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NUCLEAR ENERGY AGENCY
RADIOACTIVE WASTE MANAGEMENT COMMITTEE

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Working Party on Decommissioning and Dismantling (WPDD)

1st Meeting of the Decommissioining Cost Estimation Group (DCEG)

Proceedings of the Topical Session on
"Risks and Uncertainties in Decommissioining Cost Estimates"

Held in Krefeld, Germany
14 May 2008

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FOREWORD

The Decommissioning Cost Estimation Group (DCEG) was set up in November 2007 by the NEA Working Party on Decommissioning and Dismantling (WPDD). Its main remit is to foster the exchange of information and experience amongst its members on cost estimation issues and to define and conduct studies aimed at improving the reliability and transparency of cost estimates. Its members are drawn from 12 member states of the OECD, together with representatives from the European Commissioning and the IAEA.

At its first plenary meeting, in Krefeld (13-14 May, 2008), the DCEG held a topical session on “Risks and uncertainties in decommissioning cost estimates”. This report documents the topical session. The main text summarises the main points from the presentations and discussions and includes a summary of the main conclusions from the session. Appendix 1 and 2 provide the agenda of the topical session and the list of attendees respectively. Copies of the presentations made are attached to this report in the form of a CD-Rom. DCEG members are also able to access the presentations on line, via the WPDD Members’ Area, on the following address: http://www.nea.fr/html/rwm/welcome.html

The topical session facilitated an exchange of information and experience on the following issues in particular:

- The definition of different types of uncertainties and their treatment in cost estimations;
- How different cost methodologies analyse uncertainties; and
- Where cost estimates go wrong.

Mr Ivo Tripputi, SOGIN, Chair of the WPDD, and Mr. Staffan Lindskog, SKI, served as co-Chairs of the Topical Session.

Acknowledgement

The WPDD wishes to express its gratitude to Messrs. Tripputi and Lindskog, as well as to all those presenting papers, for their efforts in making the topical session a success.

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OVERVIEW OF MAIN MESSAGES

Ivo TRIPPUTI, Staffan LINDSKOG and Patrick O'SULLIVAN

Types of Uncertainties

Several presenters drew a distinction between uncertainties that relate to issues that come directly within the project scope (e.g. the input data and the assumed nature and sequence of dismantling operations) and uncertainties without the project scope (e.g. boundary conditions such as clearance and site release levels established by the regulatory authorities). In general, the former are included within a base cost estimate in the form of contingency costs; the latter are generally not included within base cost estimates but some kind of risk assessment is often undertaken to determine the level of confidence that can be placed in the base estimate.

It should be borne in mind that contingency costs are expected to be incurred, i.e. the broad set of events covered by contingencies are expected to occur, even though the precise outcomes are not known at the outset. In this sense, contingencies do not represent a 'safety net' to cover unexpected events.

Risk Management

Provided that adequate contingencies are included within a cost estimate, the main issues that may cause the estimate to be wrong are political, regulatory and market uncertainties. Presenters suggested a range of approaches to measure and deal with such uncertainties. Many countries aim to minimise the risks of underestimation of costs by imposing a regular reporting cycle, ranging from 1-5 years. Given that each report should reflect up-to-date information about external factors that can impact on decommissioning costs, the risk of underestimation is thus considered to be reduced.

In addition to regular reporting, some countries also require an explicit risk analysis, e.g. to enable measures to be taken to mitigate significant risks of underfunding of decommissioning liabilities. The process of risk analysis typically involves a probabilistic analysis based on a range of possible scenarios. Such a calculation is used to determine the probability of different cost levels being exceeded and to determine the factors to which the estimate is most sensitive (risk factors), e.g. different levels of labour or material costs.

Implications of Uncertainties for Financing

The level of payments made by plant owners into decommissioning funding schemes is typically based on the reference (best estimate) cost level. For a power plant with a 40-year design life, payments for decommissioning may be set aside annually over, for example, the first 25 years of the plant operating lifetime. This largely covers the risk that the plant will need to be shut down before the end of its design life, and the residual risk of early shut down remains with the plant owner, or can be covered by insurance.

There remains the significant risk (see below) that decommissioning costs will anyway be higher than those reflected in the reference estimate. Given also that actual plant decommissioning may not be anticipated to take place for perhaps a period of a few decades after the estimate is made, there is also less certainty that the then plant owner will have the financial resources to cover any additional decommissioning costs. For this reason, in some countries, plant owners are required to take out insurance to cover potential costs beyond the reference cost level.

