# Chapter 36

# Nuclear energy: perceived risk, risk acceptability and communication

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## Introduction

In the 1970s and 1980s events such as the Three Mile Island accident in the US (1979) and the Chernobyl disaster in the Ukraine (1986) received considerable attention from the media and caused a growing discrepancy between the public's experienced levels of risk and their desired level of risk associated with nuclear energy.

Research on *perceived risk* started in the late 1960s, and many see Starr's work on risk and voluntariness (Starr, 1969) as the starting point of this research tradition. Lowrance's (1976) work on determinants of the acceptability of risk was also influential, and helped to explain why some technologies were less acceptable than others. Both Starr's and Lowrance's work followed the increasing use of probabilistic tools to conduct safety analyses in the context of nuclear facilities such as power plants and the storage of nuclear waste (see e.g., Royal Society, 1983).

It has often been argued that there appears to be little consensus about what constitutes risk but, as pointed out by Yates and Stone (1992) there is also substantial consistency in the treatment of risk. Generally, risk is conceived as consisting of two components: the *likelihood* and the *severity* of possible negative outcomes.

In this chapter we briefly summarize the history of research on the perception and acceptability of the risks associated with nuclear energy. For a long time this research was based on cognitive approaches. Only occasionally were emotions and motivational factors taken into account. More recently, this has changed, and research now attempts to incorporate both cognition and emotion. These more recent approaches are also briefly covered in this chapter. Finally, we turn to the issue of risk communication, and this is followed by a number of conclusions and recommendations.

## Risk assessment versus risk perception

The rapid development of nuclear, chemical and biological technologies in recent decades has been accompanied by the potential to cause catastrophic and long-lasting damage to both public health and the environment. Some of the most harmful consequences of these technologies are rare, delayed and difficult to assess by probabilistic models. Moreover, because of the seriousness and the scale of the possible consequences, these risks are not well suited to management by trial-and-error learning (cf. Slovic, 1987). Risk assessment techniques aim to help identify and quantify risk. Since the introduction of these techniques**,** policy decision-making has become increasingly dependent on *quantitative* risk assessments. Not surprisingly, experts, regulatory agencies, and politicians frequently refer to risk assessments when deciding about possible hazards. This also applies to environmental risks such as those of nuclear energy.

Slovic, Fischhoff, Lichtenstein and their colleagues were the first to show that the way people perceive risk differs from probabilistic assessments but is both predictable and quantifiable. As argued by Fischhoff, Slovic, Lichtenstein, Read and Combs (1978) biases in perceived risk can be related to one of the most general judgmental heuristics: *cognitive availability*. People who use this heuristic judge an event as more likely if instances of it are relatively easy to imagine or recall. Slovic, Fischhoff and Lichtenstein (1979) argue that the most over- and underestimated risks illustrate the availability bias. Overestimated risks such as nuclear accidents and air crashes tend to be dramatic and sensational whereas underestimated risks concern less spectacular events that usually claim one or a few victims at a time and are also common in nonfatal form. Further support for this view is provided by Combs and Slovic (1979) who found that overestimated hazards also received disproportionate media attention.

Experts' judgments of risk differ systematically from those of non-experts. As noted by Slovic et al. (1979) experts' assessments correlate quite highly with records of annual numbers of fatalities. Moreover, their perceptions reflect the complete range, from high to low risk, inherent in these statistical measures. Lay people's perceptions of risk, however, tend to be compressed into a smaller range, and are not as highly correlated with annual mortality statistics. When asked about perceived risks, it seems as though experts see the task primarily as one of judging technical statistics, whereas lay people's judgments are influenced by a variety of other factors. Research on the impact of response mode and other context effects on risk assessments confirms this view (Daamen, Verplanken & Midden, 1986). For instance, asking for annual fatalities leads to different answers than asking for risk estimates (Fischhoff & MacGregor, 1983). It needs to be added that research also shows that lay people's perception of risk is adequate at ordinal level. It can be concluded that people can assess risks if they are asked to and that they generally produce estimates similar to quantitative estimates (at least at ordinal level, and if events are not very rare or very common). It also seems, however, that judgments of risk are related to other characteristics. We turn next to this issue.

