DECISION ANALYSIS USED IN THE PRELIMINARY SELECTION OF AN INDEPENDENT SPENT FUEL STORAGE INSTALLATION FOR THE TAIWAN POWER COMPANY

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ABSTRACT

The Nuclear Backend Division of Taiwan Power Company is in the process of selecting an Independent Spent Fuel Storage Installation for the spent fuel stored in the spent fuel pool. In this process it was found necessary and desirable to limit the extent of the preliminary investigations to a few storage facilities which appeared to best suit the technical and sociopolitical needs of the current regulatory and local environments. Thus a multi-attribute utility estimation methodology was used whereby the technical performance characteristics were considered together with the importance of each issue or factor used to judge the performance to find a relative ranking of six storage technologies. This paper briefly presents the methodology and the results of the ranking and scoring process.

INTRODUCTION

Based on the spent fuel discharge projections for the assumed 30,000 MWD/MTU fuel burnup provided by the nuclear power plants of Taiwan Power Company (TPC), an Independent Spent Fuel Storage Installation (ISFSI) is required to be operational no later than by 1999 for Chinshan Unit 1, 2001 for Chinshan Unit 2, 2005 for Kuosheng Unit 1, and 2006 for Kuosheng Unit 2 in order to prevent loss of full core reserve in the respective spent fuel pools. Accordingly the nuclear backend management division of TPC is in the process of developing an ISFSI for the spent fuel stored in the spent fuel pool. In this process it was found necessary and desirable to limit the extent of the preliminary investigations to a few storage facilities which appeared to best suit the technical and sociopolitical needs of the current regulatory and local environments. Thus, a multi-attribute utility estimation methodology was used whereby the technical performance characteristics were considered together with the importance of each issue or factor used to judge the performance to find a relative ranking of six storage technologies. Initially six different storage concepts were listed and described to all participants in the evaluation process. The six storage concepts are listed in Table I. Only dry storage concepts are considered in this study.

METHODOLOGY

The decision analysis methodology used is similar to those used by others for questions of comparable technical complexity and sociopolitical difficulty (1, 2). The methodology is a multi-attribute utility estimation. It recognizes that the importance of issues and factors used to judge the performance of a storage technology are independent of the expected performance of each. The relative importance of issues and factors may be determined by those who will be affected by the facility. It also requires the involvement of those who are intimately familiar with the performance characteristics of the various interim storage technologies, who are able to rate the technologies on a relative technical basis. The Interactive Planning Process (IPP) technique utilized is an Analytical Hierarchy Process (AHP) for the design of a multi-attribute decision model to evaluate the various alternatives. A computer program called "Expert Choice" developed by Ebasco Service Inc. is used in this study. Expert choice is a menu-driven software package which can be utilized to

a) build the model (setting up hierarchial structure),

b) compare the criteria and alternatives,

c) check consistency,

d) perform synthesis of the priorities for alternatives,

e) conduct sensitivity analysis.

TABLE I

Spent Fuel Interim Storage Facility

NAME	Abbreviation
Metal Casks	MC
Concrete Casks	CC
Interactive Vaults	IV
Passive Vaults	PV
Metal Casks in a Tunnel	MCT
Concrete Casks in a Tunnel	CCT

The spent fuel interim storage facility selection process is shown in Fig.1.

All issues are broad enough to consist of two or more specific factors. A factor is a specific consideration that more precisely identifies an issue. Each factor may be thought of as representing a particular concern of the public about the spent fuel interim storage facility.

Once the factors were defined, they were used by two independent groups as illustrated in Fig. 2. The first group, comprised of members of the non-technical public, assigned importance weights represent the relative importance the public attached to each. The sum of all factor importance weights for a given issue is 1.00.

The second group, consisting of technical experts, rated the performance of each candidate storage concept according to each factor. Each storage concept was pairwised compared and assigned a rating ranging from 1.0 (equally preferable) to 5.0 (strongly preferable), depending on the technical experts' judgment of how well it satisfied the objectives stated by the factors. Factor performance ratings were normalized to minimize scoring biases among the participants.

Weighted sums or issue percent scores were calculated for each issue by taking the product of each factor importance weight and the respective performance rating and summing these over all factors for a particular issue. These values, in turn, were weighted by the issue importance factors, which were summed across all issues to yield a final score for each storage concept. The procedure illustrated in Fig. 2. was followed for all six storage technologies.

