"The Role of Cost-Benefit Analysis for Dealing with Transboundary Risks: Challenges and Opportunities"

95-10-09

Howard Kunreuther
The Role of Cost-Benefit Analysis for Dealing with Transboundary Risks: Challenges and Opportunities

Howard Kunreuther
Wharton Risk Management and Decision Processes Center
The University of Pennsylvania
1325 Steinberg-Dietrich Hall
Philadelphia, PA 19104-6366
Phone: 215-8984589
Fax: 215-573-2130

Paper Presented at the “Transboundary Environmental Risk Management in an East-West Context” Conference
in
Stockholm, Sweden
1. Introduction

The Ignalia Nuclear Power plant example, the burning of coal in Poland and the construction of the Gabčíkova hydroelectric power station in Slovakia provide three graphic examples of the challenges countries face in dealing with facilities or activities where the risks transcendent geographic boundaries. The purpose of this paper is to examine the potential role of different policy tools in dealing with the management of these transboundary risks.

In order to address this question it is important to provide a description of the nature of the problem, the goals and objectives of the different stakeholders and the criteria which will be used to evaluate the performance of the different programs. Only then will we be in a position to explore the likely success of alternative risk management strategies.

The next section describes the nature of the problem from both the perspective of the different countries concerned with the risk as well as the stakeholders or interested parties affected by the risk. Section 3 suggests a framework for analyzing the tradeoffs in developing specific policies using the Ignalia Power plant, Polish coal examples and Gabčíkova Hydroelectric Power Stations to illustrate these points. We then turn to the challenges of dealing with the public and other stakeholders using the siting of an incinerator with transboundary risks as an example. In particular, the role of mitigation and compensation are evaluated using empirical data from past siting studies. The concluding section offers some conclusions and recommendations for
developing evaluates the promises of different policy tools for dealing with transboundary risks.

2. Nature of the Problem

*The Country Problem.* The nature of the transboundary risk problem from the perspective of the affected countries can be stated by using the following simple illustrative example. Country Y is either planning to site a facility or is currently operating one which has some risk that not only affects its own residents but those of country Z as well. There may be benefits to both Y and Z from having the facility but it is likely that Y gains considerably more from the facility than Z does. There are three interrelated questions that need to be addressed from the perspective of both countries Y and Z:

1. What actions should country Y take with respect to managing its risks recognizing that the impacts may be extend past its own boundaries?

2. What contributions should country Z make to reduce the risks associated with Y's operations given that the residents in Z will be adversely affected by the facility in Y?

3. Is there a role for international organizations to play in managing transboundary risks?

If country Y knows that Z will contribute a large sum of money to improve the safety of its facility to a given level, then it has less incentive to invest its own resources into this activity. Country Z may feel the same way about why it should not invest in Y, knowing that there will then be an incentive for Y to take protective measures.
International organizations can set standardized guidelines as to how risks should be managed simply because of the impasse created by the difficulties faced by Y and Z in dealing with the problem on their own. The challenges are compounded if there are many countries which are affected by a particular risk.

_The Stakeholder Problem._ There are a number of different parties who are affected by the facility, in Country Y as well as Country Z. The principal groups that need to be considered are as follows:

**The developer** who is interested in constructing the facility. In many countries the developer is synonymous with a government organization. For example, in Hungary and Slovakia the water management authority is responsible for developing hydroelectric power plants for managing their country's energy needs. Government agencies in Lithuania and Sweden are responsible for providing nuclear power as a source of energy.

**The affected public** who both benefit from the facility and are affected by the risk. Residents in communities nearby the facility may be more adversely impacted by it than those some distance away. Of course, the transboundary risk problem implies that individuals in distant locations may be affected by the risk.

**Public interest groups** who have their own agenda regarding future development projects. For example, environmental groups in Hungary, Slovakia and Austria have specific concerns about the short and long-term consequences of the dam system on the quality of groundwater as well as surrounding landscape. Similarly there is considerable opposition by some environmental groups to nuclear power.
Two questions that arise when dealing with transboundary risks and stakeholder groups are as follows:

1. What role should the public and different environmental groups have in making decisions regarding the siting and operation of certain facilities?

2. How does one create trust in the process of siting facilities and managing them when there is great uncertainty associated with risks?

These questions must be addressed in the context of the cultural and political system of the affected countries. Sweden has a history of public participation in the siting of its facilities, so it may require considerable discourse among the public before taking any action. Lithuania has a very different history and set of cultural norms, so that the government may be able to take action in a more arbitrary without create distrust and unrest among the citizenry and public interest groups.


Tradeoffs between benefits and costs are an integral part of the decision making process when there is uncertainty. Many of the concepts which are relevant for the transboundary risk problem facing countries can be illustrated by considering the choices facing a family exposed to a particular risk and whether it will want to invest in measures which mitigate the losses. We will then show how this example can be extended to environmental risks problems and the types of policies that are needed to address these issues.
Investing in Personal Mitigation Measures

Consider a family who lives in an earthquake prone area and is concerned with the possible damage to their house from an earthquake. One of its options is to invest in loss reduction measures such as strapping the gas water heater so it does not topple over from a quake and trigger a fire. By incurring a cost of \( C \) rubles for such a mitigation project, damage from future quakes will be reduced. To calculate these expected benefits, the family must estimate the probabilities of earthquakes of different magnitudes impacting their house \( (p_i) \) and the reduction in damage incurred \( (D_i) \) from each of these quakes.

