

## Answers to questions raised by Gerhard Schmidt concerning the planning process for a Danish nuclear waste repository

This paper answers questions raised by ing. (grad.) Gerhard Schmidt, Öko-Institut e.V., Darmstadt, based on his working paper "The Danish Inventory of radioactive waste and the required repository type" (2014). It has been prepared by the Ministry of Health, Danish Decommissioning, Geological Survey of Denmark and Greenland (GEUS) and National Institute of Radiation Protection.

An overall comment: Some of the questions contain implicit statements that are incorrect and obviously based on lack of information about the Danish process. Based on both the questions and the working paper it has become clear that the author has not collected information about the background documents, e.g. Basis for Decision, and has only read parts of the pre-feasibility study. Many of the flaws, misunderstandings and faulty assumptions could have been prevented if the author had been in contact with the relevant organizations during the process, which has not been the case.

### 1 Criteria for site selection

- *On which decision basis was the projected repository concept developed and where has this been described/laid down beforehand?*

No final repository concept has yet been developed. In the basis for decision ('Beslutningsgrundlag for et dansk slutdepot for lav- og mellemaktivt affald, Ministeriet for Sundhed og Forebyggelse, 2008 (hereafter called the 'Basis for Decision') three different concepts are described, all of which to be investigated further as possible solutions (p. 34).

Preliminary investigations were carried out in 'Forstudier til slutdepot' (Pre-feasibility study for final disposal of radioactive waste, 2011) which were published as one of three different reports in May 2011. 'Forstudier til slutdepot' encompasses feasibility studies with the purpose of establishing whether the three described concepts are viable for further investigation in later area-specific studies. The area-specific studies will be carried out if there is a political decision to aim at this time for a final repository as a long term solution.

- *What timeframe was chosen for the repository (for its isolation properties, for host rock and geologic layer integrity, for long-term safety assessments)?*

No timeframe has been chosen. In the 'Basis for Decision' it is stated that the repository has to be constructed so that with a large probability the waste can be isolated from humans and environment for a suitable period of at least 300 years (p 19). As such, there is no upper limit defined for the timeframe of a repository. It is up to the Danish nuclear regulatory authorities e.g. based on the safety case on a specific repository (for a specific concept on a specific locality with the specific Danish waste) to define this period if necessary.

However, as the repository has to be demonstrated safe at all times it may not be relevant to set up a limited time frame for the repository.

When the radioactivity has decayed it is possible that the authorities may change the status of the repository to a repository for hazardous waste (Basis for Decision p 42)

For long term safety assessments see **2 Safety Criteria**, below.

- *On which basis was decided to search for a depth between 0 and 100 m, what was the rationale for that?*

Based on the estimated composition and volume of the total Danish waste at the time of disposal it was decided to use pre-feasibility studies of three different concepts, (at depths down to 100 m below surface) as a starting point for the investigations ('Basis for Decision' p 34). The results of the pre-feasibility studies (Pre-feasibility study for final disposal of radioactive waste, 2011) showed that this is a realistic starting point.

Before a specific repository concept on a specific locality can become reality it has to be shown by a safety case that the repository will satisfy all relevant safety criteria. If the specific safety case fails to show this, the repository cannot be accepted. In this case another solution has to be investigated. Another solution could include e.g. a different locality, a different depth of disposal or a different repository building concept.

- *Why was the selected host rock not defined in the search process?*

It is incorrect that the selected host rock was not defined in the search process.

In the 'Basis for Decision' (chapter 7, p 37-40) 17 criteria for a host rock are described. The criteria include stability, homogeneity on a large scale, and chemical or physical properties of the host rock which will contribute to isolate the waste from humans and environment. Furthermore the relationship of the host rock to groundwater and geochemistry are addressed. The Criteria are based on the Guidelines from IAEA (1994, 1999,) on "Near Surface Disposal of Radioactive Waste" which is repeated in IAEA (2014): Near Surface Disposal facilities for Radioactive Waste.

As the third preliminary study a regional geological mapping on existing data was performed to recognize potential host rock types and areas. 22 areas were selected as result of the mapping with the following possible host rocks: 1 Danian limestone area, 1 Elsterian lake clay area, 3 Precambrian crystalline basement rock areas, and 17 Paleogene clay areas. From the 22 areas 6 were selected for further investigations. The host rock targets in these areas were: 1 area with Precambrian crystalline basement rocks (from ground surface to large depth), 5 areas with Paleogene clays (from a few m below ground surface to 110-200 m's depth). Therefore the target host rocks are not from the ice-ages as stated in Schmidt (2014) but old Precambrian rocks (1440 mio. years old) and Paleogene clays which are between 20 -60 mio. years old and can be compared with Dutch and Belgian plastic clay and Boom Clay which also are from the Paleogene.

