The Swedish NGO Office for Nuclear Waste Review

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Storage of spent nuclear fuel in Sweden:

The role in management of nuclear waste and the ongoing license application for a spent fuel repository

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Background – MKG

- The Swedish NGO Office for Nuclear Waste Review, MKG, was founded in 2004 and works for the Swedish environmental movement's largest organisation, the Swedish Society for Nature Conservation (Naturskyddsföreningen), specifically with nuclear waste issues.
- MKG receives funding from the Swedish Nuclear Waste Fund to participate in legal proceedings regarding the proposed Swedish repository for spent nuclear fuel near the Forsmark nuclear power plant. There has been a consultation process for the environmental impact statement until March 2011 when the Swedish Nuclear industry submitted an application to build a repository, and there is an on-going review of the application to build a repository after that.

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Management of nuclear waste in Sweden

- By law, the Swedish nuclear industry is responsible for managing and finding a sustainable method for final disposal of the nuclear waste. The industry has created the Swedish Nuclear Fuel and Waste Management Company, SKB, to take this responsibility.
- An economic system with a state-controlled Nuclear Waste Fund has been set up to guarantee that the polluter-pays-principle is upheld, but there is now an obvious lack of money in the fund and new legislation is forthcoming. The nuclear waste fee is increasing fast (≈ 0,4 €cent/kWh planned for 2015).
- Sweden abandoned a military program in the 1960s and reprocessing in the late 1970s, but there are historic wastes from these periods some which are problematic to characterize and therefore manage.

Management of nuclear waste in Sweden

- Sweden has 10 operating nuclear power reactors at three nuclear power plants. 2 reactors at a fourth plant have been phased out.
- A transportation system with a special ship to transport nuclear waste along the coast has been set up. The ship used to be called Sigyn but it was recently replaced with a new ship called Sigrid.

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Final disposal of short-lived nuclear 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 decommissioning waste there is a reluctance from the regulator even though the expansion is planned for a depth of 120 m.

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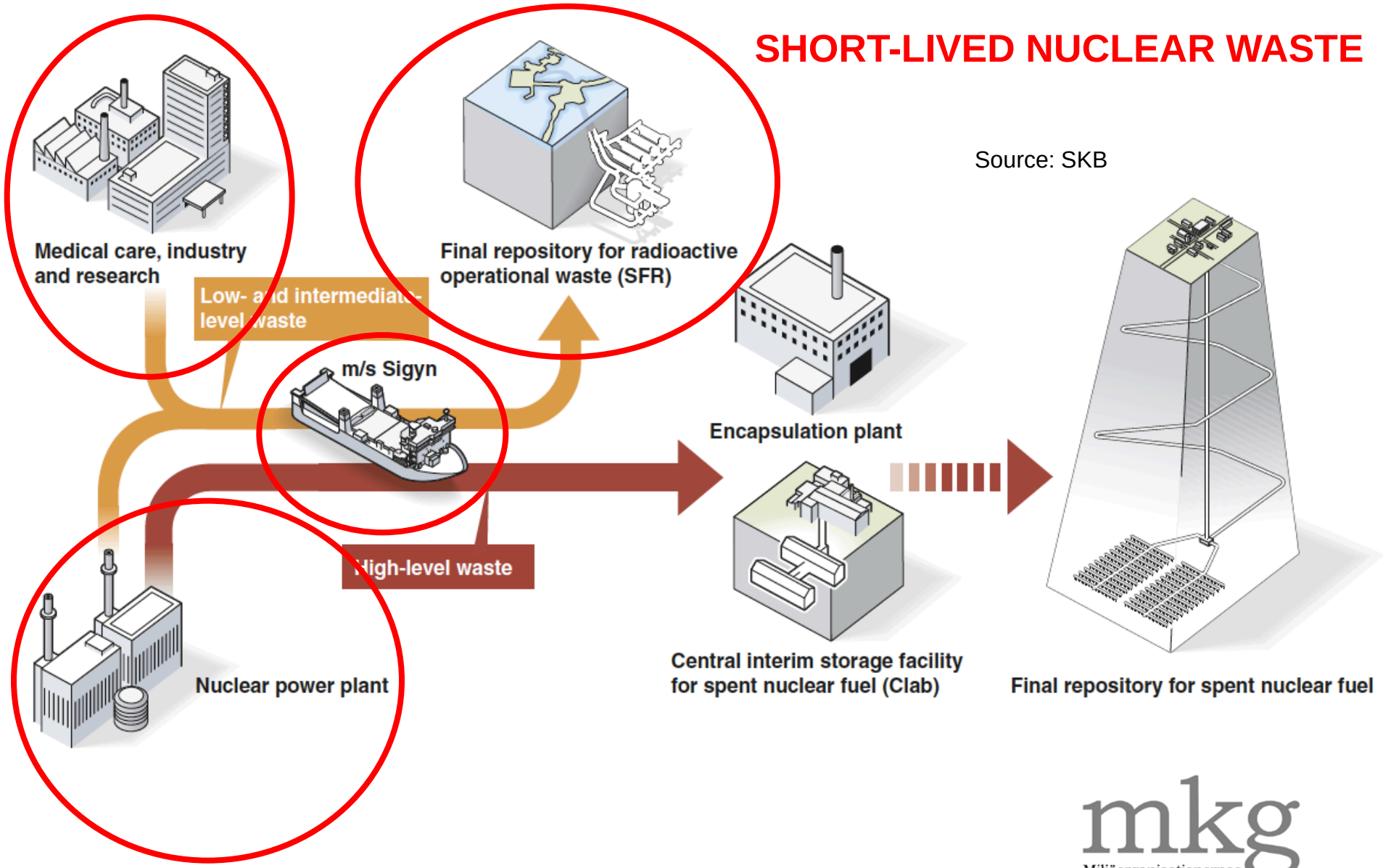
Final disposal of short-lived nuclear waste



