Status and Plans for Decommissioning of Nuclear Facilities in Norway

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1. Introduction

Norway has currently two research reactors in operation. The oldest one, the Halden Boiling Water Reactor (HBWR), is more than 50 years old and decommissioning has therefore become a highly relevant issue. This article gives an overview of the status and plans for decommissioning of nuclear facilities in Norway, including waste and spent fuel handling and financing.

2. Relevant Actors and Facilities in Norway

2.1. Norwegian Radiation Protection Authority

The Norwegian Radiation Protection Authority (NRPA) is the competent national authority in the area of radiation protection and nuclear safety in Norway. It was established in 1993 through the consolidation of the former Nuclear Energy Safety Authority (Statens atomtilsyn) with the National institute of Radiation Hygiene (Statens institutt for strålehygiene). NRPA is operated under the ministry of Health and Care Services and provides assistance to all ministries on matters dealing with radiation, radiation protection and nuclear safety. NRPA employs around 100 people in Oslo, Tromsø and Svanhovd.

NRPA is responsible for implementing the Nuclear Energy Activities Act and the Radiation Protection Act, each with its regulations:

- Act 12 May 1972 nr.28: the Nuclear Energy Activities Act
  - Regulation of 2 November 1984 No. 1809 on physical protection of nuclear material and nuclear facilities
  - Regulation 12 of 12 May 2000 No. 433 on the Possession, Trade and Transport of Nuclear Material and Dual-Use Goods
- Act 12 May 2000 nr 36: Regulations on Radiation Protection and the Use of Radiation (Radiation Protection Act)
  - Regulation of 21 November 2003 No. 1362 on Radiation and the Use of Radiation (Radiation Protection Regulations)
  - Regulation of 6 December 1996 No. 1127 on Systematic Health, Environment and Safety Work in the Workplace (the Internal Control Regulation)

2.2. Institute for Energy Technology

Institute for Energy Technology (IFE) was established in 1948 under the name Institute for Atomic Energy (IFA) for the purpose of carrying out research in the use of nuclear energy.

The first reactor facility, JEEP I, was put into operation in 1951. IFA later built other reactors, the Halden Boiling Heavy Water Reactor in Halden in 1959, NORA at Kjeller in 1961 and JEEP II at Kjeller in 1966. At the beginning of the1960s, it was apparent that JEEP I had become obsolete, therefore it was shut down in 1967 and later decommissioned. A year later, in 1968, NORA was also shut down and decommissioned.

IFA operated a pilot facility to reprocess uranium fuel from 1961 to 1968. This facility has also been decommissioned and since then its premises are occupied by IFE's facility to process and store radioactive waste (The Radwaste facility).

Today IFE operates all nuclear facilities in Norway, located in Halden and Kjeller. It currently holds the operating licenses for their nuclear facilities, which are valid until 2014 and 2018, respectively (Table 1). IFE also operates the storage facility for low and intermediate level radioactive waste in Himdalen.

Table 1: Nuclear facilities in Norway

Facility	Operating licence
Halden	
The research reactor HBWR	2009-2014
Fuel storage	2009-2018
Instrument workshop	2009-2018
Kjeller	
The research reactor JEEP II	2009-2018
Metallurgy laboratory I	2009-2018
Metallurgy laboratory II	2009-2018
Storage for spent fuel	2009-2018
Storage for fresh fuel	2009-2018
The Radwaste facility	2009-2018

3. IFE's plans for decommissioning

3.1. Overview

NRPA received the first decommissioning plan from IFE in 1996. NRPA has also received updated versions of this plan in 2004 and 2007. NRPA has requested that IFE submits an updated decommissioning plan before the end of 2010. The first plan is an "initial plan" while the following are "on-going plans" using IAEA's terminology [1]. A final plan will be developed after the decision to permanently shutdown the facilities has been taken. No formal decision of the decommissioning options will be taken before the final plan is approved.

3.2. Time frame, organization and end-point

Table 2 gives an overview of the time plan for the decommissioning of IFE's nuclear facilities. It can be seen that the whole decommissioning process is planned to take15 years. According to IFE's plan and the operating license, the decommissioning is planned to start

immediately after the decision to shut-down the facilities has been taken. This takes advantage of the competence of the personnel and their detailed knowledge of the facilities.

Table 2: Time plan for decommissioning of IFEs nuclear facilities.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Halden															
HBWR															
Instrument workshop															
Kjeller															
JEEP II															
Metallurgy laboratory I															
Metallurgy laboratory II															
Storage for spent fuel															
JEEP I fuel storage															
Storage for fresh fuel															
The Radwaste facility															

There are several possibilities how to organize the decommissioning work. A new company could be formed or the work could be performed under the existing organization. IFE has in its decommissioning plan chosen the latter option and a new department responsible for the decommissioning is planned to be established. As soon as the decommissioning process is initiated, relevant personnel will be transferred to this new department.

As shown in Table 2, the current plan assumes that the decommissioning of all facilities start at the same time. When this plan was made, all IFE's facilities had the same operating license period. After the new license was issued in 2009, the HBWR now has an operating license for 6 years while all the other facilities have 10 years. The next decommissioning plan has to take this into account. Greenfield is the suggested end-point at this stage. It is planned that buildings should not necessarily be demolished but may be used for other purposes. Another issue is whether IFE's facilities have museum value. The Directorate for Cultural Heritage in Norway (Riksantikvaren) has assessed that the two research reactors have a cultural-historical value, especially the HBWR. The museum value will depend on how much equipment that has to be removed to reach acceptable radiation levels. For JEEP II this seems to be feasible but for HBWR it seems to be more difficult to achieve.

