UNIVERSITY OF CAMBRIDGE
Electricity Policy Research Group

Another Man's Poison: Risk Management and Nuclear Power Generation

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John Ash

Abstract

A projected shortfall in bulk electrical power, coupled with concerns regarding security of supply and obligations in respect of climate change, have driven the UK government to reconsider nuclear generation. Although this is superficially a political, administrative and economic decision, it is a judgement undertaken by a network of actors, and may be viewed as a process catalysed by risk. Based on primary data drawn from interviewees associated with the nuclear power decision, this research examines the role of risk perception in the decision process, and how those perceptions compound the complexity of the problem. The results indicate a common desire amongst interviewees for assurance with respect to energy supply, and a relationship between that assurance and time. These themes underline the difficulty in reaching an accommodation between rival stakeholders in the decision process; particular power sources are preferred because they mitigate the risks that most concern stakeholders. However, because individuals prioritise risks differently, a power source that mitigates risk for one stakeholder is in itself an intolerable risk for another stakeholder. The discussion concludes with an evaluation of a deliberative approach as a prospective solution to this quandary.

Keywords Nuclear power, risk perception, decision-making, deliberative

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Another Man's Poison: Risk Management and Nuclear Power Generation

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"…Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts."

Summary for Policymakers of the Synthesis Report of the IPCC Fourth Assessment Report.

"There are some remedies worse than the disease"

Publius Syrus (42 B.C.) (Bartlett, 1919).

Abstract

A projected shortfall in bulk electrical power, coupled with concerns regarding security of supply and obligations in respect of climate change, have driven the UK government to reconsider nuclear generation. Although this is superficially a political, administrative and economic decision, it is a judgement undertaken by a network of actors, and may be viewed as a process catalysed by risk. Based on primary data drawn from interviewees associated with the nuclear power decision, this research examines the role of risk perception in the decision process, and how those perceptions compound the complexity of the problem. The results indicate a common desire amongst interviewees for assurance with respect to energy supply, and a relationship between that assurance and time. These themes underline the difficulty in reaching an accommodation between rival stakeholders in the decision process; particular power sources are preferred because they mitigate the risks that most concern stakeholders. However, because individuals prioritise risks differently, a power source that mitigates risk for one stakeholder is in itself an intolerable risk for another stakeholder. The discussion concludes with an evaluation of a deliberative approach as a prospective solution to this quandary.

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Introduction

This research considers the decision processes concerning the management of risk associated with new nuclear [2] civil electricity generation in the United Kingdom. The analysis is not an attempt to identify a theoretically best decision outcome in respect of whether nuclear should form part of the solution to the energy/carbon problem [3]. Rather, the work explores the decision network in the United Kingdom that must confront the various risks associated with the use (and non-use) of nuclear power in the civil sector. *This research attempts to consider all actors in the decision process equally, and does not try to adopt the perspective of any given stakeholder*.

Two basic research questions were posed on the basis of initial searches into the issue of risk management and the inclusion of new nuclear sources as part of the generation strategy [4]:

1. "*In what manner can the risk perceptions of various stakeholders best be incorporated into choices* [5] *regarding bulk electrical power sources?"*
2. "*To what extent does the deliberative approach adopted to inform the management of radioactive waste represent a model for risk management decision-making associated with new build civil nuclear power?"*

These questions will be addressed in turn, following a description of the research methodology and a consideration of the background to the issues involved.

Research methodology

This study identified a form of participant observation involving interviews as the most appropriate means of properly exploring the subtleties of risk related decision-making in the context of civil energy supply. A number of factors informed this choice, including the nature of the decision process, the characteristically poor return rate on survey based systems (Bernard, 1994), and their intrinsic shortfalls in the capture of significant supplementary information. Data collection involved

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[2] 'New nuclear' is the generic term for any civil power reactor(s) to be built after Sizewell B, which was completed in 1995.

[3] The "energy/carbon problem" is a convenient term for referring to the situation regarding energy supply and global warming as it confronts the United Kingdom. It does not presume that the premises assumed by the government or any other particular stakeholder are correct. Indeed, some interviewees opined that there is no "energy deficit" and that economies in demand and energy efficiency improvements could wholly resolved the supply-demand equation.

[4] To avoid repetition, generation and nuclear generation will refer to the United Kingdom case unless otherwise specified.

[5] The choices referred to here are societal. However, such choices inevitably incorporate decisions and preferences from within government and other stakeholder groups. The research questions appear here as originally stated in the study documentation.

interviewing a sample (n=25) of individuals closely involved in, or with specialist knowledge of, the decision process. The choice of interviewees rested on the requirement to obtain answers to the research questions that were appropriately valid and relevant. Following the nomenclature reported by Miles and Huberman (1994), interviewee identification followed two basic methods; 'stratified purposeful' sampling, and 'chain' [6] sampling. In the first case, the position of an individual in a specific stakeholder group prompted some invitations. In the second case, respondents were contacted as a result of the networking process that accompanied the study.

Interviewees included persons currently in the nuclear power industry, present and former members of the civil service whose expertise covered environmental and nuclear regulation, and members of environmental and other non-government organisations. Other individuals interviewed were academics and scientists responsible for engineering training, for research on nuclear or risk management, or with expertise in energy generation and distribution. Interviewee experience included employment in a company that undertook power station design and operation, work in the South of Scotland Electricity Board, and in the former CEGB. The sample featured people who had worked on, or in connection with coal powered, nuclear and renewable energy generating systems. The researcher was able to include in the interview population all of the key personnel involved in the new nuclear build project within one of the major energy companies. Various respondents had had direct involvement in a deliberative process or public enquiry related to nuclear facilities or nuclear waste. Some of those providing primary data had followed career paths that incorporated experience of different stakeholder groups. For example, some regulators had worked in power generation or in military propulsion systems. A summary of the interviewees is at Table 1.

[6] Sometimes referred to as 'snowball' sampling.

Table 1: Summary of interviewees

COHORT TYPE	TOTAL NUMBER IN COHORT
CORWM (former members of the Committee On Radioactive Waste Management)	2
Energy Industry members	8
Engineers and natural scientists in academic organisations	3
Government and former government officers	9
NGO members	3
TOTALS	25

Table 1 understates the full extent of the data collected for this study. For example, the researcher interviewed an additional member of CORWM, but because the meeting was part of the initial data search and not recorded electronically, it has not been tabulated. In addition, one of the meetings with an NGO featured two interviewees.

The interviews were mostly conducted using tested interview guides; although during the interview process, the opportunity was taken to ask supplementary questions where appropriate, and respondents were encouraged to voice their perceptions in an open manner. Interview records consisted of standard ferrite audiotapes, with supplementary notes collected for data security. Paper notation was also beneficial as some respondents were better able to provide their answers with the aid of a sketch. The researcher checked the tape transcripts against the original recordings prior to injecting the resulting text files into a proprietary database for analysis. The database automatically fractured the written narrative into text elements (TELs) at the level of the utterance; that is, the period in the interview commencing when one person begins to speak, and ending when another person begins to speak. The researcher allocated TELs to categories, with each category represented by a 'node' or address in the database. Nodes are sometimes referred to as 'codes' and the process of text TEL allocation to individual nodes is termed 'coding'. Each code represents a concept, and the analyst related concepts to derive a grounded theory of the social interaction in the population under study; in this case, the participants associated in some way with the nuclear civil power risk management decision

process. The database permitted the arrangement of the data categories (codes) into a logical structure. Figure 1 provides an overview of that logical structure in its final iteration.