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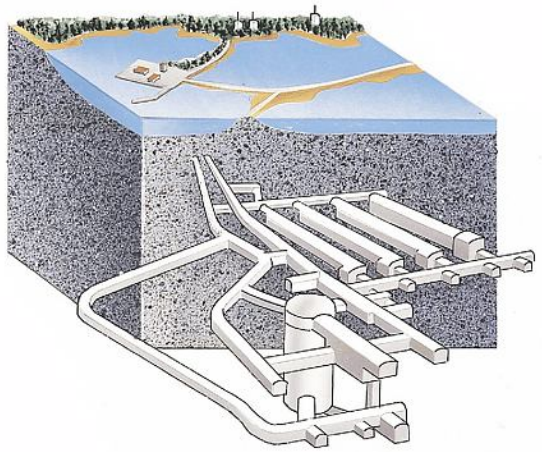
Final disposal of short-lived nuclear waste



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

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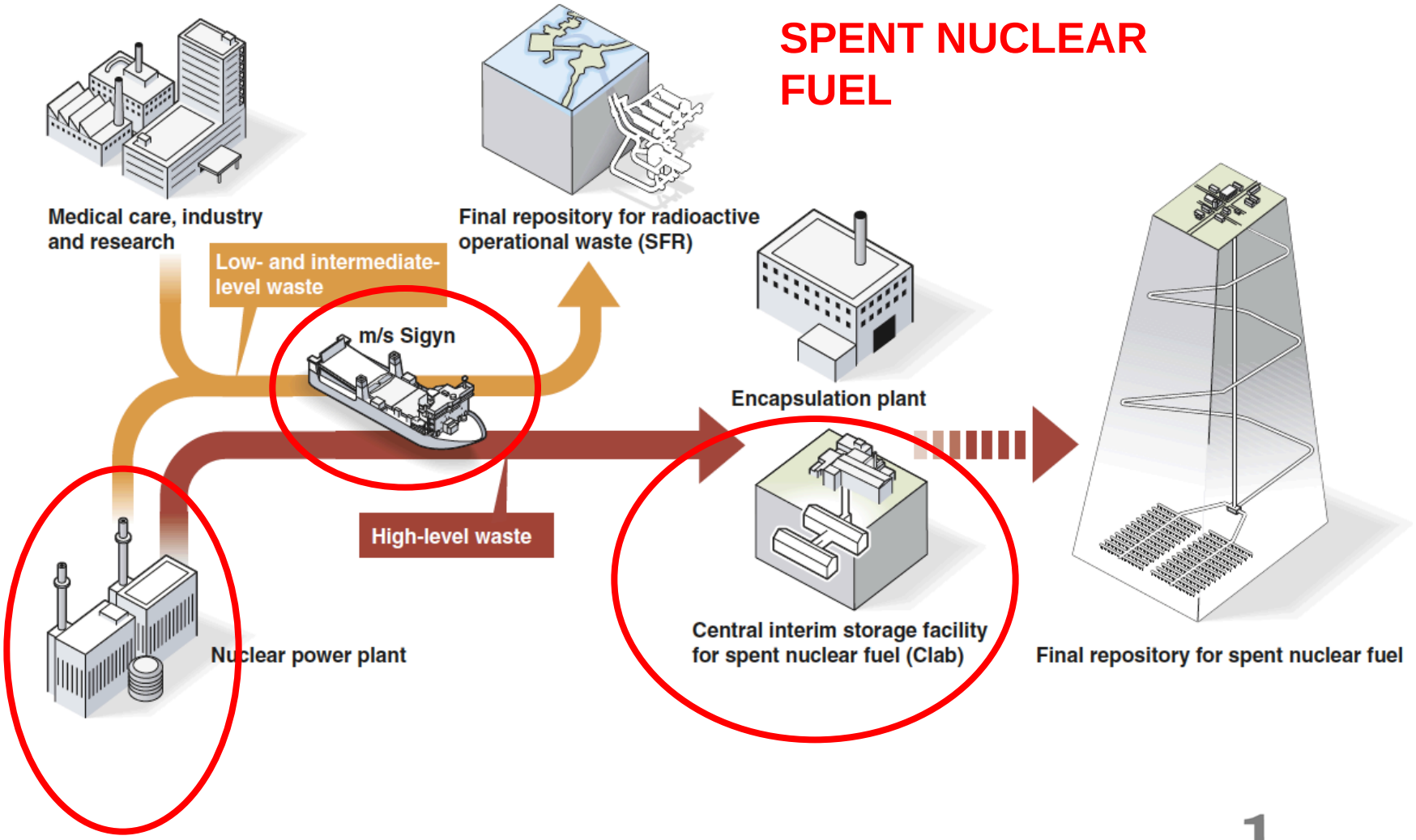
Interim storage of spent nuclear fuel

