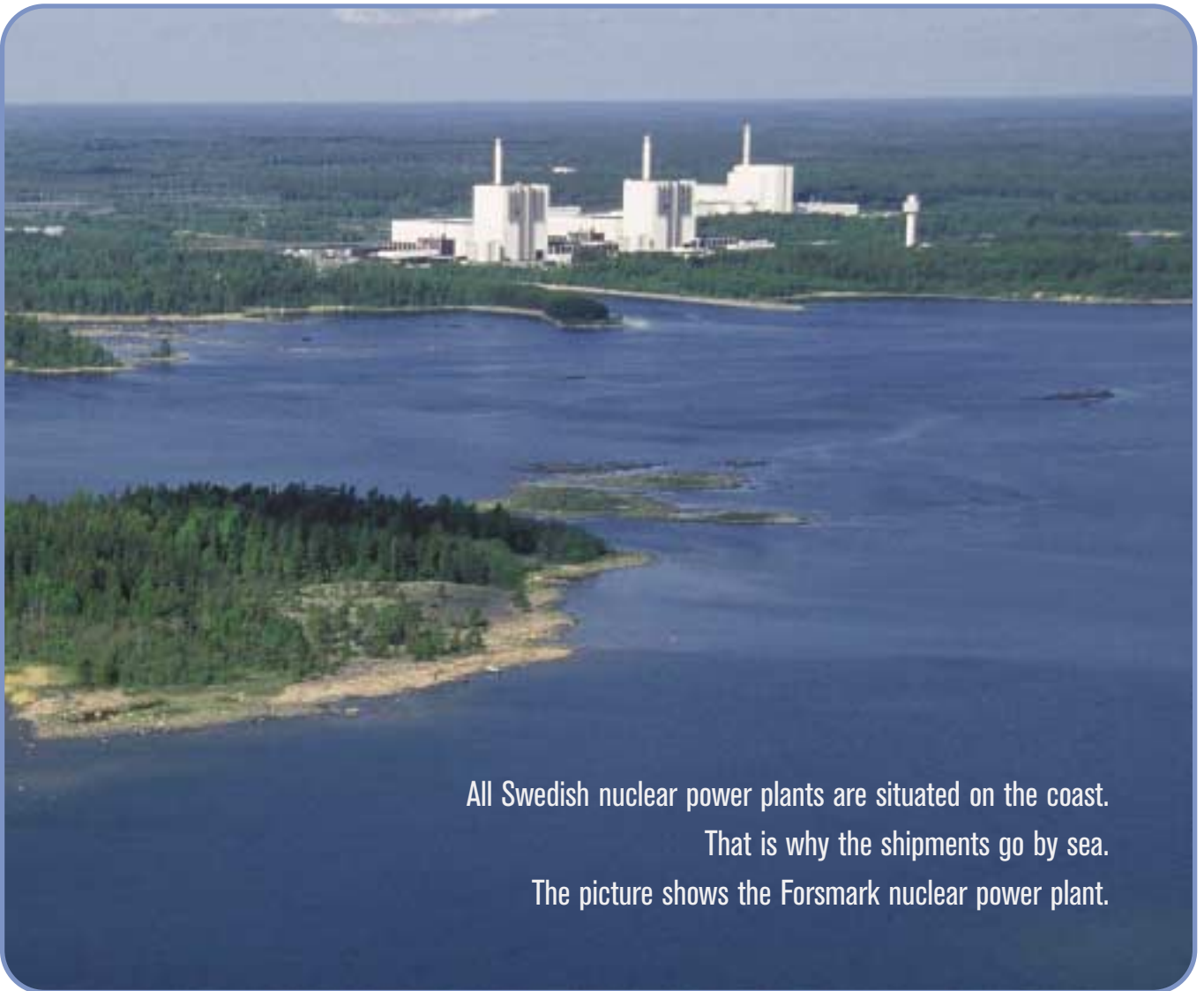




Transportation of radioactive waste



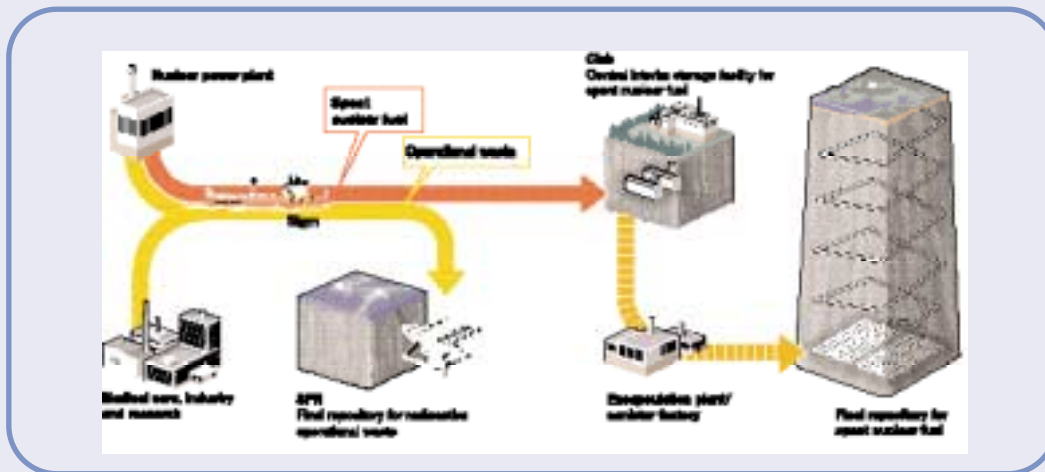
All Swedish nuclear power plants are situated on the coast.
That is why the shipments go by sea.
The picture shows the Forsmark nuclear power plant.

Sweden's radioactive waste

Radioactive waste comes mainly from the operation of the nuclear power plants, but also from research, industry and medical care. The Swedish Nuclear Fuel and Waste Management Company (Svensk Kärnbränslehantering AB) SKB, has been assigned the task of developing and realizing a method for transporting, managing and disposing of the radioactive waste in a safe manner.

Radioactive waste must be transported and stored in different ways, depending on how radioactive it is and how long it remains radioactive. The waste is therefore divided into different categories: low- and intermediate-level waste and spent nuclear fuel. Low-level waste does not need to be either radiation-shielded or cooled. Intermediate-level waste needs to be radiation-shielded, but cooling is not necessary. Spent nuclear fuel has such a level of radioactivity that it needs to be both radiation-shielded and cooled.

It is SKB's task to organize and perform the work of managing and disposing of the radioactive waste from the nuclear power plants. We have a ship for shipping the waste, a final repository for different types of operational waste (SFR), and an interim storage facility for spent nuclear fuel (Clab). The agenda also includes building a final repository for spent nuclear fuel and a final repository for long-lived waste.



Sweden has a well functioning system for managing and disposing of different types of radioactive waste.



The spent nuclear fuel is stored in pools in Clab.



Low- and intermediate-level waste is disposed of in SFR.

Operational waste in Forsmark

SFR is located 50 metres beneath the bottom of the Baltic Sea adjacent to the Forsmark Nuclear Power Plant. Besides low- and intermediate-level waste from the nuclear power plants, other radioactive waste from medical care and industry is also stored there. These wastes are processed and packaged in Studsvik outside Nyköping. The activities at Studsvik also generate their own radioactive waste.

