PERCEPTION OF RISK AND THE FUTURE OF NUCLEAR POWER

Paul Slovic*

I. INTRODUCTION

Scientists and policy makers were slow to recognize the importance of public attitudes and perceptions in shaping the fate of nuclear power. In 1976, Alvin Weinberg observed:

> As I compare the issues we perceived during the infancy of nuclear energy with those that have emerged during its maturity, the public perception and acceptance of nuclear energy appears to be the question that we missed rather badly . . . This issue has emerged as the most critical question concerning the future of nuclear energy.[1]

Today, fifteen years later, the problem of public acceptance is even more critical. Either the problem is damn tough or we haven't been working hard enough to solve it (I suspect that both of these assertions are true). Driven by a number of powerful forces and events, public support for nuclear power has declined for a decade and a half. In mid-March of 1979, the movie The China Syndrome had its premier, dramatizing the worst-case predictions of the earliest risk assessment studies. Two weeks later, events at Three Mile Island made the movie appear prophetic. Succeeding years have brought us Chernobyl and other major technological disasters, most notably Bhopal and the Challenger accident. The public has drawn a common message from these accidents: that nuclear (and other) complex technology is unsafe, that expertise is inadequate, and that government and industry cannot be trusted to manage nuclear power safely. These dramatic accidents and the distrust they have spawned have been reinforced by numerous chronic problems involving radiation, such as the discovery of significant radon concentrations in many homes, the continuing battles over the siting of facilities to store or dispose of nuclear wastes, and the disclosures of serious environmental contamination emanating from nuclear weapons facilities (at Hanford, Fernald, Rocky Flats, and Savannah River).

---

* Paul Slovic is President of Decision Research in Eugene, Oregon and Professor of Psychology at the University of Oregon. An earlier version of this paper appeared as Paul Slovic, *Perception of Risk and the Future of Nuclear Power, in* Proceedings of the First MIT International Conference on the Next Generation of Nuclear Power Technology § 6, at 1 (M. Golay ed., 1991).

1. *See* A.M. Weinberg, *The Maturity and Future of Nuclear Energy*, 64 Am. Scientist 16 (1976).

II. PSYCHOMETRIC STUDIES OF RISK PERCEPTION

Not surprisingly, the nature and determinants of public attitudes and perceptions regarding nuclear power have been the focus of considerable research. The psychometric approach to studying risk perception[2] assumes that hazards can be characterized in terms of numerous characteristics or dimensions, analogous to the personality traits that characterize people. Nuclear power has a special distinction in the perception literature. It is, to date, the technological hazard with the most negative and most problematic constellation of traits. It stands apart in having qualities that make it fearsome and hard to manage socially and politically.

The mapping of nuclear power's "personality" began in the mid-1970s with a series of psychometric studies designed to determine why people were very concerned about some hazards and not others, and why these concerns often differed from experts' assessments of risk.[3] An early study assessed perceived risk of death (for the United States as a whole) from 30 activities and technologies. Three groups of lay people and a small group of risk assessment professionals took part in the study.[4] The results demonstrated great concern regarding nuclear power (it had the highest perceived risk for two of the lay groups). The results also demonstrated great disparity between the perceptions of laypeople and experts (whose ratings placed nuclear power 20th from the top of the list of 30 hazards).

Some have argued that public concern about nuclear power reflects a concern about radiation risk in general. However, the groups of laypeople in this study rated another radiation technology, medical x-rays, rather low in risk (17th-24th); whereas, the experts rated it relatively high (7th). Apparently it was not radiation per se that was a concern to these people, but radiation as one may become exposed to through the technology of nuclear power.

In an attempt to delve beneath the surface of these global judgments, respondents were also asked to rate nuclear power, x-rays, and other hazards on a number of dimensions or attributes presumed relevant to perception and acceptance of risk. These ratings showed that nuclear power had the dubious distinction of scoring at or near the extreme negative end for most of the characteristics. Its risks were seen as involuntary, unknown to science or those exposed, uncontrollable, unfamiliar, catastrophic, severe (fatal), and dreaded. Medical x-rays, in contrast, had a much more benign profile.

---

2. Paul Slovic, *Perception of Risk*, 236 Science 280 (1987).

3. *See generally* Baruch Fischhoff et al., *How Safe Is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits*, 9 Pol'y Stud. 137 (1978); Paul Slovic et al., *Facts and Fears: Understanding Perceived Risk, in* Societal Risk Assessment: How Safe is Safe Enough? 181 (R. Schwing & W.A. Albers Jr. eds., 1980).

