Sweden: Policy and licensing

An update of projects and the new framework for regulation

by Alf Larsson, Kjell Andersson, and Stig Wingefors

In Sweden, as in other countries having large nuclear power programmes, radioactive waste management is closely connected to the organizational structure of nuclear power generation and the division of responsibility between utilities and governmental organizations.

Nuclear power in Sweden is generated in 12 stations located at four sites along the coastline. The Parliament's decision following the 1980 referendum – that the nuclear power programme should be limited to 12 stations phased out by the year 2010 at the latest – affects the nuclear waste volume. But it has no principal influence on the execution of the appropriate waste handling programme.

Reactor sites and Studsvik

Under Sweden's Nuclear Activities Act, the responsibility for management and final disposal of nuclear waste rests with waste producers. (See accompanying box for review of legislation and regulation.) Utilities using nuclear power to produce electricity have the responsibility for the radioactive waste created during production.

For other types of radioactive waste (for example, from hospitals and laboratories) the situation is not entirely clear, however, pending revision of the Radiation Protection Act. Studsvik Energiteknik AB, as a service to hospitals and research laboratories, takes care of their waste for a fee. In practice, they then also take over the long-term responsibility for final disposal. On the other hand, the company does not assume responsibility for disposal of ashes from its incineration of low-level waste from nuclear power plants.

Conditioning and intermediate storage of low- and intermediate-level waste (LILW) is done at reactor stations. A similar handling scheme exists at the Studsvik research establishment. Both bituminization and incorporation into cement is employed for conditioning.

Three reactor sites have intermediate storage facilities for LILW above ground. At one site (Oskarshamn), an intermediate storage facility for medium-level waste has been excavated in rock. At Studsvik, another facility in rock for intermediate storage of medium- and long-lived wastes has recently been put into operation.

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Legislative and regulatory framework

According to Sweden's Nuclear Activities Act (which was introduced in 1984 and superseded the Atomic Energy Act of 1956), the producer of nuclear waste has the responsibility for its management and final disposal. To own and operate a nuclear power station, the owner must carry out a research and development programme, the content of which must be presented to the Government every third year. The National Board for Spent Nuclear Fuel has the important task of commenting on this programme and also of obtaining comments from nuclear safety authorities.

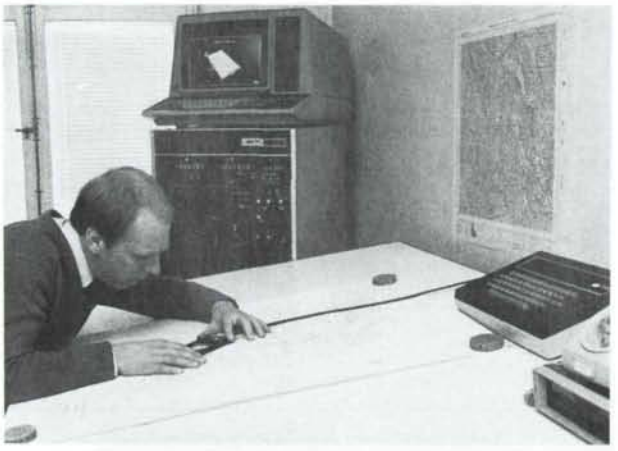
The Nuclear Activities Act regulates the safety of nuclear power production and radioactive waste management. The Swedish Nuclear Power Inspectorate has the responsibility to supervise that organizations handling fissile material and radioactive waste implement the stipulations of the law and corresponding regulations.

The Radiation Protection Act, which was introduced in 1958, is under revision. The law is basically for the protection of workers and the general public from all types of radiation hazards. It covers radiation from handling radioactive materials, as well as radiation from X-ray and gamma-emitting equipment. It also covers the safety of using other equipment emitting electromagnetic waves. The National Institute of Radiation Protection supervises the Act's implementation.

Costs related to waste management are proposed to the Government by the National Board for Spent Nuclear Fuel. The Board proposes a fee on nuclear power production that utilities then must transfer to a special governmental fund. The fund is stipulated to cover present and future handling of radioactive high-level waste and spent fuel, as well as decommissioning of nuclear power reactors.

It is not possible here to analyse the relationships created between competent safety authorities to solve different problems on waste management. It is obvious that the authorities, though established according to different laws, must have very close co-operation to be able to cover all safety aspects in a consistent manner. This close relationship has many practical implications on day-to-day work. Although authorities collaborate, the fact that they are separate entities must be kept in mind by the utilities.

Recently, the Government chose to enhance the importance of co-operation between safety authorities and the National Board for Spent Nuclear Fuel for the long-term waste management programme. A special advisory committee on nuclear waste was set up that includes personnel from the three authorities, as well as scientists from universities and other non-nuclear organizations.



