SKB

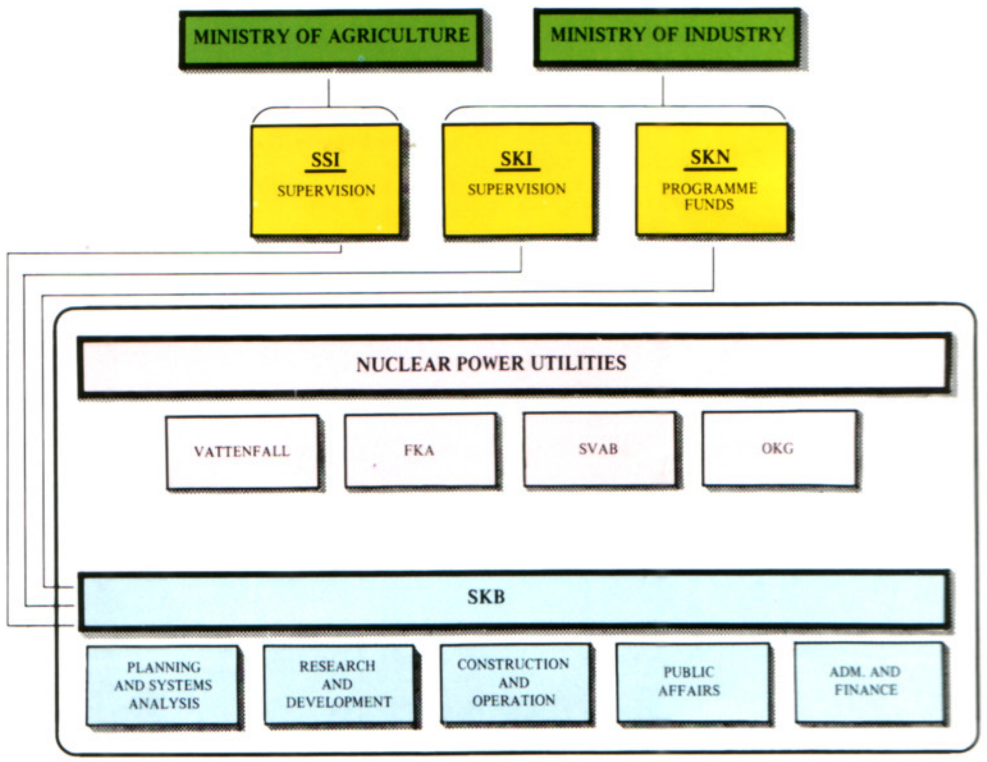
SWEDISH NUCLEAR FUEL AND WASTE MANAGEMENT COMPANY

ACTIVITIES

SKB – SWEDISH NUCLEAR FUEL AND WASTE MANAGEMENT COMPANY

Svensk Kärnbränslehantering AB, SKB (Swedish Nuclear Fuel and Waste Management Company), has been given the assignment by the Swedish nuclear power utilities to develop, plan, build and operate facilities and systems for the management and disposal of spent nuclear fuel and radioactive waste from the Swedish nuclear power stations.
SKB is also in charge of the extensive research activities within the field of nuclear waste which, according to Swedish law, is the responsibility of the Swedish nuclear power utilities.

SKB handles matters pertaining to prospecting, enrichment and reprocessing services as well as stockpiling of uranium for the Swedish nuclear power industry and provides assistance at the request of its owner utilities in uranium procurement.
SKB is owned by the power utilities in Sweden that produce electricity in nuclear power stations: Forsmarks Kraftgrupp AB (FKA), OKG Aktiebolag, Sydsvenska Värmekraft AB (SVAB, owned by Sydkraft AB, South Sweden Power Supply) and Vattenfall (the Swedish State Power Board).



SSI — National Institute of Radiation Protection, SKI — Swedish Nuclear Power Inspectorate, SKN — National Board for Spent Nuclear Fuel

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The Swedish Nuclear Fuel and Waste Management Company (SKB), previously the Swedish Nuclear Fuel Supply Company, was formed in 1972, principally to work with matters relating to supplying the Swedish nuclear power stations with nuclear material and services within the nuclear fuel cycle.

Since then, a shift of emphasis has taken place within the company so that the dominant activities today are associated with the management and disposal of spent nuclear fuel and radioactive waste.

The basis of SKB's planning and activities is the Swedish nuclear programme and what Parliament has decided concerning future Swedish nuclear power production.

This programme entails the handling and storage of spent nuclear fuel and radioactive waste from twelve nuclear power units with a total capacity of 9 500 MW, which are not to be operated beyond the year 2010.

As from 1985 45—50% of the electricity produced in Sweden will be generated by nuclear power stations.

According to Swedish law the nuclear utilities have the responsibili ty for measures needed to realize a safe system for the handling and final disposal of spent nuclear fuel and waste. This responsibility also includes the financing of the total costs.

The nuclear power utilities have delegated to their jointly owned company, SKB, the coordination, planning, design, construction, and operation of the facilities needed as well as the necessary R&D work.

The completion of the above-mentioned twelve-reactor programme during 1985 entails a transition for the SKB owners from an intensive period of construction to a more operational period. To some extent this is also the

case for SKB. A number of important goals have been achieved in recent years. These include comissioning of a transportation system for spent nuclear fuel including a special ship (Sigyn), construction of the CLAB (Central interim storage facility for spent fuel) and approval of the KBS 3 disposal method as a basis for the Government's fuelling licence for the F3 and O3 reactors at Forsmark and Oskarshamn, respectively.

Ongoing construction projects are the final repository for low- and medium-level waste, SFR, which is under construction at Forsmark and the associated transportation system for low- and medium-level waste.

Important objectives for SKB in the future will be , in cooperation with the owners, to operate the storage and disposal facilities and transportation system in a manner acceptable to society at optimum efficiency and minimum cost.

Particularly important is the R&D work, which will be conducted for the purpose of further developing and testing various options for the final disposal of spent nuclear fuel and other long-lived radioactive waste. Great importance is attached to international research cooperation.

Sweden today is completely dependent on imports of uranium and certain services within the nuclear fuel cycle.

The emphasis of SKB's future front-end activities will be on supply problems of a common nature faced by the power utilities. Together with its owners, SKB shall also work for effective action and cooperation to ensure security of supply and good economy.

Stockholm, November 1985

Sten Bjurström

Sten Bjurström
President

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NUCLEAR FUEL SUPPLY

The Swedish nuclear power programme has an annual natural uranium demand of about 1 300 metric tons. Most of this demand has been covered up to 1990 through long-term contracts between the nuclear power utilities and producers in Canada and Australia. The necessary enrichment of the uranium takes place at plants in the United States, the Soviet Union and France.

Within the nuclear fuel supply area, SKB is charged with analyzing demand etc, arranging for coordinated uranium purchases, representing the power utilities in certain matters of joint interest, and providing for strategic stockpiling and uranium prospecting in Sweden.

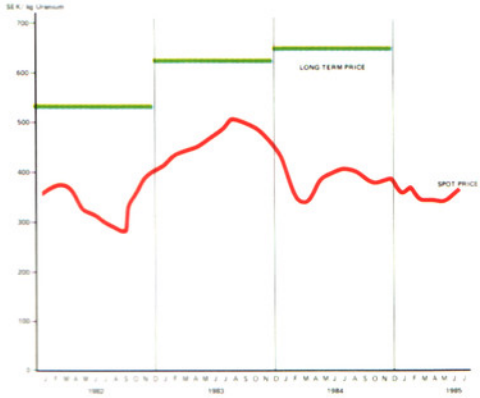
Sweden's supply of uranium today is based entirely on imports. Present-day suppliers are found in Australia, Canada, the United States and France. France supplies uranium from Niger and Gabon in Africa. Approximately 90% of the deliveries are made under long-term contracts. Canada is responsible for about 50% of the deliveries. Up to 1990, the demand amounts to about 7 800 metric tons, of which 6 800 tons had been contracted for in the middle of 1985.

