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Identifying remaining socio-technical challenges at the national level: Germany

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CONTENT

This report was written within the EU-project InSOTEC (www.insotec.eu) which aims to generate a better understanding of the complex interplay between the technical and the social in radioactive waste management and, in particular, in the design and implementation of geological disposal. In a first step 13 countries have been analysed in order to identify prevailing socio-technical challenges. This report aims to describe the current state of affair in Germany (chapter 1) and intent to identify the prevailing socio-technical challenges in Germany (chapter 2).
In a further step of the project it will be analysed in more detail how such socio-technical challenges can be considered and recommendations will be formulated. This will be done based on several case studies summarizing the experiences of all country reports.

1 State of affair

1.1 General Overview and key developments in nuclear policy in Germany

Germany's nuclear power program started in 1955 after the country officially renounced the development and possession of nuclear weapons. Germany's first nuclear power plant, the prototype reactor VAK at Kahl, Bavaria, began operating in 1960. At the start of 2011, there were 17 nuclear power reactors in operation at 12 sites with a total capacity of 21.5 GWe, producing around 23 percent of Germany's electrical power. Following the March 2011 Fukushima accidents, the government decided that the safety of all existing nuclear power plants should be analysed in a so called stress-test (RSK 2011) taking into account the experiences of the Fukushima accidents as well as specific beyond design load and accident situations. Eight reactors, mainly the oldest German reactors, were ordered to be shut down in the meantime. After finalisation of the stress test the government announced the decision to finally shut done the eight oldest reactors and the remaining nine by 2022.

In Germany, radioactive waste is categorised in heat-generating waste which also includes spent fuel and waste with negligible heat generation (BMU 2011b: 25). All types of waste are planned to be disposed of in deep geological repositories. Most of the waste with negligible heat generation with a volume of up to 300.000m³ is expected to be disposed of in the Konrad repository. After a several decades lasting licensing process, the license became legally binding in 2007. Since then the termination of construction and start of operation has been delayed several times and is currently expected for 2019.

This report focuses on the management of heat generating radioactive waste which has a volume of approx. 22.000m³. Furthermore developments at the Asse-repository are being considered as they are influencing the political and societal discussion on nuclear waste disposal in general.

Germany's current waste management policy for heat generating radioactive waste has been shaped by:

1. The amendment of the atomic law, the so called "nuclear phase-out law", of 2002 and subsequent policy changes in 2010 and 2011;
2. The end of foreign reprocessing of Germany's spent fuel, and
3. The development of disposal concepts and the siting of geological repositories.

Until 2005, utilities had the option of sending spent fuel for reprocessing in France or the U.K. or till 1998 to a central interim storage facility at Gorleben for eventual direct disposal. Since 2005, as part of the Atomic Energy Law 2002 amendment*, the only option for spent fuel management is onsite interim storage at the reactor site where it has been produced and subsequent geological disposal when a site is available.* Return shipments of high active waste from reprocessed spent fuel to the central interim storage at Gorleben are still on-going. *A site for geological disposal of spent fuel and heat generating radioactive waste has not yet been determined.* In the 1960ies the Federal Institute for Geosciences and Natural Resources (BGR) recommended to dispose of the radioactive waste in salt. Till 2011, exploration and research activities have been focused on the Gorleben salt dome in Lower Saxony, but the site remains controversial.

1.2 Main actors in the field of nuclear waste management

- **The Federal ministry of the environment (BMU)** is the regulatory authority, is responsible for the development and implementation of the waste management policy and has a supervisory function over the BfS and over the state nuclear licensing authorities.
- The responsibility for basic research on the disposal of radioactive waste lies with the **Federal Ministry of Economics and Technology (BMWi).**
- **The Federal office for radiation protection (BfS)** acts as implementer for radioactive waste disposal. It is a subordinate authority under the Federal Ministry of the environment (BMU).
- For fulfilling its tasks related to the construction and operation of repositories for radioactive waste, the BfS currently employs the services of the ***Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe*** **(DBE)** ***mbH*** (German Service Company for the Construction and Operation of Waste Repositories) as administrative aid.
- For the operation and decommissioning of the Asse II mine, the federally owned **Asse GmbH** was founded as an administrative aid for the BfS.
- Licensing is under responsibility of the **States (Länder).** E.g. the **environmental ministry of Lower-Saxony (NMU**) is responsible for licensing the closure of the Asse mine or exploration activities at Gorleben.
- **The Federal Institute for Geosciences and Natural Resources (BGR**) is the central geoscientific authority providing advice to the German Federal Government in all geo-relevant questions. It is subordinate to the Federal Ministry of Economics and Technology (BMWi).
- The **Nuclear Waste Management Commission (ESK)** advises the BMU in matters of nuclear waste management. The ESK publishes statements and recommendations. The commission is composed of several national and international experts representing the wide range of existing scientific and technical views.
- **The Commission on Radiological Protection (SSK)** advises the BMU on issues involving the protection against dangers of ionising and non-ionising radiation. The SSK publishes statements and recommendations. The commission is composed of several national experts and one IAEA expert representing the wide range of existing scientific and technical views.
- **The Reactor Safety Commission (RSK).** The RSK advises the BMU in safety-related matters and thus matters concerning the physical protection of nuclear installations and till 2008 of radioactive waste management. With the establishment of the ESK in 2008 radioactive waste management has become a topic of consultations of the ESK.

Although nuclear waste disposal is defined as a task under federal state responsibility in German Atomic law the states have strong political influence on actual activities and furthermore have the competence for spatial planning within their boundaries.

Linked with the discussions of restarting the siting process and the efforts to create a new act (see section 1.7.), a change of responsibilities is discussed. According to the current draft of the new act (BMU 2012), it is foreseen to establish a new Institute for Disposal of Radioactive waste (Institut für die Endlagerung radioaktiver Abfälle) which should as scientific expert prepare the site selection decision. A reason for the current attempts to change the responsibilities is the demand to have a

clear distinction between the role of the implementer and regulator which is stated in the EU directive 2011/70/EURATOM on the management of radioactive waste. The discussion on responsibilities is still ongoing.

1.3 The legislative and regulatory system

The legislative and regulatory system for nuclear waste management in Germany is in detail described in (BMU 2011b: 109 ff.) In the following the main points are summarised:
The Federal Republic of Germany is a Federal State. The responsibilities for law-making and law enforcement are assigned differently to the organs of the Federation and the States (Länder) according to the respective regulatory duties.

There is a hierarchy of national regulations. The specific regulations are adapted by different authorities or institutions and have a different degree of bindingness:

- Generally binding:
    - Basic Law (adopted by Federal legislator)
    - Atomic Energy Law (adopted by Federal legislator)
    - Ordinances (adopted by Federal Government, Federal Council)
- Binding for authorities:
    - General admistrative provisions (adopted by Federal Government, Federal Council)
- binding by specification in the licence or by supervisory measure in the individual case:
    - BMU publications (Guidelines and recommendations) (adopted by Federal Government, Land authorities)
    - RSK and ESK guidelines (adopted by Advisory bodies)
    - KTA safety standards (adopted by KTA
    - Technical specification for components and systems (adopted by industry)
    - Organisation and operation manuals (adopted by industry)

The Basic Law (Grundgesetz, GG) contains provisions on the legislative and administrative competencies of the Federation and the States (Länder) regarding the use of nuclear energy. In addition, there are fundamental principles that also apply to the nuclear law.
The basic legislation governing nuclear activities is set out in the 1959 Atomic Energy Act (AtG). This lays down the general national regulations for protective and precautionary measures, radiation protection and the management of radioactive waste and spent fuel in Germany and constitutes the basis for the associated ordinances.
For further concretisation of the legal regulations, the Atomic Energy Act includes authorisations for the promulgation of statutory ordinances. With regard to the disposal of radioactive waste the most important ordinances pertain to:

- radiation protection (Radiation Protection Ordinance) (StrlSchV),
- advance payments for the construction of radioactive waste disposal facilities (Repository Prepayment Ordinance) (EndlagerVlV)],
- the Gorleben Development Freeze Ordinance (GorlebenVSpV).

Safety provisions for the disposal of heat-generating waste are laid down in the “Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste” (BMU 2010).
Such Safety Requirements or Guidelines are issued by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) following consultations with the Länder and generally

by way of consensus with them. These guidelines are designed to provide a detailed specification of selected technical and administrative issues.

In Germany, a repository for radioactive waste has to be licensed in the so called “plan approval procedure” (“Planfeststellungsverfahren”). In accordance with international recommendation (e.g. IAEA 2006) a “Safety Case” needs to be prepared which collects all arguments and evidences to demonstrate the safety of the repository (see BMU 2010). For an approval, the implementer has to assess the long term safety and has to give several other evidence of safety for the operation and post-closure phase concerning radiological assessments as well as mining aspects or the protection of groundwater. Moreover, an Environmental Impact Assessment has to be conducted.

