

# Financial Planning as a Tool for Efficient and Timely Decommissioning of Nuclear Research Facilities

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## INTRODUCTION

It is generally recognized in the technical and economical literature that reliable cost evaluations with adequate estimates also of the errors and uncertainties involved are necessary in order for rational and appropriate management decisions to be made on any major plant investment[1]. Such estimates are required for the selection of technologies to be applied and for selection to be made between alternative technologies and designs as well as for the overall financing issues including the one of whether to go ahead with the project. Inadequacies in the cost calculations typically lead to suboptimal decisions and ultimately substantial overruns and/or needs for retrofits.

Actually, a very strict discipline has to be applied with adaptation of the approach used with regard to the stage of the planning. Deviations from the expected tend to raise the estimated cost much more frequently than they lower it.

The same rationale applies to planning and cost calculations for decommissioning of nuclear research facilities. There are, however, many reasons why such estimations may be very treacherous to carry out. This will be dealt with in the following.

The knowledge base underlying the present paper has been developed and accumulated as a result of the research that the Swedish Nuclear Power Inspectorate (SKI) has carried out in support of its regulatory oversight over the Swedish system of finance. The findings are, however, equally applicable and appropriate for implementers in their planning, decision, monitoring and evaluation activities.

In the nineteen fifties and sixties, Sweden had a comprehensive program for utilization of nuclear power including uranium mining, fuel fabrication, reprocessing and domestically developed heavy water reactors. Examples of facilities are presented in Figures 1-5. Eventually, the development work lead to the present nuclear program with ten modern light water reactors in operation at present.

According to Swedish law, those who benefit from the use of these plants must pay a fee which is accumulated in a fund so that all future costs for decommissioning and waste management can be covered. Each year, estimates on all future costs are submitted to the SKI for review. The Government then decides on the size of the fee, based on the results of the review.[2]

## WORK DONE

The SKI research activities of have included independent cost calculations, plant investigations and information searches of various facilities e g a waste storage facility for old intermediate level waste[2-4] and a wet spent nuclear fuel storage[5].

The results obtained illuminated the need for sharing information between old research facilities, and this prompted SKI to take initiative to a Nordic project. The results of the work include descriptions of good practice for the planning, cost estimation methodology, risk analysis, plant descriptions and examples of decommissioning projects.[6-7] This work implies sharing of information at different depth for a number of facilities including those shown in Figures 1-5.

The Nordic co-operative work has been reported[6] and presented[7] elsewhere and this will not be repeated here. Instead, there will be focus on some features that may require special attention.

## RESULTS

### *Nuclear research facilities*

The Figures 1-5 illustrate that nuclear research facilities show a wide range of features. Several of these require special attention during cost calculations:

- Facilities are frequently one-of-a-kind
- Great versatility in the purposes, designs and radionuclide compositions of the plants.
- Records on design and operation that may be incomplete and institutional memory may have been lost.
- Complex and unexpected features
- Peculiar cost structure and difficult to apply per unit costs

It has been concluded[2-3,6] that the prerequisites for cost calculations of nuclear research facilities are very different from those for nuclear power plants.

It has also been concluded that the above factors give rise to uncertainties and potential for increases in costs.

In view of these peculiarities, it is imperative that the IAEA recommendations[8-12] for planning be applied. For instance, the extent and timing of the radiological characterization, technical planning and uncertainty analysis should be dictated by the needs for cost estimations and planning.

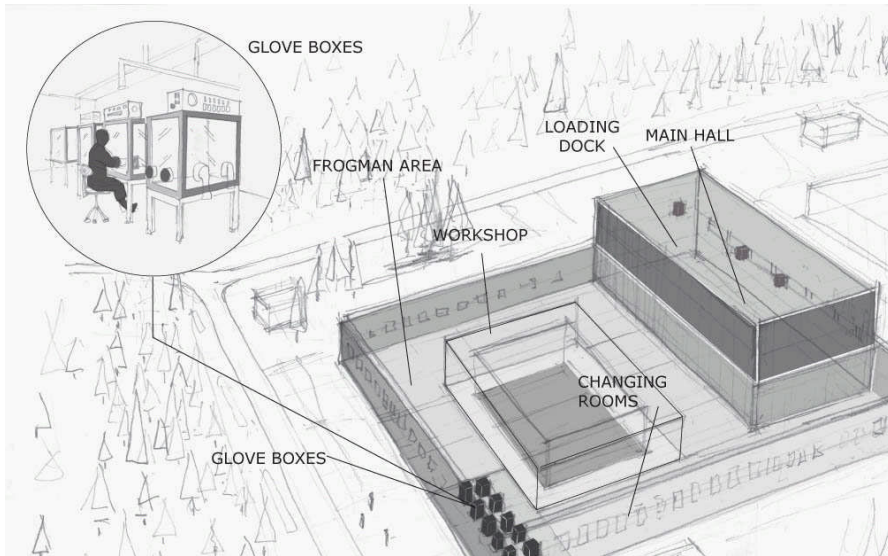


Figure 1. The Central Active Laboratory (ACL) at Studsvik was part of the early Swedish domestic concept with natural uranium fuel, heavy water moderation, reprocessing and mixed oxide fuel. It was used for laboratory scale reprocessing and preparation of mixed oxide fuel. The main hall was intended for a mixed oxide fuel pilot plant but no such plant was ever built.

