Decommissioning Cost Estimate Uncertainty: What is It, How Do You Deal with It? – 16527

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ABSTRACT

The issue of decommissioning cost estimate uncertainty has returned to plague the industry. As we gain more hands-on experience, the expectations are that the cost estimates for future projects should be more accurate and the uncertainties reduced. To some extent this is true, but there remains the issue of how to deal with the major elements of uncertainty of allowances, contingency and risk. The OECD/NEA and the IAEA have joined forces through its member states and outside consultants to bring definition and insight into how to deal with uncertainty. The author has been a participant in this joint organization effort since the outset two years ago. This paper will present the current state-of-the-art in the definitions, approaches, and limitations in the topic of uncertainty.

INTRODUCTION

In the US from the early experiences of utility bankruptcies or nearly such, the US Nuclear Regulatory Commission instituted mandatory requirements to set aside decommissioning funds in external trusts called 'Decommissioning Trust Funds.' These funds are required to be held outside of utility/licensee control to ensure the funds will be available when needed for decommissioning. While the US requirement is used in this example, this same scenario holds true for much of the rest of the world where the utility concerned is a private business entity and not a function of the state.

Cost estimates generated to provide for these Trust Funds are required by the US NRC and state public utility commissions to ensure adequate funds will be available at the time of decommissioning. This paper will briefly describe the content of cost estimates, and more importantly the uncertainties accounted for in the estimates. The uncertainties include allowances, contingency and risks. These historically have been a significant issue in understanding the meaning of the terms, how they are applied and their importance to assuring the availability of funds.

In an effort to resolve the confusion and misapplication of uncertainty in decommissioning cost estimates, the Organization for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA) and the International Atomic Energy Agency (IAEA) have endeavored to gather the combined technical expertise of its members to address this issue. The program is still a 'work-in-progress,' and considerable effort remains before a finalized document is ready for publication.

This paper describes the current technological state-of-the-art on the subject of uncertainty.

FUNDING ADEQUACY

Every US NRC licensed Nuclear Power Plant (NPP) must estimate decommissioning costs every other year and submit the estimates to the US NRC to assure adequate funding provisions are being made into approved Decommissioning Trust Funds (DTFs). The US NRC permits owner-licensees to submit estimates based on a simplified US NRC approved formula [1], or based on detailed site-specific cost estimates. The US NRC's formula approach has been challenged by the US General Accountability Office as not adequate for DTFs, but so far no changes have been made in recent years. Similarly, licensed research reactors and other NRC licensed facilities must also provide assurance of funding adequacy. For brevity, NPPs will be used for illustration purposes.

Detailed site-specific cost estimates are the preferred method of determining the costs of NPP decommissioning for funding and execution purposes. The methodology follows Atomic Industrial Forum/National Environmental Studies Project (now the Nuclear Energy Institute) AIF/NESP Guidelines document [2], and is based on a bottom-up, unit cost factor methodology. This methodology has been adopted by most regulatory agencies in the US and in Canada.

Regulated NPPs in the US are those plants whose electricity rates to consumers are regulated by individual state Public Utility Commissions (PUCs). The PUCs hold public hearings whenever the owner utility decides to request an increase in rates to cover its costs and to make a reasonable profit. Of necessity, utilities have contracted with independent consulting companies to prepare those detailed cost estimates typically every three to five years. These estimates are used by the PUC to determine the cost-of-service and are factored into the analysis of whether the rate increase is justified.

Unregulated NPPs in the US are called 'merchant plants,' as the utilities market the power produced in a competitively priced environment with other competing power sources including coal-fired, natural gas-fired, wind power, solar power and hydroelectric sources. These NPPs are not required to submit the decommissioning cost estimates publicly as they only need to assure utility company shareholders there is adequate funds in the Decommissioning Trust Fund to cover the ultimate costs of decommissioning. The unregulated utilities still have to file an estimate with the US NRC.

DETAILED COST ESTIMATE

There are three basic elements to a cost estimate: Basis of Estimate (BoE), Cost Estimate Calculations and Uncertainties. These elements are described in detail the following sections.