1.4 Timeline aid

1955: Start of nuclear power program
1959: Atomic Energy Law
1960: first nuclear power plant VAK at Kahl, Bavaria started operation
1963/64: Federal Institute for Geosciences and Natural Resources (BGR) recommended a final disposal of radioactive waste in salt
1967: Start of disposal of low and intermediate radioactive waste in the Asse-repository as a research project
1971: Morsleben repository for low and intermediate radioactive waste started operation
1977: Gorleben chosen as a potential site for a final disposal for all types of radioactive waste, later only for the heat generating radioactive waste.
1978: Stop of disposal of radioactive waste in the Asse-repository
1978/79: Hearing in Lower Saxony on the pros and contras of the “national waste management centre” in Gorleben
1979: Start of Gorleben Investigations
1982: Application for the Konrad plan approval procedure (Planfeststellungsverfahren)
1983: Publication of the safety criteria for a final disposal by BMU
1988: Start of brine entry in the Asse repository
1989: Reunion of West- and East-Germany
1990: Check whether the Morsleben repository meets the safety criteria
1994: Both reprocessing and final disposal are seen as equivalent ways for managing spent fuel
1997: Germany signed the Joint Convention on Spent Fuel and Waste Management
1998: Stop of Disposal of radioactive waste in the Morsleben repository
2000: Nuclear Consensus between German Government and the power companies for phase out of nuclear power, Start Gorleben-Moratorium
2002: Decision for final disposal as the only option of managing spent fuel
2002: Publication of the recommendations of the AKend
2005: Prohibition of reprocessing
2007: Creation of the Citizens Advisory Group in Asse
2007: License for the Konrad repository became legally binding
2008: Creation of the Nuclear Waste Management Commission (ESK)
2009: status of the Asse mine officially changed from a research project to a radioactive waste repository
2010: new safety criteria for a final disposal published by BMU
2010: End of Gorleben-Moratorium, Restart of investigations
2010: Retrieval of radioactive waste in the Asse repository chosen as the best option

2010: Start of a Preliminary Safety Assessment Study Gorleben
2011: Publication of EU directive 2011/70/EURATOM on the management of radioactive waste
2011/2012: Federal Government and Länder started discussion of a new law for siting final disposals
2012: Start of three-phased feasibility study of the feasibility of the retrieval of radioactive waste from the Asse repository

1.5 The Asse repository for low- and intermediate level waste

From 1967 to 1978, 125,800 barrels of low- and intermediate level waste in the Federal Republic was disposed of – nominally for research purposes – in the Asse salt mine which had before been used for the production of potash for many years. Since 1988 an inflow of brine at a rate of about 12 cubic meters per day has been measured in the southern area of the mine. If the amounts of brine increase, there will be dangers of flooding and of a collapse due to salt weakening and dissolution.

Planning for the closure of the Asse repository started in 1997. The objective is to prevent the flooding and collapse of the mine and the release of radioactive substances to the biosphere. *A group of regional representatives has been involved in the discussion of options for the closure since late 2007[1]. In the so called "Asse-2-Begleitgruppe" (Asse-2-Advisory Group) they meet regularly with representatives of the BfS, the BMU and nominated experts.* In 2009, the status of the Asse mine was officially changed by the Government from a research project to a radioactive waste repository after massive protest of the Citizens Advisory Group and the regional citizens' initiatives. This means that the mine has to be operated according to the atomic law now instead of the mining act paying higher attention to radiation protection and long term safety. The licensing procedure for the closure of the repository requires providing the inhabitants of the region opportunities to express their concerns. Several options for closure namely backfilling of the mine, internal rearrangement of the waste in different parts of the mine and the retrieval of the waste have been considered. Finally it was decided to favour the option of waste retrieval.

An assessment of the feasibility of retrieving all or part of the waste packages in Asse began in 2010. In parallel, measures to increase the stability of the mine are being undertaken in order to slow down the imminent collapse of the mine and to extend the potential time for future actions. Due to uncertainties regarding the condition of the waste packages and disposal chambers, possible retrieval techniques and the time required, a final decision to start the retrieval of all the waste will not be taken before a three-phased feasibility study is completed. In the first phase it is planned to drill into two disposal chambers in order to analyse the atmosphere and condition of the waste packages. In the later stages it is foreseen to open these disposal chambers and retrieve experimentally some waste package for further analysis. The first phase has been licensed in spring 2011 after a one-year period of planning. The work started in June 2012 after several delays due to management and technical problems.

The problems in the Asse repository have stirred up the public debate on the suitability of salt formations and of the concept of geological disposal in general. This also influenced the public debate over high-level waste disposal and the Gorleben salt dome: The suitability of salt for waste disposal as well as the concept of non-retrievable disposal are questioned.

[1] See www.asse-2-begleitgruppe.de

1.6 Explorations of the Gorleben salt dome for disposal of heat generating radioactive waste

German initiatives to locate a geological repository for heat generating radioactive waste have focused on the Gorleben exploration mine in Lower Saxony adjacent to the Gorleben interim storage facility. Originally, in the 1970s, Gorleben was proposed as the location of a "national waste management centre" where reprocessing, waste conditioning, interim storage and disposal would all take place. Political considerations, such as its location near the border with East Germany and the low population density, played a role in the selection of the site. One reason for locating it near the border was maybe also that the Morsleben repository in former East-Germany was operated near the border as well. When the plan of the national waste management centre proved to be politically infeasible because of lacking acceptance in the public the Government chose Gorleben as a candidate site for a repository first for all types of radioactive waste in 1977. Later its purpose was narrowed further to the disposal of heat generating waste, i.e., mainly spent fuel and high-level reprocessing waste.
As the siting process started as a search for a "national waste management centre" the selection criteria were not focussed on the suitability for geological disposal but also considered aspects like radiological releases from reprocessing. In so far Gorleben is not the result of a comparison of sites based on the potential suitability for a radioactive waste repository.

Underground exploration of the Gorleben site began in 1986. The selection of Gorleben has been controversial since the very beginning (see also section **Error! Reference source not found.**). The nuclear consensus of October 2000[2] between the then red-green government and the utilities therefore included a three to ten years moratorium on further exploration there with the aim of clarifying non site specific questions of geological disposal. Accordingly, the BfS initiated activities to work on safety related issues, independent of any site or host rock. The synthesis report was published in 2005 (BfS 2005). Nevertheless, the Government stated up to then no issue is know which questioned the potential suitability of the Gorleben site The new federal government elected in 2009 decided to end the Gorleben moratorium followed by immense public debates about the suitability of Gorleben. Exploration activities were restarted in October 2010.

The choice of exploration areas of the Gorleben salt dome is being influenced by private salt mining rights held by private owners. The Atomic Energy Act of 2010 allows for the possibility of compulsory government purchase of such rights, but there has been as yet no indication that the Government will make use of this right within the next several years.

The results of the investigations so far are interpreted differently in the scientific community as well as on the political level. E.g. the Federal Institute for Geosciences and Natural Resources (BGR) conclude that so far no geological-technical issue has been found which must lead to the exclusion of Gorleben (BGR 2007 a and b; BGR 2008.; BGR 2011). Currently a "Preliminary Safety Assessment" initiated by the Ministry of Environment shall evaluate whether the realization of a safe final disposal at the Gorleben site could be feasible (GRS 2012). The aim of the Preliminary Safety Assessment Gorleben is also to summarize the research results till today and to identify the needs for further investigations. Others point out that several geological-technical issues questioned the suitability of the Gorleben salt dome e.g. the occurrence of hydrocarbon under the salt dome (Schneider 2011) or

[2] An agreement on nuclear phase out and termination of reprocessing between Government and the nuclear power companies preceding the "nuclear phase-out law" of 2002.

the missing toplayer in the “Gorleben-Rinne” which was eroded in the last glaciation. A study of Kleemann, a geologist and former BfS employee, summarizes a lot of those unfavourable geological conditions (Kleemann 2011). Kleemann concludes that the Gorleben site is not suitable according to the AKEnd criteria (for more detail on AKEnd see section 1.8). Although Kleemann’s statements are declined by the BGR (BGR 2011b), this outlines that the discussion about Gorleben is not only a question of social acceptance but there are still some geological technical questions to be addressed.
Exploration activities are being performed under the German mining law until the decision to construct a repository has been taken. The use of the mining law in this way has been criticized by some groups as a way to avoid the formal public involvement as would be required under the atomic law.

