Submission to Energy Review

I am responding to the invitation to contribute to the 2001 Energy Review that the Prime Minister has placed under your auspices. I am a professional engineer and have been employed in the energy industries all my working life, from an apprenticeship at Rolls-Royce in the l960's, via the gas industry, to the nuclear industry, in which I have been employed in various roles since 1974. I respectfully request that you please consider my comments.

My allegiances are:

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1 INTRODUCTION

The primary role of the Government is to ensure the wellbeing of its citizens. In the 21st century, this is ensured through electricity as much as through food and clean water. The population of the UK enjoys a comfortable, or even high, standard of living. Our comforts however derive not from our citizens being more intelligent, hard-working or talented than those who subsist in the third world, but from our use of energy, in particular, two hundred years' use of coal, oil, gas and electricity. If these fuel supplies become exhausted or are taken away, we will return to the 'third world' lifestyle that our forefathers knew in the nineteenth century, which means the collapse of our caring systems. Freely available energy enables each worker to be highly productive, to transport goods to markets and to support the young, the sick and the old. Through adequate energy, our productive industries support 11 million pensioners, 1 million in the NHS and millions of other non-producers in education, media, entertainment and other services. To maintain the status quo requires secure energy supplies which, at the start of the 21st century means coal, oil and gas, but above all, electricity.

2 SECURITY

All sources of energy will be important over the next 20 years, as competition increases for the remaining supplies, but particularly electricity, as it takes an increasing share of energy at point of use each year and is used for so many vital purposes. Electricity is not a simple commodity, like apples, water or mobile phones, because it cannot be stored. It must be available when needed. No higher-priced import can be substituted for it. Many would claim that it is the most important commodity used by an industrialised economy (perhaps equal with water).

With electricity, security is more important than cost. In providing future energy supplies, it will be better to have too much plant, than too little. Fuel supplies can be cut off in weeks, but it can take seven years to commission a replacement power station, so the corrective power of the market may be of little value. In the 1990's, Governments relied upon the unseen hand of the market, but a more positive role may be needed in the next two decades. During the next twenty years, all of the remaining large coal-fired stations, together with the Advanced Gas-Cooled Reactors, will be reaching forty years of age and the end of their technical lifetimes. These and other threats to our electricity supplies and related issues are discussed below.

3 CURRENT POSITION

Energy demand continues to increase, despite conservation measures. In the 30 years since the Middle East oil crisis, plant and process efficiencies have improved, but as these have brought down the real cost of energy, more has been consumed. Consumption in the UK has almost doubled since 1970. In those 30 years, the efficiency of internal combustion engines has improved by about 50%. However, consumers have chosen to buy cars with much larger engines, to give better performance for the same cost, so that total fuel consumption has increased by about 80%.

Electricity consumption has increased by a similar amount, 1 to 2 % per annum, through boom and recession alike. Currently, supplies of electricity in the UK are secure (>99.98% availability), achieved through redundancy and diversity. Redundancy is achieved by a margin of about 20% of *reliable* capacity connected to the grid, compared with maximum demand on the coldest winter day (58GW). Diversity is very difficult to claim in the rigorous sense that would be used in a risk or safety analysis. True diversity means no significant common mode failure risk. We have this up to a point but, as the petrol crisis last year showed, too often, fuel supplies are vulnerable to unexpected threats. The diversity in fuel for electricity consists as follows.

- Natural gas from the North Sea
- Coal - mostly deep-mined with increasing quantities of imports.
- Imports - About 25% of the electricity consumed in the South East and London comes from French nuclear reactors.
- Renewables only about 2% of routine demand, most of which is historic hydro.
- Nuclear power

The following section looks at the prospects for all these supplies in the next 20 years.

