Vattenfall Decommissioning Planning in Sweden – 17544

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ABSTRACT

A rapid decrease in the power prices in the Nordic market for the last three years has drastically reduced the profitability of the nuclear power plants in Sweden. This has resulted in a very quick re-evaluation of the optimal life-term of the older generation, from the 1970-ies, nuclear units in Sweden. Hence, it was decided last year to shut-down the Vattenfall Ringhals-1 BWR and the Ringhals-2 PWR by 2020 and 2019, respectively, for financial reasons. Before that decision, the planning had been to operate the units until 50 years life-time, i.e. 2024 and 2025.

This decision resulted in a prompt start of the planning for decommissioning of the two units. The planning started with a project, called AVANS, to ensure that the overall planning and to-be-developed organisations had well defined requirements and a common platform. Another project, STURE, was started to ensure the continued operation and in some case movement of common site functions to the two younger units on the Ringhals site, i.e. the PWRs Ringhals-3 and Ringhals-4. This project also has the responsibility to optimise operation of Ringhals-1 and Ringhals-2 to EOL and the subsequent removal of the nuclear fuel from the units after necessary cool-down. A third project started is the actual decommissioning project, TYKO, benefitting from experience gained and staff involved in still ongoing decommissioning of a legacy materials reactor, i.e. the Studsvik R2/R2-0 reactor. The planning and experience to date for the three projects will be presented in the paper, as well as lessons-learned and future plans, including some critical items identified wrt dismantling and site function transfer.

Half of the nuclear units in Sweden, six units, and one legacy power reactor, will be starting decommissioning within the next few years. Impacts on the back-end system; the financial situation, with respect to the state-controlled financial funding; and the supplier market are discussed in the paper. Furthermore, the planning process and the planned management of the interfaces between the involved organisations is described.

INTRODUCTION

Vattenfall, the largest electric power utility in Sweden, operates currently seven nuclear power units in two plants. In Ringhals, on the west coast of Sweden, one older BWR, Ringhals-1, one older PWR with 15x15 fuel, Ringhals-2, and two more modern twin PWRs with three steam generators and 17x17 fuel are located. In

Forsmark, on the east coast, the twin BWRs Forsmark-1 and Forsmark-2 are co-located with the most modern plant, the Formark-3 BWR. All PWRs are of Westinghouse design, of two different designs, while the BWRs are of three different designs. The planned life times of the units has varied with the political and legal preconditions during the years but was decided in 2013 to be 60 years for all modern units built in the 1980s, while the two older units where decided to operate for 50 years, as shown in Table 1.

Table 1. Vattenfall-operated nuclear units and the years of operation

Unit	Type	Year of commissioning	Planned year of decommissioning
Forsmark 1	BWR - ASEA-Atom	1980	2041
Forsmark 2	BWR - ASEA-Atom	1981	2041
Forsmark 3	BWR - ASEA-Atom	1985	2045
Ringhals 1	BWR - ASEA-Atom	1974	2020
Ringhals 2	PWR – WH 15x15	1974	2019
Ringhals 3	PWR – WH 17x17	1980	2041
Ringhals 4	PWR – WH 17x17	1983	2043

The main reason for the plans for shorter life of the older units was the older design and the associated anticipated costs to develop safety measures a d pursue long-term operation.

In 2014, then with more than 10 years to the first planned decommissioning of a operation unit in the Vattenfall fleet, a project was performed with the purpose to determine the optimal overall organisation for performing decommissioning for the entire fleet but with special focus on the first two planned units, i.e. Ringhals-1 and Ringhals-2. One important aspect considered was the nuclear license, during operation lying with a co-owned subsidiary for each of the two plants Ringhals and Forsmark. Four different major approaches regarding the decommissioning organisation were analysed:

i. A centralised decommissioning organisation with nuclear license transferred to a new organisation or company

ii. A centralised decommissioning organisation contracted by operating licensee

iii. Local decommissioning organisation within operating licensee

iv. The operational unit runs the decommissioning project entirely with its current organisation

It was concluded, based on international experience and the conditions available that the first approach, *i*, was optimal for Vattenfall.

PROJECT AVANS – PLANNING THE OVERALL APPROACH

This implied that a new project, called AVANS, was initiated in 2015. The aim of AVANS was to develop a business plan for the company to be formed according to item *i*. The aim was to devise an organisation and outline the main activities and organisation development to take full advantage of the rather long planning time until the first decommissioning was planned. The project collected representatives for all stakeholders and also most of the people who had previous experience in the field of nuclear decommissioning, within Vattenfall. It was early concluded that the technical solutions for performing nuclear decommissioning were not the main issues but rather organisation and logistics.