Figure 1: Overview of the data category structure used for the analysis of this research

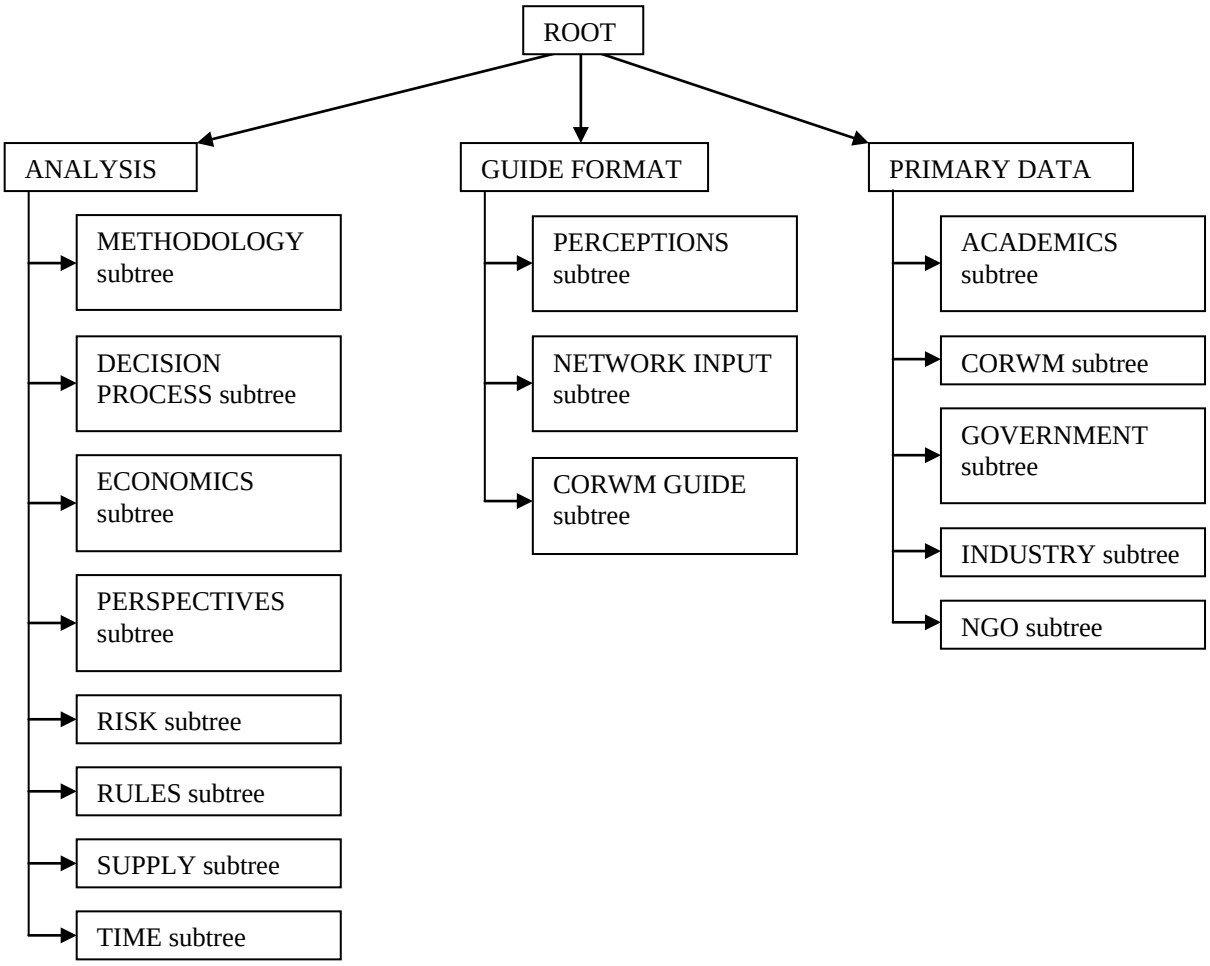


Figure 1 depicts the manner in which the 303 separate data categories created for this research were organised in the analysis database. A 'subtree' refers to a number of codes grouped under an overarching concept. For example, the 'SUPPLY' subtree consisted of 22 separate nodes under which TELS referring to energy supply as a concept are coded, including nodes for ideas such as 'base load' and 'demand reduction'. Essentially, the TELs in the interview transcripts were coded in three ways, and each coding approach resulted in a separate branch in the tree structure. The Primary Data branch contained TELs coded according to the cohort of which individual interviewees were members. The purpose of this branch was to facilitate

comparisons between cohorts. The Guide format branch contained a node for each question in the interview guides, enabling the researcher to compare interviewee responses for each question. The Analysis branch of the tree held nodes created by a process of 'open coding' (Bryman, 2004; Flick, 2006; Strauss, 1987; Strauss and Corbin, 1990, 1998). Open coding refers to the practice of generating new categories for concepts as they appear on reading interview transcripts. Although laborious, it is a very thorough method of organising TELs for comparison and the generation of a grounded theory.

Grounded Theory is a qualitative approach in widespread use in the study of phenomena in the social sciences (Bryman, 2004; Flick, 2006; Glaser and Strauss, 1967; Strauss, 1987; Strauss and Corbin, 1990, 1998; Miles and Huberman, 1994). The product of such a study is *a grounded theory* of a particular social phenomenon. The name 'Grounded Theory' derives from the *a posteriori* reasoning method involved in which, instead of proposing an hypothesis for empirical test, a theory describing the social phenomenon in question is inferred from, or 'grounded' in the data (Glaser and Strauss, 1967; Miles and Huberman, 1994). In the case of this research, the theory consisted in a set of related propositions or statements generalising concepts in the primary data. Subjecting each component statement to an active attempt at refutation tested the validity of the theory. The database facilitated this process as it incorporates search functions based on Boolean logic.

The energy challenge

The United Kingdom government, in common with the leadership of other sovereign states in the world, is confronted by a challenge of a novel nature. It faces both international and domestic pressure to reduce greenhouse gas (GHG) emissions. At the same time, predictions for electricity demand indicate an increase from 42.2 GWy in 2010 to 47 GWy by 2020 (BERR, 2008a) [7], and government will face pressure to ensure that the supply is affordable, uninterrupted, and generated by means that are within tolerable levels of safety. Much of the current nuclear generating fleet is growing old and cannot continue in service indefinitely. The retirement of the majority of this plant by 2015, together with approximately one third

[7] These demand estimates are central case predictions drawn from a range of scenarios considered in the source document. The figures are conversions from Mtoe (megatons of oil equivalent) to GWy (Gigawatt years) using a conversion factor of 1.42 rounded to one decimal place.

of the coal fired generating capacity, will leave a shortfall estimated at 15GW (POST, 2007).

The government endorses the establishment of a new fleet of reactors as part of a basket of measures to meet the predicted UK energy needs (BERR, 2008b). Nuclear generation is a technology that is already in use and has GHG emission levels comparable to those of renewable sources (POST, 2006). It offers mitigation of security of supply issues in three respects, first, by adding to the diversification of supply. Second, it suffers comparatively less vulnerability to fuel price fluctuations. Finally, nuclear generation reduces susceptibility to foreign political interruption of fuel supplies. A number of related issues militate against these attractions, conspicuous amongst which are the problems of nuclear waste, the security of nuclear installations and material, the perceived safety of nuclear plant, processes and transportation, the potential for a nuclear programme to encourage the proliferation of nuclear materials, and the cost of undertaking such a programme and its related activities [8].

It is as a result of these concerns and others that nuclear generation suffers from intense issues of political acceptability, and without government endorsement, the energy market has seen no new nuclear plant introduced in the UK since 1995. Moreover, the licensing and construction process for nuclear power stations has historically been a protracted one. Following the announcement of Sizewell B in 1980, the public enquiry lasted from 1982 to 1985, and the construction and commissioning process took from 1987 until 1995.

New nuclear generation decisions and risk management

One perspective of the policy decisions associated with a new nuclear generation programme in the UK is to consider such choices as an exercise in risk management. Rather than merely examining the comparative risks associated with power generation options, the entire decision process in respect to power sources may be viewed as one predicated on the management of societal risks. This is not to assert that benefits do not enter the calculation. A nuclear programme has the obvious potential to raise revenues for power companies, their suppliers and the government in the form of taxes. For the population in general however, a proponent of nuclear generation might couch its benefits largely in terms of reducing the likelihood of

[8] BERR (2008b) gives an overview of these issues from the government perspective.

exposure to blackouts and fuel poverty. In other words, the benefits for the broader population are themselves the mitigation of risks. Certainly, the issues driving government thinking on this issue, as revealed in material such as their public consultation documents, focus on two key challenges; first, climate change and the associated targets for reducing CO_2 emissions, and second, security of supply in terms of ensuring that an uninterrupted and affordable source of electricity is available to all members of society.