- 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.
- If a centralized interim storage were to be built today it would likely be a dry storage facility, also likely underground for better physical protection .

Interim storage of spent nuclear fuel



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Interim storage of spent nuclear fuel

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

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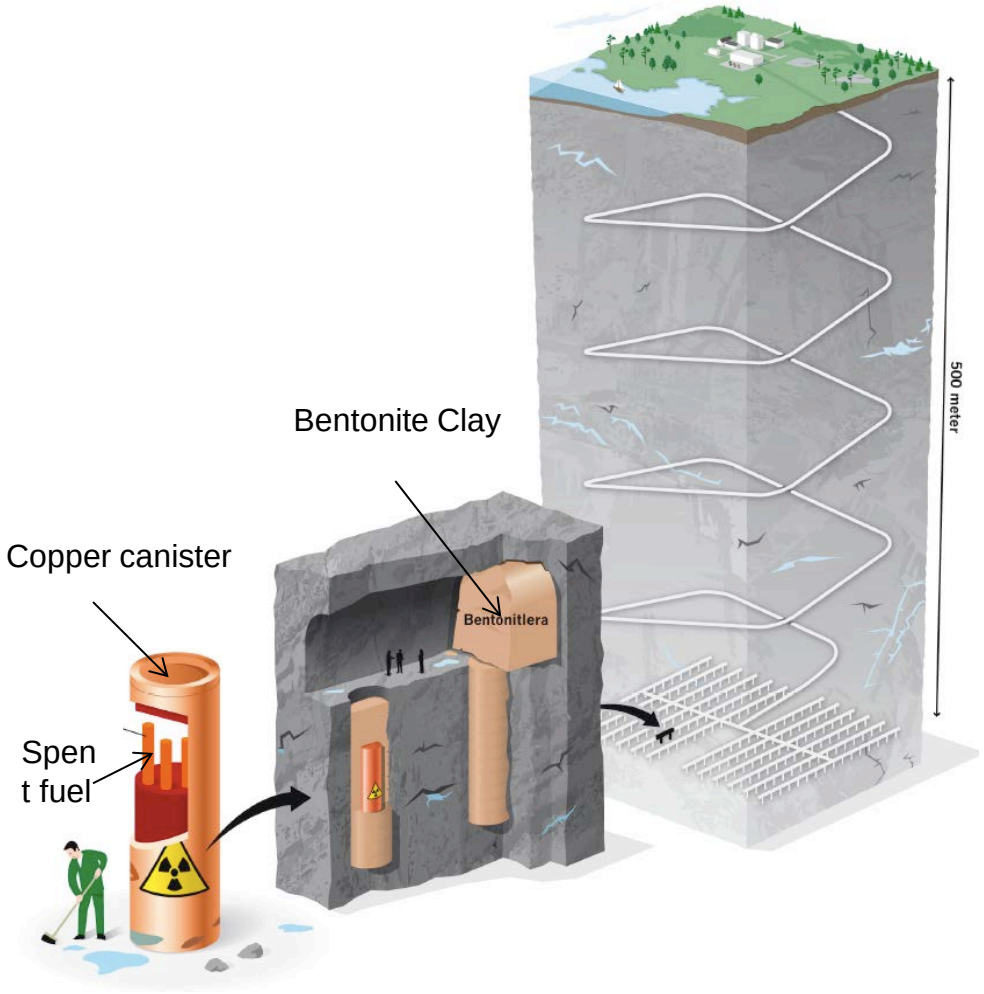
Plans for final disposal of spent nuclear fuel