## Risk acceptability

Fischhoff et al. (1978) investigated the possible causes of the limited *acceptability* of some technological hazards, and asked respondents to rate nuclear power and 29 other hazardous activities on nine characteristics which were expected to influence risk perceptions and acceptability. The 'risk profiles' derived from these data showed that nuclear power scored close to the extreme high-risk end for most of these characteristics. Nuclear risks were seen as *involuntary, unknown to those exposed or to science, uncontrollable, unfamiliar, potentially catastrophic, severe,* and *dreaded*. Nuclear power was rated far higher on the characteristic 'dread' than any of the 29 other hazards studied by Fischhoff et al. (1978). Overall these ratings could be explained by two higher order factors. The first factor was primarily determined by the characteristics *unknown to those exposed and unknown to science*, and to a lesser extent, by *newness, involuntariness* and *delay of effect*. The second factor was primarily defined by *severity of consequences, dread,* and *catastrophic potential*. Controllability contributed to both factors. Nuclear power scored high on all these characteristics.

Lindell and Earle (1983) followed a similar approach and related judgments of the minimum safe distance from each of eight hazardous facilities to ratings on thirteen risk dimensions. The eight facilities included both high and low risk facilities. Examples included a natural gas power plant, oil refinery, nuclear power plant, toxic chemical disposal facility and nuclear waste disposal facility. Their findings revealed a cluster of high risk facilities (nuclear waste and toxic chemical waste facilities and nuclear power stations). At the low risk end, facilities included natural gas power plants and oil power plants. Again, the high risk facilities were associated with similar characteristics as obtained in the research by Fischhoff et al. (1978).

Vlek and Stallen (1981) asked respondents to rate 26 risky activities (e.g., operating nuclear power plants) in order to determine dimensions underlying 'riskiness', 'beneficiality' and 'acceptability'. Dimensions underlying perceived riskiness were not unlike the ones reported by Fischhoff et al. (1978). More importantly, Vlek and Stallen found that dimensions of acceptability correlated almost perfectly with dimensions of 'beneficiality' (i.e., 'personal necessity of benefits', and 'the scale of the activity and/or the distribution of benefits') and much less with dimensions of riskiness. Operating nuclear power plants was perceived as a large-scale activity with unnecessary benefits. Consequently, the acceptability of nuclear power was low.

Overall, results of these early studies helped researchers to understand public reactions and predict future acceptance and rejection of specific technologies. The main conclusion was that people's strong fears of some technologies are not necessarily irrational, but logical consequences of their concerns about issues such as the controllability of potentially catastrophic consequences (cf. Slovic, Fischhoff & Lichtenstein, 1979). Others, however, tended to see public fears as evidence of the irrationality of the public when confronted with new, unknown technologies (see e.g., Lifton, 1979; Dupont, 1981). It should be added that an approach based on the assumption that the public is neither knowledgeable nor rational is not likely to help communication on technological risks.

In the next section we focus on more recent approaches to the study of public reaction to technological hazards. These attempt to explicitly incorporate the role of more discrete emotions as determinants of the perception and acceptability of risks.

## Emotions and risk

In this section we briefly review the recent literature and show that incorporating discrete emotions into research on risk perception and risk acceptability can help our understanding of how people deal with risky technologies. Finally, we also briefly describe a more radical approach in which general affect as opposed to cognitive appraisals is regarded as a prime determinant of the acceptability of risk.

As described above, there is some earlier research that related the limited acceptability of nuclear energy to emotions. Lifton (1979) and Dupont (1981) focused on the role of fear. They argued that the public tends to be irrational and fearful when confronted with new, unknown technologies. It seems most likely that the limited *controllability* and seriousness of adverse outcomes leads to fear and anxiety, and hence to limited acceptability. However, this does not mean that these feelings are irrational. Some argued that concern (a more cognitive concept) about technological hazards is far more pervasive than anxiety (Brown, Henderson, & Fielding, 1983). This is supported by research in which a ‘phobia’ model — consisting of fear, ignorance and lack of education — explained only between five and ten percent of the variance of the acceptability of nuclear energy (Mitchell, 1984).

