Strategy of Uniper's Swedish D&D program proven success by first years of dismantling experience

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ABSTRACT

Uniper has a unique nuclear D&D program ongoing in Sweden. The program consists of four units, two in Barsebäck and two in Oskarshamn. The units have different history and background. While the units at Barsebäck were taken into service operation 15-20 years ago, the units at Oskarshamn were taken out of operation in 2016-2018 after short preparation time for D&D.

During strategy work different alternatives for D&D were evaluated, regarding timing and sequence of the units. The selected alternative was to combine all 4 units in one program and direct dismantling of work packages in the critical path in sequence for all 4 units.

In the paper we discuss the boundary conditions and impact factors for the Uniper company strategy on D&D and the learnings, focus areas and successes and how they strengthen our belief into that we have chosen the right path from the strategy point of view

INTRODUCTION

Uniper is an international energy company with about 11,000 employees. In Sweden, Uniper operates a range of assets, including low-carbon hydro and has stakes in nuclear power stations. Uniper is the majority owner of the nuclear power plant (NPP) Oskarshamn and a minority owner of the Ringhals and Forsmark NPPs. Uniper is also the owner Barsebäck, together with Oskarshamn 1 and 2, Sweden's first commercial NPPs, which have entered into decommissioned.

About NPP Barsebäck and Oskarshamn

Uniper's Program Nuclear Sweden consists of the decommissioning of four reactors at two different geographical locations in Sweden, Barsebäck and Oskarshamn respectively. All four plants are of the type Boiling Water Reactors (BWR) and were constructed by ASSEA Atom.

The Barsebäck 1, Barsebäck 2 and Oskarshamn 2 reactors are of equal design, while Oskarshamn 1 is a previous generation. At the nuclear power plant in Oskarshamn there is another reactor, Oskarshamn 3, which is still in operation. Reactor Oskarshamn 3 will be closed no earlier than 2045.

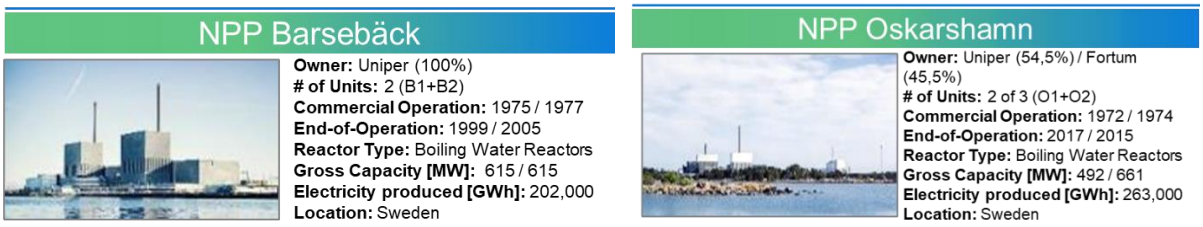

Figure 1. Data for the shut down units at Barsebäck and Oskarshamn nuclear power plants

The reactors at Barsebäck were shut down for political reasons in 1999 and 2005 respectively and have since been in service pending dismantling decisions. The shut down of the two reactors Oskarshamn 2 and Oskarshamn 1 was decided due to financial reasons originating from political decisions related to taxation of nuclear generation. Unit Oskarshamn 2 was at the time of the shut down decision in 2015 already shut down for extensive modernisation works and scheduled to start up in early 2016. Oskarshamn 1 was closed down in 2017 which was an advanced decision to shut down compaired to the previous shut down date of 2023.

This meant that the two nuclear power plants had two completely different starting points when Uniper began its strategy work on how the decommissioning of the four reactors would be carried out and organized. Barsebäck's initial position was a long-term service operation and a considerably reduced organization focused on maintenance and low intensive segmentation of internal parts on a "turn key" contract.

