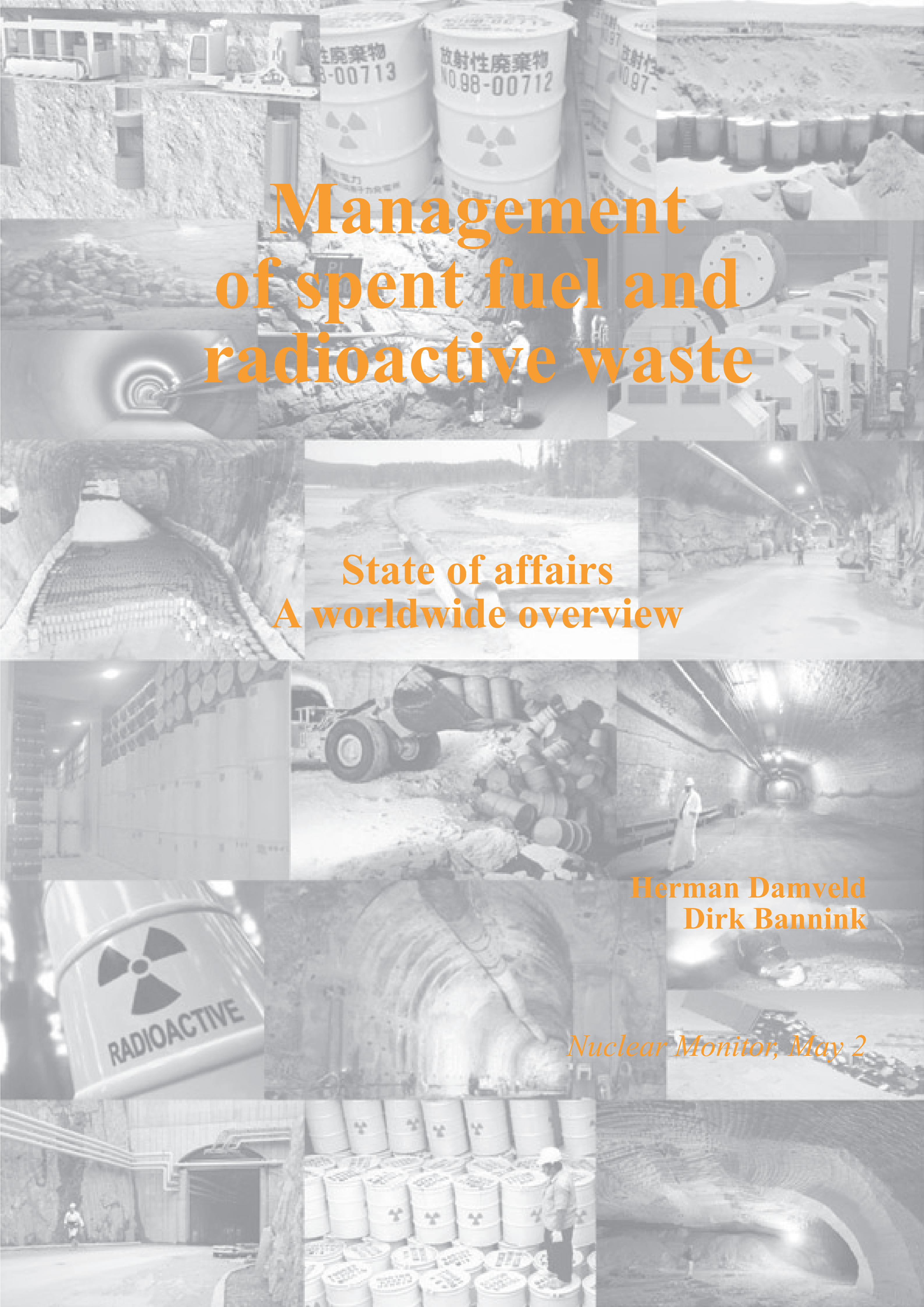

Management of spent fuel and radioactive waste

State of affairs
A worldwide overview

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CONTENT

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INTRODUCTION

„Taking into account the results already achieved, the expected technological developments in the coming years, and above all the existence of a well-established basis for the assessment in numerical terms of radiation hazards, the group are convinced that the optimum development of nuclear energy need not be impeded by radioactive waste management problems which will have to be dealt with".

This quote is from the OECD report „Radioactive waste management practices in Western Europe". It is not from the most recent report, although the wording would be the same, but from a report in 1972!

Since the beginning of nuclear power the major claim is that there will be a solution for nuclear waste soon, that the waste problem really is not a technical problem but a social problem, but, anyway, we are near a solution. So there is no reason to stop producing it or endanger the future of nuclear energy.

But as the authors describe in this worldwide overview, none of the roughly 34 countries with spent fuel (reprocessed or not) from nuclear power reactors have a final disposal facility, be it in deep geological formations or (near) surface. A very large majority of those countries are not even close. Some postpone the need for final disposal by long term interim storage of up to 100 years; and other countries use (the future option of) reprocessing as an alibi for postponing that decision.

As this worldwide overview of the state of affairs shows, siting radioactive waste repositories is seen as one of the main problems due to socio-political circumstances. Almost without exception, all radioactive waste management programs state that this generation must solve its own problems and not lay the burden of solving the waste problem on the next generations. But those same programs propose, again almost without exception, to postpone a decision on final disposal and/or reprocessing into the far-future, and consider interim storage.

Fact is that the problem of final disposal of high-level radioactive waste and/or spent fuel has not been solved, more than half a century after the first commercial nuclear power plants entered into operation and used fuel was unloaded from the reactors.

Although we briefly describe the storage and disposal of low and intermediate level waste, the focus of this report is clearly on spent (or 'used') fuel from nuclear power plants. Waste from uranium mining is not even mentioned. It is also not about fuel from research reactors, which is mostly returned to the country of origin.

Tabel 1;
Final disposal repository for HLW or SF;
expected start of disposal.

Country	… in 1989	… in 1996	… in 2012
Argentina			2060
Armenia			?
Belgium	2030	2035	2070/80
Brazil			?
Bulgaria			?
Canada	2015/25	2025	2035
China			2050
Czech Republic			2065
Finland	2020	2020	2020/25
France	2010	2020	2025
Germany	2005/10	2010	2035
Hungary			2064
India			?
Iran			?
Italy			?
Japan			2035
Kazakhstan			?
Korea, Rep. of			?
Lithuania			?
Mexico			?
Netherlands	2010		2130
Pakistan			?
Romania			?
Russian Federation			2035
Slovak Republic			?
Slovenia			?
South Africa			?
Spain			2050
Sweden	2020	2020	2023/25
Switzerland	2025	2020	2040
Taiwan			2055
Ukraine			?
United Kingdom		2030	2075
United States	2010	2020	?

Because the limitations of the number of pages of the Nuclear Monitor, this is only a brief overview of the state of affairs, but some important historic developments are covered.

We have included many references, which should make it easier to search for more information. We did not include the url's of the references, because they tend to change frequently (and not much so annoying as dead links). Instead, we described the source as best as we could. Therefore it should be relatively easy to find it on the internet when the description is copied in a search engine. Of course, not all information used is available online. If there are questions about a reference (or something else), please do not hesitate to contact us.

ARGENTINA

Nr. of reactors	first grid connection	% of total electricity
2	1974-03-19	4.97%

The April 1997 National Law of Nuclear Activity assigns responsibility to the National Atomic Energy Commission CNEA (Comisión Nacional de Energía Atómica, founded in 1950) for radioactive waste management, and created a special fund for this purpose. Operating nuclear power plants pay into this. Awaiting final disposal interim storage of spent fuel takes place at cooling ponds on site, and some interim dry storage at Embalse.(*01) No reprocessing has taken place.

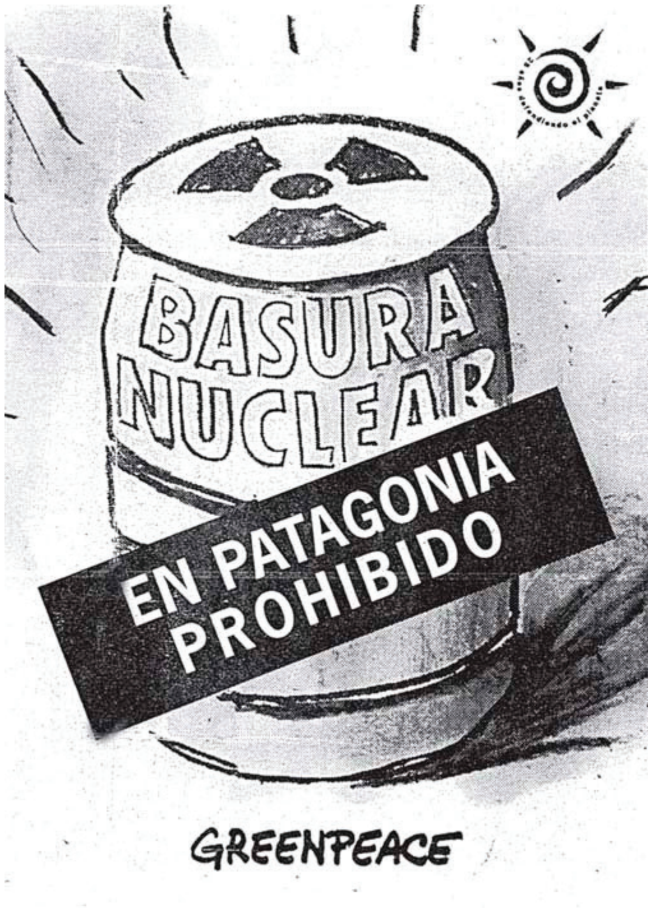
Final disposal
Final disposal of low-level waste takes place in engineering enhanced surface semi containment systems at the Ezeiza Radioactive Waste Management Area (AGE), operated by CNEA. For intermediate level wastes a monolithic near surface repository is foreseen, similar to those in operation in L'Aube, France and El Cabril, in Spain. (*02) Especially after a scandal in 2005 on high levels of water contamination with uranium in Ezeiza and Monte Grande, near the atomic center, doubts have risen about the conditions of and safety procedures at the AGE. The response from the CNEA and the government to the obvious contamination did not help to calm citizens' worries, as it was marked by obscuring and silencing the real impact. A few years later the provincial government was forced to acknowledge the contamination values measured by independent laboratories, although official reports stated, that there was no contamination from nuclear waste but just high radioactive background level.(*03)

In 1994, during the nation's constitutional reform, a broad Argentinean environmental movement won a momentous victory to make Article 41, which bans the import of toxic and radioactive waste, part of the national constitution.(*04)

The Argentine *Strategic Plan* has provided three types of technological systems for final disposal:
- Engineered Surface System, for LLW requiring isolation periods of up to 50 years.
- Monolithic Near-Surface Repository, for ILW requiring isolation periods of up to 300 years.
- Deep Geological Repository, for HLW and SF requiring isolation periods in excess of 300 years.

With regard to spent fuel originating from research or radioisotope production reactors, the strategy considers two alternatives: Shipping them back to the country where they were originally enriched, if possible, or conditioning for final disposal.(*05)

The *Strategic Plan,* updated in March 2006, at present covers the period from 2006 through 2095.
The deadline to adopt a decision on the possible reprocessing or final disposal of spent fuel is subject to the completion of the studies for the siting of the Deep Geological Repository which have to be concluded at the latest by 2030. At such time the installation of the underground geological laboratory must have been started, which allows the design and construction of a deep geological repository, which must be operative by the year 2060. (*06)



ARMENIA

Nr. of reactors	first grid connection	% of total electricity
1	1976-12-22	33.17%

The Government of Republic of Armenia established state regulatory authority for nuclear and radiation safety (ANRA). ANRA's task is the state regulation of nuclear energy, including the safe management of radioactive waste. ANRA regulates the nuclear and radiation safety of Armenian NPP, dry spent nuclear fuel storage facility, ionizing radiation sources, RADON radioactive wastes storage facility, and of other facilities where practices with nuclear materials are implemented.(*01)

Spent fuel is stored in spent fuel pools. After five years of storage the spent fuel is placed into dry spent fuel storage (DSFS) and are placed into horizontal concrete storage modules (HSM). After Unit-1 shutdown its spent fuel pool is used as a temporary storage facility for spent fuel. (*02) DSFS started operation on 1 August 2000. The license validity is 20 years. DSFS consists of 11 horizontally placed concrete modules for storage of 616 spent fuel assemblies. In 2005 the National Assembly based on proposal from the government made decision to extend the DSFS. It will enable storing 1890 fuel assemblies at least 50 years.(*03)

BELGIUM

In Belgium, after many years of discussion, a storage location has been selected for low-level and medium-level radioactive waste. It will take until 2070/80 before disposal of high-level radioactive waste will begin in clay layers.

Nr. of reactors	first grid connection	% of total electricity
7	1962-10-10	53.96%

Storage in sea
In Belgium, NIRAS (National Agency for Radioactive Waste and Enriched Fissile Materials) has been responsible for the storage of all nuclear waste. NIRAS, established in 1980, is supervised by the Ministry of Economic Affairs. From 1960 to 1982 Belgium dumped low-level radioactive waste in the Atlantic Ocean(*01) –described by NIRAS as "sea disposal at great depths".[*02] Since then NIRAS is studying the disposal of all types of nuclear waste aboveground or underground.