4 FUTURE SITUATION

4.1 Gas

UK oil and gas production will be in steep decline in ten years. It is most unlikely that large oil deposits remain undiscovered anywhere on Earth, that could affect the dominant OPEC supply position. The continued growth of demand from Europe, India and China will keep the upward pressure on oil prices and hence on gas prices (increased by 50% in the last year.) After the decline of North Sea fields, imported oil and gas will become more important. These may suffer at the same time from common mode interruptions due to political actions, supply companies' commercial decisions or terrorist groups, since the countries that could replace North Sea Gas - Algeria and FSU are not stable democracies. (There will be fierce competition for Norwegian supplies.) These threats are not unique to the United Kingdom, Western Europe is becoming ever more dangerously dependent upon imported oil and gas. The price and availability of gas is of crucial importance within the UK, as one third of our electricity is generated by Combined Cycle Gas-fired Plants and it is also the heating fuel of choice for 20 million domestic consumers, with no obvious replacement.

There will be some growth in electricity from new CHP schemes. However, encouraging the expansion of CHP schemes is a two-edged sword as, although such plants use energy efficiently, the same natural gas will be in demand for decades for domestic heating. Shortages would see problems akin to the coal crises 1947 and 1961, with fierce competition for a single fuel.

4.2 Coal

Coal use has been in decline for a decade and can be substituted as the price of gas increases. However, it is doubtful if the prospects are sufficiently attractive for private capital to support new mine developments. There are 249,000 claims for compensation being processed in the present scheme from former miners. Such problems will deter shareholders from investing in new collieries. It will be very hard to recruit employees to work in dirty conditions underground, when they have been brought up in a world of electronic offices and 24 hr supermarkets. Imports from Australia or USA are another option, but increase vulnerability to external threats. Many of the large coal-fired plants are reaching the end of their economic lives and EC Environmental legislation is almost certainly too strict to allow their replacement like-for-like. In the scenario in which oil and gas are in short supply, there are other serious implications. Coal will have to replace oil as a chemical industry feedstock. Fuel oil and gasoline are just two of the 1000 or so compounds that are produced from cracking crude oil. Our population would still be dependent upon all these materials and the Government might restrict coal burning for power generation.

4.3 Imports

The electricity imports from France cannot be considered secure in terms of decades ahead. Germany proposes to start to close its nuclear stations from 2003 and renewable supplies on their own will not power the might of industrial Germany, so competition for French nuclear electricity is very likely. Imports make up 5-6% of total UK consumption and contribute about 20% to electricity use in London and the South East. The loss of electricity would cause serious embarrassment to the Government. The new London Executive has failed to propose any new schemes that could replace these imports.

When fuel oil supplies are in decline, more use will be made of the railways, especially in London and the South East, increasing the pressure on a reliable energy source for the extra electricity to keep these functioning.

4.4 Renewables

The blind faith in the capacity of renewables to be expanded effortlessly is misplaced, evinced by the small growth that has been achieved over the last few years. There is a presumption amongst people who are not involved in electrical or power engineering, that if a renewable energy system has been tried at prototype level, it can be automatically assumed to be capable of exploitation at an industrial level, with perfect reliability, that all processes will have zero environmental impact and the disposal of end-of-life wastes will present no problems. This is a form of wilful self deception. Some pressure groups put their trust in renewables but they are not a panacea, because:

- their intermittent nature necessitates a reliable backup
- having low energy intensity they have adverse environmental impact
- waste quantities are very large for some renewables
- they can adverse effects on grid voltage, frequency and stability
- the siting of the plants would necessitate new north to south inter-connectors

The Government requires a renewables contribution of 10% by 2010, when peak demand will probably be about 70 GW. A steady contribution of 7,000MW would therefore be required from renewables. If 50% of this is wind plant, that is 3,500 MW of steady output. Allowing for 25% availability at the time of peak demand, 14,000 MW of wind plant Declared Net Capacity (DNC) would be required. With an average size of 1 MW, that equates to 14,000 machines, ie about 7 need to be commissioned every working day between now and 2010. This scale of installation is total fantasy. One can undertake similar calculations for biomass, solar and wave power. In every case, the scale of installation is impossible, or the necessary land is not available.

