The Division of Responsibilities between the State and Power Companies in the Management of Spent Nuclear Fuel and Other Nuclear Waste in Sweden - 14593

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ABSTRACT

Four basic principles

The division of responsibilities between the state and power companies when it comes to the disposal of spent nuclear fuel has been given considerable interest in parliament. Parliament has in this respect endorsed four basic principles.

The first basic principle is that the cost of disposal of spent fuel and nuclear waste will be covered by revenues from the production of energy that spawned them.

The second basic principle is that a reactor owner shall be responsible for spent fuel and nuclear waste should be disposed of safely.

A third basic principle is that the State has the overall responsibility for spent nuclear fuel and nuclear waste.

A fourth fundamental principle is that each country should take responsibility for the spent nuclear fuel and nuclear waste generated in the country.

A research and development program

The law requires a permit holder to clarify what measures are needed and how these measures can be taken. Therefore, the law requires that a licensee to a nuclear reactor shall establish a research and development program for the comprehensive research and development needed, to fulfil these obligations.

The Nuclear Waste Fund

In accordance with the first basic principle reactor licensees are required to pay a special fee to finance the future costs to dispose of SNF, other nuclear waste and for decommissioning and dismantling facilities. The fee is based on the energy produced. Fees shall be placed in a special state fund - Nuclear Waste Fund.

INTRODUCTION AND BACKGROUND

Sweden was one of the nations that early started a development work within the nuclear field. Therefore, Sweden has nuclear waste from that early period to take care of as well as spent nuclear fuel (SNF) and nuclear waste from later nuclear power program. Among the early waste it can be noted used fuel (UNF) for test and research reactors delivered from USA. Most of that fuel has been sent back to the USA.

Provided below is a brief chronological account of the Swedish nuclear energy and waste management program, and its political complications [1]:

- In 1945, the Swedish Government/State appointed the so-called Atomic Committee that would study the possibilities and consequences of nuclear energy.
- In 1947, the Atomic Energy Company was formed as a sort of joint venture between the Government/State, the technical colleges and the industry. AB Atomic Energy would do research and development (R&D) of the peaceful use of nuclear energy. At that time, Sweden also had a development program within the military sector of nuclear energy, which lasted until the late 1960s.The permit to operate Sweden's first nuclear reactor, the so-called R1-reactor, located at the Royal Institute of Technology in Stockholm (KTH), was issued in 1954.
- On June 1, 1956, the Parliament adopted the Atomic Energy Act whose purpose was to "promote the controlled introduction and use of nuclear power".
- In 1960, R2 and R2-0 a research and materials testing reactor respective training reactor was in operation – the reactors is placed in Studsvik, about 100 km south of Stockholm – closed permanently in 2005.
- In 1964 the country's first nuclear reactor was brought into operation. The reactor is located in Ågesta outside Stockholm and was productive in operation until 1974. Ågesta is a cogeneration reactor that produced electric power and district heating to Farsta, a suburb of Stockholm.
- In 1969, the Swedish Government/State and ASEA formed a joint venture, AB ASEA-Atom, to design and build commercial nuclear power plants.
- The nuclear reactor Oskarshamn 1, which became operational in 1972, was of Asea-Atom construction and the first commercial reactor, after the experimental reactor in Ågesta, which supplied electricity in Sweden.
- After an advisory referendum on the nuclear issue, held in the spring of 1980 after the Three Mile Island (TMI) accident in the USA, the Swedish Parliament decided on general guidelines on energy policy. The guidelines stated that
  - no nuclear power expansion would take place beyond the twelve already decided upon,
  - existing facilities should gradually cease operations, and
  - the last nuclear power reactor in Sweden would cease to operate in 2012.
- The 1984 Act on Nuclear Activities (the 1984 Act) emphasized the human factor and the nuclear waste management issue. According to the Government, provisions in the Act regarding the number of reactors and the decommissioning period length were not necessary.
- The 1984 Act was amended in 1987 to prohibit the issue of a licence for the construction of a nuclear power reactor. This amendment reflected the Swedish Parliament's decision after a referendum held in 1980. The amendment meant that the licensing provisions will continue to apply in relation to the operation of those nuclear power facilities that had already been constructed at the time of the 1987 amendments. Thus, the only new installations to be subject to the Act's licensing procedure at that time was those constructed for the handling, storage and final disposal of nuclear waste, including SNF.