In contrast to other countries (e.g. Switzerland and the UK), where political setbacks in the siting process led to revised procedures and a re-start, the lack of political consensus in Germany has prevented the establishment of a site-selection process based on broadly-accepted standards for many years. The 2010 extension of the operational times of Germany’s nuclear power plants made such a consensus more difficult by increasing the political and societal tensions relating to nuclear power. The June 2011 decision to return to a rapid phase-out seems to have improved the conditions for finding and implementing a site-selection process that has broad political and societal support. A clear phase-out scheme is one of the most relevant preconditions for environmental and nuclear-critical groups for entering into discussions on nuclear waste disposal.

1.7 New proposals for the site selection process

In 2011, several state premiers announced to support a country wide site selection process (DAPD 2011). In November 2011 a working group of the Federal and State governments was installed to discuss the way forward regarding geological disposal of spent fuel and heat generating radioactive waste in Germany. After several meetings the working group announced on 15th of December 2011 that they agreed on the main steps for siting a geological repository (BMU 2011a). According to their agreements there are in total six phases defining the important milestones in the siting process:
In phase 1 it is foreseen to create a disposal act till summer 2012 describing the siting and decision making process. Phase 2 should be used to work on the basics such as the safety requirements, the decision whether the waste should be retrievable or not and if possible on geo-scientific and the spatial planning criteria for defining suitable areas and those which can be excluded in the further process. This work is schedule for end of 2012 to mid of 2013. This will be approved by the Federal Council of Germany and fixed in a federal act (phase 3). In the following phase 4 the criteria will be applied to rule out unsuitable areas by mid-2014 and to identify areas with favourable geological conditions. By the end of 2014 a selection of favourable areas which are foreseen for further investigations shall be approved by the Federal Parliament and the Federal Council in a federal law. Geological investigations from above surface shall be undertaken in the favourable areas till the end of 2019. On the basis of the results from phase 4 one or more sites shall be selected and approved by Federal Parliament and Federal Council for underground investigations (Phase 5). The decision on the site will be done by the Federal Parliament and the Federal Council at the end of phase 5 through a federal act. Phase 6 finally comprises the licensing process for building and operation the facility.
At the moment it is still open how many areas shall be investigated in phases 4 and 5. Also the status of the Gorleben site remains a matter of discussions: Should it be ruled out of the selection process in advance or should it be part of the comparative assessments? If it remains in the process, how and when should it be integrated? Should underground investigations be continued during the siting process?

The enacting of a federal law for disposal of radioactive waste is planned for autumn 2012 describing the several steps for siting a geological repository.

1.8 Participatory approaches for designing a siting process

In 1999, prior to the passage of the Nuclear Phase-out law, the (Green Party) Federal Minister of the Environment constituted a "Committee on a Site Selection Procedure for Repository Sites" (AkEnd) composed of several national experts charged with developing a new framework for a siting procedure that would be transparent and impartial (AKEnd 2002). In December 2002 the AkEnd presented recommendations on a criteria-based approach that would take into account long-term safety, regional development interests and the willingness of the regional population to participate in the process. AkEnd also recommended that the site selection procedure should include public and independent expert involvement at both the national and potential host region levels. The AkEnd process ended in 2003, however, with the failure to establish a negotiation group representing the Federal and State (Länder) governments, industry and stakeholder groups to carry out the next phase of specifying the site-selection process[3].

In 2008 the BMU established a "Disposal Dialogue Forum (FED)"[4] as an inter- and intra-disciplinary dialogue group of members of the planning team for the 2008 stakeholder symposium. This forum has held regular meetings for about 2 years. Two members of the FED, both representatives of the Gorleben region, have laid down their mandate in 2010 in protest over the extension of the nuclear power plant operational times, the restart of the exploration of the Gorleben salt dome on the basis of mining law instead of the atomic law[5], and the continuation of shipments of high-level waste from La Hague to the Gorleben interim storage facility. Although the FED was never formally declared to be terminated, one can assume today that it is not being resumed as new approaches for participation are being discussed in the context of the planned disposal act.

At the beginning of 2011 the "Gorleben Dialogue" was started by the BMU[6]. It aims at implementing participatory measures mainly in the Gorleben region. A concept of this process was presented by BMU in February 2011[7] but only little steps of implementation (an online forum for discussion of basic safety questions and one dialogue event with experts' answers to questions) have been taken yet.
According to the latest draft of the disposal act (BMU 2012) participation shall play an important role in the revised siting procedure. The planned concept foresees participation measures on the national level as well as on the level of the potential siting areas. In so far it differs fundamentally from the approaches of the FED and the Gorleben Dialogue which did not develop high public visibility and political influence outside the Gorleben region.

[3] Some of the geological criteria for site evaluation (e.g. the model of the "isolating rock zone") can be found in the recently published "Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste," Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 30 September 2010.
[4] http://www.forum-endlager-dialog.de
[5] A transfer of the exploration activities from the mining law to the atomic law could – from the point of view of the two FED-members - have created an opportunity for more formal public participation during the site investigations.
[6] http://www.gorlebendialog.de/mitreden/doc/37.php
[7] http://www.gorlebendialog.de/files/pdf/application/pdf/grafik_dialog_beteiligung.pdf

2 Identification of significant socio-technical challenges

The identification of prevailing socio-technical challenges in Germany is based on a review of relevant literature and publications, the revision of research programs of relevant authorities and institutions, the exchange with key actors through interviews and on the experience of the authors of this report gained within the years in different projects, committees etc. Detailed results of the empirical analysis of the relevant literature and publications and research programs as well as results of the interviews are presented in section 3.

Based on the review of literature and on the interviews the following significant socio-technical challenges have been identified:

- Restarting siting on the basis of a criteria based, comparative procedure
- Long term storage versus retrievable disposal versus non-retrievable disposal
- Safety case/ safety criteria

In the following chapters each of these socio-technical challenges is described in more detail.

2.1 Restarting siting on the basis of a criteria based, comparative procedure

Finding a suitable site for high radioactive waste disposal is one of the most prevailing issues in Germany. During the last decades neither a consensus for restarting the siting procedure nor an agreement on the future of the Gorleben site could be reached. The controversy affects all kinds of stakeholder groups in waste management including the public, politics, science, industry etc. The various attempts to solve the problem reveal how closely the Gorleben dispute and the definition of a siting procedure are amalgamated and how deeply procedural issues are interrelated to technical-geological requirements and approaches.

Two major lines of discussion shaped the Gorleben dispute over the last decades: One is related to the procedural aspects or the site selection in the 1970s. It is characterised as intransparent, lacking scientific safety criteria and purely politically motivated by some stakeholders who therefore demand a new site selection process excluding the Gorleben site. Others on the contrary argue that the Gorleben site is the result of a justifiable process and that there were no reasons to abandon the site or to start a new selection procedure as long as site investigations did not provide evidence of its unsuitability. The second line of dispute relates to the geological situation. While one fraction of stakeholders claim that investigations proved that the site is geologically unsuitable for various reasons (see e.g.[8]) others interpret the results as such that the existing knowledge until today does not comprise any arguments that question the suitability of the site.

The political dispute is situated between these positions. Various activities were undertaken to illuminate the history of the Gorleben selection as well as to define a process for restarting site selection, however, without being successful in overcoming the fundamental controversies between political parties and different interests of the federal and the state level:
An investigation committee of the German Federal Parliament (Bundestagsuntersuchungsausschuss) was set up on 26th of March 2010 to analyse the history of the Gorleben decision. Although the committee is still working and final conclusions have not been drawn yet, several documents were

[8] http://www.greenpeace.de/themen/atomkraft/nachrichten/artikel/geheime_akten_ueber_gorleben/

found during that process supporting the opinion that the siting procedure was not straight forward. According to these documents Gorleben was not among the salt domes which were chosen after a first screening based on several criteria but introduced to the list of potential sites later in the process. This fact supported the suspicion that its selection was not based on a systematic comparative procedure with pre-defined criteria. A study of the historian A. Tiggemann, however, came to the conclusion that Gorleben was not selected randomly but based on scientific criteria (Tiggemann 2010).

In 2002 the AkEnd on behalf of the federal Government published a framework for a siting procedure including geological-technical and socio-scientific criteria for a comparative site evaluation. The implementation failed as no consensus could be reached on the necessity of such a procedure.
In 2005 a draft act (BMU2005) was presented that defined a staged approach for site selection including public involvement and obliged the private waste producers to form an association which takes over the responsibility for site selection, construction and operation of a geological repository. The draft was published by the federal ministry of the environment only some months before federal elections and was thus never finalized.

