Nuclear Free Local Authorities

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# THE HURDLES TO NUCLEAR REVIVAL

The Government is conducting a wide-ranging energy review which could pave the way for a programme of new nuclear reactors[1]. This possibility arises because of long term concerns about security of energy supply and meeting carbon dioxide reduction targets. The review is being undertaken by the Performance and Innovation Unit (PIU) in the Cabinet Office and is due to report in six months time.

The nuclear industry has been anticipating this development. Its pre-election calls for a "nuclear renaissance" are being followed up with submissions to Government setting out what it sees as the case for new build. This case is likely to receive a sympathetic hearing. According to press reports, a number of senior Ministers privately believe that a nuclear revival is inevitable.

It is essential that two things happen. First, the case for new nuclear build must be subject to critical scrutiny. The PIU review should set the tone by taking a hard-headed look at the major hurdles to new build. Second, the process of review needs to be opened up to public participation at the earliest opportunity. This must be done to lay the foundations for the high level of public support required for any radical policy developments, whether impacting on energy conservation, fossil fuels, renewables or nuclear power.

This is the first in a series of briefings intended to contribute to the process of critical and public scrutiny of the case for new nuclear build. It provides an overview of the key issues and argues that the UK is not in a position to move forward with a programme of new nuclear power stations.

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## WHY IS NEW NUCLEAR BUILD BACK ON THE POLITICAL AGENDA?

In 1995, after a major review of the prospects for nuclear power, the Government of the day concluded that intervention in the electricity market to support new nuclear build was not justified[2]. This conclusion took specific account of ways of achieving carbon dioxide reduction targets and security of supply. In particular, new nuclear stations were considered "too expensive to be justified for $CO_2$ purposes alone" and "an inflexible solution to the threat of climate change"[3]. The Government also concluded that there was "no evidence of an impending shortage of gas supplies", and no "realistic threats to the UK's supplies of a severity that would justify supporting new nuclear build"[4].

So what has changed? There are two important factors. First, the Government wants to take a longer term view. This means that the time horizon has switched from 2010 out to 2050. Second, the nuclear industry is promoting a new generation of reactors, which it claims are much less expensive than those considered in the 1995 review.

## THE CHALLENGE OF CLIMATE CHANGE

Extending time horizons can have a sobering impact. In 2000, the Royal Commission on Environmental Pollution published a detailed study which highlighted the radical challenges involved in putting the UK on a path to achieving a 60% cut in carbon dioxide emissions by 2050[5]. In order to explore the nature of these challenges, the Royal Commission constructed four scenarios. These all involved fundamental shifts in the ways energy is obtained and used, and in the associated infrastructure. Two of the scenarios envisaged large programmes of new nuclear build, with the equivalent of 19 and 46 of the UK's most recent nuclear power station (Sizewell B) respectively.

Significantly, the Royal Commission stated that it did not accept the arguments of those who hold that nuclear power is indispensible for meeting future carbon dioxide targets[6]. However, it warned that if renewables and demand reduction cannot be brought forward on the large scale required, and if capture and isolation of carbon dioxide proves unsafe or prohibitively expensive, the case for new nuclear build would be strengthened.

## NEW REACTOR TECHNOLOGIES

BNFL has become a leading player on new reactor technologies. The company has access to the ABB Systems 80+ and the Westinghouse AP600 and AP1000 as a result of company acquisitions. It also has a 20% stake in Eskom's feasibility study to develop the Pebble Bed Modular Reactor (PBMR) in South Africa.

The *System 80+* is an 'advanced evolutionary' Light Water Reactor (LWR), which builds directly on previous designs and experience. It is claimed that this leads to increased safety, improved reliability and reduced costs. The System 80+ received design certification from the US Nuclear Regulatory Commission (NRC) in 1997. Four reactors incorporating several System 80+ advances are under construction in South Korea[7].

