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Perceived Risk, Trust, and the Politics of Nuclear Waste

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The Department of Energy's program for disposing of high-level radioactive wastes has been impeded by overwhelming political opposition fueled by public perceptions of risk. Analysis of these perceptions shows them to be deeply rooted in images of fear and dread that have been present since the discovery of radioactivity. The development and use of nuclear weapons linked these images to reality and the mishandling of radioactive wastes from the nation's military weapons facilities has contributed toward creating a profound state of distrust that cannot be erased quickly or easily. Postponing the permanent repository and employing dry-cask storage of wastes on site would provide the time necessary for difficult social and political issues to be resolved.

BY THE YEAR 2000, THE UNITED STATES WILL HAVE A projected 40,000 metric tons of spent nuclear fuel stored at some 70 sites and awaiting disposal. By 2035, after all existing nuclear plants have completed 40 years of operation, there will be approximately 85,000 metric tons (*1*). The U.S. Department of Energy (DOE) has been under intense pressure from Congress and the nuclear industry to dispose of this accumulating volume of high-level waste since the passage of the Nuclear Waste Policy Act in 1982 and its amendment in 1987, by which Yucca Mountain, Nevada, was selected as the only candidate site for the nation's first nuclear waste repository. The lack of a suitable solution to the waste problem is widely viewed as an obstacle to further development of nuclear power and a threat to the continued operation of existing reactors, besides being a safety hazard in its own right.

Yet, at this time, the DOE program has been brought nearly to a halt by overwhelming political opposition, fueled by perceptions of the public that the risks are immense (*2–7*). These perceptions stand in stark contrast to the prevailing view of the technical community, which argues that nuclear wastes can be disposed of safely, in deep underground isolation (*8–10*). Officials from DOE, the nuclear industry, and their technical experts are profoundly puzzled, frustrated, and disturbed by public and political opposition that many of them consider to be based on irrationality and ignorance. Lewis, for example, argued that the risk

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from a properly constructed repository "... is as negligible as it is possible to imagine.... It is embarrassingly easy to solve the technical problems, yet impossible to solve the political problems.... High-level nuclear waste disposal is a non-risk" (*9*, pp. 245–246).

A number of important events during the past several years underscore the seriousness of this problem.

1) Official opposition by the State of Nevada has increased substantially. In June 1989, the Nevada legislature passed Assembly Bill 222, making it unlawful for any person or governmental entity to store high-level radioactive waste in the state. The state attorney general subsequently issued an opinion that the Yucca Mountain site had been effectively vetoed under a provision of the Nuclear Waste Policy Act. The governor instructed state agencies to disregard DOE's applications for environmental permits necessary to investigate the site. The state and DOE initiated federal lawsuits over continuance of the program and issuance of the permits needed for on-site studies. In September 1990, the 9th U.S. Circuit Court of Appeals ruled that the state had acted improperly and ordered Nevada officials to issue the permits. Nevada appealed to the Supreme Court, which let stand the prior ruling. Although state officials have, under duress, begun to accept and process DOE permit applications, the governor and other elected officials have announced that their opposition to the repository will not diminish.

2) In November 1989, DOE, admitting dissatisfaction with its technical assessments of the Yucca Mountain site, announced that it would essentially start over with, "for the first time," an integrated, responsible plan. This plan would subject technical studies to close outside scrutiny to ensure that decisions about Yucca Mountain would be made "solely on the basis of solid scientific evidence" (*11*).

3) In July 1990, the National Research Council's Board on Radioactive Waste Management issued a strong critique of the DOE program, charging that DOE's insistence on doing everything right the first time has misled the public by promising unattainable levels of safety under a rigid schedule that is "... unrealistic, given the inherent uncertainties of this unprecedented undertaking," and thus vulnerable to " 'show stopping' problems and delays that could lead to a further deterioration of public and scientific trust" (*12*, p. 1). The board recommended, instead, a more flexible approach, permitting design and engineering changes as new information becomes available during repository construction and operation.

Perceptions of risk from radiation, nuclear power, and nuclear waste play a pivotal role in this story and need to be thoroughly understood if we are to make any progress in resolving the current impasse. In this article, we summarize research designed to penetrate the surface veneer of nuclear fear and opposition and provide insight into the nature of people's concerns, the origins of these concerns, the emotions that underlie them, and their implications for policy.

Attitude and Opinion Surveys

There have been more than a dozen surveys conducted during the past 5 years to assess public attitudes and opinions regarding the management of high-level radioactive wastes (*2, 5, 13–15*). The picture that emerges is uniformly negative.

