FINANCIAL PLANNING AS A TOOL FOR EFFICIENT AND TIMELY DECOMMISSIONING OF NUCLEAR RESEARCH FACILITIES

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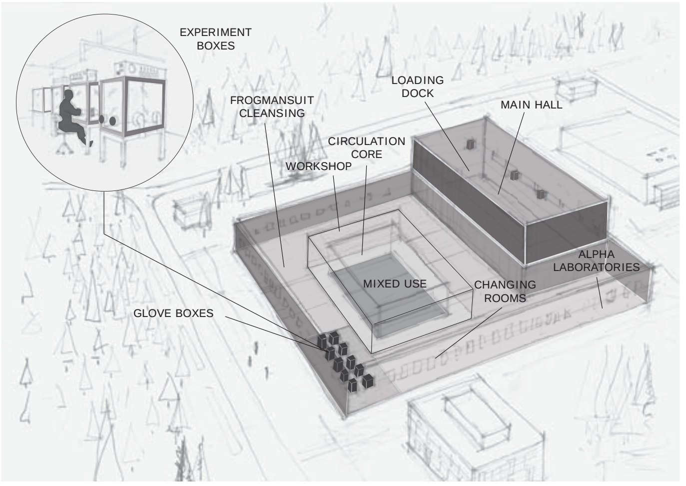

Figure 1. The Central Active Laboratory (ACL) at Studsvik, built in 1959-63 and decommissioned in 1998-2006. It was used for laboratory scale reprocessing and preparation of mixed oxide fuel. The main hall was intended for a mixed oxide fuel pilot plant but it was never built. It had a total floor area of 14 200 square meters. Artist's view.

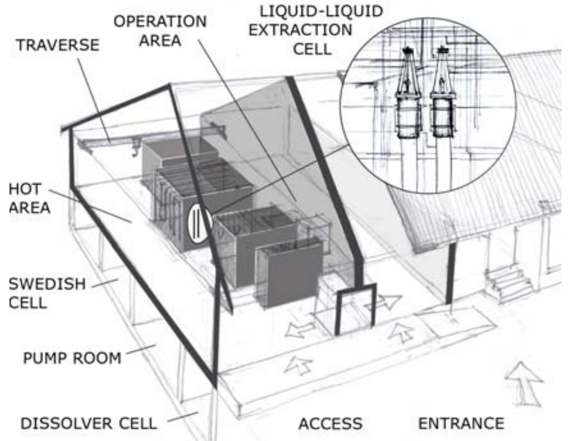

Figure 2. The reprocessing pilot plant at Institute for Energy Technology (IFE) at Kjeller in Norway. It was commissioned in 1961, taken out of operation in 1968 and decommissioned in 1982 and during 1989 – 1993. This is where Sweden carried out its pilot plant tests of reprocessing together with with IFE. Artist's view.

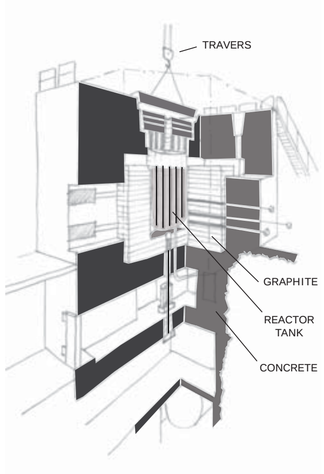

Figure 3. The R1 research reactor in Stockholm Sweden was moderated by heavy water and used natural uranium fuel. It started operations in 1954, was closed in 1970, and decommissioning was completed in 1981. The reactor was located in crystalline rock. The decommissioning was carried out by Studsvik.

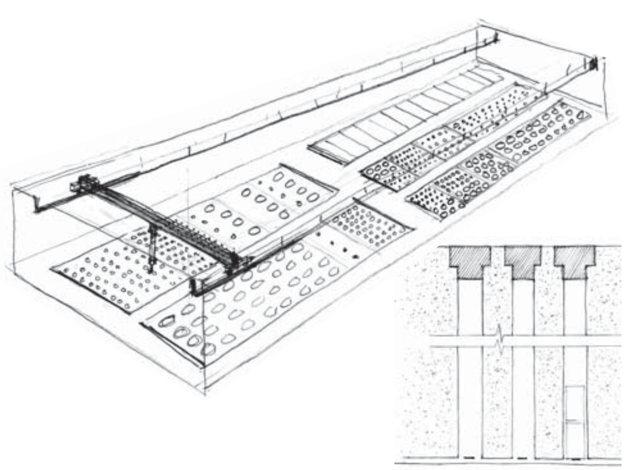

Figure 4. The storage for old intermediate level waste at Studsvik. The facility was in operation during the years 1961 - 84. The waste was stored in tube positions in concrete blocks and in concrete vaults. The thickness of the concrete in the pipe positions is three meters. Artist's view.