Low- and medium-level radioactive waste
In April 1994, NIRAS published a report on the aboveground storage of low-level radioactive waste. In all 98 mentioned suitable locations (in 47 municipalities), the report led to motions in town councils, in which storage was rejected.(*03). The government asked NIRAS if it would be possible to store the waste on one of the 25 military bases no longer in use.
In June 1997, NIRAS published a report which "ultimately had only been a preparatory exercise, based on bibliographic data,"(*04) but nevertheless gave rise to concern again. Only the town council of Beauraing, where the military base Baronville is situated, was in favour of storage, but on 28 June 1998, in a local referendum 94 percent voted against. (*05) This brought embarrassment to the government, and as it often goes in politics, the government came with a woolly policy to work towards "a final solution or a solution with definite, progressive, flexible and reversible destination."(*06) According to this decision the low- and medium-level radioactive waste can be stored either close to the surface as well as in deep geological clay formations.(*07) The government no longer points to any sites, but puts the emphasis on public support and it assumes public support can be found at existing nuclear zones. These are Doel and Tihange (nuclear power stations), Mol (Center for Nuclear Energy Research), Dessel (manufacture of fuel elements) and Fleurus (Institute for radio-elements). But towns may present themselves also voluntarily.(*08) NIRAS adopted the government's policies and stated in 1998: "To strive for a real partnership from the beginning, rather than merely an exchange of arguments, means a modernization for the nuclear waste sector."(*09)

In 1999, after much deliberation, NIRAS signed a partnership agreement with Dessel and Mol, and on June 23, 2006 the choice fell on Dessel. In 2004, the population of Dessel had already voted in favour of the so-called surface disposal, which is planned to start in 2016.(*10) The waste (appr. 70,000m3) will be stored in what ultimately will be a hill of 160 by 950 meters and 20 meters high. Barrels put in boxes filled-up with concrete (monoliths), will be placed in modules and covered with mutiple layers.

Taking into account the additional buildings, the storage requires 74 acres (30 ha). After 50 years, the storage is completed, and then it can be decided whether the roof is replaced by a definitive cover. It should be possible to retrieve the monoliths in the first 200-300 years when there will be active monitoring of the waste.(*11)

High-level radioactive waste
Since the early 1970s, Belgium has plans to store high-level radioactive waste in clay layers. From 1974 to 1989 research and construction of an underground mine (at a depth of 230 meters) into the clay under Mol in the Kempen region took place. This is a particular type of clay, the so-called "Boomse klei" (Boom clay), which is also present in some parts of the Netherlands. According to NIRAS, Belgium opted for clay because there was data available. The choice fell on Mol ("*Apart from its intrinsic qualities, the Boom clay has the advantage of being located under the nuclear site at Mol-Dessel.*") because this town is hosting the national Center for Nuclear Energy Research with the (closed) Eurochemie reprocessing plant: "*to have available a local solution for eventual disposal of reprocessing waste from the Eurochemic plant*".(*12)

Between 1990 and 2000 methods to assess the safety and the properties of clay for the long term were studied. One of the important questions is what would happen if nuclear waste is leaking from the barrels and ends up in the clay? The NIRAS 2002 SAFIR (Safety Assessment and Feasibility Interim Report) 2 report states that many questions about the safety of storing nuclear waste in clay remain unanswered: until 2017, therefore eleven issues have to be examined with priority.
Until 2017, NIRAS will show the feasibility of the studied solution and demonstrate how the nuclear waste has to be disposed of. Then construction of the storage mine may start. In the complicated words of NIRAS: "*Without frustrating the basic choice of the Boom clay, at this moment there still remain important questions unanswered, therefore it is premature to make a definitive statement today on the technical feasibility of storage in this formation or on the operational and long-term safety of such disposal*."(*13)

Keeping in mind there is still no decision on disposal of high-level radioactive waste in clay yet, the NIRAS' Board of Directors adopted a 'Waste Plan' on 23 September 2011.(*14) "*Now the legal procedure for the Waste Plan is completed and the dossier is ready to be delivered to the government which then will have all the ingredients to make a decision. With a basic decision of the government clarity will be obtained which direction further work has to be done on how long-term safety can be guaranteed. The basic decision will* *be the first step in a gradual, lengthy decision-making process in which the society will be involved. The process leading to the implementation of a long-term management option will take several decades. Currently, it is not about selection of a location. That choice, at which the local population will be 'closely involved', will be made at a later stage in the decision-making process.*"(*15) If the government opts for storage in clay, it will take until 2070-2080 before the disposal of high-level radioactive waste can begin.(*16)

BRAZIL

Nr. of reactors	first grid connection	% of total electricity
2	1982-04-01	3.17%

The National Nuclear Energy Commission (Comissão Nacional de Energia Nuclear, CNEN) is responsible for management and disposal of radioactive wastes. Legislation in 2001 provides for repository site selection, construction and operation for low- and intermediate-level wastes.

A long-term solution for these is to be in place before Angra 3 is commissioned. Low and intermediate level waste is stored on site of Angra nuclear complex and on other sites where it is produced.(*01)
A location for a national waste repository for LLW and ILW waste is due to be chosen in 2011 (but delayed again) (*02) and planned to start operation in 2018. Two options are being considered: the construction of a repository exclusively for waste from Angra or a facility that would accept material from all nuclear and radioactive installations in Brazil. (*03) Used fuel is stored at Angra pending formulation of policy on reprocessing or direct disposal. (*04)

HLW disposal: when, where and how unknown
Currently, there is no decision about the way of final storage of the waste. Brazil has not defined a technical solution for spent fuel or high-level waste disposal. Spent fuel is not considered radioactive waste. Therefore, the policy adopted with regards to spent fuel is to keep the fuel in safe storage until an international consensus and a national decision is reached about reprocessing and recycling the fuel, or disposing of it as such.(*05)

High-level wastes, after been stored on site would then be moved to an interim storage location for 500 years. This interim site is expected to begin operation in 2026; a proposed plan was due to be finished by 2009, and a prototype validated by 2013, according to Eletronuclear.(*06) For final disposal a deep geological facility has been foreseen, but a timeframe has not been developed.(*07)

Opposition to nuclear power and waste storage is strong in Brazil. Even CNEN admits that "*political and psycho social aspects related to the subject of radioactive waste disposal ("Not in my backyard syndrome") contribute enormously to the difficulties faced by the Brazilian Government in the establishment of a national waste management policy.*" (*08)

BULGARIA

Nr. of reactors	first grid connection	% of total electricity
2	1974-07-24	32.58%

The State Enterprise Radioactive Wastes (SE-RAW) is responsible for much of the waste management. On October 25 2011, a contract was signed drafting technical aspects and safety analysis for a low- and intermediate level waste interim storage facility near Kozloduy. A tender is expected mid 2012 and the facility is planned to go into operation in 2015. (*01) In 2009, a search for a location of a near-surface repository for low and intermediate level waste has been started. Four locations are taken into account.(*02)

Keep options open
In 1988, spent fuel from VVER-440 units (Kozloduy 1-4) was returned for the last time to Russia under the old contract conditions (free of charge), since then it is transferred to the wet spent fuel storage facility (WSFSF) for temporary storage, awaiting transfer to Russia or interim storage. WSFSF is in operation since 1990 on site at Kozloduy to take fuel from all the units. It is a standalone facility and is used as interim storage. Currently spent fuel is regularly transported to Russia under contracts signed in 1998 and 2002.(*03)
Under a 2002 agreement, Bulgaria has been paying Russia US$ 620,000 per ton used fuel for reprocessing in the Mayak plant at Ozersk, though some has also been sent to the Zheleznogorsk plant at Krasnoyarsk.(*04)

In March 2011 a dry spent fuel storage facility (DSFSF) construction was finished. At the DSFSF the fuel from the closed units 1-4 (VVER-440) should be stored for a period of 50 years. In July 2011 an application for commissioning was submitted and is currently under review. (*05)
The dry spent fuel depot will allow the country to store spent nuclear fuel for the long term in case it is unable to ship it abroad, its radioactive waste strategy said. Bulgaria is to decide by 2013 whether to build a deep-burying waste dump. (*06)

The principles of radioactive waste and spent fuel management were declared in the national Strategy for Spent Nuclear Fuel and Radioactive Waste Management, 2004, later confirmed and developed further in the Strategy for Spent Fuel and Radioactive Waste Management until 2030, adopted by the Council of Ministers in January 2011. It states that, accounting for the global and general European consensus for deep geological repository, this is presumably the most suitable option.

The SE-RAW implements activities related to the preliminary study of the possibilities for construction of deep geological repository. As a result from these activities a preliminary zoning of the country is made and three regions of interest are identified. In those regions 5 potential areas are localized and for every of the perspective areas an analysis of the geology-tectonic, geo-morphologic, neo tectonic, seismic, hydro-geological and engineer-geological and sociological economical characteristics is performed. On this base 6 potential geological blocks are localised, that can be additionally investigated. The potential host media are thick clay mergels and granites. (*07)

CANADA

Nr. of reactors	first grid connection	% of total electricity
18	1962-06-04	15.33%

The plans for storage of nuclear waste has not yet led to a choice for a location. In 2009, a new dialogue process began with the population. It is anticipated that an underground disposal facility will not be in operation before 2035. Meanwhile, all spent fuel is stored at reactor site in pools and dry storage.

Public debate
In Canada the search for a repository for nuclear waste has taken place since at least 1977.(*01) It is standing policy that the local population should accept the storage. In 1992, the government proposed that in addition to technical issues, also ethical and societal issues must be recognized in the debate on nuclear waste storage.(*02) As departure points for a siting process it was further accepted that the population has to think the chosen procedure is honest, it should have access to all information and the population should have the opportunity to really influence the choice of location.(*03) This discussion model had the consent of both “proponents” and “opponents” of storage and should make a meaningful discussion about the pros and cons of disposal of nuclear waste possible.(*04)

Low-level radioactive waste
The public debate about low-level radioactive waste started in 1988.(*05) 850 town councils were asked whether they would be interested, of which 21 responded positively. In these 21 towns a referendum was held, and only three voted in favor of it.(*06) But in 1994, Deep River in Ontario was the only municipality to respond to the government’s program to find a community willing to accept the low-level waste. At a referendum in September 1995 a large majority of the population voted in favor of storage of low-level radioactive waste, *if* the government would give job guarantees for 2,300 people at the local Chalk River nuclear research center for 15 years. (*07)
However, funding negotiations for job guarantees broke down in January 1997 (*08) and in early 1998, the Canadian government announced it had no success completing the deal. As a result, the option of storage of low-level radioactive waste at Deep River is off. (*09)

High-level radioactive waste
With the disposal of spent fuel elements from nuclear power plants the Canadian government has also not made any progress.(*10) Awaiting final disposal of high level waste, all spent fuel is stored at reactor site in pools and dry storage. (*11)
In August 1977, the Federal Department of Energy, Mines and Resources released a report which became known as the Hare report, after its Chairman F. K. Hare. It recommended burying the spent fuel at depths of 800 to 1000 meters in the Canadian Shield, a large area of ancient igneous rock in eastern and central Canada and called for an “effective interchange of information and ideas” among the public, industry, and government.(*12) Ten years later, in 1988, the concept of a storage mine, which had become known as the AECL-concept, was referred for a full–scale environmental review.
Estimated costs in 1991 was between 8.7 and 13.3 billion in 1991 Canadian dollars.(*13)

The Environmental Assessment Panel held hearings in the 1990s and in March 1998 it’s report was published. The main conclusion was that there is no public support and that many ethical questions are still open: Broad public support is necessary to ensure the acceptability of a concept for managing nuclear fuel wastes; Safety is a key part, but only one part, of acceptability. Safety must be viewed from two complementary perspectives: technical and social; From a technical perspective, the safety of the AECL concept had been on balance adequately demonstrated for a conceptual stage of development, but from a social perspective, it had not; the concept for deep geological disposal did not have the required level of acceptability.(*14) The committee recommended to work on the social and ethical issues first, and, for the time being, not to search for a concrete repository.(*15)
In a March 13,1998, statement the Canadian government announced that, while “*the safety of the concept has been adequately demonstrated (…) it does not have broad public support, nor the required level of acceptability to be adopted*” and that it will not proceed with siting efforts for a deep geological disposal. (*16)

Four years later, in 2002, the Canadian government created a new organization for the storage of nuclear waste: the Nuclear Waste Management Organization (NWMO). This organization is paid for by the operators of the nuclear power plants in the provinces of Ontario, Quebec and New Brunswick. Instead of an organization independent from the operators of nuclear plants, now operators will have the say. Therefore Greenpeace Canada, for instance, wondered to what extent the NWMO will really involve the population in decision making.