If the family only focused on a single earthquake with probability \( (p) \) and reduction in damage \( (D) \) then the expected benefits of the mitigation measure for next year would be \( p \cdot D \). If the house were expected to last for 25 years, then the expected benefits (in present value terms) from such an investment would be calculated over a 25 year time horizon with future savings appropriately discounted. In addition to the monetary savings, there may be other rationale for investing in protective measures such as relieving one’s anxiety and achieving peace of mind. Suppose the family takes into account all of these factors and determines that the expected benefits (in present value terms) from strapping the water heater is given by \( E(B) \). If this value exceeds \( C \) then it will want to invest in the measure; if it is less than or equal to \( C \), then it will not expend the funds. In other words, the criterion for voluntary taking action is for \( E(B) > C \).
There may be additional savings to other homes in the community: from certain loss mitigation measures which would not be incorporated in E(B). For example, by preventing a fire in your house through strapping the water heater, you may save other nearby structures from going up in flames. In general, one of the justifications for regulations and standards, such as building codes, is that these additional benefits (i.e. externalities) are not taken into account by property owners when determining whether to invest in protective measures (Cohen and Noll 1981).

*Environmental Risk Problems*

The basic tradeoffs associated with transboundary environmental risk problems are conceptually similar to the ones described above for the family facing an earthquake risk.

**Safety Investments in Ignalina Nuclear Power Plant**  
To illustrate the challenges one faces in addressing these issues we can turn to the question facing Lithuania and Sweden. In this example we will assume (as the Case Study did) that there only two key stakeholders who make the final decision—the Swedish and Lithuanian governments. Each of the governments may want to gauge public reactions to different funding proposals, but federal officials will have the final say as to what actions should be taken. There are two interrelated questions which the two governments need to address:
(1) What safety improvements should be made to the Ignalina Nuclear Power plant?

(2) How much of these costs should be borne by Sweden and Lithuania?

*Nature of Safety Improvements* If one were to use some type of benefit-cost analysis then the analysis of the expected benefits would be similar to the methodology outlined above for mitigating the losses from an earthquake. Suppose the safety improvement measure was *installing early warning radiation systems at the Ignalina plant and at various locations throughout Lithuania* at a cost of $C=10$.

To keep the example simple, but without loss of generality, assume there is only one accident that can happen with well-specified probability ($p=1/1000$) and that the reduction in damage can be quantified in monetary units. If an accident does occur, an early warning system is put in place. The expected discounted reduction in damage to Lithuania over the life of the plant will be labeled as $D_L=8000$ and the corresponding reduction in damage to Sweden will be labeled as $D_S=4000$. The expected benefits to Sweden can be direct (such as reduced radiation) as well as indirect (such as preserving nuclear power in Sweden).

Under this scenario it is clear that the warning system should be adopted since its aggregate discounted expected benefits is $E(B)=12$ [i.e. $1/1000 \times (8000 + 4000)$] which exceeds $C=10$. However, it should be noted that neither Lithuania or Sweden has any incentive to bear the cost of this measure alone, since $E(B_L)=8$ and $E(B_S)=4$. 

7
Allocation of Costs. How should costs be allocated between the two countries?

As in most situations, the answer is that it depends on both efficiency and equity considerations. If both countries were on an equal economic footing, then one would expect Lithuania to bear 2/3 of the costs, since it received twice the expected benefits from the safety improvement than Sweden. If, on the other hand, Sweden is considerably better off than Lithuania then it should be willing to pay more than its fair share and subsidize Lithuania. However, the maximum that Sweden would be willing to contribute to the safety improvement is its \( E(B_S) = 4 \). If the safety improvement were to be undertaken, this would mean that Lithuania would still be forced to pay a cost of 6 which is less than \( E(B_L) \).

Installing Scrubbers in Polish Coal Plants. The decision as to whether to install environmental scrubbers in Polish coal plants to reduce the amount of SO2 generated can be examined in a manner which is similar to the investment in safety equipment for nuclear power plants. The benefits from the scrubbers is measured by the reduction in acid rain. More specifically, one would need to evaluate the expected benefits from the reduction in acidification of lakes and damage to trees in the forest from less acid rain in both Poland and other countries.

Suppose that the only countries affected by the reduction in acid rain were Sweden and Poland. The sum of the expected benefits to Poland \( (B_P) \) and Sweden \( (B_S) \) must exceed the cost of the scrubbers \( (C) \) for the project to be worthwhile. Even if this is the case, there is still the question as to how much each country should pay for this
equipment. In reality, the problem is even more complicated since there are several other countries (Germany, Czech Republic, Denmark and Norway) who stand to benefit in different degrees from the scrubber but each may want to “free ride” by hoping that the other countries will provide support for the scrubbers.

As in the Ignalia Power Plant example, the allocation of resource will be influenced by equity and other considerations. To illustrate, suppose that \( C = 10 \), \( B_p = 5 \) and \( B_s = 5 \). If these were the only two countries affected by acid rain then each would only want to contribute at most 5 to the project and the only way to get it done would be to share the costs equally between them. If, on the other hand, Germany had benefits of \( B_G = 2.5 \) as does Norway \( (B_N = 2.5) \) and Denmark \( (B_D = 2.5) \) then a different sharing rule could be structured. If the other countries felt that Poland shouldn’t have to pay anything due to its relatively poor economic condition, then Sweden would pay twice as much as each of the other 3 countries. The final allocation would be Sweden paying 4 and Germany, Norway and Denmark each paying 2.