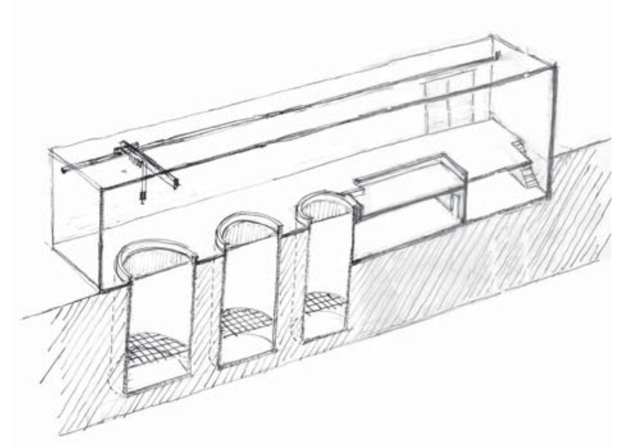

Figure 5. The spent fuel store at Studsvik showing the main hall as well as the interface between the building structures and the underlying soil and rock. It was built in 1962-64 and is still in operating condition. It was used for storage of spent fuel from the Ågesta pressurized heavy water power reactor operated during 1963-73. Artist's view.

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. Such estimates are required for the selection 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 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.

According to Swedish law, those who benefit from the use of the nuclear power 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 Swedish Nuclear Power Inspectorate for review. The Government then decides on the size of the fee, based on the results of the review.

THE SWEDISH NUCLEAR TECHNOLOGY DEVELOPMENT PROGRAMME

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.

The programme lead to the erection of the Ågesta heavy water reactor which was in operation during 1963-73. It generated a thermal power of 65 MW of which 10 MW was used for electricity generation and 55 MW for district heating.

The technology development program also included a 50 MWth materials and fuel testing reactor, R2, with light water and heavily enriched uranium fuel. It was taken out of operation in the year 2005. There is also a hot cell laboratory for post-irradiation investigations still in operation.

The residues from the hot cell laboratory were put in steel boxes which in turn were stored in the storage for old intermediate level waste (Figure 4). The spent fuel from the R1 (see Figure 3) and Ågesta reactors were kept at the interim store for spent nuclear fuel (Figure 5) which is a pool storage comprising three cylindrical concrete tanks.

The development work described above eventually lead to the present nuclear programme comprising twelve modern light water reactors, ten of which are in operation at present.

WORK DONE

The Swedish Nuclear Power Inspectorate research activities of have included independent cost calculations, plant investigations and information searches of various facilities e g the storage for old intermediate level waste (Figure 4) and the interim store for spent nuclear fuel (Figure 5).

The results obtained illuminated the need for sharing information between old research facilities, and this prompted Swedish Nuclear Power Inspectorate 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. This work implies sharing of information at different depth for a number of facilities including those shown in Figures 1-5.

RESULTS

Nuclear research facilities

The description of the Swedish nuclear development programme above as well as Figures 1-5 illustrate that nuclear research facilities show a wide range of features. Several of these require special attention for decommissioning and 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

In concordance, it has been concluded 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 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.

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 some of the literature 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, 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 even 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 at Studsvik, 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 or Brokk equipment. Studsvik, who is the owner of the facility, has selected the former method. This implied that 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 4. Literature searches 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.

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 5. 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.

Risk management and uncertainty analysis should thus be an integral part of the planning and cost calculations for any decommissioning project. Such a process process may 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

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 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 Swedish Nuclear Power Inspectorate 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.

High quality cost estimates will enable the following:

- The funding will be in balance so that future undertakings can be carried out without any delays, thus maximizing the benefits to health and environment and to the society
- There will be less room for overcompensation since the principle of financing of the various activities will be based on good and sound cost estimates, thus keeping the costs to the society to within controlled limits.