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SHOULD HIGH-LEVEL NUCLEAR WASTE BE DISPOSED OF AT GEOGRAPHICALLY DISPERSED SITES?

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ABSTRACT

Consideration of the technical feasibility of Yucca Mountain in Nevada as the site for a high-level nuclear waste repository has led to an intense debate regarding the economic, social, and political impacts of the repository. Impediments to the siting process mean that the nuclear waste problem is being resolved by adhering to the status quo, in which nuclear waste is stored at scattered sites near major population centers. To assess the merits of alternative siting strategies —including both the permanent repository and the status quo— we consider the variables that would be included in a model designed to select (i) the optimal number of disposal facilities, (ii) the types of facilities (e.g. permanent repository or monitored retrievable facility), and (iii) the geographic location of storage sites. The objective function in the model is an all-inclusive measure of social cost. The intent of the exercise is not to demonstrate the superiority of any single disposal strategy; uncertainties preclude a conclusive proof of optimality for any of the disposal options. Instead, we want to assess the sensitivity of a variety of proposed solutions to variations in the physical, economic, political, and social variables that influence a siting strategy.

INTRODUCTION

This paper considers social costs of storing and disposing of high-level nuclear waste. High-level nuclear waste refers to the long-lived radioactive products that have been produced in conjunction with nuclear powered electricity-generating plants and the production of nuclear weapons. The waste products have extremely long half-lives and must be isolated from the environment for up to 10,000 years. The Nuclear Waste Policy Act of 1982 required the U.S. Department of Energy (DOE) to develop a permanent repository for high-level nuclear waste produced at electric generation plants. Nine potential sites for the repository were identified in February 1983. The number of candidate sites was reduced to five and then three. Finally in 1987, the Nuclear Waste Policy Amendments Act directed DOE to restrict site characterization to the Yucca Mountain site, approximately 100 miles north of Las Vegas, Nevada.

Consideration of the technical feasibility of Yucca Mountain has led to an intense debate regarding the economic, social, and political impacts of the repository; see Slovic, Layman and Flynn (1991a), Slovic (1987), and Kasperson et al. (1980). Impediments to the siting process mean that the nuclear waste problem is being resolved by the status quo with the waste remaining scattered at sites near major population centers. To assess this and other strategies requires a framework for analyzing the relative importance of factors that affect siting. The options for selecting strategies include (i) the number of disposal facilities, (ii) the types of facilities (e.g. permanent repository or monitored retrievable facility), and (iii) the geographic location of storage sites. To assess the merits of alternative strategies, we consider their technical, economic, political, and social consequences. The intent is to assess the merits of alternative disposal options as a function of variations in the factors that determine site suitability.

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SIMULATION OBJECTIVES

A primary reason for considering a general siting model is to emphasize the importance of social and political factors in the siting process. We want to expand the discussion regarding nuclear waste impacts by identifying and then incorporating the important political, economic, and social variables into the assessment of nuclear waste options (see figure 1). Existing models reflect a lack of data for relevant social and political variables.

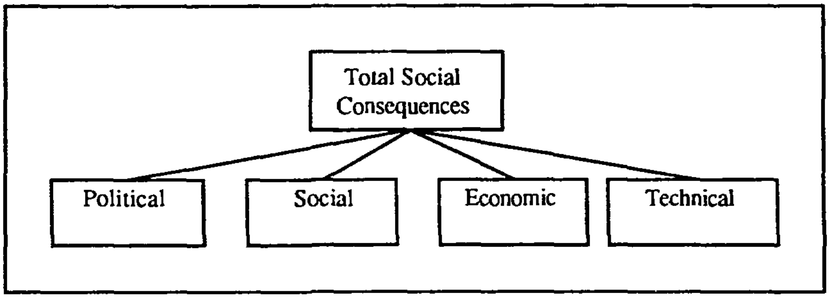

Figure 1 Total Social Consequences Are a Function of Political and Social As Well As Economic and Technical Factors