In this respect, the new nuclear decision may be seen as an aspect of the fundamental duty of government to protect the state (Smith, 1776 republished 1904), in other words to minimise, as far as it is able, the risks to which the state is exposed. This begs the question of how government establishes its priorities for addressing risk; what decision-making method can best represent the diverse and often strongly entrenched interests in the society it governs? Risks can rarely be dealt with in isolation or in absolute terms. A risk can seldom be considered properly without identifying to whom the exposure will occur, what mitigation or benefit will accompany the risk, whether such risk is imposed or voluntarily undertaken, and cultural factors such as dread; all of which will determine the tolerability of the risk (Burgman, 2005; Dobson, 1998; Starr, 1969; Slovic, Fischhoff and Lichtenstein, 1981).

In the business of governance, for any given problem, one course that is always for consideration is the 'do nothing' option - simply to leave matters where they stand with perhaps a watching brief allocated to a department, or a choice to review developments at some point in the future. In the case of the new nuclear decision, it is evident from such statements as the following that the UK government feels that doing nothing is not an acceptable position to adopt.

> "We need to look at the risks to security of supply, our climate change commitments and, to the long term, to make sure we take the necessary action. There is not a do nothing option."
>
> Alan Johnson, Secretary of State for Trade and Industry (DTI, 2006).

In fact, doing nothing in itself could be a risk, or rather, the acceptance of relatively intolerable risks. Moreover, whatever action was taken needed to be taken with some urgency. For some time it was sufficient from the government's perspective [9] to postpone a decision regarding the building of new nuclear plant

[9] Many would consider the lack of consistent government endorsement and support for the British nuclear programme over a long period to be a failing. One of the results has been a potential skills shortage in the nuclear power sector (POST, 2003).

because it was politically contentious. However, an urgency to confront a choice between undesirable alternatives has developed, particularly since target dates for plant replacement and delivery on CO_2 commitments cannot readily be postponed. To compound these issues, the licensing and construction of nuclear stations is more time-consuming than other electricity sources, and public awareness of the effects of climate change is growing steadily.

A key factor that clearly conditions government thinking, and one that is certainly risk-related is 'security of supply' (BERR, 2008b; DTI, 2006). The term 'security of supply' is traditionally a reference to the ability to meet domestic electricity demand at the point of delivery from the grid. However, evident in the primary data were two related themes; the first is the prospect of a foreign power withholding a fuel supply, and the second, a view that civil society would rapidly collapse into disorder and violence should supplies cease.

The combination of these factors evidently drove the need to address a policy decision concerning government support for new nuclear generation that had comfortably been consigned to a political shelf, away from the unwelcome and piercing attention of the media and the general public (DTI, 2003; DTI, 2006). Certainly, the concept of diversity of supply, or at least of a mix of sources that included a 'proven' technology that could create large volumes of power at any time and with relatively limited carbon output, gained appeal despite its shortcomings. However, the resilience offered by new nuclear power had a political cost – a decision process that involved a number of stakeholders.

The network perspective

As a means of visualising the complex and related decisions that characterise the management of risk in relation to bulk civil nuclear power, the analysis considered the many stakeholders involved in the process as actors in a network. Clearly, the actors each take decisions associated with a broad range of issues in their professional and private lives, only some of which relate to risk management in the context of nuclear power. In addition, addressing the decision process as the work of a network does not entail either that the network exists in some formal or permanent incarnation, or that the people of whom it is comprised see themselves as its members or components.

The evidence in the primary data reveals that a given network actor interacts with or has links to only a limited number of other actors. Actors with the closest

involvement in the risk management process tend to congregate within stakeholder groups or act in concert with other individuals. However, not only can the nature of the interaction of individuals with others in the network vary with time, perhaps as their responsibilities within a stakeholder organisation changes, but actors may migrate between stakeholder groups.

Actor roles tend to confine an individual's influence on the set of decisions that are the network's output, and which have agency on the degree and nature of the risks being managed. This is true in two senses. First, an actor may be constrained by membership of a specific stakeholder group. Second, actors may not have the authority to make specific decisions per se. However, they may be highly influential on decision makers by providing advice, data, or analysis. Moreover, an actor may simultaneously have more than one role within the network. For example, an actor with a role as a decision maker for engineering aspects of nuclear power plant may also provide peer review or audit of other organisations as part of a reciprocal arrangement designed to improve safety. The complex nature of the network and its constituent actors therefore tends to impede the induction of simple causal inferences regarding the decision process.

The clash of cultures

It is important to understand that the decisions taken by the actors in a network occur in the context of previous choices enacted by its earlier iterations. The decision process concerning the replacement or augmentation of existing nuclear plant has a long and acrimonious history that mingles issues such as radioactive waste, the economics of power production, and views on nuclear weapons [10]. It is an administrative, economic, legal and political conflict between stakeholder groups and in many cases the groups are mature and possess considerable corporate memory. It is also a conflict that has witnessed major fluctuations in apparent outcome. For example, some of the actors may consider that new nuclear is a resurrected policy, believing that it was once effectively discarded, as indicated in the 2003 Energy White Paper [11]. Despite the recent government policy announcement endorsing new

[10] CORWM (2006) gives an overview of the historical stalemate associated with decisions regarding Britain's nuclear waste. Taylor (2007) provides a comprehensive history of the British nuclear industry, albeit with an emphasis on finance.

[11] Specifically, the policy conclusion in the White Paper regarding nuclear power was: "We do not, therefore, propose to support new nuclear build now. But we will keep the option open." (DTI, 2003). Evidence in the primary data indicates clearly that anti-nuclear contributors to the process inferred that to mean effective relegation of the concept from government plans.

nuclear plant construction, it would be an error to consider the battle to be over. Nuclear industry interviewees indicated very clearly their view that political endorsement is fundamental both to obtaining the essential planning consents and to ensure that implementation of the law by regulatory agencies does not become restrictive or obdurate.

> "Initially…I think the most significant barrier has been the political barrier, where following the 2003 energy review there has been a de facto moratorium on new build… I believe it's real, in that, if anybody were to put forward a planning application for a nuclear power station, they would hit huge planning hurdles in the absence of overt government support…" [12]
>
> Nuclear Industry member 1.

> "…The other end of the risk spectrum, one might say for example that, take the example of Scotland. Recently changed from Labour to Scottish Nationalist in its dominant political complexion. Scottish Nationalists, much more anti new-nuclear build, than the previous administration. Inevitably, that will leak across into the attitude that a regulators would bring, to the last knockings of the process of issuing the authorisations and licences, it's consents and so on…"
>
> Nuclear Industry member 7.

Nuclear industry respondents perceived that a necessary condition underpinning the support of the elected government for new nuclear build was public acceptance. One nuclear industry interviewee elaborated that public acceptance depended on a belief that issues including radioactive waste, decommissioning, plant safety and the protection of nuclear installations from attack, had all been properly addressed. However, there was by no means a clear indication in the primary data of the conditions that would be *sufficient* to win the support of the elected government for new nuclear build. Moreover, while the nuclear industry views the support of the elected government as necessary to ensure that the executive, and particularly the regulatory branches of the civil service, do not obstruct new build, that support is also insufficient to guarantee that no administrative or judicial impediments will occur. Not only was there an awareness in the nuclear industry cohort that judicial review remained an option for opponents of new nuclear build, but one of the government regulators made it clear that his department's position on new reactor construction was contingent on an acceptable solution being devised for legacy waste.

The elected government has sought to mitigate regulatory risk by the introduction of a generic reactor design assessment process (HSE, 2008), and the revision of planning law to reduce legal challenges to the construction of projects of a strategic national significance (Planning Act, 2008). However, nuclear plant takes a

[12] Quotes from primary data are edited versions of verbatim transcriptions and include features of the original utterances such as errors.

relatively long period to achieve the appropriate suite of consents and to construct. Even with the potential abbreviation of the process resulting from the Planning Act 2008, there will probably be time for more than one change of government. The Conservative Party has already stated an intention to abolish the Infrastructure Planning Commission, which is the administrative fulcrum for the legislation, while the Liberal Democrats have expressed not only their reservations about the Planning Act 2008, but their rejection of new nuclear power (Anon. a, 2008; Anon. b, 2009; CPRE, 2008; Grice and Russell, 2008). Moreover, the availability of endorsement by all branches of government would not obviate investment risk. For example, a concerted process of direct action by NGOs might ruin a business plan for a new nuclear plant, because the nature of the investment tends to be capital intensive during the period of project establishment.

