

DECOMMISSIONING PROJECTS WITHIN VATTENFALL, IN SWEDEN



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Vattenfall, fully owned by the Swedish state, is one of Europe's largest energy companies with 19 000 employees and more than 7 million electricity customers. Also, the Vattenfall Group is Sweden's largest producer of nuclear power (<https://www.vattenfall.com>). As such, it is important for Vattenfall that the nuclear plants can be handled throughout their entire life cycle, from construction through operation to decommissioning and final storage. Decommissioning is an important piece of the puzzle and Vattenfall has established a specialized decommissioning unit with the vision to being leaders in safe, cost-efficient, and sustainable decommissioning. Most important is safety –to ensure that dismantling and decommissioning is safe for employees, others, and the environment– through working methods and technology. Regarding cost-effectiveness, the most important factor is to work safely, and other factors are to use experience from previous decommissioning projects, to strive for simple, smart solutions and to purchase services in competition. Sustainability is taken into account through reuse and recycle of non-contaminated and free-released materials where this practicable and by the appropriate management of radioactive and other hazardous material such as asbestos and PCBs.

Vattenfall is currently decommissioning three NPP reactors and one research facility in Sweden, and two NPPs in Germany.

WHO'S DOING WHAT WITH THE WASTE

An important task for the decommissioning projects is to separate the radioactive waste from the non-radioactive, pack it in safe containers and store it in tailor-made interim storages for low- and intermediate level waste. The waste from the R2 facility in Studsvik respectively the Ågesta NPP will be stored in the newly-built interim storage at Studsvik. The waste from Ringhals 1 and 2 will be stored on site at Ringhals' newly-built interim storage. The producer of the waste, in general the licensee of the plant, is responsible for the waste until it is placed in the final repositories.

The high level spent fuel from all NPPs in Sweden is currently stored in the central interim storage for spent fuel, Clab. This is located outside the city of Oskarshamn in the south of Sweden. A year ago, after 40 years of research, the Swedish government granted a permission to build the final repository for spent fuel. It will be 500 meters under sea level, near the



Dismantling the loading machine. © Vattenfall John Guthed.



One of the lids from the reactortank in the air. © Vattenfall John Guthed



Demolishing the cooling tower. ©Vattenfall John Guthed.



The interim storage in Studsvik © SvafoFredrik Ekenborg.

NPP Forsmark outside the city of Östhammar in the middle of Sweden. The final repositories are built and run by SKB, the Swedish Nuclear Fuel and Waste Management Company, which is jointly owned by the nuclear power companies.

The interim storage in Studsvik

By the end of 2022 the interim storage for low- and intermediate waste from the decommissioning of the Ågesta NPP and the research facility R2 in Studsvik was taken into operation at the Studsvik site. It will safely store the waste until the final repositories are built. The interim storage can hold up to 10 000 m³ waste. The building time was two years as planned and the final cost was around 14 Million Euros, a bit lower than budget.

END STATES OF THE FACILITIES

An important planning prerequisite for decommissioning projects is to determine the end state for decommissioning

the facility and site. The future use of the site is of course an important factor affecting the end state. Determining the planned future use is often a complex decision which may need to take into account wider political, regional and corporate considerations. Vattenfalls' primary objective in decommissioning is to leave a site that is cleared from radioactive contamination. Also, our decommissioning aims to support and pave the way for future energy solutions and plans on future use continue to be developed at several of our sites.

SWEDEN. SHORT FACTS ON R2 IN STUDSVIK

The facility is located in Studsvik, approximately 100 kilometers south of Stockholm.

