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Social and Ethical Considerations
of Nuclear Power Development

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ABSTRACT

A new urgency is emerging around nuclear power development and this urgency is accentuated by the post-tsunami events at the Fukushima Daiichi nuclear power plant in Japan. This urgency extends beyond these dramatic events in Japan, however, to many other regions of the world and situations where nuclear power development is receiving renewed attention as an alternative to carbon-based energy sources. As a contribution to the growing public debate about nuclear power development, this paper offers a set of insights into the social and ethical aspects of nuclear power development by drawing from published literature in the humanities and social sciences. We offer insights into public risk perception of nuclear power at individual and national levels, the siting of nuclear waste repositories, the changing policy context for nuclear power development, social movements, and the challenges of risk management at the institutional level. We also pay special attention to the ethical aspects of nuclear power with attention to principles such as means and ends, use value and intrinsic value, private goods and public goods, harm, and equity considerations. Finally, we provide recommendations for institutional design and performance in nuclear power design and management.

Keywords: nuclear power, risk perception, social context, megaprojects, energy production, applied ethics, social values, social movements, complexity, hazards, disaster response

JEL Classification: Q40, Z00

INTRODUCTION

A new urgency is emerging around nuclear power development around the world, and this urgency is accentuated by the post-tsunami events at the Fukushima Daiichi nuclear power plant in Japan. But the urgency extends beyond these dramatic events in Japan to many other regions of the world and situations where nuclear power development is receiving renewed attention as an alternative to carbon-based energy sources. In the debates and discussions around nuclear power development, there is considerable attention to technical questions such as design and cost, but there is also attention to social issues such as public perception, risk assessment, social acceptability, and public accountability. As a contribution to this public discussion, this paper offers a set of insights into the social and ethical considerations related to nuclear power development that are drawn from published literature in the humanities and social sciences.

Sections of this paper were published in a previous report by the Environmental Studies and Research Centre, University of Alberta (Davidson 2010), but this paper offers a more comprehensive summary of this literature and another contribution to this ongoing public dialogue.

Social science understandings of nuclear power and nuclear waste are generally located within the field of risk theory, social risk assessment, and institutional responses to risk evaluation. A basic premise in this literature is that citizens view risks in ways that are different from experts, but instead of being uninformed and irrational, these views turn out to be systematic and rational. In this sense, the views of average citizens (on issues of nuclear power or other risk issues such as smoking or motorcycles) involve a rationality that is consistent but different from expert views of the same risks.

The risk literature also includes the idea of a 'risk society' whereby society is being transformed from one that is organized around the distribution of 'goods' such as wealth and resources to one that is organized around the distribution of 'bads,' or risks such as pollution or crime (Beck 1992, 2009). Moreover, new risks are different from old risks in that many new risks such as climate change or genetic modification are often beyond the scope of a human lifetime or beyond human perception. Because of these fundamental transformations in the risk society, a focus on risk management has become a key concept. Finally, research in this field addresses not only individual views on risk but also views of risk and risk management at the level of institutions and governance. Within this literature, analysis is focused on the ways that risks are managed or mismanaged by agencies and how risk issue management can be improved.

Given this focus on risk theory and risk management, definitions of risk are an important first step in understanding the contribution of social science literature to the question of nuclear

power. Taken from Rohrmann and Renn (2000), risk is "understood as the possibility that human actions, situations or events might lead to consequences that affect aspects of what humans value" (p.14). The idea of human values is central to this definition. Families, communities, future generations, environments, wildlife, and many other dimensions of human value are wrapped up in questions of nuclear power development. Conversely, if human values are not in question, then we are no longer talking about risks and risk management. Because of this link to values, this paper positions risk assessment and management as an ethical deliberation. A key point here is that risks (and nuclear power more specifically) are inseparably linked to what people consider important to themselves and therefore represent a risk issue in broad terms. Experts, in particular, may argue that probabilities of harm are low from nuclear power, but given the link to human values (and ongoing public concern about nuclear power development), risk management will remain at the heart of the debate about nuclear power development for a long time to come. If risk is understood in terms of the Rohrmann and Renn definition above, then decisions about nuclear energy must weigh between competing value sets as they are put at risk by different nuclear choices. In this sense, ethics is a process of determining what is "good" and how we should develop things in order to facilitate more of the good. Institutions and social interaction implicitly make ethical decisions on a constant basis, but doing ethics is to make these decisions more explicitly, carefully, and with fuller awareness of the goods involved in different choices.

Ethics are integral to decision-making and not something done separately. Other considerations – technical issues, economic calculations, possible ecological damage, climate change mitigation, risk assessments and so on – are pieces of information that feed into the decision-making about nuclear power. But the decisions cannot be made on technical information alone. Decisions depend on what various actors consider to be "the good" and what value they attach to each of the pieces of information. For example, cost-benefit analyses (which are often calculated in monetary terms) do not automatically decide a matter. If we accept that higher dollar figures on the benefit side show us which decisions to make, an ethical decision about what constitutes "the good" has first been made: the good is that which makes or saves more money. This ethical decision also assumes that all goods and bads can be measured on the single metric of money.

In keeping with this desire for a more information-rich and transparent context for making ethical decisions about nuclear power, this paper offers a strategic literature review on risk perception, nuclear waste management, the emerging policy debates, the institutional dimensions of risk issue management and then concludes with a discussion of applied ethics as relevant to social decision-making. We do not offer an exhaustive literature review, but one that is focused on several relevant risk issues and one that draws on seminal scholarship and key ideas. Also, as a contribution to the debate about nuclear power development in Canada

and around the world, personal commentaries, editorial views and consideration of past or current events is minimized. Instead, readers are invited to reflect on this literature as a way of understanding the social dimensions of nuclear power within any given context.

SOCIAL SCIENCE AND NUCLEAR POWER

PUBLIC VIEWS ON NUCLEAR POWER

Citizens view nuclear power relative to many facets of their lives and things they value, and base their perceptions on these dimensions rather than scientific or technical information. Seminal research on public perceptions of nuclear power has been conducted by Paul Slovic and colleagues over the past 30 years. In a key article from 1987, Slovic takes survey data from different lay members of the public as well as a group with expertise in risk assessment and describes the systematic differences in risk perception between these groups. A major finding from this study is the systematic way in which risk activities were ranked by these different groups and the striking difference between lay risk perception and expert risk perception. Table 1 indicates that nuclear power is ranked by the lay groups as a highly risky technology whereas experts ranked nuclear power in the bottom tier of risks (20th of a total of 30 risk activities or technologies).

Unlike many other risky technologies or activities identified within this study, Slovic notes that nuclear power is a unique type of risk within the public's imagination, occupying a polarized set of perceptions relative to other types of risks. This position – the dramatic difference between lay perception and expert perception of risk from nuclear power in particular – has resulted in considerable discussion about the originating drivers or determinants of this difference. Slovic's key argument is that lay risk perceptions are often different from expert risk perceptions because lay understandings of risk are often more textured, drawing more than narrower technical determinations of risk.

Table 1. Ordering of perceived risks from activities and technologies. Source: Slovic (1987).

Activity or Technology	League of Women Voters	Active College Students	Club Members	Experts
Nuclear power	1	1	8	20
Motor vehicles	2	5	3	1
Handguns	3	2	1	4
Smoking	4	3	4	2
Motorcycles	5	6	2	6
Alcoholic Beverages	6	7	5	3
General (private) aviation	7	15	11	12
Police work	8	8	7	17
Pesticides	9	4	15	8
Surgery	10	11	9	5
Fire fighting	11	10	6	18

As an example, when experts are asked to judge risks, they often refer to technical estimates such as annual death rates or morbidity to judge one risky technology versus another. When lay people are asked to judge risks by estimating annual fatalities, their judgments are often in line with expert judgments. Normally, however, when lay people are asked to judge risks they do so by drawing attention to a broader set of concerns. When risks are judged to be high, it is often because "these risks are unknown, dreadful, uncontrollable, inequitable, catastrophic and likely to affect future generation" (Slovic 1987, p. 236). Such key dimensions of risk judgment discerned in this study (and in other similar studies) show that lay people are not in fact irrational, uninformed or overly emotional about certain types of risk, but are acting upon fairly predictable patterns of judgment that are based on certain aspects of a given risk concern relative to what they value. Whereas technical experts base their judgments on probabilities of harm or estimates of annual fatalities, lay people base their judgments on a sense that the risks threaten things they value, such as future generations, stability, or the capacity to control technology. Norgaard (2011) highlights a similar need for what she calls "ontological security" relative to climate change. Aspects of dread and unknowability, in particular, have led some researchers to concluded with some force that public risk perception regarding radioactive materials and nuclear power more generally should be understood as a kind of "risk DNA" – or internalized response – that should be treated like any other "essential fact" of nuclear power development. For instance, Erikson and colleagues state that:

> The ability to evoke dread in human beings must be counted as one of the key properties of radioactive wastes, not just a passing fact about human life. . . . Not to know that essential fact about nuclear wastes is like not knowing their half-lives, their thermal qualities, or any of their other physical and chemical characteristics (Erikson et al. 1994, p. 91).

Such factors as dread and unknowability and preferences for stability and controllability contribute to public understandings of risk and how the public is likely to respond to a risk issue such as nuclear power.

In addition to these key dimensions of risk perception identified by Slovic and his colleagues, researchers have discovered other factors that shape risk perception as well. For instance, in a systematic review of 36 existing studies that measured gender differences in concern regarding nuclear power, all studies showed that women were more concerned than men about these issues (Freudenburg and Davidson 2007, p. 216). The reasons for this difference are not necessarily because of greater aversion to risk amongst females nor even the special effects that radiation has on childbearing and women's bodies such as the concentration of toxins in fatty tissues and breast tissue and milk. It is likely related also to the social creation of women's

role as linked to the well-being of future generations and its relationship to ecological citizenship (MacGregor 2006).

Another aspect of risk perception discussed by researchers is that of "political anchoring." In one study, the researchers noted that risk perception of nuclear power is often aligned, or "anchored", with political affiliation or political ideology (Costa-Font et al. 2008) irrespective of knowledge of nuclear power. Using survey data from a 2005 Eurobarometer of UK citizens, results show that views about nuclear power are driven by an instinctive political position that is often deeply held by citizens. Citizens with more left leaning views are more likely to hold that nuclear power is a highly risky technology as compared to those with moderate or right leaning political views.