- In 1995, an inter-party agreement was made between the political parties forming the majority in the parliament on guidelines for a new Swedish energy policy. The aim was to create conditions for the efficient use and cost-effective supply of energy, thereby facilitating the creation of an "ecologically sustainable society". According to the inter-party agreement the specific date 2010 as the far limit for nuclear power was no longer topical on the political agenda. As a result of the inter-party agreement, the Act on the Phasing-out of Nuclear Power was adopted in 1997 and entered into force on 1 January 1998. The 1997 Phasing-out Act gave the Swedish government the right to revoke a permit to operate a nuclear power reactor. This Act confirmed that the licensee was entitled to compensation from the Government/State for losses incurred due to a forced closedown.
- Two reactors has been phased-out for political reasons hitherto under the Act on the Phasing-Out of Nuclear Power, namely the reactor Barsebäck 1 (30 November 1999) and reactor Barsebäck 2 (31 May 2005) at the Barsebäck site shown on Figure 1.
- New legislative amendments to the 1984 Act and the Environmental Code entered into force 1 January 2011 will make it possible to "gradually replace existing nuclear power reactors with new nuclear power reactors". In other words, the ban on new nuclear reactors has been removed without thereby clearing the way for an unlimited number of new reactors under the 1984 Act, as amended.
  The 1997 Act on the Phasing-out of Nuclear Power has been repealed and the Swedish State Power Board, Vattenfall, recently applied for a licence to build a new replacement nuclear reactor at one of its current nuclear power plant (NPP) sites, Ringhals (Figure 1).
- In 2011, the Swedish Nuclear Fuel and Waste Management Company AB (SKB) applied for licenses to build and safely operate an SNF-*disposal repository* adjacent to the Forsmark NPP site (Figure 1) and an SNF-encapsulation plant (Inka) adjacent to the Oskarshamn NPP site (Figure 1). These license applications are currently under review by the Environmental Court and the Swedish Radiation Safety Authority (SSM).

DESCRIPTIONS AND DISCUSSIONS

Nuclear Power Reactors

At the end of 2013, there are 10 operating nuclear power reactors in Sweden; seven are boiling water reactors (BWRs) and three are pressurised water reactors (PWRs) [2]. As mentioned in the preceding text, the two nuclear reactors at Barsebäck shown on Figure 1 have already been phased out.

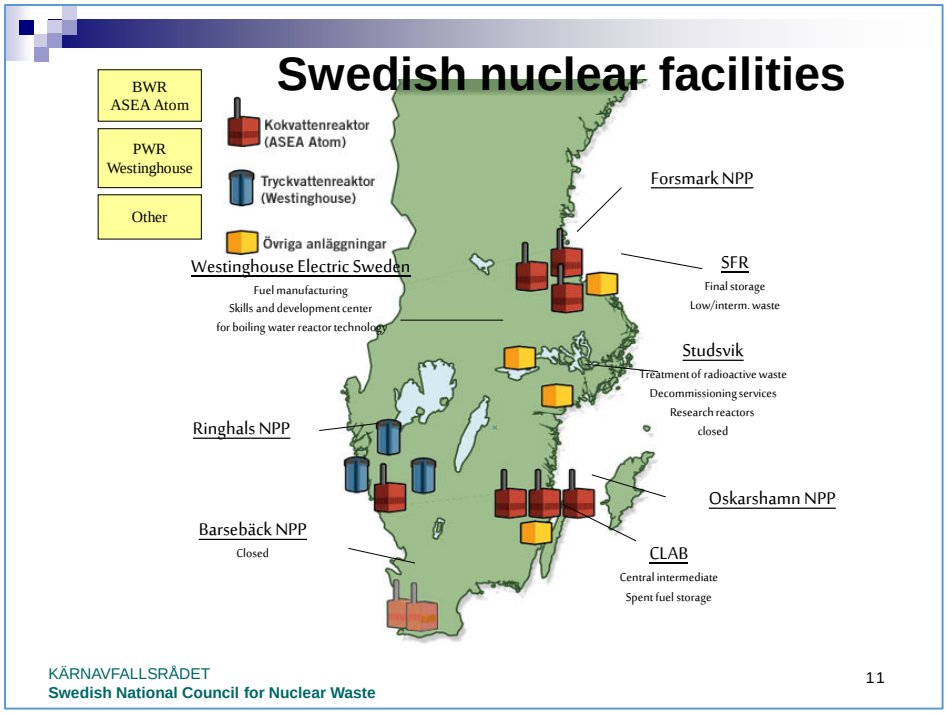

Fig. 1. Map showing the locations and number of nuclear reactors in Sweden and related facilities.

