The Nuclear Option

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SLIDE 1

Energy and human life are closely linked. Civilisation, past, present and future, depends on energy to provide the facilities we need.

The world we are creating today will determine the outcome of a number of issues and conflicting demands, which we are only now beginning to identify. The way we resolve these with Engineers playing a major role in the process, will fashion the world in which you, your children, your grandchildren and your great-grandchildren will live. But the immediate challenge, during our lifetimes will be to provide enough energy, water and food, to raise the standard of living of the ever increasing world population without "imperiling our irreplaceable environment".

SLIDE 2

In the last few years global warming, caused by the build up of greenhouse gases has been the issue on everyone's agenda. To be blunt, as stated by Sir David King, the Government's Chief Scientific Adviser, it is a bigger global threat than terrorism.

SLIDE 3

Carbon dioxide accounts for half of the human race's contribution to global warming.

SLIDE 4

Carbon emissions have been rapidly increasing since the industrial revolution. In 2002 carbon equivalent emissions from human activity were about 6,500 million tonnes per year with the prediction this would double by 2050.

So we know what is causing the problem. But is there a cure?

The UK is committed to reduce its 1990 greenhouse gas emissions by 12.5% by 2010 and the February 2003 energy White Paper called for a 60% reduction by 2050.

Carbon dioxide emissions come from various sources, such as you or I breathing, the natural world and the burning of fossil fuels, either in the generation of electricity or directly in transport.

This evening I will focus on the supply of electricity, which is responsible for 16% of worldwide carbon dioxide emissions. For the

developed world this proportion is greater. For example, in the UK, electricity generation from fossil fuels is responsible for 33% of our emissions.

Let's try to put this in context. Everyone hold your breath for 20 seconds. Start now. Breathe in.... Now, breathe out. Hard wasn't it! Let us assume that you have not cheated and did not emit carbon dioxide for 20 seconds. Assuming we have 300 people in the room, then you have all just saved about three ounces of carbon dioxide from entering the atmosphere.

Compare this to the 120 tonnes of carbon dioxide, which the UK fossil fuelled coal and gas power

stations have emitted over the same period. In order to save the emission of that much carbon dioxide I would have to be giving this lecture to about half a billion people and get them all to hold their breath.

SLIDE5

Because of nations where rapid economic change is already
under way, population on a global basis will increase from its present level of 6 billion to over 9 billion by 2025.

This brings with it a greater degree of urbanisation and increased demand for energy.

SLIDE 6

In 1950 only New York had a population of over 10 million. By 2015 there will be 21 cities of more than 10 million, whilst the number with populations between 5 and 10 million will go from 7 to 73. Asia and Africa, currently two-thirds rural, will be half urban by 2025. And, people are living longer, which also puts an increasing demand on the world's resources.

Of this global energy demand, electricity will increase faster than primary energy demand. So what are the sources of fuel that will be used to produce this electricity?

SLIDE 7

The current world demand for electricity is heavily dependent on fossil fuels with coal at 38%, gas 17% and oil 8% whilst hydro is 17% and nuclear is 17% and renewables are minimal - the dependence on fossil fuels will intensify. What is significant is coal produces twice the quantity of CO2 than does oil or gas whilst hydro and renewables produce far less CO2 with nuclear producing only 0.4% of that produced by coal.

The Asian nations account for about 30% of the world's coal reserves, China alone has 11 % of the total and India 6%. How will they produce their electricity and energy needs? Mostly from coal. For example, in the case of China, 68.3% from indigenous coal this year.

We cannot deny - nor would we wish to - the developing nations their chance to improve their standard of living. But if they increase energy consumption at the rate suggested, using their indigenous reserves of fossil fuels, emissions of carbon dioxide will rise well above sustainable levels. If this happens, without any reductions elsewhere, the world will destroy its own environment.

SLIDE 8

Many people, politicians as well as engineers, face this challenge now to convert natural resources into a form of energy which will least affect the environment.

Power engineers, like myself, can produce electricity from a number of sources, none of which are totally environmentally benign.