Böhm and Pfister (2000) introduced a model of risk evaluation in which specific emotions served as mediators of action tendencies. Their findings showed that the causal structure of a specific risk determines specific action tendencies, mediated by emotions. Their study focused on environmental risks and included both technological catastrophes and natural disasters. The emotions they considered included *prospective loss-based emotions* such as fear and worry, emotions based on the *transgression of specific norms* (e.g. anger, outrage, and guilt), and negative *loss-based emotions* to events that have already taken place (frustration, sadness, regret). Overall, their findings indicate that emotions mediate the impact of cognitive judgments on actions such as taking preventive action and helping others who have suffered from an environmental hazard. This applied to both prospective and retrospective loss-based emotions (fear, worry, frustration, and regret). Emotions concerning the transgression of norms mediated action tendencies such as aggression and retaliation. The main contribution of the research by Böhm and Pfister is that it not only focuses on risk perception and acceptance, but also address action tendencies. Their research shows that emotions play an important mediating role between the perceived causal structure of risks and action tendencies.

Finally, we turn to a more recent approach giving primacy to affective reactions in risk judgment and decision making. Loewenstein, Weber, Hsee and Welch (2001) propose a framework which they term the *risk-as-feelings* hypothesis. Their approach highlights the role of immediate affective reactions experienced at the moment of decision making and can be traced back to Zajonc’s work on the primacy of affect (Zajonc, 1980; 1984). Loewenstein et al. argue that emotional responses to risky decision situations have a powerful impact on judgment and decision making and could override cognitive, consequentialist aspects focusing on possible negative outcomes and their probabilities. Their approach thus assumes that feelings toward a risky situation can also arise without cognitive mediation. The latter viewpoint is supported by neuropsychological (e.g., Barlow, 1988; Bechara, Damasio, Tranel, & Damasio, 1997) and behavioral evidence (e.g., Slovic, Flynn, & Laymen, 1991).

To sum up, emotions may serve three functions in risk perception and risk-related behavior. Risks can cause fear (which is a poor predictor of acceptability) and concern. Secondly, emotions may serve as mediators between the perceived causal structure of risks and action tendencies. And thirdly, emotional responses to risky situations may emerge without cognitive mediation.

## Communicating risks

Recent history underscores the importance of risk communication, and research presented in this chapter hints at various factors that make risk communication a difficult task. For instance, experts and lay people tend to adopt differing frames of reference to assess risk and their acceptability. Generally, risk communication efforts focus on one or more of the following aims: (a) providing general information and education, (b) increasing hazard awareness and emergency information, (c) aiding policy decision making and conflict resolution. As noted by Covello, von Winterfeldt and Slovic (1986) these tasks frequently overlap, but can and often should be differentiated conceptually. This section presents a brief overview of the major problems that hinder adequate risk communication, and suggests a number of ways to improve risk communication efforts.

*General information and education* is the aim of a wide variety of communication efforts. This task is central to many campaigns about technological hazards. Examples concern information in the aftermath of nuclear accidents such as those at Three Mile Island and Chernobyl. In both cases, poor communication had a significant impact on the public reaction, with lack of information and inconsistencies as two major sources of public unrest (see Van der Pligt, 1992). One more recent example concerns information about radon risk. Radon is an important health risk and this gas is the second leading cause of lung cancer in the US. Kerry Smith, Desvouges and Payne (1995) reported the results of a study investigating the effects of different radon risk information booklets on households' decisions to undertake some mitigating action. Overall, their results indicate that the amount and the format of risk information both affects risk perceptions, behavioral intentions and mitigation. Concise information and clear instructions about when to act and take mitigating action seem to be most efficient.