The NWMO has held hearings from 2002 to 2005. In May 2009, it initiated a nation-wide dialogue with interested organizations and individuals to establish a procedure for selecting a site.(*17) The dialogue lasted until early 2010, after which the NWMO began with the search for a final repository on 4 June 2010. According to the NWMO it is about an underground disposal facility at 500 meters depth in a rock formation, located in an informed and willing community, securing economic benefits for the residents and to “build confidence that the program is being carried out fairly and the end result will be safe.”(*18) According to a November 13, 2009 NWMO-document, the geological facility for disposal of spent fuel will not come into operation before 2035, at the earliest.(*19)

Sofar (January 2012) nine communities, scattered across Saskatchewan and Ontario, have volunteered to host the country’s spent fuel. The towns are a combination of native reserves, old mining and lumber towns and cottage enclaves. Many have spent the past decade watching their populations shrink and economies crater, and are desperate for an economic boost - even if it is deep geological disposal of nuclear waste for eternity.(*20)

CHINA

In China, there are two storage facilities for intermediate-level waste and a centralized facility for high-level waste. A geological disposal repository for high-level waste will start operation in 2050 at the earliest.

Nr. of reactors	first grid connection	% of total electricity
16	1991-12-15	1.85%

Reprocessing
When China started to develop nuclear power, a 'closed fuel cycle' strategy was formulated and declared at an International Atomic Energy Agency conference in 1987: at-reactor storage; away-from-reactor storage; and reprocessing. China National Nuclear Corporation (CNNC) has drafted a state regulation on civil spent fuel treatment as the basis for a long-term government program. There is a levy of Chinese Yuon 2.6 cents/kWh on used fuel, to pay for its management, reprocessing, and the eventual disposal of HLW.(*01)

China began construction of a multi-purpose reprocessing pilot plant at Lanzhou nuclear complex in July 1997. This project was approved in July 1986 and began receiving spent fuels from Daya Bay reactors in September 2004. The plant is fully operational.
Moreover, a commercial reprocessing plant (800 tHM/a) is planned to be in commission around 2020 at the Lanzhou Nuclear Complex, and site selection has already begun.(*02) However, as of December 2009, no final agreement had been reached between China and France on the transfer of the relevant technologies; the plant construction appears to remain on hold.(*03)

Interim storage and final disposal
In the 1980’s, radioactive waste disposal work was initiated in China. The former Ministry of Nuclear Industry (MNI) subsidiary Science and Technology Committee set up a panel of radioactive waste treatment and disposal. The siting of solid LILW disposal site began in the 1980’s and was implemented under the auspice of the former Ministry of Nuclear Industry. Industrial-scale disposal of low- and intermediate-level wastes is at two sites, near Yumen in northwest Gansu province, and at the Beilong repository in Guangdong province, near the Daya Bay nuclear plant. These are the first two of five planned regional low- and intermediate-level waste disposal facilities.(*04)

A centralized used fuel storage facility has been built at Lanzhou Nuclear Fuel Complex, 25 km northeast of Lanzhou in central Gansu province. The initial stage of that project has a storage capacity of 550 tons and could be doubled. (*05) However, most used fuel is stored at reactor sites. New Chinese plant designs include on-site spent fuel storage with a capacity of 20 years worth of spent fuel.(*06)
Although most of China’s nuclear power plants are located in the more populated eastern regions, storage facilities are located in the far west. This policy is likely aimed at avoiding local opposition to locating these facilities near populated areas, signaling at least a marginal impact that public opinion might have on Chinese policies.
However, as one Chinese nuclear expert observed, unlike democratic systems where public opinion holds significant sway, the decision of the Chinese government is really “the only decisive factor for spent fuel management in China.”(*07) Since 2003, the spent fuel from two nuclear power plants in the southeastern province of Guangdong has been shipped to the Gansu facility – a distance of about 4000 kilometers. This is consistent with CNNC policy to ship spent fuel by rail to centralized storage facilities for interim storage and reprocessing.(*08)

In 1985, CNNC worked out an R&D program for the deep geological disposal of high/level waste. The preliminary repository concept is a shaft-tunnel model, located in saturated zones in granite.(*09)
Site selection and evaluation has been under way since then and is focused on three candidate locations in the Beishan area of Gansu province and will be completed by 2020. All are in granite. An underground research laboratory will then be built 2015-20 and operate for 20 years. The third step is to construct the final repository from 2040 and to carry out demonstration disposal. Acceptance of high-level wastes into a national repository is anticipated from 2050.(*10)

The regulatory authorities of high-level radioactive waste disposal projects are Ministry of Environmental Protection (MEP) and the National Nuclear Safety Administration (NNSA). The China Atomic Energy Agency (CAEA) is in charge of the project control and financial management. CNNC deals with implementation, and four CNNC subsidiaries are key players: Beijing Research Institute of Uranium Geology (BRIUG) handles site investigation and evaluation, engineered barrier study and performance analyses, with the China Institute of Atomic Energy (CIAE) undertaking radionuclide migration studies. The China Institute for Radiation Protection (CIRP) is responsible for safety assessment, and the China Nuclear Power Engineering Company (CNPE) works on engineering design.(*11)

CZECH REPUBLIC

Nr. of reactors	first grid connection	% of total electricity
6	1985-02-24	32.86%

State-owned utility CEZ is fully responsible for storage and management of its spent fuel until it is handed over to the state organization SURAO (RAWRA in English: Radioactive Waste Repository Authority), founded on 1 June 1997.(*01) Eventual provision of a high-level waste repository is the responsibility of RAWRA. Most of low and intermediate level waste is stored on site or moved to the near-surface repository in operation at Dukovany.(*02)

Long-term interim storage
The concept preferred at the moment is the long-term interim storage of spent fuel in container interim storage facilities at the sites of the nuclear power plants at Temelin and Dukovany. Problem concerning this is that the spent fuel must be stored in an interim storage facility for a very long period of time, because the final disposal in a repository is only planned after 2065. The condition of the nuclear waste or the level of the hazard potential of the waste at that stage is unforeseeable.(*03)

In agreement with the Policy for radioactive waste and spent fuel management of 2002 the Czech Republic anticipates to develop a national deep geological repository in magmatic crystallytic rocks (granites or homogenous gneiss massifs) after 2050 and it should start operation in 2065.
The program of the repository development started back in 1992 (in the first year jointly with the Slovak Republic). Thirty potential locations were gradually identified, of which 12 potential locations were selected with varied geological conditions and diverse host rocks. The first geological survey was performed on six locations with granitic massifs in 2003 – 2005, without utilization of surface survey methods, and areas were selected for future prospecting stage of the geological survey. The works were suspended in 2005 due to public resistance.(*04) On 17 December 2009 *"as a gesture of goodwill"*, RAWRA announced that it will make it possible for communities to claim a financial compensation for geological research work of potentially CZK 100 million in total.(*05)
On November 25, 2010 a working group for dialogue was established to *"strengthen the transparency of the process of selection a suitable site for a deep geological repository of spent nuclear fuel and high level waste, with respect to the public interests and to facilitate the active participation of the public and the communities in particular in the related decision-making process."*(*06)

Based on results of the completed stage of negotiations with the general public the Administration anticipates the start of surveying works start gradually after "negotiations with the general public are completed" and *"only if the affected municipalities get involved on a voluntary basis in the selection process of the future deep geological repository location."*(*07) One possible site is at Skalka in southern Moravia. In the late 1990s, this site was considered for a centralized used fuel interim storage facility as an alternative to the Temelin storage facility and to the storage capacity expansion at Dukovany (beyond the 600 t facility).(*08)

FINLAND

Nr. of reactors	first grid connection	% of total electricity
4	1977-02-08	31.58%

In 1994, the Nuclear Energy Act came into force, according to which all nuclear waste must be treated, stored and disposed of in Finland. Before that some of the spent fuel was sent to Russia.(*01) Posiva Oy is responsible for the final disposal of spent nuclear fuel. It is established in 1995 by TVO and Fortum, two owners of nuclear power plants.(*02) Storage of spent fuel takes place on site until the final repository is finished. Finland hopes to begin with final disposal in granite around 2020-2025.

Onkalo
Preparations for the disposal of high level radioactive waste began in the late 1970s.(*03) In 1985, 102 potential sites were listed and in 1987 reduced to five for further research. This resulted in detailed site investigation at four sites from 1992 on, two of them at the Loviisa and Olkiluoto nuclear power plants. For all sites an environmental impact assessment was carried out and in May 1999, Posiva Oy proposed for a permit for the disposal at Olkiluoto in the municipality of Eurajoki. Local consent was highest in Olkiluoto and Loviisa, but at Olkiluoto a larger area was reserved for the repository and a larger part of the spent fuel was already stored there.
In January 2000 the town council of Eurajoki accepted the repository, followed by approval by the government and parliament in May 2001. In Finland the same disposal concept is applied as in Sweden.(*04) The construction application will be submitted in 2012, and operating license application in 2018. Posiva Oy expects that the first cannisters will go down in 2020 and final disposal will end in 2112. Around 2120, the repository is finally closed and sealed.(*05)
Construction of an underground rock characterization facility (called Onkalo) started in 2004. This will later become (part of) the final repository.(*06)

In May 2010 it was found that the time schedule might not be met. The Finnish TV showed that there is still much research to be done before the application for the permit (scheduled end of 2012) can take place. The Director of the Research Department of Posiva Oy, Juhani Vira, stated his willingness to request the permit at a later date.(*07)
However, in the planned facility will not have enough space for the spent fuel from the already approved nuclear reactor at Pyhäjoki. In October 2011, TVO and Fortum stated that the repository could not safely be expanded to accommodate used fuel from Fennovoima's planned plant.(*08) In March 2012, despite pressure from the government to make a deal, Posiva Oy maintains that it could not be extended any further without compromising its long-term safety.(*09)

Because Finland has the same disposal concept as Sweden, there is the same criticism on the stability of the granite and on the use of copper. Dr. Johan Swahn, Director of the Swedish NGO office for nuclear waste review, wrote in December 2009: *"There is no way that anyone can honestly claim that Posiva has a completed robust safety case. The Posiva safety* *case has not been developed independently, but relies entirely on the Swedish safety case work. The final test of the Swedish safety case will not be done until the Swedish Radiation Safety Authority gives an approval of the safety analysis…This will not be the case before 2013-2014." "Already now there is concern from the authority about the barrier systems of copper and clay. It is not clear if all relevant copper corrosion processes are known and the risk for clay erosion is still not understood. So an approval is not at all certain. And nothing can today be claimed to be robust.*"(*10)

In 2010, the Swedish geologist Nils-Axel Mörner noted that there are many horizontal and vertical fractures around the planned repository. According to Mörner the safety is therefore not proven.(*11)
Geology Professor Matti Saarnisto, former Secretary-General of the Finnish Academy of Science and Letters, told in June 2010 Parliament that *"an exaggeratedly positive image has been presented of the integrity of the structure of Olkiluoto's bedrock".* He warns that a honeycomb of storage sites extending over an area of several square kilometres will weaken the bedrock, making it vulnerable to earthquakes, and that during an ice age permafrost could spread deep into the rock, potentially rupturing the canisters and releasing radioactivity into the groundwater.(*12)

"The matter of fact is that to some extent all of the research institutes involved are suffering from a hostage syndrome. They see it as essential that spent fuel be disposed of at Olkiluoto, because it has been planned that way for decades. There is no scientific basis for it," Saarnisto said in 2009.(*13)

FRANCE

Nr. of reactors	first grid connection	% of total electricity
58	1959-04-22	77.71%

As in almost all countries, in France, the storage of radioactive waste is controversial. Pressure groups believe the storage of high-level radioactive waste in clay, planned at Bure from 2025 at the earliest, is in violation of the legislation of the government, because there is only one underground laboratory and a 1991 law requires at least two. All spent fuel is reprocessed in La Hague. France dumped low- and intermediate level waste in sea twice, from 1967-1969.(*01)

LLW
Low-level radioactive waste was stored at the above-ground site CSM (Centre de Stockage de la Manche) from 1969 till 1994. In 1996, the government-appointed commission 'Turpin' concluded that the site also contains long-living and higher radioactive waste and that the inventory was not exactly known. The commission also found that radioactivity from the site is leaking into the environment. It however concluded that dismantling and reconditioning the waste would cost too much and might generate a significant risk to the workers involved.(*02)

ANDRA is currently operating two disposal facilities: one for short-lived low-level and intermediate-level waste (CSFMA) and the other for very-low-level waste (CSTFA), both situated in the Aube district.(*03)

The 2006 Planning Act calls for the commissioning by 2013 of a storage facility for low-level long-lived wastes. The opening of this new sub-surface (15 m to 100 m depth) facility has been seriously delayed, to at least 2019, by massive protests in the areas considered as possible sites. ANDRA launched a public call to 3,115 communities in 2008 for volunteers to host the facility. Forty-one applied for consideration and, in June 2009, the government selected two small villages both in the Aube department that already houses the two operating disposal facilities for short-lived wastes. But both communities withdrew "under the pressure of the opponents."(*04)
Currently, the project is suspended and ANDRA and the government are looking for a new approach. Pending the creation of a suitable disposal facility, existing LLW-LL waste is stored at the production sites or in facilities which have traditionally used radioactive applications.

ILW-LL and HLW
Pending the commissioning of a deep repository, intermediate-level, long-lived waste (ILW-LL) and high-level waste is stored at their production sites, mainly La Hague, Marcoule and Cadarache.