Siting the Gabcikova Hydroelectric Power Station in Slovakia Cost-benefit analysis may also be appropriate for making decisions regarding the siting of a facility which creates environmental risks, such as whether to construct the Gabcikova hydroelectric power station in Slovakia. To evaluate the project, one needs to calculate the benefits to Slovakia \( (B_{SL}) \) from constructing the dam, the costs to the citizens of Slovakia \( (C_{SL}) \) as well as the environmental costs to Hungary of diverting the Danube \( (C_H) \). From Slovakia’s point of view, the project should be undertaken if \( B_{SL} > \)
$C_{SL}$ and there are no more attractive sources of energy (when evaluated from a benefit-cost perspective). From the viewpoint of both Slovakia and Hungary, the dam should only be built if $B_{SL} > C_{SL} + C_H$ and Slovakia compensates Hungary for the environmental costs of diverting the Danube.

**Other Considerations** The above stories are high simplified ones on a number of counts as indicated below:

**Uncertainty of Risk Estimates** Most important, it assumes that one can accurately estimate costs, probabilities and losses with and without safety measures. Many environmental risks are relatively new and there is a limited data base on which to base estimates of the probabilities of specific accidents occurring and their consequences. Furthermore the benefits from sanctioning a particular facility and investing in loss mitigation measures are often not easily quantifiable. In fact, for many of the environmental risks there are significant disagreements by scientific experts on the estimates of probabilities and damage from specific risks. One may reach very different conclusions regarding the feasibility of undertaking specific measures depending on which expert one used.

**Value Differences** Even if one could specify the impacts well, they may be evaluated very differently by two people from the same country and even the same organization. The challenges of determining ways to specify environmental benefits has been widely debated by economists in recent years in the United States and other countries. Today there are no standardized procedures for eliciting "willingness to pay" amounts for
a safer environment and the contingency value methodology is still being debated by economists, psychologists and other researchers.

**Importance of International Agreements** One question, which we have not addressed in this analysis, is whether it is important to have international agreements which set standards and regulations for countries affected by a particular transboundary problem. To the extent that it is difficult to calculate benefits and costs of environmental risks, there may be no easy way to gain the cooperation of different countries in financing certain activities such as installing scrubbers. It then makes considerable sense to develop International Protocols for setting guidelines for each country regarding specific environmental risks. The 1979 Convention on Transboundary Air Pollution did just this with respect to the reduction of SO2 by European countries. Target levels were set for each specific country based on the potential impacts of reducing SO2 as well as the costs and its ability to do so. (Lofstedt 1995).

Finally we have assumed throughout the discussion that one person from the government represents the entire country, in making a decision as to whether to invest in a project and, if so, how much. In reality, the public has a stake and concern with the issues associated with environmental risk. In the next section we address the issue of public participation in the context of transboundary risks by looking at the siting of noxious facilities.
3. The Stakeholder Problem: The Role of the Public and Public Interest Groups

*Theoretical Considerations*

Consider the challenges facing a private firm or developer who is trying to find a home for a solid or hazardous waste facility. For concreteness suppose that the facility of interest is a an incinerator. Country Y (e.g. Sweden) has expressed an interest in hosting the incinerator right near its political boundary in a part of the country that has relatively few homes and businesses. Residents in Country Z (e.g. Denmark) are also subject to health and environmental risks from the facility.

A voluntary siting process has been proposed whereby all the residents in Y over 18 can vote on a referendum as to whether an incinerators should be located in their backyard. Suppose that if a certain percentage (e.g. two-thirds) of Y's residents support the facility, then it will be deemed approved and construction will begin in 1996. Those residing in Z have no official vote on whether the incinerator should be located in Y, but they can publicly protest the facility in order to encourage residents in Y to vote against it.

Each resident $j$ in country Y will determine whether to vote in favor of a particular facility by considering the benefits to him or her ($B_j$) and the perceived risks associated with the facility. The benefits can be direct compensation to an individual, such as a reduction in property taxes, or it can take the form of community-wide or regional improvements such as additional health-related services, higher salaries to attract more and better teachers for the schools and/or new recreational facilities. A benefits package may also contain
contingent arrangements such as guarantees against property value declines due to the facility if a family tries to sell its home, and reimbursement for any health and/or environmental impacts from the facility.

The risks associated with the incinerator for each individual j in Y are characterized by a perceived probability \( (p_j) \) that some type of damage \( (D_j) \) will occur to him or her. These risks can be mitigated (but not necessarily eliminated) through enforcement of safety standards and regulations. If the benefits package is attractive enough and/or the perceived risks associated with the facility are sufficiently small to resident i in community Y, then he or she will vote "Yes" to constructing the incinerator.

The developer has no economic incentive to provide residents in country Z with any benefit package or reduce the risks facing this group. From the firm's perspective the only votes that count are the ones from country Y. Thus it is conceivable that the majority of the residents in Z may face certain risks from the new facility for which they will not be sufficiently compensated by the developer, so that they would disapprove of the facility even though it was approved by those living in Y.

