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Review of Dismantling Costs
- Nuclear Installations

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Abstract

In this study three reviews of cost assessments for some smaller nuclear installations are presented for which nuclear waste liabilities shall be accrued according to the Financing Act (Lag (2006:647) om finansiella åtgärder för hanteringen av restprodukter från kärnteknisk verksamhet). It is expected that these reviews will contribute to develop premium quality assessments of future dismantling costs for nuclear installations (excl. nuclear power plants). The results stress how a systematic approach to a deterministic assessment needs to be supplemented by appropriate methodological steps to decide ranges for contingency.

Background

The Swedish Law stipulates that future expenses for dismantling of miscellaneous nuclear installations shall be financed by funds generated under the Financing Act.

The task to inject sufficient capital into the Swedish Nuclear Waste Funds is fundamental for the trustworthiness as well as sustainability of the Swedish model for financing of radioactive waste for all nuclear installations.

Objectives of the project

The aim of this study is to review three cost assessment of a number of nuclear installations at the Studsvik Site from a methodological perspective. Moreover, ways to enhance the quality on cost assessments made at an early stage of decommissioning projects are discussed in more detail.

Results

The present study discloses that accurate cost assessment for the actual nuclear installations needs to be recalculated in order to enhance the credibility and accuracy of the cost estimates. The report is as such a contribution to active learning processes in the field of how more systematic use of methodology may enhance the over-all robustness and precision of future cost assessments.

Conclusions

The report demonstrates that the common denominator for the cost studies reviewed are that they are very basic (simple) and can best be describe as budget figures at an early stage. In this context it is stated that the level of contingency ought to be at least 30 per cent. However, another independent evaluation indicates that the level of contingency mentioned in the report is unclear, in relation to the expected time for the start point of dismantling which exceeds one generation.

Project information

At DECOM, Slovakia, Marek Vasko has been responsible for the co-ordination of the project within DECOM, Slovakia. Staffan Lindskog has initiated, defined and been responsible for the steering of the entire project. Project SSM2012-4669.

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This report concerns a study which has been conducted for the Swedish Radiation Safety Authority, SSM. The conclusions and viewpoints presented in the report are those of the author/authors and do not necessarily coincide with those of the SSM.

Content

1. Introduction

This review is made upon demand of SSM with the aim to evaluate credibility of assessed decommissioning costs and approach used in following cost assessments:

- Kostnadsuppskattning för framtida avveckling av Aktiva Kemi Laboratoriet (AKL) i Studsvik [1];
- Kostnadsuppskattning för framtida avveckling av behandlingsanläggningarna, B4, B5 och T4, för vätskeburet avfall [2] and;
- Kostnadsuppskattning for framtida avveckling av materialforskningslaboratorium, autoklavhall, annex till allmänt kemiskt laboratorium samt två förrådskassuner vid Studsvik [3].

For each of above mentioned cost assessments, the review consists of examination of standard parts which are included within the common decommissioning cost assessment, both for their extent and detail to be adequate for qualified assessment. Following parts are included in the review:

- general description of reviewed cost study,
- review of used methodology for cost assessment,
- review of description of facility to be decommissioned,
- review of intended decommissioning activities,
- review of resources demands and costs, and
- one presentation of final conclusion of the review and suggestions.

At the end of the review, there is a final conclusion and suggestions presented. Reviewed cost reports were available in Swedish; review was made based on their English translations made with the help of SSM representative Mr. Staffan Lindskog.

2. Review of Cost Assessment for AKL

2.1 General description of reviewed cost study

Purpose of the cost assessment is mentioned in the chapter Main content, as following the requirements of authorities set by regulation SSI FS 2002:4 and SKI FS 2004:1.
In chapter 1 - Background, last paragraph is dedicated to previous decommissioning cost assessments for the AKL but without clear relationship to this cost assessment or documentation of particular improvements comparing to this former assessments.
The cost assessment study "*Kostnadsuppskattning för framtida avveckling av Aktiva Kemi Laboratoriet (AKL) i Studsvik*" [1] consists of 11 pages. It includes tile page, contents and following chapters:

1. Background
2. Pre-study
3. Dismantling, transport, decontamination and clearance of actual building parts.
4. Waste treatment
5. Disposal costs
6. Reporting and free release
7. Summary and conclusion
8. Reference.