In 1979, the French National Radioactive Waste Management Agency ANDRA was established to manage and provide storage of nuclear waste. From 1987 to 1990 field study was conducted but protest against four test drilling forced the government to stop research and develop new policy.(*05) In 1991 parliament passed the Nuclear Waste Act, which regulated the new policy. The law is meant as a legal instrument for the creation of underground research laboratories, where studies will be conducted in potential host formations, at least at two locations and a best site will be chosen in 2006. It clearly prohibits the actual storage of nuclear waste in these laboratories. For this a new law had to be adopted after 2006.(*06)

Shortly thereafter ANDRA began with research in three new locations, which met fierce resistance. The French government stopped the investigation and wanted to consult the population. The government contracted for this reference Christian Bataille, then a member of parliament and undisguised supporter of nuclear power.(*07) In his search for a department that wanted to host an underground laboratory he spoke with people from different locations, elected officials and associations, but that did not lead to a broad support. Sometimes the disposal plans caused big splits in small local communities. In 1994, this disagreement was the reason why the mayor Michel Faudry from the potential host community Chatain in the department of Vienne committed suicide.(*08)
On January 6 1994, after the consultations Bataille chose three candidate departments for the underground high-level waste laboratories: Meuse, Gard, Haute-Marne and Vienne. Whether that laboratory is converted into a HLW-repository is a choice that will be made later. If a permit for the construction of an underground lab is given, the host community receives a compensation of €10 million per year during construction and operation of the laboratory.(*09)

Local groups were very dissatisfied with the state of affairs. In December 1997, the Conseil d'Etat rejected a complaint laid down in 1994 by residents of Meuse and Vienne on the Bataille mission. They stated that there had never been a real involvement of the affected population, as required by law. With this decision the Conseil d'Etat did not follow the advice of the so-called government commissioner, who agreed with the plaintiffs.(*10) Elected officials near Bure organized a nation-wide committee of elected officials opposed to underground labs.(*11) Associations of winegrowers in several area's (Cotes-du-Rhone and Roussillon) fear that their sales market will collapse if a nuclear waste repository is constructed in their neighborhood.(*12)

In 1997, in response to the protests, the French government decided to commission the National Assessment Commission (CNE) to study retrievability.(*13) CNE, a group that reviews progress on HLW management for government and parliament, published its report 'Thoughts on retrievability' in June 1998. CNE proposes retrievable storage (for TRU waste: non-heat-generating transuranic wastes) be licensed for relatively short periods – 50 years - to ensure that a decision must be taken on a regular base on whether or not the facility should be kept open. It also recommends long-term interim storage for spent fuel on the grounds that the fuel contains valuable energy products.(*14) In August 1999, the government authorized ANDRA to start work on an underground waste lab in a clay formation in Bure and to begin the process of finding a second site in granite. The Bure license would expire at 31 December 2006 by which time the parliament has to decide whether to transform the Bure site into a repository.(*15)

In December 1998 the departments Gard en Vienne were considered unsuitable because of geological reasons. The French government okay'd the waste lab at Bure in clay, but called for a new granite site.(*16)

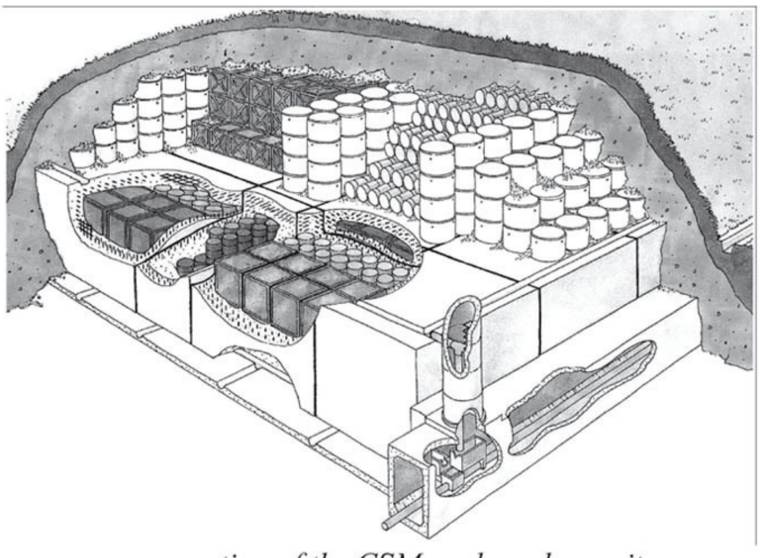
Before the end of 2006 the government had to find a way out of a tough situation. The Nuclear Waste Act from 1991 required that at least two research laboratories should have been established, from which - following similar research - a choice had to be made. But there is only one underground laboratory: Bure.

Many environmental groups think that the government and ANDRA therefor do not comply with the law. In a December 2009 email Markus Pflüger of the anti-nuclear group Stop Bure in Trier (Germany) emphasized that again.(*17) But he also points at the fact that geological fault lines in the subsurface of Bure are denied by ANDRA: and, according to Pflüger, these fault lines are definitely a safety risk.

In June 2006 Planning Act was published.(*18) Besides 'optimizing repository concepts' and complete experimental program with technological demonstrations, it states that all operators of nuclear installations must estimate the future costs for the management of their spent fuel, decommissioning operations and the management of radioactive waste, and must allocate *“the required assets to the coverage of those provisions.”*
Commercial reprocessing, although originally introduced to obtain plutonium fuel for starting up fast-neutron reactors, is now clearly established as the national policy for spent-fuel management. A disposal facility for long-lived intermediate and high-level wastes is required to be in operation by 2025. No license shall be granted, however, *“if the reversibility of such a facility is not guaranteed.”* While the conditions of reversibility will be defined in a subsequent law, its minimum duration is one hundred years.

The license for the underground research laboratory in Bure (officially called LSMHM URL, often Bure is not even referred to) was initially until the end of 2006, but was extended on 23 December 2006 by the Government until the end of 2011. Therefore ANDRA has filed an application to renew it until 2030. The public inquiry was held from October 26 to November 30 and the licensing decree was granted on December 20, 2011.(*19) By making retrievability compulsory and to commission longer research, the French Government is circumventing the 1991 Nuclear Waste Act.

In early 2012 ANDRA signed a six-year contract with Gaiya as main contractor to project manage the conceptual and front-end phases of the *Centre Industriel de Stockage Géologique* project, dubbed “Cigeo”. The first conceptual study phase is to be conducted in 2012 and will lead on to a public consultation that will take place in 2013. The storage facility will be developed on a depth of 500 meters, and will exploit the properties of the Bure clay formation as a *“geologic barrier to prevent any potential spread of radioactivity”.* Although Cigeo will be designed to accommodate the wastes permanently, French law requires that storage can be reversible for at least 100 years.(*20)



cross-section of the CSM nuclear dump site

GERMANY

Nr. of reactors	first grid connection	% of total electricity
9	1961-06-17	17.79%

In Germany spent fuel removed from reactors untill 2005 is reprocessed. In the 2002 phase-out law, reprocessing is forbidden from 2005 on.(*01) Interim storage of reprocessing waste takes place at Gorleben. Interim storage of spent fuel takes place at Ahaus and on site.
Underground storage facilities are (planned) at Asse, Schacht Konrad, Morsleben and Gorleben. There are many low- and intermediate level waste storage facilities, some undergound (Morsleben, Asse), some on site (Karlsruhe, Mitterteich, Juelich, Greisfswald).(*02) (West-) Germany once dumped low- and intermediate level nuclear waste in the Atlantic Ocean, in 1967.(*03)

The experience with storage of nuclear waste in salt domes are dramatically bad. In Germany two salt domes with radioactive waste threaten to collapse. The cost to isolate the salt domes as well as possible, amounts € 6.1 billion. The planned storage in Gorleben, on which € 1.5 billion has been spent, has been controversial and will not begin before 2035, at the earliest.

1. The Asse salt dome
The Research Mine Asse II salt dome is situated in the state of Lower Saxony. From 1967 till 1978 about 125,000 barrels (or drums) of low-level and 1,300 barrels of intermediate-level radioactive waste have been stored there, for research purposes. The low-level radioactive waste is located in 12 caverns at 725 and 750 meters depth, the medium-level waste in one storage room at 511 m depth.(*04) Around 1970 it was the intention to store also high-level waste in the salt dome.(*05) This plan was a key reason for the Dutch government to opt for high-level waste disposal in salt domes; there were even Dutch experiments in Asse.(*06) However; there never has been high-level waste stored at Asse.

According to an information brochure from the GSF in April 1973: „The mine buildings would remain stable in case of flooding". "The shaft Asse II is currently completely dry and leakproof. The possibility of flooding through the shaft into the mine buildings is therefore excluded." Now for over 20 years around 12,000 liters of water per day flows into the salt dome. The formed brine has affected the waste drums, resulting in leakage of radioactivity.(*07) In 2009 at 700 meters depth radioactive cesium-137 has been found and it become known that already in 1988 cesium, tritium, strontium-90 and cobalt-60 has been measured in salt brine.(*08)
So, although it as claimed in the early 1970s that disposal at Asse would be secure for thousands of years, it turns out there is water influx after 15 years and radioactivity is leaking after 40 years

This is an even bigger problem because in late August 2009 it was disclosed that there is not 9.6 but an amount of 28 kilograms of plutonium present in (mostly the LLW) in Asse. (*09) Ten days earlier, on August 19, the former German Environment Minister, Sigmar Gabriel, said on the TV-program "Hartaberfair" of the public German television (Erstes Deutsches Fernsehen),(*10) that the safe closure of Asse will cost between €2 and €4 billion, the nuclear industry has paid €450,000 for the storage, the taxpayer will foot the rest of the bill. According to the Federal Office for Radiation Protection (BfS) on 2009, cracks have emerged because corridors and caverns remained open for a long time, which caused instability and therefore insecurity in the salt dome.(*11)

On 3 September 2009 the Federal Office for Radiation Protection (BfS) said that it is unclear how long it takes before the shafts are no longer accessible and that therefore urgent measures are needed.(*12) Merkel's government agrees with that. On 15 January 2010 the BfS announces that all barrels must be excavated.(*13) According to the German environment minister Norbert Röttgen (CDU) retrieving the low-level waste is expected to cost €3.7 billion,(*14) with a further €200 million for the disposal of the intermediate level waste.(*15)
In May 2010 Röttgen called Asse "*an example of a collective political failure, a failure independent of political parties*". He first wants to open at least two storage chambers to investigate the condition of the barrels.(*16)

In February 2011, Dr. Heinz Geiser, the manager of the Gesellschaft für Nuklearservice (GNS), stated that for the barrels that are recovered to the surface a building has to be realized with a storage capacity of 275,000 m3. To avoid additional transports he says the facility has to be built near Asse.(*17)
End May it is published that Bfs has been granted a permit has to retrieve the radioactive waste.(*18)
The 100 page permit consists of 32 requirements BfS has to meet. If these requirements are met, exploration of two storage rooms with nuclear waste, rooms 7 and 12, can start. It will begin with drillings into these two storage rooms to get an impression of the state of the nuclear waste and the storage rooms itself. Cameras have to shed some light on the state of the barrels. Measuring equipment must give information about the air quality in those rooms, which include possibly a concentration of flammable or explosive gas, and high levels of at least tritium and radon are expected. BfS will then analyze the results of the measurements and observations. If this assessment is positive, then both chambers at 750 meters depth will be opened. The next step is the recovery of the waste drums.(*19)

But much more has to be done. For example: the retrieval of the nuclear waste must comply with the requirements of the Nuclear Energy Act. Therefore, the existing shaft has to be made safer. But there is still a risk that the salt dome is filled with water. Therefore, the storage mine has to be stabilized. If water flows in uncontrolled, emergency measures have to take into effect. These include methods to close the storage rooms and the shafts quickly and to spray magnesium chloride in the storage mine. With this, BfS wants to ensure that as little as possible radioactive substances can be released when the mine is filled with water.
Because the existing shaft is not suitable for the recovery because of the limited capacity, a new shaft has to be constructed to retrieve the barrels in a safer and faster way to the surface.(*20)

The excavated drums are temporarily stored above ground in a building, but there is still no decision on where that storage building has to come. Then the drums have to be stored somewhere permanently. But also the final destination is unknown.(*21) Although still far from clear what will happen exactly, all stakeholders are convinced that they are dealing with something unique. Retrieval of drums with nuclear waste from a geological repository has happened nowhere in the world.(*22) In December 2011 it became known that BfS-experts think that already within a year much water can come in the salt dome, which would make the retrieval of nuclear waste no longer feasible.(*23,24) This message caused much anxiety among the population and politicians. The state secretary of Environment, Ursula Heinen-Esser, declared on 8 February 2012 to stick to the excavation of all barrels,(*25) and added on 13 February 2012 that the excavation can take as much as forty years instead of the planned ten years.(*26) Wolfram König, director of the BfS, while thinking that excavation of all drums is necessary, also said in early February 2012: "*The history of Asse is a prime example of how a safe disposal of nuclear waste must not be carried out. In this textbook case is written that there is relied too much on technical solutions and there was paid too little attention to the limits of knowledge and the taking of responsibility.*"(*27)

2. The Morsleben salt dome

The (former East-) German salt dome Morsleben is a final disposal mine for low and medium level radioactive waste. The intention is to fill and close the salt dome. That will costs €2.2 billion public money.(*28) In the mine in Saxony-Anhalt are stored 37,000 m3 of low and medium level waste and 6,700 used radiation sources.

