Naturskyddsföreningen

A Serious Hiccup? Recent Developments in the Licensing of a Swedish Repository for Spent Nuclear Fuel

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Summary

- Sweden has been relatively successful in radioactive waste management and governance – “The Swedish Model”
- In recent years, however, considerable challenges have appeared. There are problems both for the financial system to pay for decommissioning, radioactive waste management and final disposal, and for the planned repository for a spent fuel repository at the Forsmark.
- The financial system has just been overhauled, but as only six reactors will remain in operation after 2020 and the future costs continue to increase, the risk for a collapse of the polluter-pays-principle is increasing.
- The regulatory and environmental court review of the 2011 industry application to build a repository for spent nuclear fuel has resulted in the court in January recommending the Government not to give a license.

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RWM governance in Sweden (1)

- In the 1980s the Swedish RWM governance system was set up in the “political calm” after the 1980 nuclear referendum.
- **Nuclear Activities Act (1983)**: The Swedish nuclear industry is responsible for managing and finding sites and methods for final disposal of radioactive waste. The reactor operators has created a private company, the Swedish Nuclear Fuel and Waste Management Company (SKB), to do the work.
- The nuclear activities act includes a process for review of the RWM research and development conducted and planned by the industry.
- An R&D report (FUD) is produced by SKB every 3 years. It is is broadly reviewed under the auspices of the regulator Swedish Radiation Safety Authority SSM and leads to a government approval. The process has been a relatively weak way for the government to follow RWM developments.

RWM governance in Sweden (2)

- The nuclear activities act and regulation also stipulates that the regulator, the Swedish Radiation Safety Authority (SSM), is responsible for reviewing applications for nuclear facilities, i.e., radioactive waste repositories.
- The regulator has set up its own regulatory framework for review.

RWM governance in Sweden (3)

- **Financial Act (1984, 2006)**: 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 is paid into the fund. It is re-evaluated and recalculated every 3 years. In addition there is a system of economic guarantees.
- There is a system for financing the RWM work of nuclear communities and environmental NGOs (until January 2017) from the fund. NGOs are now financed via the government budget.

RWM governance in Sweden (4)

- In the late 1990s a modern Swedish environmental legislation was created. The **Environmental Code (1998)** was established with its own review system for applications for environmentally harmful activities under a Land and Environmental Court ("Environmental Court").
- The environmental legislation implements the Aarhus Convention with regards to access to public participation (consultation) and access to justice for civil society and especially for environmental NGOs.
- Access to information is an old Swedish tradition but limited to public entities, i.e. the regulator SSM and the government, but not the implementer SKB that is a private company. For example, importantly, the research of SKB can not be followed in the public domain.

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RWM governance in Sweden (5)

- Applications for nuclear activities, i.e. radioactive waste repositories, are reviewed in parallel by the regulator SSM according to the Nuclear Activities Act and the Environmental Court according to the Environmental Act.
- Importantly, vital evaluation criteria from the Environmental Code (i.e, what has to be shown to be safe and when, the precautionary principle, use of best available site and technology) have been transferred directly into Nuclear Activities, and the regulator SSM has to follow them.
- The final decisions on a license permit has to finally be taken by the Government after the court and regulator has given their opinions.
- A “nuclear waste community” has a possibility to veto the government decision.

Financing problems (1)

- 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 and the creation of the new regulator (SSM).
- There is now an obvious lack of money in the fund due to expected low future rates of return, new estimates of future costs and the shutting down of reactors. Of the original 12 reactors two were shut in 1999 and 2005 (Barsebäck). Four more are being shut by 2020 as they are uneconomic to retrofit to comply with increased safety demands.
- The nuclear waste fee is increasing fast (≈ 0,3-0,6 €cent/kWh for 2018-2020) will likely be increased again.