The laboratory was built during 1959 to 1963 and was decommissioned during 1998 to 2006. It had a total floor area of 14 200 square meters. The Figure is an artist's view.

### ***Radiological characterization***

The need for radiological characterization can hardly be over emphasized. However, it is frequently the case that little differentiation is made with regard to the purpose different characterizations. Appropriate approaches in this regard can be found in References [13-14] where clear distinction is made between on one hand the characterization needed for the actual work, and on the other that needed for the planning.

In technical literature, it is frequently the technical planning that is being described. However, the basis for planning should comprise technical prerequisites as well as cost estimates, including the estimated errors[1], since the choices made should be based on a combination of "price" and "quality".

The radiological characterization for cost estimation purposes should thus be sufficiently thorough to enable the analyses needed, yet not forestall the characterization for the actual work which might be decades away.

Consequently, requirements should be identified for the decision base needed and appropriate statistics worked out for the strategy of the measuring.

A good illustration of this is the radiological characterization and methodology selection for the decommissioning of the Active Central Laboratories (ACL) at Studsvik.[15-16], see Figure 1. This facility was used for reprocessing and mixed oxide fuel laboratory scale investigations and other purposes, and consequently the alpha to gamma ratio is much higher than in most other facilities.

Thus, an important strategic decision is whether to decontaminate and measure or strip the concrete using e.g Bolero equipment. According to [15], the former method was used and the cost for radiological measurements and consultants constituted more than 50 % of the total cost.

### ***Methodology selection***

There are many vendors around who offer various more or less sophisticated techniques. However, it is frequently difficult to find unbiased and comparative information on the relative merits of various techniques and on the appropriate level of sophistication to be applied.

Plant owners that own only few facilities and do decommissioning projects at large intervals in time may easily be at disadvantage in relation to the vendors. It is therefore necessary that plant owners search for similar cases in the literature and exchange information with other plant owners.

A good example of this is the storage for old intermediate level waste at Studsvik where overcoring was planned for the removal of the contaminated pipe storage positions, see Figure 2. Literature searches[2-3] unveiled that a similar facility existed at the Argonne National Laboratories in the US and that e.g contaminated drill fluid had been lost in "rat holes" in the concrete. This initial study was later supplemented by an in depth investigation at the site.[4]

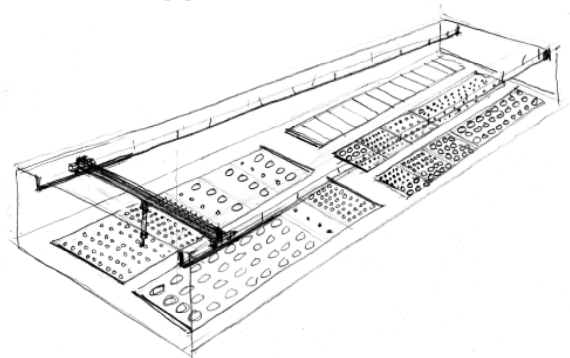


Figure 2. Layout of the storage for old intermediate level waste at Studsvik, artist's view. The thickness of the concrete in the pipe positions is three meters.

### **Financial risk analysis**

Frequently, a large fraction of the incurred cost has come as a surprise during the actual decommissioning work. There are several reasons for the appearance of such cost raisers, some of which may be very difficult to avoid such as hidden contamination.

However, there are patterns in the appearances of financial risks in essentially the same way as there are patterns in the probably much more studied technical risks. Thus, financial risks may be approached using the same kinds of methodologies as in safety work, i.e. risk identification and risk analysis. In conventional safety and plant reliability work it is frequently the systematic exploration of implications of risk indications as well as self inspections that have the largest potential for improvement, and the case is probably similar for financial risks.

