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Perspectives on economic analyses for high level waste disposal

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***Abstract** - There are both internal and external pressures on the U.S. Department of Energy (DOE) to reduce costs of disposal and still maintain radiation protection to both present and future generations. The question arises whether both of these goals are attainable.*

I. INTRODUCTION

The cumulative cost of the disposal of spent fuel and high level waste at the Yucca Mountain Repository is estimated to range from $42.8 to $57.3 Billion. [1] There are pressures on the U.S. Department of Energy (DOE) to significantly reduce the costs of high level waste disposal [2,3] while maintaining the same level of radiation protection required by the standards. [5,17] The question arises whether both of these goals are attainable for high level waste disposal. The purpose of this paper is to consider benefit and cost trends for nuclear waste disposal. This paper utilizes a comparative analysis approach and focuses on background issues related to high level nuclear waste disposal and economic issues.

II. BACKGROUND ON HIGH LEVEL WASTE

Congress decreed that the consumer of the electricity generated by commercial nuclear power plants pay the costs of the disposal of spent fuel generated by those operations into a Nuclear Waste Fund. [4] Hence the same population receiving the near term benefits of the electricity pays in proportion to the quantity of electrical energy consumed. The EPA Standards require DOE to design the repository so as to limit releases of radioactive material to the environment over a 10,000 year period. [5] The long term benefits are the prevention of the risks of a substantial number of health effects. See Table I entitled Summary of Major Costs and Benefits of the Yucca Mountain Project.

Since the State of Nevada does not directly receive the benefits of electricity generated by nuclear power, consumers of electricity in Nevada do not contribute to the costs of the disposition of the spent nuclear fuel produced by the commercial power plants. However, the citizens of Nevada do contribute through federal taxes to the costs of the disposal at Yucca Mountain of high level waste (HLW) produced from the nations atomic energy defense programs. Any releases of radioactive material to the environment from the repository will occur in the area around Yucca Mountain. So Nevada may have long term costs associated with some biological detriment. Near term benefits to Nevada are jobs related to site characterization and evaluation, waste transportation, operations and disposal. Funding has not yet been provided to any state for upgrading of highways or rail for the transportation of the waste to the repository nor have funds been provided for such activities as emergency response training for police and fire departments.

III. ECONOMIC FRAMEWORK

III.A. Cost Benefit Analysis

Utilizing efficiency as a criterion to determine whether resources are being allocated in an optimal manner, policymakers can use cost benefit analysis (CBA). Congress has taken various positions on the use of cost benefit analyses in legislation dealing with environmental protection responsibilities and authorities assigned to EPA, but was silent [6] on its use for High Level Waste disposal standards to be issued by the EPA. [5]

Table I: Summary of Major Costs and Benefits of the Yucca Mountain Project

Time Frame	Benefits	Costs
Present	Electricity generated by nuclear power Employment on YMP	Paid by consumers of that electricity Occupational Radiation Exposure
Long Term Future (over a 10,000 year period)	Prevention of risk of major health effects	Small amount of allowable radiation exposure

There are advantages and disadvantages of CBA. Main advantages include: using economic efficiency as an input in the decision-making process; making pros and cons of decisions understandable to the general public in units they understand, money; and comparing multiple options. Main disadvantages include the inability of efficiency requirements to include equity issues such as intergenerational equity; the greater the time horizon the greater the uncertainty on benefits and costs, and difficulties evaluating nonmarket values. (7)

While CBA may be of limited value in very long term discounting of benefits, it lends itself very well to activities where the benefits can be realized in the short term. By quantifying the benefits of various activities involved in the disposal of these wastes, CBA can contribute to the potential realization of substantial savings by determining the value of actions such as different levels of environmental monitoring, frequency of environmental sampling, or the degree of waste characterization. Iterative detailed analyses of labor costs, costs of delays and the benefits of improvements in confidence can be published by DOE. The examples identified below are illustrative applications deserving detailed economic treatments.