In 2000, because the salt dome threatened to be filled with water and to collapse, the German government stopped with the disposal in Morsleben. In March 2003, it was decided to fill as soon as possible 670,000 m3 of storage room of the salt dome with a mixture of salt, coal ash, cement and water. This mixture is called salt concrete. In order to cover the radioactive waste safely forever from environmental influences, a total of 4 million cubic meters must be filled. The BfS estimates that, when a license is obtained, a period of 15 years is required for filling and final closure of the salt dome. On 27 August 2009 it was found that thousands of tons of salt can fall down from the ceiling of storage rooms.(*29)

3. The Gorleben salt dome

The most important salt dome in Germany is the one in Gorleben. Since 1977 research takes place in and around the salt dome, with total costs (in 2008) of €1.5 billion.(*30) It remains unclear, however, why Gorleben has been chosen on the first place: on 30 January 2010 it was announced that Gorleben initially was not found on the list of possible salt domes.(*31) As a large number of reports from the 1970s are now public, it is possible to try to reconstruct the decision-making process. In a May 2010 study of the historian Anselm Tiggemann it is revealed that although Gorleben was on top of a 1975/6 list of 20 possible locations. In 1976, the choice fell however, on the salt domes Wahn, Lutterloh and Lichtenhorst. After much opposition against research at these locations the choice fell on Gorleben, but without any collection of data to compare Gorleben with other salt domes. That feeds, according to Tiggeman, the idea that political motives have played a role.(*32) On 10 June 2010, in an advice to the Parliament, Jürgen Kreusch wrote(*33) that little was known about Gorleben in 1977, and it is hard to understand why the choice fell on Gorleben.

Gorleben is the world's model for storage in salt domes. But already in 1977, in a large-scale study, it was discovered that the salt dome is in contact with groundwater. And the German geologists Detlef Appel and Jürgen Kreusch demonstrate in their November 2006 report that the covering layer above the salt in an area of 7.5 square kilometers is missing.(*34) With that the dome doesn't meet a central requirement for suitability.

At least since 26 August 2009, the then German Environment Minister Sigmar Gabriel thinks the salt dome is unsuitable for storage of radioactive waste, because of safety reasons.(*35) Those risks were already known 25 years ago, but research reports about that have not been published until recently. Besides all this, treaties with landowners, including the land where the salt dome lies, expire in 2015. According to the Mining Act, the construction of the disposal mine has to stop then.

In the 26 October 2009 CDU-CSU-FDP coalition agreement, the new government declared that it want to lift the year 2000 moratorium for further research. It states the research must be transparent and not anticipate a specific result. Also, the region must be compensated for the fact that the disposal is of national importance.(*36)

In December 2011 the Federal Government and the governments of the states decided that a comparative study into final disposal sites should take place and legislation should be made in 2012. According to the agreement a number of locations have to be selected in 2014, where research will be done until late 2019 leading to a final selection. From 2019 on underground research will take place, followed by authorization and commissioning from 2035.(*37)

Then a debate emerged about whether Gorleben still qualifies as a repository.(*38) Environment Minister Norbert Röttgen (CDU) is sticking to Gorleben and in a March 1, 2012 meeting of Federal and state environment ministers no agreement could be reached on this. But the ministers decided that attention should be given to education of the population at the possible disposal sites: information centers will be opened and discussion meetings with the population will be held.(*39) The local and regional groups are disagreeing and claim there are already more than enough arguments to remove Gorleben from the list.(*40)

Then, on March 2012, the government decided to stop research at Gorleben for a number of years and first investigate other locations.(*41) For the Greens, the Social Democrats and even part of the Christian Democrats, this decision is not enough: they want a 'blank map" to start with: Gorleben should be abandoned as disposal site.

HUNGARY

Nr. of reactors	first grid connection	% of total electricity
4	1983-12-28	43.25%

PURAM, the Public Agency for Radioactive Waste Management, is a 100% state owned company responsible for the management of radioactive waste, and was established on 2 June 1998 by the Hungarian Atomic Energy Authority.(*01)

The strategy on low and intermediate level waste disposal is burying in cemented form in steel drums in a shallow-ground disposal site, maintained for 600 years. Since 1986, ILW/LLW from the Paks nuclear power station has been stored at Paks, due to public opposition to its continued burial at the existing disposal site at Puspokszilagy. Public opposition also prevented disposal of Paks-generated waste at the alternative site at Ofalu. Until this situation is resolved, the waste is stored on site at Paks.(*02) In October 2008, a final surface storage facility was inaugerated at Bataapati and construction begun on underground disposal vaults. Bataapati, was selected from some 300 potential locations after a 15-year selection and development process. Final approval was given by parliament in 2005.(*03) The construction of the underground caverns has not been finished, but some low-level waste is stored on surface facilities.(04)

Final geological disposal
Awaiting a final disposal facility spent fuel is stored on site at the ISFSF (Interim Spent Fuel Storage Facility) for a period of 50 years.(*05)

The exploration program to find a final disposal repository for high level wastes was launched at the end of 1993, with the investigation of the Boda region. Although this program outlined long-term ideas, it mainly focused on the in-situ site investigations carried out by the Mecsek Ore Mining Company in the area of the Boda Claystone Formation at 1100 m depth (accessible from the former uranium mine) during 1996-98. The program was limited to three years because of the closure of the mine in 1998; the reason for this was that the existing infrastructure of the mine could be economically utilised only during this time period.(*06) It was stated in the final report, that there was no condition which could be used as argument against the disposal of high level wastes in the Boday claystone formations. PURAM launched a countrywide geological screening program in 2000, and it was concluded that the Boda Aleurolit Formation had proven to be the most promising host rock for the high level waste repository. But due to financial restraints most of the research stopped in the years after. A revised schedules foresees in developing criteria for site selection un till 2015; completion of safety assessments (2030); construction of an underground lab (in 2038) and must result in commissioning of a geological repository in 2064.(*07)

INDIA

Nr. of reactors	first grid connection	% of total electricity
20	1969-04-01	3.68%

The Atomic Energy Commission (AEC) was established in 1948 under the Atomic Energy Act as a policy body. Then in 1954 the Department of Atomic Energy (DAE) was set up to encompass research, technology development and commercial reactor operation. The current Atomic Energy Act is from 1962, and it permits only government-owned enterprises to be involved in nuclear power.(*01)

In the context of India's nuclear fuel cycle, spent fuel is not considered waste but a resource. The spent fuel is temporarily stored on site, before transported for reprocessing. A three-step strategy for high-level waste has been established: immobilization, interim retrievable storage of conditioned waste and disposal in deep geological formations. According to the national policy, each nuclear facility has its own near-surface disposal facility for low and intermediate-level waste. Currently there are seven NSDFs in operation.(*02)

Radioactive wastes from the nuclear reactors and reprocessing plants are treated and stored at each site. Waste immobilization (vitrification) plants are in operation at Tarapur and Trombay and another is being constructed at Kalpakkam. The Tarapur facility consists of an underground hydraulic vault, which in turn houses two more vaults, which can store about 1700 casks for 20-30 years before they are planned to be transported to a deep geological repository.(*03)

Reprocessing
Research on final disposal of high-level and long-lived wastes in a geological repository is in progress at Bhabha Atomic Research Centre (BARC) at Trombay.(*04)

Amid concerns over waste management at the proposed nuclear power plant at Jaitapur in Maharashtra, Environment Minister Jairam Ramesh in January 2011 said it was not an immediate problem for India and lamented a lack of balanced environmental approach towards nuclear energy. "*This discussion has come at a time when there had been a lot of concern about Jaitapur. A lot of concern has been raised about waste management...today, we don't have a waste management problem. We will have it by the year 2020-2030,*" Ramesh said.(*05)

A program for development of a geological repository for vitrified high level long lived wastes is being pursued actively, involving In situ experiments, site selection, characterization and laboratory investigations. For assessment of the rock mass response to thermal load from disposed waste overpack, an experiment of 8-years duration was carried out at a depth of 1000 m in an abandoned section of Kolar Gold mine. (*06)

The Department of Atomic Energy will set up an underground laboratory in one of its uranium mines to study qualities of the rock at the mine bottom to decide whether it can be used to store nuclear waste. "*We are looking for a rock formation that is geologically stable, totally impervious and without any fissures,*" Atomic Energy Commission chairman Srikumar Banerjee told reporters in Delhi.(*07)
Over the next five years, scientists are going to study a set of physical and geological parameters required for setting up the deep geological disposal facility before zeroing in on its location. The options vary from underground storage in rocky central India to plains where the storage may be housed inside layers of clay. The proposed repository will have large chambers with adequate shielding where nuclear waste from all over the country will be transported periodically. There would be also automatic heat management and radioactivity monitoring.(*08) There is no planned date for a final repository coming into operation.

IRAN

Nr. of reactors	first grid connection	% of total electricity
1	2011-109-03	0.04%

The nuclear industry is relatively young in Iran. Most activities, up to now, have been focused on the research and production of radioisotopes for research, medical and industrial uses. Recently, due to the planning and construction of the Bushehr nuclear power plant, Iran is investing heavily in developing its fuel cycle facilities. The Atomic Energy Organisation of Iran (AEOI) oversees uranium milling and mining at Saghand, yellowcake production at Ardakan, conversion at Esfahan, enrichment at Natanz, fuel fabrication at Esfahan, and an interim waste facility at Anarak. The AEOI also oversees the nuclear research centers.(*01)

There are a few known waste storage facilities, but only very limited knowledge about scope and capacity. The IAEA learned of the Karaj radioactive waste storage facility in 2003. In the same year, Iran shipped dismantled equipment used in laser enrichment experiments and materials resulting from uranium conversion experiments to the site, where IAEA inspectors viewed them in October 2003. Environmental samples taken by the IAEA at the site in 2005 revealed traces of highly enriched uranium on a container. In response, Iran declared that the traces originated from leaking reactor fuel assemblies at the Tehran Research Reactor. After further investigating the issue, the IAEA concluded that "the statements of Iran are not inconsistent with the Agency's findings, and now considers this issue as resolved."
Anarak is also a nuclear waste disposal site. Iran told the IAEA in 2003 that waste resulting from the experiments irradiating UO-2 targets and separating the plutonium at JHL nuclear center was solidified and sent to Anarak.(02)

In February 2005, Iran agreed to repatriate Bushehrs spent fuel to Russia and thus significantly reduced the risk of nuclear proliferation (and the need for spent fuel disposal), and Russia has a deal with Iran to provide nuclear fuel for the first 10 years to the Bushehr power plant.(*03)

ITALY

Nr. of reactors	first grid connection	% of total electricity
0	1963-15-12	0.00%

The 8 November 1987 Italian referendum on nuclear power was launched after the April 1986 Chernobyl accident by the Green Party. A majority voted against nuclear power. (*01) Subsequently, the government decided in 1988 to phase out existing plants 1990.(*02) The main national operator entitled to perform spent fuel, radioactive waste and decommissioning activities is Sogin (Società Gestione Impianti Nucleari).(*03)

A quest to find host communities for national sites to build repositories for the disposal of low and intermediate level and of high level waste met strong local and national opposition and no site was selected.(*04) A new procedure national repository for the LLW disposal was established in 2008. Sogin will make a list of suitable regions, and if no community volunteers, Sogin will submit the list to the Ministry of Economic Development indicating the first three more suitable sites. Within 30 days an inter-institutional Committee will be created, with the participation of representatives from different Ministries and Regions. However, the time schedule (site selection in 2012) has been postponed.(*05)

Reprocessing
Since the beginning of its nuclear program, Italy had pursued the option to reprocess abroad the spent fuel. After the political decision to stop all nuclear power activities, the policy of reprocessing abandoned, even though the last shipment took place in 2005 as closure of the service agreements signed in the past. As far as the spent fuel still present in Italy, in 1999 the option of on-site dry storage was initially selected , this was difficult to implement due to the strong opposition of local communities, who considered the presence of the dry stored spent fuel as an obstacle for the release of the site. So the option to reprocess was reopened and in November 2006 an agreement with the French government, regulating the transfer to France of spent fuel, was signed and in April 2007, Sogin signed a contract with Areva. The first shipment of spent fuel to France took place in December 2007 and shipping the waste has to be completed in 2012. All reprocessing waste is scheduled to return in 2025 at the latest.