Basis of Estimate

The basis of estimate is the foundation upon which the cost estimate is developed. It is based on the currently applicable decommissioning plan for the facility. Consistent and accurate cost estimates rely upon the documentation and underpinning contained in the basis of estimate. A typical list of items that might be included in the basis of estimate is noted below:

- Scope of the project
- Assumptions and exclusions
- Boundary conditions & limitations – legal, environmental and technical (e.g., regulatory framework)
- Decommissioning strategy description (DECON vs. SAFSTOR, or Delayed Dismantling)
- End point state (Greenfield vs. Brownfield)
- Stakeholder input/concerns (US NRC, state PUCs, local groups)
- Facility description (Physical inventory of systems and structures – piping, valves, pumps, tanks, heat exchangers, concrete block, poured concrete, structural steel)
- Site characterization – Radiological/Hazardous material inventory (detailed report including Historical Site Assessment)
- Waste management (packaging, storage, transportation, and disposal)
- Sources of data used (actual field data vs. estimating judgment)
- Cost estimating methodology used e.g. Bottom-Up (Unit Cost Factors), Parametric or Level-of-Effort
- Discussion of techniques and technology to be used (vessel and internals segmentation, other)
- Work Breakdown Structure, Definitions/Dictionary
- Description of computer codes or calculation methodology employed
- Schedule analysis
- Uncertainty - allowances, contingency and risk
- Quality Assurance Program/Plan for Decommissioning

Cost Estimate Calculations

Cost estimate calculations are usually performed on desk top computers using Excel, Access or other computing platforms, and are proprietary to the consultant or utility. A description of all computer codes used in the estimate, including any activation analysis codes, should be included. Any special calculation methodology employed, such as structural analysis or cost benefit analysis, should be identified.

The estimating methodology used should be identified as Bottom-Up, Specific Analogy, Parametric, Cost Review and Update, or Expert Opinion, or any other recognized method. If Specific Analogy was used, references should be provided as to the source of scaling information. The most accurate method is the Bottom-up methodology, particularly as the date of actual decommissioning draws near. The other methods listed may be used for early planning, allowing for funding collections to be initiated with sufficient time for a more detailed estimate to "true up" the fund balance.

Uncertainty – Allowances, Contingency and Risk

In the earliest cost estimates for decommissioning, estimators had little precedence upon which to predict costs with much accuracy, but knew certain costs needed to be accounted for such as the costs for special tooling to segment the reactor vessel internals and the vessel itself. In these cases, estimators used their best available information and included an "allowance" for these costs. This practice is still in use today and is recognized as a reasonable estimating approach for known activities whose costs may not be accurately known at the time of the estimate. It is expected these costs will be fully spent during actual decommissioning.

Other uncertainties need to be addressed including such events as delays, interruptions, inclement weather, tool or equipment breakdown, craft labor strikes, waste shipment problems, or disposal facility waste acceptance criteria changes, or changes in the anticipated plant shutdown conditions, etc. These uncertainties were handled simply by adding a fixed percentage contingency of the total cost to cover all undetermined events. As the costs of decommissioning increased, more attention was paid to defining uncertainty and contingency. The Association for the Advancement of Cost Engineering, International (AACE) offered guidance on contingency as follows:

"A specific provision for unforeseeable elements of cost within the defined project scope, particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events that increase costs are likely to occur," [3].

This definition introduced the concept of events <u>within the project scope</u>, thereby bounding the types of uncertainty that would be considered in the estimate. For many years this contingency approach seemed adequate and was accepted by owner/licensees and regulators.

As decommissioning funding provisions covered as much as 40 years from NPP start-up to shutdown (and now as much as 60 years), it was realized that there are events that could occur outside the project scope that could influence the costs of decommissioning. However, these costs were not certain to occur, and the cost impact was not predictable. These events introduced the concept of risk analysis to address the probability of occurrence and cost impact. Risk analyses were being performed by estimators without a clear understanding of all the issues.

To the owner-licensees, public, stakeholders and regulators these terms and definitions of uncertainty, allowances, contingency and risks were confusing leading to concerns that owner-licensees were double counting and unnecessarily adding to the cost of decommissioning.

Description of the Structure of a Cost Estimate

A decommissioning cost estimate, whether for funding provisions or for actual execution is made up of several parts. These are best illustrated in the following Fig. 1.