Several publications in the years following the AkEnd process reveal that no sustainable convergence of positions could be reached by the political initiatives.
While e.g. a comparative siting process was supported in various papers, projects and contribution to conferences e.g. (Barth/Kallenbach 2006) , (Hocke/Renn 2009) , others like e.g. the Federal Ministry of Economics and Technology (BMWi 2008) or the expert commission “International Committee on Nuclear Technology” (Internationale Länder Kommission, ILK 2007) that advised the states of Bavaria, Baden-Württemberg and Hesse in nuclear matters from 1999 to 2009 found that the safety of a repository depends on its geological characteristics but not on the way how the site was selected.
Several Federal Government Coalitions promised in their Coalition papers that they would take care about these issues. The coalition of CDU/CSU and SPD also proposed e.g. in a discussion paper in 2006 (BMU 2006) different steps for a siting procedure and outline criteria which should be used.
However, till 2011 all attempts have not led to any relevant progress because a political consensus on how the waste should be disposed was missing.

The current attempt of defining a disposal act faces to some extent similar conditions as the AkEnd process and the 2005 draft law: no broadly accepted proof of the geological suitability or unsuitability of Gorleben, and no consensus on the necessity of a new siting process. The composition of the negotiation group with representatives from federal and state governments might, however, support the consensus building between the different political powers in the federal system. The following factors may, from the point of view of the authors of this report, influence the success of this group:

- An acceptable role for the Gorleben site can be found. Such a role has to reveal the openness of the process and should thus avoid any preliminary decision on Gorleben.
- If Gorleben is defined as one of the potential sites a convincing process has to be found and communicated that avoids an advantageous position of Gorleben compared to other sites due to the predominant knowledge about the site.
- The geographical contribution of potential sites can be expected to be as such that the selection process comprises a reasonable number of states (Länder).
- The phases of the selection process and the decision making at important milestones are defined in a way that is found transparent by a majority in politics and society.

- Measures for public involvement are defined and integrated in the selection process in a way that opens a convincing approach even for the critical public.
- Financing of the process is settled.
- Room is given for clarification of fundamental questions as the suitability of geological disposal as such and the role of retrievability.

If the new disposal act shall come into force the definition of criteria for the comparison of potential sites in different host rocks will be one of the challenges that have to be faced in the early phase of the process.
Also a concept for the generation of an adequate level of knowledge about all relevant types of host rocks and the definition of host rock specific disposal concepts in an acceptable timeframe is necessary.

This chapter shows that a siting procedure depends highly on political decisions and needs to reflect public demands in order to have the chance to be successful. Next the suitability of a site depends not only on geological-technical aspects meaning that scientists only need to investigate and proof according to their technical criteria whether a repository at the site is feasible and safe but the selection process has to be fair and transparent. Otherwise the site will not be accepted by the public and the realization is in danger. In spite of the growing understanding that during siting both geological-technical and social criteria need to be considered. Adapted forms of communication and research that promote an integrated approach are still missing.

2.2 Retrievability / retrieval / long term storage

The retrievability discussion in Germany was fostered by the developments in the Asse research mine where feasibility assessments for waste retrieval are currently under way as the long term safety of waste disposal in the Asse mine cannot be proved under current conditions of the former salt mine. Influenced by the experience in the Asse mine the central argument is the question of long term safety and how safety shall be ensured for one million years if in the Asse case it cannot even be ensured for some decades. The concept of passive safety is questioned and stands versus the wish for long term monitoring and options for intervention.
Further arguments for a retrievable solution are potentially available techniques for a safer management of the waste or the freedom of future generations to decide what they wish to do with the wastes.
Arguments against retrievability are such that the safety is affected as long as the mine is not completely closed and pathways for intruding water and for the transport of radionuclides remain open. Another argument is that it cannot be foreseen how the society will develop in the future and whether they have enough resources to monitor and close the disposal facility in a proper way.

The evolving discussion of retrievability is also reflected in the number of publications on this issue. While there had been only a small number of studies on this issue in the past (e.g. by GRS 2000) a number of documents published since 2008 consider retrievability as a relevant issue.
For example the ethical commission for a safe energy supply recommended in its report of May 2011 to dispose the radioactive waste in a retrievable way while considering the highest safety requirements (Ethik-Kommission 2011).

In 2011, the German Nuclear Waste Management Commission (ESK) published a discussion paper summarizing arguments pro and contra retrievable disposal (ESK 2011). The Committee on Final Disposal of the ESK came to the conclusion that positions pro and contra retrievability result from

different basic assumptions: While the contra arguments are based on a high reliability of geology and technical measures and the predictability of underground processes the supporters of retrievability rely on the potential of human intervention now and in future. As regards the ethical dimension the objective of long-term safety free of intervention competes against the value of highest possible flexibility of future generations.
The Committee itself holds the position that the retrievability option must not have significant influence on long-term safety. It is therefore necessary to concretise the timeframe for which retrievability is discussed. Such a timeframe during which retrievability could make sense might comprise a limited observation phase after the operational phase is terminated. The necessary legal boundaries and necessary requirements and demands must be clarified.

The discussion on retrievability is also reflected in the current safety requirements for geological disposal (BMU 2010). During the development of these safety requirements over some years, the Federal Ministry of Environment introduced the concept of retrievability. While the draft versions of 2008 (BMU 2008) and 2009 (BMU 2009) stated "Retrieval of the radioactive waste shall not be foreseen in the disposal concept"[9] these requirements were changed after discussions with state representatives and stakeholders and in the light of the Asse events. The 2010 version determines "During the operating phase up until sealing of the shafts or ramps, retrieval of the waste containers must be possible." (BMU 2010). It is, however, also pointed out that all measures guaranteeing retrievability and later easier recover must not affect the passive barriers and the long term safety of the repository.
The ESK acknowledged in its statement that whether to follow the concept of retrievability or not is a purely political decision. The ESK recommended to the Ministry of Environment that if such a political decision is taken, corresponding requirements for a concept with the option of retrievability need to be reflected in the safety requirements.
One of the aspects under discussion is the time period over which retrievability shall be possible. Questions are whether the waste should be retrievable till the closure of the facility in order to have the chance to reverse decisions or should the facility be monitored also after the closure and if so for how long.
It has to be differentiated what is meant with the terms retrievability, retrieval and recovery of waste. Definitions are given e.g. in (ESK 2011): retrievability means the implementation of measures both conceptual and technical to make the retrieval of the waste possible and easier. Retrieval is referring to the real action of retrieving the waste. Contrary to that recovery means that the waste can be recovered in a more complicated way e.g. through new mining activities. A clear and broadly used and accepted definition of these terms is still missing.

Along with the discussion on retrievability questions rose regarding the concept of geological disposal in general. Driven by the demand to enable active interventions to ensure safety the concept of long term storage was brought into the political debate. This solution should be applied until better solutions for the management of radioactive waste will be available in future. However, up to now there was no broad public discourse on the different waste management options, especially retrievable or non-retrievable disposal and long-term storage and their respective implications.

[9] Requirements for the canisters are laid down to simplify a later recovery of the waste in case such a decision will be taken by future generations.

With regard to long term storage for indefinite timeframes it has to be considered that this concept contradicts the nationally and internationally agreed principle not to shift the responsibility of managing the waste to future generations.

The analyses of the German situation regarding the discussion on retrievability and long term storage reveal that the issue has a strong socio-technical component that covers societal values on passive safety versus active intervention, integration of the topic into public, political and professional discourse on nuclear waste management, the development of adapted technical concepts and the assessment and evaluation of safety for different concepts.

2.3 Safety Case/Safety Criteria

In the last years the Safety Case has been introduced internationally e.g. IAEA 2006, OECD/NEA 2004. According to these recommendations the Safety Case is a collection of all arguments supporting the safety.
The discussion on how a Safety Case shall look like and what aspects it should contain has then also started in Germany. While the number of studies on this topic is rather low in the national context a relevant number of contributions of German experts to international and national conferences can be found (e.g. Endlager Symposium 2008 in Berlin, Röhlig 2010).
In the comprehensive project of GRS and Oeko-Institut (GRS/OEKO 2008) elements and contents of a safety case in Germany were defined. The authors said that in a Safety Case geo-scientific, technical, organizational, societal and social aspects may play a role. In most of the questions which need to be answered within the Safety Case a combination of all those aspects with different priorities needs to be considered. In the study the authors identified for example the perception of risk as one important aspect in a safety case which comprises technical scientific calculations as well as moral-ethical, socio-economic or political considerations. They further stated that for the public not only safety aspects are of interest but also procedural questions, a transparent decision-making, the analysis of positive and negative impacts through the repository, the development of the region. The authors suggested that a Safety Case should give an overview over such aspects as well.