The operational waste from the nuclear power plants is low- or intermediate-level, at the same time as it is relatively short-lived. It consists for example of filters for cleaning the radioactive material in the reactor water or of tools and protective clothing. Radioactive substances may also adhere to the walls in pumps, pipes and valves. If these components are replaced, the old parts have to be disposed of.

Interim storage facility in Oskarshamn

When the spent nuclear fuel has been removed from the reactor after about five years, it is stored for at least nine months in pools at the nuclear power plants. A large portion of the radioactivity decays during this time. The water in

the pools acts both as radiation shielding and coolant. The fuel is then transported to the central interim storage facility (Clab) outside Oskarshamn, where it is stored for at least 30 years. Today there are around 5,000 tonnes of spent nuclear fuel in the pools in Clab. The facility has a total storage capacity of 8,000 tonnes.

Final repository in Forsmark or Laxemar

We have been developing a method to dispose of the spent nuclear fuel for many years. In brief, the method entails encapsulating the spent nuclear fuel in copper and depositing it in the basement rock, embedded in clay, at a depth of about 500 metres.

The work of finding a suitable site for the final repository will soon be finished. Site investigations have been under way since 2002 in Forsmark and Laxemar outside Oskarshamn. We are currently evaluating the results of the investigations and expect to be able to select a site in 2009. According to the plans, operation of the final repository will start in around 2020.



The ship m/s Sigyn transports the radioactive waste.



The shipments go by sea

All Swedish nuclear facilities are situated on the coast. The radioactive waste shipments therefore go by sea, on our ship m/s Sigyn.

The shipments between the nuclear power plants and the waste facilities are carried out by the ship m/s Sigyn, which was built in 1982. For added seaworthiness, the ship has a double bottom and a double hull, providing extra high buoyancy. The double hull also protects the cargo in the event of collision or grounding.

A modern passenger ship must remain afloat even if two of its watertight sections below the waterline fill with water. Sigyn will float even if four sections are water-filled.



Sigyn's radar and global positioning system.



Transport cask for spent nuclear fuel.



