

Nuclear Consultation Public Trust In Government



NUCLEAR CONSULTATION: PUBLIC TRUST IN GOVERNMENT

**NUCLEAR CONSULTATION
WORKING GROUP**

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1. EXECUTIVE SUMMARY

The public mistrust of policy decision-making on issues involving nuclear risk is a defining issue. In order to overcome this mistrust, government has consulted with the public about the potential role of nuclear power in future energy policy - the idea is to weigh expert knowledge with every-day knowledge to arrive at a democratic and balanced view. Here, the practice and purpose of this public dialogue, and the models of engagement to enable it, are core to the relationship between government and the public in a modern democracy.

In order to overcome the widespread belief that institutions wishing to impose their arbitrary actions upon the public may be secretive, all the key framing propositions and assumptions underpinning the nuclear power consultation need to be made explicit in any case that is put forward for new nuclear power stations. To access true public opinion about such a high-stakes issue, the public consultation should have been clear, integrated, independent, and conducted over a long enough time-frame. Failure to do so has left the government vulnerable to legal challenge and may lead to hostility and mistrust of any future energy policy decision.

Even in the most technical and sophisticated forms of analysis, it seems that the answer you get depends on the way you frame the question. We suggest that the key assumptions underpinning the government's approach to the 2007 nuclear consultation remain open to critical analysis. We are profoundly concerned that these framing assumptions were designed to provide particular and limited answers - and those answers risk locking in UK energy futures to an inflexible and vulnerable pathway that will prove unsustainable.

This report discusses the form and function of the nuclear consultation, and then addresses the issues and challenges that were elided and obscured during that consultation. We conclude that the government erred in asking the public to take a decision 'in principle' for more nuclear power when significant 'what if' issues were not consulted on in any meaningful way, or resolved in practice. These issues include uncertainty about: nuclear fuel supply and manufacture, vulnerability to attack, security and nuclear proliferation, radiation waste, radiation risk and health effects, reactor decommissioning, reactor design and siting, cost of electricity generating technologies, energy distribution models, true renewable and energy efficiency modelling.

We take no satisfaction that our Conclusions and Recommendations to government are based on the understanding that the 2007 nuclear power consultation has failed. Poor consultation practice wastes people's time and can seriously undermine people's trust in government. The extent of mistrust of the institutions and the institutional culture underpinning nuclear power underlines that this is a public mood that, although not immutable, has been deeply entrenched by long and discouraging experience. Although a broader,

deeper, even-handed consultation may have appeared an inconvenience to certain sectors of the nuclear industry, a truly involving process would have produced a better result for everyone by generating greater social consensus and trust in the eventual outcome.

2. THE PROJECT

THE PURPOSE OF REPORT

The purpose of this report is two-fold:

- To analyse the form and function of the UK nuclear consultation process.
- To provide a clear and thoughtful discussion on the issues and challenges that were not transparently presented to the public during the nuclear consultation.

At the end of the day, the authors of this report hope to open up what has been a closely constrained energy debate. Although this limited consultation may have concluded, we present evidence to suggest that this issue is still open, and will remain so.

WHO WE ARE

NUCLEAR CONSULTATION WORKING GROUP

The Nuclear Consultation Working Group comprise many of the leading experts in the fields of environmental risk, radiation waste, energy policy, energy economics, political science, social science, environmental justice, and the emergent arena of democratic involvement. It is telling that such a group speaks with one collective voice at this critical moment. The members of the group who have not directly authored sections of the report have all engaged with, contributed to, and agreed with, the main thrust of this document. The group members are:

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THE CONTEXT

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In a high court decision on the 2006 Energy Review consultation, Mr. Justice Sullivan ruled that consultation process 'misleading', 'seriously flawed', and 'manifestly inadequate and unfair'. The findings of the Judicial Review had also been echoed by a broad range of commentators: The chairman of the Trade and Industry Committee noted that the Energy Review was 'a rubber-stamping exercise for a decision the Prime Minister took some time ago'. The Sustainable Development Commission concluded that the Review 'offers no information whatsoever on what any new nuclear programme might look like and people are being asked to comment on the potential contribution of a new nuclear programme without any of the key aspects (regarding reactor design, cost, waste management, liability issues, and so on) having been addressed'. The House of Commons Trade and Industry Committee were concerned 'about the manner in which this Energy Review has been conducted, noting that 'throughout the process, the Government had hinted strongly that it has already made its mind up on nuclear power'. The House of Commons Environmental Audit Committee said: 'The nature of the current Energy Review is unclear - whether it is specifically fulfilling the Prime Minister's desire to make a decision on nuclear, whether it is a review of electricity generating policy, whether it is a wider review of progress against the Energy White Paper, or whether it is reopening the broad policy debate which the White Paper itself encompassed. We are also concerned that it does not appear to have resulted from a due process of monitoring and accountability, and that the process by which it is being conducted appears far less structured and transparent than the process by which the White Paper itself was reached'.

In other words, the 2006 consultation had failed. It was ill-conceived, carried out over too short a timescale, and did not involve the public in any meaningful way. Although the government had promised 'the fullest public consultation', what it offered was a tick-box exercise that provided limited useful information, and did not allow for full and frank disclosure of all the important issues underpinning energy production and nuclear risk.

The Judicial Review judge said that fresh discussions on the economics of new nuclear build, and how to store the resulting radioactive waste, were needed as 'consultation was a right, not a privilege'. So the government embarked on a new consultation to encompass the wider 'principles' of whether more nuclear power was needed, and Gordon Brown was said to be keen to lead the debate over Britain's future energy policy, given that it would be one of the key decisions to be taken under a his premiership. However, there still seemed to be widespread concern that government had already

made up its mind. In an unguarded moment following the judicial review ruling, the then PM Tony Blair's response was: 'This will change the consultation, this won't affect the policy at all'.

In May 2007 the government published its Energy White Paper 'Meeting the Energy Challenge', which covered a range of energy issues including nuclear power. At the same time, the government also published a consultation document 'The Future of Nuclear Power' (DTI, 2007), on the Government's preliminary view that it was 'in the public interest to give private energy companies the option to invest in nuclear power stations'. Yet there remains a concern that the way government approached this consultation may have advanced a pre-ordained solution to a well-rehearsed problem.

Surprisingly, and perhaps unwisely, Gordon Brown told MPs in July 2007, 'we have made the decision to continue with nuclear power' even before the new consultation had run half its course. The Department of Trade and Industry, which ran the consultation, had already said that it continued to believe in nuclear power. Indeed, during a parliamentary Renewable and Sustainable Energy Group conference, Lord Whitty, former Parliamentary Under-Secretary of State for Farming, Food and Sustainable Energy, said that the government was going to give new nuclear power an 'amber light', a 'presumption for' in the Energy White Paper, including pre-licensing of reactor design.

The impression that the government was clearing the way for a new nuclear programme was reinforced when the Communities and Local Government Minister Ruth Kelly published a planning White Paper that limited public rights of opposition and fast-tracked major building projects, such as nuclear new-build. The Independent Planning Commission will have the final say in all but the most sensitive projects, and there will be a principle of 'presumption in favour' of major projects as long as they conform to a declared national need. Such a streamlining of the process has taken years off planning applications and cleared away one of the major obstacles to private investment in new nuclear power stations. Meanwhile, industry is gearing up: British Energy and French utility company EDF are trying to interest Scottish gas-owner Centrica to join them in building new nuclear plant in the UK.

But although it looks sewn up, it is not over. An accumulating public sense of a lack of independence and a lack of transparency behind government initiatives in this area, and a hidden industry agenda belittling the problems seem to emit a strong whiff of mortgaging the long-term future to short-term interests. The issue is one of trust in government - what will people think if a problematic consultation directly leads to opening up the UK to a nuclear renaissance?

3. UK NUCLEAR CONSULTATION

THE PURPOSE OF CONSULTATION

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The practice and purpose of public dialogue, and the models of engagement to enable it, are core to the relationship between government and the public in a modern democracy. The quality of this dialogue is especially important in the areas of radiation science and nuclear technology because accurate determination of risk is difficult, and open to disagreement.

Society's relationship with science and technology is in a critical phase. After half a century of science-based policy, the UK and other western democracies are struggling to come to terms with the collapse of public confidence in the governance of science and technology. This deepening scepticism coincides with some of the lowest electoral turnouts ever recorded and a pervasive shift in public trust, acceptance, and willingness to engage with environmental scientific, regulatory and consultative processes.

It's in this context that throughout the EU and within the UK, there's clear policy moves to integrate public and community knowledge into environmental and health decision-making processes. The underlying social force that underpins this move to deliberative democracy is the drive from a well educated and often sceptical public for a more accountable, transparent, and publicly acceptable decision-making arena. There's also a range of strongly UK centred drivers to this dynamic, based on a perceived crisis of legitimacy in government and the role of expertise implicit in 'top-down' decision-making models (House of Lords Select Committee on Science and Technology, 2000). New Labour's modernising agenda has emphasized, again and again, greater public involvement in governance, noting that 'public participation in debate and decision making is valued'.

So it's now recognised that the old 'decide-announce-defend' approach based on the so-called 'public knowledge deficit model' is dead. As a result dialogue with the public is no longer seen as an 'optional add on' to science-based policy making. This view is echoed in more recent environmental risk controversies, where the focus of risk disputes have centred on government credibility and trustworthiness. This shift has seen government move toward an 'engagement' model, which focuses on a two-way dialogue between specialists and non-specialists. This approach views dialogue and debate as

a means of forging a more lasting consensus by increasing social involvement and participation, thereby fostering a sense of community.

Implicit within this approach is the idea that risks from technological progress may be better addressed by broadening and extending the environmental decision making community to incorporate stakeholders affected by those risks - since any approach to environmental control which ignores the knowledge, expertise and imagination of the bulk of the population seems extremely restricted. If carried out in a truly involving way, this integration of public, local community and expert scientific knowledge allows for greater accountability, transparency - and despite the slowing-down of the environmental decision-making processes, much better public 'take-up' of necessary change and improved long-term likelihood of problem resolution.

FRAMING THE NUCLEAR CONSULTATION

Dr Paul Dorfman, University of Warwick

‘We have made the decision to continue with nuclear power’ - Gordon Brown, July 2007

In May 2007, the government, the Department of Trade and Industry (DTI), and the Department of Business, Enterprise and Regulatory Reform (DBERR) launched ‘The Future of Nuclear Power: The Role of Nuclear Power in a Low Carbon UK Economy’ consultation, stating that ‘this consultation seeks views on the information and arguments set out on whether the private sector should be allowed to build new nuclear power stations’.

Over the consultation period DTI, DBERR requested full written responses, published documents, hosted a web-site, and held 12 regional meetings with representatives from industry, local authorities, NGOs and other organisations - suggesting that ‘these meetings enable us to explore in more detail the views of interested parties’.

However, government claims to agnosticism were dented by the July 2007 statement to MP’s by the Prime Minister Gordon Brown: ‘We have made the decision to continue with nuclear power’. The consensual aim of the process began to further unravel with the withdrawal by Greenpeace, the Green Alliance, WWF and Friends of the Earth from the consultation process. The withdrawal by the NGO’s was said to be born of frustration - the environmental groups noted that the ‘consultation did not provide fair or balanced information’ and ‘failed to properly consider the alternatives to nuclear power’.

‘Talking Energy: The Future of Nuclear Power’

Perhaps the defining moment in the consultation occurred on Saturday 8 September 2007, when nine ‘Talking Energy: The Future of Nuclear Power’ citizen deliberative events took place across the UK for members of the public in Belfast, Cardiff, Edinburgh, Exeter, Leicester, Liverpool, London, Newcastle and Norwich. DTI and DBERR concluded that these events would ‘enable us to understand the views of the public after they have heard the key facts and arguments in the consultation. Discussion at the events addressed the same key questions in the consultation document’. DTI DBERR stated that the total of 1,000 people who together attended these meetings were recruited to be broadly demographically representative of the UK population. However, this claim seemed to be undermined by the attendance, perhaps surprisingly as a representative member of the public, of the former head of DTI ‘Public Understanding of Science’ at the London event.

At each citizens event: films, presentation slides and handout sheets were used as stimulus materials, and DTI advisors were on hand to advise the public on any technical or scientific matter. However, at the citizen 'deliberative events' some rather contentious information was presented to the public by DTI DBERR's nuclear involvement consultant Opinion Leader Research (OLR). For example, hand-out documents at the events stilled disquiet by making three key statements on nuclear 'safety and security' issues:

- 'According to a recent report from The European Commission, a major nuclear accident in the UK is less than the chance of a meteorite over a kilometre wide hitting the earth'.
- 'The Office for Civil Nuclear Security is satisfied with arrangements to guard against terrorism and believes that allowing new nuclear power stations to be built would be unlikely to increase the risks of terrorist attacks'.
- 'Based on the advice of the independent nuclear regulators, and the advances in the design of nuclear power stations, the Government's initial view is that the security and safety risks of new nuclear power stations are very small'.

On the radioactive waste issue they allayed any concerns by concluding that:

- 'The Government believes that new waste could be managed in the same way as... our existing or legacy waste'.
- 'Waste and decommissioning costs would make only a small proportion of the total costs of building and operating nuclear power stations (less than 5%) provided that the fund for their decommissioning and waste disposal can be built up over 40-60 year lifetime of a station - just like a pension plan'.

They offered reassurances on the potential for future radiological accidents and incidents by noting that:

- 'There have been no events relating to a civil nuclear power station in the UK which have had any consequence outside the nuclear power station itself'.

On the security of future nuclear fuel supply, they confirmed that:

- 'The nuclear industry believes that accessible and affordable uranium from reserves we already know about in politically stable regions can be relied on for the full lifetime of a fleet of new UK power stations'.

They also put at rest any concerns about the possibility that the UK nuclear engineering industry may encounter a technical skills gap, by commenting that:

- 'Business representatives... are confident about the UK nuclear industry's ability to meet the demand of nuclear new build'.

Twinning Global Warming and Nuclear Power

Understandably, a core theme at the citizens events was the unequivocal nature of the imminent threat of global warming - and a substantial amount of time was spent detailing this threat. Here, DTI DBERR seemed to simplify and build on recent academic research that, perhaps unsurprisingly, revealed that people were much more likely to accept nuclear new-build if it was presented as a significant part of the solution to the threat of global warming – in fact that research also clearly stated that the issue was much more complex, and suggested that this finding should not be isolated from wider cross-cutting environmental contexts. However, OLR persisted with this twinning of global warming and nuclear power.

One of the most interesting aspects of this rhetoric was the way in which the nuclear agenda seamlessly entwined and translated the threat of global warming. In this sense, 'nuclear' was provided as an enthymemic resolution to the problem of how best to discharge a duty to diminish climate change¹ - however, this sleight of hand was performed without clear reference to how the former related to the latter.

Interestingly it was only very late in the 1-day events that the, by now tired, members of the public were given another hand-out which, half way down page 17, noted that ***the rebuilding of the UK's nuclear fleet would mitigate only 4% of our CO2 emissions.***

At the very end of these meetings, OLR carried out a voting exercise – something that is almost unheard of in 'deliberative' democratic practice. Although opposition to new nuclear power stations was stronger in the North East than elsewhere in England – at the meeting in Newcastle, only 43% of people backed a new generation of nuclear plants, with 41% opposed. The result was closer than the average eight per cent margin across the country, where 45% were in favour and 37% cent against. This suggests that:

The government will face an uphill battle to convince people that the 'voting' exercises undertaken by DTI provided a mandate for public acceptance of new nuclear build.

In this context, we conclude that the key assumptions underpinning the government's approach to the nuclear consultation remain open to critical analysis. We are profoundly concerned that these assumptions have framed the questions asked by the government during the nuclear energy consultation, and were designed to provide particular and limited answers -

¹ Here, enthymemes take the form of an argument that comprises two propositions: an antecedent, and the consequent that is deduced from it; but where one premise is suppressed (Morrell, 2006).

and those answers risk locking in UK energy futures to an inflexible and vulnerable pathway that will prove unsustainable.

In the following sections of this report we address the issues and challenges that were not dealt with in a transparent way during the public consultation. The questions are many, and important. The central one is: how can government ask the public to take a decision 'in principle' for more nuclear power when significant 'what if' issues - such as uncertainty about nuclear fuel supply and manufacture, vulnerability to attack, radiation waste, radiation risk and health effects, reactor decommissioning, reactor design and siting, costs of electricity-generating technologies, energy distribution models, true renewable and energy efficiency modelling – have not been resolved in practice?

4. ISSUES AND CHALLENGES

THE ENERGY LANDSCAPE AND RENEWABLE ENERGY VIABILITY

Prof Dave Elliott, The Open University

The UK has been fortunate historically in terms of energy supplies. The UK's large coal resource provided the power for its industrial revolution, and later it discovered oil and gas offshore, and also pioneered the use of imported uranium in nuclear plants. The use of these resources led to the development of an energy supply infrastructure based on large centralised power plants feeding national power grids and pipelines. The fact that fossil energy resources were relatively cheap and plentiful meant that attention to energy efficiency in terms of generation, transmission and use had a relatively low priority. However, as concerns about fossil resources grew, and as awareness of the need to reduce emissions deepened, new patterns of power generation and use have begun to emerge - with smaller more efficient plants better matched to local end uses. In addition we have increasingly begun to make use of renewable energy sources - a resource that, once again, the UK has in plenty.

It seems likely, although not certain, that we will continue to see a move forward to a more decentralised, locally embedded, pattern of power generation, based on larger numbers of smaller plants using renewables and more attention to end use matching management. One of the main reasons for uncertainty is the current revival of interest in nuclear power - an approach that very much relies on large centralised plants. The government seems convinced that the UK needs nuclear power in order to provide security of supply and reduced emissions, and claims that a return to nuclear can be compatible with the development of renewables.

