SHOULD THE BRITISH GOVERNMENT ALLOW THE CONSTRUCTION OF NEW NUCLEAR POWER STATIONS IN THE UK?[1]

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"A €30bn (£20bn) scheme for the construction of 26 new coal-fired power stations by 2020 has been approved by Ms Merkel's grand coalition, as [Germany] moves to abandon nuclear power." [News Report, The Independent, 23rd March 2007]

Abstract

In relation to our energy supply, the United Kingdom faces three major challenges: fossil fuel depletion, energy security and climate change. The focus here is on the problem of climate change, which poses severe threats to humanity and the natural world; with action needed urgently. Various options for meeting our future energy needs are considered. Renewable energy, energy efficiency and behaviour change are all to be recommended but suffer various physical, political and economic limitations.

Nuclear power stations have a high energy density and are not variable or intermittent. Most studies suggest that there is no medium-term shortage of uranium ore at grades high enough to make nuclear power both economic and low-carbon: there is enough Uranium in the ground to sustain at least a new generation of nuclear power stations for their entire life; with new technologies promising much greater longevity. The cost of nuclear power is at least comparable to fossil fuels, once the escalation of fuel prices and environmental costs of both are accounted for. The risks of nuclear power are not considered here in detail, but it is suggested that direct risks, of relevance to the decision to build nuclear in the UK, are extremely low.

The carbon emissions of nuclear power are approximately 1% of traditional fossil fuel technologies: comparable to wind, and lower than photovoltaic solar cells. Therefore nuclear, along with most renewable electricity technologies, can be considered an 'ultra-low' or 'zero carbon' electricity generation technology, necessary for the mitigation of climate change. In an appendix, some common objections to nuclear energy are considered.

1 This is an updated version of a short speech given to the Institute for Civil Engineers and to the Cambridge Union Society and at other venues, during the debate about nuclear power in the UK over the last few years.

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1. What Is The Problem?

Will We Have Enough Secure Energy?

This question concerns our nation's future. Will we have enough energy in the future? Shall we, as in the past, obtain our fuel from secure, reliable sources? Or instead will we be forced to compete for dwindling supplies of fossil fuels? Yet there is an even more important issue. It concerns the future of Earth, and the plants, animals and humans, which live upon its surface.

The Greenhouse Effect

It has been known for one hundred years that Carbon Dioxide in the atmosphere traps heat in the so-called `greenhouse effect'. Carbon Dioxide is emitted in the burning of coal, oil and natural gas, which presently supply eighty percent of the world's energy needs. Humanity has now reached a point, such that, if we continue like this, we will double the concentration of Carbon Dioxide within fifty years. This would lead to an increase in average worldwide temperature of 2 - 5 degrees Celsius or more (IPCC 2007a).

Urgency of Issue

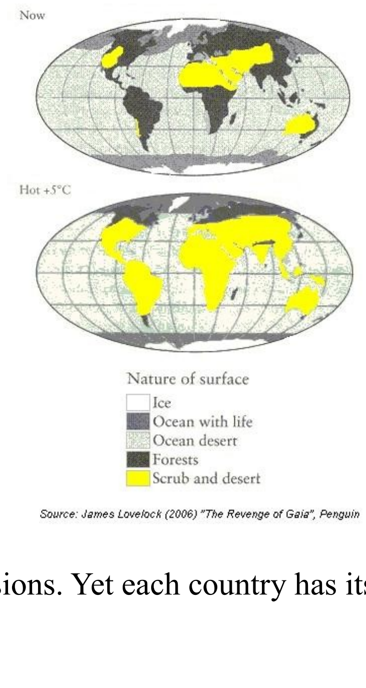
An increase in global temperatures of two or three Celsius will alter the Earth drastically and irreversibly. All coral reefs would be destroyed. The Greenland ice sheet melt would be irreversible, leading to an eventual sea level rise of seven metres. The earth's heat circulation system may shut down and the Amazon rainforest would collapse, releasing more carbon dioxide. Hundreds of millions of people would face drought and starvation.

In the 10,000 years from the end of the last ice age to 1750, just before the start of the industrial revolutions, global carbon dioxide concentrations were static at around 275-280 parts-per-million by volume (ppm). The concentration is now 388ppm (Tans 2010), and rising at 2ppm per year. Once other greenhouse gases are accounted for, the concentration is approximately 430ppm CO2e rising by 3ppm per year (Stern 2009). At current rates, by 2050, we will have doubled pre-industrial CO_2 levels (IPCC 2007b), leading to a temperature rise of approximately 3 degrees Celsius above the pre-industrial level. With strong industrialization, expected in the developing world, by the end of this century, total greenhouse gas concentrations could be equivalent to a quadrupling of pre-industrial level, leading to temperature rises of six degrees or more.

