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Abstract
The future of nuclear energy depends upon public support and acceptance of new facilities. However, survey research in Canada and the US indicates that more people oppose than support new nuclear facilities. This aversion to nuclear power results from public perceptions of risk and a lack of trust in government and industry to manage the potential radioactive hazards. A large gap exists between the risk estimates of nuclear experts and the public, making it difficult to formulate policies that will address the issues of both sides. Efforts to gain public support will have to better understand the public attitudes and opinions, and discover new ways to cooperate with public groups, communities and institutions.

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Public Trust and the Future of Nuclear Power

JAMES FLYNN

The future of nuclear energy depends upon public support and acceptance of new facilities. However, survey research in Canada and the US indicates that more people oppose than support new nuclear facilities. This aversion to nuclear power results from public perceptions of risk and a lack of trust in government and industry to manage the potential radioactive hazards. A large gap exists between the risk estimates of nuclear experts and the public, making it difficult to formulate policies that will address the issues of both sides. Efforts to gain public support will have to better understand the public attitudes and opinions, and discover new ways to cooperate with public groups, communities and institutions.

L'avenir de l'énergie nucléaire dépend du soutien de l'opinion publique et de l'acceptation des nouvelles installations. Cependant, les rapports d'enquêtes effectuées au Canada et aux Etats-Unis indiquent que les personnes qui s'opposent à l'implantation de nouvelles centrales nucléaires sont plus nombreuses que celles qui les approuvent. Cette aversion pour l'énergie nucléaire résulte de la perception par l'opinion publique des risques, et de son manque de confiance dans le gouvernement et les industriels pour gérer les risques liés à la radioactivité. Il existe un large fossé entre les estimations des experts du nucléaire et la conception du public, ce qui complique la formulation des politiques qui prennent en compte les questions posées par les deux camps. Pour gagner le soutien de l'opinion publique, il faudra faire un effort de compréhension des attitudes et des opinions et découvrir de nouvelles méthodes de coopération avec les groupes d'intérêt public, les communautés et les institutions.

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Introduction

The future of nuclear power is uncertain. Scientists and engineers assure us that the current nuclear power plants are safe and reliable, and that future plants will be even better. The operating history for nuclear power is often presented as a standard by which to measure other sources of electricity with the claim that its record of safety with workers and the public is as good or better than any other. Industry experts claim that there are important environmental reasons to use nuclear power, and that it protects national electric supplies from foreign political and economic forces. A majority of the public, however, does not support nuclear power and an active minority effectively opposes it.

I would like to start my remarks with two observations. First, the essential obstacle to the future of nuclear power is the lack of public confidence in the technology and the industry. There may be technical and safety questions involved but these are not the primary issues. Second, the policy decisions and the viability

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of future attempts to site nuclear power plants will be decided by public attitudes and opinions.

My purpose is to discuss some of the issues the public associates with nuclear power and to consider what these concerns imply for the future of nuclear energy. I will make some brief comments about the public attitudes and opinions on nuclear issues. I will focus on what we know and don't know about this topic. Then I will have some summary observations about the implications for the future and what can be done.

When looking at some of the key research and survey data available on Canada, I am struck by how similar the sensibilities of the Canadian public are to those of the United States (Angus Reid Group, 1991a and 1991b). No doubt this is due, in part, to the pervasive influence of the mass media in our time, a factor that has considerable impact upon the future of public risk perceptions and the acceptability of technological facilities.

The similarity of our cultural values and our common experience with nuclear topics also are important. Spencer Weart's work, especially his book, *Nuclear Fears*, is essential reading to understand something of the cultural context influencing public perceptions (Weart, 1988). Nuclear fears, as has been substantiated by extensive social science research, occupy a special area of concern for large numbers of the public. These are concerns that have increased over the past decades.

The 1991 reports of work done by the Angus Reid Group for the Canadian Nuclear Association included information on surveys and focus groups. These findings are very comparable with data from the United States, even to the connection of nuclear power with war and nuclear weapons. This is striking, given the vast difference between the nuclear weapons programs of the two countries. And it is important because the connection between nuclear weapons and peaceful uses of nuclear technologies is a powerful source of negative images about civilian nuclear facilities.