The model considers performance measures for assessing siting options that integrate technical (engineering), economic, political, and social impacts of a repository. It thus provides decision makers with comprehensive and multidimensional information on the social consequences of each disposal option (including the option to do nothing). Some variables deal with national impacts while others consider the regional impacts (e.g., impacts on Las Vegas or Nevada). Other variables measure the full range of environmental impacts of a strategy. For example, the status quo option may lead to a decrease in the amount of electricity produced from nuclear power and cause an increase in the use of coal and other fossil fuels to make up for the loss of nuclear generating capacity. Substituting fossil for nuclear fuel can have undesirable consequences; it can lead to increased emissions of acid rain precursors and greenhouse gases, which has the potential to affect global warming. Thus, part of the cost of the status quo option must include impacts on these areas of concern. On the other hand, storing the waste in the repository may cause significant regional impacts that are currently not well understood; see Slovic et al. (1991b), Bassett and Hemphill (1991), and Easterling et al. (1990). At present, the relative impacts of each policy option are unknown and, more importantly, not often compared with one another. Still, policymakers require a tool with which to assess the tradeoffs of alternative policies.

It is important to emphasize that the siting model cannot "prove" that one policy option is better than another. The intent of the model is to make policymakers confront the consequences of alternative policies. It can (1) show options, (2) enable comparisons of options, and (3) foster communication between affected parties.

THE STRUCTURE OF A SITING MODEL

Figure 2 presents the outline of a simple model to assess the impacts of a the choice between disposing of nuclear waste in a repository or keeping it in storage pools. The model presented is simple and is not meant to be a full assessment of these two disposal strategies. It is a first-cut attempt to understand how a simulation might be developed that 1) incorporates nonstandard social impacts, 2) assesses tradeoffs between choices, and 3) assesses the sensitivity of outcomes to underlying assumptions.

The parameters for the storage pools, repository, and transportation modes are illustrative. They show impacts through a probability/consequence function. Serious accidents are low-probability/high-impact events. Thus, one focus is on how having scattered disposal site changes the risk of an accident. On the one hand, leaving the waste in the pools means that there are more than 100 separate sites where an accident can occur. Further, if an accident occurs at one pool, there may be stigmatization of other sites, with resulting increases in security and operating costs; see Kasperson et al. (1988). Operating against these potential problems this is the fact that no serious accidents have occurred so far. Also, a permanent repository introduces additional risk due to transportation. Finally, the mere existence of the repository may affect local economies if the locale comes to be perceived as dangerous; see Slovic, Flynn, Layman (1991c), Kunreuther, Desvousges, and Slovic (1988) and Kunreuther et al. (1990).

Pools

Number of pools
Avg. pool capacity (tons)
Avg. tons waste per pool
Avg. annual fixed cost per pool
Avg. annual variable cost per pool
Cost to build new pool
New waste per year (tons)

Probability/consequence function:

Probability	Consequence
.0050	\$\$\$
.0025	\$\$\$\$
.0010	\$\$\$\$\$
.0005	\$\$\$\$\$\$
.0001	\$\$\$\$\$\$\$

Transportation

Truck
Max capacity (casks)
Cost per truck per mile

Rail
Max capacity (casks)
Cost per rail mile

Probability/consequence function:
(separate function for truck/rail)

Probability	Consequence
.0050	\$\$\$
.0025	\$\$\$\$
.0010	\$\$\$\$\$
.0005	\$\$\$\$\$\$
.0001	\$\$\$\$\$\$\$

Repository

Number of repositories
Cost to build a repository
Time to begin taking waste
start at 100 tons per year; increase by 100 until reach 1500 tons per year
Cask capacity (tons)
Cost per cask
Cost per year to operate repository
Cost per year after closure

Probability/Consequence function:

Probability	Consequence
.00500	\$\$\$
.00100	\$\$\$\$
.00050	\$\$\$\$\$
.00025	\$\$\$\$\$\$
.00001	\$\$\$\$\$\$\$

Other

Impact function should have high initial year with long-lasting effect (20 yrs)

An incident at one facility should cause impacts at other similar facilities

Incidents occuring within a short period of time (20 yrs) should have a "cumulative" effect

Figure 2 Some Parameters for a Simple Alternatives Assessment Model

The model includes political and social effects through an impact function. This function is multidimensional to account for the wide-ranging impacts that might be caused by an incident involving radioactive materials. Figure 3 presents one such dimension illustrating the probability–impact relationship. This relationship stipulates that low-probability events will have a higher impact than higher-probability events. High-probability events can be foreseen and planned for, so these are likely to have less impact than "surprise" low-probability events. It is also possible to model a "threshold effect" such that events below a certain probability have a much higher impact because of their uniqueness and the public's unfamiliarity with them.