The public consultation of the nuclear decision was couched mainly in terms of meeting an 'energy gap' that is claimed would otherwise open up, although it was also presented in terms of ensuring that we had a 'balanced' portfolio of energy sources. Less was said about the way in which the overall energy system could or should evolve: nuclear was instead mainly portrayed as something that could be injected to stabilise the more or less unchanged system. This approach has its problems. For example, we have become used to the idea that we need 'base load' supply, which is what nuclear plants provide - they are run continuously. This is actually necessary in any case, partly for technical reasons (they can't easily load follow) but also to recoup their large capital costs. However, as more and more renewables like wind, wave and tidal come on the grid system, what will be needed are

complimentary plants that can be run up and down to compensate for the variable availability of energy from these sources. Nuclear and renewables may both be able to run on the grid as long as both are making relatively small overall contributions, but both cannot expand beyond a certain point without there being operational conflicts. In addition, another current trend is for more attention to be paid to demand management, which will be very beneficial for variable renewable sources, but is more or less irrelevant for base-load nuclear plants.

Complexities and conflicts like this were perhaps understandably absent from the public consultation, but the result was a very simplified presentation of options in the consultation - nuclear, and/or a range of isolated 'other' energy possibilities that apparently could simply be plugged in, with no real sense of overall context. Obviously it would have been hard to present fully developed dynamic system modelling analyses, but what we ended up with is a rather poor menu of isolated options, with many of the 'alternatives' set up to look pretty undesirable or very limited. Thus for example, in the background briefing papers for the public sessions, participants were told that solar could be used 'in sunny countries... where there is no easy way to get electricity to a remote place'. No mention of the fact that the EU has installed around 4 GW (peak) of PV so far, most of it grid linked. Germany is the leader - hardly a sunny country.

A better, more neutral, approach might have been to offer a range of possible mixes of energy supply technologies, as the recent UKERC 'MARKAL' Report (2007) ably illustrates. Even so, a simple 'pick and mix' scenario approach would not be sufficient: some indication of dynamic opportunity costs would also be vital. If you choose a lot of nuclear as an interim option, that means there is less money for developing renewables, which you might want later on.

The DTIs main consultation document laid a lot of stress on costs. It claimed that without nuclear, the costs of a low carbon mix would be higher. This is very speculative. No one can be sure what a new nuclear programme would cost - all past experience suggests that initial cost estimates are too low. Once again, there is a need to take a wider view of what is inevitably going to be a continually and possibly radically changing energy supply and demand system. In this situation, presenting predicted costs for nuclear in isolation seems unhelpful, especially since we are talking about new as yet un-built and un-tested designs, possibly a decade or more away from actual realisation.

Some trends can however be identified from past and ongoing experience. 'Learning curve' analysis, based on the relative rate of price reduction and capacity growth, has indicated that nuclear has achieved learning curves with slopes of only around 5.2% based on N American experience, albeit for a range of different designs, whereas wind power has achieved 18% and solar photovoltaics 20%. Even the arguably more challenging technology of wave power has achieved 10-15%, while the new concept of tidal current turbines, still at development stage, has been achieving 5 -10%.

Renewable Energy Viability

The public consultation briefing documents offers a pretty meagre diet as far as renewable options are concerned, often reinforcing negative stereotypes. Thus solar power is 'unreliable unless you're in a very sunny climate' although it was 'handy for low-power uses such as solar powered garden lights and battery chargers'. No mention of the fact that there is around 118 gigawatt (th) of solar-thermal capacity in use around the world- equivalent to around a third of the world's total nuclear capacity. Perhaps more importantly, in terms of the UK nuclear decision, from what was provided, you would have been hard pressed to grasp the fact that the UK's renewable potential is very large - possibly the largest per capita in the world. For example, the 2004 Renewable Innovation Review by the Department of Trade and Industry and the Carbon Trust suggested that by 2050 renewables could in theory provide between 53-67% of electricity requirements: see Table 1.

Table 1: Potential % of overall UK electricity supply in 2050

| | |
|---------------|---------------|
| Onshore wind | 8-11% |
| Offshore wind | 18-23% |
| Wave /Tidal | 12-14% |
| Biomass | 9-11% |
| PV solar | 6-8% |
| ----- | |
| Total | 53-67% |

Based on overall likely level of supply of 400-500TWh in 2050

Source: DTI/Carbon Trust: 'Renewables Innovation Review' 2004

So far, the UK has made very little progress in exploiting this large resource. The current targets are to get 10% of UK electricity from renewables by 2010, 15% by 2015 and move towards 20% by 2020. On present form we are unlikely to achieve any of these, chiefly due to the problems created by the UK's insistence of sticking with the market-competition orientated Renewables Obligation.

For example, the UK has only managed to install around 2GW of wind capacity, while Germany, which pioneered the guaranteed-price Feed-In Tariff approach, has installed over 20GW, at less cost than in the UK (Elliott 2007).

The UK's poor performance is worrying, especially given that the UK's targets are amongst the lowest in the EU (see Table 2), and also since the EU has recently agreed the much more ambitious overall target of getting 20% of EU energy from renewables by 2020. Several EU countries have actually already achieved this. At present the UK gets around 2%.

Table 2: EU Directive : 2010 Targets for Electricity from Renewables

| | Including hydro | Excluding hydro |
|-------------|------------------------|------------------------|
| Denmark | 29.0 | 29.0 |
| Finland | 35.0 | 21.7 |
| Portugal | 45.6 | 21.5 |
| Austria | 78.1 | 21.1 |
| Spain | 29.4 | 17.5 |
| Sweden | 60.0 | 15.7 |
| Italy | 25.0 | 14.9 |
| Greece | 20.1 | 14.5 |
| Netherlands | 12.0 | 12.0 |
| Ireland | 13.2 | 11.7 |
| Germany | 12.5 | 10.3 |
| UK | 10 | 9.3 |
| France | 21.0 | 8.9 |
| Belgium | 6.0 | 5.8 |
| Luxembourg | 5.7 | 5.7 |
| EU 15 | 22.1% | 12.5 % |

(%) including and excluding large hydro (ranked in order of % excluding hydro)

It is sometimes said, by those seeking to justify switching support to nuclear, that renewables have failed to deliver in the UK. The truth is that they have hardly been tried. The Nuclear Consultation could have more reasonably said that we needed nuclear because we have more or less ignored, or at least botched, renewables. On present performance, tragically, that might be the case.

A more comprehensive consultation of UK energy options might have suggested that one policy might be to radically expand support for renewables, so making it unnecessary to consider nuclear. As it was, we were offered what was, at best, a comparison between a half-hearted renewables programme and a speculatively enhanced nuclear programme. And at worst, a comparison based on caricatures of renewables and fantasies about nuclear.

THE SECURITY AND PROLIFERATION CONSEQUENCES OF A NUCLEAR RENAISSANCE

Prof Frank Barnaby, Oxford Research Group

Can nuclear power contribute significantly to achieving a reduction in global warming and climate change and contribute significantly to a sustainable global energy future? In my opinion, it cannot. Moreover, the huge amounts of money and human skills that will be needed to achieve a significant global increase in the use of nuclear power would be best spent on research into and the development of non-nuclear energy sources, particularly renewable energy sources.

The shortage of uranium ores rich enough to give a positive net energy will lead to the use of fast breeder reactors, fuelled with plutonium usable in very effective nuclear weapons. A significant use of fast breeder reactors will carry with it the real risk that nuclear weapons will spread to new countries and that terrorist groups will eventually acquire plutonium, fabricate primitive nuclear weapons and use them in terrorist attacks.

Climate scientists say that, to keep climate change within manageable limits, and prevent the risk of runaway climate changes, the concentration of atmospheric greenhouse gases should be kept to no more than about 550 parts per million. Today's concentration is about 380 ppm. The pre-industrial concentration was about 280 ppm.

The 550-ppm threshold may be reached by about 2035 unless urgent action is taken. If nuclear power is to play a significant role in preventing this threshold being reached it does not have long to do so. Furthermore, if nuclear power is to play more than a marginal role in combating global warming then nuclear power reactors will have to be operated in many developing countries, and the amount of nuclear electricity will have to increase at least by a factor of at least eight within the foreseeable future. Such developing countries are, to say the least, unlikely to be able to obtain the capital and technical expertise needed to operate and safely maintain nuclear-power reactors and to dispose of the high-level radioactivity produced by their reactors.

To make a significant dent in the global cumulative carbon emissions, by say 2075, assuming that countries then generate one kilowatt of electricity per capita (probably an underestimation), and that they generate a half of their electricity by nuclear power the world would need to generate 3,000 GW of electricity by nuclear power-reactors, about 8 times the current generation. An

increase of at least this magnitude will be needed if nuclear power is to make a significant effect on global warming.

There is insufficient high quality uranium to fuel a large increase in the number of power reactors. According to the IAEA and the OECD, the known recoverable uranium resources are 4.7 million tonnes. Assuming that world nuclear capacity remains constant at 372 GW, the net energy from uranium will fall to zero by about 2070. Assuming that world nuclear share remains constant at 2.2 per cent of world energy supply, the net energy will fall to zero by about 2050.

The shortage of uranium ores rich enough to give a positive net energy will lead to the use of fast breeder reactors, which use fuel containing mainly plutonium and requiring only a small input of uranium. If the nuclear industry gets its way, fast breeder reactors will be used commercially after about 2030. A major security concern is that the plutonium used in fast breeder reactors will be suitable for use in the most efficient nuclear weapons, increasing the risk of nuclear-weapon proliferation and of nuclear terrorism.

If the world is using 3000 GW of nuclear electricity in 2075, and if this was based on the once-through nuclear cycle using light-water reactors, it will be generating approximately 600 tonnes of plutonium annually (and would require roughly 500,000 tonnes of uranium). But, if it this nuclear capacity were based on fast breeder reactors, as the nuclear industry predicts, more than 4,000 tonnes of plutonium will have to be fabricated into fresh reactor fuel each year, enough to fabricate a million nuclear weapons.

A significant use of fast breeder reactors will carry with it the real risk that nuclear terrorist groups will eventually acquire plutonium, fabricate primitive nuclear weapons and use them in terrorist attacks.

The UK has considerable potential for using wind, wave, tidal and solar power. If the trend in the contribution of photovoltaic cells actually achieved in the past five years is continued it will reach 10 GW by 2020, more than new nuclear build is likely to achieve by that date. The potential of offshore wind alone, for example, has been estimated to be 70 GW, the largest in Europe. This could replace the current total electrical power capacity in the UK. The British Wind Energy Association (representing 310 companies) has estimated a total onshore and offshore wind capacity of 24 GW for 2020. Given these possibilities, it is hard to see why there is a need for much nuclear power.

NUCLEAR UNCERTAINTY

Dr Jerome Ravetz, University of Oxford

As an engineering project, civil nuclear power presents uncertainties that are unprecedented and insuperable. In the medium and long run, they are so great as to swamp all the numerical calculations about costs and benefits. Only by a total discounting of the future and of our obligations to our descendants, can there be a quantitative assessment of the prospects for civil nuclear power.

Even in the short to medium term, civil nuclear power is afflicted by quite severe uncertainties. There is the delay before any large-scale construction and operation could be realised, given the lack of a skills base in crucial areas. Prior planning for training the trainers of engineers of all sorts would need to be implemented, and it is an open question whether recruits in sufficient quantity and quality would be forthcoming. Whether nuclear power could be achieved on an effective scale in time to affect the climate change issue, is totally uncertain and highly dubious. There are further uncertainties about the supply of high-grade ores; and lower-grade ores would add costs, both financial and in the energy requirements of their processing. Once in operation, nuclear materials, either in power stations, in storage or especially in transit, would present an attractive target to terrorists. For the foreseeable future, this would be a serious, though unquantifiable risk.

When we come to the medium to long term, we face uncertainties about the financial and resource costs of decommissioning and ultimate disposal. Given that decommissioning is now recognised as a cost, it is possible that these costs would be less uncertain than for the earlier generations of power stations. But these costs relate to installations that have not even been designed. Unless the taxpayer is forced to assume those costs in advance, their uncertainties will be a deterrent to any commercial investment. The impossibility of getting insurance cover (now admitted by the government) is final proof that the uncertainties of civil nuclear power are totally unmanageable.

The intermediate storage of radioactive wastes has not been successfully accomplished anywhere. Any designs that guarantee access also compromise security; and in an age of terrorism that is a serious uncertainty. For long-term geological storage, we can ask how there could possibly be a solution to the problems of guaranteeing the integrity of containments over geological time under unknowable conditions. For that prospect, we must speak of irremediable ignorance rather than of mere unquantifiable uncertainty.

Under some circumstances it is justifiable to embark on policies with extreme uncertainties, provided that the alternatives are clearly worse. Nuclear power

is promoted as, at best, one mode of electricity generation among several, presented as competing on equal terms.

Although there are uncertainties in the assessment of all technologies, those of nuclear power are so great as to render it uncompetitive in any realistic assessment.

RADIOACTIVE WASTE AND NEW NUCLEAR BUILD – THE ETHICAL ISSUES

Prof Andy Blowers OBE, Open University, member of the first Committee on Radioactive Waste Management (CoRWM)

In its consultation document on The Future of Nuclear Power, the government reaches the conclusion that 'new waste could technically be disposed of in a geological repository and that this would be the best solution for managing waste from any new nuclear power station'. It also considers that, in terms of creating new nuclear waste, 'the balance of ethical considerations does not require ruling out the option of new nuclear power' (DTI, 2007, p.146). These conclusions appear to rest on two judgements. One is the technical judgement that confidence in the safety and security of geological disposal is so far advanced that it provides a long-term solution to the problem of managing radioactive wastes safely. The other is a social and ethical argument that a voluntarist process of site selection will ensure that an acceptable location will be found for a geological repository. Both arguments are contestable and, in our judgement it is premature to claim that a solution and a site will be secured that can justify adding an unpredictable and unnecessary burden of radioactive wastes from a new build programme to the existing burden of legacy wastes which has inevitably to be managed.

1. The Technical Arguments

(a) Geological Disposal

Let us be clear: there is, as yet, no proven technical solution for the long-term management of radioactive wastes. The creation of more wastes cannot be justified unless there is a scientifically sound and socially acceptable solution. Indeed, as recently as 2003, it appeared the government recognised that the unresolved issue of nuclear waste was a reason for not proposing new build at that time (Sullivan Judgement, 2007, para. 105). The government's more optimistic position only four years later seems to rest primarily on the recommendations of the Committee on Radioactive Waste Management (CoRWM) which reported in 2006. CoRWM's first recommendation stated: 'Within the present state of knowledge, CoRWM considers geological disposal to be the best available approach for the long-term management of all the material categorised as waste in the CoRWM inventory' (2006, p.12). It is important to understand what is being stated here. Geological disposal is the best 'approach' within the state of present knowledge. It is not a solution, rather an 'approach' and one that is to be preceded with 'a robust programme of interim storage' (CoRWM Recommendation 2) and 'a commitment to an

intensified programme of research and development into the long-term safety of geological disposal aimed at reducing uncertainties at generic and site-specific levels' (CoRWM Recommendation 4). While geological disposal is currently the best approach, CoRWM also recommended that 'flexibility in decision making should leave open the possibility that other long-term management options...could emerge as practical alternatives' (recommendation 5). The qualifications surrounding CoRWM's recommendation on geological disposal would appear strongly to refute the government's claim that 'A technical solution for disposing of radioactive waste has been agreed' (CoRWM, 2006, p.143). Yet, in its two consultations, on future nuclear energy and on MRWS it is clear the government regards geological disposal as the solution both for legacy and new build wastes.

Nuclear new build should not proceed until there is an acceptable solution for the permanent management of long-lived solid nuclear waste.

(b) Overseas Experience

The apparent progress made in other countries is cited as evidence that geological disposal is the generally accepted solution. It is important that we examine precisely what progress has been made. In the US the WIPP deep facility in salt beds beneath Carlsbad (New Mexico) is receiving wastes (though only transuranic wastes from the military programme). Elsewhere, a deep geological repository has been agreed in Finland and Sweden will choose between two sites in 2009. France has adopted deep geological disposal as its end point and will review licensing a site in 2015 in order to commission a repository in 2025. In the US, Yucca Mountain (Nevada) is the proposed site for a geological repository for the country's spent fuel. But, in none of these countries has a repository yet been constructed, let alone opened. Elsewhere, for instance in Japan and Germany, proposals for deep disposal facilities have encountered strong opposition. Canada, like the UK, has completed a similar process which, as in the UK, has resulted in proposals that remain at the generic planning stage. While it is true that geological disposal is the preferred scientific solution almost everywhere, it is a long way from being successfully implemented in any country.

Overseas experience does not provide evidence of a long-term solution sufficient to justify deep disposal for new build wastes in the UK

(c) Wastes from New Build

CoRWM was quite explicit that its recommendations related only to existing and committed arisings – in other words 'legacy' wastes. It expressed concern that it's 'proposals might be seized upon as providing a green light for new build' (CoRWM, 2006, p. 15). The government considers that it would be 'technically possible to dispose of this waste in the same repository concepts as legacy wastes' (DTI, 2007, p.134). This would affect design and costs but, in terms of added volumes new build wastes could be accommodated in a co-located repository. For instance, 10 new AP1000 power stations operating

over 60 years would add only 8% volume of new build to the existing legacy although the footprint of a repository might increase by about 50%, (Ibid, p.135). However, new build wastes could increase the radioactivity of the UK's waste inventory by at least three times. While the volumes and activity of legacy wastes present a known problem, new build would introduce uncertainties in terms of volumes, activity and unknowable time-scales of implementation. 'The construction and operation of a new generation of nuclear power stations will make it difficult to define a waste inventory once and for all; there will be uncertainties over the volumes of waste and the timescale over which they will be generated' (p. 177).

Proposals for the management of legacy wastes should not be applied to wastes from new build which raise different technical and ethical issues.

