The back-end of the Swedish nuclear fuel cycle

by G. Schultz*

The Swedish nuclear programme is now perhaps better defined than that of most other countries as a result of developments in Sweden over the last few years. When after a long period of time a non-socialist government was elected in Sweden in 1976, public involvement in nuclear matters increased. This eventually led to the holding of a referendum on the future of nuclear power in Sweden in March 1980.

Three alternatives were put to the public. Alternative One suggested the completion of the present programme of 12 reactors and the use of those reactors for their technical lifetimes, or for as long as needed. Nuclear power should be abolished when possible, taking into account the demand for electricity, and the employment and welfare situation in the country. Alternative Two basically suggested the same as Alternative One though with some additional remarks of political nature implying that important future power plants should be publicly owned. Alternative Three suggested no further nuclear power and the closing down of the existing six operating reactors within 10 years. The result of the referendum was that Alternatives One and Two gained 58% of the votes and Alternative Three gained 38%. Polling was 75.7%. The results of this referendum were later interpreted in Parliament.

The Parliamentary guidelines for future nuclear policy state that the 12-reactor programme should be fulfilled and that the reactors should operate up to the year 2010, which means a 25-year operating period for the reactor last commissioned. A parliamentary commission has also been appointed to suggest ways of closing down the nuclear reactors and creating alternative sources of electricity production.

The 12 reactors, of which nine are now commissioned, are given in Table 1. For comparison, the nuclear programmes of some countries are given in Table 2.

The above situation for the Swedish programme constitutes a comparatively solid basis for future planning of the back-end of the nuclear fuel cycle and of the disposal of nuclear waste.

Table 1. Nuclear power stations in Sweden

Power station	Type of reactor	Net output (MWe)	Commissioned
Oskarshamn 1	BWR	440	February 1972
Oskarshamn 2	BWR	570	December 1974
Ringhals 2	PWR	800	May 1975
Barsebäck 1	BWR	570	July 1975
Ringhals 1	BWR	750	January 1976
Barsebäck 2	BWR	570	July 1977
Forsmark 1	BWR	900	December 1980
Forsmark 2	BWR	900	July 1981
Ringhals 3	PWR	915	September 1981
			Commissioning expected
Ringhals 4	PWR	915	1982
Forsmark 3	BWR	1 050	Autumn 1985
Oskarshamn 3	BWR	1 050	1986

Table 2. Relative national importance of nuclear electricity generation, 1981

Country	Total nuclear MW	TW(e) nuclear	Population 10^6	kW nuclear/inhab. year	% nuclear of total electr. generated
Sweden	6 400	34.1	8.2	4 200	35
Finland	2 200	14.0	4.8	2 900	34
Switzerland	1 900	14.5	6.4	2 300	28
France	21 600	99.5	54	1 800	38
Canada	5 500	37.8	24	1 600	10
USA	57 000	272.4	226	1 200	12
Belgium	1 700	12.2	9.9	1 200	25
Germany, F.R	8 600	49.6	61	800	14
Japan	15 000	85.1	118	700	17
UK	7 600	33.2	56	600	13

Source: IAEA Energy and Economic Data Bank.

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Assigning responsibility

In Sweden the responsibilities for nuclear waste are now fairly well regulated in special laws. However, these are comparatively new, and up to 1976 there were no specific provisions on this issue. With the non-socialist government in 1976 new conditions were imposed on the nuclear utilities. There was a general declaration of principles when the first government was formed, and this was followed by the so-called Stipulation Act. This Act stipulates that before the owner of a nuclear reactor will be allowed to load his reactor for the first time with fresh fuel he must show either that he has a satisfactory reprocessing agreement and is able to dispose of the high-level-activity waste in a completely safe way; or that he is able to dispose directly of the spent fuel in a completely safe way. The Act has, however, a special provision for Barsebäck 2 for which only a reprocessing contract is required. The Stipulation Act has been applied to Barsebäck 2, Ringhals 3 and 4 and Forsmark 1 and 2 all of which have been granted permits according to the law based on reprocessing contracts with Cogema*, and research-and-development work covering vitrified high-level waste from reprocessing. This work is performed under the direction of, and is totally financed by, the nuclear power utilities (the so called KBS project) [1]. The ultimate storage of unreprocessed spent fuel has also been studied [2].

The general picture with respect to all nuclear waste has been studied and has resulted in further legislation, the most important being the so-called Financing Act. This Act entered into force partly on 1 July 1981, and partly on 1 January 1982.