> "…And after all, this isn't a religion, building nuclear power stations, this is an economic decision, and it will live or die by the investors' perception of the economics. And if investors perceive that the economics will be destroyed by the actions of protestors, they will think twice about putting their money into them…on nuclear plants, depending upon the rate of return, you're talking about somewhere between 50% and 75% of the unit cost of electricity being attributable to the cost of construction. So, the investment has…huge impact on that and relatively minor changes in the level of investment could therefore destroy the economics."
>
> Nuclear Industry member 1.

Another scenario is a nuclear accident that forces the imposition of late design changes. Such an event would probably have limited effect on the existing UK reactor fleet from the engineering perspective as it features atypical designs. However, the political effects of such an accident are more difficult to predict.

The nuclear debate has an often-bitter history. Despite this, a surprising degree of discourse is possible between opponents and under particular circumstances they may come to respect each other's views.

> "…these inquiries [13] ran for several years, and you were working closely with people whose whole, sort of, role was to try and argue the opposite. But you were working closely with them at a remote site, so you were, you know, you were there both, sort of, living away from home and inevitably talking about things where you would probably w[ ]. And actually we built a high level of trust between people who had different views,…but who didn't, who ended up with a lot of respect for each other. And that respect was really based on the fact that people had integrity."
>
> Nuclear Industry member 3.

Trust is an issue that emerges from the primary data as a significant factor in conditioning risk behaviours and tolerances. Interestingly, actors who may have invested much of their career in opposing nuclear development have found a role and

[13] The interviewee is referring to the public inquiries for Sizewell B and Hinckley C.

a voice in solving its ongoing risk management issues. Clear evidence of this can be found in the membership of the Committee On Radioactive Waste Management (CORWM) [14]. CORWM included a number of eminent anti-nuclear academics, and adopted a robust and deliberative methodology. In so doing, it created a solution to a long term and previously politically intractable nuclear energy problem.

The picture that emerges from the primary data is one in which a complex and dynamic network of actors outputs an interrelated set of decisions on a long-term basis, and in so doing influences the risks represented by nuclear power generation in ways that are not always easy to identify. The decision process itself is often highly interactive between stakeholder groups in the network. The choice that overrides all of the others in the context of this study is whether nuclear generation should form part of the future energy landscape for the United Kingdom at all. Superficially, this is a question for that portion of the network that constitutes the government actors of the legislature and executive. However, the decisions that government actors make form only part of the information that flows through the network. Critically, the establishment of new nuclear plant is dependent on large quantities of risk capital. Noble (2007) has reported a significant appetite for investment in this sector. Moreover, once a plant is in production, refinancing can be undertaken on much more favourable terms. Yet the period of vulnerability between the start of construction and first electricity generation is one in which entrepreneurs are susceptible to political and regulatory risk. Political endorsement is perceived as depending on public perception.

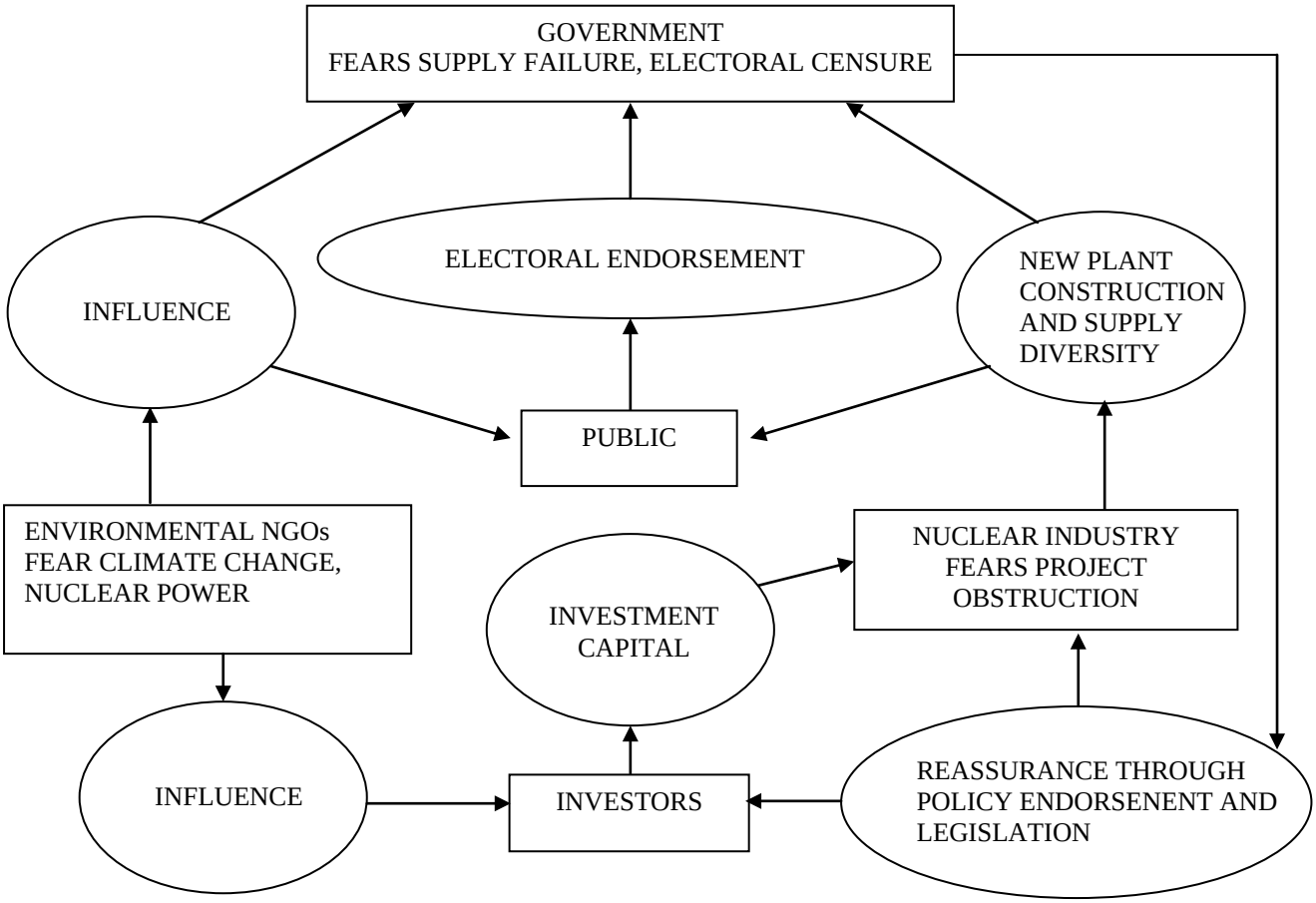
> "Well, I mean I think, y'know, the-, you can do your rational analysis and say, 'Well this is how we ought to weight it up'. Which is all fine. But if the public's not convinced that you're making the right decisions, and the politicians think that those will be vote-losing decisions they won't make them."
>
> Nuclear Industry member 2.

Thus, a set of dependencies exists within the decision network between key stakeholders, and no single stakeholder group can force a choice in isolation. Figure 2 is a simplified depiction of the network nature of this interdependent decision process. The Government wants security of supply but relies on the private sector to provide investment for new nuclear plant and on the general public for electoral endorsement. To build new nuclear plant the nuclear industry needs to attract investment capital,

[14] The term CORWM denotes that committee established specifically to examine aspects of radioactive waste management. The government has planned a second committee of similar name to take the work forward.

and investor confidence in turn depends on government endorsement. Environmental groups oppose new nuclear plant but are limited to influencing other stakeholders including the electorate or potential investors by campaigning or direct action to achieve their aims. Ultimately, the government cannot force companies to build new nuclear plant any more than companies whose business is generating electricity can force investors to fund their activities. Nor can environmental NGOs oblige government or power companies to pursue non-nuclear generation options. Each stakeholder group influences the decisions of other stakeholders and may attempt to persuade them, but the decisions link together in a complex web.