Each chapter includes approximately from quarter to half a page of text. Chapters 2, 3, 4, 5, 6 a created predominantly by tables.
Based on its small extend and very brief information used within individual chapters, this assessment can be considered as very basic (preliminary) level.

2.2 Review of used methodology for cost assessment

There is no special methodology used within the cost assessment. Although the chapters are ordered in a logical order with regard to decommissioning process, no methodical approach to the decommissioning presented in the text of a report.

2.3 Review of description of facility to be decommissioned

Very basic description of the AKL facility is presented in chapter 1 - Background. It roughly describes the inventory of AKL as hot-cells. It describes purpose of AKL and type of activities which are performed here including radioactivity which is handled within the operation (per job and total). There is no description of operational history including mention of any non-standard events which could lead to spread of radioactivity and contamination.
There is no description of facility location, dimensions, number of floors and rooms and their purposes, border of controlled area including floor drawings so it is difficult to assess AKL properties. Similarly, there is no description of inner furnishings

including technological systems and equipment together with their placement within the facility. Information on area of controlled area - 900 m^2 is the only information mentioned as well as some references to hot-cells in the beginning of the report. From the view of physical and radiological inventory, there is no list of equipment and building surfaces with any of their basic characteristics such as material characteristics, dimensions, weight, volumes and surface areas. No relevant information on appropriate radiological characteristics of these equipment and building surfaces including assessed contamination levels, contamination extent, dose rates and nuclide composition are presented.

2.4 Review of intended decommissioning activities

Activities intended to be done within the AKL decommissioning are presented in chapters 2, 3, 4, 5 and 6 very briefly.

In chapter 2, pre-study activities are mentioned within Table 1 including costs. Extend of activities deems to be adequate to this level of decommissioning cost report although some description of works within each activity could be advisable to make the content of activity more clear.

Chapter 3 mentions dismantling, transport, decontamination and clearance of parts of building. Activities are described very briefly or without any description. Transportation is not explicitly mentioned in the Table 2. No particular techniques for dismantling, decontamination, action after scanning and additional measurements are presented.

Chapter 4 on waste treatment only adopts costs for waste treatment from previous study. There are no specifications on radioactive waste types such as combustible, melt able, compactable, debris or bulk metals etc. Similarly to previous chapters no description of treatment technologies is presented including final products and their amounts.

Chapter 5 - Disposal costs only mentions amount of 30 m^3 (one container) of waste to be intended for disposal at SFR. No more details on the waste origin and its composition are provided as well as what activities are included in disposal at SFR (transports, disposal itself, fees, measurements etc.)

Chapter 6 - Reporting and clearance is also very brief. There is a lack of information on reporting and meetings from the point of view of their types, number, and frequency otherwise it could be confused with a part of project management. Clearance activities are not described completely.

2.5 Review of resources demands and costs

Costs are calculated also very simply according to description of decommissioning activities in the same tables.
For individual activities, no number of workers is assessed. Manpower is available only for the pre-study and dismantling/decontamination and clearance activities and presented in improper in units of time instead of man-power. But no relationship between decommissioned equipment amount characteristics (weights, areas, contamination) and manpower is presented. It means that manpower unit factors are

missing. So it is hard to evaluate if the time (manpower) for individual activities is appropriate or not.
Specific costs (costs unit factors) per hour or m^3 are presented without any reference to its origin. Costs are simply calculated as a product of specific costs and time or m^3 (for waste disposal) or are directly taken from previous reports. In Table 1, there is an incorrect sum of Total 215 880 SEK instead of 238 080 SEK. Sum of total costs for all tables is missing. Using of 10% uncertainty seems to be low on this basic decommissioning level, at least 30% is recommended. Recalculated costs with 10% uncertainty level is 4 246 418 SEK not 4,1 MSEK as declared in the report.

2.6 Conclusion of the reviews and suggestions

Based on observations mentioned above, it can be said that "*Kostnadsuppskattning för framtida avveckling av Aktiva Kemi Laboratoriet (AKL) i Studsvik*" is a very basic level of cost study. Cost study is very brief and simple. No methodology is used for systematic costing.