Research on political anchoring is consistent with other studies and it offers an important perspective on the relationship between risk communication and risk perception. Against the common view that risk perception is largely an artifact of media attention or relatively uninformed or emotional public reactions, the social science literature consistently shows that knowledge – such as scientific information or industry information – has no consistent effect on risk perceptions. In fact in some instances, general knowledge of nuclear power can actually decrease support for nuclear power (Costa-Font et al. 2008). Summarizing such findings, Slovic and colleagues state that "attitudes toward nuclear power are conditioned by the interplay of psychological, social, cultural, historical, and political factors that will not easily be changed by public information or educational campaigns" (Slovic et al 2000, p. 98). Based on these findings, it is likely the case that perceptions of risk from nuclear power development will vary considerably by the general political orientation of a jurisdiction (e.g., progressive or conservative).

Perhaps even more importantly, social trust is consistently observed to be influential. Trust is relevant at several levels of social interaction. Trust is an important component of individual relationship and in relation to actors who are involved in the regulation of risky technologies. Where these actors are considered to be untrustworthy, then risk perception is elevated. However, the average citizen is not in a position to form a well-informed opinion regarding the trustworthiness of individual actors. In contemporary society, citizens increasingly rely on impersonal relationships with socially distant actors and agencies that are charged with the responsibility to protect citizens from harm. In a world of complex technological developments and the specialization of individual skills and abilities, we commonly find ourselves in highly trusting relationships with individuals and institutions that are distant and often impersonal. Basic levels of trust are required in order for mundane but risky activities to be undertaken and technologies to be utilized. For example, air transportation requires trusting relationships in pilots who fly us from Edmonton to Toronto, and in the trainers and credentialling agencies that

certify pilots, and in the many people performing roles essential to the safe operation of airflight. In the same way, the Atomic Energy Board of Canada, politicians, the nuclear industry and other actors are in relationships that rely on citizen trust, and when trust is eroded or absent, then public perspectives on the risks of nuclear power are impacted accordingly.

Given the ways in which citizens are placed in trusting relationships with actors and regulators of risky technologies, it is no surprise that research finds a strong and consistent relationship between levels of risk perception and levels of trust in institutions, information, individuals or other objects of trust (Whitefield et al. 2009). Trust is destroyed quickly in situations where the appearance of secrecy or the desire to exclude publics is evident within the regulatory context (Freudenburg 2004). Moreover, as indicated below, trust has become an increasingly important aspect of contemporary society when at the same time trust is also challenging to maintain and relatively easy to destroy.

> The reliance of the technological society on trustful relationships between and among its subsystems has never been stronger than today. However, such a need for trust makes people more and more sensitive towards situations in which their investment of trust has been factually or allegedly misguided. The more trust is needed for implementing cooperative efforts or for coping with external effects of social actions, the more cautious people are in assigning credibility to those whom they are supposed to trust (Rohrmann and Renn 2000, p. 32).

Based on these insights, it is difficult to overstate the importance of trust in relation to risk perception. Where citizens judge the regulators and actors involved in nuclear power to be trustworthy, risk perception is likely to be lower. Conversely, where trusting relationships have been compromised, either by a history of regulatory failure, a sketchy industrial track record or by other challenges to trustworthiness, then the public is likely to judge nuclear power to be a more risky endeavour.

A final area of interest regarding public views of risk involves the concept of stigma. As it relates to nuclear power development, this concept is arguably less well defined in comparison to the concept of trust, but there is recognition – particularly in the literature on the siting of nuclear waste disposal repositories – that stigma is a significant factor in community opposition to waste materials. In this context, stigma involves a general sense that by association with a particular technology the community is given a negative public image and may be shunned in certain circles. Citizens value the positive image of their community and stigma places this image at risk. Freudenburg (2004) indicates that as early as the 1980s stigma was noted as one of the “special effects” in the socio-economic assessment of nuclear waste disposal. Other effects included controversy and considerable polarization within the proposed host

community. More recent research from Europe and the UK also indicates that stigma is a strong factor in community response to nuclear issues (Sjoberg and Drottz-Sjoberg 2001; Poortinga et al. 2006).

In summary, the social science literature on nuclear power is focused on understanding the differences between technical risk assessment and social risk assessment. The risk perceptions of experts are often quite different from average citizens and these differences are normally attributed to one or more of the following risk factors:

- Knowability
- Dread
- Controllability
- Equity
- Catastrophic potential
- Trust in risk managers and information
- Political alignment / ideology
- Gender
- Potential for stigma

Clearly, risk perception relies on other factors than merely technical and physical probabilities of harm. Although risk perception of nuclear power among average citizens is often higher than that of experts, the social science literature is less interested in the distinction between real risk and perceived risk, and is more interested in understanding the factors that contribute to risk perception (within expert and lay communities). Although the physical risk of nuclear leaks or other accidents may be extremely low, these physical risks are just one (small) factor that contributes to the risk evaluation of citizens. Therefore, social decision-making about nuclear power requires attending to many social factors and not merely the probabilistic or technical dimensions of risk assessment.

COUNTRY LEVEL STUDIES

In addition to individual risk perception as discussed in the section above, some researchers have focused on the differences between countries and their approaches to nuclear power. In this analysis, the focus of attention is on historical understandings of energy development and the interaction between nuclear power proponents, political decision making and industry regulation. Within Europe, Germany is currently involved in dismantling its nuclear power program in favour of alternative energy technologies. In contrast, France has a long history of nuclear power development and a French public that is largely favourable toward this energy policy.

The situation in France is of particular interest, in part, because of the long history of nuclear power development since the 1950s. The nuclear industry in France continues to enjoy strong support in contrast to several other countries in Europe that have taken a very different position on development of the industry. According to one analysis, part of the reason for this unique French position has to do with more than a desire for energy independence; it is based in a more trusting relationship between citizens and regulators.

> The French saw greater need for nuclear power, had greater trust in scientists, industry and government officials, were more likely to believe that decision-making authority should reside with the experts and government authorities, rather than with the people (Slovic et al. 2000, p. 57).

Within the North American context, desire for energy independence is commonly shared with the French, but this is likely where the similarities end. Within the United States in particular, there is strong opposition to nuclear power (Rosa and Dunlap 1994). Accompanying this opposition is considerable pressure to open up the regulatory process to much more public scrutiny than is the case in France. Publics consistently register a higher level of mistrust toward expertise as well as government institutions that are associated with the nuclear industry. Reasons for these differences are complex and often difficult to understand, but part of the answer involves different democratic cultures as well as a strong historical link – particularly in the United States – between nuclear power development and the military industrial complex. Whitefield and colleagues note this history in a recent study of U.S. views on nuclear power.

> If you accept nuclear power plants, you also accept a technoscientific-industrial-military elite. Without these people in charge, you could not have nuclear power. Historically, therefore, risk was not the only factor driving opposition to nuclear power for many citizens in those early days, and this still appears to be of considerable importance now (Whitefield et al. 2009, p. 434).

These country level studies are important because they provide a broader view of public perception, with attention to historical developments in nuclear power, linkages to other values such as energy independence, and attention to important social and institutional dimensions of nuclear power development that extend well beyond individual-level risk behavior. Government decisions to promote or dismantle a nuclear power industry are closely connected to energy demands and alternatives but also to the capacity of regulators to interact in constructive ways with domestic and international publics. Results from these country level studies show that building support for or against nuclear power requires careful attention to the design of regulatory institutions that are consistent with the dominant democratic culture. Institutional design is address in some detail in a later section of this report.

SITING NUCLEAR WASTE REPOSITORIES

In the public's mind there is a close linkage between nuclear power generation and nuclear waste management. Social science understandings of risk perception demonstrate the two issues are influenced by similar social processes as identified in the section above. Uncertainty, unknowability, and trust are associated with long-term storage, and these dimensions of risk tend to heighten risk perception. In addition, because of impacts on future generations, moral concerns about long-terms storage are highlighted.

There is evidence from countries such as Sweden that some communities are more receptive to nuclear waste repositories (Sjoberg 2004), particularly when they are able to see clear benefits for the community, have higher levels of trust in project proponents, and come to understand that their community is a suitable location for such a project. Notwithstanding these more receptive communities, a majority of siting efforts are charged with conflict, uncertainty, and feverish opposition to such developments, conflicts which can be viewed as value conflicts and not only disagreements over socio-technical details. Local opposition to nuclear power generation and waste repositories are commonly described by project proponents as a Not-In-My-Back-Yard (NIMBY) scenario (i.e., local opponents come to selfishly enjoy the benefits of power generation while allowing others to suffer the risks of such activity). Although there is some evidence that such NIMBY type behavior is present in some cases, researchers have repeatedly identified that NIMBY may not be at the heart of such opposition in many cases.

Survey data described by Sjoberg and Drottz-Sjoberg (2001) shows that only 12% of respondents were deemed to be demonstrating entirely NIMBY-like behaviour. In contrast, the vast majority demonstrated that opposition was based on the belief that nuclear power was not beneficial individually or for the country. Therefore the strict criteria for NIMBY behaviour was not met. In contrast, concerns were mostly expressed in terms of the health of others and the stigma of their community.

These authors conclude that local opposition to nuclear waste repositories may often be conflictual and highly emotional, but opposition cannot accurately be described as irrational. Rather, there is evidence that clear concerns are expressed about the risks and uncertainties regarding long-term storage and these concerns require careful consideration and appropriate policy responses.

> Opposition to siting is neither uninformed nor overly emotional. The present data show that people's risk attitudes were most affected by their perception of the fate of the community they lived in – either the health of people living there or the stigma that they believed a repository might bring about. There is nothing

> irrational about this, but waste facilities must of course be placed somewhere (Sjoberg and Drottz-Sjoberg 2001, p. 87).

These same sentiments are expressed by Kuhn (1998) who is also sensitive to the idea that local opposition is often more than just an emotional reaction against the siting of unwanted land uses. Rather, Kuhn observes a more cogent reaction by local residents to evidence of poor performance on behalf of the nuclear industry.

> To interpret these results as merely NIMBY-type responses misses the larger and more salient issue of the production of these wastes in the first place, and the checkered history of the nuclear industry worldwide in dealing with containment and safety (Kuhn 1998, p. 24).

Finally, it is important to note in this section the history of environmental impact assessment (EIA) and the subcomponent of socio-economic assessment as it relates to the siting of nuclear waste facilities. Particularly within the United States, where social impact assessment has a longer history within the regulatory context, efforts to undertake socio-economic assessment have been highly technical in character. Data on social and economic status, indicators, and scientific models are utilized to feed socio-economic information into the larger planning process. When social issues did not fit nicely into this technical model, such as findings on stigma or public controversy, they are labeled as being non-credible (Freudenburg 2004). These issues are then described as "special impacts" and were often not counted in the official account of socio-economic impacts.