This is also supported by the study of Streffer et al. 2011 which concluded that the concept of the safety case is a combination of safety related elements and arguments of the site investigation. One challenge of the safety case is according to the study that all arguments in the safety case need to be presented in a way that the general public as well as authorities and experts can understand them.
The aim of a Safety Case is to summarize all arguments supporting the proof of safety of a geological repository. This, however, requires a common understanding of how safety is defined and understood. Technicians and non-technical scientists may have a different understanding of what is safe and what is necessary to demonstrate safety. One more aspect is the handling and understanding of uncertainties (see e.g. Streffer et. al. 2011). The safety case has to identify the prevailing uncertainties and to outline the research needs and plans (see e.g. Mönig 2008).
Research about the approach of preparing a safety case in Germany was long time mainly concentrated on the “technical” aspects of developing better methods and analytical. But due to international recommendations like OECD/NEA 2004b and IAEA 2006 social aspects should be considered in the Safety Case besides the technical considerations, without giving further details on what and how these aspects should be included in the considerations. See examples below:
OECD/NEA 2004b “Learning and Adapting to Societal Requirements for Radioactive Waste Management, NEA No. 5296” states that “Social and ethical issues are at least as important as technical issues”. And further: “It is now broadly recognized that radioactive waste management

involves both technical and societal dimensions which cannot be dissociated. New processes to forecast and monitor quality of life and social impacts are being brought to the fore."
"Risk – and its counterpart, safety – are multi-dimensional concepts. FSC experience suggests that in addition to technical requirements, societal and ethical concerns about risk and safety should also be captured and addressed by radioactive waste management processes and their outcomes."
In the IAEA Safety Requirements No. WS-R-4 (IAEA 2006) it is stated that "Meeting these requirements [of radiological safety] forms a part of the wider activities involved in selecting a site and developing a geological disposal facility, where in broader planning, financial, economic and social issues as well as general safety and environmental impacts are considered."(para 1.17). And further: "[…] the optimization of protection is a judgemental process, with social and economic factors being taken into account, and it should be conducted in a structured but essentially qualitative manner, supported by quantitative analysis." (para 2.14).
In order to discuss how socio-scientific research can be included in the field of geological disposal in Germany an expert meeting organized by the Ministry of Economics and Technology and the Research Centre Karlsruhe was held in 2008. One discussion point was whether such socio-technical issues should be included in the safety case.
A project of the Oeko-Institut funded by BMWi and published in 2010 identified socio-scientific aspects which are relevant for safety and should be considered in the Safety Case in Germany (Oeko 2010). These are for example: questions of human resources, operational organisations/company structure, company and safety structure, information provision reception and transfer, risk perception and communication, availability of resources required, operator environment relationship. In the study this issues are described in greater detail, giving the respective context.
Within the project a model of an integrated safety case was developed which reflects a safety-oriented combination of scientific-technological, human resources and organisational factors.

The description above outlines that Safety Case comprises several dimensions which requires both the consideration of technical and socio-scientific aspects.

3 Results of empirical analysis

In order to identify prevailing socio-technical challenges in Germany a review of relevant literature and publications, the revision of research programs of relevant authorities and institutions were conducted. Additionally key actors were interviewed. The analyses of research programs and of results from interviews performed are presented in the following.

3.1 Developments in Socio-scientific Research on Nuclear Waste Management, especially Geological Disposal, in Germany

Within this chapter the status of socio-scientific research in the field of nuclear waste management and especially geological disposal is analysed. The aim is to trace potential developments towards an increased awareness and consideration of such aspects. Publications dealing with the consideration of socio-scientific aspects in the field of geological disposal as well as research programs have been reviewed for this analysis.

The most detailed analysis of the status of socio-scientific research in nuclear waste management in Germany was performed in 2004 by the Institute for Technology assessment and System Analysis (ITAS) at the Karlsruhe Institute of Technology. Further publications concerning this subject can be found at ITAS webpage[10].
Based on contributions to the workshop "Disposal of Radioactive Waste in Germany – perspectives of socio-scientific research" organized by ITAS in October 2004 Hocke and Grunwald put together a publication that highlights crucial issues from the national perspective (Hocke 2006).
Regarding the situation of socio-scientific research in the waste management context in general Hocke and Grunwald come to the conclusion, that existing research and publications do not meet satisfying socio-scientific standards. Where such research takes place it deals with selected points only and thus does not contribute to the understanding of fundamental structures and interrelations of the of the existing controversy [p. 23 f.].
According to Hocke and Grunwald future socio-scientific research should deliver independent as well as complementary contributions to the solutions of the disposal problem in cooperation with technical- and natural sciences [p. 14].
In several other research projects of the last ten years, it was concluded, that geological disposal of radioactive waste is not only a pure technical issue, but raises several other questions outlining that there is an increasing awareness of the importance of such aspects. But as Hocke and Grunwald said before, mostly only certain selected aspects are considered within the projects or important issues are raised but there is no comprehensive analysis on how they should be treated. Some examples are given below.
The aim of the research project: „Ethics of the final disposal of radioactive waste" („Ethische Aspekte der Endlagerung radioaktiver Abfälle") which was carried out in 2003 by the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH (Boetsch 2003) ,was "to derive criteria to form the basis of a comprehensive discussion of the ethical aspects of radioactive waste disposal". The result was a set of questions that might guide discussion processes among experts and stakeholders which comprise e.g. questions of intergenerational justice, the extent of public participation, the objectives of site selection: finding a suitable or the best site, the priority of safety versus public acceptance of a site. A broad discussion of ethical aspects, however, did not take place in Germany.

In a comprehensive study of both GRS and Oeko-Institute (GRS/Oeko 2008) with the aim to present the actual status of research in the field of final disposal of radioactive waste several socio-technical issues have been raised. E.g. it was stated that the perception of risk is not only related to scientific-technical aspects but also to economic, moral-ethical or political aspects. The authors of the study concluded in the main report that their relevance has to be checked in the safety case. The requirements and contents of a safety case in Germany, details of socio-economic effects of final disposal and chances to involve the public in the siting process are treated comprehensively in supplementary reports (GRS/Oeko 2008b).

The European Academy published in 2011 a book with the title "Ethics of Science and Technology Assessment: Radioactive Waste Technical and Normative Aspects of its Disposal" (Streffer et al. 2011). The authors state that the problem of radioactive waste management covers a lot of aspects. Besides technical also societal, legal, ethical ones which has to be treated in a multidisciplinary way. In their conclusions and recommendations the authors mention that the following issues must be addressed: ethical framework, safety requirements and goals, waste management program and timescale, selection process, criteria, transparency, communication of risks, participation, institutions in the procedure, expert groups, administrative structure, e.g. all important aspects.. Beyond the

[10] www.itas.kit.edu

technical feasibility solutions must also be practically realizable by law and within the political context. On the same hand the safe inclusion of the long-lived high radioactive waste has to be guaranteed for a long time and unreasonable loads on future generations have to be avoided.

This shows a rising awareness for the importance to not only consider technical but also socio-scientific aspects in the field of geological disposal, but comprehensive studies on how these aspects should be treated are missing.

Having a closer look at government-financed research programmes the following developments over the last years regarding consideration of socio-scientific issues can be traced:
The environment research plan (UFO-plan) of the Federal Ministry of Environment (also comprising research projects commissioned on behalf of the BfS as the implementer of radioactive waste repositories) summarises the titles of planned research projects and is published yearly. In the years 2002 to 2011 there was on average one title with a socio-scientific orientation per year (2 titles in the years 2005, 2009 and 2010; no title in the years 2004, 2008 and 2011 and one title in the other years). The total number of titles in the nuclear waste management field varied from 10 to 23 titles.

In the year 2005 one title[11] could be found among the socio-scientifically oriented titles in the UFO-plan that can be characterised as socio-technical: it analyses international experience in nuclear waste disposal projects by integrating the technical developments and the procedural and organisational framework conditions.
This research agenda shows no remarkable development in the consideration of socio-scientific or socio-technical issues of the last ten years.

The responsibilities for waste management research are basically divided between the Ministry of the Environment (BMU) and the Ministry of Economics and Technology (BMWi). The BMU is responsible for site/facility specific R&D and all related aspects, whereas the BMWi is responsible for the non-site specific/generic R&D. The research agenda of BMWi is laid down every 4 to 5 years in a research programme which describes different thematic areas in which funding of research projects is foreseen. During the development of the programme various German research organizations are consulted. The 2002 to 2006 draft-programme had also been commented by the German Reactor Safety Commission (RSK) (RSK 2001) .

While the BMWi research concept for the years 2002 to 2006 (BMWi 2001) comprises no research area that covers socio-scientific aspects some development can be traced in the following years: The research programme for the years 2007 to 2010 opened the focus of the research topic on “disposal concepts” to evaluations of socio-scientific aspects of different disposal concepts.
The draft research concept for the years 2011 to 2014 (BMWi 2011) does not only resume the point mentioned above but comprises a dedicated research field for “cross-cutting issues”. Topics named in this field cover “disposal concepts and retrievability” as well as “management and socio scientific aspects”.