The above example illustrates the divergence between private and social costs due to transboundary risks. The private costs to the developer only revolve around residents in Y, while the social costs include the impact on individuals in both Y and Z. Unless some steps are taken to protect country Z against possible economic, health and safety losses, the above voluntary siting process can prove costly when the benefits and costs of residents in both countries are taken into account.
The presence of transboundary risks are a form of externalities which are normally associated with public goods or bads. Thus a hazardous waste facility poses risks of different degrees to all individuals within a certain radius of the site, and there is little that a person can do to alleviate this risk once a facility is built, short of moving out of the area. Individuals can engage in collective action to lobby against having a facility in the first place, but this involves costs to them which they may not be prepared to incur. Hamilton (1993) has shown that private firms will want to locate facilities in communities or regions which generate the least political opposition and provides empirical evidence that the host communities will not necessarily be the ones which generate the lowest externalities.

**Importance of International Siting Authority**

The presence of externalities suggests a clear role for an international siting authority or government agency to play as part of the siting process. More specifically, such a group would need to impose strict mitigation measures and standards that reduce the risks to both the host community and its affected neighbors before any developer or firm engages in the search for a site. It would also impose specify who is liable in case an accident occurs and what the appropriate compensation would have to be.

**Role of Well Specified Standards** To adequately reflect the concerns of all the affected residents, the siting authority would have to have jurisdiction over a geographic region that encompasses both the host country as well as those areas subject to the transboundary risks from a facility. Furthermore it would need to be empowered by a
governmental body that was concerned with the welfare of a wide area rather than reflecting
the narrower interests of citizens from certain jurisdictions. In the case of waste disposal
plants which are on the border of two countries this may require international cooperation
with respect to the development of appropriate standards and regulations.

An additional reason for imposing strict safety standards by a public authority or
governmental authority before the search for a site begins is to reduce conflicts that are
otherwise likely to emerge between the developer who relies on scientific experts for
characterizing risks and the residents in the community who have their own perceptions of
the risks. While the experts normally measure risks in quantitative terms (e.g. the
probability and the anticipated consequences of an accident), the public takes other factors
such as dreadedness, unfamiliarity with the technology and catastrophic potential into
account when evaluating their concerns. Residents in Z who oppose the facility can feed
into these fears of those residing in Y, encouraging them to vote against the proposal.

Evidence on how the public's perceptions of risk differs from the scientists' views is
illustrated by two recent studies. One study showed that the amount that a layperson was
willing to pay for risk reductions is influenced by his or her degree of dread and severity for
risks, such as hazardous waste and sulphur air pollution, where there is considerable
scientific uncertainty in the degree of risk exposure and their potential effects. Scientists do
not consider factors such as dread or lack of familiarity to be relevant in characterizing the
degree of risk from a particular activity (McDaniels, Kamlet and Fischer 1992). Another

\[1\text{If a public sitting authority solely reflected the interests of those who elected}
\text{government representatives then it may be unconcerned with the safety of residents}
\text{in other communities who may not have supported them in the last election.}\]
study of laypersons and toxicologists revealed large differences between these two groups in their assessment of chemical risks. (Kraus, Malmfors and Slovic 1992).

**Role of Monitoring and Control Procedures** In addition to imposing standards and regulations at the time the facility is sited to deal with risk perceptions of both the experts and the public, there is a need for monitoring and control procedures to assess the performance of the facility once it is in place. One proposal that may convince the affected public that they will be protected against any risks to themselves and future generations is forming a committee of local residents that is granted special oversight powers, including the power to suspend operations at the facility if the prescribed standards are not adhered to.

**Role of Compensation or Benefit Sharing** For residents to support a facility in their backyard or in surrounding areas the benefits associated with having it need to be greater than maintaining the status quo. One way to satisfy this condition is to provide communities who site the facility as well as those who are nearby with compensation. However, compensation will be viewed as a bribe unless the affected groups feel that the facility satisfies rigorous safety standards that will be well enforced.

Compensation can take a number of forms: (1) direct monetary payments, (2) in-kind awards, (3) contingency funds, (4) property value guarantees, (5) benefit assurances, and (6) economic goodwill. Compensation strategies can also be classified based on when the "payments" are made: (1) at the time the facility is sited (i.e., ex ante); (2) while the facility is operating smoothly (i.e., interim); or (3) after an accident or some other negative event occurs (i.e., ex post). [For more details see Gregory et. al. (1991)]

16
Empirical Evidence

A number of surveys have been completed on attitude of residents toward mitigation and compensation measures. This section briefly summarizes some of the findings that may have relevance to challenges in dealing with the public when there are transboundary risks.

Moderately noxious facilities. A number of attitude surveys have investigated the impact that compensation has on a person's willingness to accept the development of a facility at a local site. Surveys by Bacot, Bowen, and Fitzgerald (1994) and by Jenkins-Smith, Kunreuther, Barke, and Easterling (1993) asked respondents to consider compensation in the context of a landfill for municipal waste. Respondents were first asked to indicate whether they would "accept" the construction of a landfill at a nearby site with no mention of benefits. As shown in Table 1, a local landfill was acceptable to 30 percent of the Bacot, Bowen, and Fitzgerald (1994) sample and to 25 percent of the Jenkins-Smith et al. (1993) sample when benefits were not included. However, in both cases, the rate of acceptance approximately doubled with the introduction of compensation. In the

