

A Swedish Regulatory Perspective on Decommissioning Cost Estimation – 14451

Simon Carroll *, Annika Åström **

* Analyst, Decommissioning of Nuclear Facilities; Swedish Radiation Safety Authority (SSM)

** Acting Head of Section, Financial Control; Swedish Radiation Safety Authority (SSM)

ABSTRACT

In Sweden, decommissioning cost estimates are core inputs to the process of calculating licensee contributions to the Swedish national fund for radioactive waste management and decommissioning. The estimates are produced by licensees and formally submitted to the Swedish Radiation Safety Authority (SSM), which reviews the estimates and then makes recommendations to the government on the appropriate level of fees required. There has been a shift by licensees away from generic decommissioning cost estimates for nuclear power reactors based on reference facilities and inventories, to site specific cost estimates. For the first time site specific decommissioning cost estimates for all ten nuclear power reactors currently in operation in Sweden were presented to the SSM during 2013. Presently SSM is evaluating these latest studies in detail. In its review, SSM will be making judgments on the whether the decommissioning cost estimates are well founded, transparent and robust, and take due account of major project risks and uncertainties. A further important consideration for SSM is that the cost estimates actually reflect the planned decommissioning work to be undertaken as set out in the decommissioning plans for the facilities.

INTRODUCTION

This paper describes the approach being taken by the Swedish Radiation Safety Authority (SSM), in its role as the national nuclear regulator, to evaluating new site specific decommissioning cost estimates for all ten of the nuclear power reactors currently in operation in Sweden. By way of background the paper begins with a brief overview of the financing system for radioactive waste disposal and decommissioning in Sweden, including the role of cost estimation in that system and the some of the key national developments related to reactor decommissioning. A description of the major elements of the approach being taken by SSM in its review of the studies is then given, followed by a discussion of some key challenges and expected outcomes of SSM's review of the decommissioning cost estimates for Swedish nuclear reactors in operation.

BACKGROUND

The financing system in Sweden

The holder of a license to operate a nuclear reactor in Sweden is responsible for the safe handling and disposal of spent fuel and radioactive waste produced by the reactor as well as the decommissioning of the facility [1].

In the early 1980s the Swedish parliament developed a special system for financing of the costs for safe future management and license disposal of the spent nuclear fuel and decommissioning and dismantling of the nuclear power reactors [2]. Under this system of financing for radioactive waste management, a licensee of a nuclear facility pays a special fee to the state. The Government decides on the size of the fee, based on a recommendation by SSM. The fee amounts are reviewed periodically, presently every three years. This fee is levied either at a given

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rate per kWh of electricity delivered by the nuclear power plants in operation or as a fixed fee. Initially these fees were deposited in interest-bearing accounts at the Swedish central bank. Since 1996 the funded assets have been held by a special fund for waste and decommissioning, the Nuclear Waste Fund, which is a government authority. A description of the Fund and its current status can be found in its annual reports [3]. Disbursements from the Fund need to be approved by SSM.

A central principle of this system is that it is the nuclear industry which should fund the disposal of wastes and decommissioning of facilities, and that the burden should not fall upon tax payers either now or in the future. However if it turns out that a reactor owner cannot pay, and fund assets and securities are insufficient, the state – and thereby the taxpayers – will in the end have to contribute the funds. As of January 2008, the state is entitled to charge the nuclear power companies a fee for this risk.

The role of cost estimation in the Swedish financing system

The fees levied pursuant to the Financing Act are periodically reviewed as part of the overall regulatory process relating to the national system of financing of radioactive waste management and decommissioning. This periodic review currently takes place every three years. The starting point for each review is updated cost estimates for radioactive waste management and decommissioning.

The complete process involves three stages:

1. Swedish nuclear licensees submit to SSM cost estimates for waste management and decommissioning
2. SSM reviews the cost estimates and, based on its assessment, makes recommendations to the government on the level of fees required
3. The government makes a decision on the fees

SSM's role in this system is to propose levels of fees and securities that, as far as possible, minimize the risk of the State being required to bear such costs as should be covered by the nuclear industry's liability. The actual decision on fee levels and securities is taken by the government. The purpose of the cost estimates in this context is to provide a basis for SSM to recommend the required contributions to the waste fund sufficient to cover the costs of waste management and decommissioning. The cost estimates submitted to SSM should be fit for this particular purpose.