Impacts Of Climate Change

For a five-Celsius warming, much of what is now forest or fertile farmland would become scrub or desert (Lovelock 2006).

How would we feed the 9 billion people expected to be on the planet from 2050 (United Nations 2009)? The temperature would continue to increase for a century or more, and sea levels would rise for a thousand years or more (IPCC 2007a). For those who say that we should worry about other human or environmental problems, I say: Global Warming has the potential to make all these problems much worse, if we do not act now.
So act we must.



Source: James Lovelock (2006) "The Revenge of Gaia", Penguin

International Agreements Are Difficult

Many have sought international agreement to reduce carbon emissions. Yet each country has its own individual needs, and nations are unwilling to sign agreements they cannot easily keep. We need to act with or without international agreement.

2. Possible Solutions

Energy Efficiency Cannot Eliminate Energy Consumption

Some say that energy efficiency is the solution. It is easy to turn a light bulb off. Yet once these easy savings are gone, it becomes increasingly costly to use less energy. And we must consider the fast growing giants of China and India. Who are we to say they must remain poor? In our industrial revolution, as steam engines improved, more rather than less coal was burnt, an effect known as Jevons' Paradox (Jevons 1879).

Renewable Energy Should Be Used But Is Limited

Some say renewable energy is the solution. Yet, besides their expense, wind or solar or energy crops cannot produce enough energy for economies with a high energy consumption per unit area. Some in the environmental movement might doubt that we want a large, modern, urban economy, but this remains a minority view. The Tyndall centre have estimated the total british renewable resource as 334Twhe/year or 38GW (Watson 2002); that's about 16% of our total final energy consumption. Wind energy, the most promising of UK renewable power can generate economically about one tenth of British energy needs (and only produces anything when the wind is blowing).
Solar energy from far away deserts is more promising (MacKay 2009), and with political collaboration could potentially contribute significantly to European and specifically British needs. But even with a very large concentrated solar programme, it seems likely that nuclear power would still be *additional* to any renewable energy efforts.

The 'Tragedy Of The Commons': What Can Compete With Coal On Cost?

An answer needs to be found not only for the UK, but also for the rest of the world. Yet this is not easy. Unless we invest in the correct technologies, we face a `tragedy of the commons' (Hardin 1968) on a global scale, where each country goes its own way and the planet goes to hell. Even if the UK were to reduce its energy consumption, would China and the US follow suit? Will China pay to fit Carbon Capture and Storage on its emissions?

Coal and nuclear are close substitutes. They both provide reliable baseload power at low cost. In other words, if we don't have nuclear, it is likely that we will have more coal, as revealed by the following news story about Germany, from *The Independent* (Tony Paterson 2007),

> "A €30bn (£20bn) scheme for the construction of 26 new coal-fired power stations by 2020 has been approved by Ms Merkel's grand coalition, as the country moves to abandon nuclear power."

It is probably *possible* to solve climate change without nuclear power – but is it *likely*?

3. Nuclear Energy

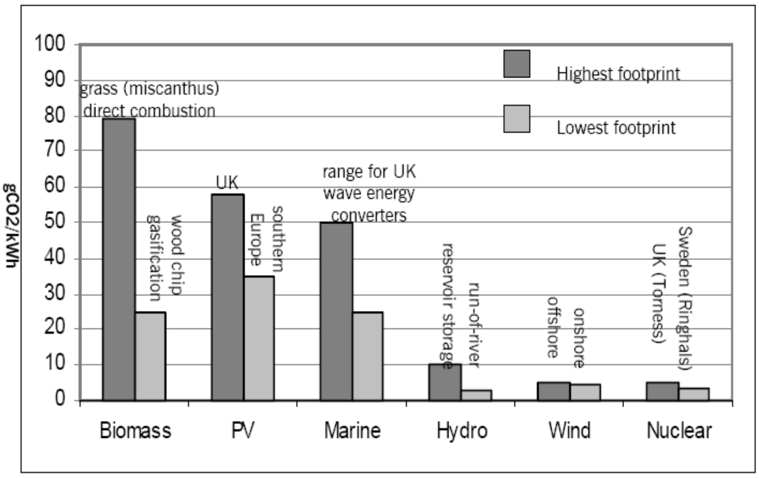
Fuel Availability

There IS a solution that is attractive for all the major economies of the world. This is found in modern, safe nuclear energy. One kilogram of Uranium generates 40,000 times more electricity than a kilogram of coal. Proven resources are 85 years, estimated resources (what's actually in the ground) of 320 years: including seawater and thorium 8000 years; future fast reactors or fusion reactors perhaps ¼ million years (Price & Blaise 2002). It is mined in stable, trading countries such as Australia and Canada.

