Parametric Cost Estimates for an International Competitive Edge

L.T. Murphy
CH2M HILL
Dounreay/D2000, Thurso, Caithness KW12 7TZ
UK

M. Hickey
United Kingdom Atomic Energy Authority
Dounreay/D2003, Thurso, Caithness KW12 7TZ
UK

ABSTRACT

This paper summarizes the progress to date by CH2M HILL and the UKAEA in development of a parametric modelling capability for estimating the costs of large nuclear decommissioning projects in the United Kingdom (UK) and Europe. The ability to successfully apply parametric cost estimating techniques will be a key factor to commercial success in the UK and European multi-billion dollar waste management, decommissioning and environmental restoration markets.

The most useful parametric models will be those that incorporate individual components representing major elements of work: reactor decommissioning, fuel cycle facility decommissioning, waste management facility decommissioning and environmental restoration. Models must be sufficiently robust to estimate indirect costs and overheads, permit pricing analysis and adjustment, and accommodate the intricacies of international monetary exchange, currency fluctuations and contingency.

The development of a parametric cost estimating capability is also a key component in building a forward estimating strategy. The forward estimating strategy will enable the preparation of accurate and cost-effective out-year estimates, even when work scope is poorly defined or as yet indeterminate. Preparation of cost estimates for work outside the organizations current sites, for which detailed measurement is not possible and historical cost data does not exist, will also be facilitated.

INTRODUCTION

The successful application of parametric cost estimating techniques is seen as a key factor between commercial success and failure in the United Kingdom and European multi-billion dollar waste management, decommissioning and environmental restoration markets. This paper briefly discusses the international market, describes the conceptual framework for development and validation of parametric models, and summarizes key issues related to development of relevant Cost Estimating Relationships (CER's) and historical cost databases. It also discusses the problem of estimate accuracy, given experience to date and the amount of decommissioning and environmental restoration thus far completed across the UK and Europe. A prediction on accuracy improvement over the next few years is presented, based on efforts currently underway to integrate developing UK and European parametric models with U.S. databases and systems.

THE INTERNATIONAL DECOMMISSIONING MARKET

Decommissioning is the final phase in the lifecycle of a nuclear installation, covering all activities from shutdown and removal of fissile material to environmental restoration of the site. At present, over 110 nuclear facilities within the European Union (EU) are at various stages of the decommissioning process. It is forecast that at least a further 160 facilities will need to be decommissioned over the next 20 years (within the present 15 Member States). Enlargement of the EU would contribute to a rapid increase in the number of nuclear facilities to be decommissioned (at least a further 50 facilities). Worldwide, 100 mines, 90 commercial power reactors, over 250 research reactors and a number of fuel cycle facilities have been retired from operations. Relatively few of these have been fully dismantled and decommissioned. [1]

For that portion of U.S. nuclear facilities licensed by the Nuclear Regulatory Commission (NRC), current decommissioning efforts include 38 complex materials sites, 18 power reactor sites, 18 research and test reactor sites, 12 uranium recovery sites and 3 fuel cycle facilities.[2]

The International Atomic Energy Agency has defined three options for decommissioning, which have been internationally adopted:

1. Immediate Dismantling (Early Site Release/Decon. in the U.S.)
2. Safe Enclosure (Safestore)
3. Entombment

There is no right or wrong approach for any given facility. Rather, in order to determine the best practical decommissioning option, it is often desirable to consider the estimated cost for each option as a part of the decision-making process. Parametric estimates – which can be completed in a relatively short period of time to quantifiable accuracy – are ideally suited for this purpose.

DECOMMISSIONING COST ESTIMATES

Estimating the total cost of decommissioning is a complex task that depends on many factors. These include the sequence and timing of the various stages of the program, location of the facility, current radioactive waste burial/disposal costs, and spent fuel storage strategy. The cost of decommissioning should reflect all activities of the decommissioning process, starting with the planning and licensing and post-operation, and finishing with radioactive waste management and site clearance. If the decommissioning is deferred for an extended period of time, surveillance and security of the facility must also be taken into account.