Figure 2: The network nature of the energy risk decision process



Note: rectangular shapes indicate stakeholders while oval shapes indicate the stakeholders' contribution to a dynamic decision process that ultimately influences societal risk.

Much of the academic consideration of the nuclear energy question, including the consideration of risk in relation to power production, has taken the form of comparisons between the likelihood of harms from different energy sources (Cohen;

1983; Fremlin, 1985; Hirschberg et al., 2004). Other literature has examined the failure of measures to address the 'information deficit' in the population as a means of aligning public risk tolerances with those of industry or government (Owens and Driffill, 2006 and sources therein), or considered the application of deliberative processes to aspects of nuclear risk management decisions (Blowers, 2005). However, there has been insufficient attention to a fundamental reason for the intractability of this issue; namely, that *the mitigation measures preferred by some stakeholders for risks associated with power generation are themselves intolerable risks for other stakeholders*. To illustrate this point, the foregoing statement by Alan Johnson emphasises security of supply as a concern. The government views nuclear generation in a diversity of energy sources as mitigation of the risk of supply interruption. However, this mitigation by nuclear power is intolerable to other stakeholders in the decision process, who not only prioritise risk to the natural environment above risk of supply interruption, but may even view an uninterrupted electricity supply as:

> "…providing a standard of living which insulates the public perception from a danger. The very fact that we have all this electricity is the problem not the solution. It prevents the public from imagining they could do without it, or, you know, or what it may cause…"
>
> (Anti-nuclear) campaigner 1.

At the same time, anti-nuclear stakeholders may favour reducing electricity supply and a greater reliance on renewable energy technologies as mitigation for the climate effects that they view as the greatest risk. As renewable sources depend on intermittent natural forces, pro-nuclear stakeholders may perceive them as 'unreliable' and therefore as intolerable risks in themselves.

Thus, the rival preference of risk mitigating measures is the source of stakeholder conflict, rather than an adherence to an energy supply method for its own sake. This study suggests that recognising that phenomenon may be a critical step in addressing the question of informing the decision process as a whole; a point that will now be developed with further reference to the primary data.

Risk perceptions and energy options

Although none of the stakeholder groups involved in the study was entirely monolithic in its views, and some stakeholders held strong and opposing opinions, a number of cross-boundary themes were discernable in the primary data. These themes fall within two general headings – a desire for assurance, and second, related

issues involving the perspective of time. The classification of the primary data themes in this manner fits with the overall model of a decision process conditioned largely by risk. This research concerns itself with such motivations in policy network actors, particularly since the issues raised can extend beyond the domain of matters discussed publicly in political and policy discourse.

The desire for assurance was evident in all of the stakeholder groups, manifesting itself in different ways. A concept raised often during interviews was security of supply, reflecting a concern that interruption of electrical power would engender a loss of civil order and harm to essential services.

> "…So, the first risk is, the first major risk is the risk to society from interruptions in a secure electricity supply. And rightly the government worries a lot about, y'know, what would happen in terms of, society if there were prolonged or frequent interruptions to the electricity supply…you would start seeing public disorder."
>
> Nuclear Industry member 2.

> "…And I think, if you see what happens when electricity fails, when we lose electricity, the veneer of civilisation is fairly thin and it [laughing] sort of breaks down quite quickly. And without electricity, and to a lesser extent I suppose other energy and water and those sorts of things, then you've got a real threat to civil society. So continuity of supply I think it must be right up there."
>
> Nuclear Industry member 6.

> "...As regards other means of generation, there's a que- well, there are risks in terms of security of supply. I think that is, that's, and I know that, that obviously is an import- a very important consideration for government."
>
> Government officer 3.

> "…The most significant risks. Security of supply…Er er yeah. If you just take your security, y'know, we look out in London here and you look down there you'll see some trees and I would just say, "Well, how long do you think those trees would last, if, if we sort of, [coughs], electricity off for a significant period of time? Days?" I don't think it'd be too long in the winter? Before those trees would be getting used as fire wood. And I think, from the point of view of having a sustainable society. Security of supply is a closely, closely linked…"
> "…You don't have sustainability without security of supply."
>
> Government officer 5.

Supply interruption is a clear concern amongst some stakeholders and may be incurred as a result of a number of factors:

> "…Remember energy security is two chunks isn't it? One of which is that the infrastructure's crap, could collapse any minute, and you can't get the stuff around the system, yeah?…And another one is, who are the nice people who are supplying it to you…And then the third one was, even if all those things worked, are there nasty people who want to interrupt the thing? …"
>
> (Former senior) government officer 2.

However supply interruption is caused, a favoured tactic for reducing susceptibility to the associated hazards is to diversify power generation sources:

> "…I think one of the other key issues is to ensure a, the greatest energy mix possible, to enhance our security of supply. And in that respect I'm referring to two areas, a, i.e. the

> greatest mix in terms of energy resources, i.e. fossil fuels we import, so we're not relying on one source, say for example Norway, when currently we're getting gas from Norway through the European inter-connector, through LNG, originating in Qatar and our own North Sea reserves, []t, but, in equal measures have a nuclear or allow the Uranium, as another source to generate electricity…"
>
> Government officer 1.

> "Well… a decent balance between various energy sources. Including the, I think including nuclear. But we need to get a clear policy on what we want, and how we balance that policy correctly to get the reasonable independence of a supply…"
>
> Government officer 4.

> "…OK, and it's not solely nuclear, it's…nuclear as part of a balanced portfolio…OK? Because, you would wish to mix the portfolio to give you the best overall."
>
> Government officer 5.

This view is also evident within the nuclear power industry:

> "…a simple answer is a mix of technologies, over-dependence on a single technology has proven to be, in the past, to result in problems… The broader you spread the technologies, the less l-, less you can be held to ransom or otherwise, fall foul of issues which affect that particular technology. Or source of fuel or, or whatever… So, there is no single technology that you can't postulate a good reason why over-dependence would be highly risky.
>
> Nuclear Industry member 1.

A perception clearly expressed within the primary data is that it is not sufficient to base electricity supply planning on past trends and that unforeseen events must be accommodated. In devising an energy mix, some industry and government respondents were cognisant of the 'unreliability' of renewable generation methods and this clearly informed part of their thinking. Nuclear risks by contrast were reported as 'manageable'. Interviewees within the nuclear power industry cohort also expressed doubt regarding the promise of both fusion technology and carbon capture and storage.

The need for assurance regarding fuel provisioning included comment on the long term consumption of Uranium, and the potential need to use breeder reactors to sustain the supply of fuel. The finiteness of supply was related to the cost of using lower grade ore, to a revised incentive to explore for new Uranium sources, to stockpiling, reprocessing and the possibility of using Thorium as a fuel. It was also noted that the geographical sources of Uranium are distinct from the sources of fossil fuels – a source of reassurance. However, aspects of the longevity of fuel supply were balanced by mention of nuclear waste.

Thus, pro-nuclear actors in the network appear to value an assurance that continuity of supply will be preserved – the associated time perspective of which prioritises the immediate over the long term. However, the adoption of nuclear as a

key element in the mitigation of risks to supply continuity strikes at the heart of risks as perceived in the anti-nuclear stakeholders. While some of them may recognise security of supply as a significant issue, they tended to emphasise consumption, and the need to reduce it both to balance the energy equation, and in turn to reduce the generation of carbon dioxide.

> "First thing you have to do is get demand under control. Smart metering, deman-, interactive demand management techniques… So once you've got your demand under control then you can decide how to match it with supply. I think you should forget the concept of base load, 'cause it's confusing. Base load is just a description of what nuclear plants do. They have to run continuously so you're just, they're always on, so you call that 'base load'."
>
> Energy systems scientist 1.

> "…You've got to reduce demand. Colossally. Not only for our own sordid budgets, energy budget but because that the present demand is intolerable on a planetary basis, an environmental basis. It's unsustainable…"
>
> (Anti-nuclear) campaigner 1.

> "[Laughs]. The first thing is to reduce demand."
>
> (Environmental) campaigner 2.

In fact, far from being a necessity, some viewed reliable supply as a threat.