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Malcolm has told you about wind power. In reality, none of the so called "benign" energy sources can provide a significant contribution to the global demand for energy. In fact a recent study predicts that renewables, other than hydro, will only contribute 4.4% of the world's electricity by 2030. In the UK to meet our target of 60% reduction in greenhouse gases, by 2050, assuming no change in technology, we should use only 30% of fossil fuel for power generation. So even if nuclear stayed at the present figure of22%, renewables would have to be almost 50%. Clearly an impossible target.

So for the next few decades, there are only a few realistic options for reducing carbon dioxide emissions from electricity generation:

Expand the use of renewable energy sources such as wind, solar, biomass and geothermal;

increase the efficiency of electricity generation and usage;

capture carbon dioxide emissions at fossil-fuelled stations and permanently store the carbon dioxide;

use of carbon offset permits;

increased use of nuclear power;

or the rationing of electricity, which would not be very popular.

Against the time scale we face, only nuclear power offers a long-term environmentally acceptable solution, able to produce the quantity of energy that the world will need in future.

SLIDE 10

To put matters in context at this moment more than 22% of the UK's electricity is produced by nuclear power, including that imported from France via the cross channel cable.

Had all that power been produced by fossil fuel, a staggering additional 50 million tonnes of carbon dioxide would have been pumped into the atmosphere per year. The saving of CO2 emissions by the UK's nuclear power stations is equivalent to allowing 120 million people to breathe continuously. It would mean taking 50% of British cars off the road to make equivalent savings.

SLIDE 11

Of the six billion people in the world only two billion have reliable access to electricity, two billion have unreliable access, leaving two billion with little or no access of whom one billion live in slums. 2.4 billion people are dependent on wood, crop residues and dung to cook their food. Electricity demand worldwide is increasing more rapidly than overall energy use and is projected to grow by 2.8% per year to 2010 and by a massive overall 85% by 2020.

SLIDE 12

Today nuclear power provides over 16% of the world's electricity, almost 24% in OECD countries, 35% in the ED and 22% in the UK.

SLIDE 13

More than 30 countries rely on nuclear power to meet their energy needs. In France nuclear supplies 78% of the electricity and when I was at British Energy we supplied 35% of the UK's electricity, including 50% of Scotland's electricity.

In 2004 there were more than 440 reactors operational worldwide and many of these were undergoing upgrading to increase their output. There are 29 more under construction and almost another 50 more planned in 11 countries. The majority of these reactors are PWRs.
Today, the world produces as much electricity from nuclear energy as it did from all the other sources combined in 1960. Civil nuclear power can boast over 11,000 reactor years of experience. With such a track record it does make you wonder what all the fuss is about in the UK where it is obvious new nuclear build is needed but it is politically unacceptable to build more. I'll return to why later and contrast the UK scene with that in Finland.

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Currently in the UK there are 8 Magnox, 14 AGR and 1 PWR reactors operational. The Magnox are being phased out and, unless there are further plant life extensions, the AGRs will start to close between 2008 and 2023.

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So without some immediate new nuclear build this will leave the 1200 MW PWR at Sizewell B as the only nuclear capacity in the UK, a mere 3% of our electrical energy requirements.

SLIDE 16

So what are seen as the current problems that count against new nuclear generation in the UK?
These fall under the headings of

Economics;

Disposal of nuclear waste;

Safety; and
Proliferation

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Decommissioning is no longer regarded as a technical problem as there are currently 21 reactors that are being decommissioned in the UK and, as a result of experience, costs are reducing.
The early days of nuclear power generation in the UK did not live up to the initial promise of providing electricity "too cheap to **meter" when the Queen opened Calder Hall.**

SLIDE18

This was because of the high capital costs arising from the insistence to have different non-standard designs, high fuel and reprocessing costs, poor plant performance and high-operating overheads. There was also the fact that nuclear had to take into account waste disposal and the final decommissioning costs. In contrast coal and gas took no account of the effects of acid rain and global warming. Thus nuclear was tarnished with the image of producing expensive electricity. However by 1999 Nuclear Electric had significantly improved the performance of its plant, negotiated lower fuel and reprocessing and storage costs and markedly reduced its overhead costs.

