G O R L E B E N -

" the endless story "

(Insights from site characterization of a proposed high-level waste repository at Gorleben, Federal Republic of Germany)

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ELECTRICITY GENERATION IN GERMANY

Total in 1992: 460.8 billion kWh

Nuclear power	**34.2 %**
Lignite	**30.7 %**
Coal	**24.2 %**
Natural gas	**4.4 %**
Water	**4.1 %**
Oil	**1.6 %**
Others	**0.8 %**
	100.0 %

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NUCLEAR POWER IN GERMANY

20 Nuclear Power Plants in operation with a total installed capacity of 22.5 MWe

- **13 Pressurized Water Reactors with 15.3 MWe**
- **7 Boiling Water Reactors with 7.2 MWe**

(Projects for High Temperature Gas Cooled Reactor and Fast Breeder Reactor have been given up)

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NUCLEAR FUEL CYCLE (1/2)

- **Interim Storage Facilities for spent nuclear fuel in operation at**

- Gorleben (Lower Saxony)	1,500 t HM
- Ahaus (Northrhine-Westphalia)	1,500 t HM
- Greifswald (Mecklenburg-Vorpommern)	740 t HM

- **Reprocessing contracts with**

- Cogéma, France, at La Hague	4,653 t HM
(Option)	(1,645 t HM)
- BNFL, United Kingdom, at Sellafield	885 t HM
(Option)	(1,365 t HM)

- **Return of vitrified high-level waste from**

- Cogéma	2,800 canisters
(Option)	(1,150 canisters)
- BNFL	700 canisters
(Option)	(1,100 canisters)

First vitrified HLW will arrive in Germany in November 1994

NUCLEAR FUEL CYCLE (2/2)

- **Direct disposal of spent fuel from HTRs already legally possible**

- **Direct disposal of spent fuel from LWRs under legislation**

- **Pilot conditioning plant for spent fuel under construction at Gorleben**

- **Repositories for radioactive waste:**

  - **Morsleben (Sachsen-Anhalt) for low- and intermediate-level waste: in operation since 1981**

  - **Konrad (Lower Saxony) for non-heat generating waste: under licensing**

  - **Gorleben (Lower Saxony) for all types of radioactive waste, with emphasis on heat generating waste (vitrified HLW + spent fuel): site under exploration**

GORLEBEN SITE SELECTION

- **Nuclear Fuel Cycle Center with reprocessing plant, waste treatment facilities, and repository was planned in the early 70's**

- **Three proposed sites with salt domes in the State of Lower Saxony:**

  - **Wahn**
  - **Weesen-Lutterloh**
  - **Lichtenhorst**

- **Not accepted by the State Government**

- **Proposal by the State Government in February 1977: G O R L E B E N**

- **Proposal accepted by the Federal Government in June 1977**

- **Gorleben Hearing in March 1979**

- **Decision by the State Government in May 1979:**

  - **Reprocessing Plant rejected (with the fatal statement of then acting Prime Minister Ernst Albrecht: "Can be realized from a safety point of view, but cannot be carried through politically")**

  - **Site exploration of salt dome accepted**

- **Start of first exploratory drilling in May 1979**

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GORLEBEN SITE
EXPLORATION PROGRAM (1/3)

- **Hydrogeology (1979 - 1985):**

  - **145** exploration boreholes
  - **322** wells for groundwater monitoring
  - **4** wells for long-time pumping tests

- **Seismic investigations (1984)**

  - **16** profiles with a total length of 150 km were shot and the data were processed and evaluated

- **Cap rock and salt dome surface (1979 - 1985):**

  - **44** exploration boreholes until about 30 m into the salt

  - **1** exploration borehole until 230 m into the salt

- **Deep exploration boreholes (1980 - 1981):**

  - **4** deep exploration boreholes were drilled into the flanks of the salt dome, each fully cored borehole about 2000 m deep

GORLEBEN SITE EXPLORATION PROGRAM (2/3)