1) An analysis by Neill and Neill of the savings in costs to ship RH-TRU waste to WIPP by rail in lieu of truck indicated the potential savings of millions of dollars for two of the ten sites shipping RH-TRU waste to WIPP. (8)

2) A 1999 WIPP Task Force report examined potential savings in different areas of the very expensive non-radiological RCRA regulated waste characterization. (9)

III.B. Benefit Issues and Trends Related to Safe Disposal of HLW

In order to compare the costs and benefits of any endeavor, it is necessary to have both in similar units and at a similar point in time. The EPA Standards for HLW Disposal permit limited releases of radioactivity over a 10,000 year period. (5) The costs to limit radioactive releases of these materials are being paid currently. To compare current costs to the benefits of the prevention of major releases of radioactivity over 10,000 years, it is necessary to calculate the value of the benefits back to today. Consider a simple discount rate formula below.

$$PV = FV\,(1+r)^{-t} \qquad (1)$$

Assuming an extremely conservative discount rate (r) equal to 1% and a future value (FV) of \$1 over 10,000 years (t) would provide a vanishingly small present value (PV) today of \$$1.6 \times 10^{-43}$!

A forum of eminent economists convened to address the issue of discounting for projects with extremely long time lines recognized the problems since discount rates in the past have been observed to be random and there is no guarantee or even a reasonable expectation that either a constant or any assumed method of variable discounting would be valid. (10) Lind (11) concludes that cost benefit analyses to address the problems can be informative and helpful, but do not provide a complete basis for decision making or for determining what is an optimal policy.

So how do we provide assurance that the long term intergenerational risks of potential health effects from the high level waste repository are equitable? Basically, we try to limit the predicted long term detriment to future generations to be comparable to allowable doses that are considered to be acceptable by society today. Two caveats temper this basic philosophy.

First, will the allowable annual exposure of 15 milirem (mrem) be an acceptable criterion over the long term future? During atmospheric weapons testing at the Nevada Test Site in 1957, the AEC guide for off-site radiation exposure to any person was not to exceed 3.9 Roentgen per test series which was essentially the same standard used in previous Nevada test series. [12] This is approximately equal to 3900 mrem We now consider 15 mrem per year to the reasonably maximally exposed individual to be acceptable for waste disposal in the area adjacent to the Nevada Test Site for the next 10,000 years. [5]

Secondly, how many additional radioactive sources of potential exposure may be emplaced near the NTS in the future? The probability of future multiple sources and their allowable radiation exposure needs to be addressed since historically the area has had atmospheric weapons testing, underground weapons testing, low level radioactive waste disposal, TRU waste disposal and a commercial low level waste site at Beatty.

III.C. Cost Issues and Trends Related to Safe Disposal of HLW

III.C.1. Willingness to Pay for Protection

What is society willing to pay to protect themselves and future generations for safe disposal of HLW? To address this, Congress established a system in 1983 [4] in which the consumers of electricity generated by nuclear power are obligated to pay 1.0 mill (one tenth of a cent) per kilowatt hour into a fund for the disposal of the spent fuel. About 20% of the electricity consumed in the U. S. is generated by nuclear power. [13] If we assume that 20% of the 288 million U. S. population uses electricity generated by nuclear power, then 57 million people are paying into the fund. [14]

III.C.2. Observed increase in Costs

The 1999 DOE Draft Environmental Impact Statement for Yucca Mountain estimated the total costs would be $28.8 Billion (in 1998 dollars). [15] By 2002, the Final EIS estimated the total cost to be in the range of $42.8 Billion to $57.3 Billion (in 2001 dollars). [1] The 2001 Evaluation of the Adequacy of the Fee estimated the total cost would be $ 57.5 Billion. [16] What accounts for this 49% to 99% increase in three years? Note that discounting at 4.2% would only account for a 13% increase over the three year period. Titanium drip shields have been added, waste package designs have been changed, ventilation increased as well as other changes. The estimates may not be a final figure since the decision as to what will constitute acceptable proof of the adequacy of the design will not be DOE's but will be made by the regulatory agency, namely the Nuclear Regulatory Commission (NRC). [17] The point is that the ultimate costs may be considerably greater which makes the importance of detailed iterative CBA for different stages of waste disposal all the more important.