Natural uranium is normally delivered in the form of uranium concentrate. The concentration of fissionable material in the form of uranium-235 in natural uranium is about 0.7%. In order for natural uranium to be used for nuclear fuel in the Swedish light-water reactors, it must be enriched to a uranium-235 concentration of about 3%. This is done in an industrial process where the crude uranium is converted to uranium hexafluoride, which is then enriched. Sweden contracts for conversion services in Canada, the United States, England and France. Enrichment is done in the USA, the USSR, at Eurodif's plants in France and at Urenco's plants in Holland, England and West Germany.

Sweden has considerable uranium resources. Most of the proven reserves consist of relatively low-grade shale deposits (Ranstad) with about 300 g uranium per ton of shale. These deposits are not exploitable at the present-day low price of imported uranium.

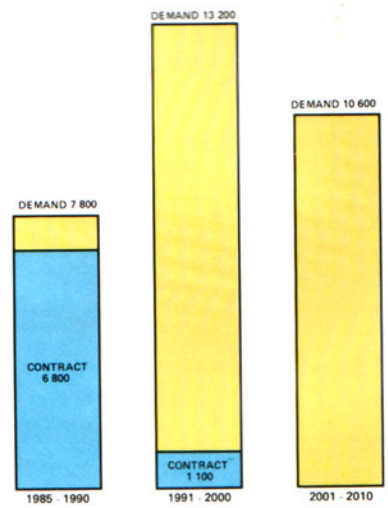
Uranium also occurs in relatively high concentrations in certain parts of the Swedish Precambrian rock. SKB is therefore conducting prospecting at a number of places within the bedrock in the northern part of Sweden. Mineralizations of at least 6 000 metric tons or uranium have been found with concentrations higher than 1000 g per ton. These ores constitute important reserves for the future.

Uranium is currently offered on the world market at favourable prices, so no mining surveys are being conducted today by SKB.



The figure shows the price for long-term contracts on the one hand and the spot price on the other hand. The long-term price is the average price for imports to the European Community. The spot price is the market quotation according to the West German company NUKEM.

Eurodif's plant for uranium enrichment at Tricastin in France.



Of the Swedish natural uranium demand up to 1990, 6 800 metric tons had been contracted for as of mid 1985. The relationship between demand and contracted supply for the coming decades is shown above.

The uranium plant at Key Lake, Saskatchewan, Canada, from which uranium is delivered to Sweden.

Containers of enriched uranium in SKB's strategic stockpile. Uranium in strategic stockpiles, under fuel fabrication and at the nuclear power stations is sufficient for about two years of operation.

Uranium deposits have mainly been found at Ranstad and at Lilljuthatten. During 1983, SKB prospected in Arjeplog, Arvidsjaur, Boden, Ånge/Härjedalen, Åsele and Östersund/Ragunda as well as in the area around Lilljuthatten.

THE TRANSPORTATION SYSTEM

Every year, 20—30% of the fuel assemblies in the Swedish reactors are replaced, which means that a total of about 250 metric tons of spent nuclear fuel (calculated as uranium) must be taken care of. The fuel is first stored for at least one year in a storage pool at the reactor, after which it is transported for central interim storage in the CLAB facility (central storage facility for spent fuel).

Spent fuel and other radioactive waste is transported by sea by the specially-designed ship Sigyn. During transport, the highly radioactive fuel is kept in radiation-shielded casks weighing 80 tons and able to hold approximately 3 tons of fuel.

The transport casks protect the environment from harmful radiation and the transported fuel from damage. The casks are extremely strongly built and can withstand falls from high heights, immersion to great water depths, heating etc. without losing their integrity. The transport casks meet the international regulations and recommendations issued by the IAEA (The International Atomic Energy Agency in Vienna).

All Swedish nuclear power installations, as well as CLAB, are located along the coast. A sea transport system has therefore been built up, consisting of the ship and terminal transport vehicles which convey the transport casks from the ship's hold to the various facilities and vice versa. The same ship and the same type of vehicle will be used later for transporting low- and medium-level wastes from the nuclear power stations to the final repository for reactor waste — SFR. Such waste is transported in a simpler type of transport cask which, however, will have about the same weight with contents as the fuel casks.

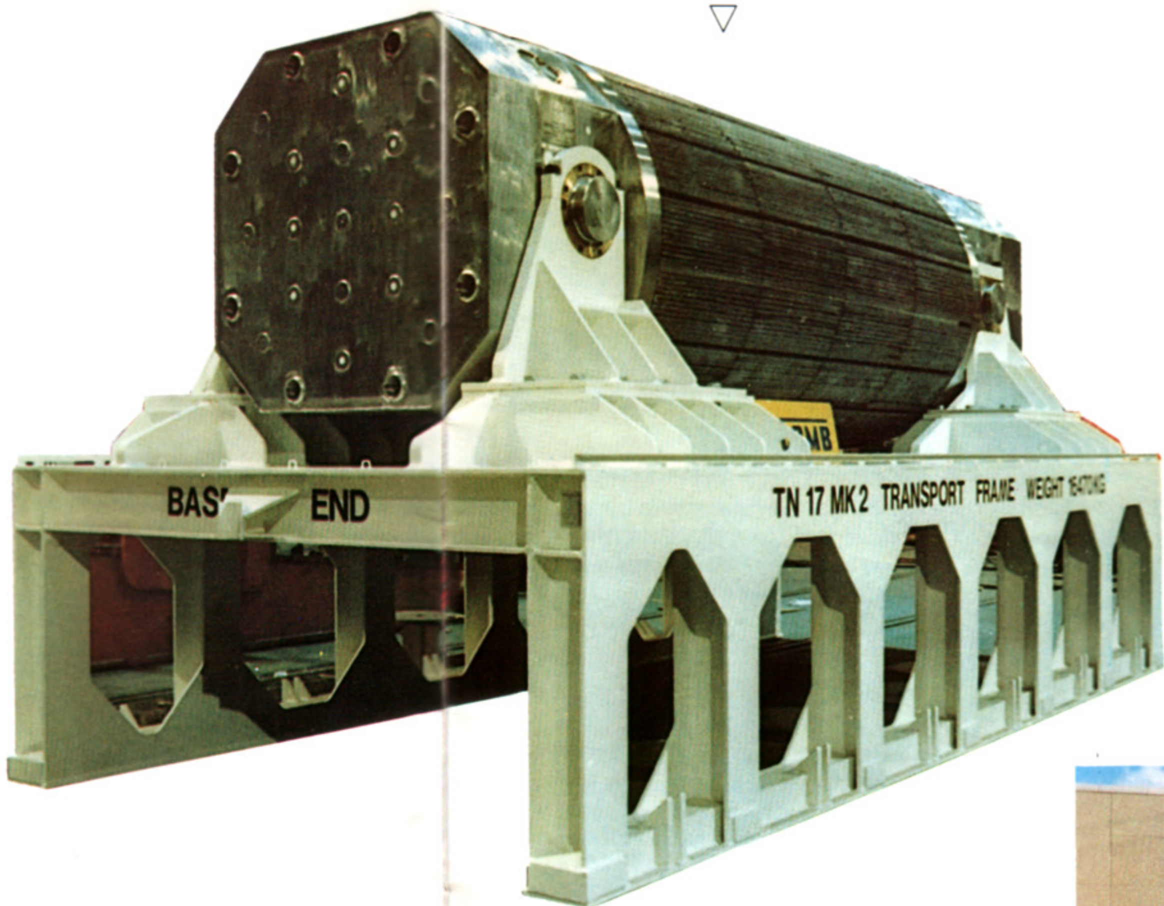
M/S Sigyn, which was used during 1983 for fuel shipments from Sweden to France, is a combined roll-on/roll-off & lift-on/lift-off vessel, which means that the cargo can either be driven directly into the hold via an opened stern ramp or lifted on board by means of shore-based cranes. In roll-on/roll-off handling, which is the normal method used at the Swedish plants, the aforementioned transport vehicle is used in order to make the handling fast, safe and efficient.

