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A DECISION-PROCESS PERSPECTIVE ON RISK AND POLICY ANALYSIS*

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Risk analysis and policy analysis can play important roles in facilitating the siting of potentially hazardous facilities if one recognizes the descriptive features of the decision process. The case of siting a liquified natural gas (LNG) facility in California illustrates the multi-party sequential nature of the process and the role that widely differing risk estimates play in fueling conflicts between stakeholders. Risk analysis does have a useful function in clarifying the nature of the potential losses, particularly if rules of evidence are instituted for evaluating different studies. Policy analysis can facilitate the negotiation process by the use of compensation to redistribute gains and losses between the different parties. Examples from case studies are presented to illustrate the challenges for risk analysis and policy analysis in the siting process.
(RISK ANALYSIS; POLICY ANALYSIS; DECISION PROCESS; LOW PROBABILITY EVENT)

1. Introduction

This paper explores how risk analysis and policy analysis can improve the decision process associated with the siting of potentially hazardous facilities. A principal purpose of risk analysis is to estimate the probabilities and consequences of a catastrophic accident. For various reasons, two risk analyses of the same potential hazard may yield radically different risk estimates. Such discrepancies may significantly influence the course of the siting decision process. We suggest the importance of rules of evidence for encouraging more constructive analyses.

Policy analysis is broadly concerned with providing decision makers with useful information and procedures, but to date has not been widely used to facilitate mutually advantageous agreements. We investigate how compensation programs for sharing gains and losses may help resolve conflicts in the siting process.

The use of risk analysis and policy analysis for improving outcomes is highly correlated with the interplay of the various stakeholders involved in the decision process. Siting actions are *not* taken by a single decision maker; rather they are a product of conflict resolution between the various interested parties, each with a different set of objectives and concerns (Fischhoff *et al.* 1981, Vaupel 1982b). Some of these stakeholders have commissioned their own risk analyses to defend their position. Others rely on published documents.

Consider the following illustrative example associated with estimating the public safety risk of a proposed liquified natural gas (LNG) terminal at Oxnard, California. One risk assessment prepared by a private consulting firm for the gas companies showed that a person living in Oxnard had between a 10^{-4} and 10^{-7} chance per year of dying from an LNG accident. A second risk analysis commissioned by the Oxnard City Council concluded that the risk to a citizen in the community was somewhere between 10^{-7} and 10^{-10}. These two ranges differ by three orders of magnitude.

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However, it was difficult to determine the basis for these discrepancies because the risk analysis did not clearly state their assumptions nor discuss the limitations of the data employed.

The Oxnard example is not an isolated case. As a study on the siting of LNG terminals in four countries (Kunreuther, Linnerooth *et al.* 1983) has shown, widely varying risk estimates for the same event are pervasive. The politics of the risk management process discourage the risk analyst from revealing the uncertainties inherent in making probabilistic estimates and has inhibited the pursuit by the policy analyst of programs such as compensation that involve explicit tradeoffs.

We will illustrate the current role of risk analysts and policy analysts through a set of concrete examples primarily related to the siting of liquified natural gas terminals.[1] The next section sketches key events in the siting process of an LNG terminal in California and highlights several features of the decision process which appears to be common in most siting controversies. §3 then considers the role of risk analysis in the siting process. §4 is devoted to how policy analysts can play a role in negotiating conflicts with particular emphasis on the use of compensation. §5 presents a brief set of conclusions.

2. Policy as Process: LNG in California

The decision processes associated with the siting of LNG terminals are roughly similar to the processes associated with locating other kinds of hazardous facilities, such as nuclear power plants and hazardous waste storage sites (Keeney 1980). Each of these problems involves multiple parties with different agendas and concerns.

In the California case, in September 1974 Western LNG Terminal Company, a firm representing the siting interests of several gas distribution companies, applied to the Federal Power Commission for approval of three sites on the California Coast: Point Conception, Oxnard, and Los Angeles. These applications generated considerable controversy on the federal, state, and local levels concerning the need for natural gas and the safety of locating a terminal at the populated Los Angeles and Oxnard sites. The most frightening possibility was that the storage tanks would fail catastrophically, releasing a large quantity of natural gas which would vaporize into a cloud that might travel over a neighboring population center and then ignite. Many questions concerning the plausibility of this scenario were left unanswered. The conflicts among the many groups involved were exacerbated by the different results of the risk analyses commissioned by different groups.