It is visible that within the last years there is a development in government financed projects – at least BMWi funded generic research issues - to address besides technical oriented projects also topics with socio-scientific aspects. But still the share of socio-scientific research in the field of

[11] “Evaluation of implementation or planning of disposal projects in different countries and the interplay of institutions involved.” [„Analyse und Auswertung des Ablaufs bzw. der Planung internationaler Endlagerprojekte und das Zusammenspiel beteiligter Institutionen“, *in German*]

geological disposal is very small compared to natural-scientific or technically oriented projects. An explicit socio-technical combination can only be found in one research project (Oeko 2010).

3.2 Results of the interviews

In order to consider a broad spectrum of views and opinions on socio-technical challenges in German waste management activities four interviews have been realized with representatives of the regulator, the implementer, an NGO and of academia.
The experts were asked by two colleagues of the Oeko-Institut via a one hour telephone interview with twelve semi-structured questions (see Annex 1). A short summary of the interview was provided and sent to the interview partners for corrections and amendments.

We want to thank all interview partners for their interest and support to the InSOTEC project and for taking the time to answer our questions in detail.

The interviews were structured in a way to lead from reflections on general topics of major interest in public, media, politics and the waste-management to the interviewees' views on explicitly socio-political topics on the one hand and on natural-scientific/technical topics on the other hand. The following questions made the link to the combination of technical and social aspects: in which topics such socio-technical combinations are estimated as relevant and if / how discourses on nuclear waste management reflect such combinations adequately. A short review of the interviewees' opinions on the most relevant topics of research in the field geological disposal and the relevance of socio-sciences in research programmes concluded the talks.

A short overview of results is given in the following:

- *On topics in the field of geological disposal which are mainly discussed in the public, in the media, in politics and in the professional waste-management-scene:*

The opinions of the interview partners on what is mainly discussed in the *public* are relatively similar with only slightly different perspectives and priorities.
Almost all interview partners identified the new start of the siting procedure resp. the plans to create a new act for siting or in general the challenge to find a site as one hot topic. One said that the main concern of the public is whether a safe management of radioactive waste is possible at all. That means the concept of geological disposal itself is questioned. Some other interview partners supported the view that the former consensus that geological disposal is the best way to manage the radioactive waste is not given anymore. They thought it is extremely important to first find a consensus on that before further details of the siting procedure or the disposal concept are discussed. The question of the future role of the Gorleben site was also mentioned in this context as a publicly discussed issue.
Most interviewees also raised the issue of the disposal concept with regard to retrievability of the waste. Some expect that the discussion on retrievability is going to become more virulent during the next years. The developments in the Asse repository (see section "The Asse repository… ") were mentioned in this context as a potential driver of the retrievability debate.
One interview partner stated that there is also a subordinated discussion on possible host rocks.
Other disposal projects like Morsleben and Konrad are according to one expert at the moment not in the focus of the public discussions.

The aspect of the contribution of responsibilities for decision making and planning of geological disposal was raised by one person who questioned if the current status is suitable for a successful management of radioactive waste in Germany.

According to all interview partners the topics discussed in the *media* are more or less the same as those discussed in the public: the new start of a siting process and the future of the Gorleben site on the one hand and the problems of the Asse repository and the conclusions to be drawn regarding the demand of retrievable disposal on the other hand.

The opinions of the interview partners on what is mainly discussed in *politics* differed. Some thought that the topics are the same as in the public and the media. The design of a new siting procedure was named as a hot topic as well as the concept of long term storage. One interview partner thought that the latter concept was mainly used in the political debate to gain public acceptance. Another important topic is according to one interview partner the new orientation in the field of nuclear energy after the accidents in Fukushima and the question how the involvement of the public can be improved.
Two interviewees criticized the working group of the Federal and the State Governments which is busy to prepare the new start of the siting procedure and the required steps as non-transparent. Before announcing their final paper on 15 of December 2011 hardly anything was known about their agreements.
Another interview partner thought that the discussions on the political level are highly influenced by the discussion in the media. This expert claimed that the politicians are very unsure on the way forward. He mentioned the efforts for a new disposal act as a proof for this theory since this was the third attempt to solve the problem by means of developing a new act, the two earlier, however, having failed.

Important topics in the *professional waste management scene* are according to one interview partner the discussion which host rocks are suitable and whether a concept with retrievability is reasonable. Other important topics are the developments and the planned retrieval of radioactive waste in the Asse repository which is critically observed and accompanied by the experts.
One interview partner remarked that the community of experts in Germany is relatively small meaning that in all discussions and committees there are always the same persons taking part.

- *On the main prevailing socio-political challenges*

The selection of a site for high radioactive waste disposal in a new siting procedure was mentioned as the most important socio-political challenge. The majority of the interview partners thought that this requires a national consensus on how radioactive waste should be disposed of. One interview partner added that it has to be considered that the issue of nuclear waste management, especially disposal, is highly contested in German society with very strong positions being taken e.g. for or against the Gorleben site. He thought that professional conflict management is necessary which, however, would require the clear confession that there is an existing conflict in order to have at least a chance to be successful. So far he did not recognise such awareness.
The public's mistrust regarding the openness of a new siting approach was also mentioned as a challenge. This comprised the fear that Gorleben remains in the process as the top candidate. Another interview partner said that a rational discussion is not possible at all.
One interview partner said that there is a problem that the responsible players and decision-makers are not seen as reliable. According to him one challenge is to increase the reliability of and the trust in the actors.

- *On open technical challenges*

The majority of interview partners mentioned open questions regarding the disposal concept as the main technical challenges with different opinions, however, on the extent of this challenge. While some think challenges lie more or less on the level of technical details one expert was of the opinion that nearly all technical questions are still open. According to the interview partners such open questions are for example questions with relation to a disposal concept with retrievability or in host rocks other than salt domes. The investigation of the existing hydrocarbon under the Gorleben salt dome may also lead to necessary adjustments of the existing preliminary disposal concepts. According to some interview partners the open technical issues depend on the specific selected site and chosen concept. One expert thought that the in situ technique has not yet been sufficiently practiced and he demanded an underground research centre in order to investigate engineering, mining and geochemical aspects.

- *On the connection of the existing socio-political and the technical issues*

This question was difficult to answer for most interviewees. This shows that so far social and technical issues are mostly handled separately. However the interview partners highlighted some connections of socio-political and technical issues:
The majority of interview partners said such a connection exists in the discussion of retrievability. The society seems to welcome such a concept whereas it affects the concept of safe enclosure of the waste and requires adjustments of the technical solutions. There is a conflict between the social demand and the safety requirements. According to another expert is still unclear how the discussion of retrievability will end. It has started, but it is not yet a social demand that only a concept with the option of retrievability will be accepted. Some interview partners referred to the solution which was found in the Switzerland where a pilot facility which will be monitored for some time will be installed next to the main repository.

Asking about the *main socio-technical issues* one interview partner said that the evaluation and comparison of different sites in the process of site selection is the most important issue. Others agreed that one big challenge is the restart of the siting procedure which raises both technical and socio-scientific aspects.
One interview partner remarked that the search for a repository site is also linked to the decision to phase out nuclear energy as a clear perspective on the amounts of spent fuel and radioactive waste and on the timeframe of their production supports the planning and implementation of geological disposal.
According to one interview partner social and technical aspects also need to be considered in the development of a disposal act. They cannot be seen separately. According to him the consideration of social aspects does not only mean to gain acceptance. The same applies for the development of safety requirements which also have to consider the technical-geological and socio-scientific perspective.
Another expert said that the communication of technical issues in the public is very difficult. He dared to ask whether the acceptance of the public is the most important challenge irrespective which technical solution was found. He thought that technical solutions can be accepted easier when the decision is not final, but there is a point of return. Also the communication of research results in a way that the public can understand them was identified as one big challenge.
One interview partner proposed that socio-political questions should build the framework within which the technical-scientific problems are solved. There could be a kind of think tank which coordinates what society wants to know and what the technicians and scientists will do.

All interview partners agreed that these problems are mostly national problems typically for Germany. The severe and long lasting controversy on the Gorleben site which strongly influences the waste management discussion in Germany was identified as a very specific situation. One interview partner pointed out that public protests against nuclear and especially against Gorleben are deep seated in German society. Also protests and difficulties to realise other big infrastructure projects in Germany were mentioned in this context. It was questioned whether the "Planfeststellungsverfahren" (plan approval procedure) is a suitable instrument for licensing such projects or whether a broader long lasting licensing procedure with the enhanced possibilities to involve the public is required.
Furthermore it was pointed out that the political system influences decision making processes on the one hand and approaches to public involvement on the other hand. Within the German federal system the interests of the states especially those with potentially suitable geological formations need to be considered in a site selection procedure. The representative democracy as a well-established basis of the German political system foresees little options for direct involvement of the public. Both aspects have to be considered in the site selection process and in an approval procedure.