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Financing problems (2)

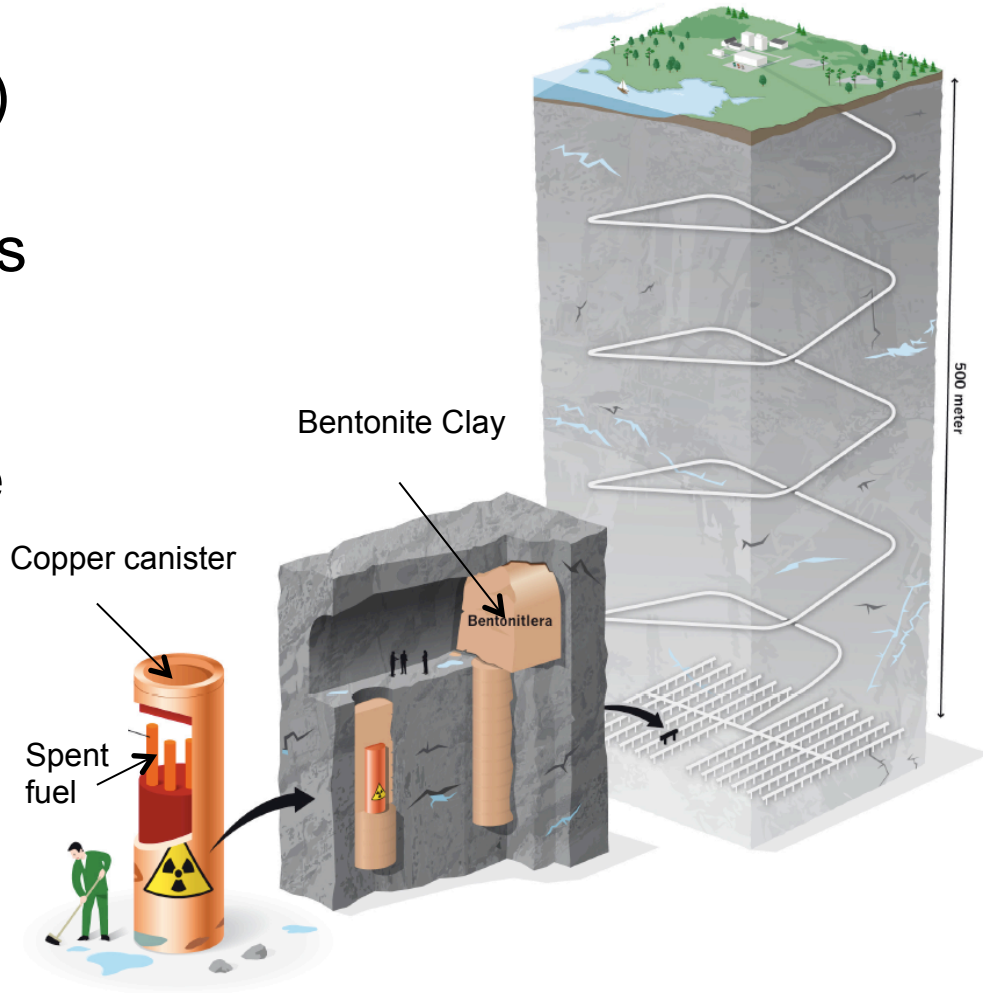
- The fee can increase even more for remaining reactors when further reactors are shut down. There is also a system with economic guarantees, but are these secure enough?
- Showing concern over the historical developments of the system, the government has now moved the responsibility of the financing system from SSM to the Swedish National Debt Office.
- The system will survive for a while, but in the future there will very likely be a “German situation” where the government will have to take over responsibility for the financing of RWM management and disposal.
- The possible future costs that would not be covered by the Nuclear Waste Fund are not unmanageable but a collapse of the financing system would break the polluter-pays-principle.

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 for a spent fuel repository was chosen in 2009 at the Forsmark nuclear power plant.
- The population in the local community Östhammar has been over 70% in support of a repository. There is a high trust in the state in Sweden. The community can veto a repository.

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 – a copper canister and a bentonite clay buffer to protect the copper – to isolate the spent fuel for hundreds of thousands of years.