Seen in this context, the civil energy decision process is less a debate centred on nuclear generation, and more an adversarial contest that divides those whose risk perceptions are led by supply-side energy considerations and those whose risk perceptions focus on the hazards of energy demand. In contrast to the continuity or emphasis placed on the immediate by the pro-nuclear stakeholders, the time related focus of demand-led stakeholders is not continuity and the predictability of the short term but inevitability and the assurance for the long term:

> "...And this is the thing, basically, we have been living in this very pleasant sort of unsustainable system of fossil fuels,…the fact is, is that we are, I would argue that we are just trying to put off the evil day, that we are not willing to bite the bullet ourselves…"
>
> (Environmental) campaigner 2.

> "Only yesterday in our local paper there was some…prediction that the collapse of the Greenland ice shelf and an Antarctic ice shelf too,…the melting of all that ice is far clo- or may be far closer than we think, in which case the rises in sea level are going to be enormously bigger and sooner than we think…And the devastation that would cause, my descendants, would make them scream at the thought that we hadn't reduced our demand in time."
>
> (Anti-nuclear) campaigner 1.

It is noteworthy that climate change as a phenomenon is not doubted by any of the interviewees. Moreover, at least one stakeholder suspected that the process is now unstoppable. However, while one argument in the primary data suggests that unstoppable change enjoins us to prioritise the political problem of security of supply,

another view insists that carbon reduction should be pursued nonetheless. The demand-focussed stakeholders envisage the need for dramatic change:

> "It doesn't really matter…whether we've become uncomfortable, by uncomfortable [or even ?] cold, and whether we are able to have more than one light bulb in a house. These are trifling compared with the alternatives, which are a total breakdown of,…of an environment which is…which is sustainable for us. And, the rest of, of the environment too…"
>
> Anti-nuclear campaigner 1.

> "So I'd say "Yes, you need behavioural change and yes, you need technological change, you need both". And the two can actually reinforce each other, actually."
>
> Energy systems scientist 1.

The technological change referred to here is not simply the development and introduction of renewable technologies in preference to nuclear plant, but a concomitant re-structuring of the Grid to accommodate distributed generation. Clearly, a programme to enforce behavioural change on the electorate in respect of electricity consumption may be an unacceptable political risk to Government, but the elimination of nuclear generation and dependence instead on renewable sources they perceive as 'unreliable' is a mitigation measure that strikes at the heart of supply-led stakeholders' fears regarding the perils of electricity loss.

The concept of 'unreliability' also played a significant role in the thinking of anti-nuclear stakeholders for the majority of whom the risks associated with nuclear generation were far from 'manageable'. For example, concerns over the reliability of information – its probity and provenance – were evident in their thinking. There was an awareness that disagreement existed in the scientific community regarding dose-effect models of radiation. NGO interviewee comments regarding information reliability extended to facts regarding nuclear incidents. For example, an anti-nuclear campaigner [15] observed that expert bodies had connived to withhold information regarding the Chernobyl casualties, while an environmental NGO interviewee [16] noted that a government claim to be able to guarantee the safety of radioactive waste over millennia was absurd.

Anti-nuclear stakeholders expressed a particular concern with security and insurgent attacks on nuclear facilities. This was paralleled by a preference for distributed generation, a system that has inherent resistance to attack and degradation. Interestingly, a nuclear industry respondent also made note of the inherent

[15] (Anti-nuclear) campaigner 1.

[16] Environmental NGO member 1.

vulnerability of a complex system such as the UK. Yet, despite a desire for supply security, the idea of distributed generation did not appear to find much favour within the nuclear industry and government. Moreover, two interviewees noted that government had not taken steps to reduce vulnerability. An energy systems scientist remarked on the UK's lack of a reserve supply of gas, as for example, Germany has; while a former senior civil servant commented on inadequate regulation of the energy market to ensure system resilience.

A desire for assurance in respect to government policy was a broad concern. This took several forms, mostly related to the issue of time. There was a concern within the nuclear industry cohort that despite extant law, there was a lack of long term vision underlying government energy policy, although this might be interpreted within different cohorts as a lack of underpinning for power project sustainability, either nuclear or renewable; an inability to confront climate change as a serious long term problem, or a failure to properly regulate the energy market. Pro-nuclear respondents noted the need for clear policy as a matter of urgency. These interviewees argued that delaying a pro-nuclear choice may result in less than optimal environmental decisions, with more fossil fuel powered plants constructed because they are quicker to certificate. Some pro-nuclear respondents also opined that delaying a pro-nuclear choice could place undesirable pressure on design engineers, whose responsibility to create appropriately safe plant may be placed at odds with the need to complete projects on time. A further element in the desire to be able to plan was associated with having a reliable price for Carbon, although that of course is not solely within the purview of the UK government.

Government response to these wishes for assurance featured in mention of changes to planning law, which restricts the potential for a project to be continuously challenged on the grounds of strategic need once that need has been determined by central government. It was also evident in mention of the Generic Design Assessment process introduced for new reactor plant. However, those opposing nuclear power did not favourably mention such mitigations, for obvious reasons. Moreover, an interviewee who favoured renewable sources noted that support for nuclear research had consumed much of the available funds, thereby restricting it.

The primary data support the inference that energy production as a societal issue cannot be divorced from the complex risk landscape within which it is viewed. It may be, for example, that actor perceptions and preferences regarding the decision

process itself may be as significant as risk management decisions. That is, stakeholders may be prepared to tolerate choices, albeit reluctantly, under circumstances in which they perceive the process to be just. This is entirely different to a perception that actors are resistant to a pro-nuclear choice because they do not understand the degree of safety incorporated into reactor engineering. To some extent, this finding has a resonance with the work of Starr (1969) and Slovic, Fischhoff and Lichtenstein (1981) on the difference between voluntary and imposed risk. The involvement of stakeholders in an open, inclusive and fair decision process gives them part ownership of the outcome. This brings the potential to raise tolerance levels, even though choices may be between undesired alternatives.

In attempting to interpret the primary data from the study, it is helpful to take an overview of the generalised risk perceptions of the interviewees (Table 2). Not all of the actors in the network evidenced strong pro- or anti- nuclear power views. Of the interviewees who were asked to state their views regarding the best means of satisfying the UK's civil power requirements in the foreseeable future, 26% [17] indicated no clear preference for or against nuclear energy. This was because the interviewees favoured the use of a market mechanism, or a mix of generating technologies without being more specific. Moreover, some of the actors may have a regulatory role in which they uphold their independence, although if no timely solution to legacy nuclear waste is implemented, some independents may oppose new nuclear. The remaining 74% consisted of 21% opposing new nuclear power and 53% who were in favour. However, these proportions are largely a function of the necessity to search some parts of the decision network in great detail, and therefore with a larger proportion of interviews. It was clear that the greater majority of network participants who support nuclear power do so in the context of a mix of generation technologies.

[17] These percentages have been rounded to the nearest whole number.

Table 2: Summary of stakeholder risk perceptions concerning electricity generation and nuclear power

RISK ASPECT	PRO-NUCLEAR STAKEHOLDERS	ANTI-NUCLEAR STAKEHOLDERS
PERCEPTION OF RISK AND DECISION-MAKING	Planning barriers arising from a lack of clear government policy. Concern with political disruption to nuclear investment.	Distrust of the science supporting nuclear, patronisation by the establishment, and political agendas.
PERCEPTION OF TIME ASPECTS OF RISK	Concern over supply continuity, delay and problems arising from short-term thinking.	Concern over supply continuity, but greater concern with the far future.
PERCEPTION OF RISK AND LIFESTYLE	Focus on reliable and prolific energy supply as essential to economic prosperity. Fear of social chaos.	Need for lifestyle change to control carbon emissions.
PERCEPTION OF NUCLEAR RISK MANAGEABILITY	Risks manageable. Few historical casualties when compared with other energy sources.	Security concerns. Lack of faith in nuclear technology.
PERCEPTION OF CLIMATE CHANGE AS RISK	Climate change regarded primarily as a source of social disruption.	Climate change regarded primarily as a source of severe harm to the environment.
PERCEPTION OF ENERGY SOURCES AS RISK MITIGATION	Nuclear power part of the mix that mitigates uncertainty and the risk of supply disruption. Renewables an unreliable or economically unproven source.	Nuclear power an unreliable, needless and hazardous distraction. Renewables and lifestyle change an essential mitigation of climate change risk.