Waiting for the availability of the national storage site, the waste will continue to be stored on site. In most nuclear installations new temporary storage facilities have been constructed or are under design or construction. In some cases the refurbishing of existing buildings has been considered. (*06)

In 2010, Sogin was selected as the organization responsible for the identification of the national site and the construction of the high-level radioactive waste repository (surface and reversible). Within the same decree is laid out the siting procedure for the repository, which, in an attempt to soften opposition in possible host communities, will be part of a technology park including a center of Excellence for research and training in the field of decommissioning and radioprotection.(*07)

From 2009 on, the Italian Government, with the aim to restart a new nuclear program, established the necessary legislative provisions. But another popular referendum (launched before the March 2012 Fukushima accident) on 12 June 2011 abandoned the new nuclear program in Italy again.(*08)

JAPAN

Nr. of reactors	first grid connection	% of total electricity
50	1970-11-17	18.14%

In Japan the Nuclear Waste Management Organization (NUMO) was set up in October 2000.
The country has interim storage facilities for all waste classifications at or near the Rokkasho-mura reprocessing plant. A final disposal facility is expected to be in operation at 2035. The waste management strategy is reprocessing of all spent fuel: first in Europe, and then domestic at Rokkasho. Japan dumped low-level waste in the Pacific Ocean in 12 dumping operations between 1955 and 1969.(*01)

The Ministry of Economy, Trade and Industry (METI) is seeking permission from the Aomori prefecture to build a low-level waste storage facility at Rokkasho, adjacent to the reprocessing plant. In particular this will be for LLW and what is internationally designated as ILW returned from France from 2013. NISA recommended approval early in 2012 to increase capacity to 2000 drums (200-liter).(*02)

Interim storage & reprocessing
In 1995, Japan's first high-level waste interim storage facility opened in Rokkasho-mura - the Vitrified Waste Storage Center. The first shipment of vitrified HLW from Europe (from the reprocessing of Japanese fuel) also arrived in that year. The last of twelve shipments from France was in 2007, making a total of 1310 canisters. The first shipments from UK arrived in March 2010, with 1850 canisters to go in about 11 shipments in the coming decade.(*03)

In 2005 the utilities Tepco and JAPC announced that a Recyclable Fuel Storage Center would be established in Mutsu City.The application was licensed in May 2010. Application for the design and construction approval was submitted to the Minister of METI in June 2010, and it was approved in August 2010, and the construction work started. The center will store spent fuel generated from Boiling Water Reactors (BWRs) and Pressurized Water Reactors (PWRs) in metallic dry casks, and is scheduled to start commercial operation in July 2012.(*04) The JPY 100 billion facility will provide interim storage for up to 50 years before used fuel is reprocessed.(*05)

The Rokkasho reprocessing plant is seriously delayed. First expected to start operation in 1992(!)(*06) and in 1998 supposed start in January 2003,(*07) is currently (April 2012) in a test phase and still not in full commercial operation. The preservice tests of the main part of the reprocessing plant are now implemented by Nuclear and Industrial Safety Agency (NISA), and the completion is planned in October 2012.(*08)

Final disposal site selection
In the 1980s and 1990's two sites were selected for underground research laboratories: already in April 1984 Horonobe, and in August 1995 Mizunami. Mizuname is adjacent to the Tono uranium mine where various kinds of research were conducted using existing mine shafts.(*09)

In May 2000, the Japanese parliament (the Diet) passed the Law on Final Disposal of Specified Radioactive Waste (the "Final Disposal Law") which mandates deep geological disposal of high-level waste (defined as only vitrified waste from reprocessing spent fuel). In line with this, the Nuclear Waste Management Organisation (NUMO) was set up in October 2000 by the private sector to progress plans for disposal, including site selection, demonstration of technology there, licensing, construction, operation, monitored retrievable storage for 50 years and closure of the repository. Some 40,000 canisters of vitrified HLW are envisaged by 2020, needing disposal - all the arisings from the Japanese nuclear plants until then.

In December 2002, NUMO started to solicit applications (without a specified deadline) from local communities to host a geological repository for vitrified high-level waste that would be at least 300 meters underground. The plan is to select a site by the late 2020s. The selection process is to go through three stages: literature survey; preliminary investigation; detailed investigation for selection of a repository site (about 15 years). The facility would open to accept high-level wastes in the late 2030s.(*10)

Due to a lack of response from municipalities, the amount of the money offered to incentivize applications for the literature-survey stage was raised in 2007 to a maximum of ¥2 billion ($25 million). Up to ¥7 billion (US$90 million) would be provided during the preliminary investigation stage.(*11)

In January 2007, the mayor of Toyo-cho in Kochi Prefecture made the first application(*12) - but without consulting his town council. This resulted in his forced resignation and a special election in April 2007 that resulted in the victory of a candidate opposed to the application. The application was withdrawn.(*13) After this fiasco, the siting policy was changed to allow the government to actively solicit targeted municipalities to apply for a literature survey. So far, as of this writing, it has been the only application.(*14)

Repository operation is expected from about 2035, and the JPY 3000 billion (US$ 28 billion) cost of it will be met by funds accumulated at 0.2 yen/kWh from electricity utilities (and hence their customers) and paid to NUMO. This sum excludes any financial compensation paid by the government to local communities.

In mid 2007 a supplementary waste disposal bill was passed which says that final disposal is the most important issue in steadily carrying out nuclear policy. It calls for the government to take the initiative in helping the public nationally to understand the matter by promoting safety and regional development, in order to get the final disposal site chosen with certainty and without delay. It also calls for improvement in disposal technology in cooperation with other countries, revising the safety regulations as necessary, and making efforts to recover public trust by, for example, establishing a more effective inspection system to prevent the recurrence of data falsifications and cover-ups.

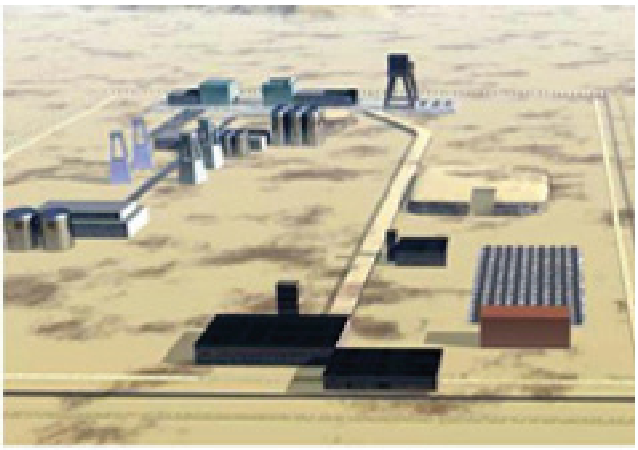
In order to make communities volunteer as possible repository host, the Nuclear Safety Commission of Japan´s Advisory Board on High-level Waste Repository Safety issued the report on 'Safety Communication on Geological Disposal' in January 2011. This report is based on the "*Committee's recognition that it is important, in confidence building of the safety of geological disposal, to establish a safety communication system, which enables stakeholders or their representatives to participate in the process*".(*15)

In the vision of Green Action Japan, *"Japan's nuclear waste management policy is unsustainable and in deep trouble because it is dependent on reprocessing with no alternative plan formulated. Aomori Prefecture is concerned that without a final repository site selected and without the implementation of the pluthermal program, it will become the final de-facto repository for spent nuclear fuel and high-level waste. In turn, local sites being targeted for interim storage are concerned that if reprocessing at the Rokkasho Reprocessing Plant in Aomori does not go forward as planned, they in turn may become a de-facto waste dump because the spent fuel stored at their sites would not be able to be shipped to Rokkasho. In the meantime, the prefectures with nuclear power plants are stating they do not want to extend nuclear waste storage space any further."*(*16)

KAZAKHSTAN

Nr. of reactors	first grid connection	% of total electricity
0	1973-07-16	0.00%

In 2003, Kazatomprom, the state owned nuclear company, developed a scheme where revenue generated from importing foreign radioactive waste would be used to fund the disposal of Kazakh waste. The country's environmental groups and the public severely opposed the proposal, and it never went ahead. (After joining the Central Asian nuclear-weapon-free zone, Kazakhstan committed itself to not importing foreign radioactive waste.) Still, Kazatomprom regularly pays fines for failing to follow laws regarding the storage of existing waste due to a lack of disposal sites.(*01)



Baikal-1 site

Radioactive waste from nuclear power is stored in five different nuclear facilities. At present time Kazakhstan has no integrated and completed system for dealing with radioactive waste, raising serious environmental concerns. The Provisions for radioactive waste disposal were enforced by the Government Decree of 18 October 1996. The Provisions define the order for radioactive waste disposal in a deep geological repository, the procedure for obtaining permission from the regulatory bodies for its deep geological disposal and also establishes the list of necessary documents for this procedure.(*02)

In May 2011, the Minister of Environmental Protection Nurgali Ashimov said, Kazakhstan will not store nuclear waste from other countries. "In accordance with the legislation, it is prohibited to import nuclear waste to Kazakhstan. Kazakhstan will never store nuclear waste. Neither the Ministry nor the Government will allow importing it."(*03)

The Aktau BN-350 nuclear power plant was connected to the grid in 1972 and was shut down in 1999. It's spent fuel was stored on site in cooling pools, but in November 2010, all the fuel was removed to a new long-term storage facility. Over the course of 12 shipments during the last year, the spent fuel was transported over 3,000 kilometers from Aktau, near the Caspian Sea, to the Interim Spent Fuel Storage Facility in Eastern Kazakhstan (MAEC).(*04)

KOREA

Nr. of reactors	first grid connection	% of total electricity
23	1977-06-26	34.64%

Low and intermediate-level waste is stored at the subsurface Gyeongju LILW repository at a depth of 80 meters. Korea dumped low-level waste in the Sea of Japan 5 times from 1968-1972.(*01) High-level waste is stored at the reactor sites, pending construction of a centralized interim storage facility (possibly by 2016). No date for operation of a final disposal facility has been established, although long-term, deep geological disposal is envisaged. Whether this is for used fuel as such or reprocessing wastes depends on national policy and will be decided later.(*02)

The Atomic Energy Act of 1988 established a 'polluter pays' principle under which nuclear power plant operators paid a fee into a national Nuclear Waste Management Fund. A revised waste program was drawn up by the Nuclear Environment Technology Institute and approved by the Atomic Energy Commission (AEC) in 1998.(*03)

South Korea's key national laws relating to spent fuel and radioactive waste management are the Atomic Energy Act (AEA) and the Radioactive Waste Management Act (RWMA). The AEA provides for safety regulations and licensing for construction and operation of radioactive-waste disposal facilities. The RWMA, which was announced in 2008, and enacted in March 2010, established the Korea Radioactive Waste Management Corporation (KRMC) and the Radioactive Waste Management Fund in which KHNP, the nuclear utility company, annually deposits funds for decommissioning its nuclear power plants, disposing of their LILW, and managing their spent fuel.(*04) KHNP now contributes a fee of 900,000 won (US$ 705) per kilogram of used fuel.(*05)

Reprocessing, either domestic or overseas, is not possible under constraints imposed by the country's cooperation agreement with the USA.(*06) Reprocessing will be central at the renewal negotiations of the agreement in 2014. KHNP has considered offshore reprocessing to be too expensive, and recent figures based on Japanese contracts with Areva in France support this view, largely due to transport costs. (*07)

Low and intermediate level waste
South Korea's attempts to site a central interim spent-fuel storage facility and repository for low and intermediate level waste (LILW) began in 1986. During the following decades, a number of failed attempts to acquire sites to host such facilities, due to fierce local opposition (*08) despite steadily growing incentive offers, (*09) were made. In December 2004, therefore, the AEC decided to pursue separate sites for the LILW repository and the central interim spent-fuel storage facility, starting with the LILW site, which was seen as politically easier. In March 2005, a Special Act on Support for Areas Hosting Low and Intermediate Level Radioactive Waste Disposal Facility was passed that guaranteed a local government hosting the national LILW facility an exemption from hosting a spent-fuel storage facility. The central government required a local referendum on hosting the facility and offered more incentives.
Success was finally achieved. Four cities competed to host the facility and Gyeongju City won after 89.5 percent of its voters approved hosting the site in November 2005. (*10) Construction started in April 2008 and in December 2010 KRWM commenced operation of the facility, accepting the first 1000 drums of wastes, which will be held in outdoor storage until the underground repository itself is commissioned in 2012. (*11)

SF-storage, temporarily or interim?
Dry storage for spent fuel has already been built at the Wolsong site, and more is being built there. Some argue that this is illegal because the national low- and intermediate-level waste repository is adjacent to the Wolsong nuclear power plant and, according to the 2005 Special Act on Support for Areas Hosting Low and Intermediate Level Radioactive Waste Disposal Facility, the same community cannot be required to host both the national LILW repository and interim spent fuel storage facilities. The KRMC argues, however, that the on-site dry storage facilities at Wolsong are "temporary," not the "interim" storage that is banned by the special Act.
A major reason for South Korea's political failures in siting a central spent-fuel storage site was that its early site-selection

process did not include consultation with local communities. Instead, the central government selected sites based on its own assessments, met strong opposition from the proposed host region, and gave up. (*12)

In April 2007, after the success in siting the LILW repository, a task force was established to design a process to achieve a public consensus on spent fuel management. Based on the task force's report, in July 2009, the Ministry of Knowledge Economy (MKE) established a committee to manage the process. A month later, however, the process was suspended and MKE announced that a legal framework and a solicitation of expert opinion were required first. An expert group composed of members of South Korea's nuclear establishment was instructed to carry out a year-long research project during 2010 as a basis for the public consensus process.(*13)

If it is to be credible, however, such a public consensus process for spent fuel management will have to be open and transparent and involve local communities and independent experts. Whether or not the public consensus process will in fact be finally launched remains to be seen.

KURT
The R&D program on the disposal technology of high-level radioactive waste was initiated in 1997. After 10 years into the research program, a reference disposal system called the Korea Reference System (KRS) was formulated in 2006 on the basis of the results of the R&D program, which included performance and safety assessment, and studies on the geo-environmental conditions in Korea, an engineered barrier system, and the migration of radionuclides.