It is noteworthy that, in the context of possible new programme of nuclear plants, the UK Government has recently given consideration to whether plant owners should carry unlimited responsibility for discharging future liabilities, such as for the ultimate disposal of spent fuel and long-lived radioactive waste, as well as decommissioning. In the case of the ultimate cost of disposal of spent fuel and radioactive waste, the Government appears to have accepted that this liability should be capped, i.e. the State should bear some degree of risk. In the case of decommissioning costs, the Government has decided that plant owners should bear full responsibility.

Where Estimates Go Wrong

The presenters again distinguished between issues that were included within the original project scope and those that were not. In the first category, errors are commonly due to insufficient data (such as the radiological inventory and the actual levels of contamination of buildings and soils); differences between the dismantling processes actually used and those assumed; the duration of the licensing phase; actual labour costs and material and waste quantities and flows (e.g. as discussed by Messrs LaGuardia, Lexow and Detilleux).

There was a widespread view that the single greatest factor leading to differences between estimated an actual costs was changes to the original project scope, sometimes resulting from issues over which the plant owner has no control such as changes in political or regulatory requirements. In some cases, these result from management changes in direction. Delays in the availability of waste disposal routes can also have significant implications in the costs of decommissioning projects.

The meeting heard that plant operators and organisations involved in producing cost estimates are applying very significant efforts to tracking actual decommissioning costs, and to recording such data in a form that enables comparison with the original estimate. This aspect is crucial to the ability of computational models to predict decommissioning costs accurately and to the engendering confidence of regulators and the general public, as well as plant owners in cost estimates.

SUMMARY OF PRESENTATIONS AND DISCUSSIONS

Patrick O'SULLIVAN
NEA Secretariat

introduction

Ivo Tripputi (Co-Chair) welcomed the participants on behalf of the NEA WPDD (Working Party on Decommissioning and Dismantling. He said that decommissioning cost estimation was a high priority issue for the WPDD and for the nuclear industry in general and he was hopeful that this topical session would provide useful insights into current good practices in this field.

Uncertainties in Decommissioning Cost Estimates

Lucille Langlois recalled the difference between contingences, which relate to issues within the defined scope of a project, and uncertainties, which relate to issues outside the project scope, e.g. inflation rates. Uncertainty assessment was variously addressed in decommissioning cost requirements, in financing requirements or in general corporate risk assessment. Current practice for evaluating uncertainties included scenario analysis, Monte Carlo analysis and sensitivity analysis. She identified several types of uncertainties, including economic (e.g. exchange rate fluctuations), legal and regulatory (e.g. changes in clearance and release levels), market (e.g. bottlenecks in supplies of labour) and technological uncertainties (e.g. new techniques).

As regards how to deal with uncertainties in estimating costs, she suggested that a flexible project plan, that could be adjusted to meet the consequences of a surprise event, were crucial. A range of possible events and outcomes should be postulated, including 'what if?' scenarios, and it was also good practice to have a back-up plan, to be used in the event that such scenarios proved to be correct.

A National Authority Perspective on Managing Uncertainty in Long-term Decommissioning Liabilities

Stefanie Murphy (UK Dept. for Business, Enterprise and Regulatory Reform, BERR) said that a new Energy Bill had been introduced for debate in the UK Parliament in January 2008. The Bill proposes a new legal duty on operators of new nuclear power plants, to provide a funded decommissioning programme, the details of which require approval from the relevant Secretary of State. The programme must include plans for the decommissioning of the power plant, provide an estimate of the costs of implementation of the plan and include financing proposals to meet the identified costs. The Bill also proposes to establish a Nuclear Liabilities Financing Assurance Board (NLFAB) to provide independent scrutiny of proposals from power plant operators.

The Bill draws a distinction between the approach for funding decommissioning costs, for which all risks are borne by the operator, and the costs for disposal of spent fuel and intermediate level waste, for which a fixed unit price (with appropriate allowance for uncertainties) is established by the Government and on which basis this liability will eventually transfer to the State.

Alex Harper (Serco Assurance Limited, UK) explained the basis on which the fixed unit price for waste and spent fuel disposal would reflect a reasonable allowance for risk and contingency. The types of uncertainty considered would include: scenario uncertainties (in relation to the base scenario), engineering contingency (addressing the reliability of central estimates for implementing the base scenario) and engineering risk (addressing 'out of model'uncertainties). He said that an outline cost methodology, based on Monte Carlo simulations of different scenarios had been developed. This methodology would be used to develop government estimates for waste and spent fuel disposal costs by early 2009.