Risk communication aiming to *increase hazard awareness and to provide emergency information* is becoming increasingly important. One example concerns the Seveso directive (named after a catastrophe in a chemical plant in Northern Italy). This EC-policy measure focuses on the exchange of information between governments, industry and the general public. The directive requires the active provision of information by hazardous industries to residents nearby who could be affected by an accident. Some progress has been made in this area, and present practices have learned from previous failures. Risk communication in the context of *policy decision making and conflict resolution* is important in the context of selecting sites for nuclear power facilities. The major difficulties of risk communication apply to all three aims described above, and can be summarized as follows:

*Complexity*

Risk information is often highly technical and complex. As a consequence, quantitative risk information is difficult to comprehend for the average lay person. Complexity is further increased by the need, sometimes the habit, to present risk information in scientific, legalistic and formal language. All these factors can lead to the view that risk communication efforts are evasive and not to the point. Suspicion and confusion are two of the most likely consequences.

*Frame of reference*

Lay people and experts tend to use different definitions of risks and often use a different frame of reference when evaluating risks. Lay people tend to focus on factors such as catastrophic potential, fairness of the risk/benefit distribution, voluntariness and controllability. Experts, on the other hand, tend to define risks primarily in terms of expected annual losses in lives or monetary terms.

*Uncertainty*

Limited experience, insufficient databases and shortcomings of available methods and models often lead to substantial uncertainties. Unfortunately, this has also led to disagreement between experts about the validity of risk assessments. These, in turn, tend to create uncertainty and confusion among the general public.

*Trust and credibility*

Experts, governmental agencies and industry sometimes lack public credibility and trust. Recent history has shown several examples of the provision of limited information about the risks of nuclear energy and/or deliberate withholding of information, usually because agencies feared emotional reactions and/or panic. Generally, this has severely damaged public trust and the credibility of some governmental agencies and industry. One example concerns the impact of the Chernobyl accident. Some European countries provided adequate information, others failed to, and in some cases inadequate communication created more public unrest than the accident itself (van der Pligt, 1992; Poumadere, 1995).

*Involvement and concern*

Risk communication is particularly difficult in highly charged situations such as nuclear accidents and the selection of sites for nuclear power waste facilities (e.g., Flynn, Slovic & Mertz, 1993). These require very different strategies from situations in which one tries to attract the attention of the public for less controversial risk issues (such as the use of seat belts).

The above difficulties give an indication of the complexity of risk communication. Some progress has been made, however, and psychology could help to make further progress by investigating the frame of reference of the various groups involved, and also by pointing to other important factors that determine the effectiveness of risk communication.

## Conclusions

Over the past three decades a considerable amount of research has addressed the antecedents and consequences of public perception and acceptance of nuclear technologies. Generally this research has focused on cognitive factors as determinants of the overestimation of nuclear risks. These risks tend to be more vivid and sensational and, hence, are overestimated, while more mundane risks tend to be underestimated.

As described above, the acceptability of nuclear energy has been related to qualitative factors such as the catastrophic potential, newness, and perceived controllability of the risks. All of these factors tend to be related to concern, worries, and anxiety about possible adverse consequences. As a consequence, communication about large-scale technological risks, such as nuclear energy, often needs to combat unwarranted high levels of fear and anxiety.

In this chapter we also discussed the role of emotions as a determinant of the perception and acceptability of risk. The added value of incorporating emotions in the theoretical framework to explain people's reactions to large-scale technological risks is that emotions seem to play an important mediating role between cognitions and behaviour.

We also addressed issues such as how to communicate risks to help public understanding, how to educate the public, how to help people to mitigate or prevent risks, and how adequate risk communication could help policy decision-making about risks. It is essential to take into account the frame of reference of the receiver of risk information. Concrete, concise and consistent information is essential for the three aims of risk communication described in this chapter. Moreover risk communication should address both cognitive and emotional aspects of public reactions to technological hazards such as nuclear energy.

Recent developments in areas such as biotechnology and genetic engineering and global risks are firm reminders of the need to increase our knowledge of people's reactions to technological risks.

**Notes**

**References**


Barlow, D. (1988). *Anxiety and its disorders: The nature and treatment of anxiety and panic*. New York: Guildford Press.

Bechara, A., Damasio, H., Tranel D. & Damasio, A.R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science, 275*, 1293-1295.

Böhm, G. & Pfister, H.R. (2000). Action tendencies and characteristics of environmental risks. *Acta Psychologica, 104*, 317-337.