Freudenburg notes in his review of the U.S. experience with nuclear waste repositories, that "the intensity of opposition is a function of three sets of actors: the nature of the nuclear materials involved, the nature of the community or region selected as a disposal site, and the way in which the siting process is carried out" (2004, p. 164). In the last section of this paper, we describe in more detail these characteristics as elements of distributional and participatory equity.

Such points about the siting process are important because they suggest that for environmental assessment to be comprehensive and to provide meaningful information to decision makers the process must move past purely technical advice. Specifically, when decisions are made that affect deeply held values such as intergenerational equity and fair distribution of risks and benefits there is no advantage to purely scientific and technical training in making these decisions. In fact, what tends to happen is an effort to systematic exclude values from the technical questions of nuclear waste management and then only a partial view of policy alternatives is explored (Sheng 2005). These efforts to segregate facts and values are a recipe for regulatory failure and Freudenburg notes that

> There is growing evidence that the naïve hope for a selection process that is 'strictly scientific' may have an unfortunate if unforeseen consequence; it may be placing on the institutions of science and technology a burden that they are simply unable to support (2004, p. 166).

Consistent with Kuhn (1998) and others, siting processes that solely rely on technical information are not likely to succeed. Instead, a comprehensive dialogue regarding the value and utility of nuclear energy development in concert with discussions regarding how and where nuclear waste will be located is likely to be a more successful public policy approach.

CHANGING POLICY CONTEXT FOR NUCLEAR POWER

> What is new in recent debates is the explicit reframing of nuclear power in terms of both security of supply and as a part of the means for tackling climate change (Pidgeon et al. 2008, p.70).

The policy context for nuclear power development has a long and challenging history. In chronicling some of this history, Pidgeon et al. (2008) note some of the overoptimistic claims of industry promoters in the 1970s and 1980s, followed by the major accidents such as the fire at Windscale in the UK, Three Mile Island in the United States and Chernobyl in the Soviet Union. After these major events and the world-wide attention they garnered, a series of smaller scale environmental concerns began to emerge. These concerns were most acute in the siting processes for nuclear waste repositories and many communities resisted the stigma associated with such siting processes. Finally, from the public's point of view, there has been a consistent stream of concern arising from these historical factors and a growing mistrust of regulators and industry proponents who are seen to be less than responsible in their actions (Wynne 1992; Rosa and Clark 1999).

Within the Canadian context more specifically, Mehta (2005) chronicles the local opposition in 1994 to the relicensing of the Pickering Nuclear Generation Station. Part of this story involves the activities of Durham Nuclear Awareness (DNA) of Oshawa that marshaled local opposition to the relicensing process. The activities of DNA dovetailed with broader nuclear protest campaigns at the national level and exemplify the classic confrontation between technical regulatory processes and public social concern.

Given this recent history of challenge and conflict in the nuclear industry we might share Mehta's conclusions in 2005 that "nuclear power in Canada began a downward spiral [in the 1990s] from which it is unlikely to recover" (p.115). Despite this grave prediction, however, in 2011 the new story of nuclear power is quite different than earlier analysts anticipated. In several countries around the world, the option of nuclear power development has become a

serious policy alternative because of the challenges of climate change. Nuclear power offers an apparent technological response for energy policy in a lower carbon future, and now draws attention from governments and some environmental organizations.

In the post-Kyoto world of climate change, the energy policy community is focused on new priorities such as reliability of energy supply and low carbon footprints. In the debates about new energy development, citizens are often faced with a trade-off between two leading alternatives, such as coal (high carbon, plentiful) versus nuclear (low carbon, radiation risks). In regions like Alberta, Canada, this debate is particularly salient given the heavy dependence of coal fired electrical generators and the prospects of shifting some future demand for energy away from coal.

In the United Kingdom, a large scale survey conducted in 2005 addressed precisely this question of nuclear energy development, climate change and energy policy (Poortinga et al. 2006; Pidgeon et al. 2008). In this survey, the public was asked about their views on nuclear power. Like other studies, the survey registered highly negative connotations for nuclear power and radioactive waste. An interesting twist in this survey, however, is how public views on nuclear power tend to change when set against the challenges of climate change. According to this research, "pursuing the nuclear option was judged by many in the group as the lesser of two evils…This discourse, of what we have termed a 'reluctant acceptance' was a common response… (Poortinga et al. 2006, p. 2).

Moreover, the vast majority of respondents preferred to reframe the debate away from a simplistic question of coal versus nuclear, toward a more complex understanding of energy policy alternatives. Figure 1 below emphasizes this point by demonstrating the popularity of alternative energy sources such as solar, wind, and hydro-electric power generation in contrast to the more distant enthusiasm for non-renewable energy sources.

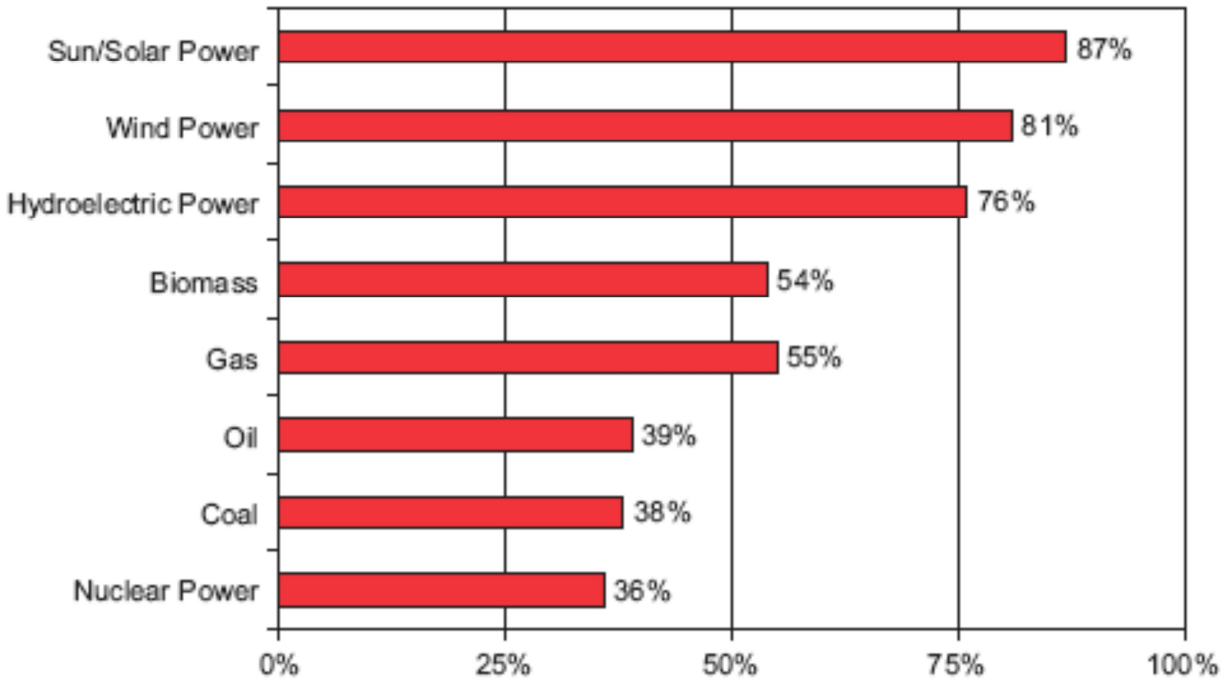

Figure 1. Public opinion on energy sources; summary of response to the question "How favourable or unfavourable are your overall opinions or impressions of the following energy sources for producing electricity currently?" Source: Pidgeon et al. 2008.

Based on these results, the authors conclude that

> The consistent message from the combined data in this survey is that while higher numbers of people are, as predicted, prepared to accept nuclear power if this is framed simply as a contribution to climate change mitigation, very few would actively prefer this as an option over renewable sources of energy efficiency if given the choice (Pidgeon et al. 2008, p. 81).

Results from this survey in the UK are important because they show how nuclear power begins to take on a more favourable picture in the public's imagination when it is perceived to contribute significantly to climate change mitigation. This favourable status appears to be fragile however. If for some reason this connection between nuclear and carbon reduction would be challenged or begins to unravel, it is likely that the current boost in public response to nuclear power would be short-lived. Moreover, in spite of favourable responses to nuclear power as a tool for carbon reduction, publics in the UK continue to call for more attention to the development of renewable energy alternatives.

Consistent with this public appetite for renewable resource development, research in policy sciences also indicates some support for a broader debate about the most sustainable

alternatives for energy development. The work of Sovacool (2007) is particularly relevant because he challenges the conventional view of energy policy in North America as a dichotomous choice between coal or nuclear. As an analytical framework, Sovacool develops a five part criteria to evaluate the sustainability of American energy policy. These criteria include:

- Technical feasibility – commercially developed and available to enter the energy market
- Costs – whether their use would increase or decrease electricity prices
- Negative externalities – impact on human health and environment
- Reliability – dependable for generating and delivering electricity
- Security – how safe and immune such technologies are from attack or accident (Sovacool 2007, p. 102).

Based on this evaluation criteria, it is possible to show that the best alternatives to reduce carbon emissions may well be clean coal and nuclear power, but when this broader set of sustainability criteria are applied, it turns out that other technologies are more sustainable in the long run. These technologies are threefold: (1) energy efficient practices that reduce energy demand and consumption, (2) renewable energy systems such as wind, water, biomass, and geothermal, and (3) small-scale distributed generation technologies where energy is produced in closer proximity to where it is consumed (Sovacool 2007).

The extent to which such energy alternatives are thought to be fanciful or even dangerous is a testament to the ways in which public debate regarding the range of energy alternatives is highly constrained and focused on the status quo. In other words, to back away from conventional approaches to energy development requires the relinquishing of capital assets (sunk costs) and long planning horizons. These investments have an inertia that is difficult to overcome so that an effective public policy process will require considerable new and sustained effort and imagination to develop alternatives along the lines of Sovacool's proposal.

In summary, this section offers several insights into the changing policy context for nuclear power development. In contrast to previous decades when the prospects for further nuclear power in North America were minimal, emerging concern about conventional energy supply and green-house gases in particular have given the industry a new sense opportunity. This opportunity comes with some caveats, however, in terms of public support that is closely linked to the need for reductions in carbon-based energy sources. This shifting policy context is also influences by other interests and opportunities such as energy efficiency, renewable energy systems, and distributed power systems.