According to recent legal frameworks in the EU, mechanisms were established before operation in order to secure the funds needed for the decommissioning of each facility. However, for plants that were constructed in earlier nuclear programs (in the 50s and 60s, or under different legal frameworks as in the Eastern European countries) funds are often limited; this may impact on selection of a decommissioning strategy. Comparisons of individual cost estimates for specific facilities have shown relatively high variations. These result mainly from the use of different cost estimation methodologies, using different data requirements. [3]

In general, decommissioning cost estimates perform up to three main functions:

1. To inform government and guide their policy for assuring that decommissioning funds will be available when needed;
2. For utilities, to determine funding requirements and financial liabilities; and
3. To serve as a basis for industrial strategy and decommissioning activity planning.

It is to this third category that this paper is primarily addressed. Cost estimates for planning and management of decommissioning activities are used to establish an overall cost envelope for funding purposes, as a basis for contracting or for solicitation of tender offers (bids), as a starting point for establishing a project baseline for cost and schedule management, and for project cost accounting and scheduling purposes during decommissioning operations. [4]

In 1999 the NEA, the IAEA and the EC produced and distributed a document providing specific definitions for cost items and cost groups: “A Proposed Standardised List of Items for Costing Purposes: Interim Technical Document, 1999.” This cost matrix can be used at various levels of detail when applied to the three main functions listed above. The top-level cost items were identified as:

1. Pre-decommissioning actions;
2. Facility shutdown activities;
3. Procurement of general equipment and material;
4. Dismantling activities;
5. Waste treatment and disposal;
6. Security, surveillance and maintenance;
7. Site cleanup and landscaping;
8. Project management, engineering and site support;
9. Research and development;
10. Fuel management; and
11. Other costs.

For each top-level cost item four cost groups were defined: labour costs; capital, equipment and material costs; expenses; and contingency. The relationships between cost items, cost groups and parametric modelling will be discussed in further detail in the following sections.

OVERVIEW OF PARAMETRIC MODELLING

Parametric cost modelling was developed in the 1950’s, but has only recently been the subject of renewed interest due to a highly competitive marketplace. Correctly developed and applied parametric cost modelling can lead to more accurate estimates with minimal subjectivity. Estimates developed from parametric models have an inherent life cycle cost orientation and are very dynamic. This means actual costs can be used to trend future costs and estimate accuracy will increase with use and time, as the database grows.

The most useful parametric estimating models will be those that incorporate individual components representing major elements of work: reactor decommissioning, fuel cycle facility decommissioning, waste management facility decommissioning and environmental restoration. The models must also be sufficiently robust to estimate indirect costs and overheads, and permit pricing analysis and adjustment.

The development of a parametric cost estimating capability is also a key component in the development of a forward estimating strategy for the organisation. The forward estimating strategy will enable the preparation of accurate and cost-effective out-year estimates, even when work scope is poorly defined or as yet indeterminate. Preparation of cost estimates for new work, for which detailed measurement is not possible and historical cost data does not exist, will also be facilitated.

The implementation and maintenance of a true parametric cost estimating system is based on a) actual cost data for similar completed projects, b) the definition of recognizable industry-wide systems, sub-systems and elements, c) transferable and scaleable parameters, d) simple quantification and validation methods, e) functionality and ease of use, f) appropriate and adequate interfaces to existing project control and financial systems, g) continuous updating of CER’s and actual cost databases as new work is completed and h) an enhanced process for planning, cost collection and project close-out that all support the parametric estimating system and process.

ESTIMATE ACCURACY

Successful project delivery will mean that companies must be able to quickly develop accurate cost estimates for defined work scope across a specific period of time. This information must then be presented in such a manner as to give confidence internally and externally that the work scope is understood and the company will be able to successfully manage the work. These estimates must be developed with sufficient granularity to form the basis for a contract and permit detailed scheduling and allocation of budget to the project. To improve their competitive positions companies will require a system capable of providing these accurate and integrated estimates.