2. Ethical Considerations

Radioactive waste is an ethical issue for several reasons. It is associated with nuclear energy, nuclear weapons, the dangers of proliferation and terrorism, all of which raise ethical concerns. Radioactivity impacts unevenly between places and across generations and raises ethical issues of intragenerational and intergenerational equity. These issues are considered in depth in Ethics and Decision Making for Radioactive Waste (CoRWM, 2007).

(a) Intragenerational Equity.

This relates to fairness between communities hosting radioactive waste facilities. There is no site yet identified for the long-term management of nuclear waste. There is a process for selecting such a site proposed by CoRWM. This process is based on the following features:

- a clearly defined inventory of wastes to be managed;
- a community's willingness to participate in a site selection process;
- a right to withdraw from the process up to a pre-defined point;
- a continuing programme of public and stakeholder engagement;
- the development of a partnership approach between host community and implementing body;
- the provision of community packages designed to enhance community well-being in both the short and long term;
- decision making based on both participative and representative democratic processes.

The government indicated that it 'is supportive of exploring how an approach to siting based on voluntarism (that is, willingness to participate) and partnership could be made to work in practice' (Defra and Devolved Administrations, 2007, p.7).

However, the various elements of this process have not yet been put into practice and agreements must be reached before the process of

implementation, including site selection, can begin. One issue concerns who is invited to participate. CoRWM considered that areas where radioactive waste facilities would be unacceptable on scientific or other grounds must be screened out initially. However, the government, in its MRWS consultation document, indicated that sub-surface screening should be used to eliminate unsuitable sites only after initial expressions of interest have been made. Whichever process is used it is axiomatic that a site must be potentially acceptable on scientific grounds. In this context it may be noted that the Sellafield RCF was rejected in 1997 partly on the grounds of 'the scientific uncertainties and technical deficiencies' in the proposals. It might, therefore, be concluded that Sellafield should be excluded from any consideration as a site for a repository on the grounds of its unsuitability in terms of geology and hydrogeology (see Smythe, 2007). At the very least, it suggests that Sellafield should not be selected merely on the grounds that it already has most of the waste and its potential willingness to host a facility.

Site selection requires an open and transparent process providing both information and resources for communities to be able to participate on an equal basis. Above all communities will need to know:

- the extent of potential packages to compensate them for hosting a burden on behalf of society as a whole;
- the extent of the commitment they are making, in particular what is the inventory (nature, volume, radioactivity) of the wastes, the footprint and infrastructure associated with the repository and the time-scales during which construction and operation will occur;
- the scope of their participation in decision making and the extent of the right to withdraw;
- how the process of representative decision making will be made effective.

While effective implementation will be difficult for legacy wastes, it will become almost impossible if new build is added. In particular it will be very difficult to provide accurate and credible information on the extent of the community's future commitment to hosting radioactive wastes.

Areas that are unsuitable on scientific or other grounds must be ruled out before a process of site selection commences.

All communities which express a willingness to participate must be able to understand the extent of the commitment they are making.

New build waste must be ruled out on the grounds that it represents an open ended commitment on the part of a potential host community.

(b) Intergenerational equity

A key problem with radioactive waste is that the risks from radionuclides persist down the generations into the far future. This fact imposes a moral responsibility on the generation that produces the waste to mitigate the

impacts on succeeding generations. This raises the question: how far can and should this responsibility extend? One view suggests that there is no justification for an arbitrary cut-off point - that responsibility extends up to the limits of the impacts of our actions. An alternative, pragmatic ethical viewpoint, argues that we should exercise what responsibility we can, recognising that our capacity to do so necessarily diminishes over time. There is, therefore, a contrast between a view of continued responsibility, against that of diminishing responsibility. These different viewpoints may be translated into alternative approaches to managing the wastes. On the one hand, it may be argued that geological disposal cannot provide sufficient assurance about safety in the very long term and, consequently, wastes must be stored or be retrievable for the foreseeable future. This position also enables future generations to participate in decisions affecting them. The other view is that geological disposal should be achieved as soon as possible. This would provide protection as far as is practicable into the far future while also removing the burden (of cost, risk and effort) from our immediate successors.

In any case, the time-scales involved in finding a site, constructing and operating a repository before closure are likely to involve one or more generations up to a hundred years or so. If new build wastes are added then the time-scales of implementation stretch forward interminably. In short, whatever view is taken about the extent of responsibility to the future, new build will inevitably impose a greater and longer lasting burden of radioactive waste. Radioactive wastes will require secure and safe storage and, if eventually disposed of, will need, for some time, careful and continued monitoring.

The ethical issues surrounding radioactive waste were a major reason why CoRWM was quite clear in stating that a new build programme would require 'a quite separate process to test and validate proposals for the management of the wastes arising' (p.15).

Any new build programme should not proceed until it has been subjected to a thorough process of citizen and stakeholder engagement on the issue of radioactive waste including the quite distinctive and separate ethical issues that arise.

(c) The broader ethical issues

There are two broader ethical issues that are often raised in connection with radioactive waste. The first is that nuclear waste can be seen as an acceptable burden on the future when set against the presumed benefits of nuclear energy. This assumes that these benefits can only be supplied by nuclear energy. Elsewhere we demonstrate that nuclear energy is not an essential component of a low carbon energy mix for the future. In any event it would seem difficult to justify the continuing and long-term risk from dangerous materials whose production for a comparatively short-term benefit is difficult to justify. The benefits to one or more generations must be contrasted with the burdens that are imposed into the far future.

A second broad ethical issue is raised in the government's Consultation Document. It states: 'we believe that the intergenerational issues of radioactive waste should not be considered in isolation, but alongside the long-term impact of climate change. We consider that we need to balance the creation of additional radioactive waste with the increase in carbon dioxide emissions that would be produced if energy demand is met by fossil fuel rather than new nuclear power stations.' (DTI, 2007, p.144).

This is a seductive argument but, on closer inspection, pure sophistry. It may be challenged on the following counts:

- it is not clear why radioactive waste should be considered alongside climate change. Radioactive waste is long-lived and dangerous per se. In terms of the dread it provokes, the dangers of proliferation it harbours and the risks of disease and death it contains, it deserves to be treated independently. Nuclear energy is an ethical issue in its own right as we have sought to demonstrate;
- it cannot be conclusively demonstrated (as we show elsewhere) that the alternative to fossil fuel is nuclear energy. Therefore, the claim that there is a carbon benefit that comes only through nuclear energy is contestable;
- climate change and radioactive waste are difficult to compare not least because of the very long time scales involved with radioactive waste. The problem of radioactive waste will persist long after the consequences of climate change;
- it is clear that climate change and nuclear energy raise fundamentally different ethical issues. By suggesting that nuclear new build should be discussed in terms of the need to address climate change the government is framing the discussion in a particular way, one that is likely to privilege the case for nuclear energy.

We have argued that new build wastes raise different and distinctive ethical issues from those pertaining to legacy wastes. That is why we support CoRWM's conclusions that 'future decisions on new build should be subject to their own assessment process, including consideration of waste' (CoRWM, 2007, p.14). Such an assessment 'will need to consider a range of issues including the social, political and ethical issues of a deliberate decision to create new nuclear wastes'.

The unresolved technical and ethical concerns related to managing radioactive wastes safely provide both a necessary and sufficient condition for rejecting the case for nuclear new build.

RADIOACTIVE WASTE – A PROBLEM WITHOUT A SOLUTION

Pete Wilkinson, member of the first Committee on Radioactive Waste Management (CoRWM)

Government support for nuclear power is based on a number of deeply questionable premises. Among these are assertions about the beneficial aspects of nuclear-derived electricity on security of supply and climate change grounds. These assertions are problematic for a number of reasons: Generation of nuclear electricity in the UK relies on the importation of high-grade uranium, a metal which is likely to prove scarce in the coming decades. The enormous investment that would be required for new nuclear build would divert resources from the decentralised technology which could have immediate impact on achieving climate change targets. Perhaps more importantly, Government also bases its support for nuclear new-build by asserting that a solution has been found to the management of the 500,000 cubic metres of long-lived legacy waste containing 78 million terrabequerels of radioactivity requiring housing in a receptacle five times the volume of the Albert Hall over a period of one million years. It argues that the Committee on Radioactive Waste Management (CoRWM) provided that solution in its report published in July 2006. This is wrong for a number of reasons:

- The CoRWM recommendation for disposal as the ‘best method of management’ applied only to legacy wastes² - CoRWM argued very strongly on several occasions that the management of wastes derived from a new build programme was clearly unresolved³.
- The statement which indicated that CoRWM felt that disposal was ‘the best means available’ was not a unanimous view, and in any case was conditioned by the phrase, ‘in the current state of knowledge and when compared to other methods of management’ when both the comparison CoRWM undertook and the current state of knowledge were acknowledged as being inadequate.
- The recommendation for disposal, even though it applied only to legacy wastes, was itself couched within a raft of interdependent and interlocking recommendations which conditioned the recommendation so heavily as to make the management of waste by the process of deep geological disposal only viable after a number of protracted and

² CoRWM, Final Report, 2006.

³ CoRWM ‘sign off’ document, 2006.

detailed processes had taken place⁴. These were, in essence, an intensified research and development programme to reduce the uncertainties around deep geological disposal, a thorough-going review for the purposes of 9/11-proofing of existing storage arrangements as a contingency against the absence of societal consensus for disposal and the identifying of one or more volunteer communities willing to host a repository. None of these prerequisites have been met and the work which is taking place in these areas is entirely inadequate.

In addition to this, the CoRWM process which arrived at the recommendation for deep geological disposal was undermined by the consideration by the Committee of an option developed by Nirex in the wake of the failed Rock Characterisation Facility (RCF) in 1997 known as ‘phased deep geological disposal’⁵. This option is inferior, and tendentiously offers a community a contradictory ‘retrievable disposal’ option. In truth, it is neither, since if left open for up to 300 years to facilitate recovery of the material (an event which will occur not for any radiological, health imperatives but only if spent fuel, uranium and separated plutonium are seen to be commercially worth retrieving), it undermines the key attribute upon which CoRWM based much of its justification for disposal – ‘removal of a burden to future generations’. On the other hand, if it is closed promptly, it simply becomes a disposal option which removes the ability to retrieve, and justification then falls back on the ability to make a safety case for disposal without the ability or intention to recover the waste⁶.

CoRWM assessed the impact of waste material arising from a new build programme on a notional deep geological repository. It concluded, the caveat above notwithstanding, that spent fuel arisings could be physically accommodated within the repository, as the volume increase over the projected 500,000 cubic metres of conditioned legacy waste represented by new build arisings would be circa 10%. In radiological terms, however, CoRWM estimated that nuclear new build spent fuel would increase the inventory from 78 million terrabequerels to around 390 terrabequerels – a five fold increase. This figure has recently been challenged as being too low. A recent report⁷, concluded:

‘There is no evidence that the ominous (terrorism-related) consequences of accumulating large quantities of spent fuel in interim stores at each reactor site have been considered by the government either as part of its nuclear power consultation or its programme of ‘managing radioactive waste safely’.

The accumulation of a huge radioactive inventory in interim spent fuel stores at each reactor site would be against the public interest. The decision ‘in principle’ to permit energy companies to build new nuclear power stations represents the casual acceptance of unnecessary hazards before their gravity

⁴ CoRWM Report Recommendations, 2006.

⁵ CoRWM Report, 2006

⁶ Letter to Environment Minister, Hilary Benn, 2007.

⁷ ‘Storing Up Trouble’, Hugh Richards, 2007.

is fully recognised. In these circumstances no 'statement of need' for nuclear power has any credibility.

The NDA's objective in decommissioning its existing Magnox stations and associated facilities such as Sellafield is to drive down the radioactive hazard by removing material from sites to ensure greater protection for those living around the plant and beyond. A new build programme will do precisely the reverse of this policy. Those nuclear sites with Magnox, AGR, and PWR complexes are experiencing a build-up of AGR or PWR spent fuel, the former caused by the continued unavailability of the Thermal Oxide Reprocessing Plant (THORP), the latter by design. Thus, candidate sites for potential new build 'C' plants are currently accumulating higher, not lower, hazard levels. Even if THORP was to become operational and was able to clear the AGR backlog; spent fuel from a new build programme, regardless of radioactive decay processes taking place during the interim storage stage for the spent fuel, would systematically and progressively increase the hazard on nuclear sites when the prevailing regulatory policy is to systematically and progressively reduce those very hazards.

There is no 'solution' to the management of radioactive waste, be it 'legacy waste' or that derived from the operation of a new generation of nuclear power plants. That Government has assumed the recommendation from the Committee on Radioactive Waste Management represents such a 'solution' is wrong and deliberately mendacious.

THE ECONOMICS OF NEW NUCLEAR BUILD

Prof Steve Thomas, University of Greenwich

Over the past 30 years there have been regular reports of a global renaissance in the nuclear industry. These re-births have always been based on a claim that nuclear power would provide cheap power and help meet objectives, such as mitigating global warming or reducing reliance on unstable fossil fuel suppliers. An examination of the economics of new nuclear plants suggests that the latest attempts to re-launch nuclear ordering in the UK and elsewhere will be no more successful than previous attempts.

Although the government maintains that it would be for the private sector to fund, develop, and build new nuclear stations, nuclear power plants in UK would only be possible if the large economic risks of building, and operating them were borne by the British public.

In the West, the only current orders for modern designs are a unit under construction in Finland and a single order for France. So why, if these new designs are as cheap and efficient as their proponents claim, are so few plants being ordered? The idea that technical progress, and learning from the experience of building and operating plants will mean that new designs are cheaper and better is intuitively plausible, but over the 50 years of experience of nuclear power, this has never happened.

Each generation of plants has been more expensive than its predecessor. We can see this most clearly with construction costs: repaying construction costs and interest charges are expected to make up at least two thirds of the kWh cost of electricity so these are critical in determining nuclear power's competitiveness. In the forecast nuclear renaissance of the late 1990s, the nuclear industry claimed it could build new plants for \$1000/kW so that a typical nuclear power plant with a capacity of a million kW would cost £0.5bn. Experience with the Finnish plant, Olkiluoto, ordered in 2005, is particularly salutary. After two years of construction, the plant is two years behind schedule and 50 per cent over budget. It was forecast to cost about \$3000/kW but, even if there are no more cost over-runs, it will cost about \$4500/kW. It is clear there has been a massive increase in expected nuclear construction costs in the past decade.

The other factor working against nuclear power results from the transformation of electricity from a monopoly to a competitive market. All nuclear plants built so far have been built by monopoly electric utilities. They could recover whatever costs they incurred from consumers, so if things went

wrong, they simply increased electricity charges. This meant that if utilities made bad decisions, there was no penalty to them because consumers paid the bill. It also meant finance for nuclear plants was cheap. Banks lending money to utilities to build nuclear plants knew that their money would be repaid because consumers underwrote the loans. Real interest rates were low, perhaps 5 %.

The privatisation of the British electricity industry in 1990 transformed electricity generation into a competitive market. Now, if nuclear power is not competitive, the owners will go bust and its creditors lose their money. This was clearly illustrated in 2002 when the British nuclear power plant owner, British Energy, collapsed at a cost to British taxpayers of about £10bn, because its costs were more than its income. This risk to financiers means the cost of borrowing for any type of power station has more than doubled and nuclear power stations with their very poor record of being built to time and cost are seen as particularly risky.

So how was this problem overcome in Finland and France, which, according to European Union legislation should also operate a competitive electricity market? In Finland, a unique set of measures including export credit guarantees from the French and Swedish governments - these are usually reserved for exports to third world countries with poor credit ratings - meant that the plant could be financed by a loan paying only 2.6 per cent interest. For France, the plant will be built by the state-controlled EDF, which has about 90 per cent of the French electricity market and is little concerned about the impact of competition.

New nuclear plants will only be viable in the UK if they are protected from the electricity market and the economic risks shifted from the plant owner to taxpayers and electricity consumers. In practice, this means that, as a minimum, the cost the plant owner would have to pay to build the plant would have to be fixed in advance with any cost over-runs picked up by consumers or taxpayers. The plant would have to be given a long-term contract (at least 15 years) so that consumers would buy the output of the plant at whatever costs are incurred (this was what happened in Finland).

Over the past 40 years, the British government has made four attempts to re-launch the British nuclear power programme. The result of these attempts is a handful of unreliable and uneconomic units that supply less than 20 per cent of our electricity.

The political and environmental concerns that nuclear is expected to meet are real, but nuclear power cannot deal with them. If Britain was to pursue nuclear power now, it would load extra costs on the British people and it would continue to divert attention and resources away from the measures that could be effective in dealing with these serious concerns.

SECURITY OF SUPPLY

Dr Ian Welsh, University of Cardiff

Nuclear Power has been presented as central to the maintenance of secure electricity supplies in the context of changed circumstances confronting the UK at the start of the twenty-first century. Key changes include the downward revision of the anticipated lifespan of North Sea oil reserves and the need to reduce carbon emissions from electricity generation. The imminent closure of the majority of the countries existing nuclear power stations combined with uncertainties surrounding gas imports have been forwarded as arguments to intensify the case for new nuclear build.

However, to meet all of these objectives a number of new nuclear power stations would need to be constructed and in operation in a time period consistent with increasingly ambitious CO₂ reduction targets and known constraints on gas supplies. This is a relatively short period of perhaps ten years and raises issues associated with security of supply.

Reactor Construction

There are significant constraints on the number of reactor construction projects which can be undertaken simultaneously due to labour force limitations including those within the Nuclear Installations Inspectorate (Financial Times, 25.20.2007, p. 3). The security of electricity generation from nuclear stations is dependent upon build quality and rigorous inspection - and rapid labour force expansion can be inimical to both.

Labour market limitations on any envisaged construction programme are likely to impact on envisaged completion dates and have implications for reactor reliability and safety.