4. Paul Slovic et al., *Images of Disaster: Perception and Acceptance of Risks from Nuclear Power, in* Energy Risk Management 223 (G.T. Goodman & W.D. Rowe eds., 1979).

Nuclear power's perceived benefits were also assessed and were found to be extremely low. These results have since been replicated with many different populations in numerous countries.[5] Perceptions of risk associated with nuclear waste and its management are similarly negative.[6] When asked to state whatever images or associations came to mind when they heard the words "underground nuclear waste storage facility," a representative sample of Phoenix, Arizona, residents could hardly think of anything that was not frightening or problematic (see Table 1). The disposal of nuclear wastes is a technology that experts believe can be managed safely and effectively. The discrepancy between this view and that of the laypeople shown in Table 1 is indeed startling.

The perception of nuclear power as a catastrophic technology was studied in depth by Slovic, Lichtenstein, and Fischhoff.[7] They found that, even before the accident at Three Mile Island ("TMI"), people expected nuclear power 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.[8] Replication of these studies after the TMI accident found even more extreme "images of disaster". The fact that the earliest technical risk assessments for nuclear power plants portrayed "worst-case scenarios" of tens of thousands of deaths and devastation over geographic areas the size of Pennsylvania likely contributed to such extreme images.[9] These early projections received enormous publicity, of which the movie The China Syndrome is an example.

---

5. *See generally* Tibor Englander et al., *A Comparative Analysis of Risk Perception in Hungary and the United States*, 1 Soc. Behav. 55 (1986); L.C. Gould et al., Perceptions of Technological Risks and Benefits (Russell Sage Foundation 1988); C.F. Keown, *Risks and Perceptions of Hong Kongese vs. Americans*, 9 Risk Analysis 401 (1989); M. Granger Morgan et al., *Powerline Frequency Electric and Magnetic Fields: A Pilot Study of Risk Perception*, 5 Risk Analysis 139 (1985); E. Rosa & R. Kleinhesselink, A Comparative Analysis of Risk Perceptions in Japan and the United States (presented at the annual meeting for Risk Analysis, S.F., Cal. 1989); Paul Slovic, *Risk Perception of Prescription Drugs: Report on a Survey in Sweden*, 4 Pharmaceutical Med. 43 (1989); Karl Halvor Teigen et al., *Societal Risks as Seen by a Norwegian Public*, 1 J. Behavioral Decision Making 111 (1988).

6. *See generally* J.H. Flynn et al., Evaluations of Yucca Mountain (on file at Nuclear Waste Project Office, Carson City, Nevada); H. Kunreuther, Nevada's Predicament: Public Perceptions of Risk from the Proposed Nuclear Waste Repository, 30(8) Environment 16, 30 (1988); Stanley M. Nealy & John A. Herbert, *Public Attitudes Toward Radioactive Wastes*, *in* Too Hot to Handle: Social and Policy Issues in the Management of Radioactive Wastes 151 (C.A. Walker et al. eds., 1983); Paul Slovic et al., *Perceived Risk, Stigma, and Potential Economic Impacts of a High-Level Nuclear Waste Repository in Nevada*, 11 Risk Analysis 683 (1991); Paul Slovic, *Perceived Risk, Trust, and Nuclear Waste: Lessons from Yucca Mountain*, 33(3) Environment 6, 28 (1991).

7. Slovic et al., *supra* note 4.

8. *Id.*

9. *See* Daniel F. Ford, The History of Federal Nuclear Safety Assessment: From WASH 740 Through the Reactor Safety Study (Union of Concerned Scientists ed., 1977).

III. ORIGINS OF NUCLEAR FEARS

The origins of people's fears about nuclear energy appear to be deeply rooted in our social and cultural consciousness. Weart argues that modern thinking about nuclear energy employs beliefs and symbols that for centuries have been associated with the concept of transmutation—the passage through destruction to rebirth.[10] 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 life and death; . . . and with weapons great enough to destroy the world . . . ."[11]

However, this concept of transmutation has a duality that is hardly evident in the imagery associated with nuclear power and nuclear wastes. Why has the evil overwhelmed the good? The answer undoubtedly involves the bombing of Hiroshima and Nagasaki, which linked this belief structure to reality. The sprouting of nuclear power in the aftermath of the atomic bombing has led Smith to observe that "[n]uclear 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."[12]

Further insights into the special quality of nuclear fear are provided by Erikson, who draws attention to the broad, emerging theme of toxicity, both radioactive and chemical, that characterizes a whole "new species of trouble" associated with modern technological disasters.[13] Erikson describes the exceptionally dread quality of technological accidents that expose people to radiation and chemicals in ways that "contaminate rather than merely damage; . . . pollute, befoul, and taint rather than just create wreckage; . . . penetrate human tissue indirectly rather than wound the surface by assaults of a more straightforward kind."[14] Unlike natural disasters, these accidents are unbounded. Unlike conventional disaster plots, they 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."[15]

---

10. *See generally* S. Weart, Nuclear Fear: A History of Images (1988).