SLIDE 19

All this resulted in the costs per unit generated dropping from 2.77p in 1993 to 1.99p by 1999. Today the economics are even better with improved reactor load factors increased fuel burn and extended fuel cycles. Nevertheless, nuclear was still more expensive than combined cycle generation using gas as the fuel. But the fuel costs in a nuclear station are only 15%-20% of the operating cost whereas for a gas fired station the fuel is 60% of the operating cost, so that any increase in gas price can make this type of generation very uncompetitive. And indeed things have moved on and the economics have changed.
As Malcolm has explained the Royal Academy of Engineering carried out an authoritative study in March 2004 on the costs of generating electricity in the UK this took into account capital costs, running costs, fuel, and maintenance costs. Decommissioning costs were assumed to be neutral except in the case of nuclear where these costs were allowed for. In the case of wind, the cost of standby generation was included.

SLIDE 20 The results are shown in the slide. For baseload plant, the costs of nuclear are marginally greater than those of combined cycle turbine plant.

SLIDE 21 However, the UK Government is about to penalise those who emit carbon dioxide and this slide shows the potential generating costs once carbon emission taxes, based on £30 per tonne, are taken into account. Here nuclear generation is the clear winner.
And, as we will see later, current designs of nuclear reactors, are being considerably simplified, thereby reducing the capital build times resulting in less financing costs.
In addition these new designs produce less waste which in turn reduces back end costs.

SLIDE 22

What about waste?

SLIDE 23 The main concern of environmentalists is the high level waste but, as the slide shows, the amount produced is very small. All of the high level waste produced to date from the civil and military programmes in the UK, before vitrification, would fill only four double decker buses.
This (SHOW EXAMPLE) piece of black glassy material is what vitrified waste looks like. It would contain the high level waste from the fuel needed to generate a lifetime supply of electricity for one person. In other words, we are not talking about pit heaps of waste.
Furthermore, in the UK we have a track record, existing over 30 years, of expertly managing all levels of waste. However, in spite of many learned studies recommending it as a solution we have not yet agreed politically on either the principle or of the location for underground storage. Yet this is now the accepted solution in many countries.
It is also important to realise that the future reactor designs use less fuel and hence produce less waste than previous reactors.

SLIDE 24

This is the fuel requirement of a future 1 GW reactor design, an AP1OOO PWR reactor, compared to that required by the old Magnox reactors to generate the same amount of electricity and the resultant waste will also be of much smaller volume.Ten API000 PWR reactors could replace all the UK current reactors and generate 25% of our electricity needs.

SLIDE 25

Assuming these reactors operated for 60 years the new waste arising would be minimal compared to what is already in existence and safely stored. So the production and storage of waste is not a viable argument against a replacement nuclear programme.

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There are concerns in the UK about nuclear safety.
The UK has an exceptional record in design and operation and hence nuclear safety.
There has never been a fatality due to a nuclear accident in the UK.
Compare this to many other industries such as coal mining, the chemical or the transport industries or the risks of smoking or drinking. 120,000 people die in the UK each year due to smoking. This is a great credit not only to the culture within the UK nuclear industry also but to the independent regulators such as the NII and the Health and Safety Executive and the international organisations such as the World Association of Nuclear Operators.

UK nuclear rectors are all designed with a defence-in-depth approach using multiple safety systems and are designed to be safe even under the impact of a fully-fuelled Boeing 747. Even in spite of the Chernobyl experience, the Ukraine switched on a new 1000MW reactor in 2004 with another one to follow shortly. These reactors will add 18% to the Ukraine's nuclear programme enabling them to export electricity and provide more independence from Russian gas and oil.

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Proliferation is a major consideration
An international response is required to reduce the proliferation risk.
The response should:
Re-appraise and strengthen the institutional underpinnings of the International Atomic Energy Agency safe-guards regime, including sanctions
Guide nuclear fuel cycle development in ways that reinforce shared non-proliferation objectives.