Panel-based Discussion

Stefanie Murphy (BERR); Lucille Langlois; Uwe Altmann (E.ON Kernkraft); Sergio Videachea (ENRESA); Ulf Jakobsson

I. Tripputi introduced the topical session saying that many cost estimates deal only with technical uncertainty (to a greater or lesser extent), making the assumption for example, that the facility being assessed will be decommissioned at current-day prices and taking no account of the actual timeframe for decommissioning. There is a tendency to regard other uncertainties (economic, legal, regulatory and so on) as being issues to be addressed only in establishing the funding arrangements.

S. Murphy said that the funding requirements for liabilities connected to new plant plants made an explicit distinction between uncertainties best managed by the operator and those best managed by Government. On this basis, for example, ultimate responsibility for delivery of a national repository for disposal of spent fuel and long-lived radioactive waste laid with the State, whereas uncertainties in the costs of implementing a decommissioning programme would be borne fully by the implementer.

U. Jakobsson suggested that the assessment of uncertainties should consider scenarios, rather than only looking at probabilities of different variables, in order to address the combined effect of different types of uncertainty. He noted that economic uncertainties (e.g. inflation, exchange rate risks) can be hedged against through the funding scheme. The issue of regulatory uncertainty and the effects of changes in Government policy were more problematic; he suggested that such risks should not be borne fully by the plant operators.

S. Vidaechea said the Spanish approach was to include a contingency amount in the cost estimate (covering issues within the project scope). No allowance was included for issues outside the project scope, on the basis that these are outside of ENRESA's competence. The requirement to produce regular updates of the General Waste Management Plan does nevertheless ensure that estimates reflect up-to-date information concerning the project scope.

L. Langlois suggested that cost estimates should address uncertainties other than technical uncertainties. This could be done, for example, through sensitivity analysis. The funding system then needs to address these uncertainties, e.g. by insurance. An important consideration is affordability of the cost consequences of uncertainties, and how these are mitigated.

U. Altmann suggested that cost estimates should reflect the most likely cost outcome, based on experience from current projects. According to approach followed in Germany, non technical uncertainties are addressed by the fact that the estimate is revised on a regular basis, e.g. each 2-3 years. The costs of nuclear projects should be calculated on the same basis as conventional projects, i.e. taking a similar approach to dealing with uncertainties. On that basis, uncertainties represented a challenge to implementers than should not always be assumed to result in an increase in costs.

U. Jakobsson said that political risks were generally higher for nuclear projects than for conventional ones; this would have an impact on the cost estimation. **L. Langlois** added that although similar uncertainties applied to both types of project, there were differences in terms of degree.

Summary of Morning Session

S. Lindskog (Co-Chair) thanked the participants from the morning session. The discussion had shown that there was a diversity of national approaches to the issue of dealing with uncertainties in cost estimates. This was an evolving issue that presented challenges for the future. He hoped that the experiences presented earlier would be helpful towards developing approaches to address those challenges.

Current Practice – How Implementers Deal with Reducible Uncertainties

US Experience

T. LaGuardia said that classic cost estimates are deterministic calculations reflecting a base scenario plus a contingency allowance to cover issues within the defined project scope. A risk analysis typically comprises a qualitative or quantitative assessment of the impact of risks or uncertainties in a decision situation (e.g. long-term budgeting or funding for decommissioning). A standard risk analysis approach involves, first, the definition of risk factors, and then an assessment of which cost items are impacted. A simulation (probabilistic) computation leads to a probability distribution of the project cost and identification of the relative influence of different risk factors on the project costs, e.g. using a Tornado diagram).

Risk analysis may be used to develop contingencies for a deterministic estimate, or to developing bounding values and confidence levels associated with an estimate, thereby enabling management to measure the level of risk associated with an estimate.

Slovak Experience

V. Daniska (DECOM) described the development of the OMEGA cost calculation code, which is based directly on the standardised list of items contained in the Yellow Book. The code has an integrated calculation structure that includes waste management. Direct data links to the inventory database for the facility and the data on material and radioactivity flows facilitates a direct evaluation of uncertainties caused by changes in input data. This methodology enables sensitivity analyses to be performed, e.g. to determine the effect of changes to the base scenario (such as levels of contamination or nuclide composition that are different than anticipated). The methodology enables the cross-linking of the standardised cost items with inventory information and with typical cost accounting and project management modules. He concluded from this exercise that the standardised list of cost items provides an effective platform for harmonisation of decommissioning cost estimates.

