Cost estimation for decommissioning: a review of current practice

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It is now common practice for decommissioning plans and associated cost estimates to be prepared for all nuclear installations. Specific requirements are generally set out in regulations that have their basis in national legislation. These estimates are important for ensuring that the necessary funds are being collected to cover the actual costs of decommissioning the facility. The long time horizon for both amassing and disbursing these funds is a particular concern for national authorities. It is thus important to maintain a realistic estimate of the liabilities involved and to confirm the adequacy of the provisions to discharge them over time.

Estimates of decommissioning costs have been performed and published by many organisations for many different purposes and applications. The results often vary because of differences in basic assumptions such as the choice of the decommissioning strategy (immediate vs. deferred), the availability of waste management pathways, the assumed end states of installations, the detailed definition of cost items, technical uncertainties, unforeseen events, the evolution of regulation and requirements. Many of these differences may be unavoidable since a reasonable degree of reliability and accuracy can only be achieved by developing decommissioning cost estimates on a case-by-case, site-specific basis. Moreover, even if considerable efforts are made to obtain reliable estimates, unforeseen events may cause estimates to go wrong. The issue of how to deal with uncertainties is therefore an important one, leading in turn to the need for risk management in terms of making adequate funding provisions.

In March 2008, a questionnaire was circulated among the organisations participating in the NEA Decommissioning and Cost Estimation Group (DCEG). Information was collected on legal requirements and the responsibilities of the main parties concerned with the preparation and oversight of cost estimates, the main cost elements and associated boundary conditions; cost estimation methodologies; and experience gained during the process. Twelve countries provided responses and participated in the analysis: Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, the Slovak Republic, Spain, Sweden, the United Kingdom and the United States. The final report[1] documenting the study is nearing publication. Its main findings are reported hereafter.

Status of cost estimation for decommissioning

The scope of decommissioning generally includes decontamination, removal/dismantling of disused plant and buildings, spent fuel storage or disposal, waste management, transport, and final disposal or long-term storage. However, some countries do not include the disposal of spent fuel, legacy wastes, waste disposal or its long-term storage in cost estimates for decommissioning.

Most countries have established requirements for cost estimation and reporting. Legal requirements include the preparation of a decommissioning plan and associated cost estimates, with periodic updates – usually every three to five years.

National requirements include administrative and substantive requirements. Administrative requirements are generally imposed by regulatory decrees or associated guidelines. Substantive requirements are generally related to explaining and justifying

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assumptions and boundary conditions in the cost estimates. These include boundary assumptions and conditions in cost estimates such as the year of the estimate, end point criteria, site release criteria, legacy waste disposal, spent fuel disposal, transition activities, characterisation, waste canisters, casks, transport, disposal options, disposal of high-level and low-level waste, scrap, salvage, remote handling techniques and project management. Some substantive requirements stipulate the use of overnight costs and means for handling escalation.

Stakeholders are generally allowed to review and to comment on cost estimates, but the owner is not usually bound to revise the estimate as a result of these comments.

A cost estimate for decommissioning is necessarily based on an assumed decommissioning strategy and on an assumed end state for the site. Given that the time frame for active decommissioning may often be several years (or even decades for plants licensed under early regimes) after the estimate has been made, these aspects represent significant uncertainties.

The nuclear safety regulator plays an important role in the approval of decommissioning strategies, cost estimating formats and funding. Most regulators do not prescribe a reporting format except in the United States where the Nuclear Regulatory Commission (NRC) has provided reference studies as guidance.

Some countries such as Canada and the US require a cost-benefit analysis or the equivalent for assessing alternative decommissioning technologies and techniques.

Clearance and release levels have a major impact on costs. Whether the selected strategy is "greenfield" (usually seeking a return to pre-industrial site conditions) or "brownfield" (site re-use with limitations) strongly affects the total costs. These terms need to be defined in detail, however, as there is no universal interpretation.

Recently, and especially in the context of new nuclear power plant construction in several countries, existing nuclear sites have been gaining increasing strategic value. This may contribute to overall cost reduction by promoting earlier decommissioning of redundant facilities and from increased commercial value of the site.

Most countries, either through regulation or by owner preference, have adopted a formal organisation of the cost estimates. In general, detailed estimates are prepared, especially for plants that are already in operation. A work breakdown structure (WBS) format is used, based either on the Standardised List "Yellow Book"[2] format or on an equivalent national format.

Calculation methods vary by country. Some countries specify the type of cost estimate expected from operators, while others leave it to the operator to determine. The use of life cycle planning models is prevalent in Canada and the United Kingdom, with worst-case scenarios being used to bound the costs. Some countries such as the United States specify in detail how costs are to be reported, while others (such as France) specify the major cost categories, while allowing greater discretion on how estimates are structured.