One of the more extensive surveys was conducted in the fall of 1989 by Flynn *et al.* (*15*). More than 2500 respondents were questioned by telephone about their perceptions of the risks and benefits associated with a nuclear waste repository, their support of or opposition to the DOE repository program, their trust in the ability of DOE to manage the program, and their views on a variety of other issues pertaining to radioactive waste disposal. In addition to a national survey, data were collected from two other populations of special interest: residents of Nevada, the state selected as the site for the proposed national repository, and residents of Southern California, the major source of tourism and migration to Nevada.

When asked to indicate the closest distance they would be willing to live from each of ten facilities, the median distance from an underground nuclear waste repository was 200 miles in each of the three surveys, twice the distance from the next most undesirable facility, a chemical waste landfill, and three to eight times the distances from oil refineries, nuclear power plants, and pesticide manufacturing plants. In response to the statement, "Highway and rail accidents will occur in transporting the wastes to the repository site," the percentage of respondents who agreed or strongly agreed was 77.4% in Nevada, 69.2% in California, and 71.6% nationally. Similar expectations of problems were expressed with regard to future earthquake or volcanic activity at the site, contamination of underground water supplies, and accidents while handling the material during burial operations.

When asked whether a state that does not produce high-level nuclear wastes should serve as a site for a nuclear waste repository, 67.9% of the Southern California and 76.0% of the national respondents answered "no" (the question was not asked in Nevada). A majority of those polled in the Southern California and national surveys judged a single national repository to be the least fair of five disposal options (the other options were storage at each nuclear plant, in each state, in each of several regions, and dual repositories in the East and West).

Strong distrust of the DOE was evident from the responses to statements such as, "The U.S. Department of Energy can be trusted to provide prompt and full disclosure of any accidents or serious problems with their nuclear waste management programs." In Southern California, 67.5% either somewhat or strongly disagreed with this statement. The corresponding rate of disagreement in the national survey was 68.1%.

Nevadans were asked whether or not they would vote in favor of a repository at Yucca Mountain; 69.4% said they would vote against it, compared to 14.4% who would vote for it. About 68% of the Nevadans surveyed said they agreed strongly with the statement, "The State of Nevada should do all it can to stop the repository"; another 12.5% agreed somewhat with this statement; only 16.0% disagreed. When asked whether or not they favored Assembly Bill 222, making it illegal to dispose of high-level nuclear waste in Nevada, 74% were in favor and 18.4% were opposed. Finally, 73.6% of Nevadans said that the state should continue to do all it can to oppose the repository even if that means turning down benefits that may be offered by the federal government; 19.6% said the state should stop fighting and make a deal.

Follow-up surveys of Nevada residents in October 1990 and March 1991 suggest that opposition and distrust have risen (*16*). The percentage of Nevadans who would vote against a repository at Yucca Mountain increased from 69.4 to 80.2%. In response to a request to indicate "how much you trust each of the following to do what is right with regard to a nuclear waste repository at Yucca Mountain," the governor of Nevada topped the list of officials, agencies, and institutions. DOE, the Nuclear Regulatory Commission (NRC), and the U.S. Congress were the least trusted entities. Between 1989 and 1991, strong increases in trust were evident for the governor of Nevada and the Nevada state legislature. In contrast, trust in DOE and NRC declined between 1989 and 1991.

Imagery and Perception

Before answering any of the attitude or opinion questions, respondents in the national, Southern California, and Nevada surveys, along with respondents in a survey of 802 residents of Phoenix, were asked to associate freely about the concept of a nuclear waste repository (*7*). The method of continued associations (*17*) was used to evoke images, perceptions, and affective states related to a repository. Respondents were asked to indicate the first thoughts or images that come to mind when they think of an underground nuclear waste repository.

The 3,334 respondents in the four surveys produced a combined total of exactly 10,000 word-association images to the repository stimulus. The associations were examined and assigned to 13 general categories (*18*). All but one general category contained subcategories. In all, there were 92 distinct subcategories. Many of these contained multiple associations, judged to have similar meanings. For example, the subcategory labeled "dangerous/toxic," within the general category labeled "negative consequences," included the terms "danger, dangerous, unsafe, disaster, hazardous, poisonous," and so on.

