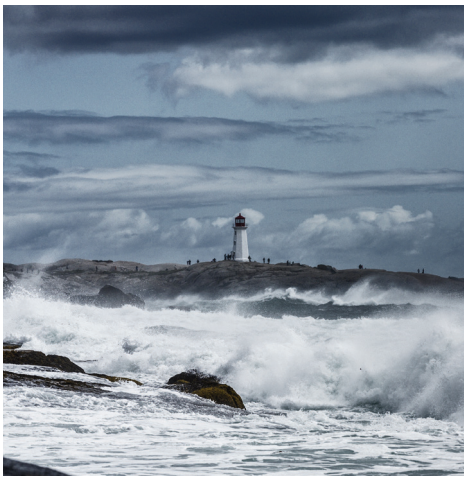
NUCLEAR DECOMMISSIONING

RAPPORT 2015:131



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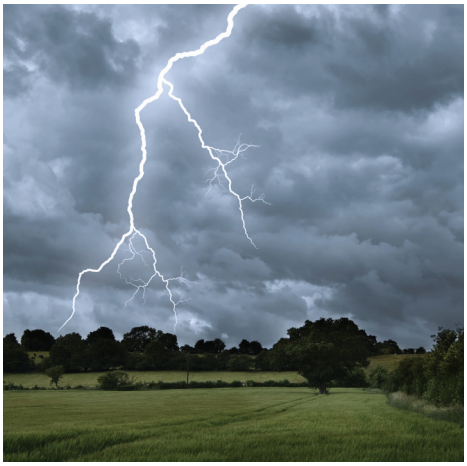

Energiforsk

Nuclear Decommissioning

A feasibility study of potential R&D initiatives for Energiforsk's nuclear programme

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Foreword

The decommissioning of the oldest Swedish and Finnish nuclear power facilities is approaching. This will be a challenging task, and it is important that it's carried out in a safe and cost effective manner. In order to assist the owners of the facilities, a mapping of possible needs for research and development has been carried out within the Energiforsk Nuclear Research. Project leader for the task has been Patrik Fors from Vattenfall AB. The feasibility study has been financed by the stakeholders of the Energiforsk Nuclear Energy Research program:

Summary

Each decommissioning project of a nuclear facility is associated with large challenges. Timely planning and project frontloading will be essential for the organizations to become successful with their undertakings.

Fortunately, the main decommissioning projects in the Nordic countries are some years ahead so there is room for development work to optimize the strategies, methods and technologies. Energiforsk nuclear programme is considered to be a promising forum for some of this targeted development work.

This report presents the outcome of a screening study aimed on identifying potential R&D initiatives to be conducted within Energiforsk's nuclear programme. The main result of the study is three project charters that Energiforsk is recommended to pursue during 2015.

Each charter covers a central aspect of decommissioning that will be essential to understand and develop in order for the upcoming projects to be successful. The areas recommended for further development are:

1. Lessons Learned
2. Logistics
3. Conventional Waste Management

Complete descriptions of the suggested projects can be obtained from Energiforsk.

Sammanfattning

Att genomföra ett projekt som innebär att avveckla en kärnteknisk anläggning är förknippat med andra utmaningar än de som råder under drift innan avstängning. En avgörande framgångsfaktor för att lyckas med avvecklingsprojektet är att förstå de utmaningar som väntar genom att analysera, värdera och definiera en optimerad väg igenom avvecklingens olika skeden.

I Norden finns det ännu ett antal år tillgängliga för detta förberedande optimeringsarbete för de större avvecklingsprojekten vilket ger utrymme för riktade utvecklingssatsningar. Energiforsks kärnkraftsprogram är en intressant kandidat för att koordinera delar av det utvecklingsarbete som planeras inom avvecklingsområdet.

Denna rapport redogör för resultatet från en pilotstudie som syftat till att kartlägga industrins, och dess huvudintressenters, önskemål gällande förberedande utveckling inför att ett kärnkraftverk nedmonteras och rivs. Fokus har legat på att identifiera och definiera det arbete som lämpar sig för Energiforsks kärnkraftsprogram.

