The great 80/50 carbon cull – a new labour for Hercules

This briefing note is one in a series prepared by Supporters of Nuclear Energy (SONE), in consultation with scientists and engineers, to bring some facts and perspective to energy-related issues that are being freely discussed by the public.

One of these is the Government's aim drastically to cut carbon dioxide (CO_2) emissions to combat global warming. Under pressure from "Greens", it has just committed itself to reducing British emissions by 80 per cent of the 1990 level by 2050, apparently without considering the implications.

How could such a massive reduction be achieved? Is the technology available to secure the political objective? Could it conceivably be implemented even within what may seem to be a reasonably generous timescale? And what effect would an 80% reduction have on the current British lifestyle?

This briefing note seeks to answer these questions to make for a more rational debate about CO_2 reduction.

In reading it, two things need to be borne in mind:

1. It is not possible to store electricity in bulk so supply has continuously to be matched with demand; this means that managers of the National Grid, or any distribution system, require predictable and controllable power.
2. Any scheme to reduce CO_2 emissions has to have regard to its economics. There is no point in Britain rendering itself uncompetitive in reducing CO_2 emissions, especially when we emit only two per cent of the world's total, if our competitors fail to address a global problem.

Sources of CO_2

To understand the implications of eliminating much of the carbon we now put into the atmosphere we need to know first where it comes from. The table below, compiled from Government statistics, shows that it arises from six main sources:

Sector	Quantity, million tonnes pa	% of total
Power stations	180.2	33
Transport	129.9	24
Industry	124.7	23
Domestic	75.8	14
Services	26.9	5
Other	8.1	1
Total	**545.6**	**100**

Main carbon sources

We now examine the four main sources of CO_2, which account for virtually 95 per cent of British CO_2 emissions, and set out the options for reducing their emissions.

Power stations

Power stations produce 33 per cent of the nation's carbon emissions since about 78 per cent of British electricity is generated by fossil fuels – almost entirely coal (34 per cent in 2007) and gas (43 per cent), though the proportions vary, according to price. The rest comes from nuclear (15 per cent), renewable sources of energy – that is those that continuously renew themselves in nature – (5 per cent) and imports (2 per cent).

Continued over

In CO_2 terms, coal is one of the dirtiest fuels, producing twice as much CO_2 as gas and 200 times more than nuclear, which emits next to no carbon. It follows that if we are to eliminate 80 per cent of our carbon emissions we need to replace coal- and gas-fired power stations by low carbon alternatives or find a way of neutralising the CO_2 produced. Here the main idea, though a long way from being proved, is to capture all the carbon produced by power stations and pipe it to and store it in the strata below the North Sea.

Transport

Transport, responsible for nearly 24 per cent of emissions, is fuelled almost entirely by oil. Carbon capture could be applied only at the margin and, as things stand, is irrelevant to the problem. Consequently, oil would have to be phased out as a means of propulsion and replaced by carbon-free electricity or hydrogen manufactured without carbon emissions.

Industry

Industry, in producing nearly 23 per cent of CO_2 emissions, uses coal, gas and oil in a variety of roles. Again carbon capture would have very little practical relevance, so fossil fuels would have to be phased out and replaced by electricity generated from carbon-free sources.

Domestic and Services

Between them, the domestic and service sectors account for nearly 19 per cent of CO_2 emissions. Gas is the main fuel, though small amounts of oil and coal are also consumed. Carbon capture is not feasible in either case so to slash CO_2 emissions by 80 per cent would require all the fossil fuels to be replaced by carbon-free electricity.

That then is the measure of the problem. To eliminate 80 per cent of the UK's carbon emissions, as measured in 1990, would require the effective replacement of the fossil fuels currently employed – coal, oil and gas – by nuclear or low carbon renewables.

The three options

Apart from reducing our demand for energy, which is exceedingly difficult in a growing economy, there are three options for drastically cutting CO_2 emissions:

- Nuclear power
- Renewables such as wind, waves, tides, solar etc
- Carbon capture and sequestration (CCS) which, to repeat, is not only not yet proven in this application and is far from being available on the scale required.

Let us examine each of the these options:

Nuclear: Nuclear power has been proven over 50 years.