There are three operating PWRs and one operating BWR at Ringhals (with a combined installed capacity of 3,715 MWe), and three operating BWRs at Forsmark (3,218 MWe) and three operating BWRs at Oskarshamn (2,320 MWe). These 10 reactors produce around 65 TWh and account for about 45 percent of Sweden's total electricity production.

Three power companies – Vattenfall, E.ON and Fortum - own the shares of the various companies licensed to operate the three nuclear power generating stations/sites in Sweden. These companies are owned by private shareholders with the exception of Vattenfall, which is Government/State owned. E.ON has a stake in every operating company and is the parent company of the Oskarshamns Kraftgrupp (OKG). Vattenfall is the parent company for the nuclear reactors located at the Forsmark and the Ringhals sites.

The two reactors that were phased-out under the Act on the Phasing-Out of Nuclear Power at the Barsebäck site (Figure 1) are in the process of being decontaminated and demolished.

Radioactive Waste and Decommissioning Services

Studsvik Nuclear AB (Studsvik) is engaged in the treatment of radioactive waste and in decommissioning services. Its two research reactors have been phased-out – one tank type (50 000 kW), and one pool type (1 000 kW).

Nuclear Waste Storage and Disposal Facilities

Since 1988, Sweden's low- and intermediate-level (L/ILW) *operational nuclear waste* is deposited in an underground repository located at Forsmark – the SFR facility. It receives short-lived L/ILW from NPPs, hospitals, industry, and research facilities in Sweden. The SFR operates under the terms and conditions of an operating licence issued by the Government, but is supervised by the Swedish Radiation Safety Authority (SSM).

Sweden does not reprocess UNF/SNF. UNF, SNF, and other high-level nuclear waste (HLW). Pending the opening of the nation's first deep geological disposal system in the second half of 2020, UNF, SN, and HLW have been stored since 1985 and continues to be stored at the *Central Interim Storage Facility for Spent Nuclear Fuel* (CLAB) located near the Oskarshamn NPP site.

As mentioned in the preceding text, the disposal facility for SNF is currently scheduled to open in the second half of the 2020s adjacent to both the Forsmark NPP site and the SFR.

Nuclear-Fuel Manufacturing

Westinghouse Electric Sweden is engaged in nuclear-fuel manufacturing and has a skills and development centre for BWR technology.

Basic Swedish Nuclear Waste Management Principles

Discussions on how nuclear waste can be safely and securely taken care of and how it will be financed have been discussed in Sweden since the early 1970s. The conditions have varied over the years. As an example, the Swedish approach in the 1960s and 1970s was that the SNF would be reprocessed. Since 1982, the Swedish policy focused on direct disposal of UNF/SNF without reprocessing. However, some basic principles have always been supported. As a result of the advisory referendum on the nuclear issue held in the spring of 1980 after the TMI accident, the Swedish Parliament has endorsed the following four basic principles in the management of SNF [2]:

1. *The first basic principle* is that the cost of disposal of SNF and L/ILW will be covered by revenues from the production of energy that spawned them. Given the long time periods required for the management and disposal of SNF, costs will be incurred long after the production at an NPP has ceased. This means that the funds required for future expenses for the management and disposal of SNF must be timely taken out of revenues from energy production. The obligation to bear the costs does not end until all SNF and L/ILW has been safely and securely disposed of.

2. *The second basic principle* is that a nuclear reactor owner must ensure that the generated SNF and L/ILW will be disposed of safely. This means that the reactor licensees are required to ensure that the necessary measures for their safe and secure management and disposal are timely available. They must also, in addition to the purely technical operation, have an organization for the business with financial, administrative and human resources sufficient to fulfil these obligations.