It is now legally established that the holder of a concession for a nuclear power plant carries full responsibility (technical and financial) for the nuclear waste he generates. Above that, the Swedish State carries the overall responsibility. In order to secure funds to cover the future costs of the back-end of the nuclear fuel cycle and of decommissioning of the nuclear power stations, the utilities have to pay a charge to the state proportional to their nuclear-generated electricity production. This charge is due from 1 January 1982, and amounts for the year 1982 to 0.017 SEK/kWh**. The money so collected is to be put into an interest-bearing account in the Bank of Sweden. The money is under the responsibility of a new authority, the National Board for Spent Fuel. This authority will later give permission to use the funds for their intended purpose and can also in the meantime grant loans to the utilities from the funds. Each year the Board shall suggest to the government the charge to be applied during the following year. The Board will also be kept informed of and scrutinize the planning and measures to be taken by the nuclear utilities for the management of the nuclear waste according to their responsibility. The responsibility for all phases of the work to be performed by the nuclear utilities – research and development, planning, erection, and operation has been entrusted to the Swedish Nuclear Fuel Supply Co (SKBF)* which is jointly owned by the Swedish nuclear utilities. The company will each year submit to the Board its future plans for the back-end of the fuel cycle, etc.

The Swedish nuclear utilities had in 1977 already pointed out their future financial obligation for the back-end of the nuclear fuel cycle in a letter to the Government, and requested tax exemption for the necessary internal funding. Parliament later decided accordingly and thus till January 1982, the future obligations of the Swedish nuclear utilities were covered by internal fundings. However, these must now be dissolved to the extent that they cover work under the Financing Act.

Current planning

With the background given above, SKBF has made general plans for the future to better define the technical measures that will have to be taken and the costs involved. To illustrate the future, a scenario has been chosen which is considered to be conservative especially with respect to economic calculations. This scenario is illustrated in Figure 1.

It can be assumed that this scenario will result in approximately 7000 tonnes of spent nuclear fuel. Sweden has reprocessing contracts for 867 tonnes. This amount of contracted spent fuel will be sent to the reprocessor and stored there before being reprocessed. Till now no shipments have been made to Cogema, but during this summer shipments of 140 tonnes will be completed to BNFL**. Shipments to France which comprise the remaining amount of spent fuel are planned to start late this year. For storage of low-active, medium-active, and high-active residues being sent back from Cogema in the future, SKBF is planning special facilities for temporary storage of such residues until they can be permanently and finally stored. It is not planned to start putting such residues into final storage until the year 2020 at the earliest.

For spent fuel not being reprocessed the first necessary facility is a temporary storage for spent nuclear fuel and such a facility is now under construction (more details are given below) and planned to be in operation in 1985. As an alternative, the direct disposal of spent fuel is also being studied within SKBF and a facility for this is included in the planning.

Another facility that is needed fairly urgently is a facility for the ultimate storage of low- and medium-level waste from the operation of nuclear reactors. Such a facility is now planned to be in operation in 1988.

* Compagnie générale des matières nucléaires, France.

** In April 1982 1 SEK was worth approximately US $0.17.

* Svensk Kärnbränsleförsörjning AB.