SLIDE 28

So against these concerns what are the advantages of nuclear power? .
In addition to its contribution in preventing global warming, nuclear also contributes to the UK's security of supply. Currently the generation mix in the UK is 32% coal, 23% nuclear, 38% gas, 4% oil and 3% others and renewables. In other words we currently have diversified supply. However, most informed people know there is a lack of coherent strategy for UK future energy demands and that this is now a major concern not only in the UK but globally.

SLIDE 29 In the UK, demand is increasing by 1-11/2% per year, our coal and nuclear plants are closing down, and the market does not see the certain economic returns required to build new power stations.

SLIDE 30

Yet we are subsidising windmills at £50/60 per MWh at a total extra cost to electricity consumers of £30 billion by 2020, more than twice the cost of a 10GW nuclear power programme..

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Without new plant, by 2010 our standby surplus plant margin will have fallen from a secure position of25% to a mere 6%. But worse still, by 2020, we will be almost totally dependent on imported gas supplies, mainly from Russia, as we only have small amounts of strategic gas and oil reserves. And these imports will be at the end of a very long supply chain traversing areas of potential political instability giving rise to risks of serious supply shortages and price instability, particularly when Russia is rapidly becoming the major supplier of oil and gas to China, Korea and Japan. Currently the UK is the highest amongst G8 countries for security of supply because it is almost completely independent of imported fuels.

By 2024 this situation will be completely reversed, the UK will be uniquely dependent on imported gas and so will be the least secure of the G8 countries. We are heading towards a situation where diversity of supply simply means different highly expensive offshore gas suppliers.

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These supplies are linked to oil prices and look where they are going! And we no longer have our own oil. The headline in the FT for Wednesday, 11th August 2004 read "Oil imports exceed exports for the first time in 11 years".

Oil reserves world wide will soon peak as was so clearly demonstrated by Shell in 2004. It is difficult to see how a nation such as ours, that was totally energy self sufficient, with the exception of uranium ore which is in plentiful supply from stable countries such as Canada and Australia, a nation that was blessed with coal, oil, gas and nuclear, that enabled it to ride through a succession of energy crises, including the oil price increases in 1973, and coal strikes in the early 1980s, has allowed itself to be at risk not only on the price of imported energy, that will affect our industrial base, but also has the potential for major

SLIDE 33 blackouts. We must also ask how with an average trade deficit of roughly £4bn a month are we going to pay for all the gas we will need to import? Many other nations have ongoing nuclear programmes to combat these risks. At least seven countries with existing nuclear power programmes, France, Finland. Russia, China, India, Japan, South Korea and South Africa, have plans to build new reactors after those currently under construction. Worldwide, some 28 power reactors with a total net capacity of about 32,000 MW are planned and a similar number are proposed. Rising gas prices and greenhouse constraints on coal have combined to put nuclear power back on the agenda for projected new capacity in both Europe and North America.

So where are we today in the UK?

SLIDE 34 Everywhere I go rational and well informed people understand that, whilst renewables and energy efficiency have a role to play, a new nuclear build programme is the only answer to our rapidly emerging energy problems and associated global warming. Yet, in spite of debates in the House of Lords and warnings by the Government's Chief Scientist, the Government, whose job it is, not that of market forces or private investors, will not grasp the situation, preferring to use words like "keep the nuclear option open" and "leave any necessary decision well into the future" when it will be too late. The energy review in February 2003 favoured renewables and energy efficiency as the way forward, with nuclear put on hold for at least five years.

However it is possible to detect the start of a change of thinking at the opinion formers level, with a spate of newspaper and magazine articles and debates supporting continued use of nuclear power in the UK.

Last year, Professor James Lovelock, the scientist and Green guru, author of the Gaia hypothesis, emphasised there is simply not enough time for renewable energy to have an effect and that only a massive expansion of nuclear power could check runaway global warming.