Reactor Location

Cooling water considerations confine the UK to coastal reactor sites. The Health and Safety Executive is amongst the organisations emphasising the vulnerability of existing sites given predicted sea level rises associated with climate change. As predicted sea level rise figures have tended to increase, this is likely to continue. Storm surges and other extreme weather events are significant issues.

The vulnerability of coastal locations to climate change related events represents a significant and difficult to quantify risk to security of supply.

Wider Issues

New nuclear build will add to the existing risks associated with reliance on national and trans-European grids fed by large generating units. These include the vulnerability of such systems to terrorist attacks and extreme weather events.

Distributed supply systems can insulate against these risks.

Estimates of proven uranium reserves vary widely (EC 2001, OECD 2004) but there is a widespread acceptance that any significant increase in nuclear generating capacity will reduce the lifetime of reserves (12 – 50 years), require an expansion of the uranium mining industry and further uranium prospecting. Some analysts are optimistic that economically viable long term reserves will become available (MacDonald, 2003): However, at concentrations below a certain point the economics and market security of uranium will become difficult to predict.

It is vital not to regard Uranium supplies as unproblematic.

Whilst nuclear power is carbon neutral at the point of electricity generation the carbon impact of the integrated nuclear fuel cycle adds significantly to the climate change impacts of the technology. Utilising marginal uranium reserves would add to the environmental impact of nuclear programmes.

The opportunity cost of investing in nuclear build may foreclose investment in more robust technical options.

Security of Supply in the 21st Century

The UK's electricity infrastructure requires a sustained period of investment as aging reactors and transmission systems require replacement. Market volatility and vulnerability to political manipulation have revealed weaknesses in reliance on gas and oil imports leading to a renewed emphasis on nuclear build.

Given the scale of inescapable investment in electricity supply infrastructure over the short to medium term there is an historic opportunity to invest in a security supply approach consistent with 21st Century challenges.

Such an approach requires thinking outside an established paradigm associated with connecting large generating sets to national and trans-national grids. Despite research efforts such grids typically result in the loss of around 60% of the thermal energy used to generate electricity. This factor increases the attractiveness of distributed electricity generation utilising solar gain, wind and other techniques.

The Government needs to lead in this area and acknowledge that consumer preference alone cannot constitute a sustainable energy market. This requires a market maker state prepared to create the necessary investment and pricing conditions for emergent technologies.

Tariff structures for domestic and independent business generation are an important requirement here. Establishing domestic generating systems as normal features of houses and not a consumer lifestyle choice can be done through changes to building regulations. This is an area where the UK lags far behind many other EU member states.

The traditional consumer / producer divide central to 20th century thinking is being eroded by advances in technology in numerous areas. Energy supply is no exception to this, yet the Government's approach to renewables remains wedded to established supply side thinking hinging on large off-shore wind farms.

Insulating the UK from energy market insecurities in the current century may require:

- Maximising the use of renewable energy as close to the point of use as possible.
- Minimising the vulnerability of electricity generation and transmission systems to a range of threats including extreme weather events, terrorist attack and rising sea levels.
- Maintaining *the necessary* levels of large scale generating capacity in an as close to carbon neutral manner as possible.
- Investing in a generating system which minimises long term risks and economic implications for future generations.

By acting to establish viable domestic and small scale electricity generating capacity in the UK the Government can move towards fulfilling these goals. Such measures can make meaningful contributions to CO2 reduction targets within the short timeframes identified as consistent with climate change mediation. New nuclear build will come too late to achieve this critical objective.

ENERGY POLICY AND REGULATION

Duncan Bayliss, MRTPI University of the West of England

Consultation about the future of nuclear power in the UK should be seen in the context of the evolution UK energy policy, and how that contrasts with other developed nations. If a broad objective overview is taken, it becomes clear that there's a range of highly contestable assumptions embedded in the UK government's approach to the Nuclear Consultation - it also becomes clear that nuclear power is not an inevitable or necessarily attractive option. In this context, there are some key points about UK energy policy that need to be considered:

- The UK has been, and remains, fixated on supply side solutions.
Nuclear power is apparently seen by the government as a necessary supply-side fix.
- The UK lags significantly behind other developed countries in the implementation of demand side management (DSM) measures such as energy efficiency and related approaches such as combined heat and power.
Consideration of approaches to energy efficiency already implemented in other countries radically alter the perception as to what supply side solutions are needed in the UK.
- The UK has been fortunate to have large fossil fuel reserves - this has gone hand in hand with the neglect of DSM.
The implementation of renewable energy supply has lagged behind comparable developed countries.
- The UK in common with many developed countries has developed a large scale centralised energy distribution system for electricity and gas. This has been structured around large scale investments and large utility companies.
Lack of policy and regulatory commitment has led to only half hearted attempts to make access to energy markets feasible for smaller scale suppliers and has favoured large scale suppliers dependent on fossil fuels and nuclear power.
- The UK has never managed to achieve a clear long-term national energy policy, developed from wide spread consultation, that integrates the full range of environmental concerns alongside security of supply and economic considerations to achieve a flexible, adaptable energy future. It is still struggling to achieve that now.
A comprehensive national energy policy should coherently integrate regulation, supply, demand, and other policy goals of government.

- The UK has developed a policy regime that has primarily focused on price and has favoured large scale investment. This has acted as a break on smaller scale localised generation, and held back the implementation and development of true renewables.

Other countries in the EU and elsewhere have found effective solutions to policy and regulation that have already resulted in far greater installation of renewable energy capacity and greater energy efficiency measures.

So, there is a clear case for both challenging the existing policy and regulatory regime in the UK, and suggesting that effective solutions other than nuclear power are viable, economic and available right now.

It was a major short-coming of both the Energy Review and the Nuclear Consultation that they both accepted uncritical views of existing regulatory and industrial regimes. A further weakness was to ignore the valuable experience of comparable European nations.

There's also a compelling case against nuclear power. As discussed in other sections of this report, there are a range of serious challenges and issues that make any nuclear renaissance highly problematic and, which if taken in the round, fundamentally question the practical, economic, ethical, environmental and health grounds for considering nuclear power an acceptable option.

These issues and challenges include fundamental problems relating to: security and proliferation, scientific uncertainty, radioactive waste, cost, security of supply, reactor design, problems in siting, health effects and more.

Competing UK Energy Futures

Within ongoing debates about energy futures there are broadly two different approaches being discussed. Although not mutually exclusive, they represent two distinct emphases:

- Centralised production, large scale facilities, big technology, fossil fuels and nuclear power.
- Localised production, diverse sources, renewables, local control, energy efficiency (demand-side management), district heating from combined heat and power.

The implied vision of UK energy futures in this consultation exercise can be seen in the context of maintaining the present centralised system - which has received enormous state support, policy preference and subsidy, both direct and indirect. This approach has favoured supply led solutions rather than managing demand through energy efficiency. It has favoured technologies that are the most economic for large scale plant, and has gone hand-in-hand with our reliance on North Sea gas and oil and nuclear power.

New nuclear build is very much part of this vision - yet that whole approach is worth questioning. Centralised electricity production results in large scale losses through the grid. Continuing to focus on a heavily centralised system distracts from finding ways to increase the efficiency of the supply system as

a whole. It also means that many of the dis-benefits of production are experienced intensely by communities where facilities are sited.

In contrast the vision of a move towards a de-centralised system with smaller scale production and localised consumption where possible, holds out the possibility of making significant gains in the efficiency of the supply system as a whole. Traditional fossil fuel power stations operate at about 40% (coal), and 50% (Gas) efficiency, when losses to heat and grid transmission are taken into account. Whereas power stations that send their heat to district heating grids that use the waste heat from the power station to heat homes easily achieve efficiencies of 60% plus. With small scale combined heat and power (CHP) and localised electricity consumption (embedded generation), further efficiency gains can be achieved. Those efficiency gains represent significant real reductions in carbon emissions that could easily be greater than any CO2 reductions achieved by nuclear power stations.

Simply put, investing in nuclear power will result in a single CO2 reduction being achieved in comparison to any fossil fuel alternative. Whereas spending the same money on progressively creating a highly efficient de-centralised energy system offers the possibility of continuing to achieve far greater CO2 reductions on an ongoing basis over the same time period. Once nuclear power stations are built they cannot become any more efficient and they represent a one-off displacement. Renewables are becoming significantly more efficient all the time and can be implemented flexibly over much shorter timescales and updated as new efficiencies are developed.

Nuclear Consultation Pressures and Drivers

The Nuclear Consultation clearly hasn't arisen in a vacuum – it has been prompted by concerns that relate closely to the three widely accepted goals of energy policy:

- Security of supply.
- Environmental protection.
- Economic supply.

In greater detail, the key concerns that have led to the present policy review are:

- Concern over security of supply - especially imported gas.
- The need to replace a large amount of existing energy supply facilities in the future - leading to a potential 'energy gap'.
- Greatly increased concern over global environmental impacts – especially the effect of CO2 emissions on the global climate.
- Recent rapidly increasing consumer utility bills.

However, it remains unclear how far a nuclear renaissance would mitigate these pressures. Firstly, the UK has no uranium reserves - demand is set to outstrip supply, and the cost of Uranium will likely rise. Secondly, although it's

true that we need new generating capacity - it's not true that nuclear is able to fill that gap. The earliest estimates as to when any new nuclear build could be delivering power is 2017, but experience from just about every country including the UK is that the timescales are longer and could easily stretch to 2020 and beyond. The current construction of the Olkiluoto reactor in Finland is a case in point, with very significant delays and cost over-runs already. Thirdly, the contribution of nuclear to CO2 reduction is small – according to government, the reduction comprises around 4% of total UK CO2. The same money spent differently on the UK energy supply system could achieve greater CO2 reductions with greater efficiency. However, if the UK is really serious about tackling climate change then it could divert resources to where the greatest benefit can be gained. Finally, the true cost of any new nuclear supply is not yet clear - neither military defence of reactors from terrorist attack, nor waste storage facilities have been fully costed. Indeed, it's acknowledged that the effects of a significant nuclear accident or incident are uninsurable. Having said that - nuclear is simply not a cheap option in any realistic price comparison. Whilst other technologies, especially renewables, are likely to continue to achieve cost reductions in real terms per KWh produced - nuclear is not.

When we consider the key pressures that are driving the current review of energy policy in the UK and the potential role of nuclear within that, it is clear that new nuclear build is not a strong contender in relation to any of those issues.

Policy and Regulation Comparisons

The current regulatory regime, and indeed the entire structure of the energy industry, has been premised on the main goal of keeping prices down through competition. This approach was conceived in an era of plentiful North Sea oil and gas under Conservative government of the 1980s - indeed it led to the UK 'dash for gas' to replace coal. The UK regulatory regime has then, with limited success, bolted on environmental and other concerns. The UK's regulatory regime and the current structure of the energy industry were largely taken as given in the Energy Review and the Nuclear Consultation - yet alternative approaches can deliver more installed renewable capacity and greater efficiency in both the supply system and in end-use of energy.

It is in this context that comparison to other countries with more renewables installed, more demand side management, and greater efficiency in the supply system highlight some of the policy and regulatory differences that have facilitated their implementation. Elements that have helped other countries' regulation deliver more renewables and demand side management include:

- Mechanisms for improving access to markets for renewable energy and smaller scale production, enabling competition with larger scale established technologies and large utility companies, e.g. capital subsidies and guaranteed buy-in rates for small scale producer's output.

- Vertical and horizontal integration in the supply system, involving greater co-ordination of investment between different energy options due to different patterns of ownership (in contrast to the UK, where an imposed economic industrial structure has effectively broken up the supply system with the primary goal of price competition between suppliers).
- Community ownership and strong local democratic accountability and control leading to a level playing-field for alternative energy options (rather than 'business as usual' inertia resulting from investment decisions to maximise profit).
- Strong intervention in markets to deliver environmental quality.
- Coherent integration between land-use and energy planning, e.g. to facilitate district heating

Some comparative examples of better practice European renewable implementation can be found in Appendix 2.

Although none of the regulatory and policy approaches adopted in other countries offer a single ideal regulatory regime for the UK to copy, they do highlight how the UK focus on price regulation (a structure designed to promote primarily price competition), and the very limited opportunities for renewables and smaller scale production afforded by the Non-Fossil Fuel Obligation (NFFO) and the Renewables Obligation, have held back greater implementation of renewable energy in the UK. Indeed, ironically, much of the subsidy available under the mechanisms ostensibly designed to support the establishment of renewables have instead gone to nuclear.

UK failure to find policy and regulatory approaches that favour new technologies and smaller scale suppliers have significantly held back the installation of renewables in the UK compared to other developed countries.

Energy policy is not neutral. It ends up supporting the plans of government not just the stated aims of policy. It cannot serve all ends. If a collective social subsidy and institutional support is put in place for nuclear it will mean other things miss out. That will mean less innovation, less technological development, less export opportunities. It will likely mean that when the UK does, almost inevitably, head towards a delayed implementation of a decentralised, renewable future - it will be buying in its technology and expertise from other countries that have developed it in the meantime. The consequences will run and run.

If the full range of options in policy, regulation and technology are looked at creatively, it's clear we could meet our energy needs and environmental goals without resorting to nuclear power.

REACTOR DESIGN

Hugh Richards, MRTPI

Britain has for many years accepted that in energy as in other sectors of the economy the market should decide how to address current and future demands. Having recently been persuaded by sectoral interests that investment in replacement nuclear power plants are necessary, the government has to try to reconcile these large long-term inflexible investments with a liberalised and fragmented electricity market.

In order to do so, the government has constructed a process which is intended to give the appearance of 'competition' in the market for new nuclear reactors, and their development sites. Of the four designs submitted to the government for pre-licensing assessment (also known as Generic Design Assessment [GDA]) in July none are proven commercially; they are design concepts, without working prototypes to test their safety. New reactor designs are said to be 'standardised' to make licensing easier, reduce capital cost and reduce construction time.

The Proposed Reactors

The 1660MW European Pressurised-water Reactor (EPR) being sold by AREVA is the largest nuclear reactor in the world. Based on the French N4 reactor its vast size was an attempt to improve its economic competitiveness and shorten construction times. Of the four candidates the EPR is the only one under construction. Despite being already two years behind schedule and reportedly £1 Billion over-budget in Finland, it is this reactor that is most likely to be developed in the UK.

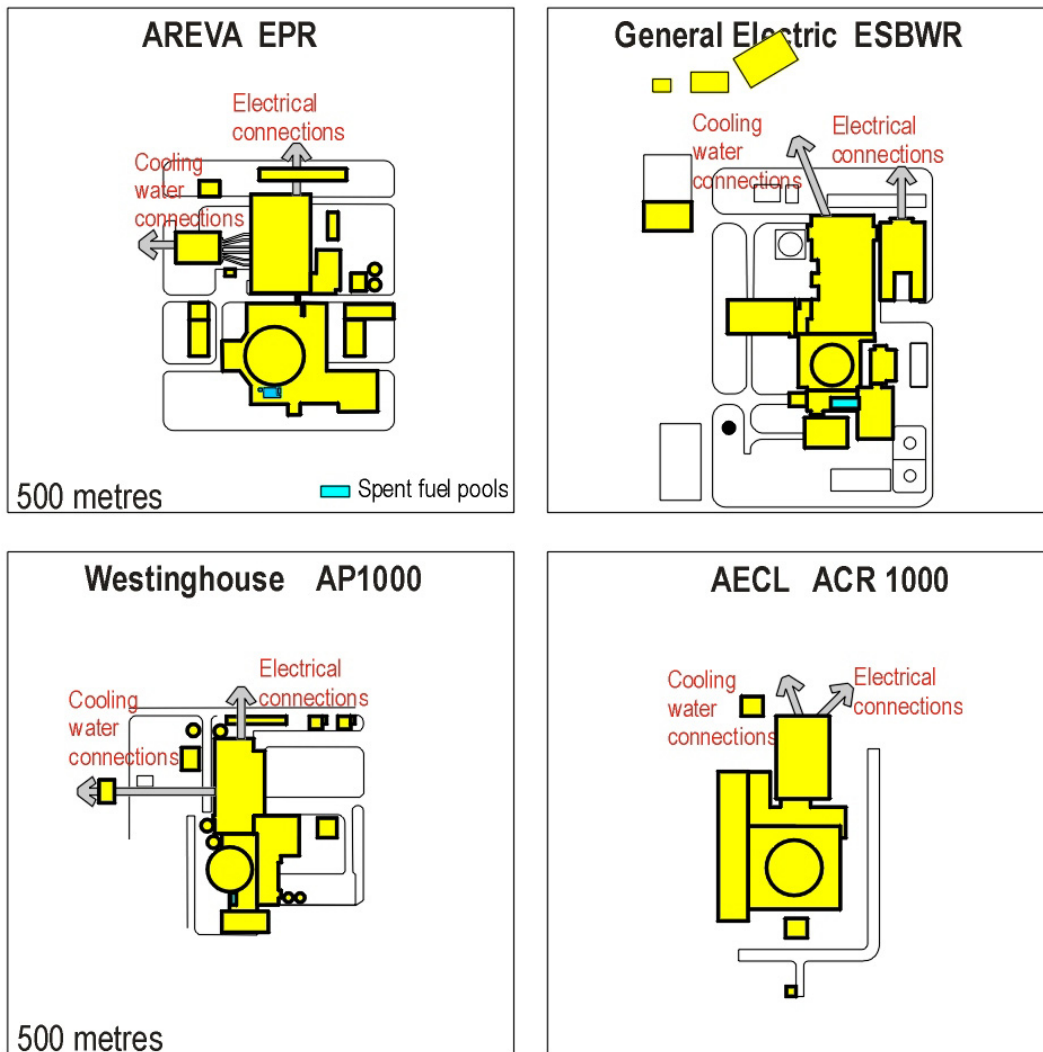
The Westinghouse AP1000 reactor, a (1117MW) Pressurised Water Reactor (PWR) rejected by Finland because it is vulnerable to aircraft strike, is unlikely to get a license in the UK because it omits safety features regarded as essential for the PWR at Sizewell B. Its cost-cutting design means that it has no secondary containment.