Through national and international co-operation, Sweden is conducting research for final disposal of high-level wastes, with sites to be explored to 1990. (Credit: SKB)

Handling facilities

In 1974, power utilities operating or building nuclear stations formed a special company – the Swedish Nuclear Fuel Supply Co. – which, as a primary task, had to handle those parts of the nuclear fuel cycle that could profit from concerted action. One important duty was the management of spent fuel and radioactive waste. At the time the company was established, attention was mainly directed towards reprocessing of spent fuel.

With the introduction in 1977 of the "stipulation law", the need for greater emphasis on waste management became apparent.* A special project organization – KBS – was formed, which at first was only formally connected to the Swedish Nuclear Fuel Supply Co. Later, KBS became an integrated part of it. The change is now reflected in the name, which recently became the Swedish Nuclear Fuel and Waste Management Company (SKB). The company is entirely financed by its owners. Activities related to spent-fuel management and decommissioning are covered by a special fund created by fees on nuclear power production. SKB handles practically all matters connected to radioactive waste and spent fuel outside the nuclear power plants.

Background studies

Initially, SKB made two studies (KBS-1 and KBS-2), but only the first one was connected to stipulations in the 1977 law mandating the safe management of radioactive waste.

At the time, utilities represented in SKB chose to sign contracts with the French company, Cogéma**, for the reprocessing of fuel from the two reactors, Barsebeck-2 and Ringhals-3. Later on, additional contracts were concluded for new reactors. Consequently, reprocessing contracts amounted to about 10% of anticipated fuel discharges from the total nuclear programme up to the year 2010.

The Government sent KBS-1 (the background study for the management of high-level waste) for comments to a number of domestic and foreign organizations. Comments made by Swedish safety authorities were considered to be especially important. (As a result of the comments and the 1980 referendum, the nuclear power programme of 12 reactors was established.) Vitrified high-level waste (HLW) from reprocessing was declared to be a waste form that could be safely disposed of in Swedish bedrock, although no site was specifically selected for the purpose.

As a second step, SKB also made a study (KBS-2) on direct disposal of spent fuel without reprocessing. This study, however, was not connected to any application for new reactors to be put into operation. KBS-2 also was sent for comments to a number of organizations in Sweden and abroad.

A third study on direct disposal of spent fuel (KBS-3) contained the necessary background material for the last two reactors, Forsmark-3 and Oskarshamn-3, to receive their operating permits according to the Nuclear Activities Act. For this study, SKB presented much more recent material from field investigations, laboratory research, and theoretical work as compared to the earlier studies. KBS-3 also was reviewed by different Swedish and foreign organizations, with the most comprehensive comments delivered by the Swedish Nuclear Power Inspectorate (the Inspectorate).* As a result of SKB's massive effort and the positive response expressed in comments, the Government gave its consent that legal requirements were fulfilled and the two reactors could be put into operation in 1984.

Spent-fuel facility

Already at an early stage, the necessity was recognized to store large amounts of spent fuel from Sweden's different reactor sites, irrespective of the fuel's reprocessing or direct disposal. For that reason, one main undertaking of SKB was to get permission to build an intermediate storage facility for spent fuel, called CLAB. SKB chose a site close to the Oskarshamn nuclear power plant for the purpose. Following the positive response

* The law made it mandatory for the reactor owner to show that radioactive waste or spent fuel could be managed in an "entirely safe" manner. It might be of some interest to mention that the parliamentary committee dealing with the law made the remark that "entirely safe" should not be interpreted in a "Draconic sense".

** Cogéma is the Compagnie générale des matières nucléaires.

* *See review of KBS-3, Plan for Handling and Final Storage of Unreprocessed Spent Nuclear Fuel,* DS I 1984:17, Ministry of Industry, Stockholm (1984); *Fuelling Licenses for Forsmark-3 and Oskarshamn-3* (in Swedish), DS I 1984:19, Ministry of Industry, Stockholm (1984); *Review of Final Storage of Spent Nuclear Fuel – KBS-3,* Technical Report SKI 84:5, Swedish Nuclear Power Inspectorate, Stockholm (February 1984); *Comments on Final Storage of Spent Nuclear Fuel – KBS-3,* Technical Report SKI 84:4, Swedish Nuclear Power Inspectorate, Stockholm (February 1984).

from safety authorities, the Government approved the application by SKB for a license to build and operate the facility.