One such example is given by the interim store for spent nuclear fuel at Studsvik, see Figure 3. Technical studies in combination with literature search and risk identification uncovered that the design is a single containment one. Modern standards call for double containment with leak detection inbetween. Leakage of fuel tank water to the ground water is unlikely, but cannot be ruled out. It should therefore be included in the uncertainty discussion in conjunction with the cost estimation of the decommissioning of the facility.[2]

Risk management and uncertainty analysis should thus be an integral part of the planning and cost calculations for any decommissioning project. According to [7], the process should include the following steps:

- “Brainstorming mode” and identification of risks
- Analysis of the risks and assessment of their significance
- Selection of those that need to be included and managed
- Action plan for how to manage
- Monitoring of the risks

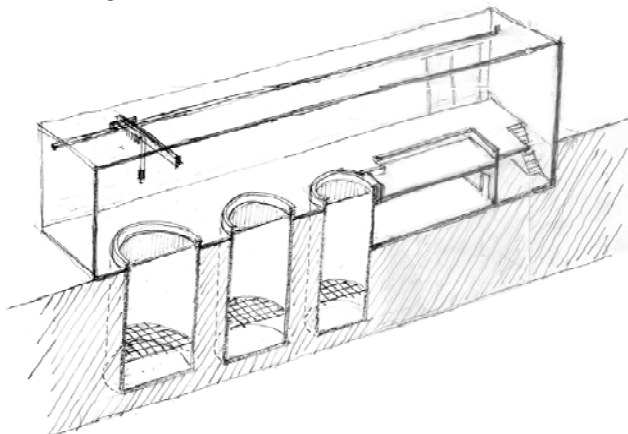


Figure 3. The spent fuel store at Studsvik showing the main hall as well as the interface between the building structures and the underlying soil and rock. Artist's view.

### **Cost calculations**

Frequently, costs are calculated by summing over a large number of terms. At early stages this may lead to severe underestimations of the costs since all terms are not identified and assessed. At such stages it is more appropriate to make comparisons with incurred costs at facilities already decommissioned, using e.g. various scale factors.

At later stages, summation methodologies may be appropriate provided that the various factors used originate from similar features in finished projects.

The accumulated experience from “conventional” cost calculations and project management clearly indicates[13] that for early stage estimates, it is the “design basis” that has the largest influence on the cost estimates. In terms of a decommissioning project this corresponds to the radiological characterization and the selection of technologies to be applied. Next is probably the uncertainty analysis, and least significant of the three is the calculation methodology. This typical relative significance should be kept in mind when early cost estimates are to be made.

## **CONCLUSIONS**

It has been concluded in the SKI work - in spite of the difficulties pointed out above - that cost calculations with the precision needed for a system of finance can be achieved even at early stages provided that the various features of the task are adequately dealt with.

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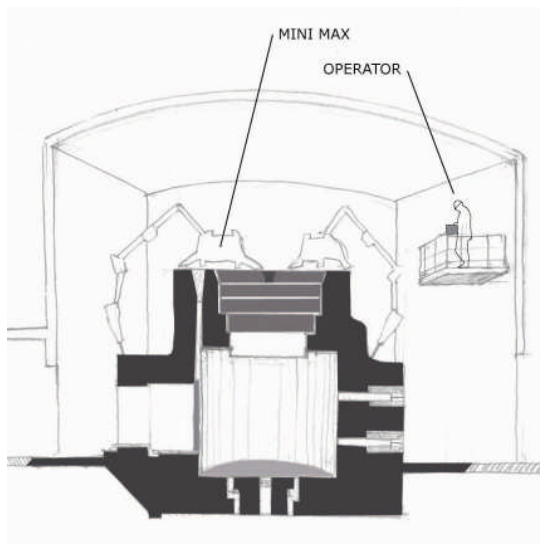


Figure 4 (above). The R1 research reactor in Sweden. It was commissioned in 1954 and decommissioned during 1981 – 1983. Artist's view.

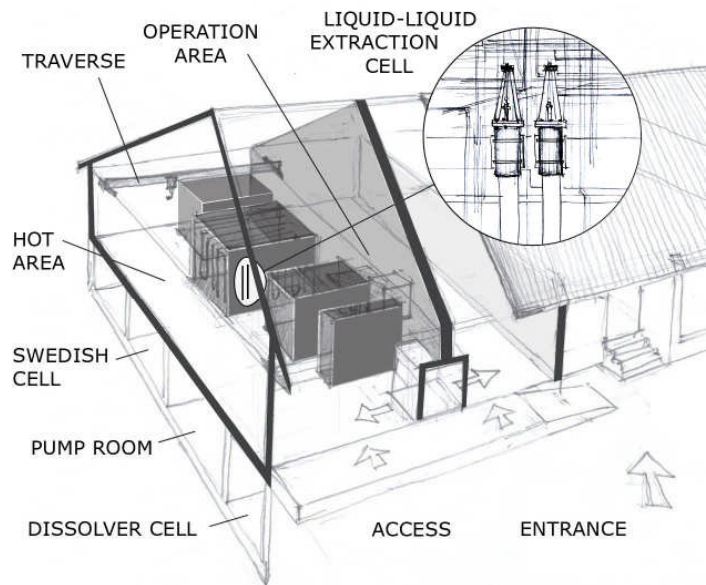


Figure 5 (right). The reprocessing pilot plant at Institute for Energy Technology (IFE) at Kjeller in Norway. This is where Sweden carried out its pilot plant tests of reprocessing together with with IFE. Artist's view.