The ship is built for unrestricted worldwide service and is specially designed for her purpose. Machinery, electrical system etc. are duplicated for higher reliability and the cargo hold is surrounded by a double hull and a double bottom. This ensures very high floatability and protects the cargo in the event of a serious collision or grounding. After one year's operating experience, a few minor modifications have been made — the bow thruster has been duplicated, making the ship easier to manoeuvre in narrow harbours.

◁ *M/S Sigyn is a ship for transporting spent nuclear fuel and other radioactive material. Length 90 metres, breadth 18 metres and draught 4 meters. Payload capacity max. 1 400 metric tons.*

Containers made of steel are used for transporting medium-level waste from reactor operation. ▷

The main components of the transport cask are body with stainless steel lining, copper fins for heat dissipation, neutron shield lid system with shock-absorbing covers at both ends, removable basket of neutron-absorbing material with channels for the fuel assemblies and lifting trunnions. ▽



The sea transports of spent nuclear fuel and radioactive waste will entail approximately 30 trips a year starting in 1985 for M/S Sigyn from the Swedish nuclear power stations to the CLAB at Oskarshamn and as from 1988 to the SFR at Forsmark.

A transport vehicle accompanies the ship and is used for loading and unloading and terminal handling of the transport casks.
While in transit, the transport cask is placed on a load carrier, which acts as a transport frame as well as a support for the cask while parked awaiting further transport. The transport vehicle is manoeuvred in under the load carrier and lifts it when the bed is raised hydraulically. ▷

INTERIM STORAGE IN THE CLAB

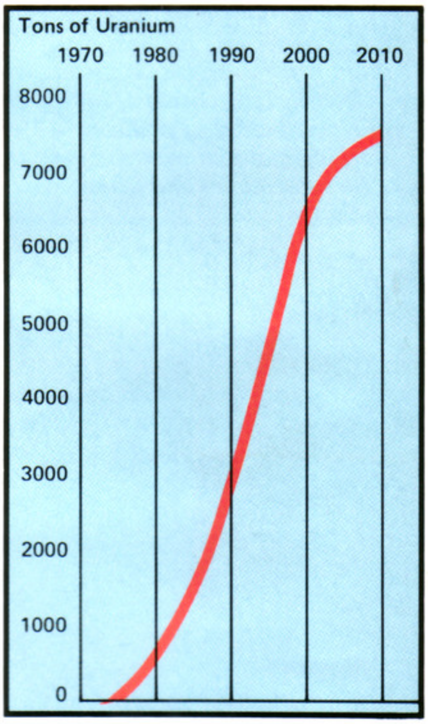
The Swedish system for the management and disposal of spent nuclear fuel is based on interim storage for 30—40 years prior to final disposal. For this purpose, SKB has built the CLAB facility. The fuel storage pools at the nuclear power stations have a capacity to store spent fuel from 3—8 years of operation. In order to expand capacity for storing fuel over a longer period of time, a central storage facility for spent fuel, CLAB, has been built adjacent to the Oskarshamn power station. The CLAB is able to receive fuel from all Swedish nuclear power stations for intermediate storage for a period of 30—40 years before final disposal can be commenced (see the SFL section).

Construction work on the CLAB facility at Simpevarp was begun in 1980 and the facility received fuel for the first time in July 1985. The storage pools now built can hold 3 000 metric tons of spent fuel, which is enough up until the mid 1990s. One or two additional expansions are required in order for all fuel from the 12 reactors to be accomodated — 7 500 metric tons (uranium).

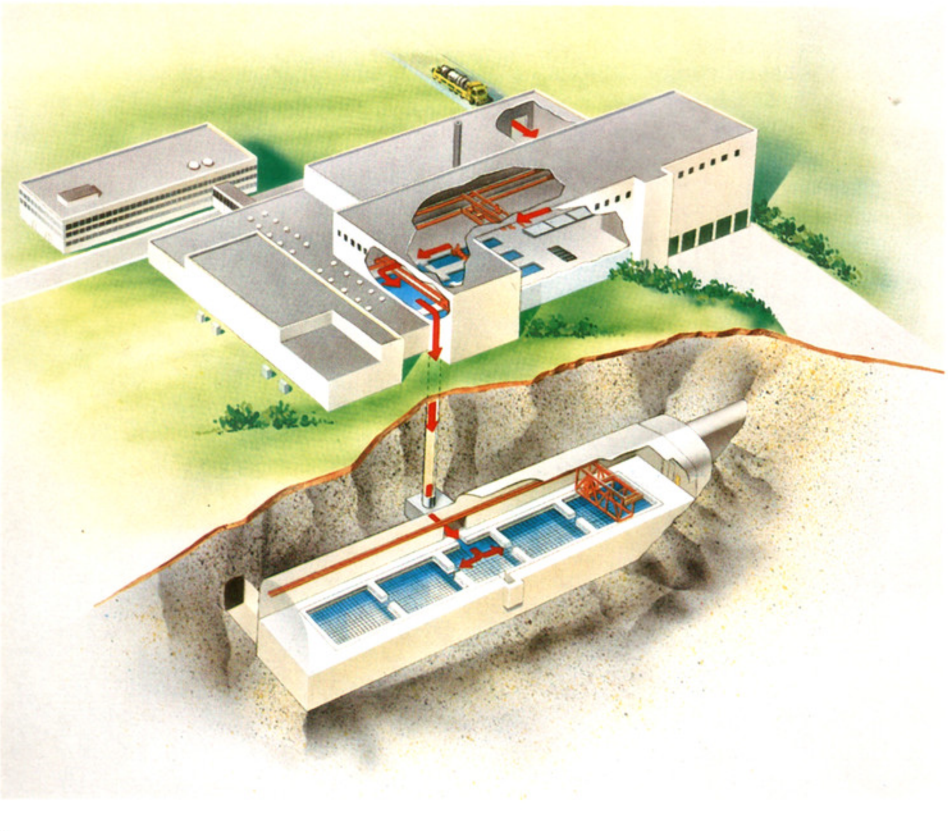
Receiving of the transport casks containing the spent fuel takes place in the CLAB in a surface building, while storage takes place in pools in a rock cavern whose roof is located about 25 m below ground level. Facilities for power supply, water treatment, ventilation, personnel quarters etc. are also located on the surface. Communication with the rock cavern is provided through well-protected shafts. All handling and storage of the fuel assemblies will take place under water, which functions as a radiation shield while simultaneously cooling the fuel. Transport down to storage will also take place in a water-filled container that runs in its own elevator shaft.

The total cost for erecting the CLAB is estimated at about SEK 1 700 million, at the 1985 price level, distributed equally between design, civil construction and systems installations.

When finished, the CLAB will have an operating staff of about 70 persons. OKG AB has been subcontracted by SKB to be locally responsible for operation of the CLAB.

