Methods for Estimating Costs of Transporting Spent Fuel and Defense High-Level Radioactive Waste for the Civilian Radioactive Waste Management Program

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The U. S. Department of Energy (DOE), through the Office of Civilian Radioactive Waste Management, is planning and developing a transportation program for the shipment of spent fuel and defense high-level waste from current storage locations to the site of the mined geologic repository. In addition to its responsibility for providing a safe transportation system, the DOE will assure that the transportation program will function with the other system components to create an integrated waste management system. In meeting these objectives, the DOE will use private industry to the maximum extent practicable and in a manner that is cost effective.

This paper discusses various methodologies used for estimating costs for the national radioactive waste transportation system. Estimating these transportation costs is a complex effort, as the high-level radioactive waste transportation system, itself, will be complex. Spent fuel and high-level waste will be transported from more than 100 nuclear power plants and defense sites across the continental United States, using multiple transport modes (truck, rail, and barge/rail) and varying sizes and types of casks. Advance notification to corridor states will be given and scheduling will need to be coordinated with utilities, carriers, state and local officials, and the DOE waste acceptance facilities. Additionally, the waste forms will vary in terms of reactor type, size, weight, age, radioactivity, and temperature.

Because the high-level radioactive waste repository will be the first of its kind in the United States and will not begin operations until around the turn of the century, many uncertainties exist as to what the overall transportation costs will be. Additional contributors to the uncertainty include the fact that operational strategies and regulations are still evolving and the program is subject to change in order to be responsive to public concerns.

OBJECTIVES FOR COST ANALYSES

In planning the development of the Office of Civilian Radioactive Waste Management (OCRWM) transportation program, there is an ongoing need for cost analyses. The objective of these studies is to provide a planning and implementation basis for the transportation program and to provide transportation cost estimates for the annual Total-System Life-Cycle Cost (TSLCC) analysis. (U. S. Department of Energy, 1989a)

The cost studies which focus on the transportation system provide quantitative information to guide management decisions in three broad areas. These are: (1) evaluation and guidance for the ongoing cask development program, (2) transportation cost estimates for various OCRWM system studies, and (3) transportation system operational planning.

The TSLCC is estimated annually to support the Fee Adequacy analysis which is required by the Nuclear Waste Policy Act, as amended. The TSLCC includes cost estimates for the total waste-management system. The cost categories used in the analysis include: development and evaluation, repository, MRS facility, benefits, and transportation. The Fee Adequacy analysis combines an annual cost stream with a forecasted revenue stream in light of economic assumptions about long term interest and inflation rates. The analysis then determines whether the fee charged to the utilities (currently one mill per kilowatt hour) will be adequate for funding the development, operation, and decommissioning of the waste management system.

ANALYTICAL TOOLS

Various computer codes or estimating tools have been developed to address the need for cost analyses. To support the cask development program, a computer code has been designed which calculates the relative life-cycle costs of specific transportation cask designs. This model, CASKCOM (cask cost model), estimates the costs associated with casks by assuming a fixed quantity and mix of spent fuel from a hypothetical origin to a hypothetical destination. The total life-cycle cost of the cask designs includes the size of the cask fleets, the distance traveled, the speed and capacity of the transporter, and the percent of time the cask is operational (Dippold, 1988). In calculating the life-cycle costs for the casks, the CASKCOM model includes the following: development and certification, acquisition, operation (hauling, security, maintenance, handling), and decommissioning costs as well as salvage values.

The CASKCOM code was used to comparatively evaluate the vendor cost estimates of the proposals for the new generation of transportation casks. CASKCOM was also used to calculate the effect of burnup credit and non-burnup credit on these new casks. A personal computer version of CASKCOM has been developed and provided to the vendors; the model will be used to assist the cask vendors in calculating the life-cycle costs of their respective cask designs.