There is a lack of information on facility description and characterization, including physical and radiological inventory. Individual decommissioning activities are not characterized or specified. There is no relationship between inventory and calculation of costs for technological activities such as dismantling, decontamination or radiological surveys. Extent of activities is not sufficient to include all decommissioning activities in more detail. Numbers of workers for individual activities is not presented.

There is also a mistake in summation of decommissioning costs. Also presence of some schedule should be good for basic orientation in decommissioning proposed dates, milestones and sequence of decommissioning activities.

Suggestions for cost study improvements are presented in Chapter 5.

3. Review of Cost Assessment for the installations B4, B5 och T4

3.1 General description of reviewed cost study

Purpose of the cost assessment is mentioned in the chapter Main content, as following the requirements of authorities set by the Act 1988:1597 on the financing of the management of certain radioactive waste. It is also mentioned that cost assessment shall be reviewed on a yearly basis and reported to SSM.
The cost assessment study "*Kostnadsuppskattning för framtida avveckling av behandlingsanläggningarna, B4, B5 och T4, för vätskeburet avfall*" [2] consists of 20 pages. It includes title page, contents and following chapters:

1. Background
2. Facility description
3. Preconditions and extent of costing study
4. The decommissioning procedure
5. Project management and support services
6. Collocation
7. Summary and Conclusion
8. Reference

The longest text chapters 2 and 3 are dedicated to description of all three buildings (4 pages) and description of decommissioning assessment boundary conditions and scope. Chapters 4, 5, 6 are created predominantly by tables. Chapters 1, 7 and 8 consist of a couple of sentences.

Although this cost report contains more information as the previous one [1] it can be similarly observed that it has a small extent and relatively brief information are used within individual chapters, thus this assessment can be considered as very basic (preliminary) level.

3.2 Review of used methodology for cost assessment

Similarly to the cost report [1], there is no special methodology used within the cost assessment. Although chapters are ordered in logical order with regard to decommissioning process and are more detailed as [1], no methodical approach to decommissioning costing is mentioned or followed in the text of a report.

3.3 Review of description of facility to be decommissioned

Basic description of the B4, B5 and T4 facility is presented in chapter 2 - Facility description and partially in chapter 3.3 Decommissioning work. The purpose and

very brief history of B4, B5 and T4 buildings is presented in the beginning of chapter 2. Figure 1 describes systematic of liquid waste and sludge flow in Studsvik including B4 and B5 (T4 is not mentioned in the scheme). In sub-chapters 2.1, 2.2 and 2.3 B4, B5, culvert systems are briefly described including basic parts of buildings and their functions and connections within the Studsvik liquid waste system. Except of starting operation dates and some additional works dates, there is no description of operational history including mention of any non-standard events which could lead to spread of radioactivity and contamination.
Based on the facilities description it is possible to provide some basic picture of facilities disposition and about the main parts of facilities such as basins or tanks. However, there is only very little information on facility location, dimensions, number of floors and rooms and their purposes, border of controlled area (if any) including floor drawings so it is hard to have some precise image of B4, B5 and T4 layout and dimensions. Similarly, there is no description of inner furnishings including technological systems and equipment together with their placement within the facility, only available drawing is for culvert system piping channel cross section.
From the view of physical and radiological inventory, there is no list of equipment and building surfaces or structures with any of their basic characteristics such as material characteristics, dimensions, weight, volumes and surface areas. In chapters 2 and 3, there are some references to volume of tanks, basins and pools, some references on building materials and on surfaces types as well as on supposed depth of contamination penetration into pools building materials. Only minimal information on appropriate radiological characteristics of buildings including assessed contamination levels, contamination extent and nuclide composition are presented.

