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Naturskyddsföreningen

Becoming the role model? Sweden's quest for a nuclear spent fuel repository

Johan Swahn, Ph.D.

The Swedish NGO Office for Nuclear Waste Review, MKG

johan.swahn@mkg.se, mobile: +46 70 4673731

Första Långgatan 18, SE-413 28 Göteborg, SWEDEN,

Tel: +46 31 7110092 http://www.mkg.se

Summary: Sweden as a model for RWM?

- Sweden built 12 nuclear reactors at 4 nuclear power sites in the 1970s and 1980s. By 2020 there will be 6 operating reactors and there is a new broad political agreement that the goal is that all electricity generation shall be renewable.
- After a turbulent time for nuclear policy in the late1970s the referendum on nuclear power in 1980 introduced a political calm that allowed the formation of a legal and organisational system for RWM: “The Swedish Model”.
- Sweden has been relatively successful in RWM, but in recent years there have been considerable challenges. There are “cracks in the wall” both for the financial system and for the existing and planned repository systems.
- The upcoming decision to license a spent fuel repository at the Forsmark NPP may be difficult for the government.

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Nuclear Energy in Sweden – The End Game?

- Sweden has 10 operating nuclear power reactors at three nuclear power plants (Ringhals, Oskarshamn, Forsmark). 2 reactors at a fourth plant (Barsebäck) have previously been shut.
- Nuclear energy supplies 35-40% of Swedish electricity production, the remainder is primarily hydro-electric, wind and biomass co-generation. There is an over-capacity.
- Recently decisions were taken to shut down 4 more reactors before 2020 due to low electricity prices and new regulatory demands for safety upgrades.
- A new political Energy Commission in 2016 set the goal of 100% renewable electricity system by 2040. A nuclear capacity tax was removed to allow safety investments and support operation of the remaining 6 reactors.

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Role Model? – RWM in Sweden

- In the 1980s the Swedish RWM governance system was set up in the “political calm” after the 1980 nuclear referendum.
- Nuclear Activities Act: The Swedish nuclear industry is responsible for managing and finding a method for final disposal of radioactive waste. The reactor operators has created the Swedish Nuclear Fuel and Waste Management Company, SKB, to do the work. Repository and transport systems have been developed and partly implemented. R&D review every 3 years.
- Financial Act: An economic system with a state-controlled Nuclear Waste Fund has been set up to guarantee that the polluter-pays-principle is upheld. A fee per kWh of generated electricity paid into the fund. Calculated every three years.
- Studsvik Act: To pay for “historic” civil and military radioactive waste and facilities. Also a fee per kWh.

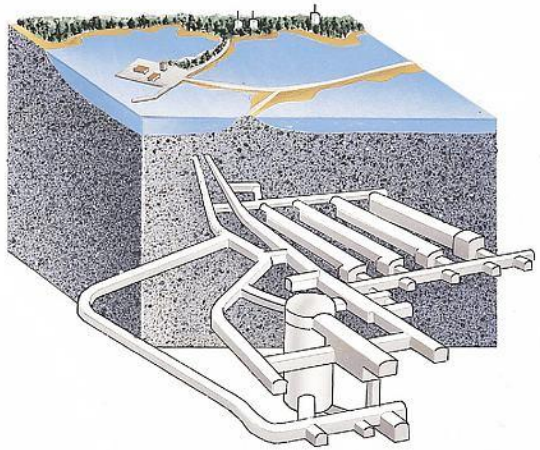
Role Model? – Financing

- The fees paid into the nuclear waste fund were for many years quite low (≈ 0,1 €cent/kWh). The regulatory oversight was weak, with under-estimated future costs and a reliance on large future returns on the money put in the fund.
- The regulatory oversight was greatly strengthened with the regulatory reorganisation in 2008 with the creation of the Swedish Nuclear Safety Authority (SSM)
- There is now an obvious lack of money in the system due to expected low future rates of return, new estimates of future costs and the shutting down of reactors “prematurely”
- The nuclear waste fee is increasing fast (≈ 0,4 €cent/kWh for 2015-2017) and is proposed to be increased again.
- New financial legislation is forthcoming.

Role Model? – Final disposal of short-lived radioactive waste

- There is an existing repository for short-lived operational waste at the Forsmark nuclear power plant, SFR. It is 75 m underground and started operation in 1988.