11. *Id.* at 42.

12. K.R. Smith, *Perception of Risks Associated with Nuclear Power*, 4(1) Energy Env't Monitor 61, 62 (1988).

13. Kai Erikson, *Toxic Reckoning: Business Faces a New Kind of Fear*, Harv. Bus. Rev., Jan.-Feb. 1990, at 118.

14. *Id.* at 120.

15. *Id.* at 121.

IV. IMPACTS OF PERCEPTIONS

During the past decade, research has also shown that individual risk perceptions and cognitions, interacting with social and institutional forces, can trigger massive social, political, and economic impacts. Early theories equated the magnitude of impact to the number of people killed or injured, or to the amount of property damaged. The accident at TMI, however, provided a dramatic demonstration that factors besides injury, death, and property damage impose serious costs. Despite the fact that not a single person died at TMI, and few if any latent cancer fatalities are expected, no other accident in our history has produced such costly societal impacts.[16] In addition to its impact on the utility that owned and operated the plant, this accident also imposed enormous costs on the nuclear industry and on society. These costs came through stricter regulation, reduced operation of reactors worldwide, greater public opposition to nuclear power, reliance on more expensive energy sources, and increased costs of reactor construction and operation.

Kasperson et. al, have presented one theory aimed at describing how psychological, social, cultural, and political factors interact to "amplify risk" and produce ripple effects.[17] An important element of this theory is the assumption that the perceived seriousness of an accident or other unfortunate event, the media coverage the accident gets, and the long-range costs and other higher-order impacts on the responsible company, industry, or agency are determined, in part, by what the event signals or portends. Signal value reflects the perception that the event provides new information about the likelihood of similar or more destructive future mishaps.

The informativeness or signal value of an event, and thus its potential social impact, appears to be systematically related to the characteristics of the hazard. An accident that takes many lives may produce relatively little social disturbance (beyond that caused the victims' families and friends) if it occurs as part of a familiar and well-understood system (e.g., a train wreck). However, a small accident in an unfamiliar system (or one perceived as poorly understood), such as a nuclear reactor, may have immense social consequences if it is perceived as a harbinger of further (and possibly catastrophic) mishaps.

The concept of accidents as signals helps to explain our society's strong response to problems involving nuclear power and nuclear wastes. Because these nuclear hazards are seen as poorly understood and catastrophic, acci-

---

16. N. Evans & C. Hope, Nuclear Power: Futures, Costs, and Benefits (1984); Carolyn D. Heising & Varghese P. George, *Nuclear Financial Risk: Economy-Wide Costs of Reactor Accidents*, 14 Energy Pol'y 45 (1986).

17. Roger E. Kasperson et al., *The Social Amplification of Risk: A Conceptual Framework*, 8 Risk Analysis 177 (1988).

dents anywhere may be seen as omens of future disasters everywhere, thus producing large socioeconomic and political impacts.

V. A CRISIS OF CONFIDENCE

The research described above demonstrates extreme negative perceptions and attitudes associated with nuclear power. This degree of negativity is remarkable in light of the confidence most technical analysis have regarding the safety of nuclear technology. Chauncey Starr, pointing to the public's lack of concern about the risks from tigers in urban zoos, has argued that "acceptance of any risk is more dependent on public confidence in risk management than on the quantitative estimates of risk . . ."[18] Public fears and opposition to nuclear-waste disposal plans can be seen as a "crisis in confidence," a profound breakdown of trust in the scientific, governmental, and industrial managers of nuclear technologies.[19]

Viewing the nuclear-waste problem as one of distrust in risk management gives additional insights into its difficulty. Social psychological studies have validated "folk wisdom" by demonstrating that trust is a quality that is quickly lost and slowly regained.[20] A single act of embezzlement is enough to convince us that our accountant is untrustworthy. A subsequent opportunity to embezzle that is not taken does little to reduce that degree of distrust. Indeed, 100 subsequent honest actions would probably do little to restore our trust in this individual.

In this light, it is apparent that the odds are stacked against nuclear power. The nature of any low-probability/high-consequence threat is such that adverse events appear to demonstrate riskiness but demonstrations of safety require a very long time, free of damaging incidents or incidents perceived as damaging. As noted earlier, the high "signal value" associated with nuclear power mishaps assures that any significant problem, anywhere in the world, will be brought to the public's attention, thus continually eroding trust.