A different transportation-specific computer model is used for calculating both costs and risks of the transportation system. This model, TRICAM (transportation risk/cost analysis model), provides an optimization approach for analyzing transportation cost and risk (Gupta, et. al., 1987). This model incorporates risks and costs as basic decision variables and can be used to evaluate system, equipment, and scheduling alternatives, subject to the applicable constraints, in terms of the lowest achievable risk and cost. Alternatively, by pre-specifying system constraints, e.g., the number of shipments, cask capacities, and waste delivery schedules, the TRICAM model can be used to calculate costs associated with various transportation scenarios.

The TRICAM code was used to calculate the transportation impacts associated with the proposed Monitored Retrievable Storage (MRS) facility. This analysis was part of the MRS System Study prepared for the MRS Review Commission which was established by the Amendments Act (U.S. Department of Energy, 1989b). In this study, the transportation costs and risks of various hypothetical MRS locations and facility configurations were analyzed.

In additional transportation-specific studies, the DOE has directly commissioned analyses to help plan and implement a safe and cost-effective transportation system. Specialized analytical efforts and tools with limited purposes have been used to evaluate specific transportation operations alternatives. Examples of these activities have included projections of the size of the cask fleet, modal option studies, and cost/benefit analyses of the use of truck convoys and dedicated trains. The techniques used for these studies have been extensions of those used for other studies or have been constructed specifically to meet the requirements of a particular analysis. The OCRWM transportation program continues to work flexibly in these areas, examining a wide range of issues in planning an efficient, safe, and cost-effective transportation system.

The WITCOM (Waste Inventory/Transportation Cost Model) has been used to calculate the transportation costs for the annual TSLCC analysis. The WITCOM model receives logistics and cost input from a series of models and utilizes these data to calculate life-cycle transportation system cost estimates. WITCOM is based upon a discrete simulation of the transportation logistics (movements of spent fuel and defense high-level waste) and a unit-cost approach for costing. The WITCOM cost estimates currently include costs for the following transportation elements: shipping, security, cask purchase, cask maintenance, and cask maintenance facility.

The final model discussed in this paper is the WASTES (Waste System Transportation and Economic Simulation) model. The WASTES model is primarily a logistics model but can be used to calculate costs for transportation and at-reactor storage. Although OCRWM has used the WASTES model to develop transportation cost estimates in several system studies, current transportation cost estimates are generally performed by the previously cited methods and models. However, the WASTES model is still being used as a logistics model and its results serve as input both to TRICAM and WITCOM.

METHODS

Generally, the models mentioned above are quite similar in terms of cost-estimating methodology. These models all share the following aspects: logistics, unit-costs, and travel mode distinctions. The logistics consist of an annual schedule of waste transportation between various points in the system. The points generally consist of reactor sites, independent storage pools, and MRS and repository facilities. Most of the models are focused on spent-fuel logistics, but TRICAM and WITCOM have included movements of defense high-level waste. With the exception of the WASTES model, which generates its own schedule, most of the models use a pre-calculated logistics schedule as input.

All of these models also use unit-costing to some degree. Generally, the first step in unit-costing is the calculation of the total cost for a single shipment. This total cost is then divided by the units--metric tons of heavy metal, assemblies, canisters, or casks--moved in a shipment. The logistics, which specify the annual quantity (units) moving along each shipment pathway, are then combined with the associated unit costs to generate the annual costs for each pathway. These pathway costs are then summed to yield the total annual transportation costs.

Because TRICAM is an optimization model, all of the costs are calculated by unit-costing. The other specified models--CASKCOM, WITCOM, and WASTES--use unit-costing to calculate shipping and security costs. The cask and cask-maintenance costs are calculated based on the logistics.

The final methodological characteristic these models share is a distinction between travel modes. The models generally have focused on truck and rail transportation, with different weight limits within each of these classifications. The OCRWM also has examined the costs for barge transportation, using variations of the above listed models. The shipment modal designations are important because the costs, risks, and number of shipments differ from one mode to the next.

MANAGING ANALYTICAL METHODS

As different codes and methods are used to calculate costs for different parts of transportation planning studies, there is a need to coordinate these analyses to assure compatibility of the results. The effective use of these various methodologies requires a thorough understanding of the differing techniques and their applicability to a given task. Depending on the purposes of specific studies, varying assumptions may be used from one study to the next. This, in turn, may create results which seem inconsistent.