- It is safe – not a single death from a radiation accident in half a century's operation and it has no problems in handling its waste;
- It is economic – the cheapest option when all costs from mining to decommissioning and environmental impact are taken into account;
- It provides greater security of supply by reducing demand for imported fossil fuels;
- It is clean – the cleanest form of power generation available, cleaner even than wind power, measured on the basis of emissions per unit of electrical output.

Renewables: Currently they produce only 5 per cent of the UK's electricity – 1.3 per cent from wind; 1.2 per cent from hydro-power which is regarded as virtually fully developed; and the rest from methane from tips and waste incineration, some of which are by no means carbon-free. It has taken 18 years of wind power's heavily subsidised development to achieve a miniscule 1.3% of national power generation.

In practice, of the clean, or cleaner, renewables only wind is available as a generator of bulk electricity. Wave, tidal, solar, geothermal and bio-fuel power are either undeveloped, unproven or likely to remain marginal. Moreover, as dilute forms of energy, bio-fuels, including wood, would take vast amounts of land required for food.

This means that, as things stand, renewables effectively mean wind power. But this has one formidable snag: it is unpredictable because of wild swings, often over very short periods, in the force of the wind. Its delivery is unpredictable and intermittent and each turbine produces on average only about a quarter of its rated output capacity. As such, it simply cannot be relied upon and therefore has to be backed up at enormous cost by conventional – i.e. fossil fuel – power stations.

This in turn means that wind power is a poor way of tackling CO_2 emissions because it results in the expensive, inefficient and "dirty" running of fossil-fuelled power stations on standby for when the wind drops or blows a gale when turbines have to be switched off.

Engineers experienced in balancing supply and demand on the National Grid maintain that whatever the notional installed capacity of wind power, there would still have to be as much conventional capacity available to the Grid in order to be sure of meeting peak demand.

As, effectively, the only source of renewable bulk supply, wind is a singularly inadequate substitute for fossil fuels. It is also extremely expensive and no commercial wind turbines would be operating today without the 100 per cent subsidy provided by the consumer. It is certainly neither a reliable nor economic substitute for fossil fuels.

Carbon capture: CCS – or carbon capture and sequestration – is advanced as a means of making continued use of coal in power stations acceptable in environmental terms.

The popular idea is to capture CO_2 emissions from coal- and presumably gas-fired power stations and then dump them in the strata under the bed of the North Sea. The injection of CO_2 into oil- and gas-bearing strata to secure greater yields of fossil fuels is a well-known technique and dumping CO_2 in them became legal in February 2007.

But to eliminate 80 per cent of the current 180m tonnes of CO_2 emissions from power stations would require the capture, transport and sequestration under the North Sea of well over 140m tonnes a year. Unfortunately, details about the proposed system remain unclear as does the $64,000 question: will the CO_2 remain locked up and harmless for a very long time.

Just as vague are the costings of the entire exercise but early estimates suggest it could double the price of electricity. This would do nothing for Britain's competitiveness. If the International Energy Agency's estimate of CO_2 disposal costs at £15-30 a tonne is anywhere near, CCS would add at least £2.1billion to the electricity bill and up to £4.2bn. This works out at a minimum of £100-200 on domestic power bills.

The truth is that nobody knows what CCS would really cost. But we do know that it is a long way from being available, is not proven and would be very expensive. In short, we cannot rely on something that is still at the early R&D stage.

Conclusion: The only safe, proven, competitive, reliable substitute for fossil fuels as producers of CO_2 emissions is nuclear power. Both renewables – effectively wind power – and carbon capture would fall a long way short of meeting the nation's objective of an 80 per cent cut in CO_2 emissions by 2050.

The 80 per cent cut: what it would mean

We will now work through each of the sources of CO_2 emissions, sector by sector, to outline what an 80 per cent cut would mean.

Power Stations: About 78 per cent of British electricity is generated by fossil fuels – coal, oil and gas. In 2007 393TWh were supplied in total so 303TWh came from gas and coal. Thus to cut out 80% of CO_2 emissions would require the replacement of 242TWh of electricity.

That would require 53,800 2MW wind turbines – compared with the 2,500 now – each generating 4.5GWh a year, assuming they perform at the average 25 per cent of their rated capacity. There is considerable doubt, to say the least, whether Britain could install an average of four turbines a day, 27 a week and 1,350 a year for the next 40 years. It is far more than has been achieved so far.