- The industry's nuclear waste company SKB has been working for almost 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 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.



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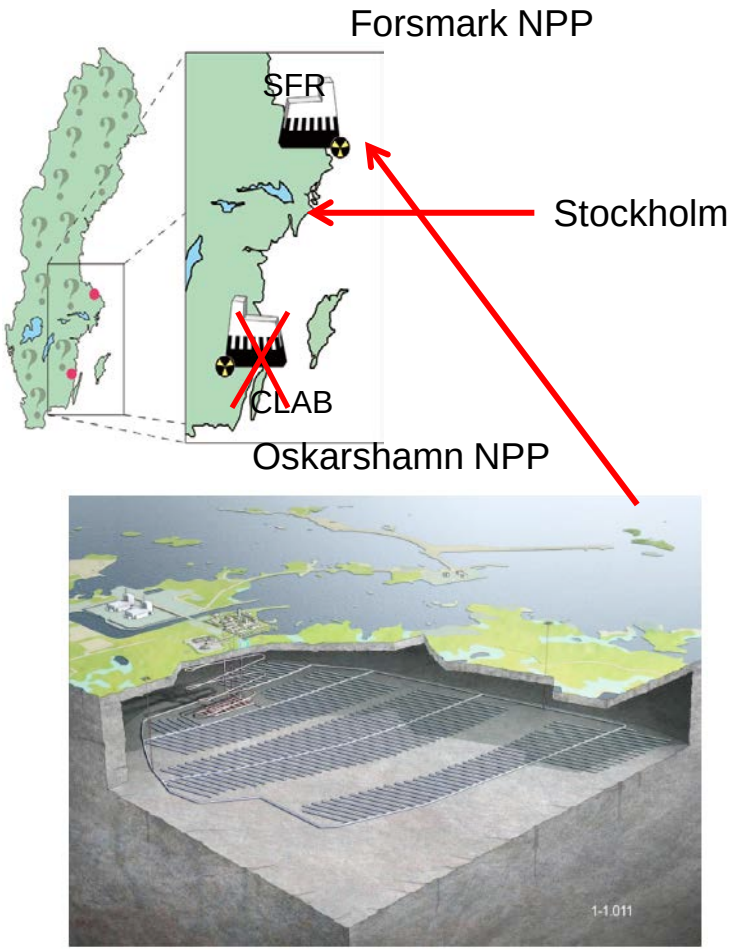
Siting of a spent fuel repository – A long road to acceptance

- 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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License application and review

- The nuclear waste company SKB submitted a license application for a spent fuel repository using the KBS method at the Forsmark NPP on March 16, 2011. (+ encapsulation plant at the Oskarshamn NPP)
- 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 will run at least until the middle of 2015.
- 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 “zero alternative”

- According to the Environmental Act and the Nuclear Activities Act the environmental impact statement, EIS, in the license application has to include a “zero alternative”.
- The “zero alternative” is what is planned if the application is rejected.
- As the spent nuclear fuel is now in the centralized interim facility, Clab, at the Oskarshamn nuclear power plant, the “zero alternative” SKB has in the EIS is for the spent fuel to remain there.
- But can Clab hold all the Swedish spent fuel and for how long?