** British Nuclear Fuels Limited, UK.

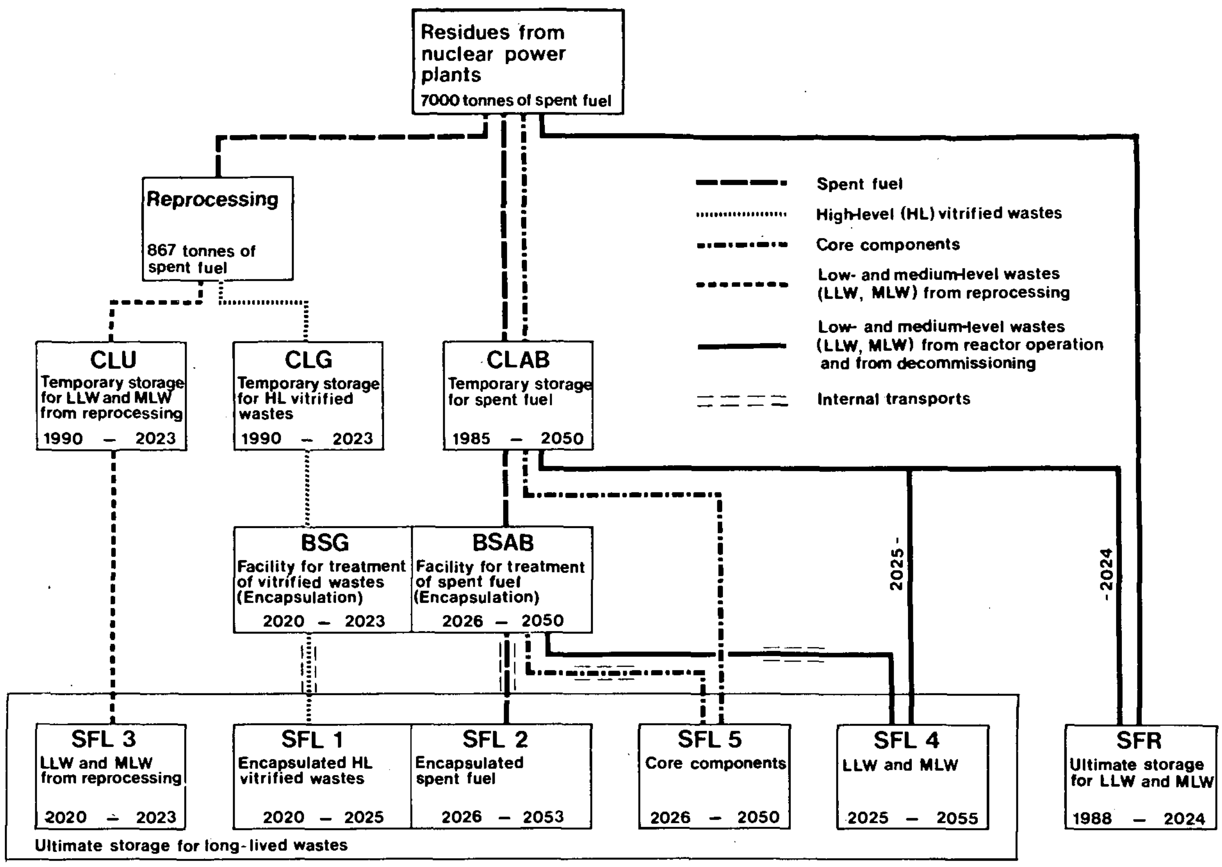

Figure 1. Scenario for the handling of radioactive residues from nuclear power in Sweden.

Current work

The R&D work aims at providing the data to realize the necessary storage and to be able to show that such final storage can be made with a very high degree of safety. All facets are covered within this programme and main emphasis today is on the very complex interactions between the waste, its natural surroundings, and the necessary man-made barriers.

A drilling programme has been started in the course of which a number of sites are to be investigated. This is done in order to characterize the sites with respect to their crystalline bed-rock and water-bearing capacity, and to obtain enough information to make it possible to choose a site for ultimate storage. Is is intended that this choice will be made towards the year 2000.

It should also be mentioned here that investigation of basic properties of Swedish crystalline rock is also going on within the framework of a four-year OECD* research project, the so-called Stripa project. This is administered by SKBF with the participation also of Canada, Finland, France, Japan, Switzerland, and the United States. In the old decommissioned iron-ore mine of Stripa in Sweden, an adjacent body of crystalline bed-rock is being investigated.

Means of transport are necessary for the Swedish scenario for the back-end of the fuel cycle. All the Swedish nuclear power stations are situated on the coast and thus a sea-transport system has been chosen and is now under procurement. A specially designed ship is under construction at the French shipyard Ateliers et Chantiers du Havre, and will be delivered towards the end of August this year. The ship has been designed by the Swedish firm Salén Technologies AB and will be owned by the Sofrasam company, a French subsidiary of SKBF (SKBF 68%, Cogema 32%), which will also be responsible for the operation of the transport ship. The operation will be entrusted to the French company Compagnie Maritime Chargeurs Réunis. The first duties of the ship will be to transport spent nuclear fuel from Sweden to France. Later on when the facility for intermediate storage of spent fuel, Clab, is in operation (in 1985) the ship is also intended to transport spent nuclear fuel from the nuclear power plants to this facility, which is situated at one of the plant sites, Oskarshamn.

* Organization for Economic Co-operation and Development.