Final disposal of short-lived radioactive waste



SFR – Final repository for short-lived low- and medium-level radioactive waste at the Forsmark nuclear power plant

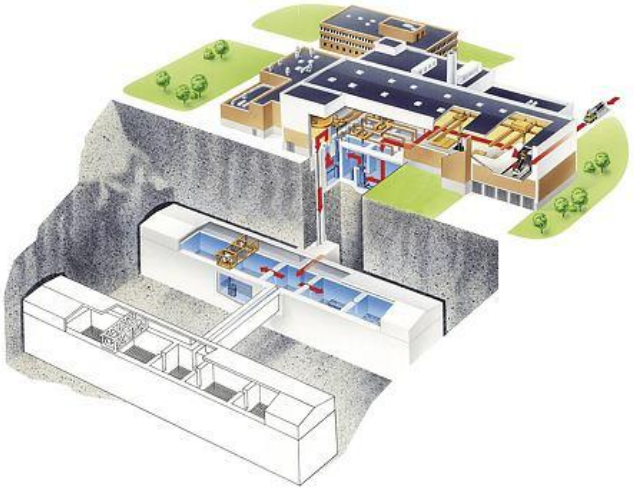
Role Model? – Final disposal of short-lived radioactive waste

- There is an existing repository for short-lived operational waste at the Forsmark nuclear power plant, SFR. It is 75 m underground and started operation in 1988.
- However, the safe-case for the repository relies on 1970s environmental thinking with dilution into a recipient (the Baltic Sea) as part of the safety case.
- When SKB now wants a license for an expansion (SFR 2) to take short-lived decommissioning waste there are problems even though the expansion is planned for a depth of 120 m.

Role Model? – Interim storage of spent nuclear fuel

- Spent nuclear fuel has since 1985 been transported to an centralized interim storage facility, CLAB, at the Oskarshamn nuclear power plant.
- The spent fuel is stored in large water-filled pools 30 m under the ground.

Interim storage of spent nuclear fuel



Clab – Central intermediate storage of spent nuclear fuel at the Oskarshamn nuclear power plant

Role Model? – Interim storage of spent nuclear fuel

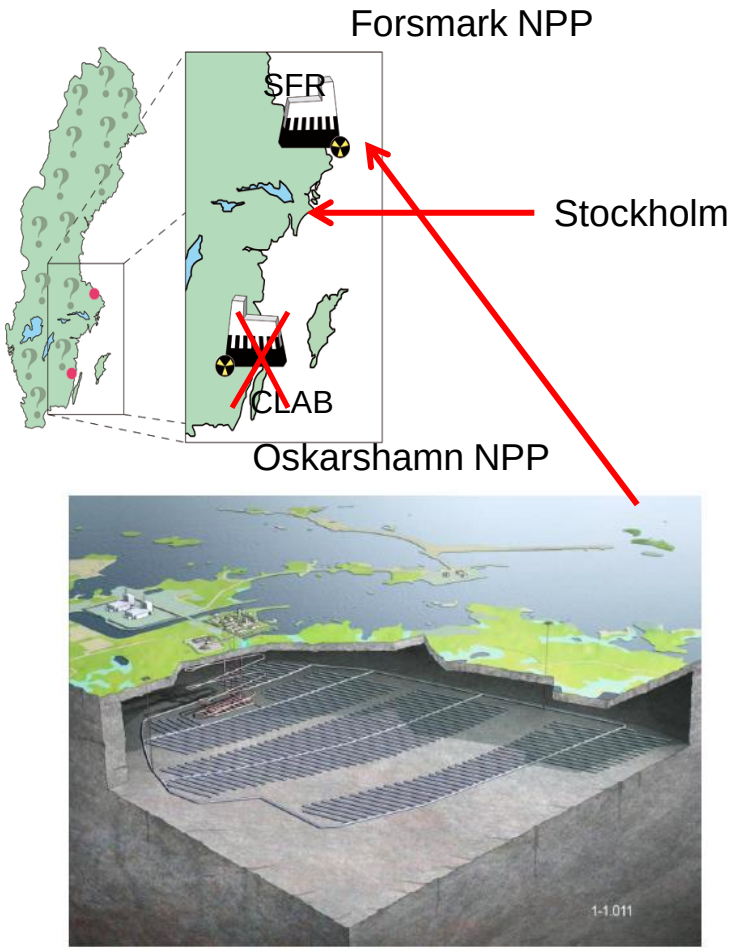
- Spent nuclear fuel has since 1985 been transported to an centralized interim storage facility, CLAB, at the Oskarshamn nuclear power plant.
- The spent fuel is stored in large water-filled pools 30 m under the ground.
- The interim storage facility (Clab) can hold all the spent fuel from the Swedish nuclear programme.
- If a centralized interim storage were to be built today it would likely be a dry storage facility that does not need active cooling.