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Problems with copper corrosion (1)

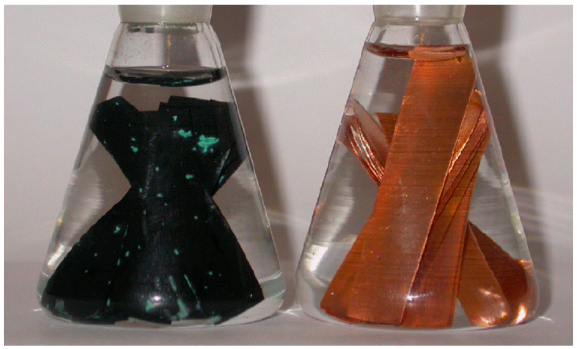


FIGURE 1 – Appearance of copper after 15 years of exposure in distilled water at room-temperature. Hydrogen from corrosion can escape from the left container but not from the container to the right. The water volume was equal in the flasks in beginning of the exposure.

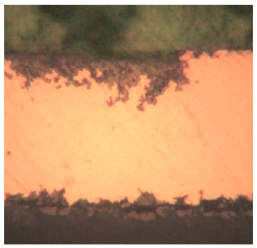


FIGURE 2 – Light optical cross-section of the initially 100µm metallic copper foil after 15 years exposure in distilled water. Localised corrosion attack is clearly visible.

- Experimental work at the Royal Institute of Technology in Stockholm has shown problems

- The scientific hypothesis that anoxic (oxygen-free) water does not corrode copper in a repository, where there is no oxygen after closure, is very likely false.
- There is a scientific paradigm shift to the fact that 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).

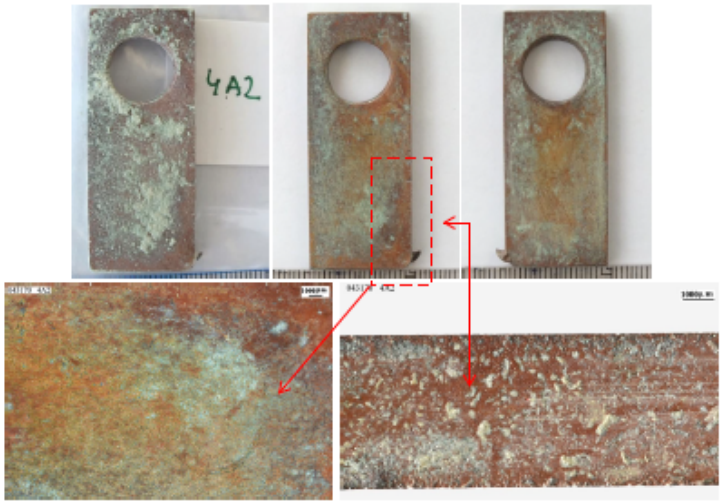
Source: Peter Szakalos et al., Royal Institute of Technology. Stockholm, several articles

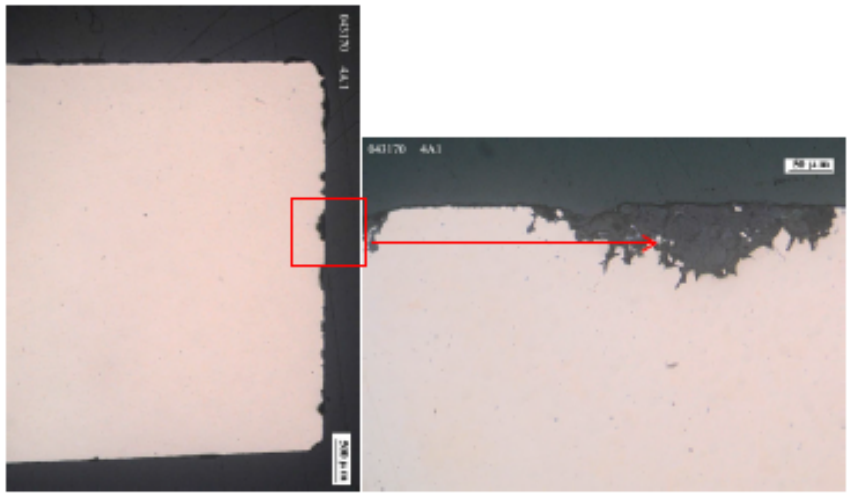
Problems with copper corrosion (2)