III.C.3. Unidentified Future Costs

Consider the following three unidentified future costs.

a) Considerable radioactive monitoring in the post closure phase may be required to insure the proper identification of any detected radioactivity. For example, the 1999 DOE Draft EIS estimated there are 300 million Curies (10^{19} Bq) at the Nevada Test Site from underground weapons testing, [15] which is about 3% of the proposed YMP repository inventory. The 2002 DOE Final EIS [1] estimated the value to be only 130 million Curies (4.8×10^{18} Bq) but did not include the 4 million Ci radioactive decay products of Sr-90 and Cs-137. Estimates of the residual radioactivity from underground weapons testing indicate uncertainties up to the following values. Fission products 10 to 30 %, unspent fuel 20%, activation products 50%, tritium 300%. [18] Additionally there are inventories of low level and transuranic wastes that have been disposed on site as well as the commercial Low Level Waste site at Beatty.

b) The Nuclear Waste Fund has been invested in long term US Treasuries. DOE notes that the assumed future interest rate of 4.2% used in their calculations significantly exceeds the 40 year historical average of 2.6% for all long-term government bonds. [16] DOE notes that $57.5 Billion will be needed,[16] and this potential shortfall of interest revenues from the Fund may require an increase of several Billion dollars in required resources.

c) Congress limited the HLW repository to 70,000 metric tons of heavy metal (MTHM). DOE has considered a repository layout with a "full inventory" case which would accommodate approximately 97,000

MTHM. [1] While that would require Congressional approval, (or the opening of a second repository) that amounts to a potential increase of 38% in the inventory with a proportionate non linear increase in costs.

III.C.4. Cost increases at WIPP

As an example, the total cumulative $1.4 Billion cost of WIPP estimated in the 1980 WIPP FEIS [19] increased to $19 Billion in the the DOE 1997 Supplement to the FEIS. [20] One can argue that the numbers can't be reasonably compared since there were no standards for TRU and HLW disposal in 1980, but is intended to illustrate the potential for escalating costs in the disposal of radioactive wastes. A discount rate to account for the increase at WIPP for the 17 year interval would require an annual rate of 16.5% for the 17 year interval, an unduly high figure.

III.C.5. Allocation of costs

The NWPA allowed spent fuel and HLW generated from the nations atomic energy defense programs to be commingled in the 70,000 MTHM repository Defense activities were allotted 10% of the total or 6300 MTHM equivalent. The most recent allocation of costs has 70% for commercial and 30% funded by DOE (defense). According to DOE, the increase from 10% to 30% of $10 Billion in the defense share is based on the relative quantity of waste packages and the underground space allotment. [16] Using the mean projected total of $50 Billion, the amount financed by ratepayers of nuclear generated electricity and that funded through taxpayers for the nations defense programs general population is shown in Table II. Since household consumption of electricity [21] comprises 28.2% of the total, [13] the costs for residential consumers were calculated to be 28.2% of $35 Billion or $9.9 Billion over 57 million consumers for $173 per person.

In summary, the average total cost is $225 per person for those using electricity generated by nuclear power of $173 per person plus their fair share of the cost for the nations defense program HLW being placed in Yucca Mountain of $52 per person. For the remainder of the US population, including the citizens of Nevada, the average share is $52 per person. Nuclear Waste Fund costs for commercial and industrial users of nuclear power are not addressed in the paper since the costs may or may not be passed on to the consumers of their products.

For comparison purposes, the $19 Billion total cost of defense transuranic waste disposal at WIPP, averaged over the 288 million U.S. population, is $66 per person.

IV. DISCUSSION

This section discusses the implications of our findings. First, no future changes in standards for high level waste disposal are anticipated unless new information becomes available that there are major additional health risks. It is essential to protect both present and future generations. Second, most cost trends appear to be upward. In contrast, there continue to be announcements by DOE to reduce costs. Finally, there appears to be some uncertainty with respect to the amount of radioactivity at the Nevada Test Site in close proximity to the location of Yucca Mountain.

V. CONCLUSIONS

We find that upward cost trends in the area of waste disposal may make it difficult for the DOE to attain one of its many goals to reduce costs. Clearly more cost benefit analyses need to be performed on short term stages of disposal to achieve both cost reductions and provide assurance in protecting the public health of our present and future generations. Making such information available to the public is an important step in developing confidence in programs for waste disposal.

Table II: Estimates of the Average costs per person for Disposal of HLW in the Yucca Mountain Project

Type of Waste	MTHM to be emplaced	Percentage of MTHM (%)	2001 Funding Allocation (%)	Funding ($ Billion)	Population (Million)	Average Cost Per Person ($/person)
Commercial	63,000	90	70	35	57	173 (Nuclear energy user)
Defense	7,000	10	30	15	288	52 (US population)
Total	70,000	100	100	50	n/a	

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