The current fees are based on the estimates of radioactive waste management and decommissioning costs formally submitted to SSM as "Plan 2010" at the start of January 2011 [4]. SSM presented its review and recommendations to the government in October of that year [5]. SSM identified some areas where it considered that the costs are underestimated. In addition, SSM also found what it considered to be methodological problems in SKB's uncertainty analysis from which it concluded that the real financial uncertainty in project is underestimated. To adjust for these, SSM adjusted the cost estimates for the respective licensees for the purpose of calculating nuclear waste and decommissioning fee. The adjustment was made as a percentage mark-up on the basic costs.

A new triennial review commenced with the formal submission of "Plan 2013" to SSM, in January 2014 [6]. The Plan 2013 estimates are currently under review.

Decommissioning of Swedish reactors

There are currently ten nuclear reactors in operation at three power plant sites in Sweden, four reactors at Ringhals, and three each at Forsmark and Oskarshamn. Of these, three are pressurized-water reactors (PWRs, all at Ringhals) and seven are boiling water reactors (BWRs). According to the industry's current planning scenario, decommissioning of the ten reactors is scheduled to commence between 2025 and 2045 (these dates refer to the commencing of the dismantling & demolition phases) [7]. The first of these reactors scheduled to be decommissioned are the two oldest reactors at the Ringhals nuclear power plant, unit 1 (a BWR) and unit 2 (a PWR).

A number of developments in the national waste system form part of the same scenario. These include the planned repositories for long-lived waste (SFL) and for spent nuclear fuel which are scheduled to be in normal (routine) operations in 2045 and 2030, respectively [7]. An application for extension of the existing repository for short-lived low- and intermediate level waste (SFR) so that it also can include decommissioning waste is scheduled to be submitted to SSM during 2014 [7]. One feature of this extension is that it is being designed to facilitate disposal of one-piece reactor pressure vessels (without internals). Also, part of the extension is planned to be used for intermediate storage of long-lived waste (mainly reactor internals) pending completion of the construction of SFL. A special transport package is being developed for reactor internals. The first decommissioning waste is planned to be received at the expanded SFR facility in 2023 [7].

Swedish decommissioning cost estimates

The Swedish Nuclear Fuel and Waste Management Company (SKB) has been commissioned by the Swedish nuclear power utilities to perform a number of number of investigations and studies to establish a reference technology for decommissioning and, based on these, estimate the costs to carry out decommissioning of the Swedish nuclear power plant sites. Up until recently these decommissioning cost estimates for nuclear power reactors were largely generic, based on reference facilities and inventories. The first site specific reactor decommissioning cost estimates for Swedish reactors were presented in 2008 for Barsebäck units 1 and 2, which were shut down in 1999 and 2005 respectively and for which decommissioning is scheduled to commence in 2023 [6]. A further site specific study was submitted in 2012 for the Ågesta pressurized heavy water reactor, which operated between 1964 and 1974, and for which decommissioned is envisaged to commence in 2021 according to the present scenario [7].

SSM has encouraged a shift to site specific decommissioning cost estimates in part because of a concern that a generic approach based on extrapolations from reactor type and power could lead to significantly underestimating the cost of decommissioning. This concern was reinforced by SSM's review of site specific decommissioning cost estimates for Barsebäck units 1 and 2 which indicated costs significantly higher than those calculated according to the generic approach [5].

Site specific decommissioning cost estimates for all ten nuclear power reactors currently in operation in Sweden were presented to SSM during 2013 [8, 9, 10]. These most recent studies are noteworthy as they are the first occasion that the Authority has received site specific decommissioning cost estimates for all Swedish reactors currently in operation. These estimates follow the International Structure for Decommissioning Costing (ISDC) of Nuclear Installations [11] and have been published in English.

DISCUSSION

The decommissioning studies presented to SSM during 2013 form part of the supporting documentation of “Plan 2013”, the industry’s submission to the present triennial review of radioactive waste and decommissioning costs. Plan 2013 was formally submitted by SKB to SSM in January 2014 [6]. SSM’s evaluation of the decommissioning cost estimates is presently ongoing, and the SSM review of Plan 2013 as a whole is planned to be completed by October 2014.