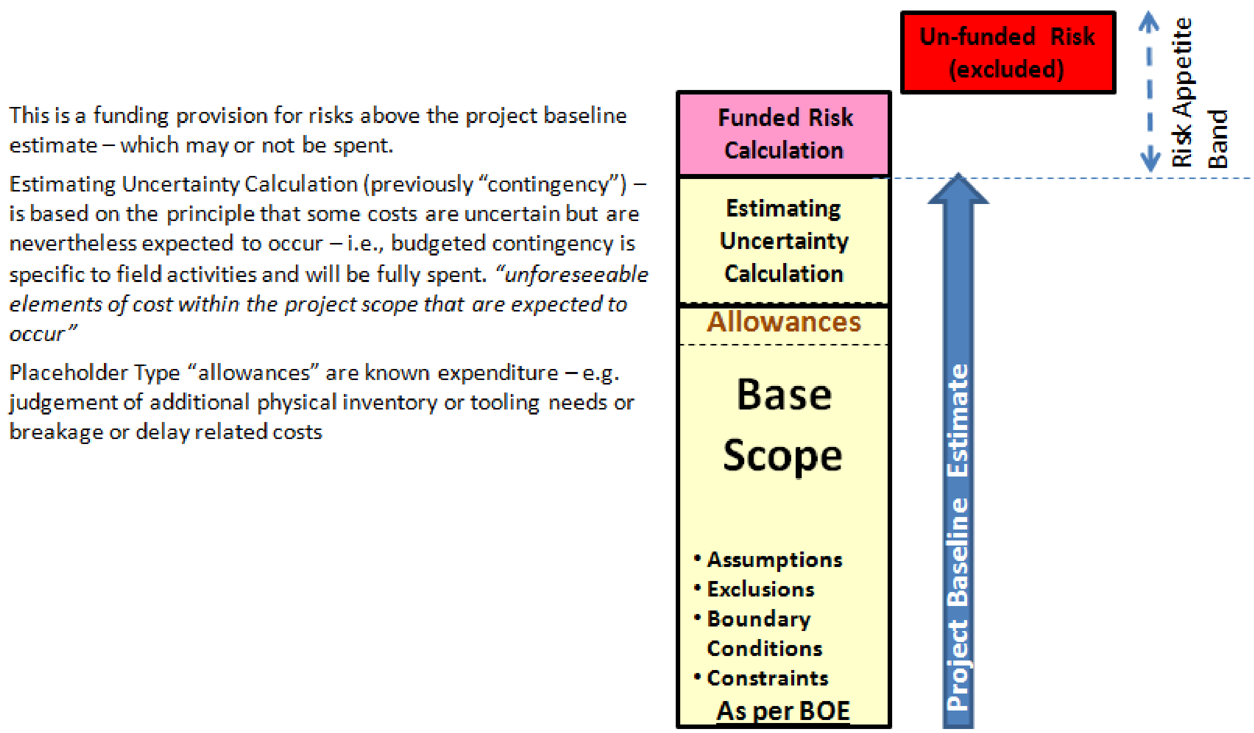

Figure 1 - Structure of a Cost Estimate

Base Cost and Allowances

The Base Scope of the estimate is defined by the assumptions, inclusions and exclusions defined in the Basis of Estimate (BoE) as described earlier. It includes allowances for known expenditures, but whose actual value is uncertain at the time of the estimate. Allowances are also used to account for an uncertain physical inventory amount (feet of pipe, number of valves, etc.), or of uncertain underground soil contamination, or the cost of special permits/insurance/taxes, at the conceptual stage of a NPP decommissioning planning. Allowances provide a means for generating an estimate to compare alternative strategies, without all the detailed facts and figures identified. Subsequent updates to the estimate will address these deficiencies for improved accuracy.

As the estimate matures over the timeline for the facility, these allowances can be refined to match the actual expected cost. The sum of the Base Scope and Allowances is sometimes referred to as the Base Cost.

Estimating Uncertainties

Next, the In-Scope Estimating Uncertainties are added to obtain the Project Baseline Estimate, sometimes referred to as the 'In-Scope Best Estimate.' Estimating Uncertainties are the events that were formerly called 'Contingency,' and typically included as a percentage of the line-item cost for each activity, or added as a percentage of the overall costs. It is included to capture events typically known to occur in the field during project execution, such as equipment breakdown, severe weather conditions (heavy rains, muddy or icy roads), delays in shipments to and return from disposal facilities, additional segment cuts of reactor vessel internals to fit disposal containers, special tooling breakdown, etc. These events occur routinely during field activities, although the exact duration or cost is not certain. The inclusion of these costs covers these types of events.