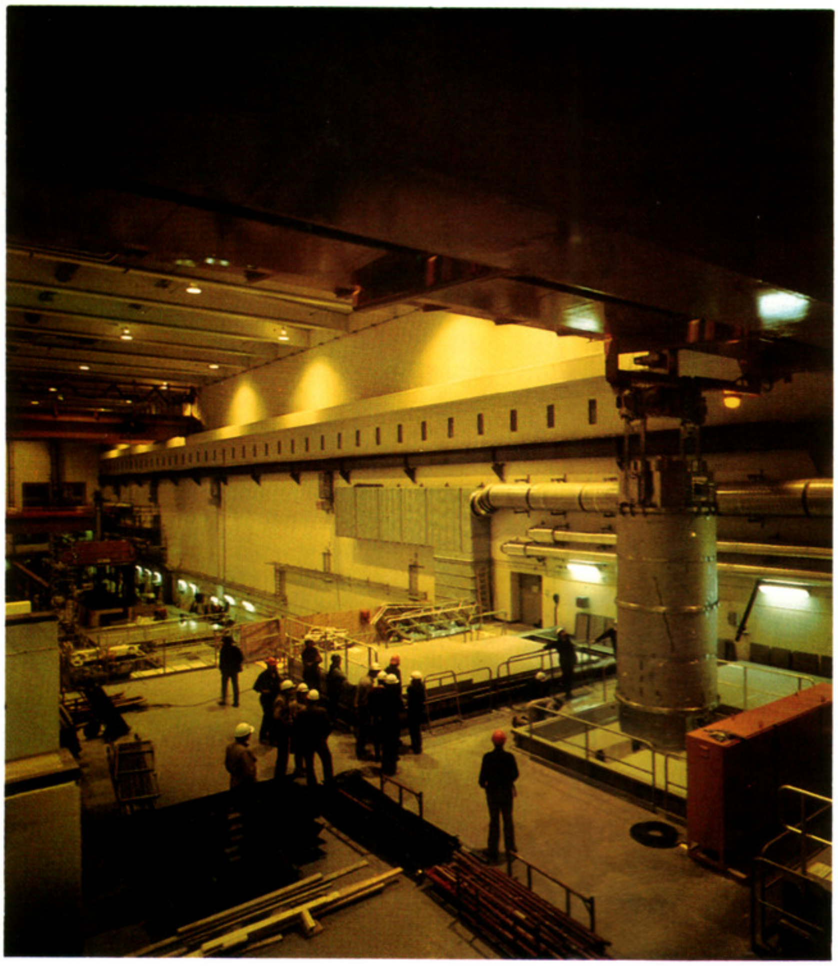


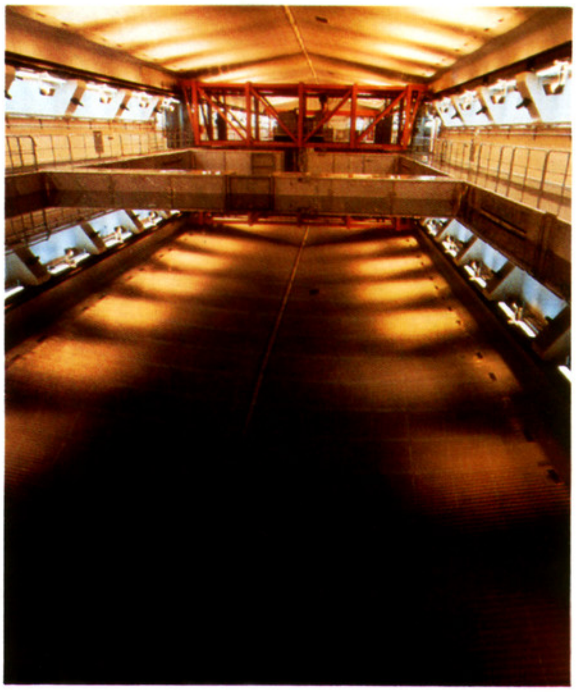
The estimated total quantity of spent nuclear fuel from the Swedish nuclear power programme contains approximately 7 500 metric tons of uranium. The figure shows how the quantity of spent nuclear fuel increases with time.



◁

On the surface, the CLAB consists of a receiving section for receiving and unloading of incoming transport casks. The storage cavern is located 25 metres below the surface. It is 120 metres long, 21 metres wide, 27 metres high and contains four water-filled pools for fuel storage and a central pool that connects to a transport shaft.





The storage pools are made of concrete, lined with stainless steel. Each pool holds 3 000 m³ of water and 750 tons of spent fuel standing in storage canisters.

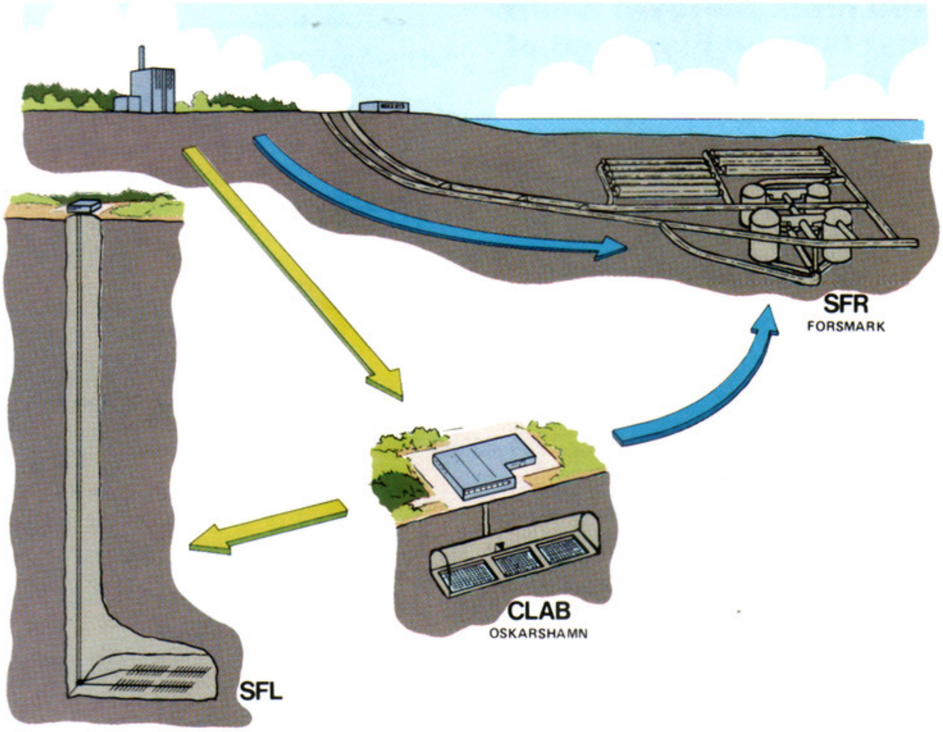
The CLAB's receiving hall. The excavation and civil engineering work began in May 1980. The construction work is now concluded and the facility started operating in July 1985.

After about a year of storage in the fuel storage pools at the nuclear power stations, the spent nuclear fuel will be taken to the CLAB interim storage facility.

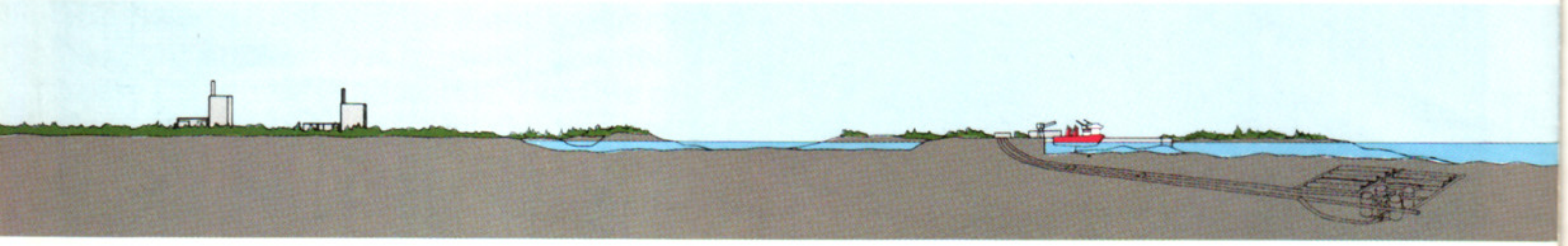
The CLAB constitutes an extension of the nuclear power stations' fuel storage pools. But the facility is operated separately and is completely independent of operation at the nuclear power stations. The CLAB will be operated even after the nuclear power stations have been decommissioned.

During storage in the CLAB, the activivy and heat flux of the fuel decays. It therefore becomes easier to handle when the time comes to transfer it to the SFL for final disposal around the year 2020.