The CLAB facility was taken into operation in 1985. It consists of a receiving station located above ground and several water pools for underground storage of spent fuel in an excavated rock cave, which has minimum rock coverage of about 25 metres. Its capacity is 3000 tonnes of spent fuel, which can fairly easily be extended to 9000 tonnes, or more than the need of the present Swedish nuclear programme.

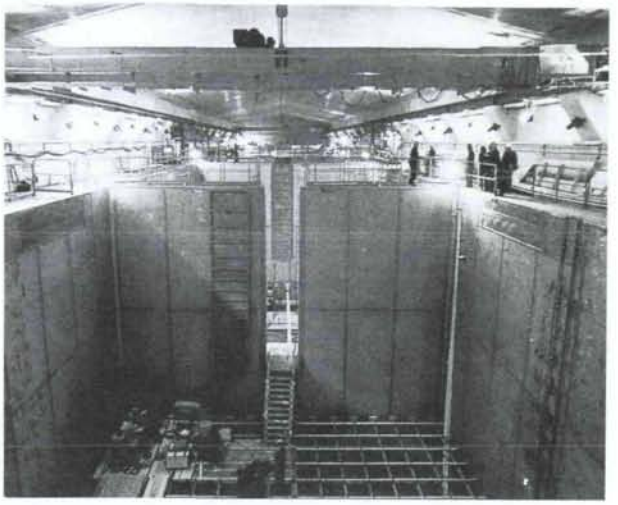
Disposal of LILW

Operational waste from nuclear power plants, as well as waste of a similar kind from Studsvik, is to be disposed of in a repository (SFR) now under construction in the vicinity of the Forsmark site. The licensing application for its construction and operation was submitted to the Swedish Government on 24 March 1982. In April 1983 the Inspectorate, in a statement to the Government, recommended that a license should be granted, subject to certain conditions.* The license was granted on 22 June 1983 and construction work started in autumn 1983. The repository is planned to be taken into operation in 1988.

SFR is built 1000 metres off the coastline and has a rock cover of at least 50 metres. It is planned to contain about 100 000 cubic metres of waste, corresponding to the present Swedish nuclear programme.** (The maximum permitted activity content is 10^{16} becquerel, of which the major part will be contained in a concrete silo 50 metres high surrounded by a sand/bentonite mixture.)

The preliminary safety report was received by the Inspectorate and sent for comments to Sweden's Institute of Radiation Protection. The Inspectorate concentrated on safety issues (especially on radionuclide release) while the Institute made an assessment of the dispersion of activity in the biosphere and radiological consequences. Among the main issues addressed by the Inspectorate were site acceptability; handling safety and long-term stability of waste products; geohydrology; rock mechanics; long-term stability of engineered and natural barriers; operation safety; and safety analysis.***

SKB now is implementing a control programme connected with construction work that is followed very closely by the Inspectorate. Of special interest now is



Sweden's spent-fuel central storage facility (CLAB). (Credit: SKB)

that the work should be performed in a way that provides all required information for a careful safety assessment of the completed facility. Most important in this connection is, of course, the geohydrological conditions in and around the repository.

Industry, as well as the authorities, also are developing criteria for quality assurance and acceptance covering various waste forms. A safety document will describe each waste category, giving a full account of the waste's handling sequence from the point of origin to disposal.* The purpose is to detail compliance with general and qualitative criteria to be issued by the authorities. To fulfill this task, the Inspectorate and the National Institute of Radiation Protection recently have formed a small joint working group. Important to this work is the waste register, in the form of a data base, that contains all relevant information for each single waste package. It is continually updated by all producers of nuclear waste.

At the plant in Oskarshamn, a substantial part of low-level waste is going to be disposed of by shallow land burial. At Forsmark, there are similar plans for disposal of low-level waste. In these cases, the grant for disposal is given directly by the Institute, since, in principle, no engineered or natural barrier exists between the waste and the biosphere. However, the Inspectorate still will supervise burial sites according to the Nuclear Activities Act.

Final disposal of spent fuel and HLW

As compared to disposal of LILW, the SKB programme for final disposal of spent fuel and HLW is still in a generic stage. No binding decisions have yet been taken on siting or on the method to be applied. Indeed,

* See *Licensing of Final Repository for Reactor Waste – SFR-1*, Technical Report SKI 84:2, Swedish Nuclear Power Inspectorate, Stockholm (July 1984), and "Aspects on the Licensing of a Final Repository for Reactor Waste", by A. Larsson and S. Wingefors, presented at Jülich conference 54 (June 1985).

** See "Swedish Programme for Quality Assurance of Reactor Waste", by H. Forsström, presented at Jülich conference 54 (June 1985).

*** Regarding handling safety and stability, see *Long-Term Properties of Bituminized Waste Products*, Nordic Liaison Committee for Atomic Energy (October 1985).