In contrast, the *AP600* and *AP1000* are 'advanced passive' LWRs, which incorporate novel design features to reduce reliance on active safety systems, plant complexity and capital costs[8]. The AP600 received final design certification from the NRC in December 1999. It has also been subject to a $200 million first-of-a-kind engineering programme which is intended to give prospective buyers firm information on construction costs and schedules[9]. The AP1000 - a scaled up version of the AP600 - is at a less advanced stage of development.

## THE HURDLE OF THE MARKET TEST

Since the 1995 nuclear review, it has been accepted in the UK that decisions about new nuclear power stations should be made on a commercial basis using private sector criteria. Commitment to this policy was most recently confirmed in December 2000 by the then Energy Minister:

> Here in the UK, there are periodic forays into the debate about whether or not there should be new nuclear build. That is a decision for the market to make and safety and cost will obviously drive that decision.[10]

This position is unlikely to change because market intervention to support new build would probably fall foul of EC rules on state aid. The European Commission has recently re-asserted that the nuclear sector should not benefit from state aid[11].

The need to make investment decisions on a commercial basis using private sector criteria presents a big hurdle, because new nuclear build has traditionally entailed very high capital costs, long construction and payback periods, and significant financial risk.

## CAN NEW REACTORS CLOSE THE COMPETITIVENESS GAP?

A clear indication of the scale of the competitiveness gap can be provided by estimating the cost of electricity from new nuclear stations - taking into account lifetime costs - and comparing this 'levelised cost' to projected electricity prices or the generation costs of Combined-Cycle Gas Turbine (CCGT) plants.

During the 1995 nuclear review, the DTI estimated a levelised cost for new nuclear build of 4.4 pence per kiloWatthour (p/kWh)[12]. This was for a twin reactor station, based on the design of the Sizewell B station. Although the DTI estimate was low compared to that put forward in expert evidence to the review[13], it still compared very unfavourably with projected electricity prices at that time of 2.9 p/kWh.

The industry is claiming that the new generation of reactors could drastically close the competitiveness gap because of reduced capital costs and shorter construction periods. In a recent paper on the economics of the AP600, Hesketh and Paulson presented data indicating that twin reactor plant could have a levelised cost as low as 2.5 p/kWh[14]. This compares with current electricity prices and CCGT costs of around 2 p/kWh[15].

Industry cost estimates, however, need to be treated with extreme caution. Independent analysis reveals that a considerable degree of 'appraisal optimism' is built into such estimates. For example, the Energy Information Administration (EIA) within the US Department of Energy considers it appropriate to assume a significantly higher overnight capital cost for the AP600 than reported by Hesketh and Paulson[16]. A recent analysis by Barker and Sadnicki derives a very similar overnight capital cost to that of the EIA[17]. Furthermore, after critically reviewing a range of key assumptions, Barker and Sadnicki estimate a levelised cost for two twin AP600s of 3.3 p/kWh[18].

This shows that the industry - at least for the AP600 - is much further from closing the competitiveness gap than it claims. It also demonstrates the need for future industry costs estimates to be subject to independent scrutiny[19].

## HOW MUCH DIFFERENCE WOULD A CARBON TAX MAKE?

Parts of the nuclear industry still argue that the introduction of a carbon tax could help transform the prospects for new build. However, there are political hurdles to the introduction of such a tax in the UK, including strong opposition from other industrial sectors[20]. In addition, the tax levels considered in other countries - at around £25-£30 per tonne of carbon (tC) - would not close the competitiveness gap, as they translate into additional costs of around 0.3 p/kWh for CCGT plant.

A view is therefore emerging from within the industry that the economic competitiveness of new build will have to be achieved by accelerated technological development and innovation, rather than by pinning hopes on possible future tax regimes[21].

## NEW REACTORS AND FINANCIAL RISKS

A dilemma for the industry is that a quest for reduced costs through technological innovation is likely to increase financial risks.

The AP600 illustrates the point. Although relying as far as possible on proven LWR technology, the AP600 incorporates a range of novel 'passive safety' features. Indeed, it took "more than eight years of painstaking attention to regulatory detail" to secure final design certification from the US NRC. This was because the "AP600 posed unique problems for regulators who initially lacked adequate yardsticks against which to judge the revolutionary new design"[22].