SOCIAL CHANGE AND PUBLIC ENGAGEMENT

Policy makers and industry players are instrumental in shaping the nuclear debate. But groups within civil society are also important contributors to this debate in a variety of ways. Social

scientists often refer to these civil society organizations in terms of social movements. The idea of a social movement is defined as a form of group action or collective action that emerges in order to effect social change. Social movements are more than political actors. Traditionally, social movements were understood to be concerned with economic or material issues that affect a certain group of people. For instance, labour unions are studied as a social movement intended to organize pressure on governments and industries for improved material conditions (such as employment and working conditions) in exchange for labour.

More recently, researchers have identified that many social movements that focus less on material or economic issues and spend more of their time developing policies and new ways of thinking and acting on issues such as world peace and environmental stewardship. Eyerman and Jamison (1991) have suggested that a distinction between social movements and "mere" pressure groups is that social movements engage in "cognitive praxis" with members and the public. By this term, the authors mean "producers of knowledge," that is, alternatives in thought that are put into practice. In a related way, some scholars believe the proliferation of new social movements in recent decades is based on an emerging set of human values, particularly in western societies that are oriented around a post-industrial economy. Citizen attention oriented toward concerns such as securing needs, financial survival and the distribution of wealth appears to have declined relative to "post-material" values and interests such as lifestyle, collective identity, and respect for human and ecological diversity (Inglehart 1995).

One of the most widely accepted theories in the field of environmental sociology is based on this transformation of human values away from what is described as the Human Exceptionalism Paradigm toward a New Ecological Paradigm (Catton and Dunlap 1978). Notions of human exceptionalism have to do with beliefs about the ways that humans are somehow above nature and in a relationship of control and domination over natural processes. Consistent with the transition toward post-industrial values, the new ecological paradigm understands humans as less exceptional and necessarily embedded in and interdependent with natural processes. Nevertheless, contemporary society finds itself caught in a flux position between the old and the new in thought, behaviour, values, infrastructure and institutions.

Gaining some understanding of these subtle processes of change in human values is important because it helps to explain some of the precipitating factors for the emergence of social movements and collective opposition to nuclear power in particular. In surveys that explore this phenomena of fundamental change in human values, research from Dunlap finds a strong inclination toward new ecological thinking where citizens from many countries increasingly express post-industrial values and see themselves as being interconnected and interdependent with the natural world (Dunlap et al. 2000).

Opposition to nuclear power in California during the 1960s and 1970s showed a similar pattern of changing values among California citizens who stopped the development of nuclear power in the state (Wellock 1998). Contrary to previous interpretations of the California situation that downplays the role of local social movements, Wellock argues that local groups were effective in part because of their ability to marshal new social values against the industry. "Values reached into the scientific community, changed views, and remade the terms of the debate" (Broadbent 1999, p.717). These post-industrial values coupled with populist movements and emerging concerns within the scientific community, serving to undermine faith in the industry during that period of time.

Although this period of California history is now well behind us, it is not a unique story or an old story. Public concern about the safety of nuclear power and the social movements that form around these concerns continue to influence public policy and limit the development of nuclear power in many parts of the world. A fictional account of a nuclear accident that takes place in the Czech Republic, near the Austria border was the subject of a recent film produced in Austria called *The First Day*. The release of this film sparked a diplomatic incident between Austria and the Czech Republic and reminded European policy makers and industry leaders of the ongoing fear among citizens about the safety of nuclear facilities and the international dimensions of this debate (The Economist, March 19, 2009).

Another recent book – by Ulrich Beck, a leading social theorist on the risk society – documents a social movement conflict in Bulgaria between a local environmental organization and its European partners, and their capacity to effectively shut down a multibillion dollar nuclear development proposal.

> The pressure exerted by a small Westphalian environmental group is jeopardizing a multibillion dollar nuclear generation project in Bulgaria. Banks pulled out the deal. Justification offered was the "high reputation risk" that forced the banks on to the defensive. Allegedly this had nothing to do with the evaluation of the project, even from an environmental point of view. The measure was solely due to the protests of the group Urgewalk, Ausgestrahlt and its European partners… The powerbrokers of global capitalism, the banks, gave in without a murmur (Beck 2009, p.2).

Research on social movements offers an important reminder about the power of civil society to affect change in public policy and plans for industrial development. This may happen in ways that are not often anticipated, especially when dealing with technologies and activities that are consistently perceived by the public to be risky, and where stakes are high. Social movement organizations have repeatedly proven to be effective in marshalling opposition to nuclear power development. Simultaneously, they have been incubators of new values and innovators

of institutional and individual practice that have become more legitimate as they are taken up by the general public.

INSTITUTIONAL FAILURE AND MEGAPROJECTS

Another area where sociology has made a significant contribution to issues of nuclear power development (and the management of risky technologies and activities in general) has to do with institutional risk management. This work is distinct from previously discussed work by Slovic and others in that the unit of analysis is changed from the individual to the institution. Institutions develop collective practices or organizational cultures that can impede perfect functioning. Acknowledging such conditions are essential in assessing nuclear risks and megaprojects.

Seminal research in this field was published by Charles Perrow (1984) in his book called *Normal Accidents: Living with High-Risk Technologies*. Perrow suggests that no matter how effective conventional safety efforts may be, some accidents are inevitable – and therefore normal. These so-called normal accidents are related to the complexity and the interconnectedness of processes (including human technicians) within a system. Certain kinds of systems that are highly complex and tightly coupled are prone to these kinds of so-called normal accidents and accidents are likely to be a matter of routine in these kinds of systems. He singles out nuclear power plants for specific attention and suggests that accidents like Three Mile Island are inevitable and, given enough time, will happen as a matter of course.

Almost 30 years have passed since Perrow's work was completed. The strength of his original claim has lost some of its grip in part because his expectation of significant accidents in the nuclear industry has not come to fruition. Yet there are signs that limited exposures, leaks, and spills are a somewhat routine aspect of the nuclear industry and incidents such as Chernobyl and Fukushima demonstrate that the explosive danger of a complex system failure is possible.

More significantly, however, some core ideas from Perrow have regained traction in recent years among prominent scholars. The idea that features of a technological system such as tight coupling and complexity are endemic to risky technologies is more widely accepted today than was the case when Perrow first introduced these concepts. As an example, the Canadian scholar Thomas Homer-Dixon (2007) refers to tight coupling as an important aspect of complex systems and technologies within a contemporary social context. In his book on catastrophe, creativity and renewal, he draws on Perrow's original work to identify the ways that systems such as stock markets, urban road networks, or electrical grids have feedbacks and a kind of interconnectivity that make them behave in ways that are not entirely expected or predictable (see Murphy 2004, for more detail on this point). These non-linear responses mean that small-scale disturbances in the system can result in much larger effects or disproportionately large

disturbances across the system. This research speaks to the challenges of managing complex technological systems – not simply because of the potential for human error or gross negligence but because of the ways in which system design alone can behave or react in ways that are well beyond the normal or the controllable.

In related literature on institutional response to disaster, scholars point to the ways in which the interconnections between industrial actors, regulators, and technologies can lead to surprising outcomes. Research by Clarke (1993), for instance, describes how institutions can repeatedly and systematical lose sight of the most risky aspects of their management and regulatory responsibilities. In hindsight (after an event takes place), some of these risks become painfully obvious and a lack of preparation for worst case scenarios appears grossly negligent. Clarke explains this lack of preparedness in terms of a disqualification heuristic where experts and decision makers can systematically disqualify or disregard information that contradicts a particular conviction or belief about how things ought to work. Clarke uses the example of the Exxon Valdez disaster to address "an under-appreciated problem in risk perception" (1993, p. 290). He suggests that the mechanisms of information disqualification can lead organizations to be systematically stupid – a mindset that allows institutions to keep the system moving and to narrow the range of alternatives even when large-scale catastrophe is a distinct possibility. This mindset comes in part from relatively circumscribed fields of knowledge within a decision making arena. Similarly, a close relationship with regulators can weaken oversight that would otherwise contest disqualification heuristics. Research on the underlying causes of the space shuttle Columbia disaster also deals with similar issues of information management and narrow decision making procedures (Vaughan 2006).

Adding to his earlier assessment of the disqualification heuristics that played into the Exxon Valdez disaster, Clarke (1999) develops a broad critique of the ways in which governments and corporations plan for accidents and disasters. He describes these planning processes as deeply flawed. As an example of these flaws, disaster response plan for the Exxon Valdez included no scenarios to respond effectively to the realistic scale or weather conditions under which this disaster took place. Therefore, even beyond planning flaws and unanticipated risks, Clarke describes some of these risk management plans as operable for conditions of pure fantasy.

> Organizations and experts use plans as forms of rhetoric, tools designed to convince audiences that they ought to believe what an organization says. In particular, some plans have so little instrumental utility in them that they warrant the label "fantasy documents" (1999, p.2).

Although Clarke's work is deeply critical of government and industry preparedness and response to disaster, he is not claiming that major risks are derived from gross negligence, willful carelessness or a kind of malicious desire to do harm. Rather, these risks are result of

institutional blinders, ideological commitments and beliefs, and the ways in which humans (individually and in institutions) tend to disregard or disqualify information that may not be valued or fit within a particular worldview, and at the same time draw exclusively on evidence that is consistent with the current direction and aspiration of their activities. These are particularly difficult challenges to overcome and require special attention to institutional design in order to limit the potential for harm from institutional failure.

Clarke is not alone in drawing attention to the institutional dimensions of technological risk management. Another source of expert error is described by Freudenburg (1993) as "recreancy," that is, the failure of institutions to carry through on their responsibilities with the degree of vigor that society expects of them. Drawing on foundational work from Weber and Durkheim, Freudenburg argues that the idea of interdependence is crucial to our understanding of risk and recreancy in that "the very division of labour that permits many of the achievements of advanced industrial societies may also have the potential to become one of the most serious sources of risk and vulnerability" (1993, p. 914). Adding to this idea of recreancy, Freudenburg also developed the term 'atrophy of vigilance' to characterize how (over time) the attentiveness of managers and regulators tends to diminish, and therefore risks become greater as the time period between accidents or incidents becomes greater (1992).

Social science shows that the institutional analysis of risk management requires attention to risk-enhancing processes such as:

- Tight coupling
- Disqualification heuristics
- Fantasy documents
- Recreancy
- Atrophy of vigilance

Another perspective on the institutional dimensions of risk management comes from research on the construction of megaprojects. Using data primarily from megaprojects in Europe, Flyvbjerg and his colleagues (2003) identify a fairly consistent pattern in the development of megaprojects such as roads, bridges and other large infrastructure developments. One of the common features of these projects is the massive cost overruns that are absorbed by tax payers. These cost overruns are a result of poor planning, a lack of transparency and a lack of public accountability that allows developers and regulators to conceive of such projects with little attention to a wide range of complexities, uncertainties and risks.