The low- and medium-level waste that results from operation in a nuclear power reactor is temporarily stored at the nuclear power stations. At present, a final repository for reactor waste — SFR — is being constructed.



FINAL REPOSITORY FOR REACTOR WASTE – SFR



The SFR is being built adjacent to the Forsmark nuclear power station and will accommodate the Swedish nuclear power industry's low- and medium-level operating waste, so-called reactor waste. Most of the reactor waste consists of filters and ion exchange resins that have been used for cleaning the water systems in the nuclear power stations. A small amount of similar radioactive waste from other industry, research institutions, and hospitals will also be disposed of in the SFR.

The activity of the low- and medium-level waste that is to be disposed of in the SFR will have declined to a harmless level after about 500 years.

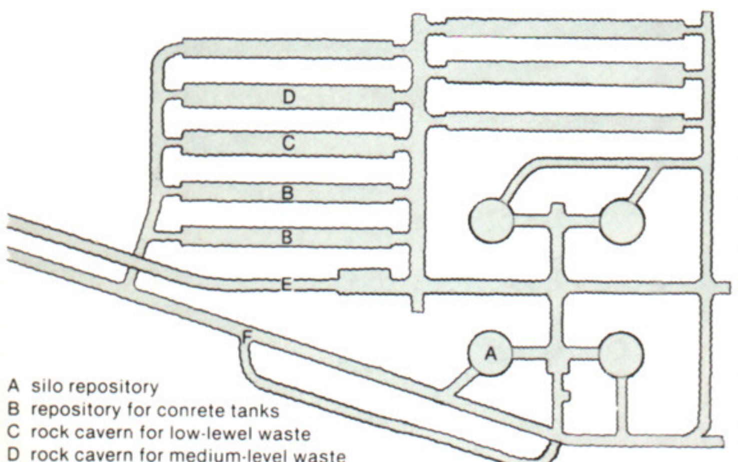
The entire repository section is situated in rock, 50 metres below the seabed. The rock on the repository site is of such quality that stable caverns with large spans can be excavated there. The horisontal sea-level above the repository eliminates the driving force for groundwater flow in the fissures of the rock mass. The groundwater around the repository will thus be nearly stagnant. The water depth is also sufficient so that the rock will not rise above the surface of the water due to the ongoing land uplift within the next 1 000 years.

In March of 1982, SKB applied to the Government for a licence to build a final repository for reactor waste, SFR, at Forsmark. On 22 June 1983, the Government granted the licence, and in August of the same year construction work on the repository started.

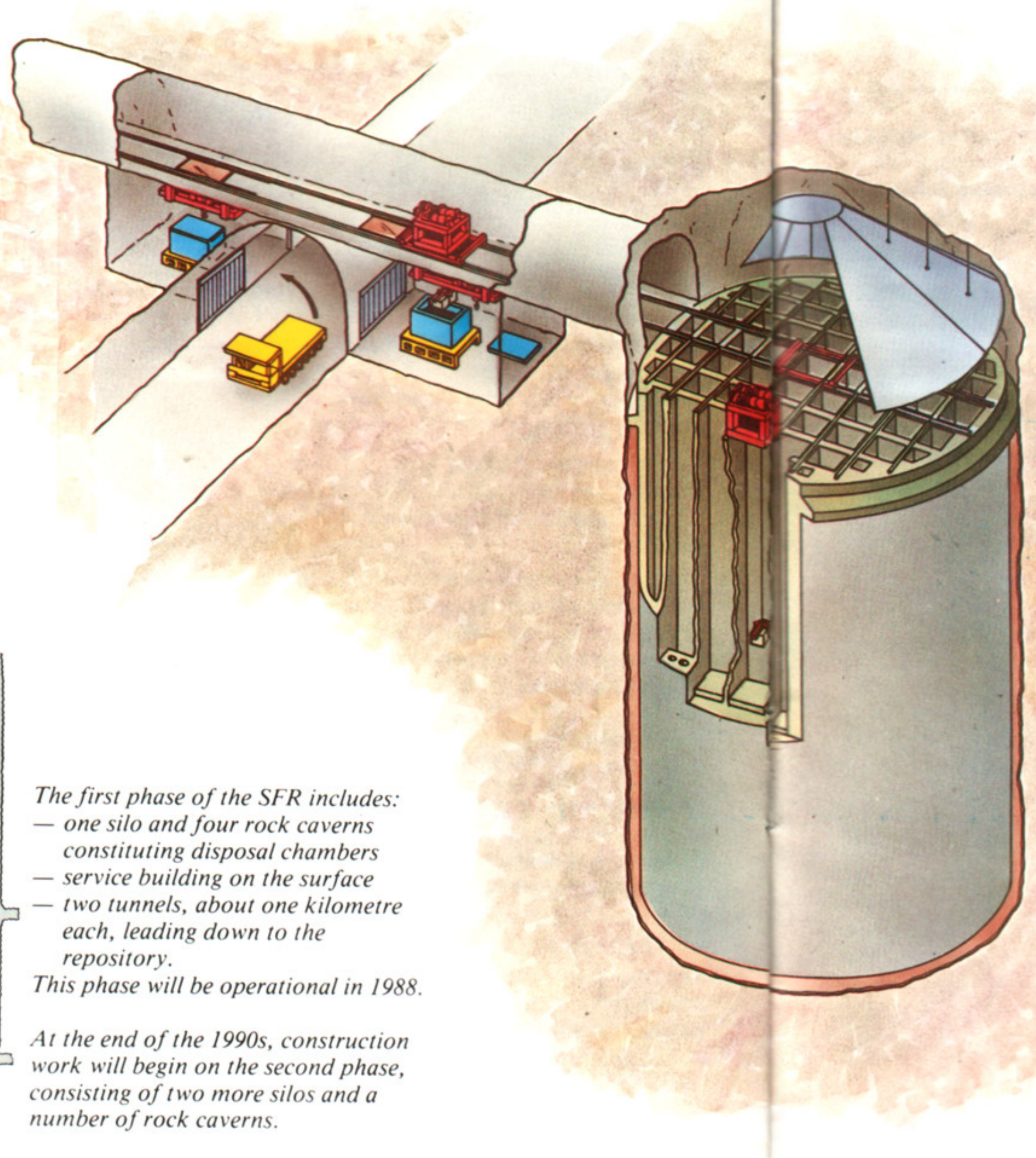
The repository will consist of rock caverns of differing design, depending on the type of waste to be disposed of there. The medium-level waste, which contains most of the radioactive substances, will be deposited in concrete silo-like structures situated inside a cylindric rock cavern and isolated from the rock by a layer of clay (bentonite).

The low-level waste is deposited directly in rock caverns designed for the particular type of containers being used for such wastes.

The total waste volume is estimated at 90 000 cubic metres. The SFR will be built in two phases. The first phase will be completed and commissioned in 1988, the second is planned for the end of the 1990s.



A silo repository
B repository for conrete tanks
C rock cavern for low-lewel waste
D rock cavern for medium-level waste
E operating tunnel
F construction tunnel



The first phase of the SFR includes:
- *one silo and four rock caverns constituting disposal chambers*
- *service building on the surface*
- *two tunnels, about one kilometre each, leading down to the repository.*

This phase will be operational in 1988.

At the end of the 1990s, construction work will begin on the second phase, consisting of two more silos and a number of rock caverns.

Blasting work for the entrance tunnels to the SFR began in August 1983. In the beginning of 1985 the two tunnels reached the storage area one kilometre outside the harbour at Forsmark.

During the construction period, a testing and demonstration programme will be conducted including studies of both waste and barriers. A series of laboratory experiments will be carried out in 1985 and later followed up with test series. The testing programme will provide more detailed information on groundwater movements in the rock and the protective capacity of the other barriers in the given environment.