General Electric have submitted the 1550 MW so-called Economic and Simplified Boiling Water Reactor (ESBWR). As the name suggests, this is an attempt to simplify the boiling water reactor design in order to reduce costs and increase reliability. It has not been built or tested anywhere in the world but is undergoing assessment by the US regulators.

Canadian Deuterium-Uranium (Candu) reactors from Atomic Energy of Canada Ltd use heavy water (Deuterium) as a moderator to slow down the neutrons. This is effective but very expensive, and has restricted its deployment. AECL have submitted the ACR1000 a 1085 MW Advanced

Candu Reactor, which proposes using a low-pressure heavy water moderator, with a high pressure light-water coolant, in order to reduce costs. An earlier 750 MW version did not get built or tested, or attract any orders, and interest in the ACR1000 has declined in the US as regulatory hurdles have threatened to delay licensing.

The Candidate Designs



The limited resources of the nuclear regulator mean that one of the designs will be eliminated. Seven potential operators have 'endorsed' one or more of the reactor designs. The Canadian ACR1000 has support only from British Energy and looks likely to be eliminated. Far from being settled designs all four candidate designs appear to be 'work in progress'. About ten years ago smaller reactor designs were thought to have a better chance in the market. As none were successful they have all been enlarged to try to achieve 'economies of scale'.

Government believes that new nuclear projects will be brought forward on a commercial basis by project sponsors with strong balance sheets. British Energy, bailed out with public money in 2002 has the sole experience of

operating nuclear reactors in Britain. Of the six foreign operators from Germany, Sweden, France, Spain and Belgium, five say they want to have a choice of the best available designs. German firm RWE, Swedish Vatenfall, and Iberdrola from Spain, support the ESBWR in addition to the two PWR designs. The Belgian Suez and German EoN want to choose between the two PWR designs. Support is limited to cautious statements that 'we are committed to exploring the option of becoming a potential nuclear licensee in the UK.' There are no commitments to assume a financial obligation at a future date.

President Nicolas Sarkozy has set out his nuclear ambitions with the foundation of a dedicated nuclear company, centred on Areva, the nuclear and mining group already under state control. He is reportedly considering setting up a holding company that would bring in partners in countries where France won contracts. The recent merger between Gaz de France and Suez means the French state is gaining effective control of GDF-Suez, which will be the world's third-largest listed power company. One of the seven potential developers, that declared an interest in new nuclear power stations in the UK in July, has thus already been subsumed by another.

Although the Nuclear Installations Inspectorate will not rule on their initial assessments of the four designs, one design (probably the Canadian ACR1000) will be eliminated. For the others, lists of safety issues on which more information is required will be published. As the Sizewell B design is to be used as the benchmark, and the EPR is closest to it in terms of its design approach it is likely to have the shortest list of further information requirements. The Westinghouse AP1000 and the General Electric ESBWR both put forward untried and untested designs incorporating novel features which run ahead of sound engineering judgement. Within a relatively short time the EPR with its relatively recognisable design will emerge as the 'only show in town'.

The question is – does the UK government think that the public are prepared to accept the potential accident and security risks associated with the exponentially higher fuel irradiation of the EPR design (2.5 times that of Sizewell PWR, and 5 times that of Chernobyl) (see Large, 2006; 2007).

It is a matter a great consequence for our democracy that demands for streamlining administrative processes advocated by the nuclear industry in general, and Electricite de France in particular, are being adopted by the British government. In order to achieve the widespread deployment of a hazardous, untried and untested reactor design it will have to be imposed, regardless of concerns.

It is not in the public interest to allow energy companies to pursue large inflexible and vulnerable nuclear investments. They would lock the country into centralised electricity generation which is insufficiently robust in an era when the dangers of deliberate disruption to the system are increasing.

SITING NUCLEAR NEW BUILD

Prof Gordon Walker, University of Lancaster

In already having given the green light to the nuclear industry to plan for the prospect of new-build, questions of where to build and the process through which preferred site locations will be given consent have become critical. For the industry, siting and construction costs need to be kept to a minimum in order to attempt to secure any form of commercial viability. The prospect of having to endure lengthy and expensive delays at the hands of the planning system is a 'business risk' big enough to scare off those contemplating new investment. Why locate capital in the shark infested waters of UK planning, when there plenty of other places to make profit from energy generation?

The government has consequently acted to reassure its favoured international energy conglomerates. It has made it clear that the pathway to construction will be very different to the extended Sizewell-B experience of the 1980s. Fast-track reforms to the planning system offer the prospect of quicker and smoother resolution of consent decisions – in England at least, Wales and Scotland are resolutely hostile and resistant at a national level. A discussion paper commissioned from Jackson Consulting⁸ and reporting on the deliberations of an 'expert siting group' made up of industry, government, regulatory and devolved administration representatives, has helpfully produced a hierarchy of most favoured and least favoured siting options, clearly identifying existing nuclear sites as the most favoured places to embark on new build. This discussion paper was only released after repeated requests by Greenpeace.

Through these and other 'pre but really post decision' actions, we can see where new-build attention is likely to be focused, how siting decisions are likely to be made and how business risks are apparently to be minimised. But how secure is the basis on which the private sector is being reassured about siting and securing consent? How complete and full is the so far semi-public analysis? And what type of ethical future are we heading towards by distributing our collective national response to climate change amongst a handful of the existing so-called 'nuclear communities' and passing on a long term legacy of radioactive waste to future generations?

Siting Nuclear Power: Siting Radioactive Waste Storage

⁸ Jackson Consulting (2007) Siting new nuclear power stations: availability and options for government, Discussion paper for DTI expert group, Jackson Consulting Limited.

There are many ways in which decisions over new build have to be wrapped up with the failure to so far realise a real and material solution to radioactive waste management. For the siting of new-build specifically, it requires the transparent and explicit statement that locating a nuclear power station also necessitates co-locating a nuclear waste store. A map in the Committee on Radioactive Waste Management (CoRWM) final report⁹ makes it clear that each current nuclear power station site is also a store for the intermediate and some of the low level radioactive waste that it has produced to-date, and if still operating or being decommissioned, is yet to produce in the future. The 'nuclear communities' have become, by default, hosts of both nuclear electricity generation and nuclear waste facilities. CoRWM express concerns about the design, engineering and security of these stores and recommend all this 'legacy waste' should be moved to a proposed underground waste repository. But until that repository is located, given consent and constructed – a process which cannot be presumed to move from start to finish at all quickly or smoothly, if at all - on-site storage continues indefinitely (CoRWM has recommended that new 'interim' stores for legacy wastes should be designed to last for at least a 100 years). It follows therefore that any new power station will also need to have a radioactive waste store co-located on-site, until a destination is found for the new waste it produces. Such a store will not only need to hold intermediate and low level wastes, but potentially also highly radioactive spent fuel, given that the current practice of reprocessing spent fuel at Sellafield is not expected to continue into a new-build generation¹⁰.

As on-site storage is the default and only certain current option for dealing with radioactive wastes, siting processes for new-build need to be explicitly for the co-location of both new generation capacity and new radioactive waste storage - potentially to include highly radioactive spent fuel wastes. This waste storage cannot be presumed to be required only in the short term and the risks and economics involved need to be fully and explicitly assessed on this basis. Communities need to be prepared to simultaneously host both power stations and waste facilities.

Existing Sites: Best Sites?

Every indication is that companies coming forward to propose new nuclear power stations will look first, if not exclusively, to sites that already have nuclear facilities. There are multiple motivations; the economics are better, grid connection is in place (although upgrading is needed in some cases), securing land ownership is presumed to be relatively unproblematic (although not certain), the locations are 'known' by the regulatory authorities¹¹ and it is assumed the local community will be more sympathetic to new-build because

⁹ Committee on Radioactive Waste Management (2006): Managing our radioactive waste safely: CoRWM's recommendations to government.

¹⁰ Gilchrist P (2006): Potential waste volumes arising from new build, Nuclear Decommissioning Authority.

¹¹ Evidence of regulators reported in House of Commons Committee on Trade and Industry (2006): New Nuclear? Examining the issues, fourth report of session 2005-6. The Stationery Office, London.

of their familiarity and experience to-date of living with nuclear power. The Jackson Consulting report, through a telling use of a green (for go), amber and red schematic, highlights four existing sites in the South of England that are seen as most viable for new build, with others in the amber and red categories less commercially attractive. How secure though is this cost controlling strategy of heading to existing sites and what are its implications?

(i) Coastal flood risk and sea level rise - the coastal locations of existing sites are vulnerable to varying degrees to the impact of climate change on both sea level rise and the increased frequency of extreme weather events. This future flood risk has been assessed in a report by the Flood Hazard Research Centre at Middlesex University¹², which concluded that for four 'favoured' sites – Bradwell, Dungeness, Hinkley Point and Sizewell - even the lowest estimates of sea level rise could significantly increase long-term dependence on expensive defences at the stations and have negative impacts on the physical stability of the coastal environment around the stations. Recent indications are that if anything climate change science has underestimated rather than overestimated the likely speed and degree of change in both weather patterns and sea level. The response from advocates for new build has been that flood defences can be constructed to provide the level of protection that is needed over the likely operational lifetime of the power stations¹³. However:

- Establishing exactly what level of protection is required is full of uncertainties and unknowns. A precautionary approach will have to be taken which builds in the possibility of sudden rather than only gradual changes in climatic conditions. This will be expensive to ensure and maintain.
- The period for protection needs to extend beyond operation to include full site decommissioning.
- The construction of defences around nuclear sites will have consequences for adjoining coastline that is unlikely to be as well defended.

If defences are affordable (a cost which must not fall on the public purse) the inequitable prospect is of nuclear power stations at best becoming outposts of secure land, better protected than homes and towns where people are living along the same coastline. At worst defences would prove inadequate, risking serious long term consequences. For these combined reasons the flood risk problem has not been adequately dealt with and remains a significant problem for both the wisdom of focusing on existing sites and the cost implications for energy companies of so-doing.

(ii) Local consent – the assumption that the existing so-called 'nuclear communities' will willingly welcome the replacement of or addition to existing power stations and associated radioactive waste storage has yet to be proven under real conditions. Undoubtedly some local authorities are actively

¹² Flood Hazard Research Centre (2007) The impacts of climate change on nuclear power stations sites: a review of four proposed new build sites on the UK coastline, Greenpeace.

¹³ Ibid refs 1 and 4

positioning themselves to welcome new build. Copeland Borough Council in Cumbria, for example, has clearly indicated that it wants a replacement power station at Sellafield, jointly commissioning a lengthy consultants report which details the 7000 person years of employment generated during construction and 1000 direct and indirect jobs to be provided during operation¹⁴. However, whether all ‘nuclear communities’ are currently so positive is doubtful, including crucially those with the ‘green lights’ in the Jackson consulting report (which does not include Sellafield because of high transmission line costs). In any case there is a dynamic and real politics to the relationship between the positions of local MPs, local authority councillors, the opinions of local people as revealed in different ways and the impact of locally organised groups on the terms of debate. Just because welcoming noises appear to be made now does not mean that they will be sustained. Experience and common sense shows that opposition galvanises typically after, not before, concrete proposals are made. Even if the immediate local authority or community does remain substantially positive, what about adjoining populations across arbitrary political borders that may benefit less directly but feel just as under threat from the risks involved? In any case, it is unclear under proposed changes to decision making process how much local opinion will actually matter in reality. It is sophistry to be extolling the virtues of existing nuclear communities as new-build friendly, whilst simultaneously emasculating local public inquiries of their role and significance.

(iii) Blight – for the ‘nuclear communities’ the fact that they have been highlighted as preferred locations for new-build raises the prospect of long term blight obstructing other forms of local regeneration. Many of the nuclear communities face the prospect of severe problems as a result of the dependency on their existing power station, and the loss of many jobs when this closes and is fully decommissioned (already becoming a reality for the hosts of the older MAGNOX reactors). They need to plan for the future and to develop alternative employment opportunities. Such plans may be stifled and obstructed if the need to ‘keep the nuclear option open’ in that location is seen as strategically important¹⁵. New land uses attracting concentrations of population have to be strictly controlled in the area around nuclear power stations and allowing new regeneration initiatives even once the existing plant is decommissioned may breach ‘remoteness criteria’ for new build. The prospect is a legacy of damaging long term blight whilst new-build developers choose preferred locations and siting decisions are made.

Existing nuclear sites in England have a ‘favoured status’ for locating new build. The criteria on which this status is based are primarily commercial and give insufficient attention to future coastal flood risk. The assumption that existing nuclear communities will welcome new build is unproven and has the likely consequence of planning blight whilst site location decisions are made. Consequently, taking on the business risks and costs involved in developing non-nuclear power

¹⁴ Environmental Resources Management (2006) Potential New Build in Cumbria: an assessment of implications for the County.

¹⁵ As discussed in the Jackson consulting report; *ibid* ref 1.

station sites on new greenfield locations has to be factored into private sector investment decisions.

Reshaping Decision-Making: Fair, Democratic, and Effective?

The process through which proposals by the private sector to develop new-build are to be given consent in the process of being radically reshaped as part of wider reform to the planning system. Many details of how the proposed 'fast-tracking' will operate, through providing a national statement of need and strategic siting assessment, alongside approving plant designs through a pre-licensing arrangement, remain unclear. Exactly how a fully informed, fair, and respected process is to be sustained at a strategic national level, whilst prohibiting the detailed examination of anything other than local issues at local planning inquiries remains open to question. Even if the new system makes sense in principle, how will it work in practice for nuclear sites, as distinct from other forms of major infrastructure? Will key environmental NGOs be prepared to become involved in the fast-track system in the orderly way that is envisaged? Will local opposition groups be prepared to be concerned only about local 'cosmetic' issues, when nuclear power and nuclear waste storage is surrounded by such contentious politics, science and strength of feeling? History suggests not, and that people who feel shut out and shut up, do not react well. As a consequence, protest action outside of formal processes will be only further provoked by the reforms proposed – something that risk and cost adverse power station developers are unlikely to welcome.

More fundamentally, the envisaged process for siting new-build contrasts starkly with that recommended by CoRWM for the siting of a radioactive waste repository¹⁶. Taking on board all of the accumulated experience and international best practice guidance on siting difficult land uses, CoRWM has recommended a volunteering approach, through which communities volunteer to be considered to host the site, are resourced to engage in careful discussion and evaluation, and, if finally selected, receive a negotiated community benefit package to compensate for taking the burden of hosting a facility on the country's behalf. Why should the siting of nuclear power stations not follow a similar process, in particular, as already argued, that this involves the co-location of nuclear waste stores? If the government are so confident about nuclear communities wanting to host new power stations, surely enabling them to volunteer and negotiate terms and conditions is the fair and effective way to proceed?

It is unlikely that the proposed fast track reforms to decision making will retain sufficient accountability, legitimacy or respect to enable the smooth and rapid playing out of siting processes. The strength of feeling that nuclear power and nuclear waste storage generates means that in practice demarcations between national strategic and local matters will be resisted. The proposed top-down evaluation of site

¹⁶ Committee on Radioactive Waste Management (2006) Moving forward: CoRWM's proposals for implementation.

suitability for new build nuclear power and associated nuclear waste stores, stands in stark contrast to the bottom-up volunteering and negotiation approach recommended for the siting of an underground nuclear waste repository

Climate change: distributing ethics and responsibility

A programme of new build is being justified in ethical terms as part of our necessary national, collective response to carbon reduction. Indeed it is ethically vital to satisfy principles of international and intergenerational justice that the UK acts on climate change to account for both its current and historic high per capita emissions. However there is the question of how, within national borders, a just and fair allocation of responsibilities and burdens should be distributed. Focusing carbon reduction on nuclear new-build does two things. First, it allocates a consequent burden of risk and environmental impact primarily to a handful of small, peripheral communities and away from the urban, commercial and industrial heartlands of consumption and demand that are driving carbon emissions. Other more effective and much less risky climate change responses – energy efficiency and distributed generation in particular - distribute responsibilities and consequences far more broadly and fairly across people, places and activities as well (also enabling far greater efficiency through making use of heat as well as electricity, something that remotely located nuclear generation cannot achieve). Second, whilst acting on climate change does address the need for intergenerational justice, producing a new ultra long term legacy of radioactive waste as part of our response and adding this to the burden that future generations will already have to deal with as a consequence of inbuilt climate and environmental change, is both unfair and unreasonable.

The UK needs to act on its ethical responsibilities to mitigate climate change, but should not be achieving this by giving the major burden to a handful of isolated and dependent nuclear host communities. Action should rather be focused on the heartlands of demand and consumption. There are better and fairer ways of distributing responsibility to reduce carbon that do not pose an irresponsible and unethical burden of radioactive waste on future generations.

RADIATION HEALTH EFFECTS

Dr Paul Dorfman, University of Warwick, former co-Secretary to the Committee Examining Radiation Risks from Internal Emitters (CERRIE)

Despite the key nature of the debate, the definition of radiation health risk is by no means agreed - in fact this risk definition remains highly controversial and open to critical analysis. This debate runs parallel to other equally fierce battles between opposing groups proposing differing solutions to questions about military security and deterrence; the disposal of radioactive waste; the half-life of a particle of uranium; the relative costs and benefits of nuclear powered energy in a warming world; and the effect of a micron sized plutonium particle on the tracheal bronchial lymph node of a child.

The issue is this:

- is radiation pollution from nuclear plant relatively safe or unacceptably risky?