By the summer of 1977, it appeared likely that none of the three sites would be approved by all the necessary local, state and federal authorities—the Oxnard and Los Angeles sites because of safety considerations, and the beautiful Point Conception site because of environmental considerations. Hence, the utility companies turned to the state legislature for help. The resulting legislation, the California LNG Terminal Siting Act, was a compromise between the interests of the utility companies and the interests

[1] We choose this technology because most of the ideas in this article arose in the context of a collaborative study of LNG siting decision processes. The study was conducted at the International Institute for Applied Systems Analysis in Laxenburg, Austria. See Kunreuther, Linnerooth *et al.* (1983). As background it may be helpful to know that:

> Liquefied natural gas (LNG) is a potential source of energy which requires a fairly complicated technological process that has the potential, albeit with very low probability, of creating severe losses. For purposes of transporting, natural gas can be converged to liquid form at about 1/600 its gaseous volume. It is shipped in especially constructed tankers and received at a terminal where it undergoes regasification and is then distributed. The entire system (i.e., the liquefication facility, the LNG tankers, the receiving terminal, and regasification facility) can cost more than $1 billion to construct (Office of Technology Assessment, 1977).

of those concerned about safety and the environment. The process was streamlined to facilitate the identification and approval of a site within a prescribed time interval. The environmentally-minded California Coastal Commission was given the authority to rank the sites but the energy-minded California Public Utility Commission would make the final choice. The Federal Energy Regulatory Commission must also approve the application.

Following this procedure, the remote Point Conception site was tentatively selected: its final approval was made conditional on the site being seismically safe. A Seismic Review Board appointed by the California Public Utilities Commission found that the earthquakes did *not* pose an unacceptable risk. Nonetheless, at the end of this ten-year process, Western LNG Terminal Company withdrew its application. Following the deregulation of domestic natural gas prices in 1978, it appears that California does not now need an LNG terminal.

This brief description of the siting saga in California reveals the following features of the decision process which are worth noting.

Multi-Party, Multi-Issue Process. There was no single person, group or institution that decided on the Point Conception site. The final choice evolved from a variety of actions taken by the many authorities involved at the federal, state and local government levels as well as interactions between the applicant, citizens groups and environmentalists (Kunreuther, Lathrop and Linnerooth 1982). The objectives of each group and their explicit mandates are narrowly focused so that conflict is bound to emerge. For example, the California Coastal Commission is explicitly authorized to protect the coastline; the local city councils are primarily concerned with creating jobs for their constituents and preventing accidents, the California Public Utility Commission is primarily concerned with assuring an energy supply to the state.

A second complicating feature of siting decision processes is that the institutions involved are usually dealing with many issues in addition to the siting question. According to Majone (1984) a public policy question, such as siting energy facilities, leads competing stakeholders to take stands on policy issues consistent with objectives related to the long-term survival of their institutions. While the problem may be formulated as approving a certain site, other institutional concerns related, for instance, to energy policy or regional development may determine a party's position on the narrower agenda item. For example, what appeared as irrational behavior on the part of Western LNG Terminal Company in pursuing the earthquake fault issue at Point Conception when California no longer needed the terminal may be rational when viewed from the perspective of Western's long-term objectives; an approval of this site clears the path for an LNG facility in the future should the gas utilities want it.

The government politics model proposed by Allison (1971) comes closest to our view of the siting process. Allison points out that each of the actors in the game focuses on multiple problems rather than a single issue. Since the parties share power and have conflicting preferences it is necessary to identify the various issues deemed important to determine why certain bargains and compromises emerge.

Sequential Processing of Issues. The siting of technological facilities is not solved systematically once and for all through the use of large-scale decision analyses and similar tools. Rather, the decision process moves sequentially through a set of questions: at each stage only segments of the problem are addressed.

Braybrooke (1974) has developed a model of the decision making process which captures this kind of siting process.[2] Over time issues are resolved, dismissed or

[2]This model is in the spirit of the incrementalism approach to political decision making developed by Lindblom (1959).

transformed as new information or new alternatives emerge. Not only are the larger problems—whether and where to site an LNG facility—broken down into smaller subproblems, but these subproblems are usually dealt with sequentially by agencies with different and sometimes conflicting responsibilities. Constraints due to legislative and legal considerations may dictate the order in which certain actions must be taken.