One piece of evidence for costs overruns is illustrated in Figure 2 below. The data shows cost overruns in megaprojects over the past century are becoming more common and the

magnitude of these overruns is also increasing. Although this research is not focused on nuclear power development per se, there are clear parallels here in terms of the scale of these megaprojects, and more importantly, the level of public financing that goes into the construction of such projects. The main thrust of the argument here is that megaprojects are often planned in a somewhat Newtonian world of direct cause and effect where projects go according to plan. If history is any guide, however, "the world of megaproject preparation and implementation is a highly risky one where things happen only with a certain probability and rarely turn out as originally intended" (Flyvbjerg et al. 2003, p. 6).

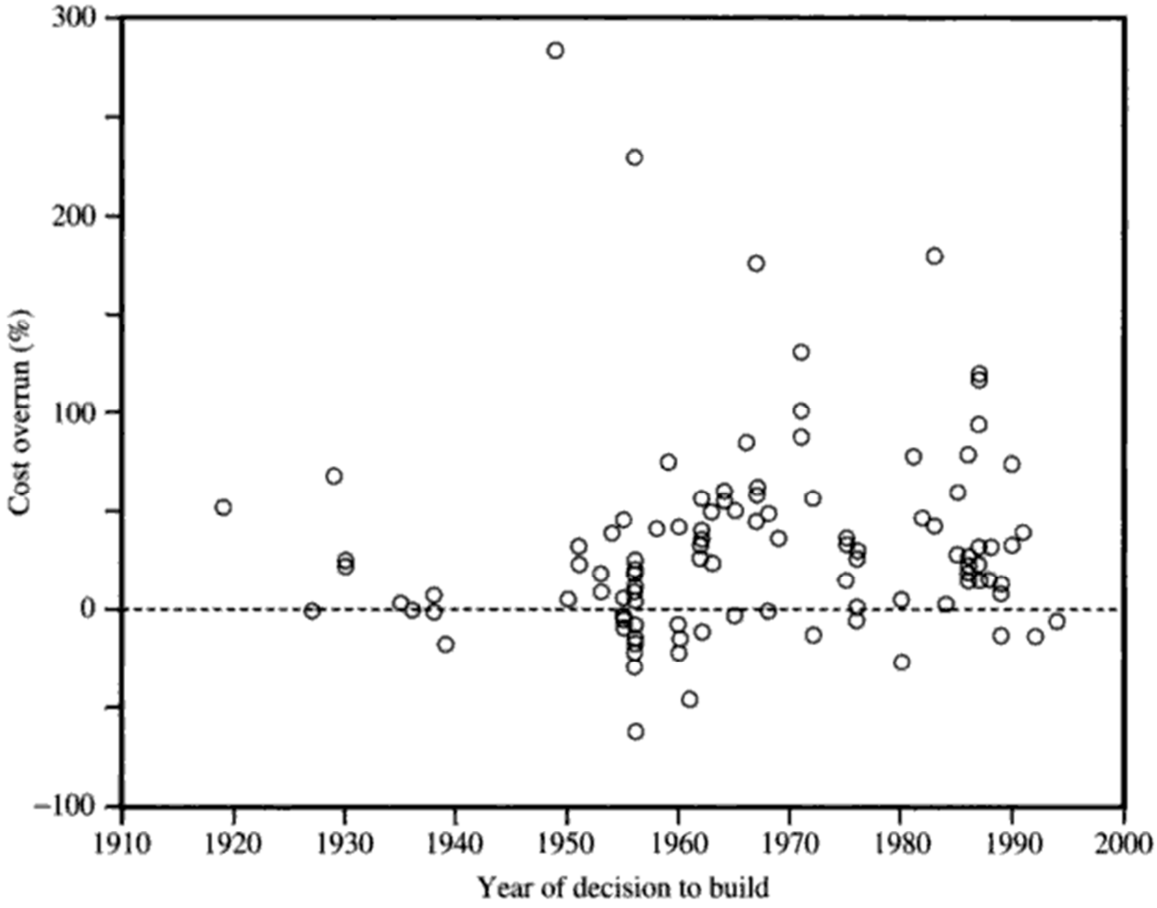

Figure 2. A century of cost overruns in 111 projects (constant dollars). Source: Flyvbjerg et al. 2003.

A solution to this dilemma of risky megaprojects proposed by these authors is to include better information for decision-making as well as good communication. The authors also call for a more democratically open and transparent process whereby accountability for the responsible use of public funds is of paramount importance. Flyvbjerg pays special attention to the link

between project risks, private sector interests, public funds and accountability. These connections are inherently difficult to make and require careful attention to the institutional arrangement that are intended to promote accountability for the use of public funds and accountability for risk in particular. The principles of "most likely development" (MLD) are put forward as a way to promote full risk assessment. This includes attention to the most risky parts of a project and a clear understanding of the worst-case scenarios. Moreover, the authors claim that

> Public financing or financing with a sovereign guarantee and no risk capital does not reduce risk or risk costs. It only transfers risk from lenders to taxpayers, and so is likely to increase the total risk and costs of a project (2003, p. 84).

These concerns about institutional arrangements and attention to transparency and accountability are entirely consistent with other risk scholars who are focused more explicitly on the nuclear power industry in North America, not to mention the important ethical implications discussed later in this paper. In their analysis of risk perception toward nuclear power in the U.S., Whitefield and his co-authors claim that "those who believe that nuclear power is an essential part of American's future energy supply will need to devote as much attention to institutional design and performance as they do to reactor design if they hope to win public support" (2009, p.436).

Based on the general trend in recent literature where perception of risk is high and the risk implications of megaprojects with regard to cost overruns are more apparent, social science offers a wide range of alternatives to consider the institutional dimensions of risk management and project development. Recommendations for institutional design and performance to take account of the issues raise in this paper are presented in the final section of the paper.

DOING ETHICS ABOUT NUCLEAR POWER

Decisions about nuclear power development can draw on economic, social, technical, and ecological facts, but must still be decided in light of whether and how nuclear energy generation might be good for a jurisdiction. Risk assessment is founded upon which things are most valued and whether the technology places these valued things at risk (Rohrmann & Renn 2000). Doing ethics is this process of determining what is "good" and how we should live in order to "do what is good." Pursuing the highest good (*sunnum bonum*, literally, "the end goal") is the prime human purpose according to classical philosophers. At the least, they believed, what is good was not to be determined solely on the basis of human preferences, desires, and perceived needs.

There are a variety of different ways of doing ethics or deciding what is "the good." The two main approaches to ethics can be summarized in terms of duty or consequences, or the means-end distinction. On one hand, the higher good might be in the consequences that result from action, that is, the *ends*. On the other hand, we may be seen as having a duty to *be* good. The saying "the ends deserve the means" characterizes the first approach; one might do what would be considered bad or wrong in order to accomplish good ends (e.g., stealing to provide for one's family, or donating to charity money gotten by unethical business practices). Many ethical disputes arise from fundamental differences in social actors' basic approaches to determining what is good and ethical. This is particularly true of the very complicated decisions about nuclear energy that more resemble ethical messes ("wicked problems") than "tame" problems (King 1993).

Philosophers from Plato to Kant have insisted that some things – humans for certain – are not to be considered only as means to an end, that is, for their *use value*. The value associated with human beings is often due to a belief that humans have *intrinsic value*, that is, that their value is located in themselves. A competing view is that humans have been given value from some external source, such as a divine being. Thus, some disputes are around how and why and what to view as good or to give moral consideration. Such disputes will arise in the nuclear energy debate as citizens debate whether present generations or future generations or economic growth or energy-consumptive lifestyles or nature should be given moral consideration and how nuclear power generation fits in as a means to what ends.

Another general distinction is that of *private goods* and *common or public goods*. The former are those things that individuals use or possess and this use excludes the use of the good by other people. Common goods are shared by all. *Public goods* are common goods specifically delivered or protected by collective action such as governments. A stable energy supply is a public good, as is environmental health. Money made by a power company would be a private good. This distinction is important as there are a variety of benefits and risks to nuclear power. The ethics of decision-making must carefully weigh which goods will accrue to individuals (including corporations) and publics, particularly if public (governmental) investment occurs as it has in most nuclear projects. In such situations the risk of economic loss becomes public, while the economic benefits (in terms of profit) remain largely private. It is also particularly telling that the risks of nuclear accident have become public expenses as private insurance only covers a small percentage of the nuclear liability. Finally, since the state (the public) is responsible for environmental protection and social stability, ethical decisions must evaluate whether placing these public goods at risk is adequately exchanged for other public benefits (such as energy sufficiency, carbon reduction, or specific economic development) and not just privatized goods. In other words, the degree of industry-government partnership in nuclear

power generation is an important ethical consideration that transcends economic and technical aspects of the nuclear issue.

Ultimately, ethics are social processes as discussion and debate proceeds over competing definitions of what is to be considered good and what is to be valued. Still, there are a number of principles that can help clarify the ethics of nuclear power development. As we have described above, attention should be given to how the social processes of valuation and deliberation proceed. Like all social phenomena, ethical debate is often characterized by uneven power relations as some actors are better able to express their values or are given greater access to media or decision-makers. Furthermore, distrust, dread and other concerns identified above will inhibit open deliberation on the ethics of nuclear power and the consequent decisions to be made.

APPLIED ETHICS OF HARM AND EQUITY

Many concerns about nuclear power generation have to do with the potential for harm, and this is often the way that the ethics of nuclear energy decisions are posed (e.g., Timmerman 2003). The likelihood of harm and the magnitude of harm are very different factors. To some extent, they can be calculated (as is discussed in other sections of this document). However, the two factors are not calculated the same way so cannot be simply compared against each other; furthermore, the ethical weighting given to each factor will vary among actors. Unintended harms are a type of "moral externality" that should not be weighed strictly against more preferred end products of business activities (Gowri 2004).

An even more significant ethical issue is the *distribution* of harm. One must ask if some communities or regions will be (or are more likely to be) harmed (or threatened with harm)? Ethical systems will answer this question differently: Is it ok to harm some in order that a greater good is produced? Whose greater good? As a corollary, we must also ask about the distribution of benefits. We also generally question the fairness of a situation where someone benefits from another person being harmed.

It is of particular ethical concern if the benefits and harms are not equally distributed among social actors. Thus, *equity* is another key ethical principle. Most theories of justice have to do with whether or not potential harms and benefits are fairly distributed; the state is generally considered to be responsible for ensuring equity, as well as protecting public goods. *Distributional equity* occurs when goods (and bads) are fairly distributed by whatever means are considered to be the measure of fairness. For example, hard work is usually considered to be a fair means of distributing income, but wealth is usually not an explicitly acceptable means for the distribution of environmental risks: should poorer people face more pollution?

