SHOULD WE USE NUCLEAR ENERGY TO TACKLE CLIMATE CHANGE?[1] (Speech)

One of the most controversial questions is whether we should use nuclear energy in our bid to tackle climate change. This document argues that we should, at least in the UK.

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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 natural gas from Nigeria, North Africa, or Russia? 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).

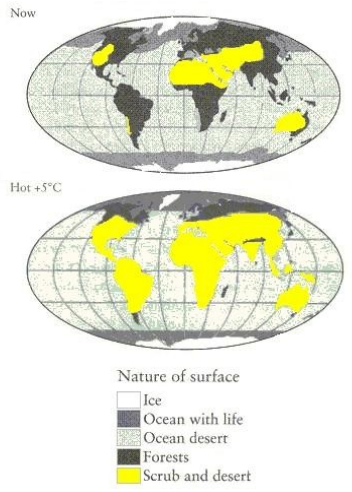
Urgency of Issue

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, and 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).



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

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.

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.

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 the

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 Euro30bn (£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.”

Nuclear Energy

Density

Yet 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. It is mined in stable, trading countries such as Australia and Canada.

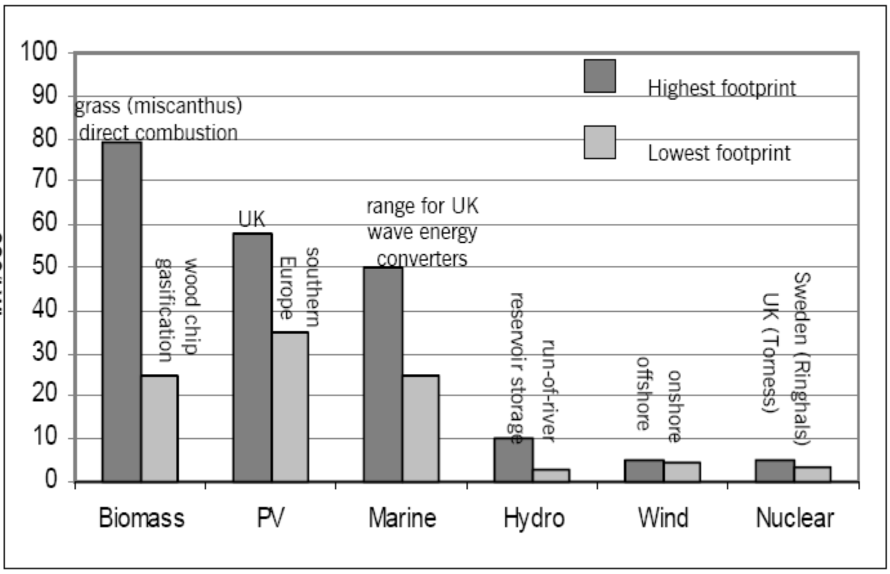
Nuclear Is Low Carbon

The following graph from The Parliamentary Office For Science and Technology (Sustainable

Development Commission 2006b) shows the carbon footprint of nuclear energy in comparison to other low-carbon sources:

Lifecycle Emissions of Low-Carbon Electricity Sources

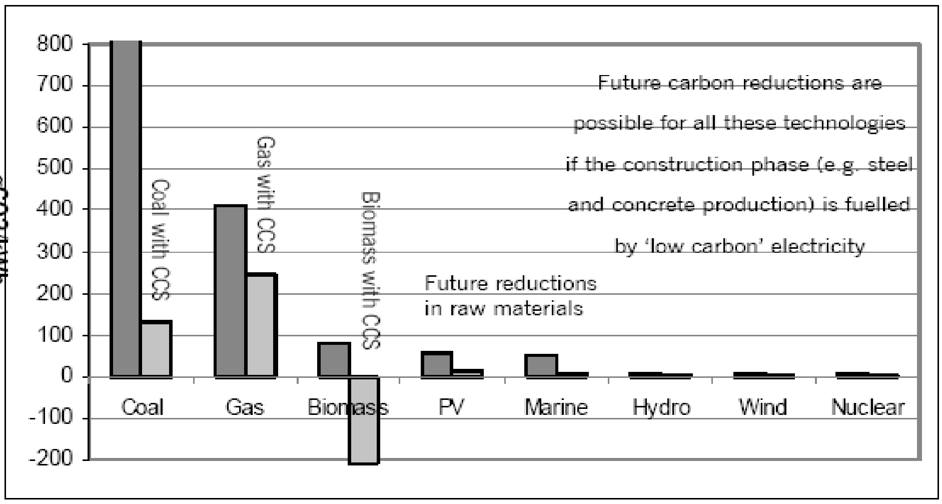
Figure 2. Range of carbon footprints for UK & European 'low carbon' technologies