Information gathered to date shows that estimates based on actual decommissioning projects (ongoing or completed), or on detailed modelling lead to higher costs.[5] However, experience in recent years for major systems acquisitions by both the U.S. Department of Defense and the U.K. Ministry of Defence has shown parametric modelling to be more accurate than bottom-up estimating. For competitive advantage in the decommissioning market, parametric modelling techniques must be refined to improve estimate accuracy while retaining the characteristics of speed and ease of use.

At present, reasonable expectations (subject to the population size of historical data) for parametric cost estimates for nuclear decommissioning projects fall within 10% when compared to actual costs data. [6] It is, however, believed this number can be improved upon significantly. Based on experience in the defense industry (on both sides of the Atlantic), accuracy within two percent may be achievable. [7] One key to cost estimate improvement will almost surely be the application of 'should cost' management techniques. Simply stated, this is the management practice of using the estimate to drive actual cost performance during project delivery.

EXPERIENCE TO DATE AND PATH FORWARD

CH2M HILL and the United Kingdom Atomic Energy Authority (UKAEA) are working closely together to develop accurate decommissioning parametric modelling techniques.

These parametric models are being developed in two distinct steps:

- Step 1 is the extrapolation of experience relating to cost gained in the decommissioning of specific facilities. This step results in the determination and validation of Cost Estimating Relationships (CER).

- Step 2 is the improvement of the historical cost databases and the collection process for existing and newly available data. Also included is the normalization of the databases for the past affects of monetary exchange rates, differing financial and accounting standards, the absence of reliable local indices, geographical location, time and post-project analysis.

Cost Estimating Relationships

The development of CERs is an iterative process. Once a potential CER is identified it must be modelled and tested. As additional actual cost data is received it must be incorporated into the model and the CER once again tested. In developing CERs the objective is to define the minimal number of relationships (to preserve the features of ease of use and speed) that will return estimates with the greatest accuracy. At present the following top-level CERs are being developed for testing:

1. Type and size of Reactor

2. Reactor cooling system design and media
3. Type and size of Facility
4. Number and type of ancillary Units/Buildings
5. Scope of decommissioning activities (immediate dismantling, safe enclosure or entombment)
6. Planned site re-use
7. Amount and type of waste
8. Facility location and date(s) of construction
9. Radioactive and hazardous waste treatment, storage and disposal strategy

Factors that would be applied to the output after initial enumeration of input would likely include:

1. Operating history
2. Security and information classification levels
3. Decommissioning strategy options
4. Regulatory standards
5. Uncertainties and uncertainties management strategy
6. Labor costs indices
7. Social and political factors

In comparing the candidate CERs and the modifying factors to the top-level cost items and cost groups used in bottom-up estimating as previously described, certain similarities can been seen.

Historical Cost Databases

The UKAEA and CH2M HILL each bring considerable decommissioning experience to the historical database development effort. The UKAEA has completely removed 15 research reactors, placed six reactors in safe care and maintenance and is progressing decommissioning on a further five major reactors. CH2M HILLs decommissioning experience includes three university research reactors, three test reactors, two commercial power reactors, seven major fuel cycle production facilities, 10 uranium facilities, 43 beryllium contaminated facilities, 29 Category II facilities and 28 Category III facilities.

A decommissioning historical cost database must serve many functions beyond the collection of historical cost data. For example, the database should:

- Be standardized across the full range of decommissioning work;
- Contain extensive project descriptions;
- Provide cost data useful across the range from conceptual estimating to budget development;
- Collect costs from bid estimates, contract awards and actual projects (including purchase orders, subcontracts and performance measurement data);
- Enable users to quickly query estimate, contract and project data;
- Be useful for cost benchmarking and comparison of costs; and
- Provide sufficient detail to adjust parametric cost models.

The interrelationships between the various sub-elements of a parametric model and a traditional cost estimating system are shown in the following figure.