Den huvudsakliga leveransen är tre uppdragsbeskrivningar för utvecklingsprojekt som Energiforsk rekommenderas att gå vidare med under 2015. Uppdragsbeskrivningarna täcker vardera en central aspekt av ett avvecklingsprojekts utmaningar och väntas vid ett genomförande bidra på ett avgörande vis till möjligheterna för en optimerad nedmontering och rivning av kärnkraftverk i Norden.

De tre områden Energiforsk rekommenderas att utveckla är:

1. Lärdomar och erfarenheter
2. Logistik
3. Konventionell avfallshantering

Den kompletta redogörelsen för respektive föreslaget utvecklingsprojekt kan fås från Energiforsk, medan föreliggande rapport redogör för projektupplägg och metodik för pilotstudien samt ger en kortfattad summering av studiens utfall och slutsatser.

Content

Definitions and Abbreviations

Table 1. Definitions and Abbreviations

Definition or Abbreviation	Description
ALARA	As Low As Reasonably Achievable
ASME	American Society of Mechanical Engineers
BAT	Best Available Technology
DoE	Department of Energy
EIA	Environmental Impact Assessment
EKS	Eon Kärnkraft Sverige AB
EPRI	Electric Power Research Institute
HR	Human Resources
ISDC	International Structure for Decommissioning Costing of Nuclear Installations
NPP	Nuclear Power Plant
OECD-NEA	Organization for Economic Co-operation and Development - Nuclear Energy Agency
PMO	Project Management Organization
R&D	Research and Development
SKB	Svensk Kärnbränslehantering AB
TECOP	Technical, Economic, Cultural, Organizational, Political
TVO	Teollisuuden Voima Oy

1 Introduction

Within the next decade the oldest commercial nuclear power plants in the Nordic countries will have reached the end of their planned time in operation, and the industry will be facing its first large-scale decommissioning projects. The preparations for these, and the already ongoing smaller-scale decommissioning projects, are making the general interest for the emerging nuclear decommissioning era grow rapidly.

Each decommissioning project of a commercial NPP is associated with large challenges. Timely planning and project frontloading will be crucial for a successful project. Fortunately the main decommissioning projects are some years away, so there is room for targeted optimization studies regarding e.g.: project approaches; methods and technologies; radiation safety and environmental impact limitation, to improve the results. Energiforsk nuclear programme is considered to be a potential forum for some of this targeted development work.

To identify the relevant areas for Energiforsk involvement, the Energiforsk nuclear programme council initiated the feasibility study presented in this report. The work has been carried out by Vattenfall Engineering and was conducted between August 2014 and March 2015. The conclusions have been based on the input and information gathered during literature studies, a seminar, and during a comprehensive series of interviews with responsible for the decommissioning preparing activities at the major Nordic stakeholders.

The aim has been to identify, and define, the three most relevant areas of decommissioning-related development work to be carried out within the Energiforsk nuclear programme. Energiforsk has been considered to be a viable alternative for decommissioning-related R&D that results in conclusions that are of relevance for the entire Nordic fleet of nuclear installations as well as for their stakeholders, i.e., not specific for a site or a country. Furthermore, R&D is considered to be preferably carried out within the Energiforsk programme if it earns from profiting, and utilizing, the organization’s already established network within the industry as well and well maintained interfaces towards e.g., authorities and the public.

2 Objectives

2.1 Purpose

The purpose of the work is to improve the opportunity for optimized decommissioning of the Nordic NPPs by conducting targeted development work.

The aim is to identify three different areas of development in which the work would significantly contribute to the optimization of the decommissioning projects, and to suggest project charters for these areas that are ready for sponsor dialogue during the second quarter of 2015.

2.2 Boundaries and Givens

The selection of the recommended development work should be based on the following three criteria:

1. *The work should be of interest for the entire Nordic NPP fleet, i.e., for both PWR and BWR reactors in Finland as well as in Sweden, and preferably also for other nuclear installations within the Nordic countries;*

   One of the strengths with the Energiforsk nuclear programme is that it involves licensees on both sides of the Baltic Sea. This strength should preferably be utilized in the R&D carried out within the programme.