A Brief History of Public Opinion

Support for nuclear power has changed dramatically over the past 15 years. Survey data from the United States demonstrates the shift in opinion and support that has taken place. According to the Harris poll about 63% of US residents favoured nuclear power in 1975 with 19% opposed. By 1988 this figure was 30% in favour and 61% opposed. The overwhelming majority of support had reversed and become an equally massive majority in opposition to nuclear power (Harris, 1989).

In Canada support for nuclear power is stronger than in the United States but it can hardly be called robust. By 1991, according to the Angus Reid Group, nuclear power had the support of 42% of the Canadian public (Angus Reid, 1991a, p. 14). Of the 42% support nationwide, less than 15% were listed as "strong" supporters. In Ontario a slight majority (54%) of the respondents either strongly or moderately support nuclear.

In a major national survey of Canadians conducted earlier this year by our group, Decision Research, the following question was asked:

> In light of health concerns about acid rain, damage to the ozone layer, and climate change associated with the burning of coal and oil, Canada should rely more heavily upon nuclear power to meet its future electricity needs.

As shown in Table 1, 45% agreed with this statement while almost 49% disagreed. In terms of the intensity of the responses, 12.4% of the respondents strongly agreed, while 22.1%, almost twice as many, strongly disagreed (Slovic, Flynn, and Mertz, 1992).

The question we asked is not an anti-nuclear power question. Quite the contrary, it presents a multi-point argument for nuclear power—the same basic argument that proponents in the United States, like the US Council on Energy Awareness, use in their advertisements. Even though the question is formed as an argument in favour of new nuclear power plants, more people oppose new nuclear power sitings than support them.

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Table 1: Responses to a Statement on Acceptability of Nuclear Power

In light of health concerns about acid rain, damage to the ozone layer and climate change associated with the burning of coal and oil, Canada should rely more heavily upon nuclear power to meet its future electricity needs:

Disagree Strongly	Disagree Somewhat	Agree Somewhat	Agree Strongly	Don't Know / No Opinion
22.05	26.83	32.54	12.42	6.18

Note: Cell entries are percentages (n=1501).

Source: Slovic *et al.* (1992).

At the current time, opposition is strong enough, and effective enough, to halt expansion of the nuclear industry in the United States and to severely limit it in many other industrial countries. In the United States, no new nuclear power plant has been ordered since 1978. I believe that I worked on the last active license application, the Puget Sound Power and Light Co. proposal for a nuclear power station to be built at the US Government Hanford reservation in southeastern Washington State. That effort was abandoned almost ten years ago. The only continuing construction in the US is on reactors well along on construction that have not been cancelled. In the period following the Three Mile Island accident, more than 100 units were cancelled, postponed, or mothballed at a sunk cost of more than $15 billion (US GAO, 1989; Davis and Fitzsimmons, 1991, p. 152).

But even completed construction is not a guarantee that a plant will be able to operate in the face of public opposition. The Rancho Seco plant in California was shut down following a public referendum. San Onofre No. 1 is scheduled to be closed prior to the end of its license. In August 1992, Portland General Electric announced plans for an early shutdown (by 1996) of the Trojan (Oregon) facility—it went into operation in 1976. This schedule will apply if two referendum measures on the 1992 November ballot, sponsored by local opponents, are voted down. Trojan would be shut down almost immediately if either of these measures pass. After 14 years in construction, the $5.5 billion Shoreham plant in New York has a federal operating license but has been taken over by the State of New York and will be decommissioned without ever going on line.[1]

The problems of public opposition to nuclear power are so well known that "what to do about it?" seems to be an annual question. The analyses of the problem and the recommendations follow a similar line which is best represented by a recent study from the National Research Council.[2]

In a summary of public attitudes as "a growing problem for nuclear power" the National Research Council listed several factors:

- For the past decade or more, electricity supplies have been ample, and the public feels no sense of urgency about supporting the addition of new generating capacity of any kind.
- The public recognizes that there are alternatives to nuclear power plants to produce electric power and believes that nuclear power is more costly than many of these alternatives.
- Well publicized problems with US nuclear power plants undermine the public's perceptions of their safety.
- The public does not have a high degree of trust in either the governmental or industrial proponents of nuclear power.
- The public has concerns about the health effects of low-level radiation.
- The public is concerned that there is no safe way to dispose of high-level radioactive

1/ A summary account of the long, difficult struggle over Shoreham is provided by K. Wilson (1992).