Quality control is important for the validation of cost estimates. For example, the French Atomic Energy Commission (CEA) tracks cost estimates twice per year, and benchmarks actual experience against the cost estimate. In the United States, the NRC reviews the accuracy of cost estimates, requiring full documentation of how the estimated cost was developed.

Many countries have adopted the breakdown of activity-dependent and period-dependent costs to structure their estimates. Period-dependent costs could be broken down into defined time frames to reduce overall uncertainties. Several countries apply this notion by having different contingency factors for different phases of the project.

Contingencies are for unforeseen elements of cost within the defined project scope. Uncertainties are for unforeseeable elements of cost outside the defined project scope (such as currency exchange rate fluctuations, inflation beyond the norm of say 5% and regulatory changes). Some countries use a defined contingency: Belgium uses 15%, Canada uses a range based on estimate accuracy – a Grade A estimate 10%, Grade B 15-20%, Grade C 30% – the Slovak Republic uses 20-25%, Spain 15%, Sweden 6 20% and the US approximately 25%.

Ensuring robust cost estimates in the context of long-term uncertainties may be addressed either by the financing scheme or by including contingency factors in the cost estimate.

Risk analyses are being used more frequently in Sweden and the United Kingdom, based, for example, on Monte Carlo calculations – calculating a range of cost estimates and assigning simple distributions to each, and then multiple iterations calculating the distributions in size of the liabilities. Canada requires that cost estimates provide for escalation whereas, in Germany, this is specifically excluded. France follows a procedure for reducing uncertainties over time as the cost estimates improve in accuracy.

Decommissioning cost drivers

Experience of actual decommissioning projects leads to the following identification of the most significant cost elements and their ranking as cost drivers:

1. Scope definition and changes to the project plan.

2. Regulatory changes and increased requirements for additional information and detail.
3. End point state and disposal of waste.
4. Site characterisation of physical, radiological and hazardous materials inventory.
5. Waste storage and the availability of ultimate disposal facilities.
6. Disposal of spent nuclear fuel and on-site storage prior to a permanent repository.
7. Clean structure disposition and availability of the site for new developments.
8. Contingency application and use in estimates to account for uncertain events.
9. Availability of experienced personnel with knowledge of the relevant plant.
10. Assumed duration of the dismantling and clean-up activities.

Important considerations in ensuring accurate and stable cost estimates thus include avoiding changes in project scope (e.g. decommissioning strategy and end point); fixing regulatory standards during the planning phase of a decommissioning project to avoid delays during active decommissioning; and accurate characterisation of materials and of soil.

Overall reflections

There is no single cost assessment methodology that applies equally at all stages of a decommissioning project. This means that different cost assessment methodologies may need to be used as the project advances. Such methodologies should be continuously updated using cost data from actual decommissioning projects, thus improving the cost assessment, providing better control of uncertainties and contingencies for each major cost category, and facilitating the preparation of an annualised schedule of expenditures for each facility.

In the future, risk management may benefit from an approach that uses a deterministic calculation (base case) that feeds into a probabilistic assessment of future costs. Such approaches may be used to gain a better understanding of potential cost and programme requirements.

Attention should also be given early on to socio-economic factors, including impacts caused by loss of employment, to help in building public support and acceptance of a decommissioning project. Early meetings with stakeholders may be used to gain agreement on project boundary conditions, strategy, release criteria and measurement protocols, and waste containers used.

In view of the very significant impacts that changes and increases in scope may have on cost estimates, it is important that these be identified and controlled immediately, and incorporated into the estimate so that the estimate may continue to provide a viable benchmarking resource.

Characterisation is acknowledged to be an important part of cost estimating accuracy, as it affects system and structure inventory, decontamination and waste disposal. Several countries look for cost reduction possibilities through waste minimisation processes.

Consideration should be given to developing upgraded decommissioning management systems to deal with latest developments, data quality, completeness and safety, while offering flexibility in data processing and cost calculations. Regular interaction between system developers and users is necessary to develop the inventory and maintain user friendliness.

Current good practices include the use of a standardised list of decommissioning activities, a strong quality-assurance programme, use of a dedicated decommissioning core group during the planning phase of decommissioning, and involvement of regulators and stakeholders in the drafting of decommissioning plans. ■

References

1. NEA (forthcoming) *Cost Estimation for Decommissioning: An International Overview of Cost Elements, Estimation Practices and Reporting Requirements,* OECD/NEA, Paris.
2. NEA (1999), *A Proposed Standardised List of Items for Costing Purposes in the Decommissioning of Nuclear Installations: Interim Technical Document,* OECD/NEA, Paris.