Thus, in juxtaposing an aggregation of the views in the primary data, Table 2 does not reveal a stereotypical division between one party in the energy debate that would like to see the UK supplied with electricity rather like France largely by a fleet of reactors, and another party that wishes to see it covered with wind turbines. Instead, the fault line primarily divides those who view nuclear as an essential and manageable tool amongst others in ensuring that the supply is secure, and those who view nuclear as an untrustworthy, hazardous and morally questionable distraction in the struggle to reduce carbon emissions.

Consequently, in attempting to answer the first research question: "*In what manner can the risk perceptions of various stakeholders best be incorporated into choices regarding bulk electrical power sources?"* it is evident that the solution must be *one that addresses the broader spectrum of stakeholder risk concerns and the manner in which they inter-relate*. Not merely the engineering safety and reliability particulars of nuclear (and alternative) technologies, but also the trust in which purveyors of such information are held, disparate weightings on the time horizons to be considered, and the very process by which such controversial issues are decided. Superficially, it might seem that those network members whose views most influence the process cannot all have their risk perceptions incorporated; not so much because they differ on the safety of a single (nuclear) technology, but because of a broader debate in which the very mitigation preferred by those on one side of the fault line is intolerably risky to those on the other, and vice versa. In fact, this broader landscape of risk perception is a source of hope, because there is more to be decided than whether nuclear power in itself is a tolerable risk, and accommodation may therefore be reached.

This begs the question as to which approach to decision-making the network can adopt in order best to accommodate the diversity of weightings actors attach to risks and forge robust, appropriate choices. Specifically, it brings us to the second research question and whether a deliberative model used in regard to radioactive waste management risks should inform new build nuclear power decisions also. To take the discussion from the examination of network actor perceptions underlying the complexity and intransigence of the nuclear power problem to the consideration of a potential solution, the reasons for considering a deliberative approach in preference to other decision methods will first be explored.

Are energy risks too important to be left to politicians and engineers?

One of the themes that characterises the history of power production in the United Kingdom, and the stagnation that has occurred in the nuclear debate that forms a part of that history, is the relationship between risk perception and decision method. From modest beginnings with the first public electric street lighting in 1881 and a central distribution supply plant in 1882 (Biscoe, 2007), the process of development in the electricity supply system has witnessed an inexorable growth and consolidation, with a centralised distribution system and large production plant with increasing capacity (Sheail, 1991). The move towards nationalisation of the system probably

commenced with the findings of the Electric Power Supply Committee in 1915 (Biscoe, 2007), although it reached its zenith under the Central Electricity Generating Board (CEGB), created in the austere period following the Second World War (Biscoe, 2007; Sheail, 1991). The CEGBs ethos, not to mention its statutory authority, emphasized a commitment to reliability of supply above all else (Biscoe, 2007; Sheail, 1991). From the 1930s, the risk of major power cuts had been the overriding priority (Sheail, 1991). The decision process was a largely hierarchical, top-down mechanism against which risk perceptions from non-governmental sources were dashed, and when the great London smog of 1952 destroyed some 4000 lives prematurely (GLA, 2002), and probably many more, the government of the day attributed the extent of the catastrophe to influenza (Bell and Davis, 2001).

Britain's early venture into nuclear power brought the CEGB new options as a producer of primary energy (Sheail, 1991). However, this programme, conceived in an era before Chernobyl and Three Mile Island, would later falter as proposals for additional development fell foul of increasing resistance. By 2003, when governance had a more consultative style, the government had effectively withdrawn its support for civil nuclear power, albeit with the intention to retain the option (DTI, 2003).

In contrast to the hierarchical risk management approach followed for the majority of the history of widespread electricity use in the UK, the end of the 20th Century and early 21st Century saw the adoption of deliberative approaches to specific energy-related decisions. These decisions concerned radioactive waste, and were undertaken by the UK Centre for Economic and Environmental Development (UK CEED) Consensus Conference on Radioactive Waste (UK CEED, 2002), and CORWM (CORWM, 2006). Eschewing "public participation as a supplement to representative democracy", which, as Pratchett (1999) observes is "nothing particularly new", deliberative democracy is a process in which citizen participation in the decision process is an active one (Ryfe, 2005). Deliberative processes may take various forms, from discussion forums to referendums (Smith, 2003). However, their particular strength is to address inherently complex and intractable issues, such as those upon which scientific opinion is divided, and decisions involving values (Blowers, 2005; Goodin, 2003); hence the adoption of deliberative procedures by CORWM (Blowers, 2005) and UK CEED, in an era in which significant policy decisions had to be taken against a background of public intolerance of imposed technical solutions (CORWM, 2006).

As with any aspect of governance, deliberative processes are not without their critics (Ryfe, 2005 and sources therein). Two potential sources of criticism in particular will be addressed here, as they were both alluded to in the primary data. The first concerns the 'information deficit' problem in energy decision-making, while the second source of criticism concerns deliberative processes and their relation to democracy; hence the title of this section.

The 'information deficit' model is one on which government campaigns in the energy and environmental field have been based, and holds that a process of science-based public education will lead to action in line with policy objectives (Owens and Driffill, 2006 and sources therein). Research indicates this view to be flawed, and that providing more information may actually fuel distrust (*ibid*.). A second strand to the 'information deficit' view was evident in the primary data. This held that the public was poor at decision-making involving risk. By implication therefore, such matters should be left to experts. However, while a grasp of the technical aspects is fundamental to identifying solutions, choices concerning nuclear risks involve values as well as scientific concepts, hence the recourse to a deliberative process by CORWM (Blowers, 2005), as well as expert testimony.

The second source of criticism stems from the view that governments are empowered to make decisions, have a responsibility to do so, and need not trouble the electorate with choices related to societal goods. This perception has resonance with concerns that deliberative governance may be anti-democratic. In fact, referenda are a familiar aspect of democracy. What is more, the government delegates policy-making to unelected organisations on a daily basis – witness the duties imposed on such groups as the Monetary Policy Committee and the UK Civil Aviation Authority.

The CORWM experience as a deliberative model for energy choices

Given the complex nature of the relationship between risk perceptions and nuclear power choices described above, previous attempts to apply deliberative approaches to the problem were obvious candidate options to be explored. This prompted the second research question "*To what extent does the deliberative approach adopted to inform the management of radioactive waste represent a model for risk management decision-making associated with new build civil nuclear*

power?" As the most recent undertaking of this kind [18], the project studied the experience of CORWM in order to determine the extent of the suitability of such a process for future nuclear power generation decisions. Of course, it is not suggested that all choices made within the decision network should be subject to a deliberative approach. Many of the decisions made by the regulatory agencies, for example, while they provide opportunities for consultation, have a statutory basis that effectively excludes direct public involvement in issues such as applied safety standards (HASAWA, 1974; HSE, 2006). Nonetheless, public consultation helps to ensure that potential hazards such as pathways for radionuclide escape receive the broadest attention, while the responses to public comment provided by prospective nuclear plant operators, assist regulators in judging the fitness of those organisations to safely manage a new build facility [19]. At time of writing, the government has already announced its intention to permit nuclear new build as part of the mix of generation sources (BERR, 2008b). Nonetheless, critical decisions remain to be taken regarding the location of nuclear waste repository and power generation facilities.

Despite government measures to 'streamline' the planning procedures by restricting legal challenge against plans for 'nationally significant infrastructure', public consultation remains a feature of the planning process for major electricity generating stations (Anon. c, 2009; Planning Act, 2008). Such consultation is required at three stages (Anon. c, 2009). Government must consult for the creation and amendment of national policy statements, the project promoters must consult with local authorities and communities prior to application, and finally, project applicants must consult with local authorities in preparing a statement on how a local community is to be consulted with regard to a project (Anon. c, 2009; Planning Act, 2008). Therefore, opportunities remain for public consultation both at the strategic level regarding national need and at the local level on matters that include where prospective stations are to be located.

While some might object that radioactive waste management and agreeing on locations for new power stations are different problems, two critical factors relate them. First, it is clear from the primary data that network actors associate them as part of the same issue. For example, some actors may insist on the closure of legacy

[18] CORWM was at the point of completing its activities when primary data collection for the Grounded Theory study commenced.