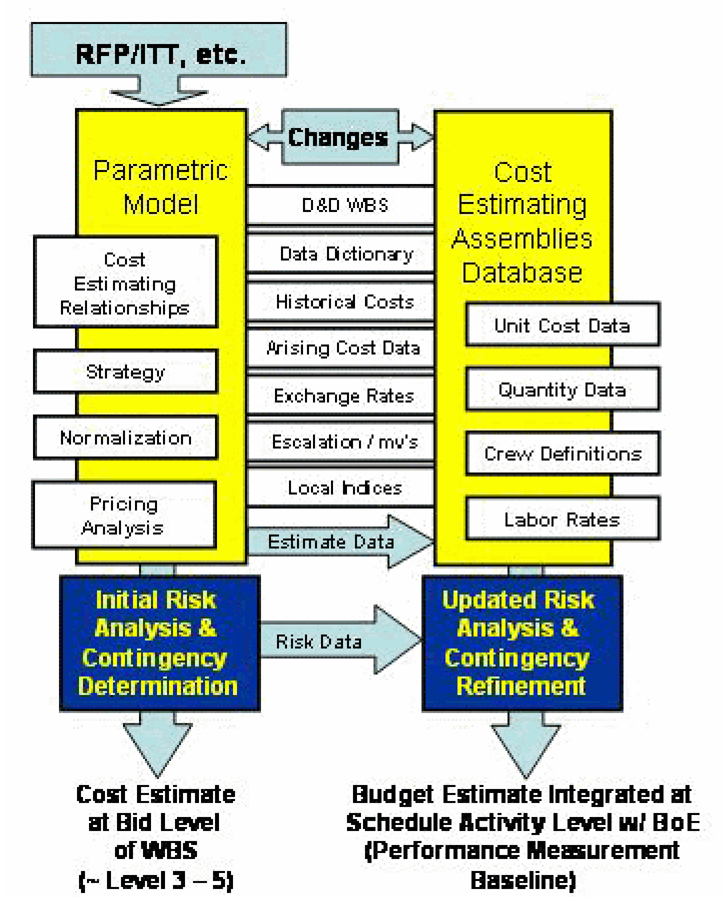

Fig. 1. Integrated estimating model

CONCLUSION

The main output of this CH2M HILL/UKAEA combined effort will be a prototype cost model that can rapidly and accurately produce an estimated cost for decommissioning major nuclear facilities, including related ancillary and support services (such as construction of waste treatment and storage facilities, treatment and waste handling operations, transportation offsite and disposal). A significant part of this effort will be the compilation of integrated databases associated with decommissioning costs and procedures as related to the model. The parametric model will encompass both North American and European facilities, and will fulfil a key strategic business development function.

Further development and enhancement of the model, and acquisition of a more extensive database, will allow future production of budget-level estimates and details from a minimal data input.

REFERENCES

1. Uranium Information Center, 2005, (www.uic.com.au/nip13.htm), *Decommissioning Nuclear Facilities*, Nuclear Issues Briefing Paper 13, January.
2. U.S. Nuclear Regulatory Commission, 2005, (www.nrc.gov), *Decommissioning of Nuclear Facilities*.
3. Bischoff, H. (2005). *Decommissioning of Nuclear Installations in the Research Framework Programmes of the EC.* European Commission Website on Decommissioning of Nuclear Installations (www.eu-decom.be/introduction),
4. Nuclear Energy Agency, 2003. *Decommissioning Nuclear Power Plants: Policies, Strategies and Costs.* Organisation for Economic Co-Operation and Development, 45-47 p.
5. Ibid., 65-67 p.
6. Simpson, T.E., 2000, *Extreme Order-of-Magnitude Estimating*, AACE International Transactions.
7. Bradford, K. and Vaughan, L., 2005, (www.galorath.com/customer_case-northrop.html), *Improve Commercial-off-the-Shelf Integration Estimates*, Case Study – Northrop Grumman.