Oskarshamn was in a position where it was in the middle of a very extensive moderation of Oskarshamn 2 with a focus on restarting in 2016 after several years of outage. At Oskarshamn 1, planning was underway by a small team to prepare for the closure of Oskarshamn 1 in 2023. At Oskarshamn, the shut down was brought forward and thus largely unplanned. In 2017-2019, the organisation at Oskarshamn underwent major adjustments in number of staff due to the shut down decisions.

Extensive company strategy development and objective

In 2017 Uniper decided to develop a company strategy for decomissining of the four unit covering the whole range of possibilities and therefore appointed a project team with the task to:

- Develop an optimzed decommissioning scenario
- Provide a business plan on work package level
- Provide a reference schedule on work package level
- Include a procurement strategy
- Asses the impact on ressources
- Perform a Risk Assessment and develop a decommissioning related risk register
- Undertake cost and sensitivety analyses
- Create a staffing plan including ramp-up and ramp-down strategies

The objective of the decommissioning strategy was to be “safe”, “compliant” and “within budget”. All other influence aspects and boundary conditions should be adapted to decomissioning.

DEVELOPED DECOMMISSIONING STRATEGY AND GAINED EXPERIANCES

The boundary conditions for Uniper strategy development, creating the the foundation for the cost structure, were divded in three main categories:

- Technical and procurement/market
- Leagislation and permits
- Financial

Site specific boundary condition at the start of strategy development

At Barsebäck , both reactors have been shut down for a long time and there are no other nuclear activities on the site, which allows for a direct dismantling without regard to other activities. Furthermore, the site has a well-developed infrastructure with its own port that allows shipping of large components via sea freight. The reactors have passed 3-4 half-lives since decommissioning and performed a full system decontamination. The fuel at Barsebäck has long been transported to the SKB/CLAB plant for all Swedish nuclear fuel. The staff at Barsebäck was reduced and adapted to only carry out service operations. In 2017, when the strategic work within Uniper began, the staff consisted of about 50 people. In connection with the segmentation of internals in 2016, intermediate storage was also established for ILW materials and storage of reactor tanks.

Oskarshamn power plant consists of three reactors, all of the type BWR. Oskarshamn 3 was commissioned in 1986 and Uniper intends to continue operating that reactor until at least 2045. All three reactors are located within a common physical protection area. A number of common service systems are installed within buildings belonging to unit O1 and O2. Also a common waste water facility is connected and operated from unit O1. Oskarshamn's site also has a well-functioning port.

Parts of the joint service on the site are shared with the production unit O3, while Barsebäck's D&D budget must bear the entire cost of joint service at the facility e.g. security, workshops and facility management.

Like Barsebäck's two reactors, Oskarshamn1 and 2 also have/will undergo full system decontamination.

The SKB/CLAB spent fuel facility is located in the same area as Oskarshamn power plant, which enables the transport of all fuel within 1.5 years after the shutdown of each reactor.

Swedish Back-end system

The Swedish back-end systems are still in a conceptual phase and final storage for LLW and ILW decommissioning waste, forecasted to be in operation by 2030 and 2045 respectively. This implies that the two sites had to manage interim storage of storage of LLW and ILW waste until final repository is available. Both sites needed to invest in and construct interim solutions in the case of direct decommissioning. At Oskarshamn an existing underground storage for ILW (RPV internals and RPV) exists on site and will be in operation until shut down of unit 3 and final decommissioning of the site.

At Barsebäck, ILW waste will remining until 2045 and by that block possibilities to reach final end state brown field in 2030-2032 e.g. get the site "non-nuclear", unless an external solution for ILW could be worked out. Interim storage solutions minimize impact on delays in the large back-end facility projects and creates a higher degree of flexibility in the program.

The Swedish backend solutions are to a large extend based on a "rip and ship" concept, also allowing shipping of large components. The following disposal routes are available for the program. Selection is made based on specific cost available deposit/capacity volumes.