In the UK, the Nuclear Installations Inspectorate has not carried out a detailed assessment of new reactor technologies, nor is it currently in a position to do so[23]. Even though the US regulatory experience could be drawn upon in the case of the AP600, it is likely that a UK licensing process for this reactor would be long and expensive because of its novel approach to safety. Indeed, early discussion of the AP600 indicates that some of the design features might infringe UK safety requirements[24]. The licensing process for the AP1000 could be even more drawn out, because it has not been through a process of design certification in the US[25].

In addition to uncertainty about regulatory demands during licensing, there is no experience of full-scale construction or commercial operation of these new reactors. There will therefore be a perception of high risk associated with investment in what are essentially unproven plant.

## THE RADIOACTIVE WASTE PRE-REQUISITE

The hurdles to a nuclear renaissance go far wider than a lack of commercial competitiveness. In particular, there is a considerable body of opinion that a solution to the long-term management of radioactive waste needs to be found before new build is allowed to proceed.

For example, the Royal Commission on Environmental Pollution argues that:

> The intractable problem is to secure public agreement on the design and siting of a secure long-term repository. Considerations of inter-generational equity embedded in the concept of sustainable development demand the solution of the waste management problem, to the satisfaction of both the scientific community and the general public, before new nuclear power stations are constructed.[26]

Similarly, in its recent Green Paper on energy, the European Commission highlighted that:

> Nuclear energy cannot develop without a consensus that gives it a long enough period of stability, bearing in mind the economic and technological constraints of the industry. This will only be the case when the waste issue finds a satisfactory solution with maximum transparency.[27]

Finding a solution is a huge challenge. In the UK, the first step is to develop a policy that commands widespread public support. This in itself could take a number of years. As the Government's Radioactive Waste Management Advisory Committee has argued, policy development requires a substantial, carefully planned and transparently structured programme of work, with considerable opportunity for stakeholder dialogue and public participation[28].

## LIABILITY PRE-REQUISITES

The 'polluter pays' principle leads to further pre-requisites for new build. These are that all the liabilities associated with the life-cycle of a reactor, including long-term waste management, should be adequately costed, and arrangements put in place to ensure that the costs will be met by the company concerned. This is necessary to remove the risk that public subsidy will ultimately be required to meet long-term costs.

These pre-requisites pose a further difficulty for new build: deriving robust and comprehensive liability estimates requires the establishment of clear policy on the long-term management of radioactive wastes, followed by the specification of technical requirements and the development of adequate cost models[29]. As reported above, the UK has still to establish a clear policy.

## REACTOR SAFETY AND PUBLIC ACCEPTABILITY

Since the 1980s, there has been concern within parts of the nuclear industry that widespread public acceptance will not be forthcoming as long as assurances about safety have to rely on statistical estimates of the frequency of major accidents[30].

This viewpoint has been forcefully put by Nicholls, who works for ESKOM, the developer of the PBMR:

> The issue of accidents also must be seen to have been solved. The classic question is 'Can the nuclear plant have an accident which could affect the public?' The answer for the current generation of plants is 'Yes, but it is such a remote possibility that...' The only part of this answer that is heard is the first word; the rest is only limited mitigation! To be acceptable, the answer must be 'No'. There must be no physically credible event which can cause off-site actions to be required.[31]

There is an emerging consensus within industry that this should be a requirement for the next generation of nuclear reactors, beyond that which includes the System 80+ and the AP600/1000[32].

This analysis suggests a further major hurdle to a programme of new build: the industry should be able to present a convincing case that it is not possible for an accident at a new reactor to cause a radiation release that could affect the public. This is likely to require the development of reactor designs that: use fuel which could survive the total absence of coolant[33]; and have a thick concrete containment so as to be immune from external events[34].

It is also likely that the industry will have to find a way of convincing a sceptical public that low levels of routine emissions of radioactivity do not present a health risk to local communities close to nuclear sites[35].