Role Model? – Towards an implementation of a final repository for disposal of spent nuclear fuel

- The industry's nuclear waste company SKB has been working for 40 years, since the mid 1970s, on developing a method, the KBS method, and to find a site for disposal of the Swedish spent nuclear fuel.
- The plan is to make a repository at about 500 m depth and an encapsulation plant to put the spent nuclear fuel in copper canisters before disposal.
- The siting process was difficult but finally in a "voluntary process" a site was chosen in 2009 just South of the Forsmark NPP.

Role model? Siting of a spent fuel repository: A long road to acceptance

- The siting process for a repository for spent nuclear fuel was started in the mid-1970s and met local resistance with a collapse in 1986.
- A restart was done with a voluntary process.
- Two communities in North Sweden decided not to proceed after local referenda said no in the 1990s.
- The search finally ended in two nuclear communities, Oskarshamn (Oskarshamn NPP) and Östhammar (Forsmark NPP).
- In 2009 the Forsmark NPP site was chosen.



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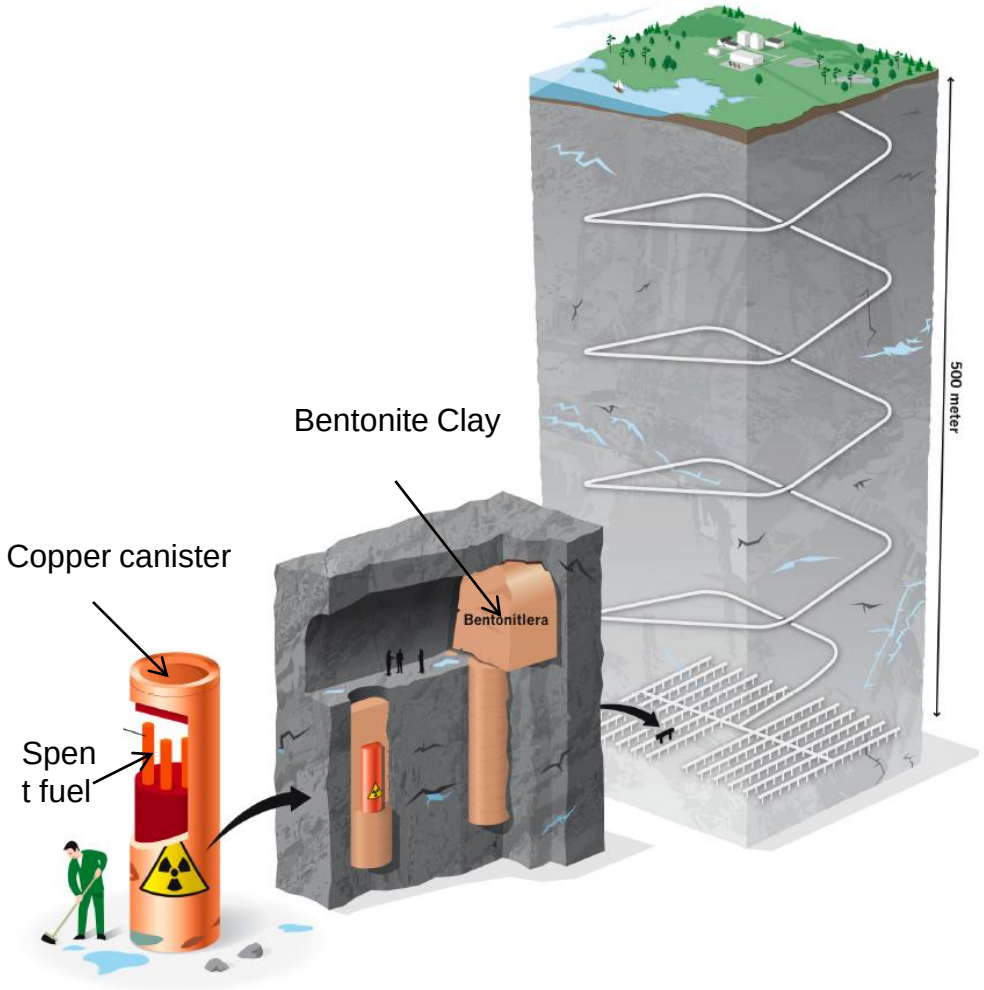
The KBS method for disposal of spent fuel