The project hence focussed on the following main aspects.

- Organisational development
- Optimal use of knowledge and skills with people in Vattenfall and the available suppliers
- The available back-end solutions for waste and spent fuel and any need to develop these
- The separation and interfaces to form between the units to decommission and the units to remain operating at the site (Ringhals)
- The clarity and sturdiness of the necessary management system needed to be developed for the new situation of decommissioning relative to operation

The project confirmed the selection of the item *i* approach when organisational development; optimal use of knowledge and skills with people in Vattenfall and the available suppliers; the available back-end solutions for waste and spent fuel; the separation and interfaces to form between the units to decommissioning and the units to remain operating at the site (Ringhals); and the clarity and sturdiness of the necessary management system needed to be developed for the quite new situation of decommissioning relative to operation were all considered and balanced.

Already in 2013, however, the electric power market situation began to deteriorate. This weakening was aggravated by falling forward market prices in the coming years. This development, in combination of significant investments needed, for instance for measures implicated from the Fukushima accident, affecting the entire nuclear business, urged a re-evaluation of the value of nuclear assets and their financially viable operational lives. Hence, in mid-2015, Vattenfall decided to shorten the life of the two oldest units Ringhals-1 and Ringhals-2, to 2020 and 2019, respectively, leaving the planned life for the younger units still at 60 years of operation.

PROJECT STURE – PLANNING THE TRANSITION

In order to manage the challenges created by the early shut-down decision, a project, called STURE, was formed. The project was created within the operator company for the Ringhals plant, Ringhals AB, within weeks after the intention of the early decommissioning was announced. The task of the project is to handle the transition period from operation to shut-down until the start of the D&D. The overall project goal is to maintain safe and secure operation for Ringhals1 and Ringhals-2 until final shut-down and that both units shall be free from fissile material by November 1, 2021. At this point, the responsibilities of the units for decommissioning are left to a new organisation, although the current situation seem to preclude a transfer of the nuclear license, as was originally planned.

The STURE project is divided into four sub-projects. The most central sub-project is “Personnel and culture” with the main goals to maintain a good safety culture, to secure the right competence and manning for safe and stable operation until the final shut-down and to define and initiate necessary organisational changes. The former two aspects apply mainly to Ringhals-1 and Ringhals-2 but must be considered also to ensure a stable and safe situation for the Ringhals-3 and Ringhals-4, continuing operation.

Another major sub-project is “Plant”. The major goals are to optimise the fuel usage for the last cycles with respect to production volume (i.e. energy output) and back-end cost. The back-end aspect is mainly the optimisation of logistics for the transport of the used fuel to the Swedish central intermediate fuel storage (CLAB). CLAB, as well as transport facilities such as a dedicated ship and transport casks, are owned and operated by SKB, the Swedish back-end utility co-owned by all domestic nuclear operators. There is a relatively short time for transporting all remaining used fuel from Ringhals-1 and Ringhals-2, which means that the overall transport volumes in 2020 and 2021 will be significantly above a typical year; failure to perform transports as required is one of the major identified risks against the target date for starting the decommissioning. This risk is managed mainly by a detailed early planning for the transports to be performed. To make such planning

as robust as possible, production plans for the remaining cycles have been fixed. Thereby the number of used fuel assemblies as well as their characteristics of relevance for transport (burn-up, residual heat) can be determined by simulations well in advance.

There is also a need for plant separation modifications. Since units 1 and 2 where first built, a large number of systems are common for the entire plant and some systems are also operated from the Ringhals-1 main control room. A large number of systems (around 150) with some sort of connection have been identified. Based on this screening, further analyses and proposed actions have been developed in a limited number (~10) of main packages. Examples of such packages are systems for information and data exchange, power distribution systems, water supply and waste water systems, Heating, Ventilation and Air Conditioning (HVAC) systems, etc. The already available waste treatment plant is one of the more complex areas. This function was originally built more or less as an extension of unit 1. Liquid and solid waste is today transported from units 3 and 4 by trucks to this common facility. The option to build a new waste treatment plant closer to units 3 and 4 has been studied but the current approach is to keep the existing plant next to unit 1 – which will require supply of water and power, control and supervision to be re-allocated from unit 1 to units 3 or 4 before unit 1 can be decommissioned.