Who benefits from nuclear power, and who may be harmed? Does it matter that harm or benefits may be unequally distributed? What are the circumstances by which harm or benefit may be distributed? These are among the ethical questions which the principles of harm and equity force us to raise.

There are a variety of types of equity that help to clarify the ethical issues in terms of nuclear power. The most obvious issue with nuclear power production is that of *intergenerational equity*, that is, equity between generations. One of the most pressing unresolved problems with nuclear energy is that of nuclear waste. Intergenerational equity makes us ask if it is ethical to spread the responsibility for the wastes hundreds of thousands of years into the future (Marshall 2005; Wilson 2003), especially if only generations present in the next few decades will benefit? Furthermore, the political system is currently organized so that future generations have no direct voice in decisions that will affect them. Picking up the issue of intergenerational justice, Taebi and Kloosterman (2008, p.177) insist the advocates of nuclear waste storage options and nuclear energy in general "should explain why they are willing to transfer all the risks for a very long period of time (200,000 years) to future generations."

Intragenerational equity has already been mentioned. This principle is about equity across the present – that all are fairly benefited or harmed, have equal opportunities, and so on (Attfield 1998). Hard work and luck are partly considered fair means of improving one's social position, but existing social conditions may also be products of past inequities. In addition, some circumstances give certain actors advantages. For example, growing up in a well-to-do or well-connected family often leads to a better education, jobs, and position, more money or other resources, a capability to access and respond to detailed technical information, and the skills to speak before a hearing in the "proper" manner, and get one's views heard. This inequality leads to concerns about *participatory* or *procedural equity*. This form of equity has to do with whether participation in the processes of our society is fair and equal for all. Decision-making on nuclear power must be very careful to proceed ethically on participation and procedure; particularly in the case of nuclear power megaproject as it would be easy to let powerful and well-resourced stakeholders drive decisions.

Sheng (2005) describes issues of participatory equity in the process to develop a Canadian nuclear waste disposal strategy. The structure of these consultations required very specific technical understanding and a narrow construction of what types of citizen concerns were to be considered legitimate. The format excluded other forms of expression in the hearings. In order to express their concerns, participants were forced to translate their core values into something else, or communicate in legalistic and technical ways with which few had familiarity. The result was participatory inequity that privileged a limited subset of stakeholders and what they valued.

A related ethical issue would be if a relatively impoverished community was showered with promises of economic prosperity for siting a nuclear reactor in the community. In some ways this might be an issue of *spatial equity* (Stanley 2009). "Not in my backyard" campaigns may enable some communities to reject hazards that other communities might have to accept. Intragenerational inequity in the form of socio-economic disadvantage can become a form of coercion despite the appearance of procedural fairness (Blowers 2003). A great deal of research shows the environmental injustices of poor distribution of environmental hazards (the most recent summary is Mohai, Pellow & Roberts 2009; see also Brulle & Pellow 2006). In the United States, poor and racialized communities have much larger percentages of hazardous waste and toxic sites, while in Canada Aboriginal communities and working class communities based on resource extraction are particularly likely to have higher levels of various types of contamination or other environmental harms (Agyeman, et al 2009). More affluent communities may have more resources, connections and skills to resist undesirable land uses. But if something is NIMBY a more ethical approach should perhaps be NIABY – "not in anyone's backyard" (Hannon & Norton 1997). One can test the NIMBY vs NIABY ethic by locating nuclear energy production near to where it will be used, rather than in a remote site. Spatial equity suggests that the beneficiaries and risks be located near each other; imagine a reactor near Edmonton if the purpose is consumer demand for electricity.

Another type of equity may be more controversial, but it clearly demonstrates how the values upon which ethical differences rest are the products of different social milieus. *Interspecies equity* implies that other species should be treated with fairness and that human decisions for the good of the human species may be instances of ecological injustice.

In Canadian society, the dominant conceptions of nature are as "natural resources" for human use. Nature may even be euphemized as "ecosystem services" or "natural capital." Such anthropocentric perspectives represent the Human Exceptionalism Paradigm at work, that is, nature's purpose is to serve humanity. Logically, there is no *a priori* reason to reject interspecies equity as an ethical principle. That we have not typically extended moral consideration beyond humans is a cultural practice that does appear to be changing (Dunlap 2000).

Most of us do not speak of other animals as our "brother" but this is part of Aboriginal traditions as well as a minor current in other religions. Extending such ethical consideration, however, is something that the Roman Catholic Bishops of Alberta recommend in a June 2009 pastoral reflection on nuclear energy in Alberta. A comparable statement was issued by bishops from five Christian denominations in Saskatchewan (Bishops 2009). In both cases, the religious leaders push ethical consideration from purely human-centred concerns to responsibility for

the integrity of all of creation. In their process of ethics, nature has intrinsic value and is not merely to serve human purposes.

To conclude, the following principles are some of the ethical principles that should be part of nuclear decision making:

- Means/Ends
- Use Value/Intrinsic Value
- Private Goods/Public Goods
- Harm
- Equity
    - Distributional equity
    - Participatory equity
    - Inter-generational equity
    - Intra-generational equity
    - Spatial equity
    - Interspecies equity

These ethical principles are only a few that are relevant to consideration of nuclear power. Roughly, we might use the following schematic for a method of applied ethics.

1. Consider the relevant ethical principles (which assumes dialogue about what principles are relevant).
2. See if the facts on the ground align or don't align with the ethical principles in #1 (e.g., if all people have equitable participation or spatial distribution of risks is not fair).
3. If they do, judge the particular action/issue/whatever as ethically acceptable or not.

It is important to emphasize that not only are the final decisions to be considered ethical goods, but an ethical means of equitable and non-coercive participation must also be followed. Furthermore, it is unethical for communication of technical information to be misleading or confusing (Dombrowski 2007). Research by both Endres (2007) and Stanley (2009) show that the language used in the debates about nuclear energy are often means of coercion and misrepresentation.

ETHICAL SPECIFICS OF NUCLEAR

There is considerable experience from other jurisdictions that can help to inform the consideration of the ethics of nuclear power. Above all, nuclear energy should make a positive contribution to society, and be pursued in a way that reduces risks and enhances public benefits (Mizuo 2008). Care must also be taken that the technical mindset not overwhelm other

social and ethical considerations and that diverse knowledges be brought to bear (di Norcia 2002).

A number of writers have emphasized the culture of engineering and technology as being particularly influential in how ethical deliberation can proceed (Hauser-Kastenberg, et al 2003; Ross & Athanassoulis 2009). For example, Dombrowski (2007) describes the commissions after both the Challenger and Columbia shuttle disasters. The later reports highlighted issues in the hierarchy and structure which silenced employees and replaced ethical responsibilities with technical proofs. While never distancing personal integrity from decisions, the commissions placed ethical duty in the context of organizations, culture and social context. Applying this to the nuclear energy industry implies such possibilities as that the social and economic contexts of energy corporations may affect operation of power plants; similarly governmental practice may shaped a culture of distrust about "consultations" and approvals of energy production projects (Garvin & Masuda 2006). Topcu (2008) discerned similar distrust about insufficient transparency and procedural equity in France.

Others have been critical of the way that nuclear energy has been propounded. Shrader-Frechette (2011) argues that methods of comparing the greenhouse gas emissions of nuclear energy versus other energy sources has often been done in ways that border on unethical representation of the benefits. Shrader-Frechette is concerned that the dedication to go the nuclear route locks out opportunities to pursue renewable and other forms of energy or conservation. Her analysis of 30 recent nuclear analyses shows that industry-funded studies tend to trim cost data and show other signs of conflict of interest (Shrader-Frechette 2009). Thus, she concludes, the economics of nuclear power are not as appealing as often presented, particularly as a tradeoff for addressing climate change. This highlights the need to ask the key question of social ethics – "who stands to benefit" from nuclear energy development.

One beneficiary is the population of a region if nuclear energy ultimately provides more stable and lower cost (in both economic and environmental terms) electricity than other forms of energy production. Such an ethical argument must be based on good cost analyses, as research shows that nuclear power is often considerably more expensive than projected.

Wellock's (1998) research shows the US nuclear industry declined from the 1960s onward primarily because financial institutions withdrew the enormous resources needed to fund construction. Feiveson's (2009 p. 138) recent analysis is that "Nuclear power seems to go forward only where governments heavily subsidize is operation." This raises substantial questions about private and public goods, benefits and responsibilities. Levendis et al (2006) argue that the free market must decide the fate of nuclear energy projects. In their analysis, reducing government regulation that "stifles" nuclear entrepreneurship is the ethical thing to do. Although Mitchell (1999) touts the benefit of codes of ethics adopted by businesses and

industry, the track record of voluntary compliance is not good (Borck & Coglianese 2009). It is hard to understand how the ethical duty to protect public safety in light of duty to shareholders can be produced without public (nee governmental) oversight. Part of ethical deliberation about the choice of the good is evidence about the huge expenditures of resources for construction, and track records of nuclear plants operating less than expected (each of the Bruce power plants in Ontario) or not at all (as at the Shoreham NY plant, Aron 1997). Decommissioning a nuclear station must also be considered an ethical issue as plans for it involve various possible harms, intergenerational equity (has sufficient bond be put in place?), types of responsibility, and public/private concerns (is the public on the hook?) (Surrey 1992).

Additionally, a nuclear plant must be placed in its overall context. Nuclear energy production generates demand for uranium. The uranium mining and enrichment industries have caused environmental injustice, particularly in Aboriginal communities (Bullard & Johnson 2000; Charley, et al. 2004; Lovelace 2009; Keeling & Sandlos 2009; Quigley, et al. 2000). The most celebrated Canadian case is that of the Eldorado Mine at Port Radium on Great Bear Lake in the Northwest Territories. Documented in the video *A Village of Widows* (Blow 1999), workers and their relatives in the Dene community of Deline claim that inadequate safety precautions have led to high cancer mortality, which is denied by government and corporate authorities (See also http:// www.sombake-themoneyplace.com and the Action Plan to Address Community Concerns available at http://reviewboard.ca/upload/project_document/ 1209682932_Port%20Radium%20Action%20Plan.pdf.).

The above matters and the ethical principles noted are only some of the facets of the momentous decision to include nuclear power in the energy production system. All indications are that decision makers ought to move slowly in the decision-making processes of whether and how nuclear power can fit in. One conservative approach, advocated by the Catholic bishops as well as other stakeholders, is that of applying caution to gather evidence that no harm will result and that equity can be accomplished before embarking on irrevocable development.