TECHNICAL DATA	
Length overall	90.60 m
Breadth	18.00 m
Depth	6.65 m
Draught	4.00 m
Deadweight	abt 1900 tons
Payload	abt 1200 tons
Engine Power	2x 1590 HP
Speed	11 knots

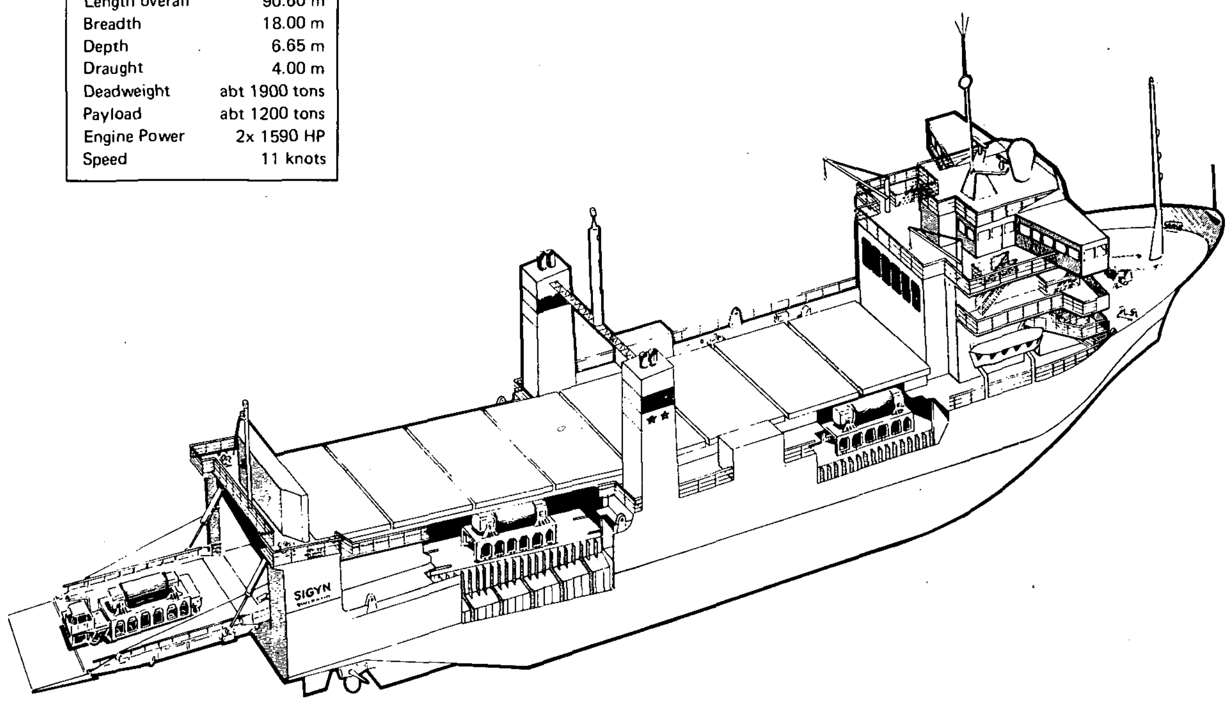

Figure 2. Layout of the transport vessel.

The transport ship (Fig. 2) is built for ocean traffic and is designed so that the cargo can be taken on board either by a transport vehicle via an after-ramp, or by crane through hatches that form the roof of the hold. The hold has double boards and a double bottom. The ship is equipped with twin engines and propellers. It has a bow thruster and twin rudders and is also classified for operation in ice. The walls between the hold and the deckhouse and between the hold and the engine rooms are built to function as radiation shields. Hence no special restrictions will be required from the viewpoint of radiation protection for the working areas and the living quarters.

SKBF is also currently building a temporary storage for spent fuel, Clab, which is being built to the following specifications:

Storage capacity: 3000 tonnes of uranium
Receiving capacity: 300 tonnes of uranium/year
Four storage pools and one in reserve
Approx. 3000 m^3 of water per pool
Water depth approx.: 12.5 m
Operating water temperature: 32°C
Pool design temperature: 100°C

The spent nuclear fuel resulting from the operation of Swedish reactors till around the year 2000 can be accommodated by this storage facility, with its design capacity of 3000 tonnes of uranium, together with the storage pools at the reactor sites.

The storage pools will be situated in a rock cavern of approximately 65 000 m^3, the rock cavern being about 120 m long, 21 m wide, and with a height of 27 m. The thickness of rock cover will be 25 to 30 m. Clab is situated at the site of the Oskarshamn reactors close to the small town of Oskarshamn in southern Sweden. The main feature of the facility can be seen in Figure 3. The total cost is estimated at about 1200 million SEK (1981 prices).