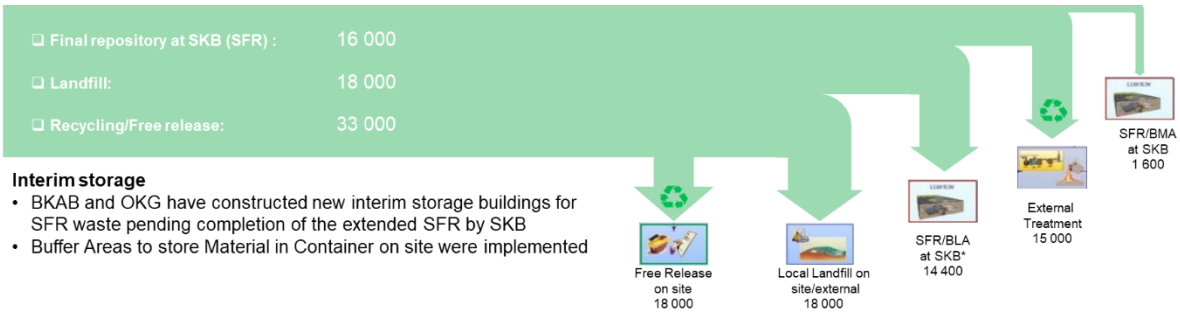

Figure 2. Available disposal routes and related volumes

Procurement and market conditions

A larger number of nuclear nuclear power plants in Sweden are subject to planned dismantling in the uppcomming years. One boundary condition, or influnce factor, was the opportunity to become first mover in the Swedish decommissioning market. A number of cost reduction advantages were identified by being first to enter the market.

Legislation and permits

The regulatory requirements with regard to nuclear D&D were at the time for the strategy development newly issued and gave room for interpretations regarding the requirements for dismantling, documentation and handling of dismantling waste. This risk that was carefully assessed when deciding on the dismantling approach and during the risk analysis of the various developed scenarios.

In addition to new regulations, waste acceptance criteria (WAC) for the Swedish back-end system (SFR/BLA and BMA) are still the preliminary, which in itself constitutes uncertainty. Final approval of WAC takes place after test operation, which was expected to be completed no earlier than 2029/2030.

The interatction betwen regulator and other authories such as regional boards and municipalities are in Sweden, to a large extent, based on trust and a pragmatic approach to resolve issues related to the nessesary permits and approvals.

Influence factors and scenario selection

In Sweden decommissing is legaly required and the license holders are responsible for financing (via KAF Fund), planning and execution so the only influencable factors are “starting point”, “execution time line” and in the what degree of “portfolio approach” can be be leveraged in the case of multiple unit site/program. KAF is the Swedish state controlled fund for decommissioning of nuclear power plants.

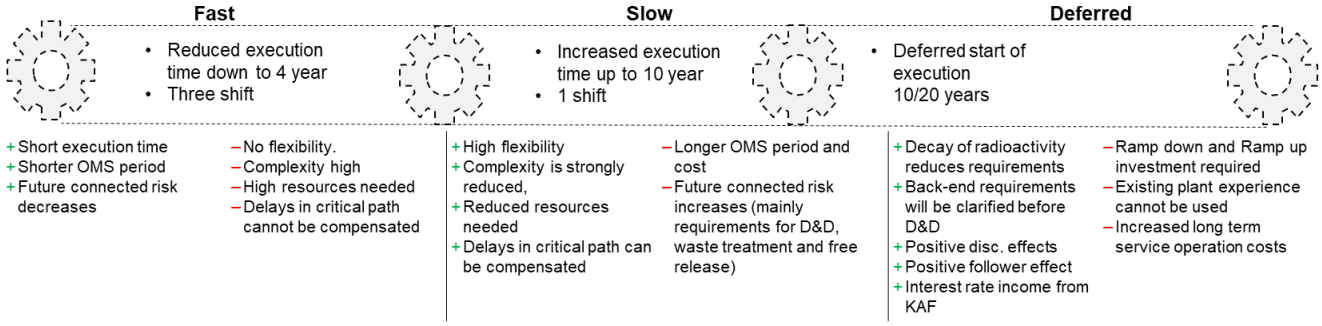

Figure 3. Summary of influnce factors Uniper strategy Development

The Uniper portfolio approach with four units (three almost identical) gives unique learning curve and cost reduction opportunities. Below are listed some of the advantages identified from applying the portfolio approach:

- Learning curve effects between work packages at the different units. Transfer experiences and leasons learned from one unit to the next one.
- Synergies in planning, work preparations and tools e.g. in Uniper’s case a posibility to “Plan once, perform four times .”
- Scaling effect due to procurement of larger volumes ,examples:
  - one contract for four similar work packages
  - shared waste sorting / packing stations stations for waste packages
- Lean organisation by applyingy portfolio steering and implenentation with common control tower, work package leaders etc.

Decommissioning scenario evaluation

During the strategy phase in 2018 a number of different sceanrios were evaluated based on defined, specific boundary conditions and influence factors. Finding the right balance between safety, quality, cost and resources is crucial to achieve an optimal outcome and company strategy.

The main influence factors “starting point” and “execution time” lead to the following three scenarios, ”Sequnce”-, “Streached”- and “Long term service operation(LTSO)”.

Sequence scenario	Stretched scenario	LTSO scenario
• Immediate start • Parallel execution, Work package executed in sequence following lead and learn approach • Site overarching portfolio • 8.5 years execution	• Immediate start • Reduced project complexity by extended schedule (approx. 10.5 years) • Small WP, in a site overarching portfolio	• Deferred start of execution 10/20 years • D&D execution as in sequence scenario

Figure 4. Range of evaluated sceanrios

Uniper´s evaluation applying a “best for company” approach provided a strategy based on a “Sequnce sceanrio” executed in one common program for optimizing the portofolio advantages with a realistic ramp-up pace and an optimized staffing and waste volume/flow plan.

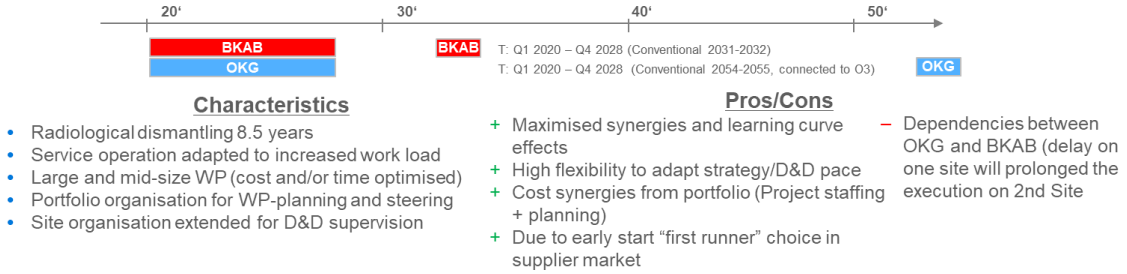

Figure 5. Selected scenario for Uniper company strategy

Benchmark shows a low cost level

An internationally based cost benchmark study shows that the Uniper decommissioning program based on the sequence senario, executed in a portfolio approach is in the lower range of overall BWR costs also and in all areas e.g. dismantling, waste, infrastructure, PMO and engineering it is below awarage for BWRs.