The Prime Minister in July 2004 revealed he had fought long and hard to make sure the nuclear option was not closed off and that America was pressuring Britain to look again at a new generation of reactors as the best way to reduce carbon emissions. But he stated that there was still public concern about safety and cost.

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So what are the others doing? In the US an MIT study demonstrated how nuclear is an important option for the future as it already supplies 20% of the US electricity. Indeed, at a time of increased political instability, amongst oil and gas exporters, policy makers in the US find it comforting that almost all the electricity generated in the US comes from domestic fuel sources with, as I mentioned earlier, a considerable increase in coal fired plant.

China, starved for energy, plans a major increase in nuclear power. BNFL Westinghouse, with French/German, Russian and Canadian suppliers are possible vendors for between 24 and 30 nuclear power plants by 2020.

France itself is getting ready to replace its oldest reactors with new designs as 39 of its reactors exceed 40 years of life between 2017 and 2030 which now means they are starting now to get five years experience on a EPR Generation 3 reactor. And, as I mentioned earlier, Finland, Russia, India, Japan and South Korea are also building new reactors.

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The European Union recognise the importance of nuclear.

The European Economic and Social Committee last year issued a definitive report on the issues involved in using nuclear power and made the statement:

"There are problems connected with nuclear power, but it also has clear benefits. Member States take the decisions on the use of nuclear power. However, it is difficult to see how the EU can in future meet the challenges of climate change and ensure energy supply at reasonable prices without nuclear power continuing to make at least its current contribution to electricity generation"

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So what does the UK need to do? The UK's nuclear power stations have a superb safety record and the industry is strictly regulated. New designs, now being proven, will dramatically reduce the costs of nuclear. So undoubtedly now is the time to make a fresh push to convince the public, and hence the Government, of the merits of new nuclear build in the UK. And the public are more in favour of nuclear than MPs believe. IN 1999 MPs thought 83% of the UK public would be against nuclear, whereas the actual figure is only 25%
The Government must play the major role and recognise the danger to our security of supply and the competitiveness of our industry if we do not start a new nuclear build programme in the near future.

So what needs to be done?

To facilitate this they must firstly acknowledge there are no technical problems in building a waste repository and so make the political decision to proceed. There is yet another working party on this topic but this does not report to the Government until 2006. How easy it is to delay decision making by forming a working party!

Currently electricity suppliers buy 3% of their power from renewable energy sources. This figure has to rise to 10% by 2010 by Government decree rising to 15% by 2015 and 20% by 2020. Should a supplier fail to meet these targets they have to purchase what is known as Renewable Obligation Certificates in the open market to make up the shortfall. Because it does not produce CO2 nuclear should be classified in the same way as renewable sources and be part of this scheme. In Canada the Ontario government has already extended tax credits from renewables to nuclear in recognition of its environmental benefits. In addition fossil fuel users have been granted carbon emission limits which if they exceed they have to make up by purchasing Carbon emission certificates. Again, since they produce no carbon dioxide nuclear stations should be granted such certificates, equal to the average coal fired station of equivalent output, to trade and receive income.

The UK Government has already recognised that there is a major skill shortage appearing in the nuclear industry, together with a lack of funds for R&D.
This recognition is vital because if we do not replace the skills that are leaving the industry we will not be able to operate the existing stations let alone act as an informed buyer for future stations.
There is also a major manufacturing, and hence servicing, problem in the UK.
When we built Sizewell B the majority of the equipment was sourced in the UK.
But the major suppliers no longer exist with the result that we will have to import not only the design and project management skills, but also the equipment. If we decide to buy the EPR from the French/German consortium I warn that I see their order book already getting very full into the distant future with orders from Finland, China and the French nuclear replacement programme.
The industry itself needs to do far more to convince the opinion formers of the merits of nuclear. In my opinion it is a myth to think we could influence the entire UK population, but the politicians have got it wrong. As polls in the UK and the US show they overestimate public opposition to nuclear by a large amount.
However, once prices start to rise or there are power cuts due to the shortage of energy, people will start to recognize the benefits of nuclear. Experience in Sweden, where 67% said yes to nuclear, and the USA demonstrates that people change from anti to pro-nuclear but by then in the UK it could be too late!