Issue and Factor Selection

In order to identify the issues and factors by which the spent fuel interim storage facilities were to be judged, Atomic energy council regulations which form the basis for many design considerations were examined. Principal requirements of these regulations include:

- The annual radiation dose for any member of the public may not exceed certain limits.
- Efforts must be made to prevent releases of radioactive materials.
- Protection must be provided against any nature and man-made accidents for the interim storage facility.
- Operations must be conducted to keep occupational radiation exposures low.
- The facility must be designed to minimize long-term maintenance.
- The facility must be physically stable for 100 years.

In addition to these regulatory aspects, social, political, economic, aspects were also considered in the selection process.

The issues and factors selected for use in the analysis are listed in Table II.

The issue and factor importance weights assigned by the public participants are listed in Table III. The performance ratings, by factor, for each of the six storage concepts were combined with the importance weights to obtain the storage concept percent scores.

Storage Facility Percent Weight Score

Issue percentage weight scores for all storage facilities are presented in Table IV.

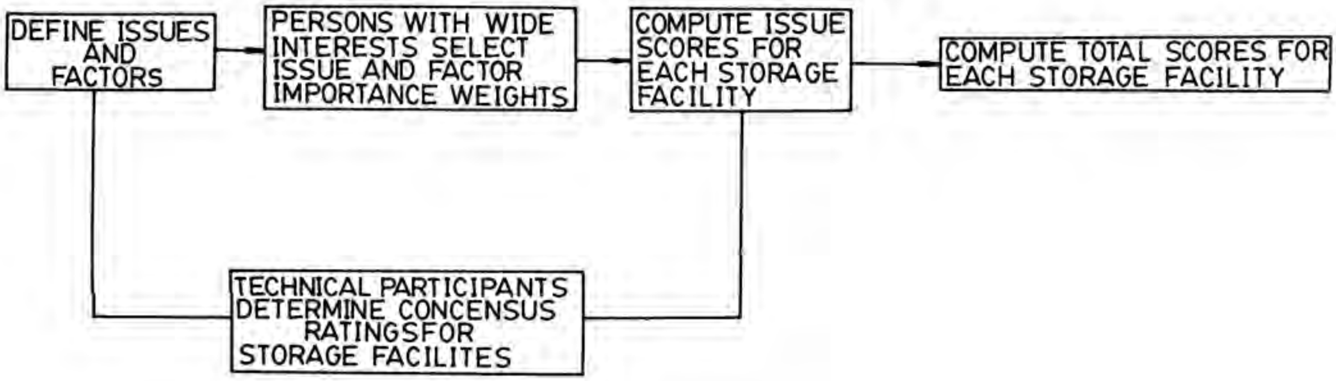

Fig. 1. Spent fuel interim storage facility selection process utilized by the TPC.

TABLE II

Issues And Factors Used in Decision Analysis of the Spent Fuel Interim Storage Concepts.

ISSUE	FACTORS
1. Safety and Licensability	1.1 Previous Licensing Experience of concepts
	1.2 Accidental Mitigation Feature of the concept
	1.3 Public Dose from ISFSI Operation
	1.4 Surface Dose Associated with each Concept
	1.5 Leakage Characteristics
	1.6 Robustness
2. Environmental Impacts	2.1 Impacts During Construction of ISFSI
	2.2 Decomissioning of the ISFSI
	2.3 Land Area Required for the Concept
	2.4 Radiological Dose
	2.5 Recoverability of the Area
	2.6 Secondary Waste Generation
3. Socioeconomic Impacts	3.1 Public Perception
	3.2 Economic Impacts
	3.3 Aesthetic Value
4. Cost and Schedule	4.1 Life Cycle Cost
	4.2 Schedule
	4.3 Competitor for Concepts
	4.4 Percent of Local Supply
	4.5 Uncertainty in Cost Estimate
5. Siting Considerations	5.1 Constructability
	5.2 Seismicity Considerations
	5.3 Utility Requirements
	5.4 Geology/Topography
6. Flexibility Consideration	6.1 Phased Expansion
	6.2 Operational Characteristics
	6.3 Fuel Characteristics
	6.4 Consolidated Fuel Acceptability
7. Technology	7.1 Automation Desired
	7.2 Retrievability of Fuel
	7.3 Passivity of Concept
	7.4 Compliance with Plant Procedure
	7.5 Technology Status of Concept
	7.6 Proveness of the Concept