2/ See the report by the National Research Council (1992). This study was requested and commissioned by the United States Congress. The findings and recommendations are consistent with a number of other studies. See, for example, S. Nealey (1990), US General Accounting Office (1989), Office of Technology Assessment (1991), and Davis and Fitzsimmons (1991, pp. 151-164).

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waste.

- Many . . . believe the potential for nuclear weapons proliferation is a major threat posed by the use of nuclear power.

The National Research Council Committees responsible for the report included outstanding experts in the areas of nuclear science and technology. Included were engineers, scientists, utility managers, administrators, legal counsellors, and investment advisors. I do not recognize any social scientists.

These experienced, capable, and thoughtful people made the following suggestions to improve public opinion of nuclear power. There should be:

- a recognized need for a greater electrical supply that can best be met by large plants;
- economic sanctions or public policies imposed to reduce fossil fuel burning;
- maintenance of the safe operation of existing nuclear plants and knowledge of this by the public;
- the opportunity for meaningful public participation in nuclear power issues, including generation planning, siting, and oversight;
- better communication on the risk of low-level radiation;
- resolution of the high-level waste disposal issue; and
- assurance that a revival of nuclear power would not increase proliferation of nuclear weapons.

These suggestions are all excellent ones. They call for a good faith effort by the nuclear industry to address some key problems.

However, in terms of addressing the existing public attitudes and opinions toward nuclear power, it is not clear what program or effort is recommended. Communication with the public, of course, is suggested. More cooperation between the utilities and the public should help. I think everyone would agree to that. How do these good intentions hope to bridge the gap between the expert opinion of the nuclear industry and the public opinion that opposes additional nuclear power facilities?

Implied in the recommendations is a point of view that is commonly heard: "If the public only would think more like the nuclear industry then they would understand things properly and they would be more supportive of nuclear power." This is no doubt true—as far as it goes. It appears that lay people generally are willing to accept the views of scientists and experts on most complex scientific issues. However, on some particular issues, where the public is resistant to expert positions, they may not change their opposition no matter how much technical information they get. This appears to be the case for nuclear power.[3]

The problem is that the public does not think like nuclear experts, nor like scientists of any kind. Lay people tend to frame the technical questions differently than scientists or experts, and additions of technical information do not necessarily address the questions of most concern to the public. For example, the public is not impressed with the safe operation of nuclear power plants but it is tremendously impressed with signals that safe operation may be in jeopardy.

Moreover, there are few groups in the public who are sitting targets—so to speak—for instruction about the safety of either radioactivity or nuclear facilities. Most people live in a dynamic and changing world, a world of uncertainty, controversy, conflicting values, and adversary movements and personalities. This means that a clear educational message is going to have difficulty getting through and being effective. The more so if conflicting messages come from different directions.

The public will not easily be brought to its lessons and be instructed by the nuclear experts so that it will support nuclear power. On the contrary, large segments of the public seem to pay more attention and to give more belief to opponents of nuclear power. Many of these opponents have their own claims to expertise, and they do not appear ready to abandon their roles in defining public policy on nuclear power. The result of perceptions of risk, lack of trust in the experts and government, and the

3/ This is the finding of much of the research on perceptions of risk, as indicated below. But also see similar results from Doble and Johnson (1990).

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adversarial nature of addressing political issues is an impasse for nuclear power. Mainstream scientific and expert values and opinions are brushed aside by the public, and public values and concerns are downplayed, attacked, or ignored in retaliation. No doubt public decisions on issues of science and technology should not be made in this way, but this is where we are.

In addition, the public opinion has tremendous influence on the institutional context which determines whether nuclear power will expand or not. The institutions responsive to strong public opinion include elected officials who make up the administrative and legislative leadership of all modern democracies. Other institutions responsive to public oversight are the governmental agencies that promote, develop, and regulate nuclear power. Financial institutions and investors are well aware of the risks involved in returns for the electric utility industry where the public is not only the consumer but also the voter who elects, directly or indirectly, those who set rates and regulate.

One of the key comments made in the National Research Council report is that "the public does not have a high degree of trust in either the governmental or industrial proponents of nuclear power." The committee makes no recommendations to deal with this problem. But make no mistake about it, trust and confidence in the government and industry management of nuclear technologies is essential to the future of nuclear power. There is not one item on the list of suggestions from the National Research Council Committee that can make a significant difference to the future of nuclear power unless there is a considerably higher degree of trust and confidence in the management of nuclear technologies and facilities than currently exits.