Nuclear Is Low Carbon

The following graph from the Parliamentary Office For Science and Technology (POST 2006)shows the carbon footprint of nuclear energy in comparison to other low-carbon sources:

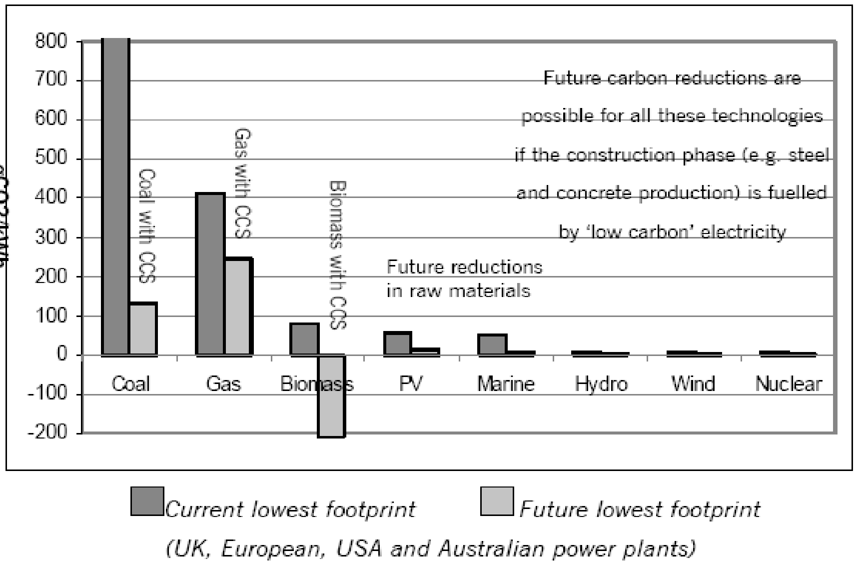
Figure 2. Range of carbon footprints for UK & European 'low carbon' technologies



*Source: DTI, UK Elsayed et.al., **2004*** | *Source: Northumbria Uni UK, **2006** (based on Utrecht Uni study **2000**)* | *Source: Carbon Trust UK **2006*** | *Source: WEC non-alpine European **2004*** | *Source: Vestas, Denmark & BWEA, UK **2005*** | *Source: Torness, UK **2006** Ringhals, Sweden **2004***

Both renewable and nuclear energy have a carbon footprint low relative to fossil fuels, as shown by the following graph from the same publication:

Figure 3. Current and future carbon footprints



The issue of the emissions from nuclear energy is discussed in detail in the POST report, which concludes that the emissions from current nuclear power stations at 5gCO2/kWh (around 1% of the emissions from gas and 0.5% of those from coal. Low grade ores of 0.03% (at which level, uranium reserves are substantial) would raise the footprint only slightly to 7gCo2/kWh *(ibid.)*.

Safety and Security

Modern nuclear plants are very safe and secure, and produce very small amounts of waste, securely managed (Comby 2001; Comby 2005). Some studies suggest that nuclear is already the least expensive energy source for the UK.(Royal Academy of Engineers 2005), although other studies suggest that nuclear requires a minimum carbon price in order to be competitive. The more reactors are built, the more the world will `learn by doing', making nuclear better still. America and China could then choose a zero-carbon future instead of returning to dirty coal.

4. How Much Can We Build?

An immediate transition to a zero carbon economy could be achieved. For example at peak construction France built over 4GW of power per year. Sustaining 5GW per year for 20 years, we could build 100GW of simple and safe nuclear power stations, over the next two decades. These would heat our homes, support our industry and power clean, quiet, electric cars. The cost would be less than what we currently spend on the armed forces. Furthermore, the *additional* cost, would be even smaller.

5. Conclusions

Climate Change Targets with Renewable Only Energy Are Not Credible

When the oil and gas run out, humanity will need a fuel to turn to. We could exploit the Arctic for tar shales. We could burn even more coal. Yet such options would be catastrophic for the earth and for our future. Nuclear energy is already the best way to fuel Britain. Let's work with the rest of the world to ensure a happy future on Earth for all. And let's keep the Amazon Rainforest, and our green and pleasant land.