The next facility needed in Sweden is the final repository for low- and medium-level waste from reactor operations. This storage facility is also planned to be built in a rock cavern. The plans for this facility are now quite advanced and the application according to the Environmental Protection Act was submitted to the Government in late March 1982. It is planned to locate the repository at the Forsmark site. The total volume of the rock cavern will be around 500 000 m^3,

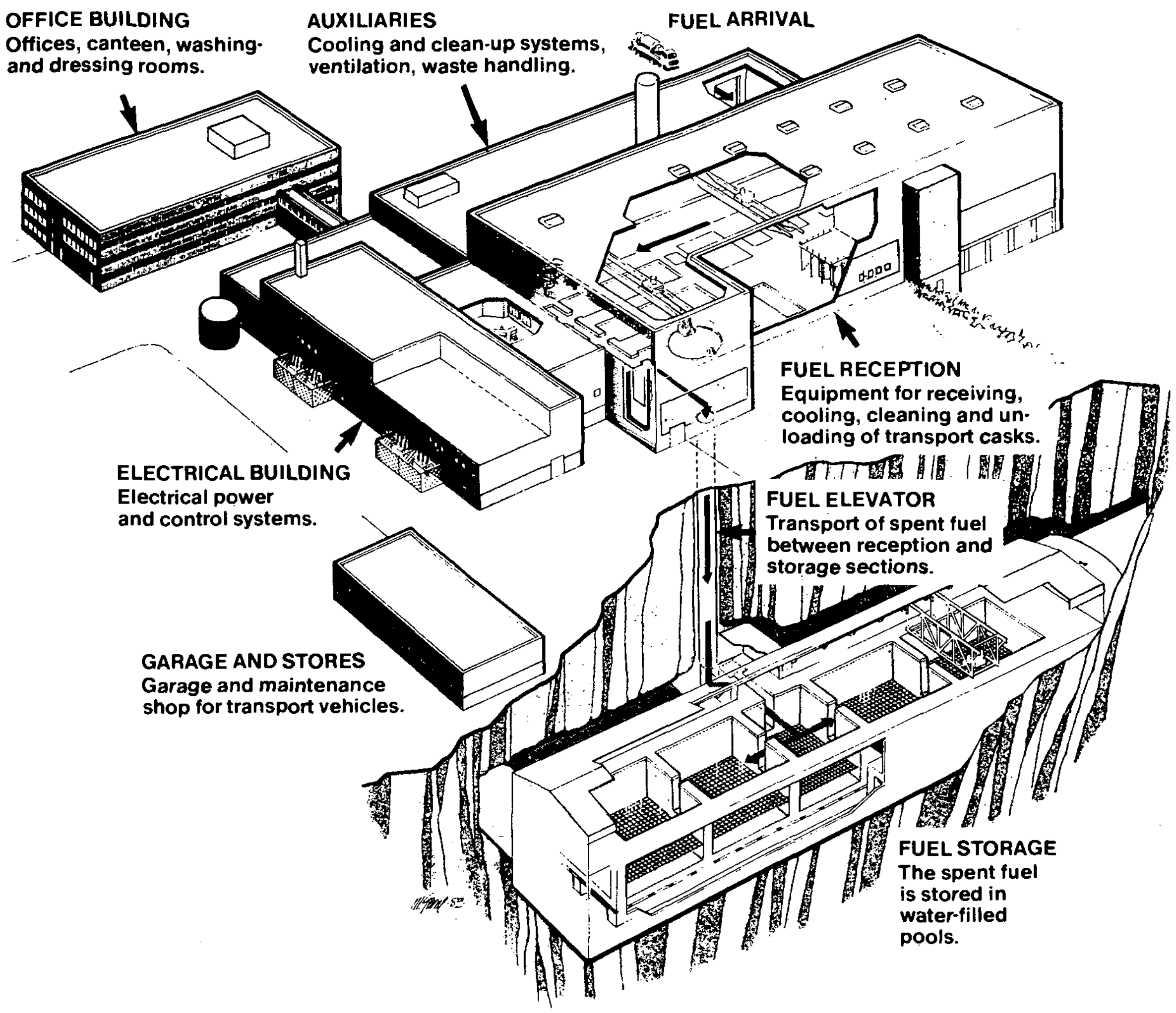

Figure 3. Temporary storage for spent fuel, Clab.

the volume for storage about 250 000 m^3. It is projected to excavate the cavern under the Baltic Sea with the help of tunnels from the shore where the entrance will be situated. The cavern will have a rock cover of about 50 m and above that 5–10 m of sea-water.

This facility will have the capacity to ultimately store the low- and medium-level waste resulting from the operation of the Swedish reactors in accordance with the Parliamentary guidelines for the future operation of the reactors. It is planned that the facility will be ready to receive waste in 1988. The total cost including that of operations until the final sealing of the storage is estimated at about 1.1 million SEK (1982 prices).

References

[1] Handling of spent nuclear fuel and final storage of vitrified high-level reprocessing waste, KBS, Dec. 1977.
[2] Handling and storage of unreprocessed spent nuclear fuel, KBS, Sept. 1978.