# PROLIFERATION RESISTANCE

There is a tendency on the part of UK policy makers to think that the risks of nuclear weapon proliferation are a marginal issue when assessing the case for building nuclear power stations. This is largely because the UK provides a low threat environment and a high level of safeguards. However, proliferation risks have to be considered over the long term, and in the context of a possible expansion of nuclear power to help meet climate change concerns.

The root of the problem is that the use of uranium fuels in commercial nuclear power stations generates spent fuel which contains weapons-usable plutonium. In the UK, this plutonium is separated from spent fuel by reprocessing, creating a large stockpile which requires the maintenance of stringent safeguard and security arrangements into the future. In contrast, spent fuel has a 'self-protecting' radiation barrier, which provides a considerable deterrent to theft and plutonium separation by sub-national groups. However, after 115 years or so of radioactive decay, this barrier declines to the extent that spent fuel would also require strict security arrangements[36].

Against this background, there is concern within the nuclear industry that new reactor and fuel cycle designs must become more proliferation-resistant in order to help secure its future. The obvious first step would be to cease the separation of plutonium by reprocessing and the international trade in plutonium (MOX) fuel. Beyond that, there is a considerable amount of research underway on technical options for increasing proliferation resistance[37].

Requirements for enhanced proliferation resistance, and potential ways of meeting them, should be taken into account in appraisals of new build.

# SECURITY OF SUPPLY

The Cabinet Office energy review scoping note refers to the supply problems that have arisen in California's liberalised electricity market. In the light of this experience, the note raises the question of whether the regime for regulating the UK market provides sufficient incentive for investment in generating capacity to minimise the risk that energy shocks will lead to interruptions in supply[38].

Care needs to be taken in generalising from the Californian experience. The literature suggests that problems have been caused by state-specific factors, including the way the electricity market in California is organised, rather than by liberalisation per se. Sioshansi, for example, concludes that the Californian market is over-regulated and that there is insufficient competition[39]. There's also been a debate about whether the Californian market is particularly prone to manipulation, involving the creation of artificial shortages to increase prices[40]. Others point to a fire at the San Onofre 3 nuclear station on Feb 3, and resulting shutdown, as an important contributory factor to electricity shortages[41]. Against this background it would be misleading to conclude that security of supply problems are ultimately inevitable in liberalised markets.

It should also be recalled that introducing more nuclear power into an electricity supply system could reduce overall security of supply. This because there is a risk that major accidents or plutonium diversion incidents could lead to the abandonment of new reactor build, the shutdown of some existing capacity, and stricter regulation causing higher costs. The major impacts of the 1979

Three Mile Island and 1986 Chernobyl accidents on international nuclear power programmes are well documented[42]. These underpin the argument that "the viability and expandability of nuclear energy anywhere depends on the safety and proliferation resistance of nuclear facilities everywhere"[43].

Over recent years, it has become widely accepted that the best guarantee of security of supply is a diversity in energy sources. Methodologies for identifying optimum levels of diversity were examined in the 1995 review of nuclear power[44]. If similar methodologies are to be developed and applied in the current energy review, the risks posed to security of supply by nuclear power need to be explicitly taken into account.

# CONCLUSIONS

The intention of this briefing has been to contribute to the process of public scrutiny of the case for new nuclear build. It has highlighted a range of critical issues:

- currently available reactor technologies are not commercially competitive;
- radioactive waste management and liability pre-requisites are far from being met;
- safety and proliferation resistance requirements demand review; and, in the light of these requirements,
- the potential role of nuclear power in enhancing security and diversity of supply requires analysis.

Finally, the procedures for weighing up the industry's case for new nuclear build need to be opened up to public and stakeholder participation at the earliest opportunity. Removing or restricting the opportunity for such participation would be a fundamental mistake, whether during national policy formulation, or during the subsequent implementation of any consent procedures. Ways of enhancing and extending public and stakeholder participation will be examined in the next briefing.

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1 'Energy Policy: Project Scoping Note', Cabinet Office, Performance and Innovation Unit, June 2001. Comments can be sent to energyteam@cabinet-office.x.gsi.gov.uk

[2] Department of Trade and Industry and the Scottish Office, 'The Prospects for Nuclear Power in the UK: Conclusions of the Government's Nuclear Review', Cm 2869, May 1995, para 2.4.