TABLE IIIA

Issue Importance Weights Used in the Decision Analysis

ISSUE	PERCENT WEIGHT
Safety and Licensability	0.205
Environmental Impacts	0.169
Socioeconomic Impacts	0.156
Cost and Schedule	0.144
Siting Consideration	0.129
Flexibility Consideration	0.098
Technology Features	0.098
Total	1.000

The interim storage facility scores appear to fall into two groups. Concrete casks, metal casks, interactive and passive vaults rank in a group with higher percent scores. The concrete cask and interactive vaults are the first two of the four. The lower ranking group is comprised primarily of Technologies with the spent fuel casks is placed in a tunnel. Comparing concepts for casks in a tunnel scored at least 23% lower for five issues (safety and licensability, environmental impact, siting consideration, flexibility, and technology feature). Other interim storage technologies had fewer extremes in issue scores. The more criteria there are of equal importance, the less sensitive and more robust the final rankings become. Furthermore, the large number of personnel participating in assign the numerical values tends to average the results by eliminating any subjective biasing of certain attributes by certain individual. This is one of the stronger features of the analytical hierarchy process, clearly demonstrated in this study. The sensitivity of the total scores to changes in the issue importance weights would be examined in the final phase of selection process by considering possible modifications to the original issue importance weights.

SELECTION OF THE SPENT FUEL INTERIM STORAGE TECHNOLOGIES FOR CONCEPTUAL INVESTIGATION

The results of the scoring process were used by the TPC, together with consideration of other information and constraints (such as radiological performance, economic performance, and legislative requirements), to select those disposal technologies which would receive