---

2 For more details on the empirical findings discussed in this section see Kunreuther and Easterling (1995).
3 Bacot, Bowen, and Fitzgerald (1994) surveyed 844 Tennessee residents in 1989. Jenkins-Smith et al. (1993) surveyed 1200 U.S. households in 1993. This sample was split into eight experimental conditions, defined by the type of facility being considered (municipal waste landfill, hazardous waste incinerator, medium-security prison, or high-level nuclear waste repository) and by the order in which the respondent was presented with various compensation and mitigation measures. The effect of economic benefits for any given facility is assessed with a sub-sample of 150.
4 In the Bacot, Bowen, and Fitzgerald (1994) survey, respondents were told that the landfill was proposed for a site five miles from their home. Acceptance was gauged by a voting question. Jenkins-Smith et al. (1993) experimentally manipulated the supposed distance to the landfill (either 1 or 10 miles away). Respondents indicated how acceptable such a facility would be. We have coded a respondent as "accepting" the facility if he or she gave a response of either "acceptable" or "completely acceptable."
Jenkins-Smith et al. (1993) survey, the form of the benefits was left vague ("economic benefits provided to residents within 50 miles of the facility"), whereas Bacot, Bowen, and Fitzgerald (1994) provided respondents with specific forms of compensation — rebates on property taxes, state money for schools, and state money for road improvements. Tax rebates produced the greatest level of acceptance (63%).

[INSERT TABLE 1 HERE]

**Radioactive waste repositories.** The positive impact of compensation on public acceptance is not replicated when the facility to be sited is a radioactive waste repository. This conclusion is supported by the five separate studies reported in Table 2: Carnes et al. (1983); Kunreuther, Easterling, Desvousges, and Slovic (1990); Dunlap and Baxter (1988); Herzik (1993); and Jenkins-Smith et al. (1993). The different samples varied somewhat in their baseline willingness to accept a "local" HL NW repository, with the greatest level of acceptance (60%) occurring among Dunlap and Baxter's (1988) sample of residents living near Hanford, Washington (see Footnote 12). However, in none of the surveys did the introduction of benefits produce a major increase in acceptance. The largest increase (4 percentage points) occurred in the Carnes et al. (1983) and Jenkins-Smith et al. (1993)

---

5 Carnes et al. (1983) surveyed 420 Wisconsin residents in 1980 on whether they "favored" the siting of a "nuclear waste repository in their community." Kunreuther et al. (1990) conducted a survey of 1001 Nevada residents in March 1987. Approximately half of these persons (n = 498) were asked about their willingness to vote for a HL NW repository at Yucca Mountain, with and without rebates; the other half was asked about their willingness to pay to have the repository located somewhere else [see Kunreuther and Easterling (1990) for results]. Herzik (1993) used a similar rebate question in a 1993 survey of 1212 Nevada residents. Dunlap and Baxter (1988) also used this sort of question in a survey of 658 residents of Frankins and Benton Counties in Washington State. Respondents declined their willingness to vote for a HL NW repository at Hanford (which was then still in contention). Jenkins-Smith et al. (1993) asked 150 U.S. residents 'how acceptable' a HL NW repository would be if it were located either 10 miles or 50 miles from their home (distance was varied experimentally).
surveys. However, in the other three surveys (each of which offered 20 years of generous tax rebates), there was no evidence of increased acceptance.

[INSERT TABLE 2 HERE]

In Kunreuther et al. (1990), 27 percent of the sample voted to put a repository at Yucca Mountain in a question that did not mention compensation, compared to 29 percent when rebates were offered. This difference was not statistically significant (chi-square(3) = 5.25, p > .1). In addition, there was no significant difference in acceptance across the three dollar amounts: $1,000 per year (26%), $3,000 per year (30%), and $5,000 per year (30%).

The contrast between radioactive waste repositories and other noxious facilities in the effectiveness of compensation is remarkable. We have found that threat to future generations is a strong determinant of voting behavior in the case of HLNW repositories.

---

6 The referendum question was worded, "If a vote were held today on building a permanent repository, where would you vote to locate the repository?" Respondents were presented with four choices: Yucca Mountain, Hanford, Deaf Smith, and "none of the above." The following question was used to assess a respondent's willingness to accept a repository with compensation:

Suppose after thorough study, the Federal government decided to put a high-level nuclear waste repository at Yucca Mountain in Nevada. This repository would be built according to Federal safety standards. Suppose also that you could receive a [either $1,000/$3,000/$5,000] rebate or credit on your Federal income taxes each year for 20 years. Would you vote to locate the repository at Yucca Mountain?

7 This difference was tested using a test of change for correlated proportions (Dixon and Massey, 1957).

8 The effect of dollar amount was nonsignificant regardless of whether the dependent variable was vote or change in vote. In the latter case, respondents were classified into one of three categories: (1) rebate had no effect on voting response; (2) rebate made repository more acceptable; or (3) rebate made repository less acceptable. The effect of rebate level was then assessed by testing whether the distribution of this change variable differed across the three dollar amounts. This yielded a chi-square(4) of 4.16 (p > .3).