Visitors on the command bridge.

m/s Sigyn

Deadweight tonnage:	2,044 tonnes
Length overall:	90.33 metres
Breadth:	18.04 metres
Draught fully loaded:	4 metres
Gross tonnage	4,166 tonnes
Payload with filled shielding tanks	1,400 tonnes
Engine power	2 x 1,170 kW
Cruising speed:	12 knots

Cargo is lashed

The cargo is driven on board via the aft ramp. It is also possible to open the cargo hatches and lift the cargo on board (roll on/roll off). There are heavy-duty lashing fittings in the hold for anchoring the different types of waste containers.

The walls surrounding the hold are radiation-shielded, and the radiation level is monitored by shipboard instruments. The measurements have shown that the crew is not exposed to any extra radiation doses, aside from the natural background radiation, which is lower at sea.

Sigyn normally makes 30–40 trips per year between the nuclear power plants, SFR and Clab. Time permitting, the ship is chartered out for other heavy (but not necessarily radioactive) special shipments.

Shipments to the final repository

In the future, Sigyn's travel route may be expanded to include shipments from Clab to the final repository for spent nuclear fuel. Since we want to build the final repository in either Forsmark or Laxemar, no long overland transports will be necessary.

Just like today, future shipments of spent nuclear fuel to the final repository will be regulated by a number of laws and national and international regulations. The regulations cover radiation protection, training of personnel, safety procedures and records. All shipments are notified in advance to the regulatory authorities. The shipments are also insured against damages to third parties.



A transport cask with spent nuclear fuel has arrived at Clab.

Safety assured by the container

M/s Sigyn is a very safe ship. But it is the transport containers and casks in which the waste is transported that ultimately ensure safety.

The transport containers are designed to suit the different types of waste to be shipped. Safety during transport ultimately lies in the design of the containers. The more radioactive the waste is, the more stringent the requirements on the container are.

The low-level waste, for example protective clothing and tools, does not need any radiation shielding at all, but can be transported in standard steel freight containers. Filter mats and replaceable parts of the reactor belong to the category of intermediate-level waste, however. Such waste must be radiation-shielded and is therefore embedded in concrete moulds or steel drums at the nuclear power plants. Containers with thick steel walls are used to ship this waste.

Subject to international regulations

The spent nuclear fuel must be radiation-shielded and cooled during transport. The transport casks are subject to very stringent requirements and tests to fulfill the IAEA regulations.

Spent nuclear fuel is transported by sea, road or rail every year, all over the world. Thousands of shipments to interim storage facilities and reprocessing plants have taken place all

over the world. Not one serious accident with radioactive release has occurred in 40 years.

In other words, the experience that exists of transporting spent nuclear fuel is very good. On no occasion have the containers been damaged in a manner that affects their integrity or radiation-shielding capacity. Nor have any radioactive substances escaped into the environment.

Drop from high height

Possible accident situations have been simulated in many countries to test the transport containers. The results have always shown that the containers provide the necessary safety and protection.

One example is a free drop test from a high height. A test was performed in the 1980s in the USA where a cask was lifted to a height of 600 metres. It was dropped onto a surface of densely packed soil, whose hardness was equivalent to that of unreinforced concrete. On impact the cask was travelling at a velocity of 380 kilometres an hour and buried itself one and a half metres down into the ground. Despite the force of the impact, the cask remained intact.

Transport cask for core components



Weight	about 70 tonnes
Length	6.15 m
Diameter	1.95 m
Wall thickness	33 cm
Material	forged steel
Capacity	5 tonnes

Transport container for operational waste



Weight	58 tonnes
Weight with load	120 tonnes
Length	7.28 m
Width	3.70 m
Height	4.30 m
Wall thickness	7–20 cm
Material	steel
Capacity	12 moulds 3 concrete tanks

Transport cask for spent nuclear fuel



Weight	about 80 tonnes
Length	6.15 m
Diameter	1.95 m
Wall thickness	32 cm
Material	forged steel with stainless surface coating
Capacity	17 BWR fuel assemblies 7 PWR fuel assemblies
Temperature	Fuel 330–450°C
(at max. thermal load)	Cooling fins 60–100°C



Freight container with low-level waste in SFR.



Concrete moulds with intermediate-level waste SFR.



In the USA, radioactive waste is transported by truck.



Our way of life gives rise to hazardous waste. Some of it is radioactive. We in Sweden bear a common responsibility for our country's radioactive waste. It must not be passed on to future generations, but rather be managed and disposed of today.

The Swedish Nuclear Fuel and Waste Management Company (Svensk Kärnbränslehantering AB, SKB) has been assigned this task. We have developed a system for disposing of the waste safely and permanently. This brochure is about transportation.



Svensk Kärnbränslehantering AB

Swedish Nuclear Fuel and Waste Management Co

Box 250, SE-101 24 Stockholm, Sweden Telephone +46 8 459 84 00 www.skb.se