- **Shaft exploration boreholes (1982):**
  - **2 exploratory boreholes were drilled to a depth of 900 m for detailed information to locate the two planned shafts**
- **Summary report of all results in May 1983 by BfS formed the basis for the decision to continue with underground site exploration**
- **Shaft sinking started in September 1986**
- **Updated summary report by BfS in April 1990 confirmed "expected site suitability"**
- **Target depth for the two shafts is about 840 m**
- **Detailed underground site investigation is absolutely necessary**
- **A coordinated program for underground exploration with drifts, boreholes, and geophysical investigations has been set up**

GORLEBEN SITE EXPLORATION PROGRAM (3/3)

- **Main target is to get a complete detailed picture of geology**

- **Rock-mechanical and thermo-mechanical data of salt were previously elabourated. Therefore, only on site-confirmation is necessary**

- **Possible presence of brines (e. g. brine pockets or brine inclusions) is not expected to cause problems**

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LICENSING (1/3)

- German Atomic Act of 1957 delegates licensing authorization for all nuclear installations to the Federal States with supervision by the Federal Government (presently BMU)

- Political impacts by State Governments on their licensing authorities, especially by Red or Red/Green Governments who want to phase out nuclear energy

- Continuous discussions and differences between Federal and State Governments

- Directions by the Federal Government according to Article 85 (3) of the German Constitution

- Licensing of the Gorleben exploration mine according to:

  - German Atomic Act

  - German Mining Law

LICENSING (2/3)

- **Consequences of using the Mining Law:**

  - **Mining Law does not provide for participation of the public**
  - **Mining Authorities are State Authorities**
  - **No directions by the Federal Government possible**
  - **Mineral rights of salt belong to the land owner**
  - **No expropriation possibility for an exploration mine**
  - **Continuous and numerous law suits**

- **Specific licensing procedure (Planfeststellungsverfahren) according to § 9 b of the German Atomic Act for construction and operation of a repository:**

  - **Partial licenses not possible**
  - **Concentration of all other relevant laws (e. g. construction, water, nature protection)**
  - **New licensing procedure necessary if substantial changes occur**

L I C E N S I N G (3/3)

- **Prescribes public layout of planning documents and public hearing with intervenors**

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UNEXPECTED TECHNICAL PROBLEMS - SHAFT SINKING (1/4)

- **Freezing technology has to be used for sinking the two shafts "Gorleben 1" and "Gorleben 2" because of the specific geological and hydrogeological situation above a salt dome**

- **Shaft "Kolenfeld" for the potash mine "Sigmundshall" near Hannover was sunk with the same technology within 4 years (1965 - 1969) to a total depth of 940 m (freezing section to 243 m)**

- **Sinking of shaft "Gorleben 1" started on September 16, 1986, after completion of freezing**

- **Unexpected inhomogeneous stress distribution occurred within frozen Tertiary clays at a depth of 234 m which endangered the preliminary precast concrete-block shaft lining**

UNEXPECTED TECHNICAL PROBLEMS - SHAFT SINKING (2/4)

- Supporting steel rings were installed within the endagered zone. One of those steel rings was not properly welded, broke, fell down and caused an accident

- Shaft accident occurred on May 12, 1987, which killed one miner and injured five

- Sinking was stopped and a new concept for the outer preliminary shaft lining was developed

- Shaft sinking could only be resumed on January 23, 1989, after 20 months' interruption with a new preliminary lining system

- Shaft "Gorleben 1" reached a depth of 312 m in December 1991. Sinking was interrupted because of brine detection in pre-drillholes within the fracture zone caused by contraction of the salt through freezing

- Tightening of this fracture zone by drilling and injection was performed between December 1991 and June 1992

UNEXPECTED TECHNICAL PROBLEMS - SHAFT SINKING (3/4)

- **After resuming shaft sinking, the shaft reached its interim target depth at 350 m in November 1992**