- It is now clear that SKB has not done the experimental work to show that copper behaves as assumed in an oxygen-free repository environment. Importantly, metal/clay environments becomes oxygen-free very fast so this would not have been difficult.
- Neither has any good laboratory work has been carried out by SKB. Such work is now being done in other countries (Germany and the U.S.) and show copper corrosion when oxygen is measured as absent.
- SKB has an experiment called LOT in its hard rock laboratory in Äspö near the Oskarshamn nuclear power plant. In 2006 a five-year old copper/clay package was removed and “unexpectedly high copper corrosion” was seen. The reporting was limited and SKB has refused to take up any further LOT packages even though there are 3 that are now 18 years old.

Problems with copper corrosion (3)

- In December 2017 the report came of the study of corrosion of copper coupons in the Swiss FEBEX experiment.
- The copper had been exposed 18 years in an oxygen-free repository environment.
- The measured corrosion was 0,1 mm and there was pitting corrosion which means that corrosion can proceed fast in the site where it starts. This is a very high rate!





Source: FEBEX-DP Metal Corrosion and Iron-Bentonite Interaction Studies, P. Wersin & F. Kober (eds.), Arbeitsbericht NAB 16-16, Nagra, October 2017. Can so far only be found on MKG's web site: http://www.mkg.se/omfattande-syrgasfri-korrosion-i-det-schweiziska-febex-forsoket

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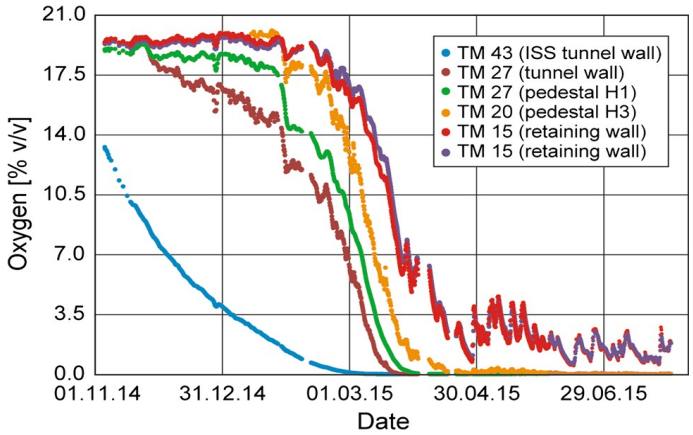
Problems with copper corrosion (4)

- Because SKB and collaborators can not admit that there is oxygen-free corrosion by water of copper many articles and reports by them claim that “oxygen must have been trapped or leaked into the experimental system”.
- It is now known that metal clay systems become oxygen-free in a matter of days, weeks or months depending on the sixe of the system due to bacterial and chemical activity.
- The best example is the new Swiss FE-experiment where a whole tunnel is measured to be oxygen-free in a few months.



Source: Implementation of the full-scale emplacement (FE) experiment at the Mont Terri rock laboratory - Müller et al - Swiss J Geosci (2017) 110 287–306. Also available on MKG’s web site: http://www.mkg.se/uploads/Aktbilagor/598_Nacka_TR_M1333-11_Aktbil_598_Yttrande_Naturskyddsforeningen_och_MKG_bilaga_2_170830.pdf

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Problems with copper corrosion (5)

- There is also a new article by U.S. researchers that have measured anoxic copper corrosion taking place in simulated repository water in an experiment that has measured the absence of oxygen.
- See: “Corrosion of Copper as a Nuclear Waste Container Material in Simulated Anoxic Granitic Groundwater”, He et al., Corrosion 74(2), February 2018.
  The article can be found on the MKG web site:
  http://www.mkg.se/nya-forsok-i-amerikanskt-laboratorium-visar-pa-syrgasfri-kopparkorrosion

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 was reviewed by the regulator, the Swedish Radiation Safety Authority (SSM) according to the Nuclear Activities Act and the Environmental Court according to the Environmental Act. The final decision on a license permit is to finally be taken by the Government.
- Initial review for completeness of the application was completed in 2015. During 2016 and 2017 the application was reviewed on issues.
- The community of Östhammar had in the spring of 2017 decided to hold a referendum in the spring of 2018, before giving a veto answer to the government.