[19] This was a point made evident in the primary data.

waste problems before fully collaborating on new build projects. Second, all major choices relating to civil nuclear power possess a significant moral dimension, irrespective of any engineering or technical dissimilarities. As a consequence of these linkages, future public consultation may benefit from the incorporation of a deliberative approach. The first of these benefits resides in the inclusive nature of deliberative governance. While governments may desire to claim the political legitimacy that comes with consultation, and there may be some question as to what extent, if any, consultation plays in informing a government decision, a deliberative procedure can provide an open forum for interest groups and private citizens to expound and test their concerns. Critically, CORWM undertook its task almost entirely in open sessions that any member of the public could attend. This undermined any suggestion that a conspiracy to return a particular finding was secretly enacted with central government. In addition, it deflated media attention, as secrecy is the fertile soil of news, and committee work tends to be orderly and tedious.

The CORWM process was also notable in pursuing approaches that government tends to follow with limited success. For example, it 'thought the unthinkable'. That is, committee members considered proposals for the disposal of nuclear waste that Whitehall would have ridiculed and dismissed out of hand. Such openness to ideas and thorough care is not merely an advantage in ensuring that no potential solution is overlooked, but also encourages requisite variety in the identification of hazards – a critical aspect of risk management (Weick, 1995, 2001).

Another aspect of CORWM's deliberations that distinguished it from the policy process characteristic of central government is long-term thinking. This is not simply a reference to the fact that a waste solution had to be appropriate for fission products with half lives measured in geological time, but a recognition that CORWM's final choice – deep geological disposal – was informed not so much by arguments based on existing engineering knowledge, but by a practical consideration of the longevity of human institutions and their resulting capacity to exercise stewardship over disposal sites. Such an approach in a decision-forming process would appear beneficial in addressing the many time-related concerns voiced by a variety of interviewees in the primary data, as it offers a route to consistent and sustainable policy.

Of course, no one realistically expects that deliberative policy solutions will bring every individual their preference. Kenneth Arrow (1950, 1951) effectively

dispelled such a notion with work identifying that disparate individual choices could not be aggregated mathematically into a single societal preference without incurring significant injustice to some citizens. Indeed, one criticism of CORWM that was reported in the study holds that it offered just such a solution because of the phased implementation process it proposed. However, a great strength of any well run deliberative process is that it is respectful of its contributors and participants. It does not provoke resistance by patronising, and attempts to build trust despite a diversity of opinion. While compromise may be essential in policy formation, a consensus thus formed brings the promise of being an enduring one.

No decision system is perfect. The CORWM experience identified three potential shortcomings in particular, and any proposal to employ such a system needs to be cognizant of them. All three problems concern the legitimacy of the decision process. The first is that government may be selective in its adoption of the recommendations from a deliberative process [20]. By favouring a proportion or subset of proposals ('cherry-picking'), it may both harm the intellectual intent of the overall decision, and retrospectively ruin the perceived decision legitimacy created during the process [21]. This leads naturally to consideration of the second problem, which is that government behaviour – perhaps the dismissal of all the findings from a deliberative procedure – may bring into disrepute not only itself but deliberative practices in general. The public may infer that a government is willing to entertain ideas in perfect alignment with its own, and simply discard any others as a cynical political ploy.

A third concern that emerges from the primary data is that the legitimacy and value of a deliberative process may be harmed by a lack of engagement by significant stakeholders. This may take the form of stakeholders abandoning a process they perceive as biased or pointless. In this context it should be recalled that Greenpeace withdrew from a consultation process separate to that of CORWM (CORWM, 2006), and held at the behest of the Department of Business and Regulatory Reform (BERR) to consider the future of nuclear power (DTI, 2007; BERR, 2008c). Of course, such a

[20] This was a point made evident in the primary data.

[21] For example, CORWM made a clear recommendation to government to establish a research and development programme focussing on reducing uncertainties surrounding the safety of long term geological disposal and improving means of radioactive waste storage for the 100-150 year period (CORWM, 2006). Should government adopt deep geological disposal without the vigorous pursuit of such a programme, their action may undermine the legitimacy of the CORWM process and compromise attempts to develop partnership arrangements with potential waste site host communities.

decision may bring political risk to the stakeholder abandoning the procedure, as others may perceive the choice as a hallmark of insincerity or mischief. However, a deliberation without key stakeholders is inevitably incomplete, and this raises the issue of resources. NGOs will likely suffer a paucity of wealth and membership by comparison with government departments. They may either not be able to provide personnel to attend a deliberative process, or see government consultation invitations as a deliberate ploy to manufacture credibility, to drain their resources, and divert them from the main task of raising public awareness of their cause. In any event, deliberative processes can be time-consuming, slow and tiring for the participants.

The issue of engagement extends to the composition of the committee charged with the problem under deliberation. Clearly, the process will reflect the skills, both technical and social, of committee members. Careful consideration must therefore be given to the degree to which the group is representative in its experience; able to function as a team, and resolutely led. Although much criticised (Baverstock and Ball, 2005; House of Lords, 2004; Royal Society 2004) the CORWM process was able to drive itself through to consensual findings despite the loss of two members, thereby proving that such a process can withstand turbulence and the dissent inherent in a contentious problem. The same cannot be said of many other decision processes.

It was noted above on the basis of the case study that the manner in which the risk perceptions of various stakeholders could best be incorporated into choices regarding bulk electrical power sources was to adopt an approach that addresses the broader spectrum of stakeholder risk concerns and the manner in which they inter-relate. The hopeful inference from these research findings is that if the *principal* concern of the key actors in a risk-driven decision process is with continuity of supply on the one hand, and with response to climate change and future sustainability on the other (Table 2), then attachment to specific mitigation measures is unlikely to be immutable. Given the acrimonious history of the energy debate and its focus on the *means* of addressing concerns, that is, energy technologies, rather than on the concerns themselves, a deliberative process stands a better chance of bringing the trust, openness and thoroughness needed to achieve compromise than less inclusive decision methodologies.

The deliberative model adopted by CORWM undoubtedly had drawbacks. Nonetheless, its approach encompassed all the attributes necessary to engage the broad spectrum of stakeholder risk concerns. Therefore, in response to the second

research question; "*To what extent does the deliberative approach adopted to inform the management of radioactive waste represent a model for risk management decision-making associated with new build civil nuclear power?"* it is inferred that the CORWM process represents a robust model for nuclear risk management decision-making that incorporates ethical issues. The caveat to this inference is that once undertaken, selective adoption of policy proposals by government may retrospectively undermine the legitimacy of the results.

Conclusions

The issue of whether to include nuclear power as a source of energy in the UK has been a bitterly fought debate, resurrected to prominence by a combination of government commitments to climate change and a projected shortfall in supply as existing plant approaches closure. Although the government has announced its intention to permit nuclear sources as part of the generation mix, investment in new plant may yet be thwarted. Moreover, despite a government intention to 'streamline' the planning process, significant decisions involving the public remain to be made, particularly regarding the location of nuclear facilities.

The primary data indicate that the broader decision process regarding power production is conditioned largely by risk, and enacted by a network of actors. The intractability of the nuclear element of the decision system is largely the result of the risk some network actors associate with mitigating measures preferred by other actors. The risk perceptions of various stakeholders could best be incorporated into choices regarding bulk electrical power sources by adopting an approach that *addresses the broader spectrum of stakeholder risk concerns* and the manner in which they inter-relate. By so doing, the *principal* concerns of the key actors will be addressed, and attachment to specific mitigation measures – power sources - is unlikely to be immutable.

Although views regarding energy supply hazards are extremely varied and bound up in considerations of the natural environment and ethics, actors can develop relationships of trust with others in the risk decision network. *The deliberative approach adopted by CORWM represents a robust model for nuclear risk management decision-making* that incorporates ethical issues; and the transparency, thoroughness and inclusiveness it brings to decision-making could foster the necessary stakeholder trust, enabling the broader spectrum of stakeholder risk concerns to be addressed. However, amongst its shortfalls is the potential for the

legitimacy of the results to be retrospectively harmed by subsequent government action.

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