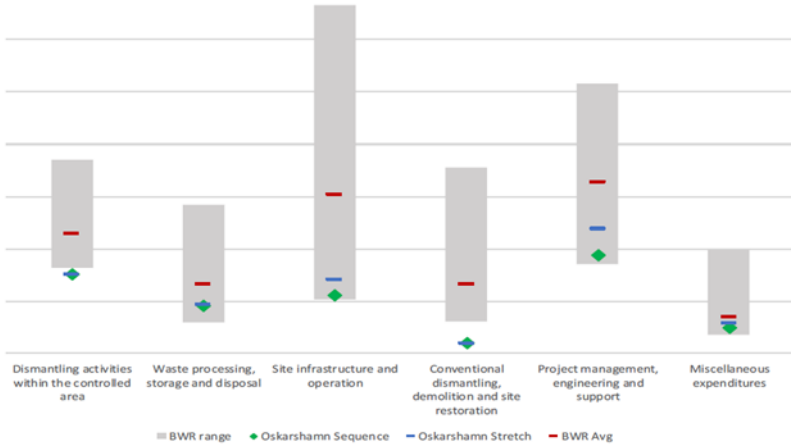

Figure 6. Example of international benchmark for Oskarshamn 1 and 2

Present status and KPIs

Below we present KPIs to show the present status on cost and performance and also on the learning curve effect.

In total, more than 12 000 Mg has been dismantled across all four units during the first 2 years which is only small deviation on less than 10% compared to the ordinal plan. It should also be noted that this has also been achieved mainly during Covid pandemic conditions. Actual total costs show that the program since strategy decision in 2018 is still within budget.

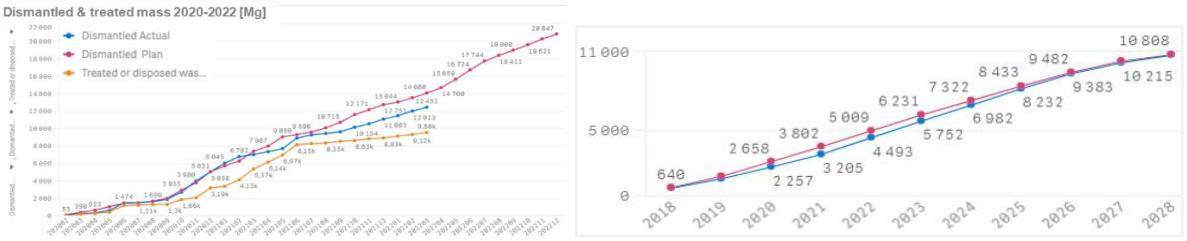

Figure 7. Total mass of actual dismantled material vs plan and actual cost vs plan

Execution of the first work packages show a clear positive impact on the learning curve effect.

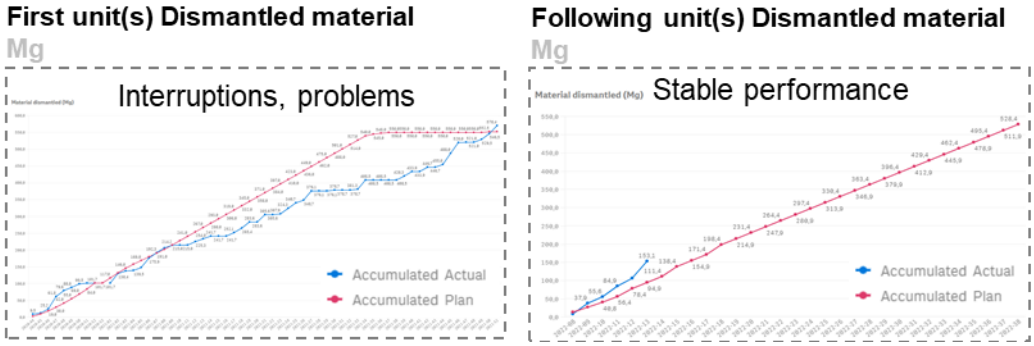

Figure 8. Learning curve effect for segmentation of RPV at unit B1 and B2

Conclusion

After 3 years of decommissioning work since strategy decision we can conclude that the Program is still within budget and materially on time (except some deviations related to non-time critical activities).

We can also today see significant benefits from our lead and learn approach, especially in work packages such as segmentation of RPV, segmentation of turbines and generators and dismantling of condensers.

The first mover approach in a new decommissioning market follows with both advantages, such as market situation, but also disadvantages, such as non-neglectable efforts to build up experience both internally but also externally e.g. service providers, sub-contractors and at regulator.

The strategy chosen for Uniper's Swedish D&D program has demonstrated proven successes in the first two years of large scale dismantling experience.