvement.[9]

The sectors exhibiting lower-than-average productivity growth include chemicals, coal and petroleum, basic metals and paper. These are major energy consumers. Not surprisingly, the rate of improvement of economic output to energy consumption, referred to as energy productivity, is lower than the rate of total factor productivity.

The longer-term trends appear remarkably stable. For the whole UK economy, output grew between 1970 and 2003 at 2.1% compound annual growth rate (CAGR) (see Figure 1). Total energy consumption also grew, at around 0.3%, showing that energy productivity growth was lower than economic growth, at 1.8%.

Figure 1 The ratio of energy consumption to GDP since 1970



Source: Department of Trade and Industry (DTI), 'Long Term Trends' (undated).

However, for climate change, what matters are greenhouse gas emissions, not energy consumption. The important indicator is the ratio of output to carbon emissions—ie, carbon productivity. The wedge between energy and carbon productivity is fuel switching, particularly upstream in electricity generation, where it made a significant impact during the 1990s. Stripping away the effect of fuel switching in generation reveals an underlying carbon productivity improvement rate that is 3.0% CAGR for industry, well above the energy productivity rate of 1.8%; for the service sector, the rate is 1.8% (see Table 1). This shows that while industry had a lower rate of energy productivity growth, it has achieved more fuel switching than the service sector. At a rate of economic growth of 2.25%, carbon productivity will have to average 4.2% CAGR to achieve the government's long-term aim of emissions reduction.[10]

Worse still, the government's last communication to the UNFCCC, reporting on the UK's progress towards Kyoto compliance,[11] anticipates a CAGR of carbon productivity at around 2.25%—that is 2.0% short of the target—which is consistent with the DTI's latest energy projections for the period 1990–2020.[12] That would leave a gap between actual and targeted emissions of 40–60% after 20 years.What can be done to close this gap?

Mind the gap

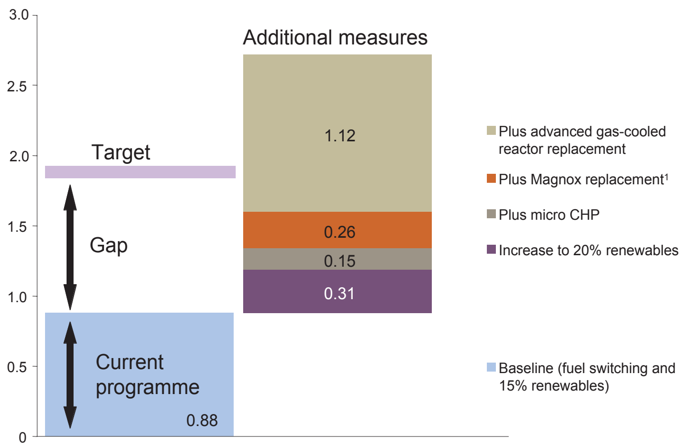
Take the electricity generation sector, for example. Responsible for between one-quarter and one-third of UK CO_2 emissions, it has a large contribution to make to the target.[13] In the soon-to-be-revised Climate Change Programme, let us suppose that the electricity sector is subject to the economy-wide target, and has to achieve a 1.92% reduction in carbon emissions. This requirement on electricity generation could be conservative if other sectors, such as transport, underachieve, as they have in the past.[14]

There are several supply-side options in the electricity sector: renewables, fuel switching, micro combined heat and power (CHP), large-scale CHP, and carbon sequestration. There is also the demand-side option of energy efficiency.

Oxera's baseline projection for emissions from the electricity sector is an absolute reduction of 0.88% per year, brought about by switching from coal and nuclear to gas and entry of some renewables. The delivery of 20% of supply by renewable sources adds a further 0.31%, and micro CHP might add 0.15%. This takes the total to 1.35%, leaving a gap of 0.57% to be filled by carbon sequestration or nuclear power, or greater energy efficiency. These figures are shown in Figure 2. Energy efficiency is at least partly included in the baseline.

It is clear that the 2050 target is rather more demanding than the current policies on renewables represented in the baseline. Even a programme of 20% renewables by 2020 is not sufficient to achieve the long-term carbon productivity rate. Replacement of existing nuclear power stations could achieve the targets to 2020 and beyond, or an equivalent programme of carbon sequestration or energy efficiency could do the same.

Figure 2 Compound annual reduction in CO_2 emissions in electricity supply (%)



Note: The growth rates have been calculated over the period 2005–20.
[1] Magnox and advanced gas-cooled reactors are types of nuclear power station.
Source: Oxera calculations.