For the validation of the KRS, a project for constructing a generic underground research tunnel in a crystalline rock called the Korea Underground Research Tunnel (KURT) started in 2003. Following the site characterization study, the tunnel design, and the construction licensing, the construction of the KURT located at the KAERI site started in May 2005. Controlled drill and blasting techniques were applied to excavate a 6m wide, 6m high and 255m long horseshoe-shaped tunnel with a 10% downward slope. After the completion of this construction of the KURT in November 2006, various in-situ tests are being carried out for the validation of HLW disposal techniques. (*14) The third phase of R&D study ended in February 2007 and phase four is underway. The Korean reference disposal system to accommodate all kinds of wastes from the advanced fuel cycle will be developed. And key technologies developed in third phase will be verified.(*15)

The KURT facility will not need to use radioactive sources to validate HLW approaches which are strictly prohibited by law. Rather, the facility will conduct a series of experiments to investigate "groundwater flow and rock mass characteristics" which with the participation of the local population could help to build trust.(*16)

LITHUANIA

Nr. of reactors	first grid connection	% of total electricity
0	1983-12-31	0.00%

The last reactor at the nuclear power plant in Lithuania, Ignalina, was closed permanently on 31 December 2010. The shutdown of the two Soviet-designed RBMK reactors was a condition of the accession to the European Union. The EU has agreed to pay decommissioning costs for the two RBMK reactors and some compensation through to 2013. Unit 1 of the Ignalina plant was shut at the end of 2004. (*01) Currently Lithuania is actively pursuing the construction of a new nuclear power plant: Visaginas. This is expected to operate from 2020 and is to be built in collaboration with Estonia, Latvia and Poland. However, in December 2011, Poland withdrew from the project. (*02)

All spent fuel is stored on site of Ignalina. First storage pools near the reactor and interim dry storage in the detached facility, where the spent fuel is stored in the same casks it is transported. It was intended to store the fuel unloaded from the reactor for several years and then to transfer it for processing to Russia. According to the Law on Environmental Protection (1992, last amended 2003), the reprocessing of spent nuclear fuel is prohibited. After that a decision was made to build a dry type interim storage for spent nuclear fuel at INPP and store it for 50 years.

The 2008 revised Strategy on Radioactive Waste Management, includes the construction of a new spent fuel interim storage facility; the transfer of spent fuel to the dry storage facilities; and to analyze the possibilities to dispose spent fuel and long-lived radioactive waste in Lithuania or to reprocess or dispose it in other countries.

Future strategy
Initial studies on geological disposal possibilities of the spent fuel were performed. The main objective was to demonstrate that in principle it is possible to implement a direct disposal in a safe way. The objective does not imply that disposal of spent fuel will take place in Lithuania. Which option shall be used for the potential disposal of spent fuel is to a large extent a political decision, and this investigation will be an important input to such decision once required.(*03)

Lithuania should start selection of a site for geological repository in 2030, if international practice is the same and there is no new advanced technologies applicable. In addition, possibilities to prolong storagetime in the storage containers are to be investigated.(*04)

MEXICO

Nr. of reactors	first grid connection	% of total electricity
2	1989-04-13	3.55%

In 1998 a Radioactive Waste Management Policy project was started, which "unfortunately has not been issued due to socio-political obstacles." Currently there is no formally established policy for radioactive waste management. (*01) No reprocessing takes place.

On site storage spent fuel
The Energy Ministry is beginning to take administrative and budgetary steps to create a national company to manage its radioactive waste. It is also planning to sign the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.
An engineered near-surface disposal site for low-level waste (LLW) operated at Piedrera between 1985 and 1987. A collection, treatment and storage centre for LLW has operated at Maquixco since 1972. (*02)

Pending final solution, spent fuel is stored on site in modified spent fuel pools, (*03) increasing drastically the maximum capacity, "*providing the time to develop an integral long-term strategy*". (*04) But even 20 years later in a January 2010 presentation ININ atmitted no specific disposal plan was established. Javier Palacios, head of ININ (National Commission for Nuclear Safety and Security) named the strategy and action on nuclear waste: "*Formulating a national policy for the management of radioactive waste generated in the country*". (*05)

NETHERLANDS

Nr. of reactors	first grid connection	% of total electricity
1	1968-10-18	3.60%

The Netherlands is searching for deep geological disposal in salt (and more recently in clay) since 1976. Spent fuel is reprocessed and interim storage of reprocessing waste takes place in a bunker at the Covra-facility in Vlissingen for about 100 years.(*01). The country dumped low and intermediate level waste in sea from 1967 to 1982.(*02) Since then all dutch LLW and ILW is stored at the Covra, first at Petten and since 1992 at Vlissingen.(*03)

The search for a suitable saltdome
On 18 June 1976 the government wrote a letter to the Executive Board of the provinces of Groningen and Drenthe. The letter stated that five salt domes are eligible for test drilling: Gasselte Schoonlo, Pieterburen, Onstwedde and Anloo.(*04) The government thought actual storage could begin around the year 2000. (*05) According to J. Hamstra, then the main government adviser on nuclear waste, the storage of nu clear waste in the German Asse salt dome was an important argument to investigate salt domes in the Netherlands.(*06) Action groups against the plans were created inmmediately everywhere in Groningen and Drenthe.(*07) In March 1980 the Dutch parliament rejected test drillings and decided to hold a

Social Debate on Energy (MDE), although everyone called it the Broad Social Discussion (BMD in Dutch). It was decided to delay exploratory drilling until after the BMD.(*08)

In 1984, shortly after the BMD, plans for test drilling reappeared again with the Commission Storage at Land (OPLA),(*09) although no specific proposals were mentioned. But in an 1987 interim report, OPLA listed 34 salt domes and salt layers in five northern provinces.(*10) Again, this list led to many protests.

A new attempt to discuss the problem of nuclear waste, was when, in 1987, Environment Minister Nijpels (VVD, Liberals), started a consultation process about criteria the storage must meet.(*11) But Nijpels made a false start publishing an almost unreadable paper for the participation process, leading to discussions and protests even at governmental level. (*12)

On May 14, 1993 the then Environment Minister Alders (PvdA, Social Democrats) wrote that underground storage will be allowed, when 'permanent retrievability' is assured. One should always be able to get to the nuclear waste, but salt domes are slowly silting up. Alders therefor called storage in salt "not very realistic", but wanted "further inquiry" into storage in salt and - a new possibility - in clay. (*13)

To study permanent retrievability, the Ministry of Economic Affairs inaugurated in 1995 the Commission Radioactive Waste Disposal (CORA), which published its report 'Retrievable storage, a accessible path? ' in February 2001. Exploratory drilling and further studies in salt domes or clay layers are to be postponed, but not canceled definetely. The nuclear waste remains above ground…. for the moment.

In the years that followed different governments voiced the same opinion. Former Environment Minister Cramer for instance wrote to parliament on June 30, 2009: "*In the current state of science and technology only geological (deep underground) disposal of highly radioactive waste is a solution, which ensures the waste will, even after millions of years, remains outside the living space (biosphere) of humans.*" (*14) According to the minister future policy will be "directed at retrievable final disposal of radioactive waste in deep underground." She also stated that the report about the preconditions for the construction of new nuclear power plants, which will be published in the spring of 2010, will discuss "possible future policy on radioactive waste."*The government wants a discussion about nuclear power with "experts and stakeholders."*

To prepare such a discussion the government commissioned a report from the Dutch Nuclear Research & Consultancy Group (NRG). The regional newspaper Nieuwsblad van het Noorden quoted from the still classified report on December 14, 2009. According to the report, which speaks of disposal in deep underground stable geological formations, the government should increase its efforts to convince authorities and public of the necessity of storage of nuclear waste, without questioning risks and dangers. As a precondition for the construction of a new nuclear reactor –in operation in 2020- the reports states: "final disposal is an accepted idea in 2015." *"There must be a step-to-step scheme to realize acceptance of geological disposal"*, according to NRG.

On January 8 2010, the Advice for guidelines for the Environmental Impact Report for the construction of a second nuclear power plant at Borssele was published by the ministry.(*15) In it it says: "*Give attention to the possibilities of final disposal of radioactive waste".* Meaning disposal in salt or clay. The Covra (the 100% state-owned organisation responsible for storing all radioactive waste) started a new research project on July 5, 2011: Research Program Final Disposal Radioactive Waste (in Dutch OPERA).(*16) "*In the current state of science and technology only geological disposal of highly radioactive waste is a solution, which ensures the waste will, for the long term, remains outside the living space (biosphere) of humans.*" And: "*The decision about a disposal facility for Dutch radioactive waste is a process with a very long time horizon (according to the current policy at least 100 years) that will be implemented gradually.*" … "*International experience show this is at least a 20-25 year long process. The ultimate construction of the facility is expected to take another 5-10 years. This means final disposal in the Netherlands will not be in operation before 2130".* (*17)

In 2011, Greenpeace commissioned T&A Survey to do a study about underground clay-layers in the Netherlands. Conclusion of the research is that the so-called Klei van Boom (Boom's clay) meet the preconditions announced by the government for waste disposal in four area's.
Then Greenpeace started an intensive campaign against the disposal in these clay-layers. Early February 2012, over 80 concerned municipalities and all provinces made statements opposing underground disposal of radioactive waste on its territories. (*18)

PAKISTAN

Nr. of reactors	first grid connection	% of total electricity
3	2000-06-13	3.77%

The Pakistan Atomic Energy Commission (PAEC) has responsibility for radioactive waste management. A Radioactive Waste Management Fund is proposed in a new proposed policy. Waste Management Centers are proposed for Karachi and Chashma.(*01) The low and intermediate level waste (short-lived) will be conditioned for pre-disposal and stored on site. After a period of time, this waste will be transported to a low and intermediate level waste disposal facility for permanent disposal.

The spent fuel from the reactors is presently stored in spent fuel pools at the plant site. It is planned that at each plant site Dry Storage Facilities will be established. The spent fuel which has cooled for over 10 years will be removed from the pool and placed in Dry Storage. It is expected that the Dry Storage Facility will be licensed for 50 years or more.

Although Pakistan is not reprocessing its spent fuel from nuclear power plants, it has not yet declared it as waste. With increasing uranium prices, it may be feasible in the future to use the spent fuel as a resource and it may be reprocessed (under IAEA safeguards) to obtain material to be used in the production of mixed fuel. Therefore, at present, the decision to put the spent fuel in a non-retrievable Deep Geological Repository is postponed.(*02)

Although there is no sizable civil society, there are examples of people opposing nuclear developments, especially when nuclear waste is involved. This is also admitted by Tariq Bin Tahir Director General Nuclear Power Waste, PAEC, at a presentation at the World Nuclear Association in 2007. Speaking about the need for a disposal facility for low and intermediate waste: *"Whereas there is no significant opposition when it comes to selecting a site for a nuclear power plant, siting for a waste site attracts an immediate negative response from the public. (…) The site selection therefore has more to do with socio-political acceptance rather than best technical choice."* Nevertheless, a number of sites are under consideration and, he expects that the disposal facility will start receiving waste in 6 years.(*03) But not much progress is made, because in 2008 a timeframe was mentioned of 8-11 years for a near-surface LILW-facility.(*04)

Also in 2008, at the same presentation, a time frame was published for a geological disposal facility for high-level waste and spent fuel (28-35 years), although it was unclear if the first phase, area survey and site characterization, had already started.

It looks like not much is happening: in one of the latest reports available on the PAEC website(*05) it is only mentioned that work remained in progress in 2009 on "Draft National Policy on Control and Safe Management of Radioactive Waste". The Draft Policy aims at *"establishing a national commitment to control and manage radioactive waste generated in the country in accordance with national legislation/regulations and international standards."* The construction of a dry spent fuel storage facility is still 'planned'.

ROMANIA

Nr. of reactors	first grid connection	% of total electricity
2	1996-07-11	18.98%

Baita Bihor repository started operation in 1985 and is a disposal facility for low en intermediate-level waste from industry, medicine and research activities. Disposal galleries are former uranium exploration galleries that have been enlarged. A new near-surface repository is under consideration at Saligny, inside the exclusion zone of the nuclear power plant. A feasibility study is prepared. The conceptual design is similar to those of L'Aube (France), El Cabril (Spain) repositories. (*01)

Used fuel is stored at the reactors for up to ten years. It is then transferred to the Interim Spent Fuel Storage Facility (DICA), a dry storage facility for spent fuel based on the Macstor system designed by AECL for about 50 years. The first module was commissioned in 2003. Regarding the spent fuel from research reactors policy is return to the country of origin and/or deep geological disposal in the national repository. No reprocessing takes place.