Resolution of the question whether an LNG terminal is needed usually precedes the site selection phase which, in turn, usually precedes the licensing phase. Occasionally, the end result may differ from the original intent. For example, in California, the applicant originally stressed the risk of an interruption in the supply of natural gas as a major reason for importing LNG to three separate sites. During the course of the decision process, the three sites were reduced to one, and the number of storage tanks at that site were reduced from four to two. Because of this concentration in one small area, and the possibility of routine closures or nondelivery due to bad weather conditions, the net result of the sequential decision process was that a project originally meant to decrease supply interruption risk was shaped over time into a project that may have increased that risk.

Agenda Setting. If the process is sequential in nature, then the setting of an agenda is likely to play a role in determining the final outcome as well as the length of time it takes to reach it. Agenda setting determines the order in which different subproblems are considered. Empirical evidence from the field as well as from laboratory experiments (Cobb and Elder 1972, Levine and Plott 1977) suggests that different agendas for the same problem frequently lead to different outcomes.

There are two principal reasons for this. A particular decision made on a subproblem serves as a constraint for the next subproblem. If the order of the subproblems is reversed, then there would likely be a different set of choices to consider. Secondly, each subproblem involves a different set of interested parties who bring with them their own set of data to bolster their cause. The timing of their entry may have an effect on later actions. For example, citizen groups normally enter the siting debate only when their own community is being considered as a possible candidate.

Salience of Exogenous Events. While different parties are concerned with many aspects of the siting decision, the risk issue nonetheless often arouses special concern. This concern is fueled by the perplexing moral and symbolic dilemmas that arise when a large number of lives may be at stake. Low probability events are frequently ignored until an exogenous event, such as a disaster, structures the political agenda by calling attention to the dangers associated with a particular technology. The small data base for judging the frequency of low probability phenomena increases the impact of these salient events on the decision process (Nisbett and Ross 1980, Slovic *et al.* 1983). Controlled laboratory experiments by psychologists have illustrated this type of estimation bias (Lichtenstein *et al.* 1978). Tversky and Kahneman (1974) describe this bias as resulting from an availability heuristic whereby one judges the frequency of events by the ease with which specific examples can be retrieved from memory. However, opposition to large-scale technology may be due to other concerns of protestors that are unrelated to the psychological biases described in the literature (Otway and von Winterfeldt 1982).

In a study of legislative decision-making, Walker (1977) suggests the importance of graphically and easily understood evidence of trouble as an important factor in setting the discretionary agenda of the U.S. Congress or a governmental agency. He also contends that the political appeal of dealing with a specific problem is increased if it has an impact on many people. To support these points, Walker presents empirical evidence on the passage of safety legislation in the U.S. The recent Tylenol scare in the United States illustrates Walker's point. Numerous examples of this process are also provided by Lawless (1977) through a series of case histories of problems involving the

impact of technology on society. He points out that frequently

> new information of an "alarming" nature is announced and is given rapid and widespread visibility by means of modern mass communication media. Almost overnight the case can become a subject of discussion and concern to much of the populace, and generate strong pressures to evaluate and remedy the problem as rapidly as possible (p. 16).

In the case of decision processes involving the siting of hazardous facilities, exogenous events such as an LNG explosion or an oil spill may be sufficiently graphic and affect enough people to cause a reversal of earlier decisions, inject other alternatives into the process, and change the relative power of parties interested in the decision outcome. The mass media may play a critical role by focusing attention on these specific events and by exaggerating their importance. For example, in December of 1976 the Los Angeles City Council voted to allow work to begin on an LNG terminal in San Pedro Bay. The following day an explosion destroyed the oil tanker in Sansinea in Los Angeles harbor, leaving 9 dead and 50 injured. A week later the City Council commissioned a study of the relative safety of the proposed site. The explosion, although it had nothing to do with liquified natural gas, alerted many Californians to the potential dangers of LNG (Kunreuther and Lathrop 1981).

3. Risk Analysis in Decision Processes

Interested parties often disagree on the nature of the risks associated with health, safety, and environmental policies. Differences are created at even the most elemental level since the word "risk" has many interpretations. In the case of LNG siting in California the utility companies were concerned about the risk of insufficient supplies of gas. They expressed the belief that the importation of LNG from foreign countries would reduce this risk. The Sierra Club and local citizen groups, on the other hand, expressed concern about environmental and safety risks from a new facility. They were each using a language of "risk" in relation to this particular issue as part of their vague and broader set of interests and objectives. Most risk analyses have focused on the threat to life or health as a potential consequence of a given activity (Fischhoff et al. 1981). This is the notion used in the following discussion.

Trans-science and Risk Estimation. Weinberg (1972) was one of the first scientists to call attention to the difficulty of estimating low-probability events. He proposed the term "trans-science" to indicate that there is no practical basis for precisely estimating the statistical chance and consequences of the occurrence of certain types of accidents.