2. *The work should not be ongoing, or better fit, in another constellation already existing among the stakeholders;*

   Decommissioning related R&D is already ongoing within some of Energiforsk's member organizations and within other national and international constellations as: SKB, EPRI, and OECD-NEA. The suggested Energiforsk development work should neither duplicate work carried out elsewhere, nor target work that has a better fit elsewhere.

3. *The work should be likely to find acceptance for sponsoring from the Energiforsk member organisations, i.e., have a strong business case.*

   Energiforsk is dependent on external financing for the R&D conducted. As a result, only R&D-suggestions that are competitive enough to receive external financing will be carried out.

The results should be presented in a public report, i.e., no commercial or in other way restricted material should be included. No individuals or organizations should be recognizable or possible to link to specific ideas or arguments.

3 Methodology

The study consisted of two consecutive phases: the first covering the main information gathering work; and the second of the data analysis and the compilation of the results.

3.1 Information gathering

The first phase of the study included a literature review and a screening of the stakeholders' needs for R&D by means of an interview series.

3.1.1 Literature study

A preparatory study was conducted in the start-up phase of the project in order for the succeeding interview-based information gathering to be as rewarding as possible.

The interview-sessions were prepared by a revising of the most discussed topics within Nordic decommissioning meetings, and correspondence, during the last years. The review was complemented by a literature study on some of the handbooks and reports published on decommissioning, and on the specific R&D needs within the area. Publically available references have been listed in chapter 6.

The purpose was to identify the main elements of interest in order to let part of the interviews be a guided topical discussion. This was done to ensure that all interviewees were given the chance to express their opinion on the broad perspectives of decommissioning.

3.1.2 Interviews

The interviewees were pre-briefed about the general topic for discussion and about the purpose of the study, but were otherwise unbiased in order for the first part of the interview to be focused on the specific interests of respective interviewee.

One interview session was held at each site with one or more representatives for the company visited. Approximate 1.5 h was allocated to each interview.

The first half of the interview consisted of an open dialogue with the purpose of identifying the stakeholders' wishes, and demands, based on their own present reality. The second half of the interview was built on a guided discussion to cover key topical areas identified in the literature study.

Interviews were held with representatives from the following stakeholders, (see chapter 6 for details):

NPP operating companies

- Barsebäck Kraft AB,

- Forsmarks Kraftgrupp AB,
- Oskarshamn Kraftgrupp AB
- Ringhals AB

The nuclear licensees and jointly owned waste management companies:

- AB SVAFO
- Svensk Kärnbränslehantering AB

The authority

- Swedish Radiation Safety Authority

The parent company for its owners' perspective

- Vattenfall AB, Fleet Strategy

In addition, contact was established with TVO (Teollisuuden Voima Oy) and EKS (E.On Kraftgrupp Sverige AB) but these companies unfortunately had no possibility to participate during the interviews.

3.2 Analysis

The second phase included an assessment of the project proposals, a seminar with the concerned licensees, and of a specification of the recommended R&D-tenders for Energiforsk to pursue.

3.2.1 Assessment and seminar

The input from the interviews was compiled and impersonalized. The aggregated information was used as basis for discussion during a seminar on the 3rd of February 2015. The seminar was for practical reasons arranged in connection with another meeting. The advantage of this was that the seminar took place with good presence; the disadvantage was that parts of the interviewees were not able to attend.

In order to verify and validate the outcome of the seminar and of the complete study, all interviewees have been given the opportunity to comment on the final recommendations before the report was finalized.

During the seminar, the attendees agreed on the top three candidates for Energiforsk to pursue.

3.2.2 Specification of R&D needs

The outcome from the interviews and the seminar was used to construct charters for the recommended projects. The information provided by the interviewees was complemented with information from the literature, and from previous experiences within the project team, in order to specify scope and objectives, business background and stakeholder aspects of respective project.

4 Results

In the following chapter, the overall results are discussed on a general level in agreement with the boundaries in section 2.2. The key deliveries, the main conclusions and the recommendation for future work are presented in chapter 5 and in Appendices 1-3.