- **Foundation for the final inner lining was installed between November 1992 and March 1993**

- **Subsequently, the final inner lining was mounted until August 1993**

- **Shaft "Gorleben 2" met the same fate:**
  - **Surface of salt dome was reached at 258 m in June 1992**
  - **Drilling and injection of contraction zone between June and October 1992**
  - **Interim target depth of 357 m reached in June 1993**
  - **Foundation installed from July until December 1993**
  - **Final inner lining subsequently mounted until March 1994**

UNEXPECTED TECHNICAL PROBLEMS - SHAFT SINKING (4/4)

- **Present situation of shaft "Gorleben 1":**
  - **Upper part penetrating the overburden is completed with final lining in place since August 1993**
  - **Freezing pumps were shut off on August 12, 1993, having been in operation since October 24, 1985**
  - **Standstill since September 15, 1993, because of lacking license for continuation of sinking**

- **Present situation of shaft "Gorleben 2":**
  - **Upper part penetrating the overburden ist completed with final lining in place since March 1994**
  - **Freezing pumps were shut off on March 24, 1994, having been in operation since April 2, 1986**
  - **Standstill beginning end of April 1994 because of lacking license for continuation of sinking**

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UNEXPECTED GEOLOGICAL RESULTS - THE GORLEBEN GROOVE (1/3)

- Multiple barrier system is internationally accepted
- Host rock "salt" is the most important barrier
- Geological overburden above the salt dome is one further barrier
- Generic information about overburden and caprock on top of a salt dome was available
- Tertiary and Quarternary clay layers were expected to form aquicludes above the Gorleben salt dome
- By extensive drilling exploration the "G o r l e b e n g r o o v e" was detected
- This groove was cut into the overburden and partially into the caprock by a glacier during the Elster glaciation period in Quarternary (500,000 to 350,000 years before now)

UNEXPECTED GEOLOGICAL RESULTS - THE GORLEBEN GROOVE (2/3)

- **The Gorleben groove is partially filled with Quarternary loose sediments**
- **The overburden above the salt dome is a complicated system of aquicludes, aquitards, and aquifers**
- **Hydrogeological investigations proved that the deeper part of the Gorleben groove is filled with saturated salt solutions**
- **Groundwater flow velocity was determined to be between 1.4 and 8.8 m/a in the aquifers**
- **There is, however, n o f l o w within the saturated salt solution. Radionuclide transportation could only occur by diffusion**
- **Groundwater travel modelling was performed in the mid 80's using fresh water data**
- **At present, there is no fast computer program available which can include saturated salt solution**

UNEXPECTED GEOLOGICAL RESULTS - THE GORLEBEN GROOVE (3/3)

- **A program was initiated to develop such a computer code**

- **The political critics of the Gorleben project, supported by so-called "critical scientists", claim that the plain existence of the Gorleben groove is a "k.o.-criterion" for the site**

- **The overburden above the salt dome is only one barrier in the total system**

- **It can be proved - in spite of the existence of the Gorleben groove - that the total system of the Gorleben repository is able to meet the safety goals**

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CRITERIA (1/2)

- The German Reactor Safety Commission elabourated "Safety Criteria for Disposal of Radioactive Wastes in a Repository" in 1982

- These criteria were enacted in January 1983 by the then responsible Bundesminister des Innern (BMI) through publishing in the Federal Register

- The criteria define the overall safety goal according to the German Radiation Protection Ordinance:

  Maximum dose of an individual

  shall be less then 0.3 mSv/a

  (has to be proved for about 10,000 years)

- This has to be achieved by a site specific safety analysis

- The criteria make use of the system's approach and the multiple barrier system:

  - Waste form
  - Waste packages
  - Backfill and sealing
  - Host rock formation
  - Overburden and adjacent rock formations
  - Biosphere

CRITERIA (2/2)

- Criteria cover the normal expected behaviour of the repository system as well as the consequences of accident scenarios