The trans-scientific nature of risk estimation is aptly illustrated by the LNG analyses done in California. Consider first some examples of differences in the choices made by analysts in defining the boundaries of the risk problem they were addressing. One study of the Oxnard site focused on a geographical area that put 15,000 people at risk; another study considered a broader area that put 90,000 people at risk. Two of the three risk assessments done for the Point Conception site considered risks involving transport ships, the transfer of LNG to shore, and the storage tanks on shore; the third study considered only risks involving the transport ships. One major risk to an LNG facility is sabotage and another is war: none of the various California risk assessments, however, included either possibility. The chapter by Mandl and Lathrop in Kunreuther, Linnerooth et al. (1983) provides more details on the risk studies.

Analysts also have to make judgements about how to model complex phenomena. Simplifications have to be made—but which simplifications? A risk analyst's time is spared if various events are assumed to be independent—but when are such convenient assumptions of independence justified? How likely is it that the human operator of a hazardous facility will err and prove yet again Murphy's law? Should best-guesses or prudently conservative estimates be used for the various parameters in the risk

assessment? Risk analysis is a craft that requires analytical judgements on a series of questions like these.

As a result, it can happen that two analysts portray the same hazard very differently. For example, one California LNG analysis indicated a probability of about one in 100 million per year of a ship collision in the harbor, whereas another analysis indicated a probability of one in 2000—a series of differing analytical judgements produced a 50,000-fold difference.

The Use of Risk Analyses. Institutions of all sorts battling in the political arena quite naturally seize upon the estimates that aid their cause. Utility companies advertise the risk assessments with narrow problem limits by analysts which rely on the best-available scientific estimates and leave out nebulous factors. Environmentalists and nearby residents prefer broad risk assessments done by analysts who are willing to use subjective judgements, who strive to be prudent by cascading conservative estimates, and who can vividly imagine a myriad of possible errors and disasters. Advocates, in general, exploit the statistics that support their arguments and interests (Vaupel 1982a).

The opportunities for conflicting interpretation of risk assessments are widened because advocates not only can pick their study but can also choose their numbers and figures from a study. For instance, one Oxnard risk study included, among many other estimates, a worst case scenario that indicated that a spill of 125,000 cubic meters of LNG from all five tanks on the tanker would cause a vapor cloud which might kill up to 70,000 people. Any resident could look on a map to determine whether the cloud covered his own house (Ahern 1980). Although no estimate of a probability was attached to this scenario, the chances were miniscule. Nonetheless, the graphic depiction of these consequences generated a strong public reaction by groups of local citizens. The California legislature was influenced by this public reaction. One legislative staff member stressed that it was not possible to allow a site that could lead, no matter how remote the chance, to a catastrophe (Kunreuther and Lathrop 1981). This report was influential in persuading the state legislators to rule out Oxnard as a possible site by including the remote siting provision into the California LNG Terminal Siting Act. Thus, the risk number and the map that the analyst calculated had a large political impact due to the way the data were presented.

The Myth of Objectivity. Several authors have discussed how and why an analyst's values color his or her methods and results (see, for example, Quade 1975, Majone 1980). Wynne (1982) suggests that these biases be recognized as part and parcel of science, and not lapses from rational scientific analysis.

> There is a pervasive myth about the nature of science which supports this false approach to the question of "analytic bias". The tendency in the literature is to regard bias or mistakes as individual and isolated in origin, which suggests that ideal objective scientific knowledge can be attained in professional practice and as an input to policy issues . . . . This gives a fundamentally misleading and politically damaging picture of the role of expertise . . . .

The myth of objectivity, especially where the policy sciences are concerned, has led to a dual perspective on risk analyses. On the one hand, because the analyses are quantitative they appear to be factual and objective. On the other hand, the large uncertainties involved necessarily preclude the assessments from being definitive. This *dual nature* of a formal risk study has fogged discussions of its role in the policy process. The numbers produced by a risk analysis are not exact or "hard". They incorporate a number of judgements, but hardly anyone in our culture is capable of handling inexact quantities or "soft" numbers as has been pointed out by Ravetz (Kunreuther, Linnerooth, and Starnes 1982, p. 402).

In many ways, science has served to maintain the authority and legitimacy of our

public institutions. The full objectivity of scientific investigation has been, and remains, a concept necessary for upholding authority. As scientific investigation moves into areas with a clear subjective element, there is a danger that the myth of full scientific objectivity will be exposed and that institutional authority will be threatened. Thus, institutional leaders, in guarding this myth, are reluctant to expose the uncertainty and subjectivity inherent in risk analyses. The analyst, himself, is caught in a system that offers little choice but the cloaking of results in a veil of scientific objectivity.