License application and review (2)

- In the autumn of 2017 the main meeting of the Environmental Court was held. The regulator SSM told the court that some issues, i.e., the copper corrosion issue, could be dealt with after a government decision. The court questioned this in the meeting. According to both the Environmental Act and the Nuclear Activities Act the repository had to be shown safe before a government decision.
- The chair of the court showed a high interest and competence in radiation safety issues. The court was indirectly very critical of how SSM had done its judicial analysis and how it had not used the evaluation criteria from the Environmental Code.
- It was also found that the regulator SSM had internal criticism of its standpoints regarding copper corrosion. Internal documents were leaked to media.

License application and review (3)

- On January 23, 2018 the Environmental Court made its recommendation to the government. The court recommended that the government say no to the application unless the copper canister problems were resolved.
- On the same date the regulator SSM told the government that it could say yes, as the copper corrosion issue could be dealt with later, after a government decision.
- The “government” is quite upset about the situation. It lacks routines, competence and resources to perform its own review, especially on complicated technical issues.
- This summer the government gave SKB until the end of April 2019 to comment on the opinions of the court and SSM as well as further comments from scientists and NGOs that have been made during the spring.
- SKB will make its own “international review”.

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License application and review (4)

- The researchers at the Royal Institute of Technology have stated that further research on copper would not help. It would just show how bad copper really is as a canister material. They have nonetheless suggested what experiments can be done if the government wants to make a more elaborate review.
- The Swedish Society for Nature Conservation and MKG wants the next LOT experimental package to be taken out and examined. If the corrosion is as bad as in the FEBEX experiment then it is shown that copper will not work.

License application and review (5)

- Sweden has parliamentary elections on September 9.
- There will be a (perhaps extended) review process also after SKB replies next spring, especially if new information comes up on copper corrosion. Comments will be requested from SSM, scientists and NGOs.
- The role of the regulator SSM will be for a future decision by the government. The regulator has lost a lot of. Basically SSM is saying that even if the copper does not work, the whole system can be good enough to give long-term safety. A new general director will take over in 2019.
- Finally the government has to take a decision. If it is a yes Östhammar community will also have a say and may have a referendum. It can also say no, or even pass the case back to the environmental court.

What ways forward if copper will not work?

- Accept a method that will not work as intended? The release of radioactivity will be relatively long into the future – maybe after 500 to 1 000 years. Maybe the consequences will not be so bad? Such a discussion is problematic as it means to go ahead while not following safety criteria or legal obligations. This is not likely.
- Find a better canister material? A good steel is better, but likely not good enough for the safety over hundreds of thousands of years.
- Use an alternative method? The use of very deep boreholes has been examined in the United States and also been discussed in Sweden.
- Always the possibility of a system of rolling stewardship but the present legislation stipulates a final repository.

Summary (1)

- The Swedish governance system for RWM has after many years of successes in the last few years seen some setbacks.
- This is despite ambitious efforts at creating a good governance system (legislation, implementation, R&D programme and review, financial system with nuclear waste fund, advanced public participation including funding of communities and NGOs, good access to information from public entities and a very open and an inclusive decision-making process in the Environmental Court).
- One reason for the problem is a relatively weak regulator that did not change its work when the Environmental Act was introduced. The regulator SSM has now lost much trust.

Summary (2)

- Another reason is lack of access to information from the private company SKB. This has led to scientific problems, most specifically copper corrosion issues, not being dealt with properly.
- It has not helped that the political interest and competence in radioactive waste issues from the side of the government historically has been quite low.
- The result is:
  - not enough money put into the Nuclear Waste Fund
  - a definite risk that the KBS method and the planned repository for spent nuclear fuel in Forsmark will not be licensed.
- Alternatives now have to be discussed, for instance the use of very deep boreholes for final disposal.

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