3.4 Review of intended decommissioning activities

Activities intended to be done within the B4, B5 and T4 decommissioning are presented in chapter 3, 4 and 5.
In chapter 3, there is a list of activities which are (among others) taken into account for decommissioning of B4, B5 and T4 building. It has to be said that this list is not comprehensive as it does not follow any methodical approach for identification of needed decommissioning activities. Conventional demolition is not included within these activities but the reason is not presented in the document.
Sub-chapter 3.1 mentions preconditions for relevancy of presented cost estimations for future decommissioning process.
Sub-chapter 3.2 describes frame approach to decommissioning of individual buildings in shortcut. There are mentioned assumed decontamination techniques for building surfaces for individual buildings in this chapter, dismantling techniques are not specified and they solved by reference to another document.
In chapter 4, radiological measurement techniques are listed with very brief commentary about their purpose.
Waste management including transports activities are not mentioned only amounts of radioactive waste and waste for municipal dumps are presented in chapter 4.
In chapter 5, activities of project management and support activities for radiological measurements are very briefly mentioned.
It can be observed that there is a lack of information on individual activities and technologies or techniques which are intended to be used for decommissioning of B4, B5 and T4 facilities. Activities should be described in a more systematic and detailed way together with basic assumed features and parameters of used techniques and technologies such as capabilities, capacities, cost unit factors and others. It is advised that all activities should be presented within the cost study including dismantling, waste management and also demolition or if they are not included it

should be reasoned why they are excluded from costing. Similarly, there should be described at least basic concept to decommissioning including the way of decontamination dismantling and performance and approach to handling of waste from decontamination and dismantling (segmentation, in-situ measurements, packaging, transportation routes, storage etc.).

3.5 Review of resources demands and costs

Costs are calculated very simply according to descriptions of decommissioning activities. They are presented in tables 1 to 7 in chapter 4, table 8 in chapter 5 and table 9 in chapter 6.

In Table 1, it is not clear which activities are included in man-hours, decontamination or dismantling or clearance. Also worker types and numbers of workers is not assessed and labour cost units for individual workers types factors are missing. By recalculation from table figures it can be found out that one average labour cost unit factor of 500 SEK/man-hour is used.
No relationship between decommissioned equipment amount characteristics (weights, areas, contamination) and manpower is presented. It means that manpower unit factors are missing. So it is hard to evaluate if the time (manpower) for individual activities is appropriate or not.

For Table 2, there is no connection between amount of analyses and contaminated area in individual facilities and specific costs (costs unit factors) per analysis are presented without reference to its origin. Costs are not divided according to individual facilities.

Table 3 presents amount of radioactive waste assumed to be produced during decommissioning. Volume of contaminated concrete is calculated based on information in chapter 3 for B4 and B5, for culvert system area of contaminated concrete is not presented so 2 m^3 is probably estimation. Origin of contaminated piping length is not referenced. There is no information on volume filling factor to 200l drums in the text both for concrete debris as well as for cut plastic pipes. Origin of 17 drums of 2 m^3 of concrete for culvert is not clear because for the same concrete volume of 2 m^3 for B4 only 14 drums are used. Row with total numbers of drums is missing.

In table 4, it is not clear why 500 drums are being measured because based on Table 4 total amount of drums is 438. Similarly, it is not clear why only 100 alpha and Sr-90 measurements are intended to carry out. Costs are not divided among individual facilities.

Table 5 presents disposal costs of radioactive waste. There is no header of the table and no unit for costs, based on Table 9 it should be thousands of SEK. It is not clear how these figures were calculated, based on amount of drums or volume of radioactive waste. No cost unit factor for disposal is presented. Costs are divided among individual facilities.

Table 6 presents amount of conventional waste from decommissioning. It is assumed to be 10 tons. This amount seems to be very low as it is not based on any input database or other specific presumes. Costs are not divided among individual facilities.

Based on text in chapter 4.1.4 transport costs are included in Table 4, but Table 4 is dedicated to measurement costs. It would be better to include transport costs in disposal costs in Table 5 or the best way is to present transport costs in an individual table.

Table 7 presents costs for measurements after decontamination. The amount of measurements is not clear it should be derived from surface area being measured. Amount of tritium and strontium measurements should be also reasoned. Reference to cost per analysis should be also presented.

Table 8 contains costs for decommissioning organisation and some support activities. There should be activities and no professions presented in the activity column in the table. Activities should be presented in accordance to the text in the chapter 5.1.1 and individual professions should be assigned to given activities otherwise it is not clear how much time is dedicated to given professions to individual organisational and support activity.