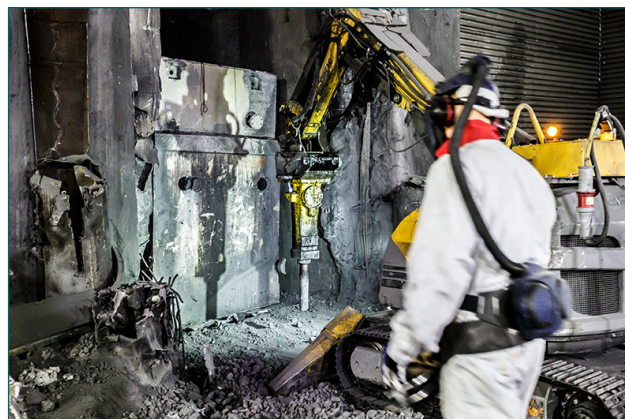
The facility contained two research reactors and an isotope production facility. It was in operation 1960-2005, carrying out numerous research activities and produced radioisotopes.

Decommissioning started in 2015 and finished in 2022. The application for free release of the facility has been submitted to the regulator and a decision is expected by the summer of 2023.

The decommissioning project is seen as a success in terms of safety, cost and recycling of free released material.

Decommissioning of the research facility R2 in Studsvik, "Reactor 2"

The R2, Reactor 2, facility in Studsvik outside the city of Nyköping, approximately 100 kilometers south of Stockholm, was the second nuclear reactor site in Sweden. It was



Demolition robot in action at R2 in Studsvik.
© Svafo Fredrik Ekenborg.



Waste containers in the interim storage in Studsvik.
©Svafo Fredrik Ekenborg.



Sorting of materials in R2 in Studsvik. © Svafo Fredrik Ekenborg.

in operation 1960-2005. There were two smaller reactors in the same, divided, pool and the facility was part of the governmental nuclear research program. It was used for a variety of operations, including testing of materials to be used in NPPs, training of employees, production of medical and industrial radioisotopes, medical treatments, and a range of different radiological science projects.

The nuclear dismantling and decommissioning started in 2015 and finished in 2022. The application for free release of the facility has been submitted to the regulator and the decision expected by this summer (2023). If it gets approved, the R2 in Studsvik will be the first reactor site to be free released in modern times in Sweden.

The facility, and also the decommissioning project, has been run by Svafo, a company within the Vattenfall Group responsible for legacy waste management and decommissioning of older facilities from the early development of nuclear technology in Sweden. The decommissioning project of R2 is seen as a success in terms of safety, cost and recycling of free released material.

The decommissioning project was carried out in three phases.

- **Phase 1:** Dismantling of the reactors including systems in the reactor pool, treatment and handling of the material. When all parts of the system had been dismantled and removed, the water in the pool was emptied and the pool was sanitized.
- **Phase 2:** Dismantling of the pool structure and biological shield, and handling of the waste.
- **Phase 3:** Dismantling of the reactor systems in the rest of the buildings, treatment and handling of the materials, disposal of the waste and remediation of contaminated areas. Radiological mapping to support the application for free release.
- **Now:** Awaiting decision on free release from the regulator, Swedish Radiation Safety Authority. Once that is given, the free released buildings will be demolished.

R2 is located within a larger nuclear technology park which hosts several licensed nuclear facilities. This larger site includes Svafo's facilities for the ongoing management of Swedish legacy waste which will continue until at least the 2070s, and the other licensees that will continue to operate for many years ahead. This means that the area will not be of public use in a near-time future.

SHORT FACTS ON THE ÅGESTA NPP

The NPP was a prototype nuclear power reactor located in a rock cavern approx. 15 kilometres south of Stockholm city.

It was in operation 1964 - 1974.

Shortly after shut-down, the fuel and heavy water was removed from the facility but almost all other systems and materials remained, and the facility has been under a maintenance phase until the start of the decommissioning.

The decommissioning operations started in the summer of 2020 and are expected to be finished by the end of 2025. In terms of both time and material being dismantled and disposed of, the decommissioning is half-way.