Very similar responses to compensation were obtained in a 1987 national survey conducted by the same authors (Kunreuther et al., 1990). Here, respondents were asked whether they would accept a repository 50 or 100 miles away in return for rebates of between $1,000 and $5,000 (distance and dollar amount were varied experimentally). Overall, 28.7 percent of the sample responded positively to the compensation offer, compared to 28.9 percent of the Nevada sample.
(Kunreuther et al., 1990). Moreover, if a person believes that a repository will pose serious risks to future generations, rebates are unlikely to win his or her acceptance of a repository. This resistance to rebates is illustrated in Figure 1, which shows the proportion of respondents in the 1987 Nevada survey who favor a repository at Yucca Mountain (with rebates) as a function of perceived risk to self and risk to future generations. This figure shows that the majority of respondents reject rebates if either the perceived risk to self is high or the risk to future generations is deemed serious. Among respondents with both beliefs, only 8 percent vote in favor of the repository when rebates are offered.

[INSERT FIGURE 1 HERE]

The data in Figure 1 cast doubt on one of the assumptions that underlie most compensation strategies: compensation will succeed in gaining a person's acceptance of a facility if that person believes he or she will be better off with the facility than without it. Compensation is likely to be rejected whenever a person believes that the proposed facility is somehow illegitimate (i.e., should not be built on ethical or moral grounds). This conclusion is supported by McClelland and Schulze (1991). In their study, subjects were given a Norfolk pine at the outset of the task and were asked to indicate the price at which they would sell the pine back to the experimenter. In the condition where subjects were told nothing regarding the fate of the plant, the average asking price was $8. However, among subjects who were told that the plant would be destroyed at the end of the experiment, the average asking price was $18 and a number of subjects reported an asking price that they knew was higher than the experimenter would accept.
Individuals who consider the proposed HLNW repository to be illegitimate will similarly be inclined to reject offers of compensation. The facility might be viewed as illegitimate because of a perceived inequity in the distribution of risks across generations or because of beliefs about the potential of the facility to contaminate the planet (Easterling and Kunreuther, 1995). Monetary payments are inherently unable to offset these objections. For example, a rebate package paid out over 20 years rewards the current generation for accepting the repository, but imposes uncompensated costs on future generations.

Mitigation Studies By requiring stringent standards which address public concerns with the risk, there is a greater likelihood that a positive vote will be forthcoming if a siting referendum was instituted. In a survey of over 1200 American households selected at random conducted by the University of New Mexico in February 1993, individuals were asked about their attitudes toward alternative mitigation measures as a condition for siting different types of facilities.

Table 3 indicates what percentage of individuals would vote in favor of a landfill for municipal waste (LANDFILL) or an incinerator for hazardous waste (INCINERATOR) within either one or ten miles of their home and a repository for disposal of high-level nuclear waste (REPOSITORY) within either 10 or 50 miles from your home under the following conditions. In the case of the LANDFILL only 18% approved the facility with NO MEASURE. The percentage increased to 67% when both INSPECTION and SHUTDOWN were made part of the mitigation package. These two measures had a positive impact on attitudes toward both an INCINERATOR and REPOSITORY but the percentage favoring either of the facilities was somewhat less than for a LANDFILL. In
fact, in the case of a repository only 43 percent of the respondents would have voted in favor of hosting the facility, even if the mitigation package included both measures. The data do suggest the importance of instituting stringent safety measures if one wants to gain support for a facility.

4. A Siting Procedure for Dealing with Transboundary Risks

At a National Workshop on Facility Siting in 1990 a group of practitioners and researchers developed a set of guidelines for siting noxious and/or hazardous facilities. These guidelines, which were formalized in a Facility Siting Credo, focused on developing a workable and fair procedure for locating a facility as well as an outcome which satisfied distributional (equity) and benefit-cost (efficiency) considerations.

A study of 29 siting cases, both successful and unsuccessful, across the United States and Canada confirmed the importance of two features of the process in finding a host community that agrees to host a facility: having a broad-based public participation process and the perception by host community residents that the facility was the best solution to their waste problem. (Kunreuther, Fitzgerald and Aarts 1993). Both of these elements should be considered in designing a siting process.

The Facility Siting Credo also emphasized the desirability of a voluntary siting process but did not explicitly take into account the presence of transboundary risks. This section proposes a two stage siting process which explicitly addresses the issues of transboundary risks while addressing the concerns with equity and efficiency through compensation. The implicit assumption is made that a new facility is viewed as socially
desirable. However, if a volunteer site cannot be found then the status quo will be maintained rather than forcing a community or region to site a facility. The key questions are what type of facility to construct and where it should be located?

**Stage 1: Screen Appropriate Sites and Specify Standards**

In this first stage of the process the Public Siting Authority (PSA) determines a set of sites that meet prespecified technical criteria. At the same time the Siting Authority specifies a set of safety standards that a proposed facility will have to meet. The PSA can be based at the local, regional or national level depending on the nature of the transboundary risks and the candidate areas for the facility. The PSA could consist of representatives from more than one country if the facility poses transnational risks.

The screening and standard-setting process should take into account both the risks of the facility to the host community as well as the expected impact it will have on the surrounding areas. If there are transportation risks associated with shipping the material from different sources to their final resting place, then this factor should play a role in determining what sites are suitable candidates. If the facility has the possibility of causing air pollution to neighboring areas, then this risk needs to be considered when setting specific performance standards for the facility.

One issue that should be addressed in screening acceptable sites is whether to exclude certain communities or regions on equity or fairness grounds. There are two extreme views normally taken with respect to this question. If a voluntary siting process is to be utilized, then one can argue that any community can decide for itself whether or not it wants the facility. This is the position which will be taken in this paper. On the other hand,
suppose that most taxpayers feel that low income areas which already have noxious facilities should be excluded from consideration. Then a siting map should be drawn which excludes these places from being considered, even though they may be technically suitable areas.