Table 9 is a summary table for all costs for decommissioning of B4, B5 and T4 buildings. Rows of the table do not follow the structure of the previous chapters in the document. Costs should have the unit - SEK. There should also be tables for decommissioning costs of individual buildings B4, B5 and T4 as well as shared costs. Costs should be presented without 20% contingency and then with this contingency in the table. Total costs with 20% uncertainty level is 28 667 100 SEK. Using of 20% uncertainty seems to be low on this basic decommissioning level, at least 30% is recommended.

3.6 Conclusions

Observations gained by reviewing the cost study "*Kostnadsuppskattning för framtida avveckling av behandlingsanläggningarna, B4, B5 och T4, för vätskeburet avfall*" [2] are very similar to those of the previous presented cost study [1]. Based on the review it can be observed it is a very basic level of cost study. Cost study is brief and simple. No methodology is used for systematic costing.

There is a lack of information on facility description and characterization, including physical and radiological inventory, it is not clear if the culvert system is a portion of B5, B4 facility or if it is standalone entity. Individual decommissioning activities are characterized only to a minimal extent and not completely. Although there is some relationship between assumed contaminated areas and calculation of costs for decontamination for other activities such relationship is not clear.

Technological activities such as dismantling, decontamination, waste treatment or radiological surveys should be calculated in more detail and a thorough way. Extent of activities is not sufficient to include all decommissioning activities in more detail. There should also be tables for decommissioning costs of individual buildings B4, B5 and T4 as well as shared costs. Using 20% uncertainty is low for basic decommissioning level, at least 30% is recommended. Also presence of some schedule should be good for basic orientation in decommissioning proposed dates, milestones and sequence of decommissioning activities. Suggestions for cost study improvements are presented in Chapter 5.

4. Review of Cost Assessment - material research laboratory

4.1 General description of reviewed cost study

Purpose of the cost assessment is presented in the chapter Main content, as following the requirements of authorities set by the Act 2006:647 on financial measures for handling of waste products from nuclear technical activities authorized by the Nuclear Act 1984:3. It is also mentioned that cost assessment shall be reviewed on a yearly basis and reported to SSM.
The cost assessment study "Kostnadsuppskattning for framtida avveckling av materialforskningslaboratorium, autoklavhall, annex till allmänt kemiskt laboratorium samt två förrådskassuner vid Studsvik" [3] consists of 21 pages. It includes title page, contents and following chapters:

1. Background
2. Facility description
3. Preconditions and extent of costing study
4. The decommissioning procedure
5. Project management and support services
6. Collocation
7. Summary and Conclusion
8. Reference

The longest text chapters 2 and 3 are dedicated to the description of all buildings - M-huset, A-hall, AKL annex and Coffers - (3 and half pages in chapter 2 and one and half page in chapter 3) and description of decommissioning assessment boundary conditions and assessment of extent of contamination within the buildings (1 page in chapter 3). Sub-chapter 3.2 - Scope is put into the document without any text, it is supposed that the text from the beginning of chapter 3 (a list of decommissioning activities) had been intended to be placed in this sub-chapter. Chapters 4, 5, 6 are created predominantly by tables. Chapters 1, 7 and 8 consist of a couple of sentences.

This cost report is structured identically to the previous one [2] and also its extent is almost identical. Description of facilities is more detailed comparing to the previous two reports, as well as description of contamination extent. On the other hand, only relatively brief information is used within individual chapters and no systematic information on input inventory (including equipment and structures) and decommissioning activities characterisation is provided, thus this assessment can be considered also as the basic (preliminary) level.

4.2 Review of used methodology for cost assessment

As it is mentioned above, this cost report [3] is very similar to the previous one [2], there is no special methodology used within the cost assessment. Although chapters are ordered in logical order with regard to decommissioning process and are more

detailed as in [1], no methodical approach to the decommissioning costing is mentioned or followed in the text of a report.