A bitter pill

The cost of moving to low-carbon options from coal and gas is inextricably linked to the prices of fossil fuels. So, with the price of oil seemingly set on a new, higher path well above the old watermark of $30 per barrel, renewables and new nuclear could offer better value.

Even so, renewables—which, in the UK, consist almost entirely of onshore and offshore wind power—cost around £12 billion more in present value terms than conventional generation, for the current programme.[15]

Oxera has taken some illustrative estimates to construct an equivalent figure for a nuclear power replacement programme of similar electrical output to the renewables programme.[16] The total injection of public capital would be around £1.1 billion, and publicly backed debt guarantees required would be around £3.3 billion.[17] Public liability insurance has not been estimated but should also be included. These figures may be compared with the £12 billion cost for the renewables programme. Thus, the total investment required is:

- renewables programme support costs = £12 billion
- nuclear programme support indicative costs = £1.1 billion capital grants + £3.3 billion loan guarantees + public insurance risk.

Conclusion

The use of carbon productivity as an indicator of progress towards long-term carbon emission targets is a new perspective that offers insights across the economy, and is particularly helpful in understanding how long-term targets may translate into action today.

It seems likely that the electricity sector will be expected by government to achieve at least its pro-rata target for carbon productivity improvement—that is the experience of the recent allocation of emission rights under the EU ETS. It may also be justified by slow productivity growth in manufacturing and increasing emissions from transport—two of the largest-emitting sectors. For the electricity sector to pull its weight, current policies would have to be tightened further, going beyond the delivery of a 15% renewables target in 2015, and even going beyond a 20% target for 2020. Energy efficiency and micro CHP help to some degree, but there is still a gap to plug.

That gap could be filled by further switching from coal to gas, carbon sequestration, or new nuclear build, and contributions from all three may be required. The costs will run to several billions, but relative to the £12 billion being invested in renewables, may look relatively affordable.

The revision of the Climate Change Programme could provide an opportunity to begin to debate future targets for the electricity generation sector. Whether the pill is nuclear power or an alternative, early prescription of the medicine will minimise the future rates of improvement that have to be achieved, and the expected cost is in the order of several billions of pounds.

[1] UK Department for Environment, Food and Rural Affairs (Defra) (2004), 'Review of the UK Climate Change Programme: Consultation Paper', December.
[2] Defra (2005), 'Greenhouse Gas Emissions Figures Released Today', press release, March 21st.
[3] Ibid.
[4] HM Treasury (2005), 'Budget 2005: Report'.
[5] The government's preferred units for greenhouse gases express emissions of any gas in the global-warming equivalence of CO_2, measured in tonnes of the element carbon in that CO_2. One tonne of carbon is defined as the equivalent global-warming effect of 3.67 tonnes of CO_2. Defra (2001), '3NC: The UK's Third National Communication under the United Nations Framework Convention on Climate Change', October.
[6] Royal Commission on Environmental Pollution (2000), 'Energy—The Changing Climate'.
[7] A compound annual reduction of 1.92% over 60 years achieves a 60% reduction by the end of the period.
[8] As a first approximation, the rates of economic growth and of emissions reduction can be summed to give the rate of carbon productivity improvement.
[9] O'Mahony, M. and de Boer, W. (2002), 'Britain's Relative Productivity Performance: Updates to 1999', National Institute of Economic and Social Research, March.
[10] Between 1990 and 1997, the UK achieved a 3.12% CAGR in greenhouse gas emissions productivity, and in the period since 1997, the figure was 3.58%. Defra (2005), op. cit.
[11] Defra (2001), op. cit.
[12] See DTI (2004), 'Updated Energy Projections', November, Addendum, Table 3.
[13] Defra (2001), op. cit.
[14] DTI (2003), 'Our Energy Future—Creating a Low Carbon Economy', February.
[15] Oxera (2005), 'The Performance of the UK Renewables Obligation and Capital Grants Policy', a report for the National Audit Office, January, www.oxera.com.
[16] £1,600m/GW for the first station, falling to £1,200m/GW by the third station and for subsequent stations, and adding in public inquiry and licensing costs of £100m, plus first-of-a-kind costs of £100m, a contingency of 10%, operating maintenance, fuel and decommissioning costs, a load factor of 93%, a maximum financial gearing of 70%, and a return on equity of at least 11–12%.
[17] If the capital costs of the first station were £1,200m/GW, the overall public support needed would fall to £700m of grants and £2.6 billion of loan guarantees.