4.4.1 Intermittent Nature

The mean output of wind turbines is only a fraction of the their DNC. If this power source is to provide a high proportion of renewable power, it will be necessary to retain nuclear and fossil-fuel plant to cope with unfavourable wind conditions (speeds too high or too low), with backup permanently available to prevent interruptions to supplies.

Solar heating/voltaics can contribute in a small way to energy demand over a narrow time window, but produce no electricity at night, or during blizzards, freezing fog, thunderstorms or the other times when a school, hospital or water works needs it most. Peak night time demand will soon reach 40,000MW. They can only ever be a small scale supplement to a reliable base load system in a North European climate. The output of small hydro and wave machines is also going to vary in unpredictable ways.

Demand patterns for electricity are well understood throughout the year. Plant availability is declared and through a combination of additional plant and variation of voltage within legally defined limits, supply and demand can be matched and blackouts can be avoided. When renewables contribute more than 15-20% of the grid supply, the matching problem takes on a much more serious dimension. The supply now becomes more unpredictable than the load, risking high levels of voltage variability both above and below the 240v ac value. The sudden increase in power from wind turbines responding to an increase in wind speed, brings a very great risk of serious damage from current surges, as total grid power increases rapidly and voltage limits are met. On the other hand, midwinter anticyclones and fogs would see escalating electrical demand when both solar and wind power output was plummeting. To prevent massive blackouts, it would be necessary to operate a large stock of spinning reserve and require black starts for large gas turbine or other fossil fuel plant. As the mismatch could be tens of GW, it would be necessary to have as much reserve plant available as renewables. All this plant would have to be paid for, maintained and kept in readiness, representing a massive surcharge to the proclaimed *lower* cost of the solar and wind plant. In addition, much of the backup plant would be fossil fuelled and so be contributing to CO_2 emissions. These problems are appearing with the early stages of the NETA arrangements, which require reliable forward predictions of electrical supplies, an area where renewables are severely challenged. (Of course, their unpredictability is of the main reasons why renewables were abandoned by previous generations)

4.4.2 Adverse Environmental Effects

Biomass requires at least lsq.mi/ 10 MW ie 100 sq.mi to replace Dungeness B or one third of Drax. If land area is available on this scale for a monoculture crop, there will be pressure to use it for low intensity farming or for planting a variety of traditional hard wood trees to restore some of our natural forests. Biomass on this scale will conflict with policies to introduce less intensive farming. It would be necessary to cut and transport the materials when demand for electricity is at its peak – ie mid winter, when weather conditions are at their worst. There are also other less obvious hazards. A conflict that would arise if, in a decade, there was another F&M epidemic whilst some power plants in remote parts of rural Britain were dependent upon the transport of biofuels for a large fraction of local power supply. There would be a stark choice between controlling F&M and electricity.

Offshore wave plants have to employ enormous structures to recover natural energy at an economic level. The very largest structures will pose severe environmental threats, such as sea bed sedimentation, coastal erosion, silting of estuaries and impacts on fauna and flora. It should be compulsory to model offshore wave or wind systems weighing hundreds of thousands of tons in great detail before construction, to assess and understand damage to the environment.

4.4.3 Waste quantities

Waste problems have yet to emerge with renewables, because we are only just entering the front end of the life cycle. Being low energy intensity, renewables will inevitably generate large quantities of waste. Solar panels to generate 1000 MW will comprise hundreds of thousands of tons of mixed toxic materials. The production processes have so far received little attention, because of their small size, of the order of tons per week. To scale up to thousands of tons per week would almost certainly exhaust all the presently known supplies of the rare metals and other special materials needed.

The processes used in for example PV manufacture, such as extraction, melting, plating, dissolution, flocculation and filtration, as used in many industries, produce wastes and have to comply with EC

Directives and IPPC. The Environment Agency should be no less strict in dealing with these applications than others, when production is increased to an industrial level. These issues will restrict the rate of development of such embryonic technologies.