Interim storage of spent nuclear fuel

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

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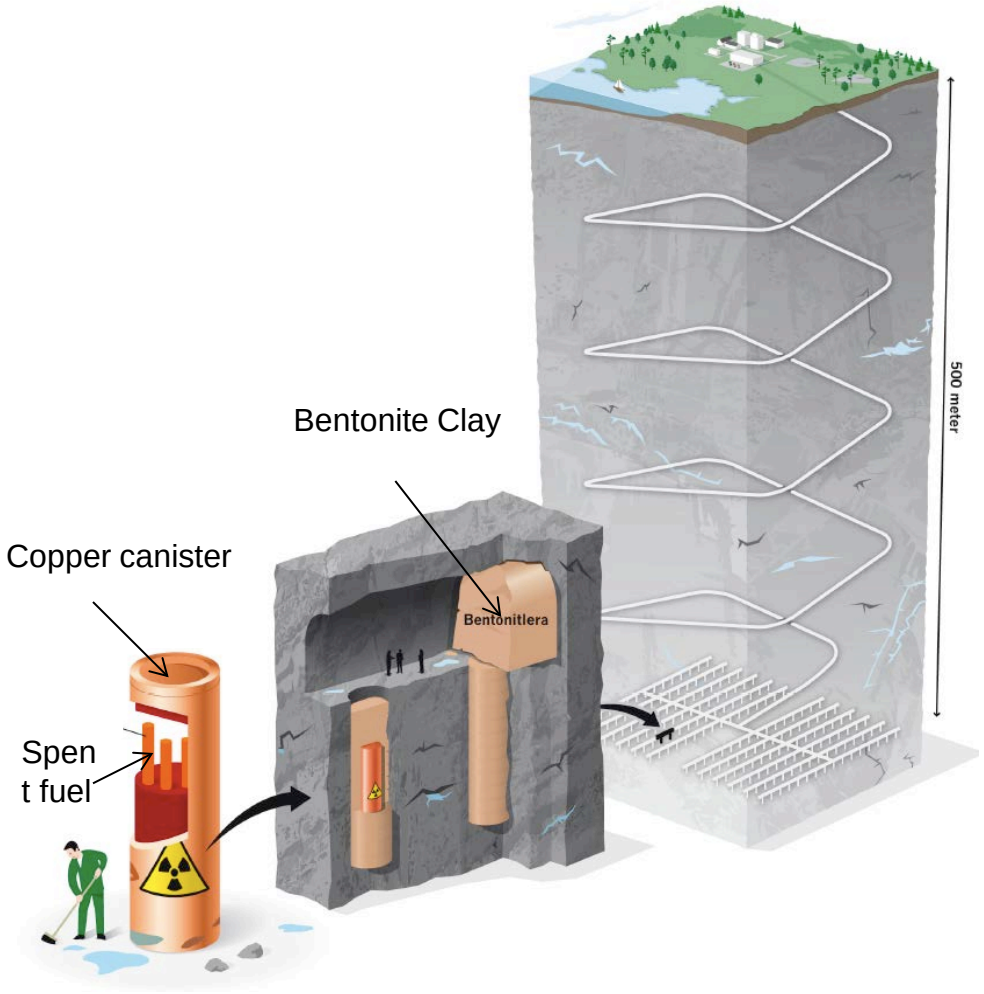
The “zero alternative”

- At the end of 2013 Clab contained 5 740 tonnes of spent nuclear fuel.
- The present capacity of Clab is 8 000 tonnes.
- With a “planned” operating life of 50 to 60 years for the 10 remaining reactors approx. 12 000 tonnes of spent fuel would be produced.
- Some of the storage canisters today are more compact. If all storage canisters were compact the capacity would increase to 10 000 tonnes.
- A third basin could also be built or a dry storage facility could be added.
- SKB says that spent fuel could be stored safely for 100-200 years.

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.



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Problems with copper corrosion

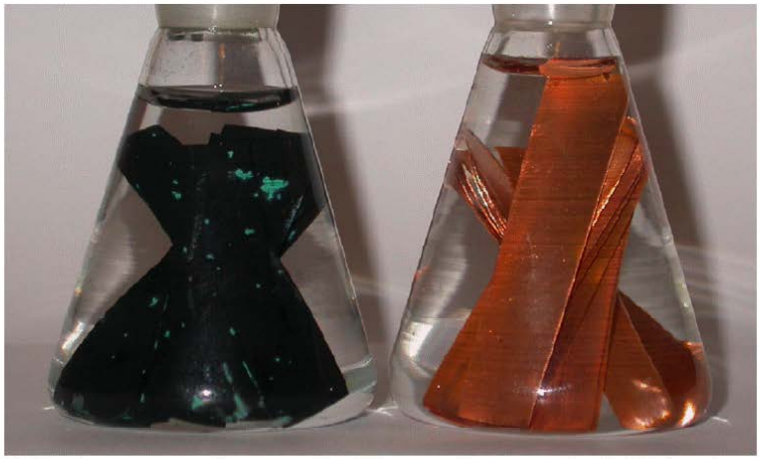

FIGURE 1 – Appearance of copper after 15 years of exposure in distilled water at room-temperature. Hydrogen from corrosion can escape from the left container but not from the container to the right. The water volume was equal in the flasks in beginning of the exposure.