4.1 Decommissioning topics

The topics discussed during the guided part of the interviews were:

Soft aspects

- Experiences, lessons learned, and data from operations
- Organization and HR
- Stakeholder engagement and communication
- Overall strategies and philosophies
- Documentation and governance

Hard aspects

- Technical preparations during operations for optimized decommissioning
- Technical optimization of the decommissioning project (BAT)
- Dose and ALARA aspects
- Logistics
- Waste treatment, optimization, and minimization
- Waste disposal alternatives/routes

4.2 General outcome

The general outcomes of the interviews were:

- Great response and large willingness to participate
- Interviewees were rather forced to stop talking, than to start
- Differences were seen among the interviewees' responses depending on the site's/company´s position relative to the planned date for decommissioning
- Some issues appeared spontaneously during all interviews and appeared to be of general concern

4.3 Soft issues

During the interview series there was a general interest in national and international lessons learned. However, it was stressed that the compilation of these must be intelligible. A connected suggestion was to create decommissioning training sessions for different types of stakeholders including

the: PMO, entrepreneurs, and different authorities. This training could partly be based on the compiled lessons learned.

The HR and organizational challenges related to transforming the entire, or parts of, the operation into a decommissioning project was appreciated to be underestimated presently. Important questions still to answer are: how to keep staff motivated until the end of operations; what professions are important to keep during the transition; and how to best separate remaining operations from decommissioning at the sites with simultaneous power production and decommissioning?

It is known to take time to change the mind-set of the organizations and its individuals from power production, with complete organizational support, into project-oriented with clearly stated goals and limited time/budget etc. At the same time it is essential to keep knowledge and parts of the operational culture from the power production in the decommissioning project. Thus, a way to build this competence within the decommissioning project needs to be found. Exactly what this knowledge transfer and includes, and how it is done, needs to be identified.

4.4 Hard issues

Due to the large amounts of materials and waste, the main waste and material streams during decommissioning should be assessed with respect to an overall optimization of the handling. This optimization should start in the room to be dismantled and include the entire chain to the final disposal or recycling facility.

The logistic pathways, together with the planned solutions for temporary storage within, and adjacent to, the buildings to be dismantled will determine the progress of the project. Logistical studies needs to be carried out to identify e.g.: the most optimal and safe way to dismantle a building with clearly subed rooms; the preferred way to dismantle rooms containing systems with very different level of contamination; the optimal place for waste conditioning, etc.

Different techniques are argued for as BAT for the same type of operation on the international decommissioning arena. An explanation is that the choice of e.g. a BAT cutting method is rather a result of local and national preconditions, and limitations, than determined by the type of cut to be carried out. Hence, the Nordic BAT technologies for nuclear decommissioning are of interest to identify.

The waste disposal routs for a large part of the conventional materials are uncertain. Even though the material is cleared, there is a general concern on the market to accept material from a nuclear site. Even so, the decommissioning of the nuclear sites is expected to follow the Environmental Code. As a result, work is needed to define the conventional waste routs available during decommissioning.

5 Conclusions

This section contains an executive summary of the three projects that are suggested to initially form part in an Energiforsk nuclear decommissioning venture.

5.1 Project 1, Lessons Learned

Project one aims to prepare the Nordic nuclear industry for its decommissioning by making best possible use of previous experiences and lessons learned within nuclear decommissioning.

After the project, the industry will be better prepared and have better chances of identifying and mitigating project unknowns, which will lower the risks and enable the opportunities associated with different activities in the project. The potential economic benefit in not re-making already known mistakes, easily sums up to tens of M€ per decommissioning project. In addition, the lessons learned project will increase the potential to better optimize the decommissioning work with regard to radiation exposure and environmental impact.

This project is considered successful if a user-friendly database filled with more than 500 items of national and international lessons learned, best practices and experiences answering to the known and expected needs regarding the industry´s decommissioning planning is delivered. The database should be of wiki-type, easily editable by its users and provide a structure and shape that allows for growth. In addition, a separate compilation of the key findings should be supplied in a format suitable for training purposes.

In order for the project to be as beneficial for the costumers as possible, it should be launched without unnecessary delay, i.e., preferably during Q3 or Q4 2015.