There will be similar problems with disposal at the end of plant life (25 yrs). No process plants yet been designed to separate and dispose of wastes at this level. Landfill of the mixed wastes would not be BPEO and would conflict with sustainability policies. Unlike waste from the nuclear programme, synthetic materials from solar panels and toxic metals such as battery lead, cadmium and mercury, do not decay. The precautionary approach should be applied. Unlimited expansion should not be permitted until all the disposal paths for the waste streams are agreed.

4.4.4 Frequency and Voltage Stability

Small scale renewables (mini-CHP, landfill gas, bio-mass, and windfarms) share with other forms of embedded generation the problem that they are connected to distribution networks that are generally designed and operated in radial configurations and are not designed to accommodate active sources of energy. This historic practice is based on the aim of minimising infrastructure costs such as arising for the number of conductors, protection equipment and switchgear size, apart from obviating the need for power flow control. Embedded generation adds to local fault levels and hence, sooner or later, leads to the need for larger switchgear as well as the restructuring of the protective systems.

Frequency is controlled automatically to a certain degree by generators responding and changing power output to correct frequency drift. Many new forms of renewable generation do not provide the expected response to low frequency drift however, exposing users to more severe and more frequent excursions in system frequency without operator intervention. These are most undesirable in an industrial economy with so many computer controlled systems.

4.4.5 Transmission Problems

Both large off-shore plants and wind farms are likely to be sited hundreds of miles from final users. They would often require new transmission lines and protection equipment to be able to contribute effectively. The Scotland/England inter-connector has only a capacity of 1600 MW although this is being enhanced to 2200 MW. However, the full capacity of the inter-connector cannot be used because of a restriction in the capacity of the high voltage grid across North Yorkshire. To remove these limitations will require major investment in reinforcing and expanding the transmission grid (costs to be carried by the consumer-polluter). New rights of way to build such circuits face determined and prolonged opposition from environmental lobbyists; the time spent in public inquiries is already a major factor in transmission planning. In the case of wind power, in the opinion of two of the REC's, only a possible maximum of 100 MW from offshore wind power installations per REC can be accommodated, because of its impact on the networks.

In essence, renewables will introduce many serious problems that were largely eliminated with the establishment of the 132 kV grid system 70 years ago. Certain power matching and stability problems would be faced weekly or even daily at some times of the year as described above, but there are more severe problems.

4.5 Increased Vulnerability with Renewables

If our main electricity supplies become dependent upon the vagaries of the climate, we will be vulnerable to the less frequent, but more severe atmospheric disturbances from volcanic events of the Vesuvius, Sertsey or Mount St Helens type, as well as to floods and droughts of the kind that have destroyed previous civilisations. Renewables such as biomass, solar, wave or wind power are uniquely susceptible to common cause effects and several of the power supplies would be crippled simultaneously. UK death rates from hypothermia are the worst in Europe, with an increase of about 50,000 deaths in the winter compared with the summer. This will be made worse if we suffer electricity shortages from weather-related effects. Realistic fault cases need to be modelled using auditable data for weather patterns and other unpredictable events before renewables are built up to a scale that brings in such risks.

4.6 Nuclear Power

The great advantage of nuclear power is the security that it brings, but it scores well on a range of other factors.

The fuel has no other use
The fuel is available from many parts of the world
The quantities of fuel used and waste generated are very small
The power station sites are very small
The safety record is established and excellent
The economics of the plant are predictable for many years ahead

There are several sites owned by British Energy and BNFL Magnox that could be used for new nuclear reactors. These could be plants larger than 1000 MW, based on Sizewell B, smaller light water reactors such as the Westinghouse AP600 or very small modular reactors. New licensing procedures may be needed to reduce unnecessary planning delays. There is strong electricity growth in the South, with possible sites being Hinkley Point and Sizewell. However existing sites may not be sufficient. There will soon be difficulties in the North, with the sequential closure of the large coal-fired plants on the Trent and the Humber and the reuse of the sites at Wylfa and Chapel Cross should be considered in the very near future.