This pretense of objectivity has been observed by Moss and Lubin (1980), who emphasize the appeal of risk analyses that present a rational and scientific approach to public decision making. Precise numerical results provide comfort by concealing such inherent and fundamental uncertainties as those reflected in the millionfold difference between risk estimates for saccharin or in the Inhaber–Holdren debate (Inhaber 1979, Holdren *et al.* 1979) concerning the risks of nuclear power plants. Even at an institution like the National Research Council (NRC), where analysts are somewhat insulated from political pressures, it is difficult to avoid biases in risk assessments. A concern over this was expressed recently in a report surveying the way in which risk analyses are prepared by the NRC.

> Science is strongly biased towards numbers, for when numbers can be justly employed they denote authority and a precise understanding of relationships. Because this is so, there is an equally important responsibility not to use numbers, which convey the impression of precision, when the understanding of relationships is indeed less secure. Thus while quantitative risk assessment facilitates comparison, such comparison may be illusory or misleading if the use of precise numbers is unjustified. (NRC Governing Board Committee on the Assessment of Risk 1981, p. 15.)

According to this view, it appears that the responsibility for exposing the imprecision of risk estimates lies with the analyst. But it is mistaken to suppose that the analyst can be removed from the social and political setting in which he or she is bound. In our adversarial system of policy making, the livelihood of consultants depends on their ability to prepare persuasive analytical arguments. Piehler (1974) provides an interesting example of this phenomenon in the context of a court case involving product liability.

Constructive Roles of Analysis. One possible direction for reform is discussed by Ackerman *et al.* (1974). They note that differences of opinion are often exacerbated by simultaneous studies of the same phenomenon and that traditional approaches, such as agency hearings and judicial reviews, are inherently limited in evaluating these conflicting assessments. To deal with this problem, they advocate establishing rules of evidence for scientific studies used in legal proceedings, in much the same spirit as a science court. These rules would encourage more uniform analyses so that the debate could focus on the alternatives themselves rather than the particular assessment or presentation promoted by an interested party. Lathrop and Linnerooth (1982) provide a suggested set of guidelines with respect to establishing rules of evidence. In particular, they stress the importance of defining the risk being assessed and clarifying the assumptions and error bounds, as well as indicating the conditional nature of specific analyses which are undertaken.

Without questioning the validity of our adversarial system of policy making, which has certain advantages over other political systems, we should recognize that analysts are constrained by the realities this system imposes on them. From this decision-process perspective, it is illusory to expect substantial changes in analytical practices without changes in the institutional foundations on which the system rests.

4. A Role for the Policy Analyst: Negotiating Conflicts

If each of the individual parties focuses on different attributes in judging the attractiveness of a particular site and if risk analysts differ widely in their risk assessments, then it is not surprising that proposed options, like the California LNG sites, may be rejected after a debate that is more heated than it is illuminating. Policy analysts may be able to make an important contribution by developing creative processes for resolving conflicts in mutually advantageous ways.

Conflict negotiation may be facilitated if policy analysts can develop programs for sharing gains and losses from a proposed project. By arranging for winners to compensate losers, by monetary payments or by payments in kind such as a recreation park, all parties may feel they are better off after the siting of a new technological facility.

A distinction can be made between *ex ante* compensation, by which payments in money or in kind are made at the time a facility is approved or constructed, and *ex post* compensation, by which reimbursement is paid to individuals or groups who suffer losses from an accident. In this section we illustrate several types of *ex ante* and *ex post* compensation arrangements which have been considered in siting facilities in different countries. The most difficult aspect of designing these compensation agreements is the problem of misrepresentation of preferences and concerns by some of the parties for personal gain. Designing systems which encourage parties to tell the truth independent of what others do (truth dominant procedures) or to tell the truth when others are also telling the truth (incentive compatible procedures) requires some ingenuity (Raiffa 1982). Here we will provide illustrative examples of the types of compensation systems which appear to have worked well and others which have had their problems.