VI. THE FUTURE OF NUCLEAR POWER

What are the chances for a rebirth of nuclear power, driven by new reactor designs and a heightened awareness of the need for nuclear power (along with a growing awareness of the risks associated with other sources of energy)? Certainly an increased perception of benefit or need will increase public tolerance, if not public acceptance, of nuclear risks. Our society's

---

18. Chauncey Starr, *Risk Management, Assessment, and Acceptability*, 5 Risk Analysis 97 (1985).

19. *Id.*

20. Myron Rothbart & Bernadette Park, *On the Confirmability and Disconfirmability of Trait Concepts*, 50 J. Personality and Soc. Psychol. 131 (1986).

tolerance of nuclear weapons supports this fact. However, in the absence of revolutionary changes in the ways that nuclear risks are managed in our society, it is not likely that public trust, confidence, and acceptance can easily be regained. For example, although the consensus opinion of technical experts asserts that nuclear wastes can be sequestered with essentially no chance of any member of the public receiving a non-stochastic dose of radiation[21], public perceptions do not reflect this view. Why will the public be more likely to believe that the new generation of reactors are inherently safe? Weinberg argues that special interest environmental groups (skeptical elites) could turn the tide of public opinion by siding with nuclear power as a solution to the greenhouse problem.[22] It appears likely, however, that environmentalists will embrace conservation and energy efficiency rather than nuclear power.[23]

In the long run, an old problem dating to the birth of nuclear weapons may rear its head. As noted by Williams and Feiveson, to assure an adequate fuel supply, worldwide uranium shortages will provide strong motives for reprocessing spent nuclear fuel into plutonium, making it widely available as a stimulant for nuclear weapons proliferation.[24] So far we have been saved from this prospect because of the relatively slow development of civilian nuclear power, and the establishment of substantial international monitoring. Nevertheless, reborn nuclear power may accelerate the proliferation threat and require "unprecedented institutional changes" worldwide.

VII. CONCLUSION

Before we spend billions of dollars pursuing a path that is destined to lead to failure, we should pause for a moment to confront the problem of trust. Restoration and preservation of trust in risk management needs to be given top priority. A solution to the problem of trust is not immediately apparent. The problem goes beyond the nuclear industry (e.g., the chemical industry is similarly troubled). The problem is not due to public ignorance or irrationality, but is deeply rooted in individual psychology and in the adversarial nature of our social, institutional, legal, and political systems of risk management. Public relations efforts will not create trust. Aggressive and competent government regulation, coupled with increased public involve-

21. A.M. Weinberg, Public Perceptions of Hazardous Technologies and Democratic Political Institutions, *in* 1989 Proceedings of Waste Management '89.

22. *Id.*

23. J. Beyea, *Nuclear as Last Resort to Change in Climate*, 5 F. for Applied Res. and Pub. Pol'y 90 (1990).

24. R.H. Williams & H.A. Feiveson, *How to Expand Nuclear Power Without Proliferation*, 46(3) Bull. Atom. Scientists 40 (1990).

ment, oversight, and control, and a "trouble free" performance record might create such trust.

We can be sure, however, that without a serious effort to address the problem of trust, neither public acceptance nor a rebirth of civilian nuclear power in the United States will be achieved.

Table 1. Hierarchy of images associated with an "underground nuclear waste storage facility"

Category	*Frequency*	*Images Included in Category*
1. Dangerous	179	dangerous, danger, hazardous, toxic, unsafe, harmful, disaster
2. Death/Disease	107	death, sickness, dying, destruction, lethal, cancer, deformities
3. Negative	99	negative, wrong, bad, unpleasant, terrible, gross, undesirable, awful, dislike, ugly, horrible
4. Pollution	97	pollution, contamination, leakage, spills, Love Canal
5. War	62	war, bombs, nuclear war, holocaust
6. Radiation	59	radiation, nuclear, radioactive, glowing
7. Scary	55	scary, frightening, concern, worried, fear, horror
8. Somewhere Else	49	wouldn't want to live near one, not where I live, far away as possible
9. Unnecessary	44	unnecessary, bad idea, waste of land
10. Problems	39	problems, trouble
11. Desert	37	desert, barren, desolate
12. Non-NV Locations	35	Utah, Arizona, Denver
13. Storage Location	32	caverns, underground salt mine
14. Government/Industry	23	government, politics, big business

Source: Slovic et al., *Perceived Risk, Stigma, and Potential Economic Impacts of a High-Level Nuclear Waste Repository in Nevada, supra* note 6. (survey of 400 residents of Phoenix, Arizona).