As mentioned this mapping was based on the criteria from the "Basis of Decision" but before the mapping was started, several studies were carried out and reported. One report on existing data, maps, models and methods used in the mapping was prepared (47 pages) and one report on low-permeable rocks and sediments in Denmark which possibly could be host rocks was written (78 pages). This report contains existing knowledge of characteristics of the Danish rocks and sediment as lithology, age, thickness, mineralogy, chemistry and hydrogeology. Finally, one report on the geological setting in Denmark was also prepared (51 pages). These reports were put out on GEUS home-page in 2011, where the reports have been available together with all the 14 reports with mapping results from 2011 and 2012. Several other reports and papers were also available on the Home-page.

The methods and the criteria have been repeated in reports and papers.

Based on the available Danish geology four different possibilities were selected for further investigation as a part of the prefeasibility studies which were published in 2011.

- *Why were minimum geologic layer suitability properties not defined in site selection?*

It is incorrect that minimum geologic layer suitability properties were not defined in site selection.

A number of properties were defined and described in the publications mentioned above, (See answer above and 'Basis for Decision' chapter 7, p 37-40 and publications on GEUS homepage). The most important mapping criteria used above was the low-permeability characteristics of the layers and the thickness and horizontal distribution. Because Denmark uses groundwater for drinking water purposes (99 % groundwater) the knowledge about the aquifers (groundwater reservoirs) and aquitards (low-permeable layers) is very comprehensive because of the many surveys and nation-wide mappings of the groundwater conditions and a database with more than 250.000 boreholes, with boreholes reaching down to more than 300 m below ground surface.

- *Why were the site evaluation criteria not principally discussed beforehand and laid down in a document before the selection started?*

It is incorrect that site evaluation criteria were not principally discussed beforehand and laid down in a document before the selection started.

The first steps in the site selection were based on purely technical and geological criteria and geological mapping in accordance with the IAEA guidelines. The criteria were indeed described in the 'Basis for Decision' (Chapter 7, see above) and published in reports and papers (see above). Schmidt (2014) has several undocumented remarks on Danish geology, the mapping and process and selection procedure but the reference list in his report does not include any references on Danish geology, the mapping and the process although 17 reports and several papers on these items could have been found on GEUS homepage: [www.geus.dk/DK/nature-climate/land/Sider/index-dk.aspx](http://www.geus.dk/DK/nature-climate/land/Sider/index-dk.aspx) since 2011.

## **2 Safety criteria**

- *Are there any safety criteria for the repository, beyond the simple dose criterion, planned or discussed?*

Chapter 5 in the 'Basis for Decision' – "Safety Criteria and Safety analyses", outlines the general safety principles to be considered for a Danish final repository. Proposed dose constraints for a repository in the operational phase, the phase after closure and for potential events affecting one or more repository barriers (such as malfunction of engineered barriers, unintentional emplacement of a drinking water well, seismic events) were given as 0,1 mSv, 0,01 mSv and 1 mSv, respectively. Corresponding risk factors as well as criteria for environmental protection were outlined. Furthermore, the purpose, contents and limitations of planned preliminary safety analyses were described. Specifically, features (repository design and surroundings), events (natural processes and unintentional human intrusion) and processes (physio-chemical reactions) to be considered in safety analyses were listed. Events of extremely low probability or with vastly devastating effects, such as meteorite impacts, ice ages, major earthquakes and volcanic eruptions were deemed beyond the scope of the described preliminary safety analyses, but may be addressed at later stages. Although considered to be a very low probability event, the special situation in Denmark, where the majority of drinking water is extracted from the groundwater reservoirs, placed emphasis on analyses of events and processes leading to release of radionuclides into aquifer layers.

Safety analyses were to be developed in a sequential process, first evaluating generic scenarios (cf. Pre-feasibility study for final disposal of radioactive waste, 2011), including generic repository

designs, generic geological settings and simplified dispersal models. The outcome of these analyses will serve as basis for deciding which scenarios, nuclide inventories, dispersion models etc. define the bounding conditions of a specific repository concept at a given location. Such analyses will provide input into the safety assessment and overarching safety case for the repository, which will be developed through iterations of analyses and assessments. Establishing a repository can only take place once all safety criteria have been met, and demonstrated in the safety case.