4.3 Review of description of facility to be decommissioned

Basic description of the M-huset, A-hall, AKL annex and coffers facilities is given in chapter 2 - Facility description and partially in sub-chapters 3.1.1 to 3.3.4 Decommissioning work. The purpose and brief history of the buildings is presented in sub-chapter 2.1 to 2.4. Outer dimensions of buildings are mentioned (except of coffers) as well as numbers of floors. Chapter 2 contains also contains 3 photos which enable better picture of buildings being decommissioned. For better orientation more photos could be provided. Although some basic description of building is given, no information on disposition within the site is provided including drawings of individual buildings as well as drawings of internal building structures and placement of decommissioned equipment.
Proposed areas of contamination spread are mentioned and reasons of contamination/non-contamination are discussed in the text. Although it is mentioned that alpha-, beta- and gamma activity samples were tested in laboratories, more detailed information on operational history could be provided especially concerning radionuclides having been handled within the laboratories. It enables to classify amount of radioactive waste and its categorisation.
From the view of physical and radiological inventory, there is no list of equipment and building surfaces or structures with their basic characteristics such as material characteristics, dimensions, weight, volumes and surface areas. In chapters 2 and 3, there are some references on building materials and on surfaces types as well as on supposed depth on contamination penetration material. Only minimal information on appropriate radiological characteristics of buildings including assessed contamination levels, contamination extend and nuclide composition is presented.

4.4 Review of intended decommissioning activities

Activities intended to be done within the M-huset, A-hall, AKL annex and caissons are presented in chapter 3, 4 and 5. The characterisation of activities is almost the same as in [2], it means that reviewing observations are also identical.
In chapter 3, there is a list of activities which are taken into account for decommissioning of M-huset, A-hall, AKL annex and caissons buildings. Similarly to the cost study [2], this list is not comprehensive as it does not follow any methodical approach for identification of needed decommissioning activities. Conventional demolition is excluded from these activities because buildings are assumed to be re-used for other purposes.

Sub-chapter 3.1 mentions preconditions for relevancy of presented cost estimations for future decommissioning process. It is supposed that the list of prerequisites for cost relevancy places in the end of sub-chapter 3.1.4 chapter had been intended to be placed in the beginning of the sub-chapter 3.1.
Sub-chapter 3.2 - Scope is put into the document without any text, it is supposed that the text from the beginning of chapter 3 (a list of decommissioning activities) had been intended to be placed in this sub-chapter.

Sub-chapter 3.3 describes frame approach to decommissioning of individual buildings in a shortcut. There are mentioned assumed decontamination techniques for

building surfaces for individual buildings in this chapter, dismantling techniques are not specified. This sub-chapter also contains assumptions on contamination form and its extent in individual buildings.

In chapter 4, radiological measurements techniques are listed with very brief commentary to their purpose.
Waste management including transports activities are not mentioned only amounts of radioactive waste and waste for municipal dumps are presented in chapter 4.

In chapter 5 activities of project management and support activities for radiological measurements are very briefly mentioned.

Similarly to previously reviewed document [1] and [2] it can be observed that there is a lack of information on individual activities and technologies or techniques which are intended to be used for decommissioning of the facilities. Activities should be described in more systematic and detail way together with basic assumed features and parameters of used techniques and technologies such as capabilities, capacities, cost unit factors and others.

It is advised that all activities should be presented within the cost study including dismantling, waste management. Similarly, there should be described at least basic concept to decommissioning including the way of decontamination dismantling and performance and approach to handling of waste from decontamination and dismantling (segmentation, in-situ measurements, packaging, transportation routes, storage etc.).

4.5 Review of resources demands and costs

Costs are calculated in the same way as in previous reviewed cost studies [1] and [2]. They are very simple according to description of decommissioning activities. They are presented in tables 1 to 7 in chapter 4, table 8 in chapter 5 and table 9 in chapter 6.
In Table 1, it is not clear which activities are included in man hours, decontamination or dismantling or clearance. Also worker types and numbers of workers is not assessed and labour cost unit for individual workers types factors are missing. By recalculation from table figures it can be found out that one average labour cost unit factor of 500 SEK/man hour is used.
No relationship between decommissioned equipment amount characteristics (weights, areas, contamination) and manpower is presented. It means that manpower unit factors are missing. So it is hard to evaluate if the time (manpower) for individual activities is appropriate or not.
In Table 2, there is no connection between amount of analyses and contaminated area in individual facilities. Specific costs (costs unit factors) per analysis are presented without reference to its origin. It is good that the costs are divided according to individual facilities.
Table 3 presents amount of radioactive waste assumed to be produced during the decommissioning. Volume of contaminated concrete is calculated based on information in chapter 3 for each facility. Evaluation of active sewage and active ventilation volumes is problematic since no reference to contaminated lengths and diameters of piping is present as well as conversion factor from length to volume of these piping is presented. There is also no information on volume filling factor to 200l drums in the text for concrete debris as well as for cut sewage plastic pipes and ventilation hoists. Row with total numbers of drums is missing.