The only significant issue in connection with nuclear power is the disposal of the small quantities of waste. This is to some extent a red herring, as environmental groups object to all other large power sources because of the wastes they produce eg

- Acid rain from sulphurous gases in oil
- Spoil from deep mined or open cast coal
- CO_2 from gas fired plants
- Toxic chemicals from incinerators
- Areas laid waste by hydro plants

There are also objections to wind power for other reasons, namely land loss, noise and visual damage to landscapes. No usable power source is environmentally benign. It is mainly a question of personal preference. The disadvantages of nuclear power are however much smaller than those of the other options, as repeated studies of the health and environmental effects have shown (EC ExternE programme). Only with nuclear power is the waste generated in sufficiently small quantities to be amenable to an engineering solution.

5 SAFETY

There is no evidence that any member of the public in Western Europe has been harmed by nuclear power, since Calder Hall started almost 50 years ago and nuclear industry workers live longer than the population in general. It is possible to claim that there is a remote *hypothetical* risk of a fatal cancer from the effect of a power plant or radionuclides from a waste store a half mile underground. This risk is trivial compared with the risk from air travel or the medical uses of radioactive materials. The risk has to be balanced against deaths in the extraction of coal, oil rig disasters, the explosion of natural gas pipelines and even dangers from radon in over-insulated houses. As James Lovelock has shown, mammals have evolved when the natural radioactivity of the Earth was many times greater than current levels.

Expanding the renewables industry will bring significant new industrial hazards, with much new activity in three sectors that have the worst industrial safety records - heavy construction, offshore working and forestry. It would be instructive to use HSE statistics to extrapolate the number of fatalities for personnel working on the maintenance and repair of 5,000 wind turbines 100 m high off the west coast of Great Britain. Similar extrapolations for the impact of the toxic metals in solar PV systems and back up batteries should be carried out. As they involve many hundreds of thousands of tons of materials, more deaths would be predicted.

6 SUSTAINABILITY

With regard to sustainability, the case for the use of uranium (and thorium) is without equal. These materials have no other potential use and yet by the judicious use of breeder reactors, more fuel can be bred from ^{238}U that will keep us self-sufficient for several millennia. The awful reality is that through misplaced confidence in renewables and nuclear hysteria, no new PWR may be ready until 2010, by which time great harm could have been caused to our plans for recycling with inadequate electrical supplies, more fuel poverty and hypothermia deaths.

7 SUMMARY

Finding large sums of money for long term investments is never easy. In the short term, it is possible to avoid investment in expensive and unpopular schemes, but this brings the certainty of serious long-term economic and social problems. In California, it has taken only about 10 years to go from electrical self sufficiency to crisis. The nuclear plant at Rancho Seco was closed in 1989 and Sano Onofre in 1992. The thousands of wind machines have proved inadequate.

It would be highly irresponsible for the UK to follow the same path and to adopt a Mickawberish stance, trusting in some untried system being expanded sufficiently to meet demand at the end of this decade or the next, without having secure supplies as insurance.

The Government must not allow fossil fuel dependency to increase any further and only nuclear and renewables can be substituted. The latter will require the solution of a very wide range of intractable technical problems. These range from installation and maintenance of massive offshore structures in all weathers, via novel waste processing, to fine control of voltage and frequency in response to unpredictable mismatches between power generation devices and demand. There may not be a sufficient number of engineers and scientists to solve these problems in the time available and yet there are no contingency arrangements to install reliable non-fossil plants as insurance. This represents reckless tampering with one of the most complex and well run engineering achievements in the world - the British electricity supply industry - in the furtherance of a number of energy sources that have short term political appeal, but little engineering logic. There are no serious technical issues facing the growth of new nuclear plants, the problems are with public perception, planning and funding for long term investment.

Only nuclear power offers the reliable energy source to supply the power that we all crave. There is no alternative if wish to preserve long term security with a high degree of confidence, but it will require investment of many billions of pounds and some Government encouragement. The Government and all its functions (if it continues in office) will not be immune to the blackouts that will begin in the next 10 or 20 years if short term pressures are allowed to over ride good strategic judgement on the issue of electricity supply.

Yours faithfully,

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