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



Current lowest footprint *Future lowest footprint*

(UK, European, USA and Australian power plants)

The issue of the emissions from nuclear energy is discussed in detail *(ibid.):*

"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."

Safety and Security

Modern nuclear plants are very safe and secure, and produce very small amounts of waste, securely managed. They are already the least expensive energy source for the UK.(Royal Academy of Engineers 2005) The more that 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.

False Arguments against Nuclear

"Nuclear Crowds Out Renewables"

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 renewables 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 Is Not Sustainable Because It Relies On Finite Resources"

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.

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

I have already earlier mentioned that the lifecycle greeenhouse 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).
The Sustainable Development Commissions, published an evidence paper (Sustainable Development Commission 2006a) 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 campainging organizations such as Greenpeace and commentators such as David Flemming (David Flemming 2007) have quoted a websitethat 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 Energy Is Not Sustainable"

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.

Conclusions

How Much Can We Do?

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 one hundred 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.

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.

Appendix: Response to the Commission for Sustainable Development report on the future of nuclear energy, March 2006.

The commission for sustainable development (CSD) has produced an important and timely report into the UK's future energy needs (Sustainable Development Commission 2006b). It acknowledges that nuclear is a low-carbon technology with an impressive UK safety record, which could contribute to stabilising CO_2 emissions and add to the diversity of the British energy supply. Yet the commission's report argues in the final instance against the construction of a new generation of nuclear power plants. Its overall conclusions must therefore be considered in conjunction with the scientific evidence pointing to ongoing climate change and the necessity for the security of future UK energy supplies.

Climate scientists predict significant environmental consequences such as the shutting down of the Gulf Stream, the collapse of the Amazon rainforest and the irreversible melting of the Greenland ice sheet, unless immediate, sustained, and significant action is taken to curtail the emission of greenhouse gases (GHGs) such as carbon dioxide (CO_2) (Schnellnhuber & Cramer 2006). The CSD, along with all environmental non-governmental organisations, and all three major political parties, accept the importance of the warnings of climate scientists and the relatively short window of opportunity (perhaps one decade) to turn around global habits and avoid 'dangerous' climate change. Such global action should be consistent with, but not limited by, the 1997 Kyoto agreement on climate change and the recent Copenhagen accord.

The UK will probably meet its Kyoto commitments due to the large-scale switch in the 1990s from coal to gas-fuelled electricity generation, which emits less CO_2. Further reductions (the UK aims for a 60% reduction on 1990 levels by 2050) must involve either a) using less electricity b) capturing the CO2 generated in gas turbines to store e.g. in aquifers under the north sea, or c) a large scale switch to a carbon-free source of electricity. In fact, in order to achieve such ambitious targets, it is probably necessary to do all three of these things. Furthermore, given the political concerns and resource constraints connected with gas imported from Russia, it seems that there are significant uncertainties in cost and security of supply, which would count against the reliance on this source of power over the medium and long term.