The two largest categories, "negative consequences" and "negative concepts," and their combined frequencies across all four samples are shown in Table 1. The subcategories are also shown, ordered by frequency within their superordinate category. The most arresting and most important result is the extreme negative quality of these images. These two largest categories accounted for more than 56% of the total number of images. The dominant subcategory, "dangerous/toxic," contained almost 17% of the total number of images. The five largest subordinate categories—"dangerous/toxic, death/sickness, environmental damage, bad/negative, and scary"—were thoroughly negative in affective quality and accounted for more than 42% of the total number of images. The four most frequent single associations were "dangerous" (n = 539), "danger" (n = 378), "death" (n = 306), and "pollution" (n = 276).

Positive imagery was rare. A general category labeled "positive" accounted for only 1% of the images. Other positive concepts, "necessary," "employment," and "money/income" combined to total only 2.5% of the images. The response "safe" was given only 37 times (0.37%). In addition, there were 232 associations pertaining to war, annihilation, weapons, and things military. The famous NIMBY position (not in my backyard) was expressed in 273 images.

Table 1. Dominant images of a nuclear waste repository: totals for four surveys.

Image categories	n
Negative consequences	
Dangerous/toxic	1683
Death/sickness	783
Environmental damage	692
Leakage	216
Destruction	133
Pain and suffering	18
Uninhabitable	7
Local repository area consequences	6
Negative consequences—other	8
Total	3546
Negative concepts	
Bad/negative	681
Scary	401
Unnecessary/opposed	296
Not near me	273
War/annihilation	126
Societally unpopular	41
Crime and corruption	40
Decay/slime/smell	39
Darkness/emptiness	37
Negative toward decision-makers and process	32
Commands to not build or to eliminate them	24
Wrong or bad solution	19
No nuclear, stop producing	15
Unjust	14
Violence	10
Prohibited	5
Negative—other	15
Total	2068

Associations indicative of distrust appeared in the category "negative toward decision-makers and process," and in another subcategory dealing with mistakes. A number of images in the "bad/negative" category also seemed to reflect lack of trust (for example, "stupid," "dumb," "illogical").

Jones *et al.* (*19*) have attempted to characterize the key dimensions of stigma. Two such defining characteristics are peril and negative aesthetic qualities (ugliness and repulsion). These qualities dominate the repository images. Peril is pervasive throughout the "negative consequences" category and negative aesthetics and repulsion form the bulk of "negative concepts" (Table 1). Indeed, the large subcategory "bad/negative" is remarkable in its reflection of antagonism and hostility toward the repository concept. Common responses in this category were "terrible," "ugly," "disgusting," "anger," "evil," "insane," "hate it," and, simply, "bad" (107 responses). Associations indicating locations ("desert," "Nevada," "underground") and concepts such as "radiation," "nuclear," and "chemicals" made up the bulk of the responses not covered in Table 1.

The images were similar in content and frequency from one survey to another. Demographic differences were also small. The negativity of repository images was remarkably consistent across men and women of different ages, incomes, education levels, and political persuasions.

After free-associating to the repository stimulus, each respondent in the Nevada survey rated the affective quality of his or her associations on a five-point scale ranging from extremely negative to extremely positive. These affective ratings were highly correlated with the respondent's attitudes and perceptions of risk. For example, more than 90% of the persons whose first image was judged very negative said they would vote against a repository at Yucca Mountain; more than half of the persons whose first image was judged positive would vote in favor of the repository. A similarly strong relationship was found between affective ratings of images and a person's judgment of the likelihood of accidents or other problems at a repository. Negativity of the image rating was also strongly related to support for the state of Nevada's opposition to the repository program.

What was learned by asking 3334 people to associate freely to the concept of a nuclear waste repository? The most obvious answer is that people do not like nuclear waste. However, these images (as well as the responses to the attitude and opinion questions) demonstrate an aversion so strong that to label it a "dislike" hardly does it justice. What these responses reveal are pervasive qualities of dread, revulsion, and anger—the raw materials of stigmatization and political opposition.

Because nuclear waste is a by-product of an impressive technology capable of producing massive amounts of energy without contributing to greenhouse gases, one might expect to find associations to energy and its benefits—electricity, light, heat, employment, health, progress, the good life—scattered among the images. Almost none were observed.

Moreover, people were not asked to reflect on nuclear waste; instead, they were asked about a storage facility or repository. One might expect, following the predominant view of experts in this field, to find a substantial number of repository images reflecting the qualities "necessary" and "safe." Few images of this kind were observed.

How Did It Get This Way?