Some estimators used Probabilistic Risk Analyses and Monte Carlo techniques to estimate these in-scope Estimating Uncertainties if they did not have experience-based guidance on individual or overall contingency percentages. Note that Contingency as used herein takes on a broader definition as additional funds fully expected to be spent to provide the Project Baseline Estimate. This portion is fully consistent with the AACE definition of Contingency as defined earlier.

Risks

Last, the ‘Out-of-Scope Uncertainties’ are added to address events that have a probability of occurrence and uncertain cost impact. These uncertainties are generally addressed using Probabilistic Risk Analyses and Monte Carlo techniques. The resulting additional costs called the ‘Funded Risk Calculation’ adds to the need for additional funding provision (contingency) to fund the project. The ‘Risk Appetite’ of the owner-licensee to accept some level of risk for the project costs are the costs above the Project Baseline Estimate. The funded portion (Funded Risk Calculation) is associated with a calculated probability that the costs will not exceed some value. For example, most risk analyses use a P80 confidence level, which term is derived from selecting a low probability of 10% (meaning there is a 10% probability the costs will not be lower than that low value), and a high probability of 90% (meaning there is a 90% probability the costs will not exceed that high value). The difference between 90% and 10% is 80%, hence the term P80.

The Un-Funded Risk is the cost deemed to be excluded from the risk analysis and therefore not funded. That might include a thousand-year flood, or forest fire, or wars. These would be excluded from the risk analysis. Similarly, there are ‘Black Swans’ (events of very low probability of occurrence, but with very high financial impact), which would be excluded such as a tsunami event on a far-inland NPP, or a meteor strike.

The method used to develop a risk analysis should be included in the Basis of Estimate, and the approach to develop a risk register, mitigation techniques to reduce or eliminate risks by technical or administrative changes to the Base Scope and Estimate, and the residual quantitative risk analysis should be identified. A comprehensive risk analysis should include “opportunity issues,” where a positive effect might conceivably be encountered. As risks for decommissioning are a site-specific consideration, the Risk Analysis Team Workshop is an important element of risk planning and mitigation.

SCHEDULE UNCERTAINTIES AND RISK

As discussed previously, and as the schedule should normally be developed in unison with the cost estimate, appropriate schedule allowances must be considered and documented. This information would be noted in both the risk management documents and in a Basis of Schedule (BOS) document. Industry guidance for establishing separate schedule contingency is less defined and less prescriptive than for cost. Uncertainties in project planning and delivery can affect project cost and project duration or both. By Documenting the Schedule Basis, areas or activities of concern for which there has been an extra schedule allowance can be defined and better tracked in unison with the risk register. In general, documentation of schedule basis should provide the same basic information as a basis of estimate document. Specifically:

- Issues and Concerns
- Risks and Opportunities (identified through a quantitative assessment)
- Assumptions
- Exclusions
- Exceptions

It is therefore important to analyze potential initiating events in the context of both cost and schedule and conduct impact assessments against one or other, and in some cases both. Care needs to be taken to understand cost and schedule inter-dependencies but equally avoid a duplicated allowance or double counting. In general, a 'schedule only' impact can be assessed in terms of critical path and specific activity overhead and then converted to an equivalent cost impact. This enables it to be analyzed as an additional cost contingency in an analogous way to that described above. The use of logically linked resource loaded schedules is essential for review and analysis of schedule uncertainties.

Additionally, one can assess the level of maturity of the schedule or schedule development and apply a buffer or allowance according to the assessed level of schedule maturity.

CONCLUSION

While each subject area discussed within this paper has several individual volumes of work and information published, the intent of this paper is to provide an overview and provoke thought and discussion regarding the understanding and use of allowances, contingency and risks in establishing a NPP decommissioning Project Baseline Estimate and adequate funding provision.

Developing a decommissioning baseline is a complex challenge that must be approached in a methodical manner. The planners must assure that for each element, a full and complete cost / risk / and stakeholder benefit analysis is carried out and that implications of the decisions are carefully considered. In this way, planners can make sure that what they do is performed in the right sequence to derive the maximum benefit from the project life-cycle. The risk of doing things out of sequence is that costs are actually driven higher at a later stage of the project. This must be balanced with the consequences of undue delay. Procrastination, the loss of vital knowledge, and the deterioration of vital assets can drive costs higher and extend schedules to a disproportionate extent.

REFERENCES

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