* See "Assessment of Properties of Swedish Reactor Waste", by R. Sjöblom, J.P. Aittola, K. Brodén, K. Andersson, and S. Wingefors, *Radioactive Waste Management*, proceedings of the 1983 international conference in Seattle, USA, Vol. 2, IAEA STI/PUB/649 (1984).

the Government based its licensing approval of a number of nuclear reactors on the condition that the KBS-1 and KBS-3 studies show that nuclear waste can be safely conditioned and finally disposed of by the methods the studies described. That does not imply, however, that these methods will eventually be chosen. Better methods might in principle be developed. It is part of the duty of the National Board for Spent Nuclear Fuel to see that alternative disposal methods will be investigated and compared as regards their applicability to Swedish conditions.

To get a permit for taking Forsmark-3 and Oskarshamn-3 into operation, the utilities (using SKB as their representative) also were required to submit a research and development (R&D) programme on final disposal to the government, which they did in the form of a plan. As a first step, a number of possible sites will be explored until about 1990. Then a selection will be made to reduce the number of sites to two or three. These sites will be subjected to detailed characterization, eventually including the sinking of an exploratory shaft and experimental tunnels. Application for approval of the final site chosen is expected to be submitted to the Inspectorate around the year 2000.

SKB also has presented the general outline of a research programme supplementing the general development programme. In its comments to the programme, the Inspectorate found a number of areas where further R&D would be necessary to prove that safety requirements can be achieved at the selected disposal site. Areas of concern include hydrological, geological, thermal, mechanical, and chemical conditions at the disposal site. For example, the transport of groundwater and radionuclides in fractured rock can be mentioned as a research area of particular importance for site characterization. Furthermore, the potential importance of couplings between different effects, such as thermomechanical impact on groundwater flow, should be further investigated.

To fulfill its role in the expected licensing procedure, it is important for the Inspectorate to develop its own research programme. The development and evaluation of performance assessment tools is a key element in this programme so that a satisfactory level of confidence will be gained.

This was the main reason why the Inspectorate initiated two international co-operation projects – INTRACOIN and HYDROCOIN.* These projects deal with verification, validation, and sensitivity analysis of models for geosphere nuclide migration and groundwater flow that were used in the performance analysis. The Inspectorate's opinion is that systematic and comprehensive efforts within the problem area of validation of geosphere transport models are needed and should be performed, preferably through international collaboration.

To develop necessary resources for regulatory guidance and future decisions in connection with the SKB programme, the Inspectorate has decided to start a study whose aim will be to perform a complete safety analysis of the SKB concept for final disposal. The study, which will be of a generic nature not naming a specific disposal site, will also provide a means for setting priorities in the Inspectorate's waste management research programme.

Challenges, co-operation, consensus

Now that Sweden has put into practice large parts of its programme for nuclear waste management and disposal, the major remaining field is final disposal of spent fuel and HLW. Given the complexity of safety issues in radioactive waste disposal in geological formations, and the number of different technical fields and methodologies involved, international co-operation is essential.

For a long time, Sweden's policy has been to contribute to global co-operation, principally through the IAEA and Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA). Examples are the Stripa test facility (with SKB as the managing participant), INTRACOIN and HYDROCOIN (with the Inspectorate as managing participant), and BIOMOV, a project dealing with various effects appearing in the biosphere, such as nuclide transport and dispersion (with the National Institute of Radiation Protection as co-ordinator).

The rapidly evolving field of safety assessment related to final disposal of radioactive waste is a veritable challenge to safety authorities, requiring expertise and resources to deal with licensing applications. At the same time, it must be realized that both manpower and funds are limited. In Sweden, the Inspectorate, the National Institute of Radiation Protection, and the National Board of Spent Nuclear Fuel have certain funds for their own safety research that must be spent efficiently, often in collaboration with other organizations in Sweden and abroad.

The objective of achieving scientific consensus on the main safety issues in the disposal of radioactive waste governs much of the work of Swedish safety authorities. In that regard, they are well aware of the important role that international organizations, especially the IAEA and NEA, play in gaining a common understanding among politicians, scientists, and the general public.

* For background on the two projects, see *INTRACOIN, Final Report Level 1 (1984), INTRACOIN, Final Report Levels 2 and 3* (1986), and *HYDROCOIN Progress Reports No. 1–2* (1985), Swedish Nuclear Power Inspectorate, Stockholm. Also see "Prospects of Model Validation Against Field/Laboratory Observations", by K. Andersson, presented at Nuclear Energy Agency second workshop on Systems Performance Assessment for Radioactive Waste Disposal, Paris (October 1985).