Imagery and attitudes so negative and so impervious to influence from the assessments of technical experts must have very potent origins. Weart's (*20*) historical analysis shows that nuclear fears are deeply rooted in our social and cultural consciousness. He demonstrates that modern thinking about nuclear energy employs beliefs and symbols that have been associated for centuries with the concept of transmutation—the passage through destruction to rebirth. In the early decades of the 20th century, transmutation images became centered on radioactivity, which was associated with "uncanny rays that brought hideous death or miraculous new life; with mad scientists and their ambiguous monsters; with cosmic secrets of death and life. . . . and with weapons great enough to destroy the world . . ." (*20*, p. 421).

This concept of transmutation has a duality that is hardly evident in the imagery observed in the surveys. Why has the destructive aspect predominated? The answer likely involves the bombings of Hiroshima and Nagasaki, which linked the frightening images of nuclear energy to reality. The sprouting of nuclear power in the aftermath of the atomic bombing led Smith (*21*) to observe: "Nuclear energy was conceived in secrecy, born in war, and first revealed to the world in horror. No matter how much proponents try to separate the peaceful from the weapons atom, the connection is firmly embedded in the minds of the public" (*21*, p. 62).

Research supports Smith's assertions. Fiske, Pratto, and Pavelchak (*22*) elicited people's images of nuclear war and obtained results that were similar to the repository images described above. A study by Slovic, Lichtenstein, and Fischhoff (*23*) found that, even before the accident at Three Mile Island, people expected nuclear reactor accidents to lead to disasters of immense proportions. When asked to describe the consequences of a "typical reactor accident," people's scenarios were found to resemble scenarios of the aftermath of nuclear war (*24*). The shared imagery of nuclear weapons, nuclear power, and nuclear waste may explain why a nuclear waste repository is judged by the public to pose risks at least as great as a nuclear power plant or a nuclear weapons test site (*5*).

Further insights into the special quality of nuclear fear are provided by Erikson (*26*), who describes the exceptionally dread quality of accidents that expose people to radiation. Unlike natural disasters, these accidents have no end. "Invisible contaminants remain a part of the surroundings—absorbed into the grain of the landscape, the tissues of the body and, worst of all, into the genetic material of the survivors. An 'all clear' is never sounded. The book of accounts is never closed" (*26*, p. 121).

Another strong determiner of public perceptions is the continuing story of decades of mishandling of wastes at the nation's military weapons facilities, now operated by DOE (*27*). Leakage from these facilities has resulted in widespread contamination, projected to require more than $150 billion for cleanup over the next 30 years. The recent revelation of unprecedented releases of radiation from the Hanford, Washington, weapons plant in the 1940s and 1950s (*28*) will certainly compound the negative imagery associated with a nuclear waste repository and further undermine public trust in government management of nuclear waste disposal.

A Crisis of Confidence

The fear and revulsion evoked in the general public by the thought of a nuclear waste repository stand in contrast to the confidence that most technical analysts and engineers have in their ability to dispose of radioactive materials safely. Even the report of the National Research Council (*12*), though highly concerned about the difficulties of predicting the long-term performance of a repository, conceded that "these uncertainties do not necessarily mean that the risks are significant, nor that the public should reject efforts to site the repository" (*12*, p. 13).

Starr has argued that "acceptance of any risk is more dependent on public confidence in risk management than on the quantitative estimates of risk. . . " (*29*, p. 98). Public fears and opposition to nuclear waste disposal plans can be seen as a "crisis of confidence," a profound breakdown of trust in the scientific, governmental, and industrial managers of nuclear technologies. The breakdown of trust was clearly evident at the time the Nuclear Waste Policy Act was signed (*30, 31*) and has been documented repeatedly in subsequent public opinion surveys (*2, 15, 32–34*).

Viewing the nuclear waste problem as one of distrust in risk management gives important insights into its intractability. Social psychological studies (*35*) have validated "folk wisdom" by demonstrating that trust is a quality that is quickly lost and slowly (if ever) regained. A single act of embezzlement is enough to convince us that our bookkeeper is untrustworthy. A subsequent opportunit to embezzle that is not taken would likely do little to reduce the degree of distrust. Indeed, 100 subsequent honest actions would probably do little to restore our trust in this individual.

In this light, the attempt by DOE to regain the confidence of the public, Congress, and the nuclear industry by rearranging its organizational chart and promising to do a better job of risk management and science in the future (*11*) was naive. Trust, once lost, cannot so easily be restored. Similarly naive is the aim professed by DOE officials and other nuclear industry leaders to change perceptions and gain support by letting people see firsthand the safety of nuclear waste management. The nature of any low-probability, high-consequence threat is such that adverse events will demonstrate riskiness but demonstrations of safety (or negligible risk) will require a very long time, free of damaging incidents. The intense scrutiny given to nuclear power and nuclear waste issues by the news media (*36, 37*) ensures that a stream of problems, occurring all over the world, will be brought to the public's attention, continually eroding trust.

