

Possible Locations of Monitored Retrievable Storage from a Spent Fuel Transportation Perspective

Amitava Majumdar
Department of Nuclear Engineering
University of Michigan
Ann Arbor, Michigan 48109

and

Debu Majumdar
U.S. Department of Energy
Idaho Operations Office
Idaho Falls, ID 83401

Introduction

A considerable effort is being made by the U.S. nuclear Waste Negotiator's office to find a suitable site for a Monitored Retrievable Storage (MRS) facility. However, approximately 20,000 metric tonnes of spent fuel has already accumulated at the commercial reactor sites and this number is increasing rapidly. The process of finding a solution for the nuclear waste management has largely become a political process. In this context all possible solutions must be explored, and a consensus must be reached by the public.

The criteria for the selection of a location for the MRS can be divided into three broad categories: (1) industrial hazard and radiological risk to the people of the area, (2) cost of construction and operation of the facility, and (3) issues related to the transportation of spent fuel from the reactor sites to the MRS location and their eventual transportation to the repository. Criterion (1) gives rise to the so called "not-in-my-backyard" or NIMBY syndrome and is beyond the scope of this study. Criterion (2) is relatively independent of location. Item (3) will be a huge effort involving a large number of truck and railroad transportation of nuclear materials over many years. This effort must be minimized. In this paper we concentrate on item (3) and determine possible regions in the nation that will minimize the transportation risk. No geographic region in the contiguous U.S. is excluded for the MRS.

Description of the method

An accurate minimization study of transportation miles would require knowledge of the mode and routes of transportation. Since we are interested in determining only a zone for the MRS and not in the precise location for the MRS, we have used a flat geometry for the U.S.

Let us consider that there are N reactor sites whose X and Y coordinates $(X_k, Y_k; k=1, 2, \dots, N)$ are known. We need to find the coordinate of position (X_0, Y_0) so that the summation of distances from N sites to (X_0, Y_0) is minimum. We also introduce the following definitions:
 $D_i^P \equiv$ distance from i^{th} PWR site to MRS; ($i=1, 2, \dots, I$).
 $D_j^B \equiv$ distance from j^{th} BWR site to MRS; ($j=1, 2, \dots, J$).

Here $N = I + J$.

$W_i^P \equiv$ total number of trips from i^{th} PWR site to MRS.

$$= \frac{\text{number of PWR assemblies at } i^{th} \text{ site}}{\text{number of PWR assemblies transported per trip}}$$

Similarly W_j^B is defined for BWR.

$T \equiv$ total transported miles

$$= \sum_{i=1}^I D_i^P * W_i^P + \sum_{j=1}^J D_j^B * W_j^B \quad (1)$$

Now to minimize T w.r.t X_0 , we set first derivative of T w.r.t. to X_0 to zero and get:

$$X_0 = \frac{\sum_{i=1}^I \frac{W_i^P X_i}{D_i^P} + \sum_{j=1}^J \frac{W_j^B X_j}{D_j^B}}{\sum_{i=1}^I \frac{W_i^P}{D_i^P} + \sum_{j=1}^J \frac{W_j^B}{D_j^B}} \quad (2)$$

We get similar expression for Y_0 with X_i and X_j replaced by Y_i and Y_j respectively in equation (2).

It can be easily verified that the second derivative of equation (2) w.r.t. X_0 results in a positive quantity. Hence solution of equation (2) for X_0 will minimize T and same is true for the expression of Y_0 . Equation (2) and the expression of Y_0 were iterated for X_0 and Y_0 respectively until a convergence limit was satisfied. The repository (Yucca Mountain) was treated as another site where all the spent fuels need to be transported from the MRS location.

Discussion of results

A new angle studied here is the concept of regional ownership of the spent fuel problem. Previous studies have been conducted on a single location for the MRS¹. We have studied possible separate regional locations of MRS within the contiguous U.S. The country is divided into one, two, three or four contiguous regions, and then the best MRS location for each region is determined. It is assumed that spent nuclear fuel from any one region would be stored in that region. Commercial spent fuel generated in 1990 and projected generations² at each site by the year 2030 have been considered. Different shipping casks (for transporting from MRS to the repository) with capacities varying from 1 to 63 PWR assemblies, and 1 to 156 BWR assemblies have been utilized. Similarly number of assemblies (1 to 4 for PWR and 1 to 9 for BWR) transported from reactor sites to MRS were varied. The results for one and four region models are shown in Tables 1 and 2. Cases 1c, 1d, 1e, 2d and 2e of the one region model point to a zone for the MRS with a center around 1740 (± 102) miles east and 554 (± 58) miles north of San Diego. Similarly cases 1c, 1d, 1e, 2d and 2e were considered for the four region model. Eastern, Mid-Western, South-Eastern and Western regions' MRS locations are respectively at 2231 (± 16) miles east and 727 (± 28) miles north of San Diego, 1541 (± 23) miles east and 650 (± 21) miles north of San Diego, 1850 (± 85) miles east and 116 (± 28) miles north of San Diego, and 133 (± 59) miles east and 332 (± 175) miles north of San Diego.

Our first observation from this study is that the current distribution of spent fuel at different sites can determine the optimum location for the MRS based on minimization of transportation miles. Secondly the future accumulation of spent fuel does not change the location substantially except for the Western region of the four region case. The Western region contains fewer sites compared to other regions and therefore a nonuniform increase in number of spent fuels (over years) has a more noticeable change in location of MRS for that region. Third and the most important observation is that as long as the number (say N_R) of spent fuels transported (per trip) from MRS to the repository is less than or equal to that (say N_{MRS}) transported from reactor sites to MRS, locations of MRS tend to be at the repository. It should be noted here that Congress has forbidden location of MRS in Nevada. As the ratio N_R/N_{MRS} increases, locations of MRS become independent of the repository and eventually approach that of no-repository cases.

References

1. G.M. Holter and J.L. Braitman, "Siting of an MRS Facility", *PNL - 5424*, 1985.
2. "Spent Fuel Storage Requirements 1991-2040", DOE/RL-91-54.