Studies about the effect of ionising radiation on the living environment take many forms – the most direct one concerns radiation exposure to humans. This work is done either by epidemiological studies on human populations that have been affected by radiation, or by radiation biology – exposing animals or cells to radiation insult and monitoring the result. At present the current institutional regulatory view is that, although there is no dose which does not carry a risk, radiation pollution from UK nuclear plants do not present a significant risk to the population. However, other work on radiation risk provides an alternative view (ECRR, 2003).

Radiation epidemiology - the analysis of incidence and distribution of disease, is fundamental to radiation risk determination and standard setting. Epidemiological investigations ranging from A-bomb survivor studies to more numerically and temporally limited studies have provided an enormous weight of evidence about the effects of ionising radiation on humans. Since the link between radiation and the aetiology of cancer and leukaemia is well documented, this aspect of the debate has devolved to an intense, long-lived, and at times vitriolic discussion of the risks of those diseases, in the survivor populations of Hiroshima and Nagasaki, post-Chernobyl, and near to operating nuclear installations.

A-Bomb Survivor Data

The single most important sources of information upon which institutional radiation risk standards are built are the Hiroshima and Nagasaki A-Bomb survivor studies.

In 1958, 13 years after A-bomb detonation, a cohort of 91,000 people were chosen for long-term follow-up from the 120,000 survivors identified by the US Atomic Bomb Casualty Commission (ABCC) from census data for 1950. These survivors (who had not died of post-blast injuries, disease, increased immune deficiency, malnutrition, and old age between 1945-1950) are known as the Life Span Study (LSS) cohort. In general, the institutional interpretation of this data set tends to suggest that there have been few significant health legacies in the A-bomb survivor population.

Perhaps the most important and cogent critique of the findings of A-bomb survivor data is that of Stewart and Kneale (2000), who point out that the research into A-bomb effects was based on a survivor group selected for 'good health', and subject to 'age-bias'. In other words since the survivor population was not a normal representative one, there may be very real problems applying this data to other populations subject to radiation insult.

Other aspects of A-bomb survivor studies have also been hotly contested. The point is that although radiation to A-bomb victims was limited to external high-dose, whole body acute, low-LET mixed gamma and neutron insult (see Shigematsu, 2000) – all subsequent radiation risk standard setting concerning low-dose, chronic, high-LET alpha and beta are based on that data set. In this sense there seem to be significant questions about the quality, quantity, and delivery of radiation dose to A-bomb victims, and the applicability of this data for radiation protection standard-setting.

Post-Chernobyl Epidemiology

On the 26th April 1986 an explosion at the Chernobyl Nuclear power Plant Number 4 in Northern Ukraine resulted in widespread atmospheric pollution by fission-product radioisotopes. As recently as 2000, the institutional understanding of post-Chernobyl risk was that, apart from highly significantly raised incidence of treatable and non-fatal thyroid cancers in children, 'there is no scientific evidence of increases in overall cancer incidence or mortality or non-malignant disorders that could be related to radiation exposure' (UNSCEAR, 2000).

However, with each updated report the Chernobyl harvest grows, and there exists a significant body of evidence from Russia, Ukraine and Belarus, that clearly contradicts the institutional response to the human and environmental disaster (ECRR, 2006). As Prof Alexey Yablokov, Director of the Russian Academy of Sciences, Moscow concludes, 'each year it has become clearer and clearer that the real consequences of this catastrophe are much more widespread and severe than has been predicted' (Yablokov, 2006, p. 34).

Childhood Cancer and Leukaemia Clusters near to Nuclear Installations

There is a proven, highly significant, universally acknowledged, and on-going 10-fold childhood leukaemia excess near the reprocessing plant of Sellafield. There has also been a significant 8-fold increased incidence of childhood leukaemia in Caithness near the Dounreay reprocessing plant in Scotland, and a statistically significant childhood leukaemia excesses were found in the West Berkshire region near the Atomic Weapons Establishment (AWE) at Aldermaston, and former USAF Greenham Common.

COMARE have published 7 influential reports on these radioactive environmental risk controversies (COMARE, 1986; 1988; 1989; 1994; 1998; 1999; 2005). Without exception, all of the COMARE reports have concluded that none of the excess childhood leukaemia's or cancers in the local population could possibly be explained by exposure to radioactive emissions resulting from normal operations of those nuclear facilities. Interestingly, although about half of the members of the Committee Examining Radiation Risk from Internal Emitters (CERRIE, 2004) were concerned that raised rates of cancer and leukaemia near nuclear plants in Sellafield and Dounreay 'may well be linked to radio-nuclides from nuclear facilities'; COMARE's (2004) document on the work of CERRIE did not respond to this concern.

However, the radiation risk and health debate is ongoing. A very recent case control investigation of the German Childhood Cancer Registry (GCCR), carried out on behalf of the Federal Office for Radiation Protection in 41 districts in the vicinity of the 16 nuclear power plant sites in Germany between 1980 and 2003, found that risk of tumour or leukaemia in children under 5 years of age significantly increases the closer they live to a nuclear power plant (GCCR, December 2007).

There are real concerns that infants and children living near nuclear facilities may be subject to greater cancer and leukaemia risk.

Committee Examining Radiation Risk from Internal Emitters (CERRIE)

The internal radionuclide argument is hot because it's here that fundamental scientific uncertainties are greatest – and this has real implications for safety standards. Although conclusions from CERRIE were mixed, the Committee stated that 'uncertainties in dose co-efficients for some radionuclide were large', and that 'a particular concern was the adequacy of current models for the estimation of risks for short range alpha, beta and auger emitters' (CERRIE, 2004). What this means is that our regulatory protection standards for some important internal radionuclide emitters is subject to uncertainty of an order of magnitude - a factor of 10. In other words - could be out by 10 times. It should also be noted that the CERRIE Minority Report (2004) suggested that current regulatory radiation protection standards are in error by at least 2 orders of magnitude – out by at least 100 times.

Genomic Instability

One of the most significant radiation-biology findings concerns the acknowledged phenomena of 'genomic instability'¹⁷. Genomic instability research has demonstrated a novel alpha particle irradiation effect at low levels (Kadhim et al, 2001). Although the underlying mechanisms (molecular, genetic and cellular) for this phenomenon are not fully understood, the single most important implication of genomic instability is the potential for enhanced germ-line mutation of the human gene pool.

Not only does genomic instability suggest that radiation health effects are potentially far more widespread, but risks potentially arise after exposure to doses far lower than current safety limits allow. The number and complexity of the biological effects of differing qualities of radiation tends to bring into question the concept of dose.

The implications of genomic instability are many and varied. Since these changes are unpredictable they are potentially implicated in a range of diseases other than cancer, e.g. immune suppression and degenerative diseases - thus traditional epidemiological methods may fail to pick up this link since the level of effect is too uneven, and the numbers of diseases (potentially induced) so wide.

It is significant that genomic instability demonstrates substantial differences between different qualities of radiation. For current radiation protection purposes, alpha radiation is considered to act similarly, albeit more effectively than other radiations. However, genomic instability demonstrates that the difference is not simply a matter of efficiency - rather there is a real qualitative difference in the action of differing radiations. In other words, the concern is that genomic instability provides a mechanism whereby low-level alpha radiation can transmit down to the blood-forming system.

Since current radiation risk standards are subject to large levels of fundamental scientific uncertainty, and may underestimate risk to public health, it would be unwise to subject critical groups and the general public to further radiological insult through new nuclear build in the UK.

¹⁷ Morgan et al (1996, p. 247) define genomic instability as an 'all-embracing term to embody a variety of genomic alterations, including chromosomal de-stabilisation, gene amplification and mutation', thus 'genomic instability is characterised by the increased rate of acquisition of alterations in the mammalian genome'.

NUCLEAR POWER'S BROKEN PROMISES

Paul Brown, University of Cambridge

The public mistrust of policy decision making on nuclear issues comes from 50 years of cover-up, secrecy, misinformation on cost, performance, and waste. The first and best remembered false promise of nuclear fission was that the electricity would be too cheap to meter. Surprisingly the myth that nuclear was cheaper than coal was the official industry line until the mid-1980s when the Thatcher government exposed it as untrue when attempting to privatize the nuclear stations.

Now the industry is trying again. This time nuclear will be cheaper because it will be quicker to build – against all evidence to the contrary. It is also being sold as a carbon free technology that will cut emissions. Even on the government's own calculations if four of the world's largest nuclear power stations were built in the UK by 2025 they would only reduce gas imports by 7%.

There has been no evaluation of the comparative costs of nuclear new build and a combination of reducing energy demand and developing alternative forms of energy production as has been done in Germany. Reducing demand through energy efficiency means the existing German nuclear power stations can be phased out and new ones are not needed.

The current experience of Finland shows the claim that the new generation of nuclear power stations will be quick and easy to build is bunk. Billions has been poured into nuclear research and development with the claim that a breakthrough into cheap and almost endless power was just around the corner. In reality every nuclear project built so far in the UK has been late and over budget. Delays have got worse over time.

When the Conservative government privatised the rest of the electricity industry ministers were forced to introduce a 10 per cent nuclear levy on all domestic electricity bills as a subsidy and to pay for waste disposal.

The Central Electricity Generating Board (CEGB), without any public debate or apparent approval from the government, spent this levy money building a pressurised water reactor, Sizewell B, thus avoiding interest charges on the capital. Against all previous experience the CEGB claimed Sizewell would produce cheap power. Delays brought cost escalations from £1.69 billion to 2.03 billion. Nuclear power from Sizewell B cost double that predicted and three times the price of that from coal.

When the misuse of the levy was discovered the CEGB claimed that profits from Sizewell would pay for future nuclear clean up. Instead Sizewell B was sold off to shareholders at a knock down price, and all the money disappeared into private hands.

Nuclear Decommissioning Authority £70-100 bn bill

There are two related sets of false promises. The first is wild or wilful optimism about costs. The second is that despite much construction experience there have always been staggering delays. Then even when completed years late plants frequently fail spectacularly to reach design targets.

Nuclear accounting standard tricks include discounting costs of nuclear waste disposal by deferring them so far into the future that they disappear from balance sheets. Also when any current cost figures look potentially embarrassing, they are immediately classed as “commercial in confidence” – thus details are removed from public scrutiny.

An example of wild optimism is the fast breeder reactor programme begun at Dounreay in 1975 and run ‘successfully’ until 1994. The plutonium fuelled prototype produced power but at such a high cost it was too expensive to meter. The government saved £200 million a year by closing the programme down.

The UK’s other nuclear reactors, not just Sizewell, are also uneconomic. The Magnox reactors were originally designed to produce plutonium for nuclear weapons with electricity as a by-product (something the public was not told for 25 years). Construction of each of the 8 civil Magnox reactors took between one and three years longer than planned. None has ever run at full capacity because of safety restrictions.

Of the next generation of Advanced Gas Cooled Reactors none were completed on time or on budget, nor have they performed as the designers claimed. The worst Dungeness B became an industrial legend. Ordered in 1965 for completion in 1971 it did not produce commercial energy until 1989. Fourteen AGR reactors are still in service.

None of the proposed new range of reactors for the UK have been built or operated. The most likely candidate is the European Pressurised Water Reactor, the first of which has started construction in 2005 in Olkiluoto, Finland. It is heavily subsidized by the French government which is underwriting the finance. The plant has a guaranteed fixed price of 3.2 billion Euros but is already radically over time and budget. It was expected to be completed by 2009 but production problems, including pouring the wrong kind of concrete, have already delayed the project by two years.

Other financial disasters include the Thermal Oxide Reprocessing Plant (THORP) planned to produce plutonium for the non-existent fast breeder reactor programme. THORP was allowed to continue because it had foreign contracts which the industry claimed would produce £500 million profit in the first 10 years by reprocessing 7000 tonnes of spent fuel. Fourteen years after it opened it has reprocessed 5780 tonnes of fuel and is currently not operating. The plant’s losses are ‘commercial in confidence’.

The failure to deal with the high level liquid waste stream from reprocessing is holding up production at THORP and the government has so far failed to fulfil its promise to return foreign wastes to the country of origin. Three evaporation tanks which reduce the volume of this waste break down frequently. A fourth has been ordered but will not be completed until (at least) 2010. Once reduced in volume the waste goes to the vitrification plant to be turned into glass blocks. Two production lines were designed to produce 600 blocks a year but averaged less than half that. A third line was added but maximum production reached 482 units before falling again.

The most recent costly failure is the MOX plant that produces new fuel from plutonium and uranium. It was built with taxpayers' money on the promise of foreign orders which never materialised – just as well, because it does not work. It was designed to produce 120 tonnes of fuel a year and is now expected to produce 40, and its losses are still 'commercial in confidence'.

And perhaps the most moveable promise in history - the intermediate level waste depository. It has been scheduled many times and moved back by successive government from 2005 to 2015 and now is estimated by this government to be 2045.

All these issues should be resolved before any new nuclear build is contemplated. The taxpayer will have to foot the bill for the disastrous THORP project, for the collection and making safe of the nuclear waste stream, for the losses of the MOX plant and the disposal of contaminated plutonium and uranium. All this the government wants to brush under the carpet while compounding the problem with new nuclear build, ensuring more insoluble problems are passed on to future generations.

CHOOSING ENERGY FUTURES: FRAMING, LOCK-IN, AND DIVERSITY

Prof Andy Stirling, University of Sussex

The Challenge of Choice

Debates over energy futures are routinely couched in terms of ‘autonomous, unavoidable imperatives’ – by this we mean, when we think of solutions to our energy future problems we often think of simple, single answers set apart from a more complex and messy reality. Nowhere is this more true, than in discussions of the role of nuclear power. Here, attention turns again and again to ostensibly concrete limits on what is possible by other means. Very often, the bottom line is simply that there is no alternative. As any politician well knows, even the most ardent sceptic can be cowed by this rhetoric. This section looks at what happens if we remain sceptical and un-cowed.

Of course, this language of autonomous, unavoidable imperatives is wider than the nuclear debate alone – or even than energy policy more generally. Though their origins are challenges like climate change, resource depletion, population growth or industrial development, all are often seen as independent of deliberate human action. It is not a question of *whether* these challenges command responses, but *how quickly*, and (above all) *how effectively*. The point is, that the nature of the responses themselves are assumed to be equally incontrovertible. Across the board, the latitude for decision-making appears to lie simply in submitting to an unambiguous logic, rather than in exercising any intentional selection across alternative possible responses.

This kind of uncompromising language is compelling. In considering challenges like climate change, there is no doubting the scale of the potential catastrophe, nor the fundamental character of the drivers, nor the importance of the moral principles at stake. What is often overlooked, however, is that the gravity of the imperatives themselves is in no way denied or diminished by asking what scope we may still retain for societal choice. Are there alternative ways to meet these challenges? What are the uncertainties? How should we prioritise our explorations of different possible pathways? What are the trade-offs and opportunity costs? Who are the winners and losers? Why are we so often told that there is no room for choice? Whose interests does such denial serve?

These are precisely the kinds of question that are often neglected in current high-profile policy discussions of the role of nuclear power in energy futures. The purpose of the next few pages is not to claim definitive answers. The task is to point to some implications that arise when these questions are so

systematically neglected – and what we might do about this. In considering this, there are two main issues on which to focus.

- (i) The first issue concerns the conventional ways in which we think about the **appraisal** of contending energy strategies. Even under the urgency of climate change, do there really exist single definitive, unconditional answers to the question: ‘which are the best performing energy options?’ Or do the answers depend on the context in which the questions themselves are **framed**?
- (ii) The second issue concerns the intrinsically **dynamic** qualities in the performance of energy technologies and resources. Starting with a wide diversity of framings, a host of powerful mechanisms typically cut in at the earliest stages of technological trajectories in order to **lock-in** certain directions of development and so ‘close down’ others. The question is: ‘how can we most fully realize the diverse potentials of our possible energy futures?’

Each of these questions will be taken in turn in the pages that follow. The discussion will conclude by highlighting the role of plurality and diversity – both in the framing of appraisal and in the pursuit of technological pathways to sustainability. A fixation with nuclear power presents a threat to both.

Framing Nuclear Consultation Appraisal

It is a recurrent feature of debates over future energy strategies to hear the relative merits of contending technology or resource options (like nuclear energy, gas-fired generation, wind power or energy efficiency investments) referred to as if they are concrete, fixed quantities. In describing the Government’s own approach to repeated policy consultations discussed elsewhere in this report, Energy Minister Malcolm Wicks said in 2005 ‘now is the right time for a cool-headed, evidence based assessment of the options open to us... I want to sweep away historic prejudice and put in its place evidence and science’ (Wicks, 2005). It is ostensibly on this basis that the UK Government’s Chief Scientist was later able to assert that ‘*we have no alternative to nuclear power*’ (King, 2006). In stark contrast to the many queries raised in this document, policy appraisal is portrayed as a means to escape from the messy ambiguities of politics. The apparently clean crisp language of science is presented as promising an objective, definite basis for justifying hotly contested decisions. So domineering can this voice become, that it begins actually to suppress even the legitimacy of dissent.

Though there are many different approaches, the favourite way to express the performance of energy technologies in these kinds of terms, is as precise monetary costs. This kind of quantification is, after all, the bottom line. Other key indicators – like system value, environmental emissions or supply security – are also typically treated in essentially the same static, scalar fashion using different quantitative metrics. It may sometimes be admitted that the numbers are difficult to derive in practice. But this general principle of reduction and quantification is rarely questioned. Even on the relatively rare occasions

where uncertainties are acknowledged to render the absolute cardinal numbers ambiguous, it is still normal to see the different options ranked on some apparently straightforward relative ordinal scale. In other words, it is held to be synonymous with the Minister's aspiration to a 'cool-headed evidence based assessment', that we pursue an apparently simple – preferably neatly quantified – picture of performance (Stirling, 2003).

The problems with this approach are tackled head-on in the section on Nuclear Uncertainty in the present report. In short, the bottom line is actually rather different than it might at first seem. A number of equally rigorous approaches to technical appraisal may – under similarly legitimate (but different) institutional, disciplinary or social and political perspectives – perfectly reasonably yield radically different merit orderings across the available field of energy technology or resource options. This is true across a wide array of different empirical fields and technical methods.