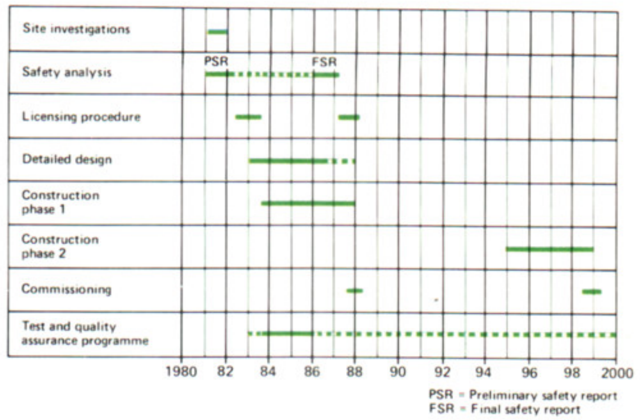
The probable level of the actual dose from the SFR is less than 1/1 000th of the natural background radiation in the area today.

The licence application for the SFR was based on a preliminary safety report from SKB. The report has been reviewed by the Swedish Nuclear Power Inspectorate and the National Institute of Radiation Protection. A final safety report will be submitted to the authorities for review and approval before the repository is taken into service.

The total cost of the SFR is estimated at SEK 1 250 million. This is broken down into SEK 950 million in construction costs, SEK 240 million in operating costs up to the time all the waste has been deposited and SEK 60 million in sealing costs, all in 1985 prices.

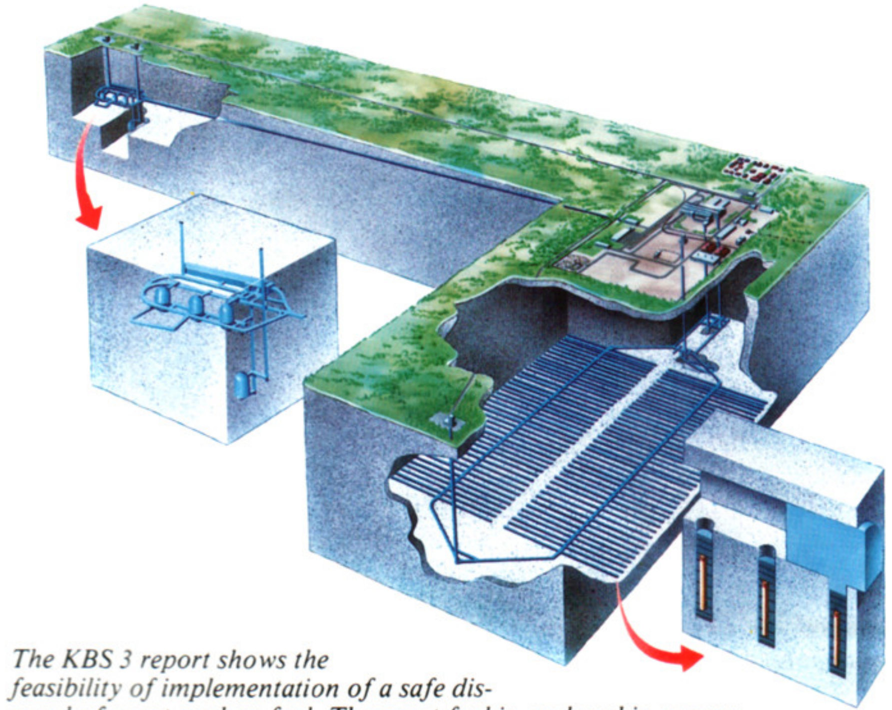
◁ *Since the silos will contain most of the radioactive substances in the SFR, they have been provided with the most qualified barriers. They consist of the waste package itself and a concrete backfill, the silo wall of concrete, the clay fill between the silo and the rock and, finally, the surrounding rock mass.*

The SFR is being constructed in two phases. The first phase will be commissioned in 1988. Phase 2 will be built at the end of the 1990s. ▷



FINAL REPOSITORY FOR HIGH-LEVEL AND LONG-LIVED WASTE – SFL

According to Swedish law, the nuclear power utilities are obligated to ensure that the radioactive waste products of nuclear power are disposed of in a safe manner — in both the short and the long time perspective. The function of the Government and national authorities in this context is to lay down the safety requirements and to regulate and supervise the activities of the power utilities.



The KBS 3 report shows the feasibility of implementation of a safe disposal of spent nuclear fuel. The spent fuel is enclosed in copper canisters, which are deposited 500 metres down in the Swedish crystalline bedrock. Both natural and engineered barriers prevent the radioactive substances from reaching the biosphere in harmful concentrations.

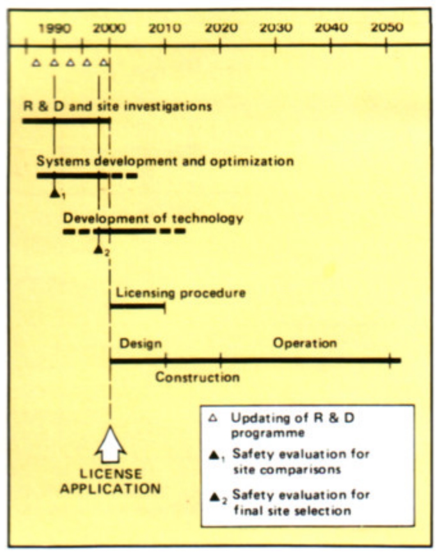
The Act on nuclear activities that entered into force on 1 February 1984 contains, like previous legislation, requirements that new reactors may only be taken into operation if the owner has demonstrated a method for safe handling and disposal of the spent nuclear fuel. The Act also requires that the reactor owners produce a plan for the research and development work that is required to implement the final disposal scheme. The plan shall be updated for review and submitted every three years to the authorities.

The research report KBS 1 was presented to the Government in November 1977 together with an application for fuelling permission for Ringhals 3 and Forsmark 1 and later also Ringhals 4 and Forsmark 2. It was based on the assumption that the spent nuclear fuel would be reprocessed, which was then regarded as a preferable option.

The following year KBS 2 was published, which was based on direct disposal of the spent nuclear fuel without prior reprocessing.

KBS 3 — which was appended to the fuelling permit application for Forsmark 3 and Oskarshamn 3 and submitted to the Government in May 1983 — proceeded further with the method introduced in KBS 2, but with a much broader base of knowledge and resulting modifications.

In June 1984, the Government granted fuelling permission on the basis of the KBS 3 report and after extensive domestic and foreign specialist review. The Government has thereby arrived at the conclusion that the Swedish reactor operators have satisfied the requirements of the Act by demonstrating that a method exists for the handling and final disposal of spent nuclear fuel and radioactive waste deriving from it which is acceptable with regard to safety and radiation protection.



Overall timetable presented in SKB's programme for research and development. The timetable presumes that a site for the final repository will have been chosen and approved by the authorities by the year 2010.

Four fundamental principles

The Swedish nuclear waste management programme is characterized by:

— very high safety requirements, both in a short and a long time perspective
— the use of technology available today
— the greatest possible independence of other countries
— no burdens on future generations

In principle, final disposal according to KBS 3 is simple: The spent nuclear fuel is encapsulated in tight copper canisters, which are deposited 500 metres down in the crystalline bedrock. When the repository is full, all shafts and tunnels are backfilled and sealed, after which the repository does not require any further surveillance. The safety of the repository is based on the fact that degradation of the canisters and subsequent transport of their contents with the groundwater to the surface of the ground will take such a long time that the radioactive substances will decay and be diluted to such a degree that they reach the biosphere only in harmless concentrations.

Site investigations

Under the management of SKB test drillings are being conducted in the bedrock in order to gain further knowledge of the geological conditions prevailing on different potential disposal sites.