Where Next for Nuclear Waste?

Although everyone recognizes the sophisticated engineering required to store nuclear wastes safely, the political requirements necessary to design and implement a repository have not similarly been appreciated. As a result, notes Jacob, "While vast resources have been expended on developing complex and sophisticated technologies, the equally sophisticated political processes and institutions required to develop a credible and legitimate strategy for nuclear waste management have not been developed" (*30*, p. 164).

In the absence of a trustworthy process for siting, developing, and operating a nuclear waste repository, the prospects for a short-term solution to the disposal problem seem remote. The report of the National Research Council (*12*) is quite sensitive to issues of risk perception and trust, but makes the strong assumption that trust can be restored by a process that openly recognizes the limits of technical understanding and does not aim to "get it right the first time." It seems likely that such open admission of uncertainty and refusal to guarantee safety might well have opposite effects from those intended—increased concern and further deterioration of trust. Moreover, the National Research Council statement also assumes that DOE will continue to manage the nuclear waste program, thus failing to come to grips with the difficulties that agency will face in restoring its tainted image.

The lack of a trustworthy process for siting, developing, and operating a nuclear waste repository has evoked numerous other comments and suggestions. Weinberg (*38*) draws an analogy between fear of witches during the 15th through 17th centuries and today's fear of harm from radiation. He hypothesizes that "rad-waste phobia" may dissipate if the intelligentsia (read environmentalists) say that such fears are unfounded, much as eventually happened with fears of witches. Carter argued that "trust will be gained by building a record of sure, competent, open performance that gets good marks from independent technical peer reviewers and that shows decent respect for the public's sensibilities and common sense" (*39*, p. 416). Others have called for more radical changes, such as creating new organizations to take over DOE's management role (*40, 41*) and developing procedures to ensure that state, local, and tribal governments have a strong voice in siting decisions and oversight of actual repository operations (*30, 42, 43*). In this spirit, an official of the Canadian government has argued for making repository siting in that country voluntary by requiring public consent as an absolute prerequisite for confirming any decision (*44*).

Whatever steps are taken, it is unlikely that the current "crisis in confidence" will be ended quickly or easily. We must settle in for a long effort to restore the public trust. Krauskopf (*45*) has argued that postponing the repository to an indefinite future can be defended on a variety of technical grounds and points out that the choice between repository construction or postponement ultimately rests on the shoulders of the public and their elected representatives. The problems of perception and trust described above imply that postponement of a permanent repository may be the only politically viable option in the foreseeable future.

In an address to the National Association of Regulatory Utility Commissioners in November 1990, Joseph Rhodes, Jr., a commissioner from Pennsylvania, pointed out the implications of the polls indicating that most Nevadans oppose the siting of a repository anywhere in Nevada and want state leaders to oppose such siting with any means available (*46*). "I can't imagine," said Rhodes, "that there will ever be a usable Yucca Mountain Repository if the people of Nevada don't want it. . . . There are just too many ways to delay the program . . . (*46*, p. 6).

What are the options in the light of insurmountable public opposition to a permanent underground repository? Rhodes lists and rejects several: (i) Continuing on the present path in an attempt to site a permanent repository is a costly and doomed effort. (ii) Permanent on-site storage is unsafe. (iii) Deploying a monitored retrievable storage (MRS) program is also politically unacceptable. Without a viable program to develop a permanent repository, the MRS would be seen, in effect, as the permanent site. (iv) Reprocessing the spent nuclear fuel is also politically unacceptable because of concerns over nuclear weapons proliferation. Moreover, reprocessing reduces but does not eliminate high-level wastes, and the record of managing reprocessing residues at West Valley, Hanford, and other sites is hardly encouraging (*27, 39, 47*).

Rhodes concludes, and we concur, that the only viable option is to postpone the siting of a permanent repository and store the wastes on site in the interim—employing dry-cask storage that has been certified by NRC as being as safe as geological storage for 100 or more years (*48*). Should this course of action be followed, technical knowledge will undoubtedly advance greatly during this interim period. Perceptions of risk and trust in government and the nuclear industry may change greatly, too, if the problem of establishing and maintaining trust is taken seriously.

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