SSM’s approach to reviewing the estimates

The cost estimates submitted to SSM need to be “fit for purpose”, namely informing SSM’s determination of the level of fees for contributions of the Fund for radioactive waste and decommissioning. As part of its evaluation and review, SSM will be making judgments as to whether the decommissioning cost estimates it receives are well founded, transparent and robust, and take due account of major project risks and uncertainties. This leads in turn to expectations on the part of SSM for clarity (as to the actual results and how these are presented), transparency (assumptions, sources of data), and traceability (how data has been processed to yield the results). This requires that a cost estimate clearly describes the limits to accuracy and completeness of the cost estimate process. In its evaluation and review, SSM is focusing on cross-cutting issues such as: clarity (as to the actual results and how these are presented); completeness and accuracy (including presentation of data gaps and uncertainties); transparency (assumptions, sources of data); and traceability (how data has been processed to yield the results); and risk analysis.

Risk analysis and uncertainties

The decommissioning cost estimates themselves do not contain a risk analysis as such. Instead industry presented certain analyses of risk and uncertainty as part of the overall “Plan 2013” submission. SSM will need to be satisfied that the decommissioning cost estimates and the Plan 2013 submission, taken together, provide robust cost estimates with major project risks identified and due account taken of uncertainties and risk. This is a particular focus of SSM’s review and evaluation.

Linkages between decommissioning cost estimates and planning

In SSM’s view site specific cost estimates should offer more assurance than generic assessments provided that they are based on the foreseen reactor specific inventories of materials and radioactivity for each unit together with realistic descriptions of the decommissioning work actually planned. This includes that the estimates are developed in accordance with Swedish requirements and practice, and include realistic scenarios for the required project organization, and time frames for planning and execution of the work, etc.

In its evaluation of the decommissioning cost estimates SSM is therefore seeking assurances that the cost estimates as closely as possible actually reflect the planned decommissioning work to be undertaken. SSM expects that decommissioning cost estimates will be based fully on the currently applicable decommissioning plans for each facility.

Clearly any assumptions incorporated into the cost estimate should be consistent with Swedish regulatory requirements and practices; any significant variations between these requirements and the basis of the cost estimate should be clearly identified and the implications for the cost estimate

explored. SSM recognizes that for reactors currently in operation, decommissioning plans are necessarily preliminary and will increase in the level of detail and specificity as actual decommissioning approaches. Thus SSM would expect that any such uncertainties related to future final decommissioning plans would be clearly identified also in the cost estimates. These linkages between the cost estimating and decommissioning planning mean that the two processes should develop in synchronization with one another.

Moreover it is important that any significant variations between what is envisaged in the decommissioning plan and the basis for the decommissioning cost estimate are identified and the implications for the cost estimate explored. Accordingly part of the evaluation of the cost estimate by SSM involves cross-checking with the current decommissioning plan, system and waste inventories, and any characterization studies in order to assure consistency between the decommissioning plan and supporting data and the cost estimate. In general, it is expected that the decommissioning plans contain realistic, clearly defined and achievable plans for decommissioning and waste management with any technology or gaps clearly identified.

CONCLUSIONS

The 2013 site specific decommissioning studies for the reactors currently in operation marks an important development in the approach to decommissioning cost estimation by the Swedish industry. This approach entails an increased level of complexity when compared to the earlier more generic approach to decommissioning cost estimation in Sweden. This creates challenges to both the licensees and SSM in ensuring that the studies are of the necessary completeness and quality to support the calculation of the fees for radioactive waste and decommissioning. In this context, particular attention needs to be given to ensuring that the estimates of decommissioning costs take due account of major project risks and uncertainties.

The present evaluation of these estimates and the review of Plan 2013 are important to the identification of necessary further refinements in methodologies – both in the cost estimation by industry and the review conducted by SSM. Thus the current process should not only form the basis for SSM's recommendation on radioactive waste and decommissioning fees to the government in 2014, but should also inform the development of the cost estimates for decommissioning for the subsequent submission in Plan 2016. In addition, there is potential to develop further the inherent linkages between the cost estimating and decommissioning planning, to ensure not only that the two processes develop in synchronization with one another, but also to help identify strategic possibilities to further refine and improve decommissioning planning.

There is relatively limited experience of fully completed decommissioning projects for nuclear power reactors. As a consequence of this, the planning for financing of nuclear reactor decommissioning remains predominantly reliant on cost estimation rather than on the application of actual experience from completed projects. It is essential that the approaches taken in cost estimation are of sufficient quality to ensure a robust estimate of the future costs of decommissioning. This requires further refinements in the application of decommissioning cost estimation methodologies and further development of approaches to review these estimates and provide assurance on adequate financing for decommissioning activities. Given the burgeoning numbers of nuclear power reactors already shut down and expected to be permanently shut down over the coming decade in a number of countries, there is considerable potential for adding value through strengthened sharing of information concerning estimating methods and their review internationally.

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