The Scope of the Problem

There are a multitude of technical conditions and issues that are important to the future of nuclear power. Many of these problem areas —the effects of different levels of radiation on health, for example—are difficult for the public to evaluate. How these issues are presented to the public, and how the public responds to them, will continue to be important to public perceptions of nuclear facilities of all kinds. Uranium mining and milling, fuel processing, reactors, weapons production, reprocessing, transportation, waste management, decommissioning of facilities, and waste storage all have their technical as well as their public opinion components.

We do not understand fully how the technical and public opinion factors overlap and influence each other in the case of nuclear power. Nor do we fully understand how information about nuclear events carries over time and space. According to research done on the "social amplification of risk," nuclear events seem to have an exceptional ability to impress the public and they seem to carry important "signals" of potential difficulties (Kasperson *et al.*, 1988; Kasperson, 1992).

Let us recall for a moment that the public strongly views Three Mile Island as evidence that nuclear power poses serious risks even though the events of the accident took place well over a decade ago (in 1979) and since that time the industry in the United States has compiled a history of hundreds of years of operations without any comparable failure. This perception of risk has been reinforced by the 1986 accident at Chernobyl in the Ukraine and by the failures of other highly technical systems in modern society, such as the NASA/Challenger accident and the chemical plant failure at Bhopal, India.[4] Obviously we cannot go into these topics today, but we need to recognize that a wide range of events combine to form public risk perceptions, and that understanding the "social amplification of risk" is very important to understanding public responses to nuclear facilities.

4/ The Angus Reid focus group studies report that Three Mile Island and Chernobyl are important items in people's associations with the word "nuclear." The nuclear fears driven by such associations "were mentioned often in all the groups" (Angus Reid Group, 1991b, p. 5).

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Perceptions of Risk

Risk perception research examines the opinions and attitudes that people express when they are asked to evaluate some of the hazards in life. Numerous studies carried out within an approach called the *psychometric paradigm* have shown that perceived risk is quantifiable and predictable. While this area of research has demonstrated that "risk" means different things to different people, it has also shown that every hazard has a unique pattern of qualities that appear to be related to its perceived risk.

Many of the qualitative risk characteristics that make up a hazard's profile can be elicited from respondents and the results show that these characteristics tend to be highly correlated with each other across a wide range of hazards. Figure 1 presents a spatial representation of hazards collected from more than 40,000 individual ratings of 81 hazards for 15 characteristics per hazard. Factor analysis was used to condense the information into a small set of higher-order characteristics or factors.[5]

Subsequent research has replicated these findings numerous times and has shown that public risk perceptions and attitudes are closely related to the position of the hazard within the factor space.

The most important factor is "Dread Risk." The higher the score on this factor, the higher its perceived risk, the more people want to see its current risk reduced, and the more they want to see strict regulation. In contrast, expert risk perceptions are not closely related to these factors (e.g., dread risk) but are synonymous with expected annual mortality. This contrast suggests that experts and public definitions of risk are based upon different concepts. In such cases, expert presentations of "risk statistics" can be expected to have little influence on public opinions and attitudes. To many in the public, the information that the risks from nuclear power are small compared to the risks from smoking or driving automobiles is simply irrelevant.

Perhaps the most important message from risk-perception research is that there is wisdom as well as error in public attitudes and perceptions. Lay people sometimes lack certain information about hazards. However, their basic conceptualization of risk reflects legitimate concerns that are typically omitted by expert risk assessments.

In looking at the factor space along the "dread risk" axis we can see that nuclear hazards occupy a unique and extreme place. This suggests that communications to support nuclear power by claiming that it is safe will confront a resistant public that sees potential catastrophe. Arguments that the public is mistaken, and that the hazards of nuclear power are more acceptable than the public commonly thinks, are unlikely to be powerful enough to gain much support.

The public also must have a much higher degree of trust and confidence in those who will manage the hazards of nuclear power than is the case today. One component of that trust will be based upon a belief that the experts share the public values and concerns. It is not just *public* relations and *public* education and *public* information that is needed; equally necessary is education of the experts about the public values, perceptions, expectations, and ways of thinking.