But after all that effort we would be left with one snag: we could never rely on receiving the power when we needed it. In other words, the figure of 53,800 2MW turbines is wholly theoretical. Even double that figure would not deliver any power as and when Britain came under the influence of a large anti-cyclone inducing calm conditions across the country.

Nuclear could eliminate 80% of the CO_2 emissions from power stations by building 27 new power stations roughly the size of Sizewell B (1,188MW) in Suffolk. That would be well within the nation's capacity over 40 years.

As for CCS, as we have already shown, up to 140m tonnes of CO_2 would need to be captured, compressed and then piped up to 1,000 miles each year before sequestration. It remains an open question whether this is feasible, let alone economically feasible, and whether the CO_2 would stay put once pumped into the strata.

Running total *– So far to eliminate 80% of CO_2 from power stations would require* ***53,800 2MW wind turbines****, or the* ***sequestration of up to 140m tonnes of CO_2 a year*** *under the North Sea; or* ***27 new nuclear power stations****. Only nuclear power stations could be relied upon to do the job.*

Transport

Only two of the three options apply to transport, which is responsible for nearly 24 per cent of CO_2 emissions. They are renewables and nuclear. There is virtually no prospect, as things stand, of carbon capture being applied to vehicles whether cars, vans and heavier vehicles (oil or diesel), aircraft (kerosene), or ships (heavy fuel oil).

Bio-fuels – and specifically ethanol – are in use in road vehicles but vegetation, as a dilute form of energy, requires vast areas of land. There have already been complaints that, even with today's relatively limited use of ethanol, the price of corn has soared through the diversion of part of the crop for fuel manufacture. Ethanol is by no means a ready alternative, especially if it were further to impoverish the poorest in developing countries by raising the price of food.

A more promising alternative is the replacement of petrol and diesel in road transport by fuel cells using hydrogen manufactured by the electrolysis of water by nuclear or renewables electricity. (See the SONE briefing note on The Hydrogen Economy). Already hybrid – electric and petrol-driven – vehicles are being sold and this opens up the possibility longer-term of electric cars recharged from the National Grid.

But this would require a great deal of electricity. In fact, it takes 7Kwh of electricity to replace one litre of petrol by electrolysis. To eliminate 80 per cent of the 22m tonnes of petrol used in light vehicles each year would require roughly a third of the electricity currently supplied by the National Grid – that is 132TWh. This would greatly add to the cost of motoring, not to mention the cost of all the infrastructural changes that would be required to switch from petrol pumps to power plugs for recharging. And it would eliminate 80 per cent of the CO_2 emissions from only cars – not heavier vehicles or other forms of transport.

Translated into generating hardware, it would require another 29,300 2MW turbines or another 15 nuclear reactors the size of Sizewell B.

Running total *– To remove 80 per cent of CO_2 emissions from power stations and just light road transport would require* ***83,100 2MW wind turbines*** *or* ***42 nuclear reactors,*** *with the proviso that you could never rely on the turbines.*

Industry

As things stand, CCS is of limited relevance in industry, which is responsible for nearly 23 per cent of CO_2 emissions, using coal, oil and gas. Its total energy use is the equivalent of 30m tonnes of oil, of which about 10 per cent is in the form of electricity. If this were produced cleanly, well over 20m tonnes of oil equivalent would still have to be displaced to remove 80 per cent of CO_2 from industry. That would require 185 TWh of electricity and demand 41,100 more 2MW wind turbines or 21 more nuclear reactors with the capacity of Sizewell B.

Running total *– Removing 80 per cent of CO_2 emissions from power stations, only light transport and general industry would require* ***124,200 2MW wind turbines*** *or* ***62 more Sizewell B capacity nuclear power stations.*** *Again it is necessary to add, we could never rely on the turbines.*

Domestic

Domestic consumers use a mixture of fossil fuels. The dominant one is natural gas and the others are propane, oil, coal and marginally biomass (wood). Gas consumption alone in this sector is equivalent to almost the total annual output of British power stations. To reduce emissions by 80 per cent would mean replacing 320TWh by either nuclear or renewables- i.e. effectively wind. That would require another 71,100 2MW wind turbines of 35 new Sizewell B-capacity nuclear reactors.