Asked about the *important topics for the research* in the field of radioactive waste the interview partner gave a wide spectrum of ideas:

- Comparative evaluation of sites,
- The development of criteria for the comparison and evaluation
- Development of methods for socio-economic studies
- Long term safety assessment (safety case)
- Preservation and transfer of knowledge
- Safety against anthropogenic effects and impacts.
- In situ technique
- Concepts for clay and granite
- Reduction of waste and better organization of transport and storage

Some interview partners are of the opinion that in our days social aspects are better considered in the research programmes, but demand an increasing significance in the future. As there is an enormous demand one interview partner stated that socio-scientific issues should be a main topic in future research programmes instead of an add on to the mostly technical programmes.

REFERENCES

AKEnd 2002: Committee on a Site Selection Procedure for Repository Sites: Site Selection Procedure for Repository Sites - Recommendations of the AkEnd, Köln, December 2002

Barth/Kallenbach 2006: Barth, Kallenbach-Herbert, Arens: Further development of public participation in the site-selection and approval process of a final repository in Germany, Valdor 2006, Proceedings pp. 106-113

BfS 2005: Federal Office for Radiation Protection (BfS): Conceptual and safety-related issues regarding the disposal of radioactive waste-A Comparision of differnet host rocks[Konzeptionelle und Sicherheitstechnische Fragen der Endlagerung radioaktiver Abfälle-Wirtsgesteine im Vergleich, *in German*], Synthesis report issued by the Federal Office for Radiation Protection, Salzgitter 2005.

BGR 2007a: Klinge, H. et al. (2007): Description of the Gorleben site. Part 1: Hydrogeology of the overburden of the Gorleben salt dome. – Federal Institute for Geosciences and Natural Resources (BGR), Hannover. http://www.bgr.bund.de/EN/Themen/Endlagerung/Downloads/Description_Gorleben_Part1_Hydrogeology_overburden_en.pdf

BGR 2007b: Köthe, A. et al. (2007): Description of the Gorleben site. Part 2: Geology of the overburden and adjoining rock of the Gorleben salt dome. – Federal Institute for Geosciences and Natural Resources (BGR), Hannover. http://www.bgr.bund.de/EN/Themen/Endlagerung/Downloads/Description_Gorleben_Part2_Geology-overburden-adjoining%20rock_en.pdf

BGR 2008: Bornemann, O. et al. (2008): Description of the Gorleben site. Part 3: Results of the geological surface and underground exploration of the salt formation. – Federal Institute for Geosciences and Natural Resources (BGR), Hannover. http://www.bgr.bund.de/EN/Themen/Endlagerung/Downloads/Description_Gorleben_Part3_Geological-surface-underground-exploration-salt-formation_en.pdf

BGR 2011: Bräuer, V. et al. (2011): Description of the Gorleben site. Part 4: Geotechnical exploration of the Gorleben salt dome. – Federal Institute for Geosciences and Natural Resources (BGR), Hannover.
http://www.bgr.bund.de/EN/Themen/Endlagerung/Downloads/Description_Gorleben_Part4_Geotechnical_exploration_en.pdf

BGR 2011b: Federal Institute for Geosciences and Natural Resources (BGR): BGR-Statement to reports about the new „Gorleben-Study“ [BGR-Stellungnahme zu Berichten über neue „Gorleben-Studie“in German], Presserelease, Hannover, 13.12.2011 http://www.bgr.bund.de/DE/Gemeinsames/Oeffentlichkeitsarbeit/Pressemitteilungen/BGR/bgr-111306.html

BMU 2005: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Act on the formation of an association and on the siting procedure for the disposal of radioactive waste [Gesetz zur Errichtung eines Verbands und Festlegung eines Standortauswahlverfahrens für die Endlagerung radioaktiver Abfälle (Verbands- und Standortauswahlgesetz – VStG), in German], draft June, 2005

BMU 2006: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU: Taking on Responsibility: Implementing the Consensus Agreement on Disposal [„Verantwortung übernehmen: Den Endlagerkonsens realisieren“, in German], Berlin, September 2006

BMU 2008: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste - Draft - Bonn, 29 July 2008

BMU 2009: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste – First Revision as of 18 March 2009

BMU 2010: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste, as at 30 September 2010

BMU 2011a: Paper of Working Group of the Federal and States Governments: Safe Management of heat generating radioactive waste in Germany, [Die sichere Entsorgung Wärme entwickelnder radioaktiver Abfälle in Deutschland“, in German] 15.12.2011, Download: http://www.bmu.de/files/pdfs/allgemein/application/pdf/hintergrund_standortsuche_bf.pdf

BMU 2011b: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Report of the Federal Republic of Germany for the Fourth Review Meeting in May 2012, August 2011
http://www.bmu.de/files/english/pdf/application/pdf/jc_4_bericht_deutschland_en.pdf

BMU 2012: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU): Draft law for siting a repository for heat generating waste, as of June 13, 2012 [Entwurf eines Artikelgesetzes zur Suche und Auswahl eines Standortes für ein Endlager für Wärme entwickelnde radioaktive Abfälle und zur Änderung anderer Gesetze vom XX.XX.2012, in German]

BMWi 2001: Federal Ministry of Economics and Technology: Main focus of future RD&D work in the field of final disposal of radioactive waste (2002-2006) [Schwerpunkte zukünftiger FuE-Arbeiten bei der Endlagerung radioaktiver Abfälle (2002 – 2006) *in German*]. Advanced concept of the Federal Ministry of Economics and Technology, November 2001

BMWi 2007: Federal Ministry of Economics and Technology: Main focus of future RD&D work in the field of final disposal of radioactive waste (2007-2010) [Schwerpunkte zukünftiger FuE-Arbeiten bei der Endlagerung radioaktiver Abfälle (2002 – 2006) *in German*], December 2007

BMWi 2008: Federal Ministry of Economics and Technology: Geological Disposal of high level radioactive waste in Germany – The disposal project Gorleben [„Endlagerung hochradioaktiver Abfälle in Deutschland – Das Endlagerprojekt Gorleben“, in German], Berlin 2008

BMWi 2011: Federal Ministry of Economics and Technology: Main focus of future RD&D work in the field of final disposal of radioactive waste (2011-2014) [Schwerpunkte zukünftiger FuE-Arbeiten bei der Endlagerung radioaktiver Abfälle (2011 – 2014) *in German*] – draft, October 2011

Boetsch 2003: Boetsch, W.: Ethical Aspects of radioactive waste disposal [„Ethische Aspekte bei der Endlagerung radioaktiver Abfälle“, in German], BMU Schriftenreihe 2003-619, Bonn, 2003

Dapd 2011: dapd: “Mc Allister fordert Endlagergesetz“ (“McAllister calls for disposal act“, in German), 18 June 2011; Download: http://de.nachrichten.yahoo.com/mcallister-fordert-endlager-gesetz-041855525.html,

ESK 2009: Nuclear Waste Management Commission (ESK): Statement on the BMU draft Safety Requriements Governing the Geological Disposal of Heat-Generating Radioactive Waste [„STELLUNGNAHME zum Entwurf des BMU „Sicherheitsanforderungen an die Endlagerung wärmeentwickelnder radioaktiver Abfälle“, in German], January 2009, http://www.entsorgungskommission.de/downloads/snsianf290109.pdf

ESK 2011: Nuclear Waste Management Commission (ESK) Committee on Final Disposal: Retrieval / retrievability of high-level waste from a repository – a dicussion paper [„Rückholung / Rückholbarkeit hochradioaktiver Abfälle aus einem Endlager – ein Diskussionspapier“, in German] 02.09.2011

Ethik-Kommission 2011: Ethical Commission for a Safe Energy Supply (Ethik-Kommission Sichere Energieversorgung): Energy transition in Germany – Cooperative Efforts for the Future [Deutschlands Energiewende –Ein Gemeinschaftswerk für die Zukunft“], Berlin, May 2011 in German

GRS 2000: Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH: Retrievability of long lived radioactive waste from geological repositories - arguments pro and contra [„Rückholbarkeit von langlebigen radioaktiven Abfälle aus geologischen Endlagern - Argumente pro und kontra“, in German], Köln, September 2000

GRS 2012: Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH Homepage of the Prelimnary Safety Assessment Gorleben (Vorläufige Sicherheitsanalyse Gorleben) : http://www.grs.de/vorlaeufige-sicherheitsanalyse-gorleben-vsg

GRS/Oeko 2008: Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) bmH und Öko-Institut e.V.: Disposal of radioactive waste, [„Endlagerung wärmeentwickelnder radioaktiver Abfälle in Deutschland, Hauptband“, in German]. Final Report, BMWi-Project FKZ 02E9783 and 02E9793 Braunschweig, Darmstadt, September 2008. Download: http://endlagerung.oeko.info/