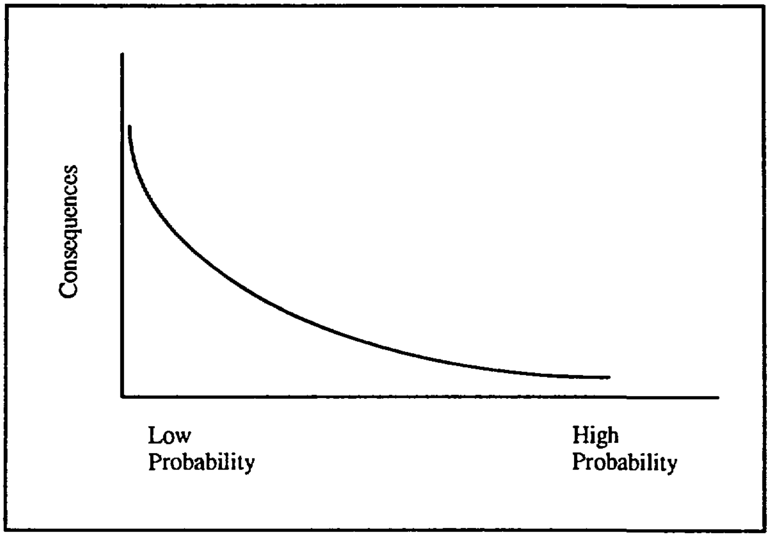

Figure 3 The Probability/Consequences Tradeoff in the Impact Function

A second dimension of the impact function is the extent to which effects linger (see figure 4). Events, especially those involving radioactive materials, can have lasting effects. The figure illustrates an impact function that has three phases after an initial event. In the first phase, the impacts are high but relatively short lived. Most of the obvious and standard economic impacts would occur in this period, as well as some social and political impacts. In the second phase, the impacts last a much longer period of time (for example, 20 years) but at a lower level. This reflects the heightened sensitivity of the area to the original incident. Finally, the impacts fade down to pre-incident levels.

Another dimension to the impact function reflects correlations between impacts at different sites. For example, if a number of storage pools were to use a similar technology and that technology were to become involved in some type of accident, then an incident at one site could lead to impact at all similar sites.

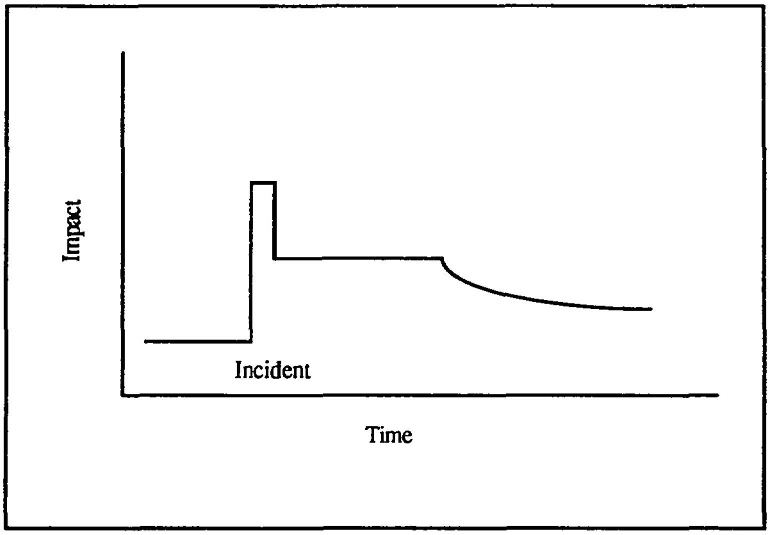

Figure 4 The Lingering Effect of the Impact Function

SUMMARY

Delays in reaching a solution for the disposal of high-level nuclear waste have been caused by intense debates over the social, political, and economic impacts of a repository. These delays have pushed back the opening of any repository until at least 2010, at a cost of several billion dollars. Additional impediments to the siting process mean that the nuclear waste problem will be solved by adhering to a status quo strategy with nuclear waste remaining at scattered sites near major population centers.

To understand the tradeoffs of policy options and to emphasize the importance of political and social factors that influence policy decisions, we have considered the structure of a simple siting model. The model allows a sensitivity analysis of the factors that affect solutions to the nuclear waste problem. The model accounts for political and social impacts through a multidimensional impact function. The model's structure attempts to show the tradeoffs associated with policy options. It provides a simple way for presenting options and assessing the importance of all the variables that affect the disposal problem.

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