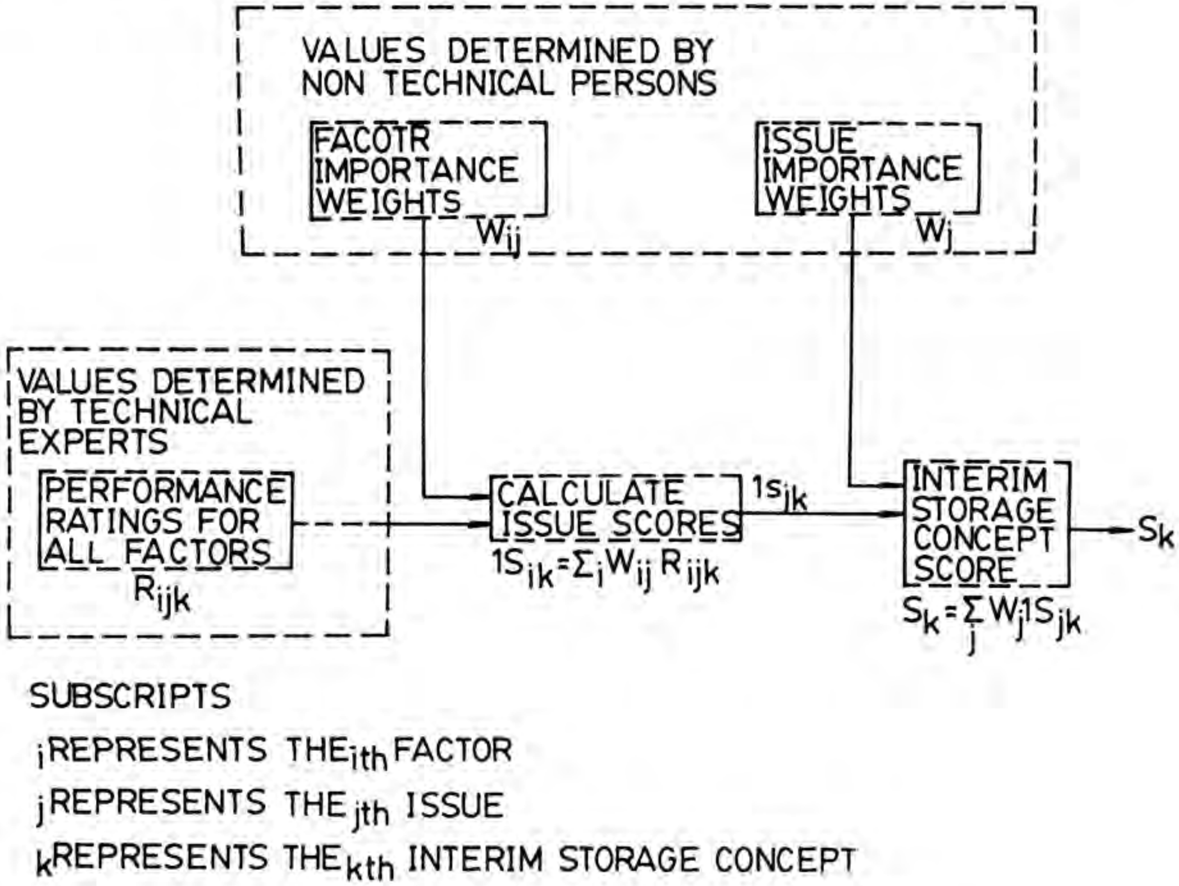

Fig. 2. Schematic representation of decision methodology.

TABLE IIIB

Issue and Factor Importance Weights Used in the Decision Analysis

ISSUE/FACTOR	PERCENT WEIGHT
1.Safety and Licensability	
1.1 Previous Licensing	0.252
1.2 Accidental mitigation Feature of the Concept	0.192
1.3 Public dose from ISFSI operation	0.186
1.4 Surface Dose	0.146
1.5 Leak Characteristics	0.131
1.6 Robustness	0.093
Total	1.000
2.Environmental Impacts	
2.1 Impacts During Construction of ISFSI	0.247
2.2 Decommission of the ISFSI	0.220
2.3 Land Area Required for the Concept	0.186
2.4 Radiological Dose	0.145
2.5 Recoverability of the Area	0.107
2.6 Secondary Waste Generation	0.095
Total	1.000
3.Socioeconomical Impacts	
3.1 Public Perception	0.462
3.2 Economic Impacts	0.305
3.3 Aesthetic Value	0.233
Total	1.000
4.Cost and Schedule	
4.1 Life Cycle Cost	0.373
4.2 Schefule	0.232
4.3 Competion for Concepts	0.165
4.4 Percent of Local Supply	0.138
4.5 Uncertainty in Cost Estimate	0.092
Total	1.000
5.Siting Considerations	
5.1 Constructability Considerations	0.377
5.2 Seismicity Considerations	0.270
5.3 Utility Requirements (Acess Roads, Security, Electricity, etc.)	0.192
5.4 Geology/Topography	0.161
Total	1.000
6.Flexibility Considerations	
6.1 Phased Expansion	0.389
6.2 Operational Characteristics	0.294
6.3 Fuel Characteristics	0.172
6.4 Consolidated Fuel Acceptability	0.145
Total	1.000
7.Technology Features	
7.1 Automation Desired	0.247
7.2 Retrievability of Fuel	0.209

TABLE III-B, CONT'D

ISSUE/FACTOR	PERCENT WEIGHT
7.3 Passivity of Concept	0.174
7.4 Compliance with Plant Procedures	0.123
7.5 Technology Status of Concept	0.123
7.6 Proveness of the Concept	0.123
Total	0.999

TABLE IV

Percent Weight Score For Six Storage Facilities

	Metal Casks	Concrete Casks	Interactive Vaults	Passive Vaults	Metal Cask in a Tunnel	Concrete Cask in a Tunnel
Safety and Licensability	0.034	0.033	0.039	0.037	0.032	0.030
Environmental Impacts	0.031	0.033	0.030	0.028	0.022	0.024
Socioeconomic Impacts	0.024	0.024	0.024	0.024	0.030	0.030
Cost and Schedule	0.019	0.025	0.031	0.027	0.020	0.025
Siting Consideration	0.030	0.030	0.021	0.024	0.011	0.011
Flexibility	0.019	0.019	0.017	0.018	0.012	0.012
Technology Feature	0.020	0.017	0.018	0.019	0.0115	0.0115
Total	0.177	0.183	0.180	0.178	0.139	0.143

further development and evaluation in the conceptual design process.

Based on the results of the decision making process, the advice of the experts, and the staff's analysis of the available technologies and applicable law, four interim storage technologies were selected for further analysis. These are:

- Metal Casks
- Concrete Casks
- Interactive Vaults
- Passive Vaults.

These concepts were selected to satisfy the legislative and the TPC requirements. Each of the interim storage facility has its own advantages and disadvantages. Technological feature, siting consideration and cost estimation of the selected technologies needs further study before final decision.

In summary, the TPC identified four of the initial six interim storage technologies to receive further development and assessment.

REFERENCES

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