3.3. Cost and financing

IFE's cost estimate of the decommissioning is shown in Table 3. It can be seen that the total cost is estimated to be 1.2 billion NOK (150 M€). About 75% of the costs will be used for decommissioning of the Halden reactor, assuming the structures inside the mountain hall shall be removed.

Table 3: Estimate of cost, time and dose during the decommissioning. The estimated costs are in 2007 kroner. The cost of salaries assumes that IFE does the decommissioning themselves.

	Salary [kNOK]	Direct costs [kNOK]	Total [kNOK]	Estimated time	Dose [Man-Sv]
Halden					
HBWR + Halden fuel storage	561 000	352 000	913 000	~ 12 years	3 900

Instrument workshop	700	-	700	< 1 year	< 0.1
Kjeller					
JEEP II	44 500	25 500	70 000	~ 5 years	50
Metallurgy laboratory I	90	15	105	< 1 year	1
Metallurgy laboratory II	94 000	48 000	142 000	< 11 years	750
Storage for fresh fuel	1 100	150	1 250	< 1 year	5
Storage for spent fuel	38 300	11 200	49 500	~ 3 years	220
JEEP I fuel storage	5 800	6 000	11 800	< 1 years	5
The Radwaste facility	14 000	4 500	18 500	~ 2 years	120
Himdalen					
Transport costs Kjeller-Himdalen	2 100	250	2 350		
Total	***761 590***	***447 615***	***1 209 205***		

The question of how the costs for decommissioning should be financed has been discussed for several years but no formal decision has yet been taken. IFE is the owner of the nuclear facilities and the spent fuel and has therefore the formal responsibility. Accordingly, in the operating license IFE is requested to establish a plan for financing the decommissioning before the end of this year. However, IFE has requested that the government has to take the responsibility for the costs since the reactors were originally built and financed by the government. In addition, of the four research reactors built in Norway, two have been decommissioned (JEEP I and NORA). These decommissioning costs were covered by the government and IFE therefore claims that the same principle should be used for the other two reactors. IFE is an independent entity (non-profit foundation) and has no allocated resources dedicated for covering the decommissioning costs. IFE has estimated that the collected value of their resources (including buildings, land area, equipment etc) will cover less than 20 % of the total decommissioning cost.

3.4. Waste

All low and intermediate level radioactive waste generated in Norway is currently shipped to the waste storage facility in Himdalen. Himdalen is owned by the state company Statbygg and presently operated by IFE. Low and intermediate level radioactive waste generated during the decommissioning of IFE's nuclear facilities, currently estimated to be 3000 canisters with each canister containing 220 litres, will be disposed in Himdalen. However, Himdalen is not licensed for spent nuclear fuel and it is not decided where it should be deposited. Currently all spent nuclear fuel generated in Norway is stored at the two reactor sites. Several Norwegian governmental commissions have since 1999 been working on how to handle the spent nuclear fuel. The work of these commissions is described below.

The first commission was appointed in 1999 to develop a national strategy for the spent nuclear fuel from IFE. The commission presented its report in 2001 [2] where it was

recommended that a national intermediate storage facility should be established. In this the spent nuclear fuel and long-lived radioactive waste will be stored for 50-100 years in order to wait for cooling and to make plans for a final disposal.

Following these recommendations, another governmental commission, the Phase 1 Commission, was appointed in the beginning of 2004 and it presented its report in mid-2004 [3]. The mandate of this commission was to survey Norway's storage need for long-lived radioactive waste and spent nuclear fuel. The commission also investigated technical solutions for the intermediate storage facility. It concluded that Norway in 2004 had approximately 16 tonnes and 8 m^3 of spent nuclear fuel, which is increasing by about 200 kg/year. It was also pointed out that about 12 tonnes of this is metallic uranium or aluminium clad fuel, which constitutes a challenge for long-term storage and disposal. The commission recommended building a dry-storage facility for the spent nuclear fuel in a concrete structure or transportable storage containers. The construction time for such a facility was estimated to be 2-2.5 years and costing approximately 100 MNOK.

In January 2009, two new commissions were appointed to continue the work on a more detailed level. The mandate of the main commission, the Phase 2 Commission, is to work to find the most suitable technical solution and localization for the intermediate storage facility for spent nuclear fuel and long-lived radioactive waste. This commission will present its result in 2011 [4]. A technical commission was appointed at the same time as the Phase 2 Commission. The mandate of this commission was to investigate how to handle the 12 tonnes of metallic or aluminium-clad fuel, currently stored at IFE. The commission presented its report in January 2010. The main recommendation was to consider commercial reprocessing options to render the fuel stable for long-term storage.

4. Summary

This article has given an overview of the status and plans for decommissioning of nuclear facilities in Norway. The decommissioning plans of IFE are well developed and describe the time and costs for the decommissioning, though not how it should be financed. The financing issue has been discussed for several years but no formal decision has yet been taken. It is also not decided what to do with the spent nuclear fuel and Norway is currently in a process to identify the options. The current proposal is to build an intermediate deposit where the fuel can be stored for 50-100 years.

5. References

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