In the highly sophisticated, mature and influential field of energy externalities assessment, the disciplines of cost-benefit analysis are extended from narrow financial performance to address broader strategic issues like carbon abatement, other environmental impacts, and supply security (CEC, 2003). Individual studies typically express themselves with refined precision, encouraging high confidence and often commanding great influence. Yet the large and authoritative underlying academic literature taken as a whole, actually generates extremely wide ranges of possible results for individual energy options. For any single option, these typically extend across many orders of magnitude. The values obtained for different options (like wind, solar, biomass, tidal, nuclear, gas and coal with carbon capture) frequently overlap by at least an order of magnitude or so (Sundqvist et al, 2004).

Despite the apparently definitive picture yielded by these individual exercises, then, the strategic energy appraisal literature as a whole permits pretty much any ranking order we may imagine across the major technology or resource options. Even in the most technical and sophisticated forms of analysis, it seems that the **answer you get depends on the way you frame the question** (Stirling, 1997).

Just as this is a feature of the highly developed field of cost-benefit analysis, so it is equally pronounced in disciplines like comparative risk assessment, life cycle analysis or multi-criteria appraisal. Across the board, a ubiquitous sensitivity to divergent 'framing assumptions' seriously undermines the apparently authoritative image of 'sound scientific' analysis and 'evidence based' policy. The alluring picture of pristine scientific appraisal is thus potentially dangerously misleading. It obscures the crucial uncertainties, ambiguities and sensitivities. Even in the absence of cynical manipulation, this creates a serious vulnerability to highly instrumental forms of misrepresentation.

As a result, perhaps the most crucial evidence based finding concerning the role of technical appraisal in a complex field like energy policy is that, while technical expertise is essential, it cannot alone determine authoritative policy

decisions. What must also be considered – and declared as part of the evidence base – are the values and interests which frame the analysis. Beleaguered politicians may frequently resort to the simplistic language of ‘sound science’ as if it offered freedom from honestly subjective judgement – what the Minister refers to pejoratively above as ‘prejudice’. But the real evidence is that this is expedient rhetoric. It is a way for powerful actors to close down decisions that are actually made according to more circumscribed and contingent values and reasons, of a kind which might not be so robust to scrutiny (Stirling, 2005).

The practical relevance of this fundamental finding could hardly be more important. Nor could the stakes be higher. The purpose of appraising energy technologies and resources is to inform long term policy choices. Decisions across the entire field of industrial strategy depend on the resulting pictures. It is in this way that we justify the configuring of scientific research programmes, technology development projects, infrastructure investment portfolios and the implementation of entire suites of policy instruments like taxes, standards, regulations and subsidies. Taken across the full range of public and private actors engaged in energy systems, annual commitments worth many billions of pounds rest (directly or indirectly) on the framing of appraisal methods like those considered above.

Nowhere is this phenomenon more prominent in the UK energy debate, than in the current government’s advocacy of nuclear power. Here, irrespective of the perspective one takes on nuclear power itself (or, indeed, any other option), the only truly evidence based finding that can be derived from the complex energy policy appraisal literature, is that ***there does exist real choice***. As is amply demonstrated elsewhere in the present Report – and in the Government’s own detailed background appraisals (PIU, 2001; PMSU, 2002; DTI, 2003; 2006) – assertions (or implications) that there is no alternative are actually artefacts of highly idiosyncratic framings of much more open-ended appraisal results. Though nuclear is undoubtedly attractive in some powerful and influential quarters, there are many other equally legitimate and rigorous framings and interpretations of the available evidence, under which the nuclear option lies very far down the strategic merit order.

This real bottom line is therefore not about attributing some mystical authority to any single set of appraisal results, quantified or otherwise. It is only to be expected that different interest groups or political constituencies will frame and interpret the evidence differently. But it is neither politically legitimate nor scientifically rigorous for any single perspective – especially that of government – effectively to deny the validity of other framings or interpretations. Instead, the answer lies in accepting that – whilst technical analysis and expertise are essential – they should be ‘on tap, not on top’. In the end, decisions cannot be justified by simplistic Ministerial references to ‘cool-headed, evidence based assessment’, as if all other viewpoints are ‘prejudiced’. Instead, it is a matter both of analytical rigour and democratic accountability that policy be presented with an open acknowledgement of the sensitivities and a transparent acceptance of responsibility for the intrinsically political judgements that must inevitably be exercised by government.

Realisation of this conjunction of rigorous analysis and democratic decision making, need in no way prove a recipe for conservatism or paralysis. Far from delaying essential decisions on transitions to sustainable energy, recognition of the legitimacy of a diversity of different framings can free policy debates from the kind of protracted attempts at spuriously definitive analytical justification that we have seen in recent repeated UK energy reviews. Indeed, this recipe for greater acceptance of responsibility on the part of leadership promises not only more robust, but also more efficient policy making on transitions to sustainable energy futures. We must get away from the misleading language of prescriptive advice and be more honest about uncertainty and mature about accountability.

The Dynamics of Lock-in

The second issue raised at the beginning of this section concerned the dynamic ways in which our commitments to energy technologies and resources evolve over time. The preceding discussion of alternative framings in appraisal shows that (even under the straightened conditions of climate change) there typically exist multiple possible pathways – each favoured under different social and political perspectives. Nuclear is just one of these. Others include wholesale shifts to carbon capture and storage, moves towards trans-continental infrastructures for large centralized renewables and the fundamental restructuring of our built environment to provide for more distributed and integrated energy services. Each of these subsumes a number of more specific possibilities.

Offshore wind, waves, tides, biomass and photovoltaics collectively offer the potential to harness potentially enormous energy resources. These may equally be adopted in remote centralized infrastructures or by radical shifts towards distributed networks of small scale energy supply and demand reduction technologies. Electricity, hydrogen or fluid biofuels all offer quite radically different secondary energy carriers for mobility, heat or mechanical power. Each of these options can exist in various forms and permutations. But we cannot equally do all together. This second challenge, then, highlights the ways in which unduly blinkered processes of policy appraisal can lead us to become trapped at an early stage in one particular pathway, leaving the others forever unexplored – or even unrecognised. At this turning point in the evolution of our energy systems, this is the nature of the dilemma in which we now find ourselves.

So neglected is this crucial point in current energy debates, that it deserves some deeper discussion here. Time and again in the history of technology, the detailed mechanisms have been well documented through which innovation can take certain evolutionary pathways rather than others. Often, apparently random contingencies can play a formative role (Mokyr, 1992). This is so, for instance, with the standard QWERTY format that – due to a mix of essentially arbitrary initial conditions and the constraints imposed in the earliest nineteenth century mechanical typewriter designs – persists as the contemporary default for computer keyboards more than a century later

(David, 1985). Overlying this, there exist a variety of powerful mechanisms through which the forms taken by emerging technologies are socially shaped (Bijker, 1995) – or co-constructed (Misa et al, 2003) – as much by proximate social factors as by any general requirements of science or engineering.

This is why, for instance, contemporary commercial nuclear power reactor designs continue to derive from principles originally prioritised for two key military purposes. The high power densities characteristic of light water reactors present particular challenges for safety, but were ideal as a basis for the highly compact propulsion systems required for naval submarines. Provision for on-load refuelling was a major consideration in the initial designs for gas-cooled and heavy water reactor designs, in order to supply urgent demands for plutonium at the height of the Cold War. Some of the resulting features are less well adapted to safe, stable or low-waste operations for civilian purposes. Though detailed positions differ, it is conceivable that the ideal of financially-efficient, inherently-safe, low-waste, readily-decommissioned, proliferation-resistant civilian electricity would have been more readily optimised if rather different basic design principles had been adopted in the early stages of nuclear power development. The problem is – whatever view one takes of the merits of nuclear power – that once large scale global infrastructures have become ‘locked-in’ to these basic design concepts, it is almost impossible to go back to the drawing board and redevelop radically new pathways. This is why all existing commercially available next-generation nuclear reactors follow the same basic design principles established for military purposes in the 1950’s (MPA, 2006).

It is these kinds of sensitivity to initial conditions and to the social shaping of technology that provide the basis for multiple possible evolutionary pathways. The paths actually taken right at the outset are then quickly reinforced by a range of positive feedback effects. Even in the most competitive of markets – like those for consumer products – it is now widely understood how increasing returns to adoption (due to factors like learning by users, incremental improvement, ‘network externalities’ and economies of scale) can lead to powerful processes of ‘lock-in’ (Arthur, 1989). This has been widely recognised in areas like audiovisual and digital media formats, for instance, as well as in computer software, where the performance of modern PC’s shows that conventional market economics provide no guarantee that the direction of progress will follow some kind of single optimal path. The early development of railway systems and the internal combustion engine can also be well understood in these terms (Arthur, 1996).

In areas of newly emerging science and technology that are highly dependent on long-term large-scale financing, the form taken by the early expectations and interests of investors and developers can amplify these kinds of positive feedbacks (Brown and Michael, 2003). This is shown, for instance, in the role played by intellectual property considerations in pharmaceuticals development – disproportionately aimed at addressing the diseases of the rich. It is also evidenced, for instance, by the ways in which the development of genetically modified organisms for agriculture have tended to prioritise the exploitation of dependencies on existing products like proprietary pesticides. These are not

necessarily criticisms. Whether or not this is the case depends on personal values and priorities. The point is that these kinds of process are a fact of life.

As markets are seen to become less than perfectly competitive, then further powerful forces come into play, which compound the tendency for technological evolution to take certain particular pathways rather than others. Where technological developments are most subject to the direct exercise of institutional power, they can become quite autonomous from processes of wider social selection (Winner, 1977). Acting back on society itself, this can sometimes – as with the civilian nuclear reprocessing industry in Europe or the worldwide role of military equipment industries – lead to the entrapment of technological decision makers, who find themselves highly constrained in the way past decisions shape future possible choices (Walker, 2000).

Taken together, these various well-documented forms of ‘lock in’ show the many ways in which certain technological configurations can come to dominate others at the earliest stages of development. Even though these may be for historically contingent – or even quite arbitrary – reasons, they can quickly become very concrete – and even effectively immovable. It was shown in the last section how the UK Government’s uncompromising ‘science based’, ‘no alternatives’ language in current energy policy debates is itself highly subjective. The point here, however, is that – even if the views are not widely shared (or just plain wrong) – this kind of assertive envisioning of the future can quite quickly become a self-fulfilling prophecy. Whether it is archaic keyboards, urban automobiles, audio-visual formats, inferior software, inherently vulnerable reactor designs – time and again we have seen how we can become locked-in on a global scale to technological configurations that everyone in retrospect would recognise as poorly performing options. This is the danger we face if we continue to treat our current energy choices in a blinkered ‘no alternatives’ fashion.

The particular implications for energy choices are easily illustrated by more specific reference to current debates in the UK. Here, the apparent relative economics of nuclear power and renewable energy look very different under two contrasting scenarios. If we assume that our future electricity infrastructures will shift towards distributed, low-voltage, smart-metered electricity systems, subject to intelligent control and flexible supply and energy service contracts, then small-scale, renewable energy and energy service innovations can be expected to thrive (Sauter and Watson, 2007). If we assume instead the persistence of traditional large power stations, presiding over high-voltage transmission systems, with one-way distribution and conventional tariffs, then nuclear power and traditional fossil (with carbon capture) are likely to enjoy a corresponding persistent advantage (Patterson, 1999).

Yet if cost assumptions were always based on the old infrastructure rather than the new, then major investments like those in canals, railways, and electricity itself might themselves never have been undertaken. This widely acknowledged general phenomenon, is nowhere better documented or understood than in the energy sector. As shown by pioneering work on the

development of our current electricity systems, the acquisition of technological 'momentum' is not necessarily a negative thing (Hughes, 1983). It is an essential element in allowing us to achieve any kind of positive transformation. Just as electricity grids themselves, and later hydroelectricity and nuclear power, required enormous advance investments, reorganization of institutions and regulatory systems and long-term public subsidies in order to become established, so too is this required in any large scale shift to renewable energy on new distributed electricity infrastructures (MacKerron et al, forthcoming).

If we are to take this path, then large-scale, up-front innovation is needed in research and development and capital infrastructures alike. International experience shows how new-build housing standards can shift us quickly over to step jumps in energy performance. The remarkable history of North Sea oil extraction shows how entire offshore energy infrastructures can be developed in the most challenging environments. The phenomenal (and continuing) rise in the performance of wind turbines shows what can be achieved by these new technologies even at the margins of existing industrial strategies. Intelligent metering and advanced network control and communications systems offer to transform the nature of our distribution infrastructures. The advent of energy service contracting, shows how organisational innovations can transform the structure of energy markets to take greater advantage of these opportunities. The present enormous rate of progress in technological learning and high volume production for second generation options like rooftop photovoltaic arrays show the scope to continue this direction of development into further new possibilities, if the pathway is pursued (Mitchell, 2007).

Current high levels of resistance to these kinds of development are not some kind of inevitable consequence of natural science, technological logic or market rationality. They are to a large extent artefacts of the present path-dependent distribution of power and interests in the existing historically-hard-wired evolutionary pathway pursued by present energy systems. Powerful positive feedback mechanisms – in some cases incidental, in others actively promoted by influential incumbent interests – are reinforcing the lock-in of current energy markets. There are many such mechanisms, involving factors such as: the tuning of terms of finance; the fixing of pricing tariffs; the influencing of standard-setting; the shaping of planning provisions; the setting of procurement strategies; the steering of regulatory policies; investments in training capacity; controlling professional accreditation; forcing contractual terms and the limiting of liability rules (Hughes, 1983; 1994).

Just as a large scale shift to nuclear power or carbon sequestration would require massive investments and restructuring of energy markets, so do all these – and other – detailed aspects of existing arrangements require attention if we are to achieve a shift to a distributed renewable and energy-efficient future. When contemplating the kinds of large scale transitions in energy infrastructures that all agree are now necessary, the key point is that all such transformations require deliberate disruption of existing practices (Smith and Stirling, 2007). These can be variously structured to favour or

disfavour a range of different technological and resource options. The question which therefore arises, is: which of a number of contending visions for new infrastructures will actually bear fruit? As we have seen, whilst rigorous technical appraisal will always be a necessity, it is not in itself sufficient. Also important are the underlying values, assumptions and expectations over the broad characters of our possible desirable futures. This highlights the need (already discussed) always to place analysis in the context of open reflection, critical deliberation and effective public participation.

For now, the point is that the two preceding sections taken together show how the implications of framing and lock-in depend fundamentally on context and perspective. Neither is necessarily negative. Both are just facts of life. Indeed, they are as essential for success in the pursuit of distributed efficient-renewable pathways as centralized nuclear power. There are, however, circumstances where the consequences of framing and lock-in can become more unequivocally negative. This is where the narrow formative influences conditioning a particular technological trajectory, are concealed from public scrutiny or protected from political challenge. This is precisely what is threatened by the UK Government's current insistence on simplistic and highly exclusive notions of 'evidence based' appraisal and a 'no alternatives' doctrine in the face of climate change.

Towards Energy Diversity

The central message of this chapter is easily put. There is no denying the imperatives radically to transform our existing world energy systems. But this does not necessarily mean that there is only one possible course of action – or even any one necessary element. The challenge of achieving a transition to sustainable energy is not a matter of slavishly following some particular set of political framings or technical possibilities, as if there were no alternatives. The truth is that we also face a second, rather different, dilemma: one of rich and bewildering choice. A variety of quite radically different options present technically and economically viable alternatives. Many are no more or less straightforward to achieve than is the nuclear pathway: large-scale infrastructures for carbon sequestration; massive centralised forms of renewable energy; new continent-scale networks for energy distribution; revolutionary moves towards small-scale distributed energy; radical market innovations from energy supply to energy services. Each broad pathway can be combined with others and includes a diversity of subordinate variants.

The dynamics of framing and lock-in mean that we cannot fully realise the full potential of all these trajectories at the same time. On the other hand, the achieving of any large-scale future transition must necessarily involve a diversity of different strands, woven tightly together (Stirling, 2007). By accepting that 'it takes all sorts to make a world', diversity can help us accommodate otherwise irreconcilable divergences in social values and interests (Stirling, 1997b). By allowing 'horses for courses', diversity pushes technological evolution to be more sensitive to local context (Landau et al, 1996). By not 'burning bridges', diversity hedges against persistent intractable uncertainties and guards against surprise (Brooks, 1986). By 'putting eggs in

different baskets', diversity militates directly against the challenges of lock-in (David et al, 1996). And by 'letting many flowers bloom', the business literature shows that deliberate fostering of diversity offers a powerful way to promote effective innovation of the kind that is essential in achieving any radical transformation of the kind that all agree is now necessary in energy (Rosenberg, 1982).

But the economics of technology mean that diversity is never a free lunch (Stirling, 2008). It is as meaningless to assert we should do equal amounts of everything as to insist that there is a single alternative. Diversity still requires choices. And many of the energy alternatives that currently present themselves do not sit easily together. The relative inflexibility of base load nuclear power, for instance, does not work well with intermittent energy sources like wind power in the way that is possible, for instance, with biomass or natural gas. Massive infrastructure investments compete in finite capital markets. Allocations to technology research and development are forced into multiple trade-offs.

It is for such reasons that, even in the pursuit of diversity, difficult decisions still need to be made. These are not about seeking some single magic bullet technology or policy, but about the more complex ways in which we configure portfolios in order to reflect dynamic and contending underlying profiles in technical performance, social priorities and path-dependent potentials. The richness – and intractability – of the choices we face, means that we can still maintain ample diversity, even if certain high profile options are entirely excluded. This is all the more true where the appeal of such options like nuclear power requires centralized and highly specialized institutional responses and rest on the language of 'no alternatives'.