6. Appendix: False Arguments against Nuclear

"Nuclear Faces An 'Energy Cliff' – CO_2 Emissions Are Very Large For Low-grade Ores"

I have already earlier mentioned that the life-cycle greenhouse gas emissions of nuclear power are around 5-7gCO2/kWh (compared to 800-100gCO2/kWh for coal and 400-500gCO2/kWh for gas (POST 2006). Here is the passage in full:

> *"Nuclear power generation has a relatively small carbon footprint (5gCO2eq/kWh) (Fig 2). Since there is no combustion, (heat is generated by fission of uranium or plutonium), operational CO2 emissions account for <1% of the total. Most emissions occur during uranium mining, enrichment and fuel fabrication. Decommissioning accounts for 35% of the lifetime CO2 emissions, and includes emissions arising from dismantling the nuclear plant and the construction and maintenance of waste storage facilities. The most energy intensive phase of the nuclear cycle is uranium extraction, which accounts for 40% of the total CO2 emissions. Some commentators have suggested that if global nuclear generation capacity increases, higher grade uranium ore deposits would be depleted, requiring use of lower grade ores. This has raised concerns that the carbon footprint of nuclear generation may increase in the future (see Issues) A 2006 study by AEA Technology calculated that for ore grades as low as 0.03%, additional emissions would only amount to 1.8 gCO2eq/kWh. This would raise the current footprint of UK nuclear power stations from 5 to 6.8 gCO2eq/kWh (Fig 3). If lower grades of uranium are used in the future the footprint of nuclear will*

increase, but only to a level comparable with other `low carbon' technologies and will not be as large as the footprints of fossil fuelled systems."

The Sustainable Development Commission, published an evidence paper (2006) collating evidence collating a large number of scientific papers and reports on the carbon footprint of nuclear. 29 out of the 31 studies suggested a carbon footprint in the range 2-40gCO2e/kWh (the remaining two studies considered either old reactor design or old enrichment technologies).

Some campaigning organizations such as Greenpeace and commentators such as David Flemming (Flemming 2007) have quoted a website that claims to deny that nuclear power is not genuinely low-carbon (Storm van Leeuwen & Smith, P 2005). The website argues, that, where the majority of world resources lay, at concentrations around 0.03%, the energy required to extract Uranium, and therefore the greenhouse gas emissions would be prohibitive.

However, this paper has been comprehensively debunked (NuclearInfo.net 2009):

> *"Employing Storm van Leuven and Smith's calculations predicts that the energy cost of extracting the Olympic Dam mine's yearly production of 4600 tonnes of Uranium would require energy equivalent to almost 2 one-GigaWatt power plants running for a full year (2 Gigawatt-years). […] This is larger than the entire electricity production of South Australia and an order of magnitude more than the measured energy inputs." The Rossing mine has a lower Uranium concentration (0.03% vs 0.05% by weight) than Olympic Dam and the discrepancy is even larger in the case of Rossing. [...] SLS predict Rossing should require 2.6 Giga-Watt-Years of energy for mining and milling. The total consumption of all forms of energy in the country of Namibia is equivalent to 1.5 GigaWatt-Years, much less than the prediction for the mine alone. Furthermore, yearly cost of supplying this energy is over 1 billion dollars, yet the value of the Uranium sold by Rossing was, until recently, less than 100 million dollars per year. Since Rossing reports it's yearly energy usage to be 0.03 GigaWatt-years, SLS overestimates the energy cost of the Rossing mine by a factor of 80."*

In summary, I see no reason to doubt the POST estimate (POST 2006) of 5-7gCO2e/kWh.

"Nuclear Electricity Crowds Out Investment in Renewable Electricity"

Our Energy supply is 85% Fossil Fuels. Nuclear and renewable electricity are different. There is no reason why you cannot have both. In the UK, new nuclear will compete in the open market against fossil fuels If we are to make the changes required, we might need both renewable and nuclear electricity, as well as fossil fuels with carbon capture, if available.

"Nuclear Locks Us In To A Centralized Energy System"

Nuclear aids "System Change" Nuclear energy provides the backbone - always on. This security would allow low-carbon electric transport and storage systems to be developed.

"Nuclear Energy Is Not Sustainable"

It is true that nuclear resources are finite, but they are still relatively large. Booked reserves are 85 years at current rates; 300 years estimated. A 10-fold increase in nuclear use. Twice as much thorium as Uranium (Tripling resources). Use of a breeding cycle would multiply resources by a factor of 40.

What is important is not whether an energy source is 'resilient' or 'sustainable' in isolation, rather whether an energy source contributes to the resilience and sustainability of the whole system. On this front, nuclear is likely to contribute positively, both in conserving scarce fossil fuels, ensuring energy security and reducing greenhouse gas emissions.

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