3. *The third basic principle* is that the Government/State has an overall responsibility for all L/ILW, UNF, SNF, and HLW. The long-term (post-disposal) responsibility for this waste thence lies with the Government/State. After a repository has been sealed, it requires that some form of responsibility for and oversight of the repository can be maintained for a considerable time. A state agency may assume responsibility for the closed repositories.

4. *The fourth fundamental principle*, which repeatedly has been established by the Swedish Parliament, is that each country must take responsibility for the nuclear waste generated in the country. It follows that the disposal of SNF and other nuclear waste from nuclear activities in another country may not be stored or disposed of in Sweden, other than in very exceptional cases.

The responsibilities embodied in these fundamental principles are reflected in the current Swedish legislation. These principles were also essential for the construction of the 1984 Act (1984:3). They have also had an amended impact on the 1984 Act, the Act (2006:647) on financial measures for the management of waste from nuclear activities (finance law).

Current Swedish Laws

The framework of Sweden's nuclear law is to be found in the following five Acts:

1. *The Environmental Code* (1998:808), which addresses environmental aspects of nuclear activities, and lists "nuclear activities" among several other "environmentally hazardous activities"; applies to all kinds of inconveniences of ionizing and non-ionizing radiation and thus includes nuclear safety and radiation protection.
2. *The 1984 Act* (1984:3), which addresses mainly security and control issues, and the overall safety of nuclear operations.
3. *The Radiation Protection Act* (1988:220), which aims to protect people, animals and the environment from the harmful effects of radiation.
4. *The Act (2006:647) on Financing of Management of Residual Products from Nuclear Activities*, which contains provisions for the future costs of spent fuel and nuclear waste disposal, decommissioning of reactors and other nuclear installations and research in the field of nuclear waste.
5. *The Nuclear Liability Act (1968:45*), which implements Sweden's obligations as a Party/Signatory to the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy and the 1963 Brussels Convention Supplementary to the Paris Convention.

The provisions of the Environmental Code, the 1984 Act, as amended, and the Radiation Protection Act lay down the general principles, of the regulatory regime in Sweden. These Acts are supplemented by a number of ordinances and other secondary legislation, and these contain more detailed provisions for particular aspects of the regime.

Two other laws of importance are *the Act (2000:140) on Inspections according to International Agreements on Non-proliferation of Nuclear weapons* and *the Act on Control of Export of Duel-use Products and Technical Assistance (2000:1064).*

Current International Laws, Treaties, and Conventions

The Euratom Treaty is to be adopted and followed by all member states in the European Union. The Euratom Treaty is mainly important here in that it imposes the requirement of: uniform standards for radiation – Basic Safety Standards; and Euratom monitoring application.

The Euratom Treaty is also important when it comes to the disposal of radioactive waste, including disposal of SNF [3].

The Euratom Treaty also contains rules relating to the transportation of SNF and other radioactive waste. It also exercises the Euratom Commission's control of ores and nuclear materials, for which the Euratom has set up a special inspection process.

Sweden has also ratified/signed the following international treaties and conventions:

1. The 1968 Treaty on the Non Proliferation of Nuclear Weapons (on 9 January 1970).
2. The 1979 Convention on the Physical Protection of Nuclear Material (on 1 August 1980).
3. The 1996 Comprehensive Test Ban Treaty (on 2 December 1998).
4. The 1994 Convention on Nuclear Safety (on 11 September 1995).
5. The 1986 Convention on Early Notification of a Nuclear Accident (on 27 February 1987).
6. The 1986 Convention on Assistance in the Case of Nuclear Accident or Radiological Emergency (on 24 June 1992).
7. The 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (on 21 February 1974).
8. The 1997 Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (on 29 July 1999).

Sweden's obligations under these Treaties and Conventions are given effect by means of several general provisions in the 1984 Act (1984:3) and wide regulation making powers authorised to the Swedish Nuclear Power Inspectorate under the Ordinance on Nuclear Activities (1984:14).

Responsibility of the Licensee

Below is a summary of some of the provisions of the 1984 Act, as amended, concerning the responsibility of the licensee [4].