Nuclear is the only viable non-carbon emitting energy source for secure 24-hour-a-day ('base load') UK energy requirements. Wind power, the main renewable alternative, produces energy only when it is a windy day. It could be an alternative to gas for 'peak' load (when, during the day, electricity demand is particularly high and the wind is blowing) but is simply not reliable enough for base load requirements. Although it could be stored, for example in new pumped storage schemes in Scotland, this adds significantly to the overall cost of a delivered unit of energy. Even wind projects capable of generating a relatively small amount of electricity can attract massive local opposition (perhaps not as much as nuclear on new sites; but the amounts of electricity generated for wind are smaller)At reasonable cost, domestic renewable electricity can generate only about 10% of our total energy (Inter-departmental Analysts Group 2002). Coal with carbon capture and storage cannot yet capture more than about 85% of the total CO_2 from burning coal. In a fossil fuel dominated world all carbon-free energy sources at present compete with fossil fuels - not with each other

The CSD criticises nuclear on the grounds that:

1. it centralises energy supply
2. it undermines measures to reduce energy efficiency,
3. the problem of long term waste has not been solved
4. it is (according to the CSD) impossible to deny nuclear technology to less stable countries if the UK nuclear industry is expanding and
5. there are risks in construction cost which would be borne by the taxpayer.

Yet each of these criticisms is either misguided or not relevant to the issue of the renewal of the UK's nuclear generating capacity.

Making energy use sustainable and decentralising its production are both important and necessary. Yet investment in nuclear power in no way detracts from these initiatives. Even with a future of domestic micro generation of electricity, a significant amount of centrally generated power would always be required for industry, commerce, rail transport etc. Government incentives (taxes and subsidies) to promote efficiency without consumers increasing fuel use elsewhere (e.g. 'carbon taxes') would actually make nuclear energy more rather than less economically attractive.
It is true that the UK has so far failed to find a solution to the long-term disposal of high- and intermediate-level nuclear waste. However, there are geologically suitable sites. A political solution does need to be found for existing and future nuclear waste. But the political decisions, costs, and security requirements for this solution are mostly independent of decisions regarding renewed nuclear power plant construction. (The variable costs and risks of storing extra nuclear waste in a repository are small compared to the fixed and already sunk costs and risks of having to set up such a repository in the first place.) Furthermore, this is all less global risk than using fossil fuels. Great Britain already has a network of nuclear sites (where future reactors would be built) and an existing infrastructure for transporting and temporarily storing nuclear material. A well-funded domestic nuclear energy industry would be on balance more secure and more likely to contribute positively to international stability than either a declining sector or the absence of a nuclear industry in this country.

Great engineering improvements have been made in recent years in both reactor design and use. Such improvements mean that the nuclear industry is now globally competitive. (Sustainable Development Commission 2006b) Reactors of the Westinghouse AP1000 or European pressurised water reactor (EPR) types have already achieved regulatory approval in countries such as the US and Finland. They have a modular design and include 'passive' safety features, reducing both cost and complexity. Construction periods of 5-6 years are possible in the absence of regulator-induced safety modifications.

Current UK nuclear energy capacity is 10GW, of which almost all are older reactors that are scheduled to be retired in the next two decades. Typical UK base load energy requirements are approximately 25GW in summer and 35GW in winter. All of this could potentially be provided by nuclear power.

A renewed nuclear build could involve an initial fixed-cost contract of £2-3bn for 2GW of capacity offered to perhaps both Westinghouse and EPR. The best of the two bids would then be contracted to build the remaining approximately 30GW of base load capacity over the next 10-15 years. Does' ~ ' mean approximately? For such a program, costs of less than £1bn per 1GW power station and construction periods of 5 years or less are viable. If an appropriate regulatory framework is set up, nuclear reactors could be funded privately or through public-private-partnership (PPP) schemes, rather than directly through the public budget. A clear statement of intent would also allow universities and the nuclear industry sufficient time to act to avoid skills bottlenecks.

Large scale concerted practical action amongst the biggest economies (G8 plus China and India) could avoid the worst of the potentially devastating environmental consequences of climate change. These ten countries already have nuclear technology, and could massively reduce their GHG emissions through the renewal and expansion of their nuclear industries. The UK has consciously taken on a leadership role to avoid 'dangerous' climate change, in recent presidencies of the G8 and EU, and in the hosting of an international conference (Schnellnhuber & Cramer 2006). By re-embracing nuclear power now, the UK could both meet its long-term targets and send out a influential and timely message to the leaders of the other major economies.

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