Stage 2: Engage in a voluntary siting process.

The proposed procedure for finding a site is a voluntary one based on procedure that was successfully used in Alberta. Fourteen communities were initially interested in hosting a proposed hazardous waste facility. Nine of these were subsequently eliminated either on environmental grounds or because of strong public opposition. Of the remaining five, Swan Hills presented a proposal (including benefits) that best met the needs of the developer (McGlennon, 1983).

A similar procedure was used in Illinois in an attempt to find a home for a low-level radioactive waste repository (English 1992) and by the Nuclear Waste Negotiator in an attempt to find a state or Indian tribe willing to host an MRS facility for the temporary storage of spent nuclear fuel (Office of Nuclear Waste Negotiator, 1993; Easterling and Kunreuther, 1995). In each of these situations, planning grants were given to communities that expressed an interest in hosting the facility without implying a commitment to accept the facility. Rather, the funds were designed to initiate a process so that the community or region would have input into the process and could specify conditions, including compensation arrangements, that would make the site acceptable.
Depending on the type of facility that is being considered, different types of compensation arrangements might be proposed. If a private developer is the applicant, the firm could offer a monetary payment that could be utilized by the community in any way it sees fit. Browning Ferris has operated in this manner in contacting communities in New York State that might be interested in hosting a landfill through its Community Partnership Program. In 1992, the town of Eagle (with 1300 residents) overwhelmingly voted in favor of hosting such a facility in return for a benefits package that included tipping fees, local jobs, and free trash disposal worth between $1 million and $2 million (Angell, 1993).

A key aspect of this procedure is that no community is forced into accepting a facility against its wishes. This means that it may take a great deal of time to site a particular facility; communities must gain some familiarity and comfort with the concept underlying the facility before they will be willing to enter into negotiations with the developer. In some cases (particularly with respect to radioactive waste disposal facilities), the developer might even conclude that the procedure will not succeed in finding a willing host community. In such a case, it may be necessary for the developer to revisit the choice of technology, examining whether other facilities might be more acceptable to the potential host communities. For the HLNW case, this revisiting of the waste-disposal technology should be performed by a group that includes not only scientists and utility executives, but also representatives of the general public. Opening up this decision process provides the only chance of the selected facility being regarded as legitimate by persons living in a candidate state (Easterling and Kunreuther, 1995).
5. General Conclusions and Recommendations

In this concluding section we will suggest a set of questions that need to be addressed regarding the involvement of the interaction between policy makers, risk management institutions and the public in dealing with transboundary risk problems facing countries and their affected stakeholders. The following conclusions and recommendations point toward ways that the social context may be changed to establish trust among the different interested parties concerned with a particular risk management problem that involve transboundary risks.

*Higher Quality Public Involvement*

Research clearly shows that public involvement is a necessary part of risk management. Research is less clear on the specifics of what that involvement should look like. Though some researchers recommend *greater* public involvement in risk-management decisions, we are less certain that more is necessarily better. It is perhaps more appropriate to conclude that public involvement of high quality is more important than, for example, involving more members of the public, or involving the public more deeply in issues that they are poorly prepared to grasp. There is a risk in taking the tack of "involving" the public by allowing them to express their anger and rage, but doing very little to accommodate their views or change how things are done. This form of involvement is perhaps better characterized as indulging the public, which sometimes happens under the guises of "involving the public more."

---

9 This concluding section is based on material in a Kunreuther and Slovic (1994).
High quality public involvement has not yet been well defined. We suggest that risk-management institutions develop guidelines for high quality public involvement. These guidelines should be based on definitions of what is wanted by the public and from the public, and how their viewpoints will be incorporated into risk-management decisions. Are there technical decisions where public values would be relevant? Can the public be helpful in defining approaches for relating to their own constituency? Is there training and education that the public needs in order to be an active, valued, and respected participant in risk management?

Earlier Involvement of the Public

Very often, the difficulties in dealing with the public are brought about because those impacted by a project are among the last to know of its existence. Project development is a complex and risky process. For project developers, the road that leads from an idea to a construction permit or operating license is a long and hazardous one. Only a very small number of the projects that are considered actually make it to the point of filing an application with a regulatory or licensing agency. Usually by the time an application is filed, many decisions have been made that are very difficult to reverse, making it difficult, if not impossible, for a proponent to incorporate the public's input. Project proponents need better advice on how to involve the public earlier in the development cycle. And, risk-management institutions need better guidance on how they can give that advice in a responsible way that is sensitive both to the needs of the public and to the constraints and problems faced by the proponents.
Greater Reliance on "Volunteer Communities"

For the public to be a willing partner in technology, it needs to know what is in it for them. For a project to be of true benefit to a country or a region within the country, it must fit within their own framework of goal and objectives, and not just those of project developers. Project proponents should be encouraged to strive for a partnership with host countries and their neighbors. The first step in establishing that partnership is a recognition of the critical importance of voluntariness in decisions about technology. The "normal" project development process can seem to community members as imposing the results of decisions made by others upon them, particularly when public involvement does not occur until far downstream from project planning. By working toward voluntary participation in project development, proponents may actually reduce the risks that a project will run into trouble that can result in costly delays or even more costly abandonment.