THE BIGGER PICTURE OF THE GOOD LIFE

The above discussion leaves out some significant bigger issues. Historian and sociologist Jacques Ellul (1982) insists that nuclear power is representative of the human lust for power – including electrical power, but also power in general, and private power for some in society. Often called a technological pessimist, Ellul demands that we consider the bigger questions of nuclear energy, such as whether there are legitimate limits to what human ingenuity should try to accomplish. These questions about limits are profoundly philosophical, ethical and religious questions. Is it good for humans to do whatever we want to try to technologically achieve?

Only slightly smaller in scope is the question of Why do we want/need nuclear energy? That the typical answer is "to fill needs [sic] for electricity" is no real answer. An ethical stance is to query whether these energy "needs" are really demands and desires. North American lifestyles are very energy-consumptive, the choices made collectively over time have made us energy-dependent with an ecological footprint that outstrips nearly all other humans on the planet as well as the available resources of the planet over the long term (www.worldwatch.org). Is that energy-intensive lifestyle *good*? Is it good for us humans, the natural environment or the global biosphere? Is it good to be unsustainable? And, is it fair? That is, does our energy and resource consumption help produce inequities elsewhere on the globe (Roberts & Parks 2007)? If the end goal of human purpose is the *sunnum bonum*, then we need to ask the broader ethical questions about what is the good life, and whether nuclear energy production is an appropriate means to pursuit of that goal.

SUMMARY

The social science literature on nuclear power development is vast and expanding very quickly, therefore limiting quick conclusions. But there are a few strong and consistent points in this literature, and these points are summarized below:

- Risk perception is associated with consequences to other valued objects
- Public risk perception is different than expert risk perception and involve distinct forms of rationality
- Risk perception of nuclear power is persistently associated with issues of dread, unknowability and lack of control
- Risk perception is difficult to change, and anchored to political affiliations / ideology
- Risk perception is closely linked to levels of trust in risk management institutions
- Differences in risk perception between countries are due in part to political aspiration such as energy independence and different political models of risk management
- Opposition to nuclear waste repositories are not simply reliant on a NIMBY syndrome
- Recent public acceptance of nuclear power is contingent (perhaps temporarily) on the ability of the nuclear development to facilitate lower carbon futures
- Debates about energy development between fossil fuels and nuclear power represent a false dichotomy (that exclude options of demand reduction and renewable energy)
- Social protest movements are driven by social values and can have real impacts of energy policy debates
- Technologies that involve tight-coupling and close feedbacks are recognized as risky
- Disaster response plans are not always well developed and don't anticipate worst case scenarios
- Megaproject risks involve cost overruns and require greater public accountability

- Decision-making is inherently ethical judgment because competing values are weighed
- Both harm and equity must be assessed
- Other ethical principles involved in nuclear issues include intergenerational equity, the distributional equity of risks, equity in participation and fairness to nature
- Managing risky technologies and activities requires risk issue management which involves meaningful interaction with science, policy, and civil society.

RECOMMENDATIONS FOR INSTITUTIONAL DESIGN AND PERFORMANCE

The design of public institutions and public processes to more effectively deal with risky activities and risky technologies is an important challenge in contemporary society. This challenge is exacerbated by several factors. First, civil society is less trusting and less deferential to all forms of expertise. Challenging expert opinion of science with alternative evidence has become common place. This transformation has implications for risk managers and a risk assessment that is based on narrow scientific evidence or a limited definition of probabilistic risk. Second, civil society and social values are more diverse than was the case in previous decades. Through education, immigration, and the on-going impact of social movements within the environmental community, civil society is culturally and ideologically pluralist. At times this pluralism results in deep divisions about issues of livelihood and sustainability. Third, there are emerging complexities and uncertainties that limit our ability to made decisions with full knowledge of impacts on others within the human and non-human world. Prions that that lead to mad cow disease and the human variant CJD; nanotechnology and the maintenance of natural processes in plants and animals; persistent organic pollutants and the maintenance of environmental quality, along with many other complex processes lead to uncertainty and a need to make decisions within the context of such technological and environmental change.

Given these social realities, the issue of risk management through institutional design is no small task. Moreover, there are precious few examples within the real world to signal cases where institutional design has made an important difference in the management of risky technologies and activities. What we do know, however, is that simple solutions that limit accountability, rely on overly technical risk assessments, and fail to recognize or account for risk and uncertainties are not likely to lead to successful technological innovation and wide-spread social acceptance.

Toward a more careful consideration of institutional design, Canadian scholar William Leiss (2001) has invested his career in understanding risk controversies and in imagining ways of improving the risk management capacities of responsible institutions. A primary concern for Leiss is the way that risk management institutions persistently fail to understand the essential difference between risk management and risk issue management. Risk management is mostly

associated with technical risk assessment, where probabilities of death or harm are calculated for a particular technology. In contrast, risk issue management involves attention to risk communication, and careful attention to the nexus of science, policy and civil society. Risk issues management is fundamentally about the contested domains of a particular issue and how risk issues are formulated, managed, and translated by various publics. In this sense, risk issue management involves attention to stakeholder interaction, overcoming intractable behaviours, and dealing with high levels of uncertainty, as well as attending to the values particular stakeholders perceive to be at risk (2001, p.10).

Based on these qualities of risk issue management, Leiss goes on to describe the basic competencies of risk issue management for institutions. These competencies are briefly outlined below (p. 288).

1. Accepting responsibility – this involves accepting the legitimacy of a risk controversy such as nuclear power. Rather than dismissing risk perception as uninformed or misguided, risk issue management would involve meaningful interactions with the public and accepting responsibility and obligations to understand and address risks that are represented within the public sphere as opposed to dismissing them as unfounded.

2. Addressing uncertainties – recalling the persistent public perception of nuclear power risk as dreadful, unknowable and uncontrollable, these aspects of uncertainty are a fundamental challenge when dealing with this risk issue.

3. Managing the science/policy interface – the science policy interface involves a willingness to take responsibility for engaging with the public in a timely fashion and in representing the complexity of scientific evidence, and historical experiences with nuclear power in other parts of the world.

4. Communicating risks appropriately – the tendency within traditional risk management institutions is to announce and defend the development of a risky technology, and then invest considerable resources in marketing the risky decision to the public. In contrast, appropriate risk communication involves longer-term dialogue about risks that are fair, open and well informed.

Further to this last point, Leiss calls for the development of an arms-length agency to facilitate the science policy interaction and to support this longer-term dialogue regarding the merits of a risky technology.

> Put directly, those actors should surrender control over the process of consensus building for risk understanding, as well as the risk messages themselves that

> emerge from that process. These tasks should be entrusted to independent and credible third parties who are capable of demonstrating to the wider public that they can be trusted to create a fair, informed, and disinterested forum for these risk dialogues (Leiss 2001, p. 291).

Decision-making about nuclear energy will weigh various notions of what is good, and use a variety of ethical principles and social science research conclusions. Information will have to be collection to determine whether the facts and projections align with the principles. Key among these principles and the public consultations, procedures, dialogue and decision-making is if these processes themselves are ethical, that is, if they are open, transparent, fulfilling the principles of participatory equity and so on. Harm and benefit, and their distribution, collective goods and justice are other key principles to be used in the dynamic process of deciding on the "ifs" and "hows" of nuclear energy production. Technical, economic and social facts will provide additional insights for use in ongoing analysis of the extent of nuclear development.

REFERENCES

Agyeman, J., P. Cole, R. Haluza-DeLay, and P. O'Riley, Eds. 2009. Speaking for Ourselves: Environmental Justice in Canada. Vancouver, BC: University of British Columbia Press.

Aron, J. B. 1997. Licensed to kill? The Nuclear Regulatory Commission and the Shoreham Power Plant. Pittsburgh: University of Pittsburgh Press.

Attfield, R. 1998. Environmental Ethics and Intergenerational Equity. Inquiry: An Interdisciplinary Journal of Philosophy 41(2):207-22.

Beamish, T.D. 2002. Silent Spill. The Organization of an Industrial Crisis. Cambridge, MA: The MIT Press.

Beck, Ulrich. 1992. Risk Society: Towards a New Modernity. London: Sage Publications.

Beck, U. 2009. World at risk. Malden, MA: Polity Press.

Bishops Call for Critical Reflection on Uranium Mining and a Proposed Nuclear Power Plant in Saskatchewan (March, 2009). Available at: http://www.saskatoonrcdiocese.com/news_articles/documents/Bishops_letter_nuclear.pdf

Blow, P. 1999. The Village of Widows: The Story of the Sahtu Dene and the Atomic Bomb. [videorecording]. Peterborough, ON: Lindum Films.

Blowers, A. 2003. Inequality and Community and the Challenge to Modernization: Evidence from the Nuclear Oases. In Just Sustainabilities: Development in an Unequal World, ed. J. Agyeman, R. D. Bullard and B. Evans. Cambridge: MIT Press.

Borck, J. C. and C. Coglianese. 2009. Voluntary Environmental Programs: Assessing Their Effectiveness. Annual Review of Environment and Resources 34(1):305-24.

Broadbent, J. 1999. Critical masses: Opposition to nuclear power in California, 1958-1978. Contemporary Sociology - A Journal of Reviews 28(6): 716-718.

Brulle, R. J. and D. N. Pellow. 2006. Environmental Justice: Human Health and Environmental Inequalities. Annual Review of Public Health 27:3.1-3.22.

Bullard, R. D. and G. S. Johnson. 2000. Environmentalism and Public Policy: Environmental Justice: Grassroots Activism and Its Impact on Public Policy Decision Making. Journal of Social Issues 56(3):555-78.

Catholic Bishops of Alberta (2009, June). Pastoral Reflections of the Catholic Bishops of Alberta on Nuclear Energy. Available at: http://www.caedm.ca/archbishops-office/pastoral-letters/nuclear

Catton, W. R., Jr., and R. E. Dunlap 1978 Environmental Sociology: A New Paradigm. The American Sociologist 13:41-49.

Charley, P. H., S. E. Dawson, G. E. Madsen, and B. R. Spykerman. 2004. Navajo Uranium Education Programs: The Search for Environmental Justice. Applied Environmental Education & Communication 3(2):101-8.

Clarke, L. 1993. The Disqualification Heuristic. Research in Social Problems and Public Policy 5:289-312.

Clarke, L. 1999. Mission improbable: Using Fantasy Documents to Tame Disaster (A Critical Look at How Governments and Corporations Plan for Accidents and Disasters). Chicago: University of Chicago Press.