In table 4, it is not clear why only 3 alpha and Sr-90 measurements are intended to carry out. Costs are not divided among individual facilities.
Table 5 presents costs for radioactive waste management. It is not clear how were this figures calculated, based on amount of drums or volume of radioactive waste. No individual waste technologies are listed and no cost unit factors for waste management are presented. Costs are not divided among individual facilities.
Table 6 presents amount of conventional waste from the decommissioning. In the text it is assumed to 1,2 tons but only 0,5 ton is presented in the table. Moreover, this amount seems to be very low as it is not based on any input database or other specific presumes. Costs are not divided among individual facilities.
Table 7 presents costs for measurements after decontamination. The amount of measurements is not clear; it should be derived from surface area being measured. Amount of alpha measurements should be also reasoned. Reference to cost per analysis should be also presented.
Table 8 contains costs for decommissioning organisation and some support activities. There should be presented activities and no professions in the activity column in the table. Activities should be presented in accordance to the text in the chapter 5.1.1 (it should be numbered 5.1) and individual professions should be assigned to given activities otherwise it is not clear how much time dedicates given professions to individual organisational and support activity.
Table 9 is a summary table for all costs for decommissioning of M-huset, A-hall, AKL annex and caissons. Rows of the table do not follow the structure of the previous chapters in the document. Costs should have the unit - SEK. There should be also tables for decommissioning costs M-huset, A-hall, AKL annex and caissons as well as shared costs. Costs should be presented without and also with 20% contingency. Total costs with 20% uncertainty level is 3 143 000 SEK. Using of 20% uncertainty seems to be low on this basic decommissioning level, at least 30% is recommended.

4.6 Conclusions

Observations made by reviewing the cost study "*Kostnadsuppskattning for framtida avveckling av materialforskningslaboratorium, autoklavhall, annex till allmänt kemiskt laboratorium samt två förrådskassuner vid Studsvik*" [3] are very similar to previous cost studies [1], [2]. It is a very basic level of cost study. Cost study is brief and simple. No methodology is used for systematic costing. Although there is more information provided comparing to previous cost studies, there is still a lack of information on facilities description and characterization, including physical and radiological inventory. Individual decommissioning activities are characterized only in minimal extend and not completely. There is some relationship between assumed contaminated areas and calculation of costs for decontamination for other activities but this relationship is not clear. Technological activities such as dismantling, decontamination, waste treatment or radiological surveys should be calculated in more detail and thorough way. Extent of activities is not sufficient to cover all decommissioning activities in more detail. Decommissioning costs of individual buildings M-huset, A-hall, AKL annex and caissons should be distinguished as well as shared costs. Using of 20% uncertainty is low for basic decommissioning level, at least 30% is recommended. Also presence of some schedule should be good for basic orientation in decommissioning proposed dates, milestones and sequence of decommissioning activities. Suggestions for cost study improvements are presented in Chapter 5.

5. Conclusions & Recommendations

In this document the result of the review of three cost studies for decommissioning of small older nuclear facilities at Studsvik site has been presented:

- Kostnadsuppskattning för framtida avveckling av Aktiva Kemi Laboratoriet (AKL) i Studsvik [1];
- Kostnadsuppskattning för framtida avveckling av behandlingsanläggningarna, B4, B5 och T4, för vätskeburet avfall [2] and;
- Kostnadsuppskattning for framtida avveckling av materialforskningslaboratorium, autoklavhall, annex till allmänt kemiskt laboratorium samt två förrådskassuner vid Studsvik [3].

The main findings and observations are as follows:

All three of the reviewed decommissioning cost studies are very similar and are written following the same pattern set by the first study. They are written as basic level studies because of what is given both by the extent of documents (and its chapters) and by the level of detail used in their texts and tables.