The Role of Trust and Confidence

In the last few years the issue of trust and confidence, as it applies to nuclear facilities, has been suggested as a key to understanding public attitudes and opinions (Slovic, Flynn and Layman, 1991).[6] Social scientists doing research in this field have demonstrated that

5/ The classic statement of the psychometric paradigm studies of risk is found in P. Slovic, 1987.

6/ Several interesting essays are contained in Gambetta, 1988. On a more applied level, the US Secretary of Energy created a Task Force on Radioactive Waste Management in May, 1991, specifically to address the issue of public trust and confidence and to provide recommendations and guidance for promoting trust and confidence in the DOE programs. The record of their hearings and findings is forthcoming.

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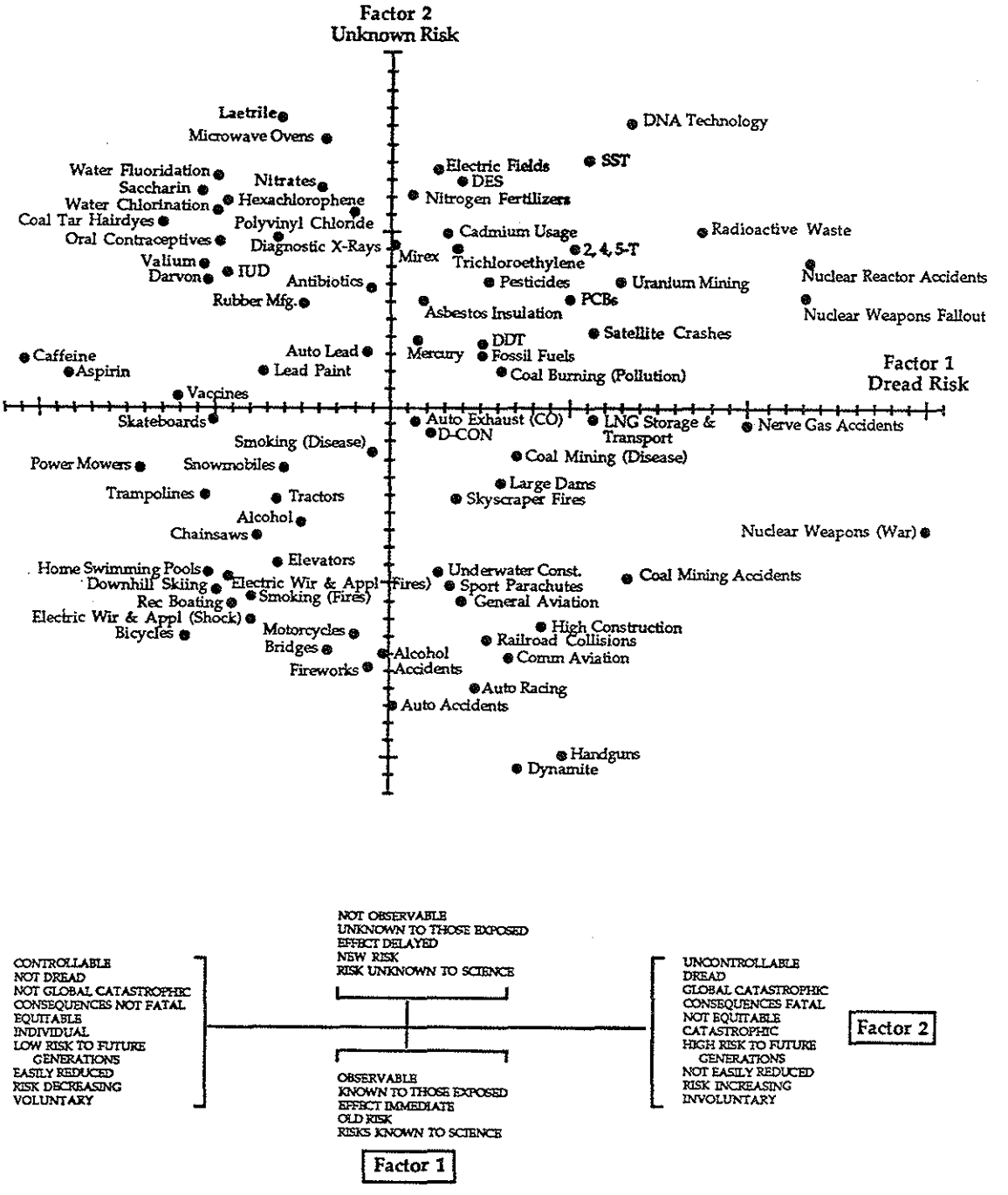

Figure 1: Location of 81 hazards on factors 1 and 2 derived from the interrelationships among 15 risk characteristics. Each factor is made up of a combination of characters, as indicated by the lower diagram.