***Running total** – The elimination of something approaching 80 per cent of CO_2 emissions from British life would require a total of **195,300 2MW wind turbines** or **97 Sizewell B capacity nuclear reactors.** And none of the wind turbine output could ever be relied upon.*

But... it's an under-estimate

It may be an inconvenient truth but our inability to store electricity in industrial quantities means that the National Grid has to be prepared to cope with peaks and troughs of demand. So, if we eliminated 80 per cent of gas usage, the National Grid would have be able to cover peak demand which, translated into electricity terms, would require at peak 75,000 MW or the equivalent of 75 conventional power stations.

Running total** – To meet that peak gas demand with electricity would require another **38,000 2MW wind turbines operating flat out** (which they never do all at once) or **65 nuclear reactors of Sizewell B capacity.

Grand total

It follows that to eliminate something approaching 80 per cent of CO_2 emissions by 2050 would require in total another 233,300 2MW of wind power or another 162 Sizewell B capacity nuclear power stations. And we still could not rely on getting the wind power when we needed it.

Feasibility

None of this takes account of whether such a massive investment is feasible even over the next 41 years, where it could be sited, whether it would be acceptable, given the damage it would do to our coast and countryside, or what it would cost both in terms of generating hardware, transmission, the complete revamping of motor transport's fuelling infrastructure or the massive re-wiring of people's homes to carry the vastly increased use of carbon-free electricity.

But what about energy saving?

We have taken energy saving into account. We can no more rely on reducing demand in an expanding economy than we can on any wind turbine generating its rated power capacity.

Engineers will continue to get more useful work out of the energy put unto plants, offices, vehicles and buildings. More insulation and the installation of controls over energy usage will help to cut out waste. Higher prices will also lead to economies. But, outside an emergency or slump, none of this has so far actually reduced electricity demand, which has been rising steadily at 1-1.5 per cent a year. There is a ready explanation for this. It is a combination of the “rebound” and “multiplier” factors, which lead to financial savings resulting from economies being used to buy more means of using energy, which has a multiplier effect on the energy consumed.

Perhaps the most we can expect of a vigorous campaign to secure greater energy efficiency and economy in the use of energy is to moderate steadily increasing demand. This does not mean trying to reduce demand by improving energy efficiency and a variety of conservation measures is a waste of time. It never makes sense to waste anything. But, in the light of experience, it makes no sense to harbour exaggerated expectations of what even a vigorous energy saving campaign could produce. We simply cannot rely on its obviating the need for even one new power station.

Conclusion

It is clear that the idea of reducing the UK's carbon emissions by 80 per cent on the 1990 level by 2050 has been plucked out of thin air without the slightest regard for its feasibility, its cost, the availability of capital and hardware or its consequences.

The target is about as realistic as an idle daydream. It is time policymakers came down out of the clouds and faced up seriously to what practically might be done to make our energy future more secure at competitive rates while combating global warming.

Only nuclear power offers the means to achieve this but the massive scale on which it would be required to do so serves only to underline how incredible the 80/50 target really is.

Its only value is to demonstrate the depths to which policymaking has plunged in the UK and Europe.

If you want to read more about nuclear issues or different aspects of energy policy you can download the following briefing notes from SONE's website at www.sone.org.uk:

- The Looming Energy Crisis (update)
- Uranium Availability
- Renewable and alternative sources of electricity
- The Hydrogen Economy
- Micro-generation Briefing Note
- The Management of Nuclear Waste
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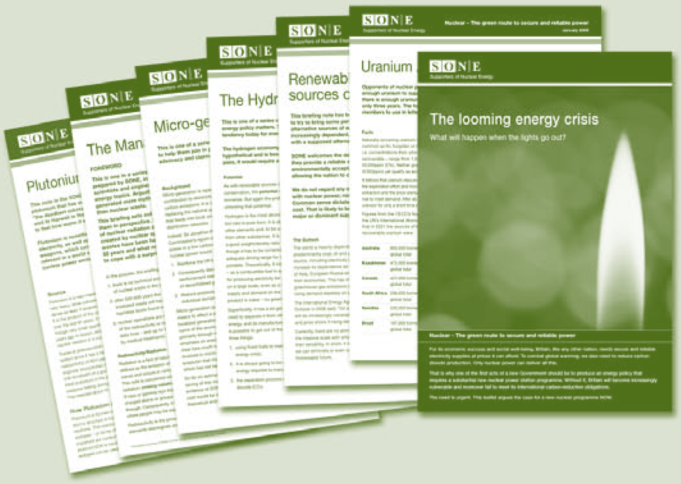

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