No special costing methodology is used within the studies. Defining the decommissioning extent and description of individual decommissioning activities is very limited as well as the description of the facilities. Very little or almost no physical and radiological inventory is provided and presented in some complex and systematic way. Accordingly, the amount of radioactive and conventional waste should come out from such more detailed inventory.

Evaluation of costs should come out from manpower calculated by defined manpower unit factors or capacities of workforce or machinery and amounts of equipment and building structures being decommissioned (weights, areas, contaminations, equipment and material types). Cost unit factors for all activities should be presented and referenced.

Management and support activities (time-dependent activities) activities should come out from duration of the project. Moreover the extent of these activities should be defined more clearly and numbers of workers for these activities seems to be underestimated. Presence of some schedule should be good for basic orientation in decommissioning projects, their milestones and sequence of decommissioning activities.

Using of 20% uncertainty is low for this level of detail used in the studies, at least 30% is recommended.
Based on these findings it can be observed that all of the above mentioned cost studies are of a basic level. At this level, they provide an initial framework of the cost demands for the decommissioning of mentioned small older nuclear facilities at Studsvik site.
The level of discussed decommissioning costs studies should be enhanced to provide more reliable cost figures.

For enhancement of the quality of the studies, our suggestions are as follows:

- Usage of some methodology for systematic assessment of decommissioning costs. We recommend use of ISDC methodology [4]. This allows to go through the whole process of individual decommissioning projects (facilities) and minimizes omission of some decommissioning activities (including support administrative, management and other activities) to be done as well as gives a systematic and transparent approach to costing. ISDC is an internationally recognised decommissioning costing structure encouraged by IAEA, OECD-NEA and EC.
- Operational history should be investigated more deeply. It could avoid unexpected findings such as spilled contamination in spaces where it was not anticipated and which can have a high impact on overall costs.
- Similarly the description of the facilities should be more detailed. It includes providing of drawings, photos and other documentary material to gain as much clear view as possible.
- Usage of appropriate inventory database containing all equipment and building surfaces which are intended for decommissioning including their basic physical and radiological characteristics mainly type of equipment, weight, material composition, dose rates levels, level of contamination and main contaminants. This should be done with as much effort as possible.
- Identified decommissioning activities (coming out from ISDC systematics) should be described more in detail, especially decontamination and dismantling techniques (as well as waste management) including their manpower unit factors and capacities.
- Costs should be calculated based on manpower or consumption unit factors and inventory parameters such as weights, areas and contamination levels.
- Specific costs should be used with reference to source of their origin.
- Calculations should be divided among individual buildings within the project and also shared costs should be identified (mainly support activities) and presented without and also with uncertainty factor. Uncertainty factor depends on detail level and quality of inputs, 30% per cent is recommended for basic level, 20% -10% for higher levels (updated or final decommissioning plan/assessment).
- Presentation of some basic decommissioning schedule with main dates, milestones and sequence of decommissioning activities is good to identify durations and sequence of decommissioning activities as well as the whole project which can have an impact on duration on management and support activities.

6. References

[1] Eriksson E., Fjällström N. Kostnadsuppskattning för framtida avveckling av Aktiva Kemi Laboratoriet (AKL) i Studsvik, Rapport No. N-08/032, Studsvik Nuclear AB, 2008.

[2] Eriksson E. Kostnadsuppskattning för framtida avveckling av behandlingsanläggningarna, B4, B5 och T4, för vätskeburet avfall, Rapport No. N-10/077, Studsvik Nuclear AB, 2010.

[3] Huutoniemi T: Kostnadsuppskattning for framtida avveckling av materialforskningslaboratorium, autoklavhall, annex till allmänt kemiskt laboratorium samt två förrådskassuner vid Studsvik, Rapport No. N-10/127, Studsvik Nuclear AB, 2010.

[4] OECD NUCLEAR ENERGY AGENCY, INTERNATIONAL ATOMIC ENERGY AGENCY, EUROPEAN COMMISSION, 'International Structure for Decommissioning Costing (ISDC) of Nuclear Installations' OECD/NEA No. 7088, ISDC, 2012.

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The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 270 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

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