Role of Public Interest Groups

One of the issues that deserves further discussion is the role that environmental groups and organizations can play if a voluntary siting process is utilized. Suppose that one of these public interest groups feels that it would be inappropriate for community Y to host a proposed incinerator because they feel that the technology is unsafe. It is fair game for information on the public interest group's views of the risk to be presented to the affected residents, who may then revise their feelings about the facility and/or demand additional safety and mitigation measures before agreeing to vote in favor of hosting it in their backyard.
Organizations like Greenpeace have strongly opposed the construction of incinerators in communities because they feel they produce environmental hazards. They have developed a set of guidelines for preventing these facilities from being built (Greenpeace 1991), but there is limited empirical evidence as to what impact these efforts have had on community attitudes toward these facilities.

*Increase Public Trust*

We are currently at an important junction in the evolution of socially accountable risk management. All the research to date on the failures of risk management point strongly to the erosion of trust both in government and in many of our social institutions as an important causal factor in the conflicts that exist between the community of risk experts and the public.

At this juncture, we need to move forward in one of two directions. One path that has been advocated by a number of researchers is to work toward increasing public trust in risk management. While it is much too soon to express either optimism or pessimism about the likely success of this strategy, it is a significantly challenging problem that at the moment appears to have no easy answers.

A second path leads in the direction of developing risk-management processes that don't rely on trust, or rely on it only minimally. Though it is seldom acknowledged explicitly, many of the steps currently being taken by government and industry to involve the public through community advisory panels and the like are, in effect, establishing layers of oversight such that the checks-and-balances principles inherent in democratic
governments are instituted within technological risk management. This may be a fruitful avenue to pursue, and research along these lines is currently needed.
SELECTED REFERENCES

Angell, Philip (1993), Personal communication regarding Browning-Ferris Industries, Inc.'s program for siting landfills, April (Houston, TX: BFI).


Table 3: Attitude Toward Mitigation Measures

Percentage of U.S. Residents Favoring Different Facilities Under Alternative Mitigation Packages

<table>
<thead>
<tr>
<th></th>
<th>Landfill</th>
<th>Incineration</th>
<th>Repository</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Measure</td>
<td>18</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Inspection</td>
<td>53</td>
<td>42</td>
<td>32</td>
</tr>
<tr>
<td>Inspection and Shutdown</td>
<td>67</td>
<td>58</td>
<td>43</td>
</tr>
</tbody>
</table>

Source: University of New Mexico Survey (February 1993).
Figure 1

Effect of Risk to Self and Risk to Future Generations on Nevadans Willingness to Vote for a Repository With Rebates
[1987 Nevada Survey (Kunreuther and Easterling, 1990)]
Table 2. Limited Effectiveness of Compensation the Case of Nuclear Waste Repositories

<table>
<thead>
<tr>
<th></th>
<th>Study 1</th>
<th>Study 2</th>
<th>Study 3</th>
<th>Study 4</th>
<th>Study 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acceptance without incentives</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22%</td>
<td>10%</td>
<td>27%</td>
<td>24%</td>
<td>60%</td>
<td></td>
</tr>
<tr>
<td><strong>Acceptance with economic benefits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;substantial payments&quot;</td>
<td></td>
<td>26%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;economic benefits&quot;</td>
<td></td>
<td></td>
<td>14%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$1,000/yr for 20 yrs</td>
<td></td>
<td></td>
<td>26%</td>
<td>23%</td>
<td></td>
</tr>
<tr>
<td>$3,000/yr for 20 yrs</td>
<td></td>
<td></td>
<td>30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$5,000/yr for 20 yrs</td>
<td></td>
<td></td>
<td>30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$100–$900/yr for 20 yrs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>51%</td>
</tr>
</tbody>
</table>

---


2 Jenkins-Smith et al. (1993). Total sample of 1200 U.S. residents. Each condition has n = 150.


Table 1. Effect of Compensation Measures in Increasing Acceptance of Facilities

<table>
<thead>
<tr>
<th>Landfill for Municipal Waste</th>
<th>Study 1(^1)</th>
<th>Study 2(^2)</th>
<th>Haz Waste Incin(^2)</th>
<th>Prison(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceptance without incentives</td>
<td>30%</td>
<td>25%</td>
<td>15%</td>
<td>29%</td>
</tr>
<tr>
<td>Acceptance with economic benefits</td>
<td>\quad</td>
<td>50%</td>
<td>32%</td>
<td>51%</td>
</tr>
<tr>
<td>Rebatess on property tax</td>
<td>63%</td>
<td>\quad</td>
<td>\quad</td>
<td>\quad</td>
</tr>
<tr>
<td>State money for schools</td>
<td>62%</td>
<td>\quad</td>
<td>\quad</td>
<td>\quad</td>
</tr>
<tr>
<td>State money for roads</td>
<td>56%</td>
<td>\quad</td>
<td>\quad</td>
<td>\quad</td>
</tr>
</tbody>
</table>

\(^1\) Bacot, Bowen, and Fitzgerald (1994). Sample of 844 Tennessee residents. The 30\% figure for acceptance without incentives was derived from the reported result that 70\% opposed the landfill; 30\% is an upper bound on the actual figure. The authors do report the proportion in favor under the incentives conditions.

\(^2\) Jenkins-Smith et al. (1993). Total sample of 1200 U.S. residents. Each condition has \( n = 150 \).