The aim of the 1984 Act (1984:3) is, to the extent possible, eliminate the risks of a nuclear accident, and thus ultimately, to the loss of life or property. Given the weight that must be placed on licensee's ability to meet the regulatory safety requirements, a license to operate a nuclear plant is set exclusively to a specified person. A licensee can therefore not transfer its license to someone else without a new license procedure. The other person must apply for its own license for the operation.

The 1984 Act has been designed so that the licensee has been given the responsibility for the operation and it cannot be transferred to another entity. The licensee is thus responsible for all

related necessary measures. The demands made on the disposal of SNF and other nuclear waste must necessarily be very stringent with regard to safety and radiation protection. The same applies to the decommissioning of a nuclear facility. This obligation includes the complete disassembly and removal of the reactor and other facilities included in the NPP.

Therefore, the law requires from a licensee to - not only comply with the conditions and regulations imposed by the Government or the supervisory authority, i.e., the SSM,– but also by itself be effective to take all necessary measures to maintain safety, handle and dispose nuclear waste and nuclear material in a safe manner, and decommission and dismantle the nuclear facility safely after the operation has been terminated.

In summary, the licensee has all of the responsibility for the operations of the nuclear facility and cannot blame an authority or its regulations if an incident occurs.

The Swedish Research, Development, and Demonstration Program

The 1984 Act requires that a licensee shall clarify [5]:

a.) What measures are needed to safely dispose of nuclear waste and dismantle the facility; and
b.) How these measures can be implemented.

To fulfil these obligations, the licensees are obliged to establish a program for the comprehensive research, development, and demonstration (RD&D) activities needed in consultation with other nuclear reactor owner.

Furthermore, the program shall focus on the RD&D that needs to be undertaken to solve issues/problems related to the safe handling and disposal of the radioactive waste in accordance with the method deemed to be suitable with respect to safety and radiation protection.

The program shall also include an overview of all measures that may be necessary, and further specify the action to be taken within a period of not less than six years.

The RD&D must cover the entire process chain for waste treatment and disposal, including different types of storage facilities and other facilities needed prior to disposal.

The planned/proposed RD&D program shall be submitted every three years to the Government for review and evaluation. The government may impose conditions to the reactor owners for the continued research and development activities.

The Nuclear Waste Fund (Kärnavfallsfonden)

Pursuant to the responsibility imposed on the licensees it includes to account for the actual costs required for safe and secure management and disposal of SNF and other nuclear waste, and the nuclear waste generated by the decontamination and demolition of the nuclear facilities [6].

The Act (2006:647) on Financing of Management of Residual Products from Nuclear Activities requires the producers of nuclear power to pay an annual fee to the state. The amount of the fee is calculated according to the energy output of each nuclear facility and according to information provided by the producers as to the estimated costs of carrying out their legal obligations in relation to nuclear waste, including its safe handling, storage, and RD&D. The fees are paid into a special state fund - Kärnavfallsfonden - whose assets are to be used to cover both current and future costs for SNF disposal, decommissioning of reactors and RD&D in the field of nuclear waste.

The fund is also used to cover the ongoing costs of the safe handling and storage of nuclear waste, and of the research and development programmes carried out by the producers in fulfilment of their obligations under the 1984 Act. The SSM has the responsibility for reviewing the calculations of the fees and for proposing the fee to be paid every year by the owners of the nation's nuclear reactors.

The licensees are also required to grant and obtain guarantees for such costs not covered by the fees paid.

SUMMARY

Permission to own and operate a nuclear facility involves a long-term commitment.

The obligation to dispose of SNF and other nuclear waste, including demolition waste, and to pay a nuclear waste disposition fee remains with the nuclear facility operators until the operations have been completed or an exemption from them has been granted.

These obligations have not been completed until a repository is finally sealed. This means that the licensee's obligation may persist long after the nuclear-waste-generating facilities have been closed. Furthermore, if a license is revoked or a license expires, the obligations concerning waste treatment, storage, and disposal still remains.

In conclusion, there is a clear division of responsibilities between the Swedish Government and the licensees - prescribed by law – that has been successful in terms of developing methods for treatment, storage, and the disposal of SNF and other nuclear waste, i.e., the waste generator/polluter pays!

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