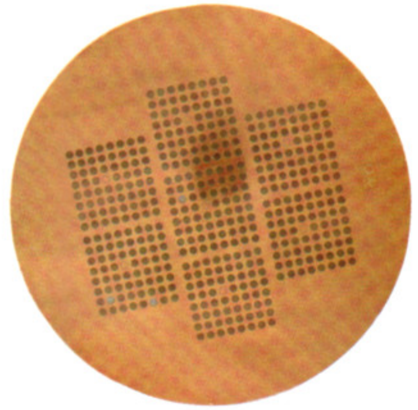
The primary objective is to study the properties of the bedrock, the pattern of fracture zones and the physical and chemical conditions of the groundwater. The investigations are performed in and adjacent to rock formations that can be expected to be large enough to host all the spent fuel, around 7 500 metric tons, that has been generated up to the year 2010. The geological conditions play a decisive role in the final choice of repository site. But demographic factors, transport conditions and economics must also be taken into consideration. All of this justifies investigating a large number of areas in order to obtain comprehensive knowledge and data to serve as a solid basis for a screening process and siting decision some time around the turn of the century.

Encapsulation of the fuel

Once the site has been chosen and the facility is ready to receive the spent nuclear fuel, it will be transferred from the CLAB interim storage facility at Oskarshamn to the final repository.

Prior to final disposal, the fuel assemblies will be encapsulated in copper canisters which will then be lowered into the repository about 500 metres down in the rock.

Sites which SKB has investigated during the period 1977—85.



Cross-section of a copper canister with seven simulated fuel assemblies from a boiling water reactor. A copper canister with lid and filled with fuel and copper powder has been compressed under high temperature and pressure into a solid unit.

In the repository, the canisters will be placed in vertical deposition holes drilled from the floor of the repository tunnels. In each deposition hole, the canister will be surrounded by a layer of highly compacted bentonite clay. In this manner, the fuel will be isolated from the biosphere by a series of barriers that interact with and complement each other. The copper canister protects against mechanical forces and radiation during handling. When the canister has been deposited in the deposition hole, it prevents groundwater from coming into contact with the spent fuel for a very long period of time. The bentonite clay limits the flow of water around the canister. The rock itself retards the radionuclide migration and protects against both natural and human intrusion such as future ice ages and acts of war.

Schematic diagram of a canister in its deposition hole, surrounded by blocks of highly compacted bentonite clay. The tunnel has been backfilled with a mixture of sand and bentonite.

The site investigations in the first phase cover some ten sites and will be carried out up to about 1990.

RESEARCH – COOPERATION

The waste problems associated with nuclear power are urgent and topical questions in all countries with nuclear power programmes. The expansion of nuclear power has also led to comprehensive R&D activities concerning nuclear waste in many countries. International cooperation within the field is well developed and proceeds on several levels, through agreements between individual countries and within the framework of international organizations. In order to streamline and broaden Swedish research, Sweden has established an extensive international exchange of research findings and practical experience.

Intensive Swedish efforts in recent years in the field of research and technology for the handling and disposal of nuclear waste — exemplified by the CLAB, SFR and KBS projects — have put Sweden in the forefront today on many matters in this field. This is particularly true of research on geologic disposal in crystalline bedrock, where a number of countries have expressed their interest in establishing joint research under various forms.

Research agreements have been signed with the U.S. Department of Energy — DOE, Atomic Energy of Canada Ltd—AECL, NAGRA of Switzerland and Commissariat à l'Energie Atomique — CEA, France. Annual meetings for information exchange and joint ventures undertaken in cooperation with these organizations are important complements to SKB's own programme.

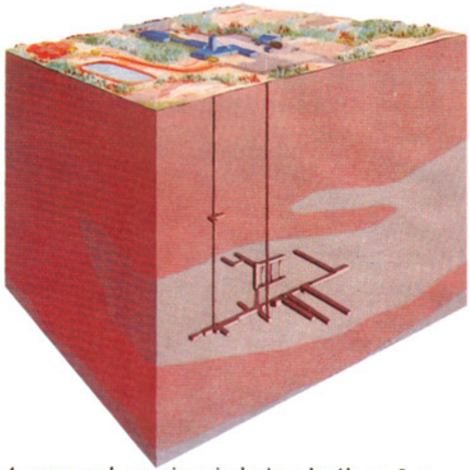
Exchange also takes the form of placing guest researchers at institutions in other countries.

An information exchange also takes place with the EEC's special group for radioactive waste and various Japanese organizations. SKB participates in the OECD/NEA information system for data on the migration of radionuclides in rock.

Moreover, SKB participates in various committees on nuclear waste etc. within the IAEA and the OECD/NEA. SKB is a member of the Atomic Industrical Forum in Washington and the Uranium Institute in London.

The STRIPA project has been pursued in an abandoned iron ore mine at Stripa in Västmanland since 1977. Field tests are conducted here on a large scale and under realistic conditions at a depth of 350 metres in the granitic rock surrounding the ore formation. The research is organized in the form of an autonomous OECD/NEA project, with SKB in charge of the management of the project. Participating countries are Canada, Finland, France, Great Britain, Japan, Spain, Sweden, Switzerland and the USA.

Japan, Switzerland and Sweden are conducting joint studies within the JSS project on the process of corrosion and dissolution in high-level radioactive glass from reprocessing. The test species are supplied by CEA, France. Most of the studies are being conducted at Studsvik Energiteknik AB and certain tests are being performed at EIR in Switzerland. The project is being managed by SKB and advisory experts from the USA, France and West Germany are participating.



A research station is being built at Lac du Bonnet in Manitoba, Canada, for research on the disposal of radioactive waste in the Canadian Precambrian Shield. A comprehensive research programme concerning groundwater conditions on the site is included in the project. SKB is participating in the evaluation.

Considerable international interest has been shown in Swedish technology and research concerning the management and disposal of nuclear waste. Therefore the nuclear power utilities' company for international consulting, SwedPower Service AB has, together with SKB, established a special group for coordenating and marketing Sweden's collective know-how and experience within this field. The members of this group also include associated groups at universities and institutes of technology, consulting firms, research organizations etc. Contracts have so far been obtained from Finland and Switzerland.

The photograph shows a rock cavern in granite at a depth of 400 m at the Nevada Test Site in the USA. In a demonstration test, the U.S. Department of Energy — DOE — has emplaced spent nuclear fuel in deposition holes and studied the effects of radiation and heat flux on the rock and the canisters.

COSTS OF THE NUCLEAR FUEL CYCLE

The total cost of the nuclear fuel cycle includes costs from uranium mining to the fabrication of the fuel as well as costs for handling, storage and final disposal of spent fuel and radioactive waste, including decommissioning and dismantling of the reactor installations.

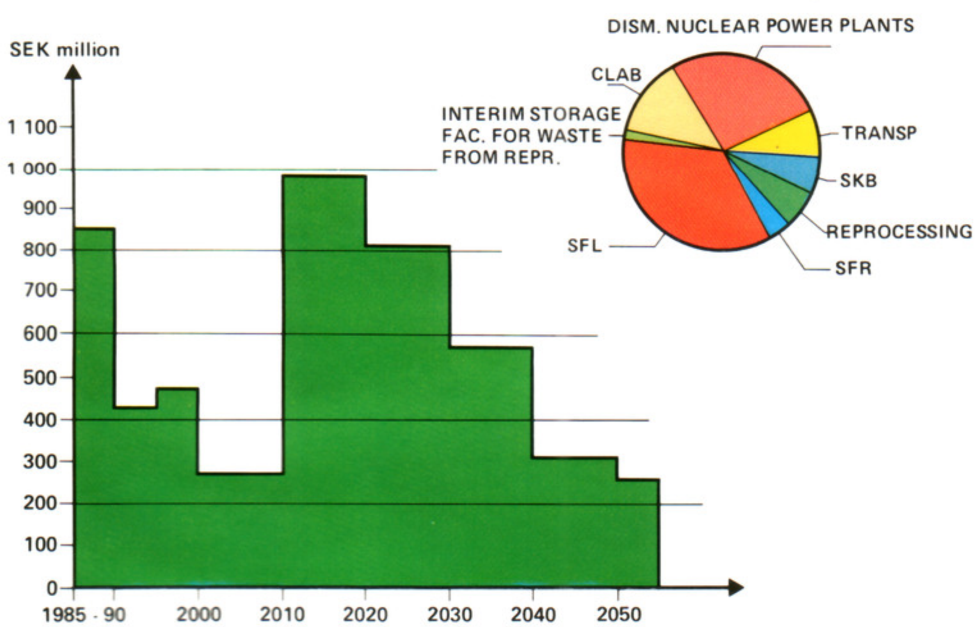
For 1984, the costs of fabricated nuclear fuel (front end) have been calculated to be SEK 0.037 per kWh of generated electricity. The costs for the management and disposal of spent fuel and radioactive waste (back end) as well as dismantling of the nuclear power stations have been estimated to be about SEK 0.020 per kWh. Of this, SEK 0.019 consists of a fee paid to a government fund, while SEK 0.001 per kWh is being set aside internally within the nuclear power utilities for the final disposal of low- and medium-level active waste.