GRS/Oeko 2008b: Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) bmH und Öko-Institut e.V.: Disposal of radioactive waste. Appendixes “Siting”, “Safety Case“ and “Socio Economic Impacts“ [„Endlagerung wärmeentwickelnder radioaktiver Abfälle in Deutschland. Anhänge „Standortauswahl“, „Safety Case“ und „Sozio-ökonomische Auswirkungen“, in German]. Final Report, BMWi-Project FKZ 02E9783 and 02E9793, Braunschweig, Darmstadt, September 2008. Download: http://endlagerung.oeko.info/

Hocke 2006: Hocke, Grunwald (editors): Where to take radioactive waste – Perspectives of socio-scientific research on nuclear waste disposal [“Wohin mit dem radioaktiven Abfall – Perspektiven für eine sozialwissenschaftliche Endlagerforschung”, in German], Berlin, 2006

Hocke/Renn 2009: Hocke, P.; Renn, O.: Concerned Public and the Paralysis of Decision Making. Nuclear Waste Management Policy in Germany. Karlsruhe: ITAS Pre-Print: 26.03.2009; http://www.itas.fzk.de/deu/lit/epp/2009/hore09-pre01.pdf

IAEA 2006: International Atomic Energy Agency (IAEA) „Geological Disposal of Radioactive Waste”2006, IAEA Safety Requirements WS-R-4

ILK 2007: International Committee on Nuclear Technology (ILK) Statement on BMU Paper „Taking on Responsibility: Implementing the Consensus Agreement on Disposal“, July 2007

Kleemann 2011: Kleemann, U.: Evaluation of the final disposal site Gorleben-Geological problems and open questions in relation to the Prelimnary Safety Assessment Gorleben(Bewertung des Endlager- Standortes Gorleben - Geologische Probleme und offene Fragen im Zusammenhang mit einer Vorläufigen Sicherheitsanalyse Gorleben (VSG) Regionalgeologie und Standorteignung), on behalf of Rechtshilfe Gorleben e.V., 2011 in German Download: http://www.bi-luechow-dannenberg.de/dateien/2011/12/Bewertung_Endfassung_29Nov11.pdf

Mönig 2008: Mönig J.: The haziness of numerical safety analyses [„Die Unschärfe nummerischer Sicherheitsanalysen“, in German] contribution to expert disscussion, Karlsruhe April 2008

OECD/NEA 2004: OECD/NEA Nuclear Energy Agency: Post-Closure Safety Case for Geological Repositories – Nature and Purpose, 2004.

OECD/NEA 2004b:OECD/NEA: Learning and Adapting to Societal Requirements for Radioactive Waste Management, NEA No. 5296, 2004

Oeko 2010: Öko-Institut e.V.: Socio-scientific Issues in the Safety Case, [German with English summary], Final report, BMWi-Project FKZ 02E 0628, Darmstadt 2010

Röhlig 2010: Röhlig, K.-J.: The Safety Case Concept - International Developments in Demonstrating Long-term Safety of Repositories [“Das Konzept des Safety Case – International Entwicklungen zur Demonstration der Langzeitsicherheit von Endlagern”, in German] , in: Documentation of the International Symposium on Radioactive Waste Disposal, Berlin 2008 (Hocke P., Arens G. Editors) April 2010

RSK 2001: Statement of the RSK from 13.09.2001: Main focus of future RD&D programmes in the field of geological disposal of radioactive waste [Schwerpunkte zukünftiger FuE-Arbeiten bei der Endlagerung radioaktiver Abfälle), *in German]*. Download: http://www.rskonline.de/downloads/snfue81101.pdf

RSK 2008: Reactor Safety Commission (RSK) and Commission on Radiological Protection (SSK): Common statement on the GRS-report „”Safety Requriements Governing the Geological Disposal of Heat-Generating Radioactive Waste” [“Gemeinsame Stellungnahme der RSK und der SSK zum GRS-Bericht „Sicherheitsanforderungen an die Endlagerung hochradioaktiver Abfälle in tiefen geologischen Formationen“”, in German], July 2008 http://www.rskonline.de/downloads/rsksskstellungnahmeendg.pdf

RSK 2011: Reactor Safety Commission (RSK) RSK- Statement: plant specific safety check of German nuclear power plants under consideration of the Fukushima-events [RSK-Stellungnahme 11. – 14.05.2011 (437. RSK-Sitzung) Anlagenspezifische Sicherheitsüberprüfung (RSK-SÜ) deutscher Kernkraftwerke unter Berücksichtigung der Ereignisse in Fukushima-I (Japan*), in German*], http://www.rskonline.de/downloads/rsk_sn_sicherheitsueberpruefung_20110516_hp.pdf

Schneider 2011: Schneider. U. : Gas and condensate deposits in salt especially in the saltdome Gorleben-Rambow- literature study on behalf of Greenpeace Germany e.V (Erdgas und Kondensatvorkommen in Salz,speziell im Salzstock Gorleben-Rambow. Literaturstudie im Auftrag von Greenpeace Deutschland e.V.), Hamburg ,2011. In German Download : http://www.greenpeace.de/fileadmin/gpd/user_upload/themen/atomkraft/20110204_Gorleben_Gasstudie_Schneider-Korr-US-.pdf

Streffer et al. 2011: Streffer, C; Gethmann, C. F.; Kamp, G.; Kröger, W.; Rehbinder, E.; Renn, O.; Röhlig, K.J.: Technical and Normative Aspects of its Disposal - Ethics of Science and Technology Assessment | Volume 38, Springer 2011

Tiggemann 2010: Tiggeman, A.: Gorleben as a waste management and disposal site – the selection and dicision making process in Lower-Saxony. An expert opinion[“ Gorleben als Entsorgungs- und Endlagerstandort .Der niedersächsische Auswahl- und Entscheidungsprozess. Expertise zur Standortvorauswahl für das „Entsorgungszentrum“ 1976/77“, in German] on behalf of the Ministry for the Environment and Climate Protection of Lower Saxony, May 2010

ANNEX 1

List of questions for the interviews [Frageliste für semi-strukturierte Interviews, in German]

1. Was sind in Ihrem Land nach Ihrer Meinung die derzeit am meisten diskutieren Themen im Bereich der Endlagerung…?
    - In der Öffentlichkeit
    - In den Medien
    - In der Politik
    - Zwischen Fachexperten
2. Welche wichtigen gesellschaftlichen und politischen Herausforderungen bestehen derzeit?
3. Welche wichtigen technischen Herausforderungen sind derzeit offen?
4. Gibt es Verknüpfungen zwischen diesen gesellschaftlichen und politischen Herausforderungen und den technischen Anforderungen? Können Sie die Verknüpfungen/ Auswirkungen beschreiben?
5. Was sind Ihrer Meinung nach die wichtigsten sozio-technischen Herausforderungen in Ihrem Land?
   Mögliche Nachfragen:
    - Aus der Literatur und der Verfolgung der aktuellen Ereignisse ergeben sich nach unserer Einschätzung auch folgende sozio-technischen Herausforderungen:
        - Diskussion des generellen Endlagerkonzeptes (Langzeitzwischenlagerung (Rückholbarkeit der Abfälle
        - Standortauswahlverfahren-Standortsuche/Wirtsgestein
    - Wie ist Ihre Meinung zu diesen Aspekten? Halten Sie diese auch für wichtige sozio-technische Herausforderungen?
6. Sind dies auch international wichtige sozio-technische Herausforderungen oder handelt es sich um eine landestypische Herausforderungen? Wenn letzteres, warum hat dieses Thema in Ihrem Land eine so hohe Relevanz?
   Mögliche Nachfragen:
    - Handelt es sich um kulturelle Gepflogenheiten? Liegt es am politischen Kontext? Basiert dies auf den ordnungspolitischen Zusammenhängen?
7. Welche Ansätze gibt es, sich mit solchen sozio-technischen Herausforderungen auseinander zu setzen? Gibt es positive Ansätze? Wo sehen Sie Verbesserungsbedarf?
8. Haben Sie Vorschläge, wie man mit diesen sozio-technischen Herausforderungen umgehen sollte?
9. Welche Auswirkungen hätte es Ihrer Meinung nach, wenn Ihre Vorschläge bei der Planung und Realisierung von Endlagern berücksichtigt würden?
10. Was sind Ihrer Meinung nach wichtige Themen in der Endlagerforschung?
11. Gibt es aus Ihrer Sicht Entwicklungen, sozialwissenschaftliche Aspekte in der Endlagerforschung verstärkt zu berücksichtigen?
12. Haben Sie weitere Anmerkungen?