Against this background, an argument for more plural framings in appraisal and greater diversity in the resulting energy portfolios, does not imply indecisiveness. Instead, it shows a healthy humility over the uncertainties attached to any particular view, a tolerance for other points of view and a hard-nosed realism over the need to engage with complexity. But an appreciation of these qualities does not require some kind of agnostic suspension of personal opinions or analysis. It is entirely consistent with support for diversity, that convictions may remain strongly held and vigorously argued. Indeed, it is in the essence of pluralism and diversity, that we free ourselves from barren, despairing counsels of necessity and enable instead just these kinds of more fertile arguments over choice.

For the present author, like many other under-represented voices in present energy policy debates, the overwhelmingly rational and preferable direction of travel is all-too-clear. Nuclear power presents a unique and remarkable conjunction of intractable problems (SDC, 2006). Unlike renewables, nuclear: depletes highly concentrated resources; presents risks of catastrophic accidents; generates toxic wastes requiring management over many millennia; presents highly vulnerable and potent symbolic targets for attack; contributes to pressures to proliferate weapons of mass destruction and reinforces centralized systems of coercion and control. The 'no alternatives'

discourse now developing is itself indicative of these attributes. Taken together (and shorn of this totalitarian language), it is not difficult to appreciate why the difficulties associated with nuclear power might quite reasonably be seen as prohibitive.

Fortunately, the remainder of the sustainable technology choices mentioned here present ample scope for a wide variety of different diverse systems. In general, it is clear from the international literature that there is no technical or physical reason why the energy requirements of a much more contented world could not be fully provided by maintaining a sustainable equilibrium with the natural flows of renewable energy in which we are immersed (WEC, 1994; Grubb, 1997; WBGU, 1999; WEA, 2000; Soerenson, 2000; de Vries et al, 2007). What is true for the world as a whole is even more so for a country like the UK – enjoying an almost uniquely rich endowment of renewable resources (PIU, 2001; PMSU, 2002; DTI, 2003; 2006). We already have the basic technologies and techniques to achieve this. The great network transitions of the past – from canals, through railways, roads, telecommunications and electricity itself, all show what can be achieved with the right imagination, leadership and commitment. None of these great innovative steps of the past were realised by relying on previously incumbent vested interests. With the defining human genius for innovation, there is no reason why we should not acquire a momentum down a path that leads this way. All that stands in our way is the equally human proclivity for inertia.

Whatever directions it takes, however, the political steering of the next great energy transition means opening up a multitude of apparently closed technical decisions and asserting a wider diversity public values and interests. Only in this way, can we be sure of overcoming the negative effects of forced framings and blinkered lock-in discussed here, and acquire a more positive momentum towards real sustainability. This requires on the part of those in power in energy systems: a daunting level of commitment to transparency, participation, flexibility and diversity. It requires on the part of the rest of us: a willingness to become engaged; self-confidently to argue for our own visions and values; and tolerantly to accept a plurality of others. Most of all, for everyone, it means avoiding intimidation: by over-assertive expertise; by narrow vested interests; by expedient appeals to ‘sound science’; by counsels of despair over a lack of alternatives; and by disabling apocalyptic fears. This is the nature of the real choice that we have to make. So far, it seems that Government has yet to fully grasp this challenge.

5. CONCLUSIONS

KEY CONCLUSIONS OF THE NUCLEAR CONSULTATION WORKING GROUP

1. Framing the Nuclear Consultation

1.1 Because an uncritical view of the problems associated with nuclear power was presented to the public at the citizen deliberative events, the government will face an uphill battle to convince people that the ‘voting’ exercises undertaken by DTI provided a mandate for public acceptance of new nuclear build.

1.2 The key assumptions underpinning the government’s approach to the nuclear consultation remain open to critical analysis. The framing assumptions that underpinned the nuclear energy consultation provided only particular, limited, and constrained answers.

2. Energy Landscape and Renewable Energy

2.1 Nuclear power is not just a technology you can simply add on to an unchanged energy supply and demand system. It has implications for how the system runs and develops. It can only be sensibly assessed by looking at ways in which the system might develop, at the role of other supply options and at the potential for demand management.

2.2 Instead of that, the consultation back-up information tended to simply list individual alternative energy options in isolation, often in prejudicial terms. The result is a very limited and arguably partisan presentation. It gave very little indication of the large potential, of renewables.

2.3 A more coherent presentation would offer a range of energy scenarios with different supply mixes and assumptions about demand, and some indication of the opportunity costs associated with each selection

3. Security and Nuclear Proliferation

3.1 Information presented in the consultation offered bland and optimistic reassurance on security, safety, and proliferation. However, there exists clear and present danger of nuclear weapon proliferation and nuclear terrorism associated with the plutonium economy.

4. Nuclear Uncertainty

4.1 Information supporting new nuclear build provided in the consultation was presented as sound science and evidence-based. However, as an engineering project, civil nuclear power presents uncertainties that are unprecedented and insuperable. In the medium and long run, they are so great as to swamp all the numerical calculations about costs and benefits. Only by a total discounting of the future and of our obligations to our descendants, can there be a quantitative assessment of the prospects for civil nuclear power.

5. Radioactive Waste

5.1 Although there is, as yet, no proven technical solution for the long-term management of radioactive wastes, information supplied in the consultation suggested otherwise. However, overseas experience does not provide evidence of a long-term solution sufficient to justify deep disposal for new build wastes in the UK.

5.2 Whereas material presented in the consultation stated that government believes that new waste could be managed in the same way as existing or legacy wastes, the scientific advisory Committee on Radioactive Waste Management has concluded that the management of legacy wastes should not be applied to wastes from new build, since they raise different technical and ethical issues.

5.3 In this context, the unresolved technical and ethical concerns related to managing radioactive wastes safely provide both a necessary and sufficient condition for rejecting the case for nuclear new build.

6. Economics of New Nuclear Build

6.1 Although the government has maintained, during the consultation, that it would be for the private sector to fund, develop, and build new nuclear stations – that would only be possible if the large economic risks of building and operating new nuclear power stations were borne by the UK public purse.

6.2 The political and environmental concerns that nuclear is expected to meet are real, but nuclear power cannot deal with them. If the UK was to pursue nuclear power now, it would load extra costs on the British people and continue to divert attention and resources away from the measures that could be effective in dealing with these serious concerns.

7. Security of Supply

7.1 Whilst information presented in the consultation suggests that accessible and affordable uranium can be relied on, it is vital not to regard uranium supplies as unproblematic.

7.2 Information presented in the consultation provided a confident and upbeat view on industries ability to meet the demands of new nuclear build.

However, it is clear that labour market limitations on any envisaged construction programme would impact on reactor reliability, safety and completion date.

7.3 The consultation provided no information on energy market and demand side management. The government needs to acknowledge that consumer preference alone cannot constitute a sustainable energy market. This requires a market maker state prepared to create the necessary investment and pricing conditions for emergent technologies. By acting to establish viable domestic and small scale electricity generating capacity in the UK the government can move towards fulfilling meaningful contributions to CO2 reduction targets within the short timeframes identified as consistent with climate change mediation. New nuclear build will come too late to achieve this critical objective.

8. Energy Policy and Regulation

8.1 It was a major short-coming of both the Energy Review and the Nuclear Consultation that they both accepted uncritical views of existing regulatory and industrial regimes. A further weakness was to ignore the valuable experience of comparable European nations.

8.2 Only constrained and limited information on UK and European renewable energy comparisons were provided during the consultation. The fact remains that UK's failure to find policy and regulatory approaches that favour new technologies and smaller scale suppliers have significantly held back the installation of renewables in the UK compared to other developed countries.

8.3 In this context, if the full range of options in policy, regulation and technology are looked at creatively, it's clear we could meet our energy needs and environmental goals without resorting to nuclear power.

9. Reactor Design

9.1 It is of great concern that the issue of potential reactor design was not integrated into the nuclear power consultation, and this omission has significantly compromised the integrity of that process.

9.2 The displacement of core issues, such as the clear accident and security risks associated with the exponentially higher fuel irradiation of the EPR design (2.5 times that of Sizewell PWR, and 5 times that of Chernobyl) is deeply problematic.

9.2 In this context, it is a matter a great consequence that the nuclear power consultation did not include discussions on demands for streamlining administrative processes advocated by the nuclear industry in order to achieve the widespread deployment of un-tried and un-tested reactor designs.

10. Reactor Siting

The issue of reactor siting is key to the any future of nuclear power in the UK, and should have been fully integrated into all parts of the consultation process. That this was not done significantly weakens that process. This is because:

10.1 The coastal locations of existing sites are vulnerable to varying degrees to the impact of climate change on both sea level rise and the increased frequency of extreme weather events.

10.2 As on-site storage is the default and only certain current option for dealing with radioactive wastes – nuclear new build will be sited beside radioactive waste stores, potentially to include highly radioactive spent fuel wastes.

10.3 The assumption that existing nuclear communities will welcome new build is unproven. It is unlikely that the proposed fast track reforms to decision making will retain sufficient accountability, legitimacy or respect to enable the smooth and rapid playing out of siting processes.

10.4 The strength of feeling that nuclear power and nuclear waste storage generates means that in practice demarcations between national strategic and local matters will be resisted. The proposed top-down evaluation of site suitability for new build nuclear power and associated nuclear waste stores, stands in stark contrast to the bottom-up volunteering and negotiation approach recommended for the siting of an underground nuclear waste repository.

10.5 The UK needs to act on its ethical responsibilities to mitigate climate change, but should not be achieving this by giving the major burden to a handful of isolated and dependent nuclear host communities. Action should rather be focused on the heartlands of demand and consumption. There are better and fairer ways of distributing responsibility to reduce carbon that do not pose an irresponsible and unethical burden of radioactive waste on future generations.

11. Radiation Health Effects

11.1 There was no attempt at a coherent discussion of radiation health effects during the consultation. This is problematic because recent research suggests that there are real concerns that infants and children living near nuclear facilities may be subject to greater cancer and leukaemia risk.

11.2 In this context, since current radiation risk standards are subject to large levels of fundamental scientific uncertainty, and may underestimate risk to public health, it would be unwise to subject critical groups and the general public to further radiological insult through new nuclear build in the UK.

12. Nuclear Power's Broken Promises

12.1 The nuclear power consultation presented no discussion on the problematic past of the nuclear power industry in the UK. The taxpayer has had to foot the bill for the THORP project, decommissioning all our reactors, for the collection and making safe of the nuclear waste stream, for the losses of the MOX plant and the disposal of contaminated plutonium and uranium. Current experience of Finland shows that the rhetoric of nuclear power is still wanting – and that the new generation of nuclear power stations will be quick and easy to build is untrue.

13. Choosing Energy Futures

It is deeply unfortunate that the structural framing of the nuclear power consultation was both limited and constrained. This had the effect of excluding a broad range of important cross-cutting issues that are fundamental to the consultation. This is significant because these issues pre-condition the eventual outcome of the consultation. In this context, conclusions from this section of the report are wide-ranging:

13.1 The purpose of appraising energy technologies and resources is to inform long term policy choices. Decisions across the entire field of industrial strategy depend on the resulting pictures. Nowhere is this phenomenon more prominent in the UK energy debate, than in the current Government's advocacy of nuclear power.

13.2 Equally rigorous approaches to technical appraisal may - under similarly legitimate but different conditions - yield different energy technology or resource options. For example, the apparent relative economics of nuclear power and renewable energy look very different under contrasting energy market scenarios. So, even in the most technical and sophisticated forms of analysis, it seems that the **answer you get depends on the way you frame the question.**

13.3 Unduly blinkered processes of policy appraisal can lead us to become trapped at an early stage in one particular pathway, leaving the others forever unexplored. Well-documented forms of 'lock in' show how certain technological configurations can dominate others at early stages of development - even though these may be for quite arbitrary reasons. Once large scale infrastructures have become locked-in, it is almost impossible to go back and develop new pathways.

13.4 In this context, the only truly evidence-based finding that can be derived from complex energy policy is that **real choice does exist.** This is all the more true where the appeal of such options like nuclear power requires centralised and highly specialised institutional responses, and rest on the language of 'no alternatives'.

BETTER PRACTICE CONSULTATION

In order to overcome the widespread belief that institutions wishing to impose their arbitrary actions upon the public may be secretive, all the key framing propositions and assumptions underpinning the nuclear power consultation need to be made explicit in any case that is put forward for new nuclear power stations. In order to access true public opinion about such a high-stakes issue, the public consultation should have been clear, integrated, independent, and conducted over a long enough time-frame. Failure to do so has left the government vulnerable to legal challenge and may lead to hostility and mistrust of any future energy policy decision.

A general rule of faulty consultation processes is that those who define the scope, remit and function often achieve the outcome they desire - get your ducks in a line, and a predetermined outcome emerges. It's not good enough to ask a few audiences in a few short meetings over a few short months to make complex judgments about how best to power our society - we needed a consultation worthy of the name. We needed an open and informed discussion, access to a range of information, enough time to think the issues through, a fair hearing for all sides, and a consultation structure that outed all the 'what-if' questions by setting the nuclear issue within the wider energy production, consumption, efficiency, and risk contexts.

The first pillar of the EU Aarhus Convention on 'Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters' aims to ensure that the public is informed about its environment and that its role in decision-making. In order for the public to be able to invest trust in the governance of nuclear technology, science and risk; consultation must be a truly involving process, forwarding important problems, rather than pre-ordained solutions based on problematic information. For complex issues with uncertain futures, the goal of involvement may not be to find the single 'right answer' to the problem, but rather to bring people together, and keep them together, in order to ensure that better decisions are made in the future.

6. RECOMMENDATIONS TO GOVERNMENT

We take no satisfaction that our Recommendations are based on the understanding that the 2007 nuclear power consultation has failed. Poor consultation practice wastes people's time and can seriously undermine people's trust in government. To access true public opinion about such a high-stakes issue, the public consultation should have been clear, integrated, independent, and conducted over a long enough time-frame. Failure to do so has left the government vulnerable to legal challenge and may lead to hostility and mistrust of any future energy policy decision.

The extent of mistrust of the institutions and the institutional culture underpinning nuclear power underlines that this is a public mood that, although not immutable, has been deeply entrenched by long and discouraging experience. Although a broader, deeper, even-handed consultation may have appeared an inconvenience to certain sectors of the nuclear industry, a truly involving process would have produced a better result for everyone by generating greater social consensus and trust in the eventual outcome.

Recommendation 1.

Government should embark on an involving consultation addressing the significant inter-locking 'what if' issues - such as uncertainty about nuclear fuel supply and manufacture, vulnerability to attack, radiation waste, radiation risk and health effects, reactor decommissioning, reactor design and siting, costs of electricity-generating technologies, energy distribution models, true renewable and energy efficiency modelling.

Recommendation 2.

All key assumptions underpinning the framing of that consultation should be set out. The public should have good access to a broad range of scientific and technical information, be assured that all relevant views and judgements are included, and be in a position to process and evaluate that information.

Recommendation 3.

The renewed consultation should develop a realistic scenario based approach to possible energy mixes, to inform debate about choices, with renewables given their proper place.

APPENDIX 1

EUROPEAN 'BETTER PRACTICE'

Denmark

Denmark currently gains 15% of its total energy and 28% of its electricity from renewables (Danish Ministry of Foreign Affairs, 2007), and by 2001 18% of Danish electricity supply came from wind power alone (ibid). This has come about as the result of a consistent policy and regulatory approach since the early 1990s. Several factors have combined to facilitate this. The Danish government provided capital subsidies and enforced guaranteed buy in rates for renewable production. This provided the confidence for investors and kick-started the installation of renewables. As the policy succeeded the subsidies were reduced.

However, some key differences in the structure of the energy industry in Denmark made implementation of broad policy goals on renewables relatively easy to implement. Many local authorities have some ownership of utilities and the utilities themselves often owned the full range of supply options. Strong local democratic accountability and control enabled a strategic overview to be taken when making investment decisions about new generating capacity and seeking to take up government incentives. In other words, co-operation rather than competition between supply technologies made possible by the structure of the energy industry in Denmark, proved effective in getting renewable capacity installed. There has also been a large number of community owned schemes which have had the advantage of incentivising local communities, since they gained financially from new schemes rather than just having to act as host communities to technology with a diffuse national benefit. The subsidy and guarantee buy-in rates also facilitated many smaller-scale schemes.

The wider benefits for the Danish economy have been considerable. The wind industry is now a major employer and more than 40% of wind turbines installed world wide have come from Denmark (ibid). Denmark has also been a world leader since the 1930s in district heating. Careful heat planning linking new developments with combined heat and power schemes is still expanding the number of homes on district heating grids. Not only new homes have been connected, retro-fitting to large communities has occurred. This approach massively increases the efficiency of the energy supply system as a whole.

Germany

Germany has a large scale centralised energy supply not dissimilar to the UK, yet it has made policy decisions and chosen regulatory options that have

resulted in the implementation of significantly more renewable energy than the UK.

Germany as of October 2003 had 13,512 MW of wind power installed (40% of the global total). It also had approximately 350MW of photovoltaics installed (second only to Japan). Germany is the largest European market for solar water heating systems with 4.75 million sq. meters installed as of December 2002. The rate of production of wind turbines has been so great that the cost of their production in Germany fell 50% 1996 – 2004 (Runci, 2003).

These impressive outcomes have followed from the 1991 Energy feed-law and the more recent 2000 Renewable energy law. The 1991 legislation required utilities to buy renewable energy from producers with guaranteed buy-in rates. This made investment in renewable energy attractive to investors and facilitated entry to the market for smaller producers, although it also seems to have stimulated action by the larger utilities. The 2000 legislation has attempted, through fixed tariffs, to direct subsidy to technologies and/or suppliers most needing help to become established, given the nature of the technology, the scale or location of production.

Approaches such as this could be adapted to the UK to ensure a much greater implementation of sustainable renewable technology.

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