Brown, J., Henderson, J. & Fielding, J. (1983). *Differing perspectives on nuclear related risks: An analysis of social psychological factors in the perception of nuclear power*. Paper presented at the meeting of the Operational Research Society, September, University of Warwick, UK.

Combs, B. & Slovic, P. (1979). Causes of death: Biased newspaper coverage and biased judgments. *Journalism Quarterly*, *56*, 837-843.

Covello, V.T., Von Winterfeldt, D. & Slovic, P. (1986). Risk communication: a review of the literature, *Risk Abstracts*, *3*, 171-182.

Daamen, D.D.L., Verplanken, B. & Midden, C.J.H. (1986). Accuracy and consistency of lay estimates of annual fatality rates. In B. Brehmer, H. Jungermann, P. Lourens & G. Sevon (Eds.), *New Directions in Research on Decision making*, pp. 231-243. Amsterdam: Elsevier Science Publishers.

Dupont, R. (1981). The nuclear power phobia. *Business Week*, *September 7*, 14-16.

Fischhoff, B. & MacGregor, D. (1983). Judged lethality: How much people seem to know depends upon how they are asked. *Risk Analysis*, *3*, 229-236.

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S. & Combs, B. (1978). How safe is safe enough: A psychometric study of attitudes toward technological risks and benefits. *Policy Sciences*, *8*, 127-152.

Flynn, J., Slovic, P. & Mertz, C.K. (1993). The Nevada Initiative – A risk communication fiasco. *Risk Analysis*, *13*, 497-502.

Kerry Smith, V., Desvouges, W.H. & Payne, J.W. (1995). Do risk information programs promote mitigating behavior? *Journal of Risk and Uncertainty*, *10*, 203-221.

Lifton, R.J. (1979). *The broken connection: On death and the continuity of life*. New York, NY: Simon and Schuster.

Lindell, M.K. & Earle, T.C. (1983). How close is close enough: Public perceptions of the risk of industrial facilities. *Risk Analysis*, *3*, 245-253.

Loewenstein, G.F., Weber, E.U., Hsee, C.K. & Welch, E.S. (2001). Risk as feelings. *Psychological Bulletin*, *127*, 267-286.

Lowrance, W.W. (1976). *Of acceptable risk*. Los Altos, CA: Kaufman.

Mitchell, R.C. (1984). Rationality and irrationality in the public's perception of nuclear power. In W.R. Freudenberg & E.A. Rosa (Eds.), *Public reactions to nuclear power: Are there critical masses*? (pp. 137-179). Boulder, Colo: Westview Press.

Poumadere, M. (1995). Issues in communication with the public on health and environmental risks. *European Review of Applied Psychology, 45*, 7-16).

Royal Society (1983). *Risk assessment: Report of a Royal Society study group*. London, UK: The Royal Society.

Slovic, P. (1987). Perception of risk. *Science*, *236*, 280-285.

Slovic, P., Fischhoff, B. & Lichtenstein, S. (1979). Rating the risk. *Environment*, *21*, 14-39.

Slovic, P., Flynn, J.H. & Layman, M. (1991). Perceived risk, trust and the politics of nuclear waste. *Science*, *254*, 1603-1607.

Starr, C. (1969). Social benefits versus technological risks. *Science, 165*, 1232-1238.

Van der Pligt, J. (1992). *Nuclear energy and the public*. Oxford**:** Blackwell.

Vlek, C. & Stallen, P.J. (1981). Judging risks and benefits in the small and in the large. *Organizational Behavior and Human Performance, 28*, 235-271.

Yates, J.F. & Stone, E.R. (1992). The risk construct. In J.F. Yates (Ed.), *Risk taking behavior* (pp.1-26). New York, NY: Wiley.

Zajonc, R.B. (1980). Feeling and thinking: Preferences need no inference. *American Psychologist*, *35*, 151-175.

Zajonc, R.B. (1984). On the primacy of affect. In K.R. Scherer & D. Ekman (Eds.), *Approaches to Emotion* (pp. 259-270). Hillsdale, NJ: Erlbaum.