Currently, the safety documentation is limited to the pre-feasibility studies, notably the pre-feasibility study for final disposal of radioactive waste (2011), which demonstrates that it is likely possible to establish a repository for the Danish inventory of radioactive waste. Selection of a small number (down to two) locations out of the initially screened 22 locations, will enable further geological and technical surveys and evaluations, before updated safety analyses can become part of a preliminary safety assessment and safety case for each of the studied locations. If, at any point in this process, failure to demonstrate compliance with safety criteria becomes evident, the justification for continuing the process will be taken up for evaluation.

- *What role will the overall safety play in the comparison of sites? To what extent will systematic preliminary safety assessments play a role in comparison?*

Cf. answer to question about safety criteria.

- *Is long-term predictability and the integrity of protective isolation layers a suitability criterion?*

Cf. answer to question about safety criteria.

Note that it is specifically stated in Chapter 5 in the 'Basis for Decision' – "Safety Criteria and Safety analyses", p.24, that a final repository must be located, designed, built, operated and closed such as to ensure that:

- Anticipated and potential exposures are optimized taking into consideration societal and economic factors.
  - Neither the radiation exposure nor the risks to individual members of the public in the long term exceed the criteria stipulated for the repository.
- *Are quantitative enclosure criteria planned that sites have to meet (e. g. to enclose more than 99% of all immobile species and >50% of all mobile species)?*

With the development of a site-, inventory- and repository design-specific safety case, further quantitative safety criteria will be derived, pertaining to relevant scenarios identified in the safety case.

### **3 Site selection process**

- *What further stages in the site selection and evaluation process are planned?*

It has been agreed between the political parties in the Danish Parliament on March, 11. that all work concerning the repository shall be discontinued for now and work in stead concentrated on a long term storage solution before a choice between the two can be made in a year from now.

If planning for a depository were to be continued, there would follow a long process with many steps. Some important stages would be as follows: First two areas among the six appointed so

far would be selected. Proposal would come from the interministerial working group and based primarily on geological criteria. A bill would be presented to Parliament for work on two alternative detailed projects on two different locations. On that basis detailed geological and other studies would be conducted to select optimal locations within the selected larger areas taking account of other restrictions as specified in the overall plan as amended in the environment assessment process. Alternative repository concepts would be worked out adapted to the specific locations.

In-depth safety analyses would be conducted based on the concrete projects and concrete geology, see item 2 above. These analyses should document that the multibarrier system (incl. geology) would prevent any exposure to radiation to man or environment beyond specified safety criteria at any time in the future. The overall safety case and the process would be reviewed by an international expert panel appointed by for instance IAEA. Without a fully satisfactory and well documented safety case a repository cannot be established. Full environmental project assessments (Danish: VVM) would be conducted. Work under the projecting act would take probably 2-3 years.

Finally a new bill would be presented to Parliament proposing the single most suitable repository to be build among the two alternative projects - if and only if safety requirements are met. With the bill enacted construction could begin.

- *Who is responsible for the selection process, which institutions are responsible for reviewing the process and the results?*

The interministerial working group would propose the two areas for the projecting bill. Further organization and responsibilities would be determined by Parliament in the projecting act. Compliance with safety criteria would be reviewed by an international panel, see above. The final project would need a number of approvals from authorities according to law. As for safety and radiation protection approval by the nuclear regulatory authorities (Danish Health and Medicines Authority by the National Institute of Radiation Protection and the Danish Emergency Management Agency) would be required.

- *Who/which institutions can appeal in that process and on which formal basis, who decides on which basis about those appeals?*

This is hardly the place for a full scale description of the Danish environmental legislation. But there are several mechanisms for public involvement: public hearings, complaints etc.

- *Is any kind of volunteering sought for in that process?*

If planning for a repository is to be continued there will undoubtedly be efforts to seek cooperation with the selected communities.

- *Do host communities have the right to veto against those decisions?*

No, even though cooperation will be sought, at the end of the day the Parliament sometimes has to decide against local wishes on unpopular but necessary projects.

- *How are expenses of host communities covered in this process?*

We are not sure which expenses the question is about. In general the costs of a central government project are covered by the government.