Source: Redrawn from Slovic (1987).

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there is a highly correlated relationship between trust in nuclear management and perceptions of risk. This has been shown with data from several recent surveys dealing with the United States high-level radioactive waste program. A recent article in *Risk Analysis* presents the results of a causal model analysis of survey data and finds that trust influences both perceptions of risk and support (or opposition) for a radioactive waste repository (Flynn et al., 1992). If the findings about trust and its relationship to perceptions of risk, and to support for nuclear facilities, hold true for other nuclear facilities, then some important implications follow.[7]

The information shown in Figure 2 is derived from a structural model analysis of survey data.[8] The survey took place in the Fall, 1989 and included a sample of residents in the State of Nevada. The model that was tested included the "constructs" of standard effects (new jobs and public revenues), stigma effects (loss of tourism and labelling of the state as "nuclear waste state"), risk perceptions, and trust. The central importance of trust and risk perceptions are clear. The role of economic benefits is small—although this may be quite different for other populations and places—and the potential for stigma impacts is important but almost wholly determined by the risk perceptions.

Of these "constructs" or "latent variables," trust is probably the least well understood or defined. We all have ideas about what trust is and we intuitively understand how fragile it is—one instance of betrayal or dishonesty can easily destroy trust forever—but it has not been well defined as a variable for social science research.[9] First, we are going to have to understand more about what trust is and its relationship to perceptions of risk and approval of nuclear risk management. In particular, we will have to think carefully about the relationship between trust and some of our basic democratic processes. Do the adversarial processes that are embedded in our political heritage add to, or subtract from, the trust and confidence that is needed to manage the existing and emerging hazards of modern technology?

What are the conditions that compromise trust and confidence, and how can these be addressed? For example, companies must make a profit in order to stay in business—but the public sees the profit motive as conflicting with the requirements for safety and attention to public concerns. In short, people who are motivated to make money are not easily trusted by their customers, clients, or markets.

Regulators must both protect the industry and its future **and** discipline the industry and directly address the cost implications of public concerns. The public sees this as an inherent conflict of interest. How can regulation be accomplished and public trust and confidence increased at the same time? How are decisions to be made about potential distributions of costs and benefits resulting from nuclear power, including potential stigma effects?

How are incidents and accidents to be managed? Both short- and long-term costs should be considered. The question is not just what are we spending in immediate dollars, but what are we spending in units of trust and what are the real costs over time of those trust decisions.

Then there is the question of distrust. Is distrust a lack of trust which can be measured on a scale (for example, from 0-10—"no trust to complete trust"), as we have done in the past, or do these two concepts belong on different scales altogether? Preliminary experimental data suggests that people will have a different response to information depending upon

7/ Decision Research is currently designing and conducting major surveys in the United States and France on issues related to nuclear power including trust and confidence in utility management.

8/ This approach defines a causal model and uses a confirmatory multivariate method known as covariance structure analysis to test the model with data, in this case from the 1989 Nevada survey.

9/ Decision Research is now studying the structure, meaning, and role of trust under a grant from the National Science Foundation and the Electric Power Research Institute.