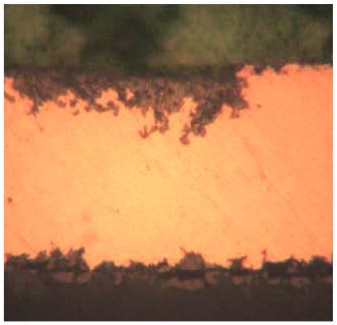

FIGURE 2 – Light optical cross-section of the initially 100μm metallic copper foil after 15 years exposure in distilled water. Localised corrosion attack is clearly visible.

Source: Peter Szakalos, Royal Institute of Technology. Stockholm

- The scientific hypothesis that anoxic (oxygen-free) water does not corrode copper in a repository may be false.
- Water can directly corrode copper!
- Copper in a KBS-repository may corrode at much faster rates than acceptable (<1 000 years until release of radioactivity).

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A number of other problems

- Siting issues (slow clay swelling, geotectonic fault, leakage current due to DC power cable to Finland can cause corrosion, nature preservation …)
- Glaciation issues (earthquakes, permafrost, stress on rock …)
- Human intrusion scenarios, long-term nuclear weapons risk

Also, perhaps a possibility:

- Alternative methods have to be presented, including deep boreholes

MKG briefs on the issues to be solved before the application is complete enough to be reviewed:

– June 1, 2012 (38 pages + appendices)

– October 15, 2013 (82 pages + appendices)

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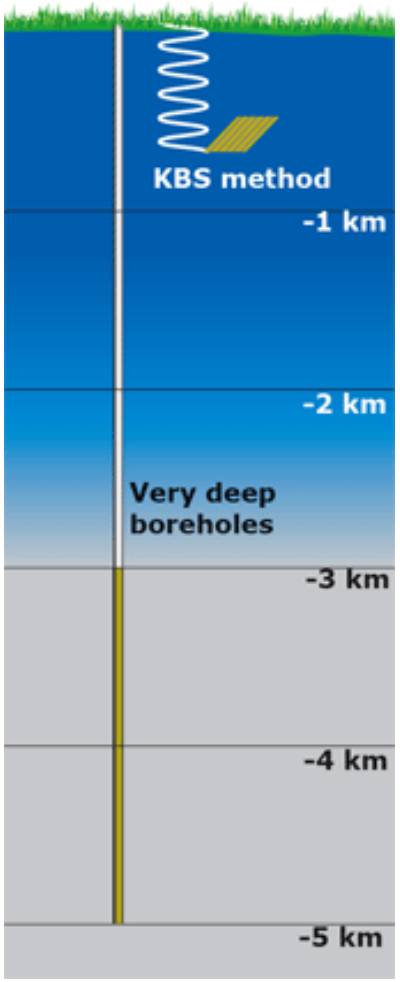
Very deep boreholes: An alternative method

- Also important in the review process is the comparison to alternatives. In Sweden the main alternative considered has been the use of very deep boreholes.
- An alternative method for geologic disposal of spent nuclear fuel or other high-level nuclear waste is disposal in very deep boreholes at depths of between 3 and 5 km.
- Deep boreholes may be able to provide higher long-term environmental safety and prevent long-term risks for nuclear weapons proliferation. All at a lower cost.
- Technology advances have made the method much more feasible than 20-30 years ago. There is a US development program at Sandia National Laboratory.



Source: MKG/Mikael Kårelind, Ummagumma

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Summary

- Sweden has an advanced system for financing and managing nuclear waste, but there are problems.
- There is a shortage of funds in the Nuclear Waste Fund
- There is a repository for short-lived nuclear waste, but it is built according to 1970s thinking and a planned expansion may have licensing difficulties.
- There is a central interim storage site for spent nuclear fuel.
- A method for final disposal of spent nuclear fuel, the KBS method, has been developed since the 1970s but may never be implemented due to copper corrosion problems and other problems.
- There is an interest in using deep boreholes as an alternative, a method that needs more development but that could be safer and less expensive.

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