The third sub-project deals with the legal issues such as permits according to the Swedish nuclear and environmental legislation as well as EU-directives.

Finally the fourth sub-project deals with the financial aspects of the transitioning phase and financing the decommissioning via funding from the national nuclear decommissioning fund. This fund is financed by a fee on each produced kWh. The funds are collected and governed by the state of Sweden.

PROJECT TYKO – PLANNING THE DECOMMISSIONING

The responsibility for planning, and eventually executing, the decommissioning of Ringhals-1 and Ringhals-2 was given to a new business unit within Vattenfall, BU Nuclear Decommissioning. The BU was formed around already ongoing decommissioning activities within Vattenfall, encompassing the two German nuclear reactors KK Krümmel and KK Brunsbüttel which were not operating but awaiting decommissioning, and the SVAFO company, destined to decommission legacy nuclear facilities in Sweden, whereof one materials research reactor and one small commercial heavy water PWR, as dictated by law.

The new decommissioning project for Ringhals, called TYKO, plans to achieve a free-releasable previous operational area for Ringhals-1 and Ringhals-2 within the funding made for this work in the state-controlled nuclear fund. The project must also, within the budget, manage intermediate storage of the nuclear waste,

awaiting that the repositories have been commissioned, currently planned for the period 2028 to 2045. The project must also plan for interfaces and common infrastructure and functions with the units that continue to operate, i.e. the Ringhals-3 and Ringhasl-4 units, through interaction and common planning with the STURE project.

The TYKO project shall also produce all needed background information and planning for the environmental assessment, to be approved by a special Swedish court, and the permits required by the Swedish nuclear law. The formal applicant and responsible organisation will remain Ringhals AB, and the work hence requires good common planning and cooperation to ensure common understanding and proper allocation of responsibilities.

The TYKO project is also responsible for all aspects of the decommissioning and dismantling work for the units to be decommissioned. i.e. the dismantling planning, developing the dismantling concepts, the waste stream logistics, the decontamination planning, etc. The analysis part of the TYKO project has been divided into four main sub-projects; technical, legal, waste management and operation. The latter refers to the operation, planned to be almost continuously changing, of the facility once all fissile material has been removed, the proper environmental and nuclear permits have been obtained, and the dismantling has started. The overall project is divided into three main areas: operation, back-end (waste management and logistics but also interfaces with the Swedish industry-common waste management company SKB), and Decommissioning and Dismantling.

Currently, some 110,000 m^3 of material is planned to be dismantled from the two units, whereof about 15,000 m^3 is planned to go to nuclear waste repositories and the rest decontaminated or streamed to conditional free release.

One important aspect, determining the overall dismantling schedule and to some extent the cost for dismantling. is whether the reactor pressure vessel (RPV) is to be cut into segments while in the containment and put into waste containers, or if it should be lifted, whole or in a few large pieces, out of the containment for potential transport (by ship) and final storage in the repository as is.

DISCUSSION

The original basic approach by Vattenfall, as proposed by the AVANS project, of having long time for planning of the decommissioning, originally at least 10 years, and to transfer the nuclear license to the organisation executing the nuclear decommissioning could not be fulfilled. The reasons were a deteriorating market outlook and a policy shift by the Swedish government in a related case, respectively. This change in preconditions influenced the planning as new

approaches and solutions had to be developed concurrent with developing the more detailed plans for decommissioning. The two changes in preconditions had not been fully embraced in the rather comprehensive risk analysis that was performed in the AVANS project. Rather, the risks identified were more associated with delays in environmental and nuclear permits, devising the proper organisation and finding the proper skilled manning and the interfaces to be defined and managed between the operating units and their organisation and the decommissioning organisation to be developed.

Some of the identified risks mentioned have also to some extent occurred. In these cases, the fact that they have been identified, some impact has been possible to impede or even mitigate while others, especially when related to roles, have been more difficult to manage.

CONCLUSIONS

Nuclear plant decommissioning is often regarded as technical challenges, in finding technical solutions for dismantling, waste treatment, free release and waste storage. In a system with a rather well developed and planned back-end system, as in Sweden, especially in combination with the gradually enhanced international experience of decommissioning, organisation, local skills, roles and interfaces will need significant consideration, especially when efficiency, together with safety, are in focus.