- In the KBS method the waste canisters (5 m high) are to be deposited in holes in the floor of tunnels about 500 m underground in granite bedrock.
- The long-term safety case relies on two artificial engineered barriers – the copper canister and a bentonite clay buffer to protect the copper. Both barriers are now questioned.



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Problems with copper corrosion

Source: Peter Szakalos, Royal Institute of Technology. Stockholm

FIGURE 1 – Appearance of copper after 15 years of exposure in distilled water at room-temperature. Hydrogen from corrosion can escape from the left container but not from the container to the right. The water volume was equal in the flasks in beginning of the exposure.

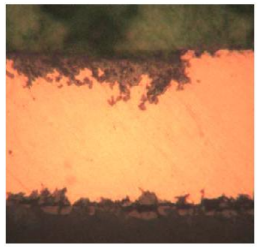

FIGURE 2 – Light optical cross-section of the initially 100µm metallic copper foil after 15 years exposure in distilled water. Localised corrosion attack is clearly visible.

- The scientific hypothesis that anoxic (oxygen-free) water does not corrode copper in a repository, where there is no oxygen after closure, may be false.
- But it looks like water can directly corrode copper even when there is no oxygen
- Copper in a KBS-repository may corrode at much faster rates than acceptable (<1 000 years until release of radioactivity).
- This issue is still not resolved in the autumn of 2016, whilst in the middle of a license review!

Role Model? – Towards an implementation of a final repository for disposal of spent nuclear fuel

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- The plan is to make a repository at about 500 m depth and an encapsulation plant to put the spent nuclear fuel in copper canisters before disposal.
- The siting process was difficult but finally in a "voluntary process" a site was chosen in 2009 just South of the Forsmark NPP.
- The regulatory oversight has historically been weak compared to a very strong and forceful nuclear waste company.
- Low political interest. Low public interest.

License application and review (1)

- The nuclear waste company SKB submitted a license application for a spent fuel repository system using the KBS method at the Forsmark NPP on March 16, 2011.
- The application is under review by the Swedish Radiation Safety Authority according to the Nuclear Activities Act and the Environmental Court according to the Environmental Act. The final decision on a license permit has to taken by the Government. Initial review for completeness of the application was completed in 2015 and the application is presently reviewed on issues.
- The regulator has is now “folding”, it is since June strongly leaning to saying yes, mainly because it thinks it can “fix remaining problems” after a positive government decision.

License application and review (2)

- The community of Östhammar has now decided to hold a referendum which can affect their veto possibility.
- One of the main issues in the review is whether the copper canister and the bentonite clay buffer artificial barriers will behave as modeled in the safety analysis – there has been strong and apparently highly relevant scientific criticism for a number of years – all disputed by SKB. The regulator wants to solve the problem later but the environmental court may have a problems with this, as may the government.
- Issues regarding alternative siting and alternative methods (deep boreholes) have been dismissed by the regulator because even if there may be better option it will take too long time to explore them. If the KBS method is safe enough at the Forsmark site, that is enough.

Summary

- The Swedish model is still holding up but there are very large challenges and the cracks in the model are showing.
- The financial system is close to collapse.
- The repository system for short-lived wastes has problems with meeting modern demands.
- The licensing process for the proposed spent fuel repository in Forsmark is “on course” and a government decision in a few years to go ahead is likely, but there is still a risk (chance?) that the repository will never be built.
- The interim storage facility (Clab) can hold all the spent fuel from the Swedish nuclear programme.

Johan Swahn, johan.swahn@mkg.se, +46 70 4673731

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