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No doubt the swing in the US public opinion towards nuclear came about because of the California power cuts. I regret the decision of British Energy to close its visitor centers that did so much good work to attract and educate visitors at its nuclear stations.

Furthermore, the industry needs to state that future build would be on existing sites SLIDE 39 such as Sizewell, where there is a track record of safety and there should be little local opposition. Public opinion is swayed by the way the question is asked. After all would you here tonight rather have more nuclear units on existing sites or be surrounded by a vast number of windmills that, for technical reasons, can only produce limited amounts of our energy needs?

Serious thought needs to be given as to how we can reduce the extremely long and laborious planning approval process. Even allowing for a five year period to go through a public enquiry and other planning permissions and then a six year period to build and commission if we are to replace the existing AGRs starting in say 2015 we should be making the decision to proceed today! Furthermore we need to plan a serious build of at least eight plants to lower the construction costs.

Politicians do not seem to recognize the long time scale required for nuclear approval and build compared to all other types of generation. They feel we can afford to wait several years before making any decision. This is not the case and we are now getting perilously close to literally our last gasp in the UK on the decision time-scale.

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So what conclusions can I draw? Undoubtedly nuclear will play an increasing role in the global energy scene alongside coal and gas. New advanced designs are available now and are being built, with even more advanced designs becoming available by 2035.

Many countries are building new nuclear plant for diversity, security of supply and to reduce the potential of uneconomic energy supplies. In other words, they have coherent energy policies.

It should be a salutary lesson to the UK Government that the US has carried out a major review of its energy policy and established the "Nuclear Power 2010" initiative. This initiative provides government support for reactor development and regulatory changes, both to deliver new nuclear plant by 2010 and to rebuild the nuclear industry skill base in areas which have been dormant since the last order for a new US reactor was placed in the 1970s.

In the UK the phasing out of nuclear stations will mean we cannot meet our emission targets because it is technically and logistically impossible to replace the generating capacity with renewables. The only solution is to replace nuclear with nuclear and retain at least a 25% nuclear component in our energy mix. To do so will require 10 new stations of 1200MW to be commissioned between 2010 and 2025. Clearly, with the time scale of planning permission and construction, if we started today it would be at least 2015 before the first station would be commissioned and there is as yet still no sign of the political will to start the process off.

The Government, who own BNFL and exert strong control over British Energy, should decide with those companies and other interested parties how to create the regulatory framework to encourage financial investment so that new nuclear build can begin as soon as possible. Designs for this medium term programme are already available. The AP 1000 Westinghouse design is owned by BNFL, and hence the UK, whilst in Europe the EPR is available. From North America, CANDU reactors are a possibility. We need to undertake a review of UK and worldwide manufacturing capability and capacity to build the chosen reactor design and this should include not only Europe, America and Japan, but also South Korea who are now building complete reactor systems.

So what we need the Government to do is:

1. Ask the Nuclear Installations Inspectorate to begin the process of licensing a choice of reactors for construction on existing nuclear sites in Britain
2. Ensure that public inquiries cannot be indefinitely held up by challenges.
3. End the discrimination against nuclear power by exempting it from the climate change levy since nuclear emits next to no greenhouse gases.
4. Designate a site for a long-term repository for nuclear waste.

To do all this requires an informed national discussion about our energy needs and how they might realistically be met. For, don't forget, Ministers who fail to ensure security from blackouts will have to fall on their swords**.**

It is time we recognized that Brian's life blood - electricity - is at risk and we cannot dilly dally any longer. We have dillied and dallied long enough.

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Do you remember those car stickers much loved by the so called ***"greens"*** exclaiming ***"Nuclear power - no thanks!?".***

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In view of the advantages of nuclear surely the environmentalists should now be displaying car stickers ***proclaiming "Nuclear Power- YES PLEASE!".***