5.2 Project 2, Optimized Logistics

Logistic aspects are important during all stages of large scale industrial project planning; this applies also for nuclear decommissioning projects. As the Nordic nuclear power plants plans for short decommissioning projects (in relation to the international standard today), the demands on the logistical planning are considerable in order not to create bottlenecks that will cause delays during the dismantling and demolishing processes.

The second project aims to improve the understanding of the logistical challenges that will be met during decommissioning, and to settle the main logistical principles to be used as guidance during the planning.

As delays related to improper logistical preparations readily sums up to tens of M€ in projects with the size and complexity of a commercial NPP decommissioning, the economical driver for the suggested work is the financial benefit in maintaining an optimized flow for moving, storing, accommodating,

organizing and supporting staff, materials and equipment during the decommissioning.

The deliveries will consist of three technical reports describing: i) the prevailing logistical options and limitations for typical Nordic NPPs in operation and the change in demands during decommissioning; ii) general rules for logistics based on experiences from conventional industry; and iii) an overall judgment and recommendation on how to arrange the logistics in order to minimize the global costs during the decommissioning projects.

In order for the project to be as beneficial for the customers as possible, it should be launched without unnecessary delay.

5.3 Project 3, Conventional Waste Management

The majority of the material leaving the site during a decommissioning project is to consider as conventional material/waste. As a result, one of the main issues to settle early in the pre-planning of the decommissioning project is the management system and selected back-end solution for the conventional waste streams.

The third project aims to identify the alternatives for the conventional waste after leaving the site, and to increase the possibilities for reuse and recycle by application of a well-considered waste management process in the decommissioning project. In addition, the results from this proposed project will support the environmental impact assessments of the Nordic decommissioning projects regarding how recourses are managed.

The deliveries will consist of: i) a technical report on the available routes for different material streams including a TECOP assessment of the identified alternatives; and ii) of a report on the recommended conventional waste management for a decommissioning project and supplement the recommendations with a motivation for the choices made.

The potential economic benefit in making this project comes from the increased chances of maintaining optimized conventional material flows during the project, and from the increased acceptance for the EIA due to sustainable management of the waste.

In order for the project to be as beneficial for the customers as possible, it should be initiated without unnecessary delay.

6 Literature and Interviewees

6.1 Literature

1. R&D and Innovation Needs for Decommissioning Nuclear Facilities, OECD, NEA No.7191
2. Nuclear decommissioning, Planning, execution and international experience. Michele Laraia (ed), Cambridge: Woodhead Publishing, 2012.
3. International structure for decommissioning costing (ISDC) of nuclear installations. Paris: OECD/NEA, 2012.
4. Decommissioning Handbook, Procedures and Practices for Decommissioning, Washington: US DoE, 2000
5. The Decommissioning Handbook. Anibal L. Taboas, A. Alan Moghissi and Thomas S. LaGuardia, ASME: 2004

6.2 Interviewees

Table 2. List of Stakeholders and interviewed persons

Name	Stakeholder
Kjell Westerberg	AB SVAFO
Victoria Tangner	AB SVAFO
Henrik Stridsman	AB SVAFO
Håkan Lorentz	Barsebäck Kraft AB
Lars Olof Jönsson	Barsebäck Kraft AB
Leif Johansson	Barsebäck Kraft AB
Ulf Borgvald	Forsmark Kraftgrupp AB
Thom Rannemalm	Oskarshamns Kraftgrupp AB
Jörgen Eriksson	Oskarshamns Kraftgrupp AB
Svante Andersen	Ringhals AB
Thomas Norberg	Ringhals AB
Andreas Knutsson	Ringhals AB
Catharina Nästrén	Strålsäkerhetsmyndigheten
Nils Sandberg	Strålsäkerhetsmyndigheten
Anna Gordon	Svensk Kärnbränslehantering AB
Marcus Calderon	Svensk Kärnbränslehantering AB
Fredrik De la Gardie	Svensk Kärnbränslehantering AB
Börje Torstenfelt	Svensk Kärnbränslehantering AB
Erika Bohl Kullberg	Vattenfall AB- Fleet Strategy
Veronica Wejander	Vattenfall AB- Fleet Strategy

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