Decommissioning of the Ågesta NPP, "Reactor 3"

The Ågesta NPP outside Stockholm was a prototype but also Sweden's first NPP in commercial use, in operation 1964-1974. Decommissioning of the Ågesta NPP started in the summer of 2020. Before the decommissioning work could start, some of the facility's infrastructure also had to be built and/or modernized, such as ventilation systems, the lifting equipment and dressing rooms. Currently Vattenfall is half-way through the project and in total the works runs according to plan. The prognosis is to finish D&D by the end of 2025, and then start the process for final sealing of the rock cavern.

Several items and systems have been dismantled in the cavern, and the waste from them removed. This includes the control rods, loading machine, heavy water tanks and turbines. The by far biggest item remaining in the cavern is the reactor pressure vessel (RPV) which currently is being dismantled by segmentation in place, under water. The prognosis is to finish removal of the RPV by the end of this year (2023).

The total amount of waste from the decommissioning of the Ågesta NPP is calculated to be about 2000 tonnes, of which around half is contaminated. Outside the cavern has never been contaminated, but structures such as the concrete cooling tower on the surface, will be removed if they can degenerate over time and become hazardous. Full scale inventory of potentially hazardous materials hasn't been performed yet, but so far e.g. electricity cables, asbestos and even quicksilver has been found. These materials are not dangerous as long as they are intact, but when Vattenfall leaves the area there will be no new owner of these items that can monitor them.

The proposed end state for decommissioning is to remove the radioactive material from the rock cavern and then permanently seal the cavern. Once the decommissioning is completed and the site free released by the regulator, it will be returned to the owner, the City of Stockholm. Parts of the site are already being used for some decades by the fire department for training purposes, and this is expected to continue.

SHORT FACTS ON RINGHALS 1 AND 2

The four reactor Ringhals NPP is located outside the city of Varberg in the south west of Sweden. The two oldest reactors, Ringhals 1 and 2, are under decommissioning.



Ringhals 1 and 2. ©Photo Ringhals.

Ringhals 2 was in operation 1975-2019, Ringhals 1 in operation 1976-2020.

The large-scale D&D is planned to start by the end of 2023 and go on for a decade.

The fuel is removed and the two units under decommissioning are separated from Ringhals 3 and 4 which are still in operation.

Planning, licensing, and procurement has come far and most big decisions on how to dismantle items and systems are made.

Decommissioning of the Ringhals 1 and 2 NPPs

In 2015, Vattenfall decided to permanently shut down the two oldest of the four reactors at the Ringhals NPP, outside Varberg in the south west of Sweden. Ringhals 1 and 2 were closed in 2020 respectively 2019, about five years before their prognosed operational time, for commercial reasons. Ringhals 3 and 4 remain in operation, and are expected to produce power at least into the 2040s.

Currently the nuclear fuel is removed from Ringhals 1 and 2 and these two units have been separated from Ringhals 3 and 4. This was a quite challenging task because of the many dependencies between them, such as mutual systems, electricity connections and even phone lines. An important consideration for the decommissioning of units 1 and 2 is not to impair the ongoing operation of units 3 and 4.

The plan is to start large-scale dismantling by the end of this year. For the large radioactive components such as the reactor tanks, there are detailed dismantling plans and



The top of the reactortank of Ringhals 1. © Photo Ringhals.

a contractor has been signed. For the other contaminated systems and material there are also detailed plans and a “letter of intent” with a contractor. Also, several logistical issues have been solved such as the plans for handling and transport of waste on site, including construction of new roads on the site. Likewise, an interim storage for low- and intermediate waste has been built on site.

From “first cut”, the plan is that the large-scale dismantling will continue for about a decade. It will generate approximately 340 000 tonnes of waste, of which 5-10 per cent is expected to be contaminated. A majority of the free released material is expected to be reused and recycled, for example as filling material on site.

The end state will be so called “brown field” where the buildings are demolished and the ground is free released for industrial use. Currently future use options are under evaluation, including the possibility of additional reactors to be built on the site. ■