Costa-Font, J., C. Rudisill, E. Mossialos. 2008. Attitudes as an Expression of Knowledge and "Political Anchoring": The Case of Nuclear Power in the United Kingdom. Risk Analysis 28(5): 1273-1287.

Davidson, D.J. (Editor). 2009. Nuclear Energy in Alberta: What You Need to Know. Report prepared for the Environment Research and Studies Centre, University of Alberta. Accessible at: http://www.ualberta.ca/ERSC/

di Norcia, V. 2002. Diverse Knowledges and Competing Interests: An Essay on Socio-Technical Problem-Solving. Science and Engineering Ethics 8(1):83-98.

Dombrowski, P. M. 2007. The Evolving Face of Ethics in Technical and Professional Communication. IEEE Transactions on Professional Communication 50(4):306-19.

Dunlap, R.E. , D. K.D. Van Liere, A. G. Mertig and R. Emmet. 2000. New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. Journal of Social Issues 56 (3): 425-442.

Ellul, J. 1982. A Theological Reflection on Nuclear Developments: The Limits of Science, Technology, and Power. In Waging Peace, edited by Jim Wallis, 114–20. San Francisco: Harper and Row.

Endres, D. 2009. From Wasteland to Waste Site: the Role of Discourse in Nuclear Power's Environmental Injustices. Local Environment: The International Journal of Justice and Sustainability 14(10):917-37.

Erikson, K T., E. W. Colglazier and G. F. White. 1994. Nuclear Waste's Human Dimension. Forum for Applied Research and Public Policy (Fall): 91-97.

Eyerman, Ron and Andrew Jamison. 1991. Social Movements: A Cognitive Approach. University Park, PA: Pennsylvania State University Press.

Feiveson, H. A. 2009. A Skeptic's View of Nuclear Energy. Daedalus 138(4):60-70.

Flyvbjerg, B., N. Bruzelius and W. Rothengatter. 2003. Megaprojects and Risk: An Anatomy of Ambition. Cambridge University Press.

Freudenburg, W. R. 1988. Perceived Risk, Real Risk: Social Science and the Art of Probabilistic Risk Assessment. Science 242(4875), 44-49.

Freudenburg, W. R. 1993. Risk and Recreancy: Weber, the Division of Labor, and the Rationality of Risk Perceptions. Social Forces 71(4): 909-932.

Freudenburg, W.R. 2004. Can We Learn from Failure? Examining US Experiences with Nuclear Repository Siting. Journal of Risk Research 7(2), 153-169.

Freudenburg. W.R. and D.J. Davidson. 2007. Nuclear Families and Nuclear Risks: The Effects of Gender, Geography, and Progeny on Attitudes toward a Nuclear Waste Facility. Rural Sociology 72(2), 215-3243.

Gowri, A. 2004. When Responsibility Can't Do It. Journal of Business Ethics 54(1):33-50.

Hauser-Kastenberg, G., W. Kastenberg, and D. Norris. 2003. Towards Emergent Ethical Action and the Culture of Engineering. Science and Engineering Ethics 9(3):377-87.

Inglehart, Ronald. 1995. Public Support for Environmental Protection: Objective Problems and Subjective Values In 43 Societies. PS: Political Science and Politics. 28:57-72.

Katsuya, T. 2001. Public Response to the Tokai Nuclear Accident. Risk Analysis. 21(6): 1039-1046.

Keeling, A. and J. Sandlos. 2009. Environmental Justice Goes Underground? Historical Notes from Canada's Northern Mining Frontier. Environmental Justice 2(3):117-25.

King, J. B. 1993. Learning to Solve the Right Problems: The Case of Nuclear Power in America. Journal of Business Ethics 12(2):105-16.

Kuhn, R.G. 1998. Social and Political Issues in Siting a Nuclear-Fuel Waste Disposal Facility in Ontario, Canada. Canadian Geographer / Le Géographe canadien 42(1): 14 – 28.

Leiss, W. 2001. In the Chamber of Risks: Understanding Risk Controversies. Kingston, ON: McGill-Queen's University Press.

Levendis, J., W. Block, and J. Morrel. 2006. Nuclear Power. Journal of Business Ethics 67(1):37-49.

Lovelace, R.. 2009. Notes from Prison: Protecting Algonquin Lands from Uranium Mining. Pp. ix-xix in Speaking for Ourselves: Environmental Justice in Canada, J. Agyeman, P.Cole, R.Haluza-DeLay, and P. O'Riley, Eds. Vancouver, BC: University of British Columbia Press.

MacGregor, S. 2006. Beyond Mothering Earth: Ecological Citizenship and the Politics of Care. Vancouver: UBC Press.

Marshall, A. 2005. The Social and Ethical Aspects of Nuclear Waste. Electronic Green Journal 1(21): Available at http://www.escholarship.org/uc/uclalib_egj?volume=1;issue=21.

Masuda, J. R. and T. Garvin. 2006. Place, Culture, and the Social Amplification of Risk. Risk Analysis 26(2):437-54.

Mehta, M.D. 2005. Risky Business: Nuclear Power and Public Protest in Canada. Toronto, ON: Lexington Books.

Mitchell, J V. 1999. Ethics and International Business. Annual Review of Energy & the Environment 24(1):83.

Mizuo, J. 2008. The Social Responsibility of Nuclear Energy. Progress in Nuclear Energy 50(2-6):694-99.

Mohai, P., D.R. Pellow, and J. T. Roberts. 2009. Environmental Justice. Annual Review of Environment and Resources 34(1):405-30.

Murphy, R. 2004. Disaster or Sustainability: The Dance of Human Agents with Nature's Actants. Canadian Review of Sociology & Anthropology 41:249-267.

Norgaard, K. M. 2011. Living in Denial: Climate Change, Emotions, and Everyday Life. Cambridge MA: MIT Press.

Norton, B. and B. Hannon. 1997. Environmental Values: A Place-Based Approach. Environmental Ethics 19(4):227-46.

Perrow, C. 1984. Normal Accidents: Living with High Risk Technologies. New York: Basic Books.

Pidgeon, N.F., I. Lorenzoni, and W. Poortinga. 2008. Climate change or nuclear power – no thanks! A quantitative study of public perceptions and risk framing in Britain. Global Environmental Change 18, 69-85).

Poortinga, W., N. Pidgeon and I. Lorenzoni. 2006. Public Perceptions of Nuclear Power, Climate Change and Energy Options in Britain: Summary Findings of a Survey Conducted during October and November 2005. Understanding Risk Working paper 06-02. School of Environmental Sciences, University of East Anglia.

Quigley, D., V. Sanchez, D. Handy, R. Goble, and P. George. 2000. Participatory Research Strategies in Nuclear Risk Management for Native Communities. Journal of Health Communication: International Perspectives 5(4):305-31.

Ramana, M. V. 2009. Nuclear Power: Economic, Safety, Health, and Environmental Issues of Near-Term Technologies. Annual Review of Environment and Resources 34(1):127-52.

Roberts, J. T. and Bradley C. Parks. 2007. A Climate of Injustice: Global Inequality, North-South Politics, and Climate Policy . Cambridge, MA: The MIT Press.

Rohrmann, B. and O. Renn. 2000. Risk Perception Research: An Introduction. In O. Renn and R. Rohrmann (eds.). Cross-Cultural Risk Perception: A Survey of Empirical Studies. Boston, MA: Kluwer Academic Publishers.

Rosa, E. and R.E. Dunlap. 1994. Nuclear Power: Three Decades of Public Opinion. Public Opinion Quarterly 38:295-325.

Ross, A. and N. Athanassoulis. 2010. The Social Nature of Engineering and Its Implications for Risk Taking. Science and Engineering Ethics 16 (1): 147-168.

Sheng, G. 2005. Values, Social Acceptability and Social Capital: The Canadian Nuclear Waste Disposal Case. Pp. 209-26 in A Dynamic Balance: Social Capital and Sustainable Community Development. Eds Ann Dale and Jennifer Onyx. Vancouver: University of British Columbia Press.

Shrader-Frechette, K. 2009. Data Trimming, Nuclear Emissions, and Climate Change. Science and Engineering Ethics 15(1):19-23.

Shrader-Frechette, K. 2011. Climate Change, Nuclear Economics, and Conflicts of Interest. Science and Engineering Ethics 17(1): 75-107.

Sjoberg, L. 2004. Local Acceptance of a High-Level Nuclear Waste Repository. Risk Analysis. 24(3): 737-749.

Sjoberg, L. and B.M. Drottz-Sjoberg. 2001. Fairness, Risk and Risk Tolerance in the Siting Of Nuclear Waste Repository. Journal of Risk Research 4 (1), 75-101.

Slovic, P., J. Flynn, C.K. Mertz, M. Poumadere, C. Mays. 2000. Nuclear Power and the Public: A Comparative Study of Risk Perception in France and the United States. In O. Renn and R. Rohrmann (eds.). Cross-Cultural Risk Perception: A Survey of Empirical Studies. Boston, MA: Kluwer Academic Publishers.

Slovic. P. 1987. Perception of Risk. Science, 236 (4799), 280-285.

Sovacool B. K. 2007. Coal and Nuclear Technologies: Creating a False Dichotomy of American Energy Policy. Policy Sciences 40, 101-122.

Stanley, A. 2009. Just Space or Spatial Justice? Difference, Discourse, and Environmental Justice. Local Environment: The International Journal of Justice and Sustainability 14(10):999-1014.

Surrey, J. 1992. Ethics of Nuclear Decommissioning. Energy Policy 20(7):632-40.

Taebi, B. and J. Kloosterman. 2008. To Recycle or Not to Recycle? An Intergenerational Approach to Nuclear Fuel Cycles. Science and Engineering Ethics 14(2):177-200.

Timmerman, P. 2003. Ethics of High Level Nuclear Fuel Waste Disposal in Canada. NWMO Background papers. Nuclear Waste Management Organization. Available at www.nwmo.ca/publications?media_file_id=612&action=downloadfile

Topcu, S. 2008. Confronting Nuclear Risks: Counter-Expertise as Politics within the French Nuclear Energy Debate. Nature and Culture 3(2):225-45.

Wellock, T.R. 1998. Critical Masses: Opposition to Nuclear Power in California, 1958–1978. Madison: University of Wisconsin Press.

Whitfield, S. C., E. A. Rosa, A. Dan, and T. Dietz. 2009. The Future of Nuclear Power: Value Orientations and Risk Perception. Risk Analysis. 29(3): 425-437.

Wilson, L. 2000. Nuclear Waste: Exploring the Ethical Dilemmas. Toronto: United Church Publishing House.