The OCRWM transportation program uses several mechanisms to address these potential problems and to achieve comparable study results. First of all, a transportation technical data base maintains the data, assumptions, and cost components to be used for all transportation cost analyses. Independent technical reviews also are used to assure comparability of results. As a specific report is produced by one organization of the transportation program, it is distributed in draft form to other program organizations. There, the various technical staff provide their review and comments from their own technical perspective and in light of analyses they may be performing. Finally, a designated group within the program serves as a clearinghouse to review all technical reports to confirm that the analyses are consistent with data and program assumptions contained in the transportation technical data base.

This process allows the DOE to utilize a wide array of resources for necessary transportation analyses. Because there are many analysts from several organizations working on cost studies, it is necessary to have the ability to manage these resources and understand results which may, at times, seem contradictory. This process identifies real and important conflicting results as well as those which are inconsequential.

Transportation program analyses will become more standardized as the program matures. The number of models used for cost studies will be reduced as actual cost data become available and there is less need for cost projections. Some models may become obsolete as real cost data are developed and cost estimates will be replaced with actual accounting data.

In contrast to the analyses which are conducted specifically for the transportation branch of the OCRWM, the Total-System Life-Cycle Cost analysis must, by definition, estimate costs for all aspects of the program. Therefore, a systems engineering approach has been taken for the TSLCC analysis. This approach outlines the functions and requirements of the complete waste-management system and then estimates the costs for that system.

For the transportation component of the TSLCC, the assumptions relating to policy, functions, requirements, and operational strategy of the transportation system are developed by the OCRWM Transportation Branch. The TSLCC analysis depends on consistent and complementary assumptions developed by the various system elements. Apparent contradictions in these areas are resolved by technical staff and reviewed by appropriate management. Once agreement has been reached upon a consistent system, the integrated costs for each element of the system are calculated for inclusion in the TSLCC and the Fee Adequacy analysis. The Transportation Branch thus uses specific analytical tools to help plan the transportation system and also provides appropriate input to the TSLCC analysis so it can accurately reflect the current plans for the transportation system.

SUMMARY

In planning and developing its transportation program for the shipment of spent fuel and defense high-level waste, the OCRWM has performed ongoing analyses of the costs of the transportation system. The objective of these cost studies is to provide input to management decisions and to develop transportation cost estimates for the annual Total-System Life-Cycle Cost (TSLCC) analysis. The DOE has employed various methodologies in performing these analyses. The CASKCOM code was designed to support the cask development program; the TRICAM code calculates costs and risks of the transportation system; specialized analytical efforts have been used to evaluate specific transportation operations alternatives; and WITCOM is used to calculate the transportation costs for the total-system life-cycle cost analysis.

To use these various methodologies effectively, a thorough understanding of the techniques is required. Choosing the right tool for a given task is necessary to assure that the plans for the transportation program are consistently reflected in the various analyses. The DOE has established mechanisms to assure that the studies are coordinated and that their results are comparable and compatible. In so doing, the DOE has been able to effectively use a wide array of resources to assist in planning the transportation system.

REFERENCES

Dippold, David G., "Burnup Credit in Nuclear Waste Transport: an Economic Analysis," presented to ANS Tutorial Session, Washington, D.C. (1988)

Gupta, Shashikant; Dippold, David G.; Shay, Michael; and Boggs-Mayes, Cynthia, "Nuclear Waste Transportation: An Optimization Model," presented to Waste Management '87, Tucson, Arizona (1987)

Ouderkirk, S. J.; WASTES-II: Waste System Transportation and Economic Simulation - Release 24 User's Guide, (1988)

U. S. Department of Energy (a), "Analysis of the Total-System Life-Cycle Cost for the Civilian Waste Management Program," (1989)

U. S. Department of Energy (b), "Transportation Impacts of a Monitored Retrievable Storage Facility," presented to the MRS Review Commission (1989)