French Experience

S. Desecures (EDF) gave an overview of EdF's current dismantling programme (for its early light water reactors and for the fast breeder reactor at Creys Malville) and for the future decommissioning of its 58 PWRs currently in operation. He said the budget for the current programme was determined from a deterministic analysis, with confirmation by a parametric analysis, with money being collected in a dedicated fund. The cost forecast is reported to the French authorities on a three-yearly basis.

According to the approach followed by EdF an allowance for uncertainties is included in the estimate according to a pre-determined formula, e.g. the contingency level applied to an ongoing dismantling project is 6.5% -10%, whereas the allowance added to a project at the 'preliminary studies' phase is 15% - 22%. In the case of the dismantling programme for the current fleet of reactors, an overall uncertainty allowance of 26.5% is included.

EC Perspective and Recent Study and its Recommendations on Important Cost Drivers and Impact on Cost Estimate

T. Kirchner (DG-TREN) explained the background to the European Commission's interest in cost estimation issues, which stemmed from its responsibility to report regularly to the European Parliament (EP) and the council on the management of decommissioning funds. Commission Recommendation 330/31 (28.11.2006) proposes measures to ensure that adequate financial resources for decommissioning are available when needed. The Commission's second report to the EP on the use of financial resources earmarked for decommissioning identified large differences in cost estimates, due to different country-specific underlying assumptions including the scope of the calculation, differences in manpower costs and different waste management systems, e.g. different clearance levels.

A study undertaken for the Commission on funding methodologies in the European Union suggested that the validity of cost estimates would improve as more cost data becomes available. For the moment, certain risks were inadequately addressed, including the risks of accidents during decommissioning, higher contamination levels than predicted and political decisions that change the scope of a decommissioning project. The study recommended cost estimates should be site specific and based best estimates of costs.

He concluded that the Commission foresaw more effort being need to ensure that cost estimates were sufficiently transparent and complete. This may require the current recommendation to be further elaborated. It was in any case essential to have a good transfer of information between the DCEG and the Commission's Decommissioning Funding Group.

Impact of External Economic Factors on the Cost of Decommissioning Nuclear Facilities

U. Jakobsson said that Swedish experience showed a strong tendency for covariation within groups of cost and price variables, and as a result, it was easier to make an accurate forecast on an aggregate level than on a detailed level, just as it is easier to analyse macroeconomic relations on an aggregated rather than disaggregated level. He said that all long-term forecasting is made in 'real prices', i.e. actual prices deflated by the Consumer Prices Index, and there is considerable evidence of a strong covariation between real wages and productivity. On this basis the Swedish cost model regards 'unit labour cost' (real wage / productivity) can be regarded as an external economic factor, i.e. it is important for the cost of a project but is not itself affected by the project.

Experience of Cost Overruns – Where Estimates Went Wrong and Why

T. LaGuardia said the most important factor contributing to variances between estimated and actual costs was project scope changes, e.g. resulting from changes in direction decided by management or changes in regulatory requirements. Other factors included inflation of wages or equipment costs and insufficient levels of contingency, e.g. due to a greater need to work in high radiation areas than anticipated. He noted also that the degree of accuracy of cost estimate was dependent on the methodology used and on the quality of data. He noted also that, unless actual cost tracking system was correlated to the cost calculation, direct comparison of cost outcomes and the original estimates may not be possible.

T. Lexow (Siempelkamp Nukleartechnik) said that a key aspect of the cost estimation framework in Germany was the transfer of information from decommissioning g projects to those responsible for cost estimation, to ensure that the calculation model was as accurate as possible. He noted that recently undertaken calculations using the STILLKO methodology showed a cost advantage for immediate dismantling strategies for PWRs (over deferred dismantling), but little difference between the two strategies in the case of BWRs.

The issues that had a significant impact on cost estimation were partly internal, such as: insufficient data on the radiological inventory and contamination levels; different technical processes being used than the ‘idealised’ processes assumed by estimators, extended licensing processes; labour costs and different materials and waste flows to those assumed in the estimate. As regards external factors, he cited changes (/growth) in the project scope; changes in laws and regulatory standards and the non availability of waste disposal repositories.