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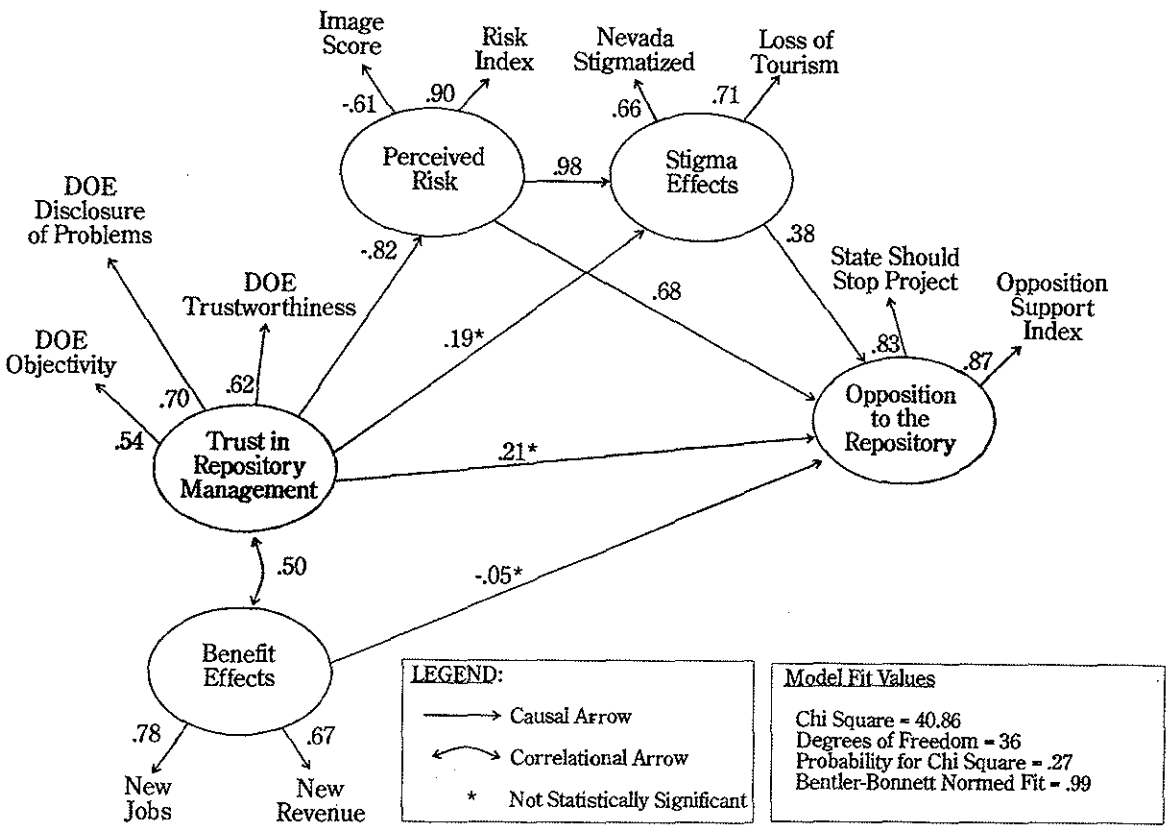

Figure 2: Covariance structure model to examine public opposition to the Nevada Repository: results with 1989 survey data.

Source: Flynn *et al.*, 1992.

whether they classify the source (e.g., the nuclear industry or an environmental activist group) as trusted or distrusted before they hear the messages and reports.[10]

The Public and the Future of Nuclear Power

A number of years ago there was a popular bumper sticker that said: "If you think education is expensive, then try ignorance." I suppose that this was popular with teachers, especially those looking for a raise in their salaries. At the risk of appearing to make an analogous recommendation, I would observe that the future of nuclear power is intimately joined with the public attitudes and opinions. This means that it rests on public perceptions of risk, trust, and the cost/benefits of stigma effects as well as the traditional economic benefits of electric production, jobs and tax revenues. Unfortunately, neither the industry, government, nor social science knows enough about the dynamics of these public conditions to effectively engage the public so they will support development of potentially hazardous new technologies, especially those with a nuclear component.

Now we are faced with campaigns for a new generation of nuclear power. Before we

10/ These experiments were conducted earlier in 1992 by Decision Research with University of Oregon students as part of a grant funded by the National Science Foundation and the Electric Power Research Institute to study trust.

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spend billions of dollars pursuing a path that is leading to failure, we should pause to confront the problems of trust and public attitudes toward nuclear power. Establishing trust in risk management must be given a top priority, but a solution to the problem of trust is not apparent. The problem goes beyond the nuclear industry (e.g., the chemical industry is similarly troubled). These problems are not due to public ignorance or irrationality, but are deeply rooted in individual and social psychology, and in the nature of our institutional, legal, and political systems of risk management. Creating workable agreements with communities and institutions to settle the risk perception and trust problems will be difficult, and such efforts will require much more understanding of, and cooperation with, the public than has been achieved in the past.

We can be sure, however, that without a serious effort to address the problems of trust, perceptions of risk, and the decision processes that characterize the multitude of publics involved, a rebirth of nuclear power will not take place.

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