Ex Ante Compensation Measures. In siting power plants, an applicant may propose to reduce electricity rates to residents within a certain distance of the hazardous facility in order to compensate them for the increased risk or unpleasantness. Such a system has recently been introduced in France with respect to nuclear power plants. People living within approximately 15 km of a facility can apply to the local authority for a reduction of up to 15–20% in electricity rates. (Personal conversation with Gaz de France 1982.) Another example of *ex ante* compensation relates to the construction of a 1500 MW coal-fired power plant in Wyoming. A law suit had enjoined construction of the plant because of its potential damage to the surrounding environment. The suit was settled when the utility companies agreed to set up a $7.5 million trust fund for the express purpose of preserving a 60-mile stretch of the Platt River, the habitat of migratory birds, including the whooping crane. The coal plant was completed in 1981 and is fully operational today. (Personal conversation with Patrick Pateneau, National Wildlife Federation, 1982.)

We have been able to find only a single case where direct monetary compensation was given to individuals and this provoked a very strong reaction from others. In West Germany, the utility company STEAG (Steinkohle–Elektrizitatswerke AG) announced plans in 1976 to construct a 1400 MW coal power plant in the city of Bergkamen in the Ruhr area. A citizen action group protested the project and threatened to delay the licensing procedures. In March 1977 a contract was signed between the utility company and three representatives of the action group: the group would be reimbursed with a payment of $750,000 if they agreed not to oppose the project. However, a court case was provoked when the city of Bergkamen refused to distribute the money. The federal court decided that the contract was valid because the citizen group should be compensated for legitimate rights, but the decision was greeted with negative reactions by German public opinion. Concerns were voiced in the media that health and safety were citizens' inalienable rights that could not be bought off.

Ex Post Compensation. In *ex post* compensation the key question is who is responsible for the damage should an accident occur. To encourage safer designs there is good reason to have the applicant responsible for any damages from an accident. Pfennigsdorf (1979) points out that for ultra-hazardous or abnormally dangerous activities, such as an LNG terminal, public policy supports the doctrine of strict liability whereby the operator of the facility is liable for damages regardless of fault. Whether the developer actually will have to pay for these losses in the event of a catastrophic LNG accident in the future remains to be seen. If the courts hold the applicant responsible, then some form of public or private insurance appears to be attractive on the surface since, to the extent premiums are based on risk, it creates incentives for firms to make their facilities safer. Yet, as we have discussed above, experts often disagree on the chances and consequences of a catastrophic accident; this makes it difficult for an insurance company to set premiums. For this reason and because premiums are small compared to the potential losses should an accident occur, insurance and reinsurance companies are reluctant to provide protection against these low probability, high consequence events. A unique set of *ex post* compensation arrangements between the developers, insurance firms, government and victims may well emerge depending on the exact characteristics of the accident. In fact, we could not determine for any of the four case studies of LNG siting what fraction of the damage would be shared by each of the interested parties should an accident occur.

Rather than using direct monetary payments to make *ex post* compensation, it may be attractive for all parties to arrange for payment in kind. A landmark case in this spirit was the settlement by Allied Chemical in Virginia after being found guilty of polluting the James River with the pesticide kepone. Rather than paying a fine, the company proposed paying $5.2 million and establishing an $8 million trust fund to be used for environmental grants in Virginia. In essence, the firm provided *ex post* compensation in the form of support for research to prevent future damage to the environment (1982 Annual Report of Virginia Environmental Endowment).

These types of compensation arrangements may be important tools in the analyst's repertoire if certain individuals or groups have the power to block the approval of a facility that promises to increase general social welfare.

5. Conclusion

Viewing siting decisions from a decision-process perspective leads to some insights that might not be apparent from the simplifying vantage point of a single decision maker resolving a single decision once and for all.

Most risk analysts recognize that risk estimation involves vague uncertainties and subjective judgments and that two risk analysts may therefore produce widely differing assessments of the same hazard. The decision-process perspective highlights a key consequence of such discrepancies: interested parties seize the assessments that favor their position and try to use them as conclusive arguments rather than as a bit of incomplete evidence. Furthermore, from a decision-process perspective it seems naive to expect that such misuse of risk analyses can be curtailed by exhorting analysts to reform their practices. Institutional changes, including perhaps rules of evidence, are required.

The decision-process perspective also suggests that a major role for policy analysts is to help negotiate conflicts. One promising approach that deserves more careful study is to facilitate agreement by using various compensation strategies to redistribute gains to losers. Transfer payments either in monetary form or more likely through payments in kind may lead groups who opposed a facility to favor its construction. How well these tools are likely to work depends upon the nature of the problem, degree of opposition

and the view which society has on satisfying all interested parties. In the end it comes down to how society deals with tradeoffs between parties when there is imperfect information on both the risks and the benefits.[3]

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