M. Detilleux (Tractabel Engineering) presented generic findings on where estimates go wrong on the basis of a wide range of reviews undertaken, including projects in Belgium, France and the Netherlands. Key issues emerging from these reviews included: physical and radiological inventories needed to be improved; decommissioning scenarios needed to be better defined at all project stages; better planning of the necessary extent of decontamination of buildings and soils; better definition of material and waste flows and of options for waste minimisation; better definition of dismantling operations. He noted that licensing delays, including delays related to internal factors, and poor execution of tendering processes (i.e. process of contractors were above budget) were also significant reasons for exceeding cost estimates.

He recommended the use of sensitivity analysis as a means of developing a good understanding of the range of potential costs. He suggested also that management resources may need to be reinforced on some projects, especially in the areas of project management and radiation protection. There was also sometimes confusion about the sharing of risks between owners of facilities and contractors, related to confusion about what elements were included in contingency costs.

Overall Conclusions

I. Tripputi and S. Lindskog (Co-Chairs) ended the Topical Session by thanking the contributors and noting that the presentations and discussions had been extremely informative and would provide a good basis for the future activities of the DCEG.

Appendix 1

AGENDA

OF THE TOPICAL SESSION ON RISKS AND UNCERTAINTIES IN DECOMMISSIONING COST ESTIMATES

MAY 14, 2008

Topical Session

"RISKS AND UNCERTAINTIES IN DECOMMISSIONING COST ESTIMATES"

Co-Chairs: **Ivo Tripputi & Staffan Lindskog**

10:30 **1.** **UNCERTAINTIES IN DECOMMISSIONING COST ESTIMATES**
Lucille Langlois, Consultant to Secretariat

11:00 **2.** **A NATIONAL AUTHORITY PERSPECTIVE ON MANAGING UNCERTAINTY IN LONG-TERM DECOMMISSIONING LIABILITIES**
Stefanie Murphy (UK Dept. for Business, Enterprise and Regulatory Reform, BERR)

11:30 **3.** **PANEL-BASED DISCUSSION**

Many cost estimates deal only with technical uncertainty (to a greater or lesser extent), making the assumption for example, that the facility being assessed will be decommissioned at current-day prices and taking no account of the actual timeframe for decommissioning. There is a tendency to regard other uncertainties (economic, legal, regulatory and so on) as being issues to be addressed only in establishing the funding arrangements. This issue will be explored from different perspectives (implementer, national authorities etc.), e.g.

- Is this approach is adequate?
- Which are reducible and irreducible uncertainties?
- Can a cost estimate ignore uncertainties other than technical ones?
- Are there grey areas such as the sensitivity of the estimate to assumptions about decommissioning strategies and site end states that cannot be ignored in the cost estimation process?

Stefanie Murphy (BERR); Lucille Langlois; Uwe Altmann (E.ON Kernkraft); Sergio Videachea (ENRESA); Ulf Jakobsson

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12:15 *Lunch*

13:15 **4.** **SUMMARY OF MORNING SESSION**
Co-Chair: Staffan Lindskog

13:30 **5.** **CURRENT PRACTICE – HOW IMPLEMENTERS DEAL WITH REDUCIBLE UNCERTAINTIES**

Spectrum of techniques and approaches used (e.g. probabilistic analysis, expert elicitation, periodic revision of estimates etc.)

- **US Experience**
  Thomas S. LaGuardia
- **Slovak Experience**
  Vladimir Daniska, DECOM
- **French Experience**
  Jean Thirion, EdF

14:30 **6.** ***EC PERSPECTIVE AND RECENT STUDY AND ITS RECOMMENDATIONS ON IMPORTANT COST DRIVERS AND IMPACT ON COST ESTIMATE***

- *Thomas Kirchner, DG-TREN*

15:00 **7.** **DISCUSSION OF ITEMS 5&6**

15:20 *Break*

15:40 **8.** **IMPACT OF EXTERNAL ECONOMIC FACTORS ON THE COST OF DECOMMISSIONING NUCLEAR FACILITIES**
Prof. Ulf Jakobsson

16:00 **9.** **EXPERIENCE OF COST OVERRUNS – WHERE ESTIMATES WENT WRONG AND WHY**

- *Thomas S. LaGuardia*
- *Thomas Lexow (Siempelkamp Nukleartechnik)*
- *Michel Detilleux (Tractebel Engineering)*

17:00 **10.** **OVERALL CONCLUSIONS -**
Co-chairs: Ivo Tripputi/Staffan Lindskog

Appendix 2

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Topical Session on Risks and Uncertainties in Decommissioning Cost Estimation

May 14, 2008

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