- Criteria take into account "the general geological situation which cannot be standardized"

- Consequently, the criteria do not specify figures or numbers, but establish deliberately some "margins of discretion"

- The licensing procedure for the repository shall be performed within these margins of discretion "according to the level of science and technology" taking into account the site specific situation

- Consequently,

it is not necessary to find

the best site for the repository

but a site which is able to meet the safety goal within the system's approach

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SITE EVALUATION (1/2)

- The Gorleben salt dome is investigated with
  - an exploration program from the surface
  - an underground exploration program

- Exploration program from the surface was performed from 1979 until 1985

- Results achieved formed the basis to continue with underground site exploration ("expected site suitability")

- Underground site exploration of the Gorleben salt dome is absolutely necessary to get a detailed picture of the internal geological structure of the salt dome

- Two approaches for site evaluation:
  - Site evaluation can be done straight forward by application of the present state of knowledge in geological exploration and of mining experience
  - Site evaluation can only be done by a complete performance assessment (a safety or risk analysis) for the planned repository with a perfect set of site specific data

SITE EVALUATION (2/2)

- **Yardsticks for site evaluation:**
  - **Legal requirements**
  - **Technical requirements**
  - **Performance assessment methodology**
  - **Multiple barrier system**
  - **Experience from prospecting and mining**
  - **Underground research laboratories**
- **Concurrence on site suitability is necessary between applicant and licensing authority**

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LESSONS LEARNED (1/3)

- Consensus on nuclear energy is desirable
- Understanding for the need of a repository must be established in spite of the NIMBY- and NIMEP-syndroms
- In a Federal System, basic understanding between the Federal Government and the State and Local Governments is required for siting a repository
- Legal situation should be clarified in advance as detailed as possible
- Clear licensing requirements and responsibilities are indispensable
- Criteria for site selection and site evaluation should make allowances for the system's approach and should not be too specified
- Positive basic understanding between licensing authority and applicant is necessary

LESSONS LEARNED (2/3)

- Certain flexibility within the licensing procedure is recommended
- Time schedules for site investigation and repository construction should be as realistic as possible, but must continuously be adjusted
- Quantities and qualities of radioactive wastes to be disposed of in the repository must be kept "à jour"
- Unexpected geological results and technical problems will occur
- Procedure for site evaluation and acceptance should be established
- Experiences (positive and negative) in geological exploration and mining should be used as much as possible
- Costs are not to be completely neglected
- Positive interaction with the public should be strived for without the possibility that public opinion prevents the project

LESSONS LEARNED (3/3)

- **International Commission on Nuclear Waste Disposal (ICND) should be established with reference to ICRP**

- **Discussions on international repositories should not be a taboo any longer**

INTERACTION WITH THE PUBLIC

(1/2)

- **Gorleben Hearing on the planned Nuclear Fuel Cycle Center in March 1979**
  (Chairman: Prof. Carl-Friedrich von Weizsäcker)

- **Public Hearing by the then responsible Committee of Interior of the Deutscher Bundestag (German Parliament) on Gorleben in 1984**

- **Public Hearing by the State Government of Lower Saxony in June 1987**

- **Second Public Hearing by the Committee for Environment, Nature Conservation and Reactor Safety of the Deutscher Bundestag after the shaft accident in April 1988**

- **Government changed in the State of Lower Saxony to a Red/Green-Coalition in May 1990:**
  Installation of a committee with the objective "to consult the State Government for its target to phase out nuclear energy"

- **"Braunschweig-Hearing on Radioactive Waste Disposal" by the State Government in September 1993**

INTERACTION WITH THE PUBLIC

(2/2)

- **Continuous information of the public about all technical and scientific results of the Gorleben project**

- **Public hearing with the intervenors is prescribed in the licensing procedure**

- **Public hearings and discussions were not interested in solving the problem of siting and constructing a repository, but in fighting "a religious or ideological war against nuclear power"**

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