The costs for the front end of the nuclear fuel cycle in 1984 prices are roughly as follows:
(At an annual production of about 49 TWh)

	SEK/kWh	per year (SEK million)
Natural uranium	0.013	640
Conversion	0.001	50
Isotope enrichment	0.016	780
Fuel fabrication	0.006	290
Strategic stockpile	0.001	50
	0.037	1810

Despite the large amounts of money involved here, a comparison with equivalent electricity production in a coal-fired condensing power plant shows that the nuclear fuel costs about 20% of the equivalent quantity of coal.

The total costs for managing and disposing of spent nuclear fuel and radioactive waste from the Swedish nuclear power programme have been estimated at SEK 47 billion in 1985 prices. This calculation also includes dismantling of the nuclear power plants and final sealing of the repositories around the year 2060, as well as the costs of reprocessing of around 10% of the spent fuel. The reprocessing option is still being considered even if the present preference is the direct disposal route.



Total cost for waste management and dismantling of nuclear power plants (price level January 1985). In the circle diagram, the costs are apportioned by object/purpose.

In order to cover the future costs for management and disposal of spent nuclear fuel etc, including dismantling of the nuclear power plants, the nuclear power producers are paying a fee to a special government fund under the terms of the Financing Act.

The fee is based on a "scenario" drawn up by the nuclear power utilities through SKB, which is presented annually together with a cost estimate to SKN (National Board for Spent Nuclear Fuel). After examining SKB's report, SKN makes a recommendation to the Government concerning the fee for the coming year.

The fee for the costs falling under the Financing Act for 1985 is SEK 0.019/kWh. These costs are broken down as follows:

	SEK/kWh
Intermediate storage of spent fuel	0.0047
Transports	0.0013
Reprocessing	0.0037
Final disposal of spent fuel	0.0037
Dismantling	0.0036
SKB, general costs	0.0020
	0.019
Final disposal of reactor waste	0.001

Up till January 1985 the SKN fund amounted to SEK 1 824 million. With the fee unchanged and normal operation at all the power plants SEK 1 200 million will be put into the fund each year.

SKB's costs and investments

Most of SKB's costs and investments concern actitivies related to the disposal of high-level nuclear waste. These expenses are covered by funds from the reserve within SKN. Other costs for SKB activities are covered through owner contributions.

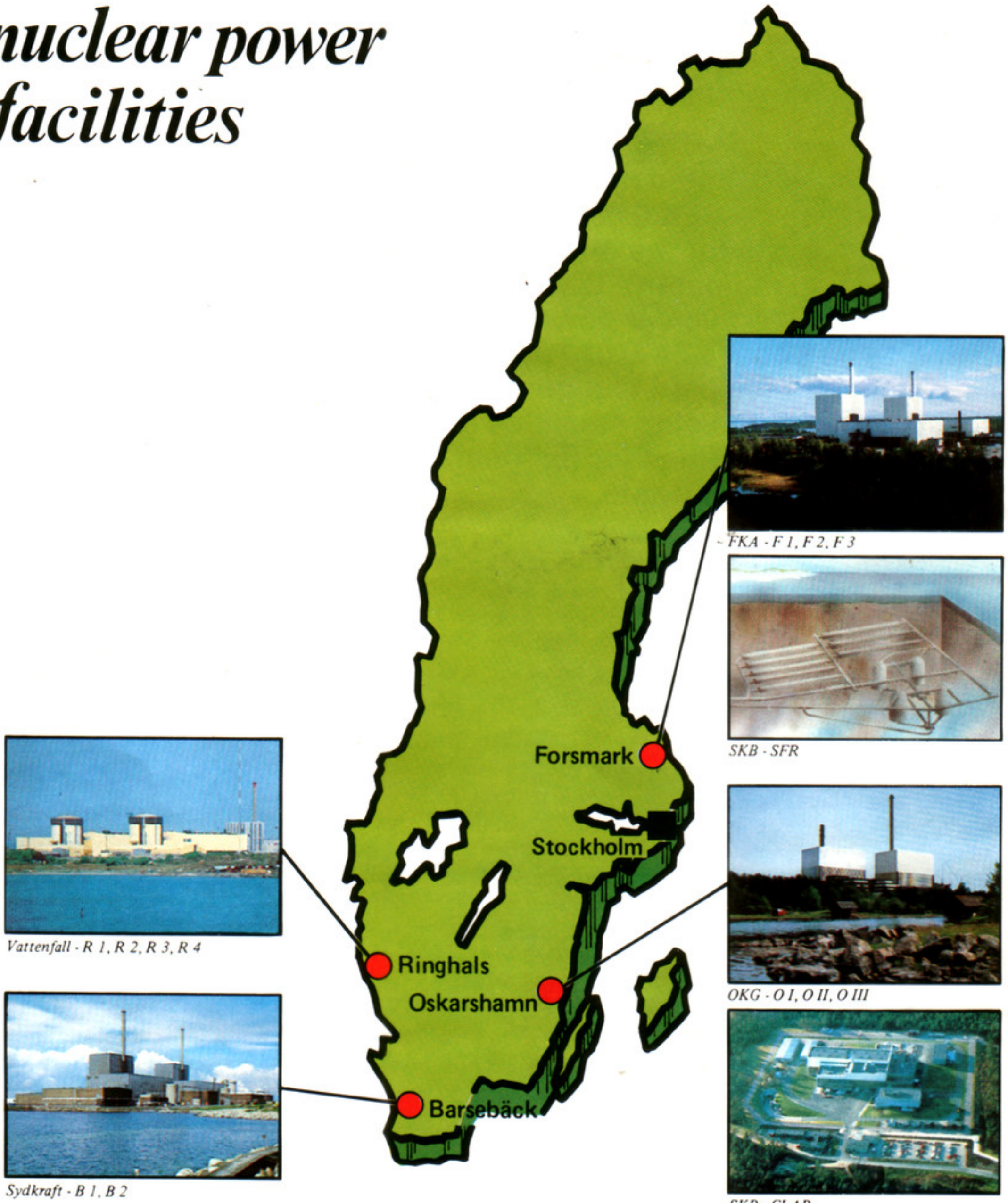
For 1984, SKB's turnover is broken down as follows:

Operating expenses	SEK Mill. (approx)
Research & development	60
Operation of transportation system	58
Reprocessing services	3
Strategic stockpiling	4
Prospecting	12
Enrichment services	221
Other expenses	29
Total	387

In 1984 SKB invested SEK 860 million in i.a. the CLAB, the SFR and the Transportation system.

Investments (total)	SEK Mill.
CLAB	1725
SFR	830
Transportation system	200

Sweden's nuclear power facilities



FKA - F 1, F 2, F 3

SKB - SFR

Vattenfall - R 1, R 2, R 3, R 4

OKG - O I, O II, O III

Sydkraft - B 1, B 2

SKB - CLAB

SKB
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Fem Konsulter AB/Kindbergs tryckeri, Jönköping, 1985