[3] As above, paras 5.23-5.26.

[4] As above, para 5.73.

[5] Royal Commission on Environmental Pollution, 'Energy - the Changing Climate', Cm 4749, 2000 (http://www.rcep.org.uk). A 60% cut in carbon dioxide emissions by 2050 is the long term target recommended by the Royal Commission. The UK's short term target is to reduce annual carbon dioxide emissions by 20% from their 1990 level by 2010.

[6] As above, summary, para 31.

[7] R A Matzie and Ki-In Han, 'The Evolutionary Development of Advanced Reactors', Paper to the Uranium Institute Symposium, 1998.

[8] H J Bruschi, 'AP600 - a Safe, Simplified, Economic Plant', Nuclear Energy, Vol 39, No 3, June 2000, p163.

[9] 'Advanced Reactors', Nuclear Issues Briefing Paper 16, Uranium Information Centre, December 1999.

[10] H Liddell, Speech to the British Nuclear Energy Society/British Nuclear Industry Forum Congress 2000, 6 December 2000.

[11] Commission of the European Communities, 'Towards a European Strategy for the Security of Energy Supply', Green Paper, COM (2000) 769, November 2000, p65.

[12] DTI, 'The Role of Nuclear Power in Carbon Dioxide Abatement beyond 2000', May 1995. This paper was produced for the nuclear review by economists in the Energy Policy and Analysis Unit of the DTI.

[13] COLA, the Consortium of Opposing Local Authorities, estimated a levelised cost of 5.6-6.3 p/kWh, based on detailed analysis by Gordon MacKerron ('The Capital Costs of Sizewell C', COLA Submission Vol 3, September 1994), and Elroy Dimson and Mike Staunton ('New Plant and Financial Factors', COLA Submission Vol 4, September 1994).

[14] K W Hesketh and C K Paulson, 'Competitiveness of Evolutionary PWRs in the UK Market', Nuclear Energy, Vol 39, No 5, October 2000, p273-278, Figure 1. The 2.5 p/kWh estimate assumes a discount rate of 11%.

[15] Increasing competition and replacement of the electricity pool with new trading arrangements have lead to prices below 2 p/kWh. The Royal Commission on Environmental Pollution (as above, para 9.30) quotes a levelised cost of 2 p/kWh for new CCGT plant.

[16] M J Hutzler, Energy Information Administration evidence before the Subcommittee on Energy and Air Quality, US House of Representatives, 27 March 2001. The EIA reports an overnight capital cost of $1730 per kiloWatt, which is around $350/kW more than assumed by Hesketh and Paulson.

[17] F Barker and M J Sadnicki, 'The Disposition of Civil Plutonium in the UK', April 2001, Section 9.6.

[18] As above, April 2001, para 379. Barker and Sadnicki also show that it is likely to take well over a decade of operation before cumulative undiscounted income first exceeds cumulative undiscounted costs (Figure 16, p144). This extended payback period places new nuclear build at a further competitive disadvantage to CCGT.

[19] The industry is likely to claim that the levelised costs for the AP1000 and PBMR will offer further substantial cost savings beyond that of the AP600. These claims will require close scrutiny.

[20] See, for example, 'CBI response to the Government Task Force Consultation on Economic Instruments and the Business use of Energy', Industrial Policy Group, CBI, July 1998.

[21] GH Marcus, 'Considering the Next Generation of Nuclear Power Plants', Progress in Nuclear Energy, Vol 37, No 1-4, p5-10, 2000.

[22] 'Westinghouse AP600 Wins Seal of Approval', Nuclear Energy Insight, October 1998, p1.

[23] Nucleonics Week, 14 December 2000.

[24] A B H Chevalier, 'Passive Safety Features - a considered view of UK safety arguments', Nuclear Energy, Vol 30, No 2, April 1991, p79-83.

[25] NRC, 'Pre-application review of the AP1000 standard plant design - phase 1', letter to the Advisory Committee on Reactor Safeguards, 14 September 2000. The letter identifies the specific issues that will need addressing in the certification of the AP1000 in the US.

[26] As above, Royal Commission on Environmental Pollution, Cm 4794, 2000, para 7.19.

[27] As above, Commission of the European Communities, COM (2000) 769, November 2000, p33.

[28] RWMAC, 'Twentieth Annual Report', Chapter 3, 'Building Consensus on Future Radioactive Waste Management Policy', November 2000.

[29] The specification of technical requirements and development of cost models is particularly challenging for spent fuel and plutonium waste forms, because very little work has been done in the UK to date. See F Barker and M J Sadnicki, as above, April 2001, Section 8.5 and paras 566/569.

[30] See, for example, I Spiewak and A M Weinberg, 'Inherently Safe Reactors', Annual Review of Energy, Vol 10, 1985, p431-62; and W Kröger, 'Non-catastrophic release requirements for the next generation of nuclear power plants', Nuclear Engineering and Design, Vol 109, 1988, p295-298.

[31] D R Nicholls, 'Status of the Pebble Bed Modular Reactor', Nuclear Energy, Vol 39, No 4, August 2000, p231-236.

[32] J A Lake, President of the American Nuclear Society, 'The Fourth Generation of Nuclear Power', Symposium of Latin America's Nuclear Energy, Rio de Janeiro, June 2000.

[33] L M Lidsky, 'Nuclear Power: Levels of Safety', Radiation Research, Vol 113, 1988, p217-226. Eskom argue that the design of the PBMR will be such that the fuel could survive the total absence of coolant.

[34] I Spiewak and A M Weinberg, 'Inherently Safe Reactors', Annual Review of Energy, Vol 10, 1985, p433.

[35] For the latest controversy see 'French nuclear plant in spotlight after leukaemia study', 28 June 2001, http://www.abc.net.au/news/science/health/2001/06/item20010628033142_1.htm

[36] E Lyman, 'Can the Proliferation Risks of Nuclear Power be made Acceptable?', paper presented to the 20th Anniversary Conference of the Nuclear Control Institute, April 2001. As Lyman suggests, one way to mitigate the long-term proliferation risks posed by spent fuel is to ensure that it is 'irretrievably' emplaced in a deep disposal facility.

[37] 'Technological Opportunities to Increase the Proliferation Resistance of Global Civilian Nuclear Power Systems', report by the TOPS Task Force of the Nuclear Energy Research Advisory Committee of the US Department of Energy, October 2000. See also, E Kiriyama and S Pickett, 'Non-proliferation Criteria for Nuclear Fuel Cycle Options', Progress in Nuclear Energy, Vol 37, No 1-4, p71-76, 2000.

[38] 'Energy Policy: Project Scoping Note', Cabinet Office, Performance and Innovation Unit, June 2001.

[39] F P Sioshansi, 'California's dysfunctional electricity market; policy lessons on market restructuring', Energy Policy, 29, 2001, 735-742.

[40] See, for example, Union of Concerned Scientists, 'Where has the Power Gone?', www.ucsusa.org/energy/, N T Quan and R J Michaels, The Electricity Journal, Jan/Feb 2001, 99-108, and G Palast, 'Why the lights went out all over California', The Observer, 1 July 2001.

[41] Nuclear Information and Resource Service, 'Little noticed accident at San Onofre nuclear power reactor is key story behind California blackouts', www.nirs.org, press release, 22 March 2001.

[42] F Barker, 'Main Case', COLA Submission to the Nuclear Review, Volume 2, paras 4.4.4 - 4.4.7, September, 1994.

[43] J P Holdren, 'Improving US Energy Security and Reducing Greenhouse-Gas Emissions: What Role for Nuclear Energy?', Testimony for the Sub-Committee on Energy and Environment, US House of Representatives, 25 July, 2000.

[44] Department of Trade and Industry and the Scottish Office, 'The Prospects for Nuclear Power in the UK: Conclusions of the Government's Nuclear Review', Cm 2869, May 1995, paras 5.31-5.75.