The research of the geological environment for a deep geological repository of spent fuel and high-level waste, which should be available around 2055 is at a very preliminary stage.(*02) In the 1990's, studies identified as potential host rock the following geological formations: salt, volcanic tuff, granite, shield green slate – Moesian Platform, clay. One to several potential host rock were identified in each geological formation. Over the last years, several R&D studies on general aspects of studying host rocks for a geological repository and general reference design concepts were performed by different organizations within the national R&D supported programs. (*03)

Since Romania is a country with a small nuclear energy program the preliminary estimation of the costs for siting and construction of a deep geological disposal for spent fuel and long lived waste in a national repository are extremely high. This is the reason for Romania to consider that deep geological disposal in an international repository "*could be a better solution for avoidance of leaving unfair burden for future generations,*" according to a 2003 statement.(*04)

RUSSIAN FEDERATION

Nr. of reactors	first grid connection	% of total electricity
33	1954-06-26	19.59%

Russia will soon start storing spent fuel in a new centralized 'dry' interim storage facility (ISF) at Zheleznogorsk, near Krasnoyarsk. The first phase of the facility, for RBMK-fuel, was completed December 2011, and the first fuel was planned to in March 2012. Reprocessing has always been a major part of waste management. The Russian Federation (and its predecessor the Soviet Union) is the champion of sea dumping. It dumped low and intermediate level waste in Arctic Seas (1964-1991): liquid radioactive waste in Arctic Seas (1959-1991); objects with spent nuclear fuel in Arctic Seas (1965-1981); liquid (1966-1992) and solid (19680-1992) waste in the Pacific Ocean; liquid waste in Barents Sea and Far Eastern Seas (1992) and finally, liquid radioactive waste in Sea of Japan (1993).)(*01). The Russian state nuclear corporation Rosatom is responsible for waste management, but in March 2012, a National Operator for management of radioactive waste was established in accordance with the "Federal Law on the Radioactive Waste management" signed in summer 2011.(*02)

Interim storage and reprocessing

Russia needs to build a centralized long-term dry storage due to the limited capacity of existing storage pools. In 19 December 2011, the first phase of a centralized storage facility has been completed at the Mining and Chemical Combine (MCC) at Zheleznogorsk. The initial stage of the facility will be

used for storing 8129 metric tons of RBMK fuel from Leningrad (4 units), Kursk (5) and Smolensk (3 reactors). The used fuel from these plants is currently stored in on-site cooling pools, but these are reaching full-capacity, and spent fuel discharges are expected to exceed on site storage capacity. (*03)
The second stage of the facility, for VVER-fuel, is now beginning. Later, used VVER-1000 fuel from reactors at the Balakovo, Kalinin, Novovoronezh and Rostov plants will also be stored at the facility. VVER fuel has already been sent to Zheleznogorsk for storage in water pools. The ISF - measuring some 270 meters in length, 35 meters wide and 40 meters high - will ultimately hold 38,000 tons of used RBMK and VVER fuel.
The fuel will be stored in the facility for up to 50 years,(*04) during which time substantial reprocessing capacity should be brought online. Currently, Russia reprocesses about 16% of the used fuel produced each year, but Russia aims to reprocess 100% in the year 2020.(*05)

In the long-term, a geological repository for high-level radioactive waste is planned.
No waste repository is yet available, though site selection is proceeding in granite on the Kola Peninsula. In 2003 Krasnokamensk in the Chita region 7000 km east of Moscow was suggested as the site for a major spent fuel repository. (*06)
Since the early 1970s, Minatom (Ministry of Atomic Energy) has been studying various sites and geologic formations to determine their suitability for use in the construction of underground radioactive waste isolation facilities. According to the regional approach that has been developed in Russia with regard to the selection of geologic sites for permanent isolation, it is most expedient to have the burial sites near the waste sources. Purposeful research for the high-level waste geological isolation has been done in the two areas where the Mayak Production Association (Chelyabinsk Oblast) and the Mining-Chemical Complex are located. After the results of all research studies were analyzed, two sites nearby Mayak reprocessing plant were selected as top priorities.
A second Russian geological isolation site is the Nizhnekansk granitoid massif, one of the largest massifs in central Siberia, very close to the MCM. It is composed of various types of magmatic and metamorphic rock. Here, also two specific sites were selected. In 2005, however, because of a lack of financing, work on the study at the two Nizhnekansk sites was halted. (*07)
Then in 2008 the Nizhnekansky sites were on the table again as a site for a national deep geological repository. Rosatom said the terms of reference for the facility construction would be tabled by 2015 to start design activities and set up an underground rock laboratory. A decision on construction is due by 2025, and the facility itself is to be completed by 2035. (*08)

Although the import of foreign fuel for the purpose of final disposal is prohibited, much Russian-origin spent fuel is imported. In the 1990s contracts for fuel for reprocessing, has been signed with Ukraine, Bulgaria (both for spent fuel from nuclear power plants), Uzbekistan, Kazakhstan, Czech Republic and Latvia (spent fuel form research reactors). The contracts envisage the return of the solidified radioactive waste resulting from the reprocessing. (*09) During Soviet times, spent fuel from VVER-440 reactors in Finland, Hungary, Bulgaria and Slovakia was shipped to Mayak for reprocessing. (*10)
The reprocessing waste from Russian-origin fuel can be left in Russia. Most of the Russian-origin fuel that Russia has repatriated has not been reprocessed in Russia's existing reprocessing plant, however, but is in long-term storage pending the construction of a larger reprocessing plant.(*11)

SLOVAK REPUBLIC

Nr. of reactors	first grid connection	% of total electricity
4	1972-12-25	54.02%

The state regulation over nuclear safety for radioactive waste and spent fuel management is entrusted to the Nuclear Regulatory Authority of Slovak Republic (ÚJD SR) established on 1 January 1993.(*01)

Low and intermediate level waste is stored at a near-surface disposal facility in Mochovche. Selection of the site has been carried out between 1975-1979 out of 34 sites. Permission was granted in1999 and operation started in 2001.(*02)
Spent fuel was transported prior to 1987 to Soviet Union for storage and reprocessing: all spent fuel from Bohunice A-1 as well as VVER-440 fuel. Currently spent fuel is not reprocessed.
Waste management strategy is long-term interim storage (40-50) years at a facility at Bohunice, called MSVP, in pools. MSV is in operation since 1987.(*03)

Looking for international solution
Slovakia started its own program of development of deep geological disposal in 1996. Fifteen potentially suitable areas for further investigation were identified, later narrowed to three distinct areas: with five localities: three in granitoid rocks, two in sedimentary rocks environment.(*04)

The research program had been stopped in 2001,(*05) however, and a new strategy had been specified by the government in 2008: disposal in deep geological repository; an international solution (export to Russian Federation, international repository); or a zero alternative, interim storage for a further not specified period of time (“wait and see“ approach).(*06)

The handling of spent fuel after interim storage has not been defined in the Slovak Republic. It can be assumed that this will hamper the determined search for a location for a repository and for the development of a repository concept. According the original plans, decision on selection of the host environment was expected after 2005, selection of a candidate site around 2010, and commissioning of a deep geological repository by 2037.(*07) This has now been postponed for an indefinite period of time.

There is no definition, whether the five locations shall be further explored in case of a decision for a Slovak repository. A time schedule for the further procedure is not stipulated as far as publicly known.(*08)

SLOVENIA

Nr. of reactors	first grid connection	% of total electricity
1	1981-10-02	41.73%

The Agency for Radwaste Management is the state-owned public service for radioactive waste management. It is financed through the national budget and partially through the Fund for the Decommissioning of the Krško nuclear power plant. Operational low and intermediate-level wastes are stored on site of the Krsko nuclear power plant, as is used fuel. (*01)

A permanent repository for low- and intermediate-level wastes is due to open in 2013 at Vrbina, near the Krsko plant. Site selection has been undertaken over five years, and compensation of 5 million euro per year will be paid to the local community. Vrbina is only for Slovenia's portion of the waste, although it could be doubled in case of an agreement between with Croatia or further use of nuclear power. It will also hold all of Slovenia's industrial and medical radioactive waste as well as the LLW and ILW from the 250 kW research reactor at the Josef Stefan Institute in Ljubljana.(*02)

The 2006 long-term strategy for spent fuel management foresees spent fuel storage in dry casks. Spent fuel will be moved to dry storage between 2024 and 2030 and will be stored until 2065, when a deep geological repository is assured. The operational phase of the spent fuel repository will end in 2070 and the repository should be closed in 2075. In the case of export option, the removal of spent fuel from dry storage is planned between 2066 and 2070. The option of multinational disposal is kept open.(*03)

A particular problem for waste management could be the fact that the reactor at Krško is operated jointly together with Croatia. Differing interests and responsibilities of the two countries may lead to problems when developing a Waste-Management Concept, or with respect to the financing of the Waste Management and to the determination of a location for the repository. The final disposal of the spent fuel is planned, however no efforts are visible regarding the realization.(*04)

SOUTH AFRICA

Nr. of reactors	first grid connection	% of total electricity
2	1984-04-04	5.19%

The 2008 National Radioactive Waste Disposal Institute Act provides for the establishment of a National Radioactive Waste Disposal Institute which will manage radioactive waste disposal in South Africa. The responsibility for nuclear waste disposal has been discharged by the Nuclear Energy Corporation (Necsa) until now. Necsa has been operating the national repository for low- and intermediate-level wastes at Vaalputs in the Northern Cape province. This was commissioned in 1986 for wastes from Koeberg and is financed by fees paid by Eskom. Some low- and intermediate-level waste from hospitals, industry and Necsa itself is disposed of at Necsa's Pelindaba site.(*01)

Koeberg spent fuel is currently stored in pools as well as in casks. The site has enough storage capacity for the spent fuel that will be generated during the current operational lifetime of Koeberg.
Pending the outcome of current investigations into possible reprocessing of spent fuel, it is not classified as radioactive waste. Rather than been in its final form for disposal used fuel is. Interim storage takes place on site, awaiting investigations into the best long term option for the management of spent fuel.(*02) If chosen as a preferred option in South Africa, geological disposal of radioactive waste shall take place with an option for retrieving the waste.(*03)

Plans by Eskom to seek contracts for reprocessing surfaced in August 2009. The stae owned utility and operator of Koeberg said the resulting MOX-fuel could be sold to other countries rather than used at home. It turned out to be a plan to try to finance new build.(*04) Not surprisingly it was never heard of again.

According to Nesca CEO Rob Adams South Africa would need a fully operational high-level waste management site by 2070 to deal with spent fuel. The negotiations with the National Nuclear Regulator to identify a high-level waste disposal site would likely start before 2015. Three possible disposal sites would have to be identified, and three individual environmental impact assessment studies would have to be conducted. Necsa would then argue the case of the most suitable site. Vaalputs will most likely be one of them.(*05)

SPAIN

Nr. of reactors	first grid connection	% of total electricity
8	1968-07-14	19.48%

Low- and intermediate level wastes is stored at ENRESA's storage facility at El Cabril, Cordoba. Spent fuel is stored at the reactor sites awaiting a centralized interim storage and geological disposal A final geological disposal facility is not expected before 2050, at the earliest. No reprocessing of spent fuel takes place, but in the past spent fuel of Vandellos-1 reactor has been reprocessed.

Low-level Waste
In the 1950s, the El Cabril uranium mine was shut down and started to be used for storing low and intermediate level waste. In 1986 ENRESA took responsibility for El Cabril and moved the waste from the mines to new built buildings on the

same site.(*01) It is planned to receive waste until 2015.(02) The state-owned radioactive Waste management organization ENRESA, created in 1984, is responsible for managing radioactive waste and decommissioning of nuclear plants. (*03)

High-level waste and spent fuel
ENRESA is since 1987 developing a disposal program aimed at providing a final solution for the spent fuel and high level waste. The program comprised of three areas: identification of suitable sites, conceptual design and performance assessment of a geological repository and research and development.(*04) At that time a repository was expected to be realized by 2020. By end-1990, some 25,000 km2 of possible regions were found. Finally, some 30 areas were identified for further research.(*05)

Although ENRESA had identified favorable areas for further underground research, work was halted in 1996 due to public opposition; or in the words of ENRESA: "*the reaction of the public advised to discontinue any field work in 1996.*"(*06) In 1995, it had become known among environmental groups that ENRESA had plans for the construction of underground disposal laboraties and a list of possible locations was released. The groups accused ENRESA of not having informed the public and of having inspected possible sites. Large demonstrations were organized which culminated in a demonstration of 20,000 people in 1998 at Torrecampo. (*07) At the end of 1996, the Senate Commission for Industry established an inquiry commission to develop a new waste policy. It had to study the difficulties in finding a site for waste disposal and should include socio-political and public acceptance aspects. The commission's work was expected to result in guidelines for the government to develop a legal framework for siting. The commission received contributions from groups and institutions and visited other countries for comparison.(*08)

In 1999 the 5th Radioactive Waste Plan was adopted with a new policy: construction of a centralized interim HLW storage by 2010 for reprocessing waste as well as spent fuel; and no decisions about final disposal before the year 2010. (*09)

In mid 2006 Parliament approved ENRESA's plans to develop an interim centralized high-level waste and spent fuel storage facility by 2010, and the Nuclear Safety Council CSN approved its design, which was similar to the Habog facility near the Borssele power plant in the Netherlands. In December 2009 the government called for municipalities to volunteer to host this €700 million Almacen Temporal Centralizado (ATC) facility. The government offered to pay up to €7.8 million annually once the facility is operational. It is designed to hold for 100 years 6700 metric tons of used fuel and 2600 m3 of medium-level wastes, plus 12 m3 of high-level waste from reprocessing the Vandellos-1 fuel. The facility is to be built in three stages, each taking five years. Fourteen towns volunteered, attracted by the prospect of a €700 million investment over 20 years and the annual direct payments, plus many jobs, but only eight were formally accepted.(*10)

In September 2011 the Ministry for Industry announced its selection and rankings: Zarra (Valencia) 736 points; Asco (Tarragona) 732 points; Yebra (Guadalajara) 714 points; Villar de Canas (Cuenca) 692 points. In December 2011 the Ministry announced that Villar de Canas had been selected, though only a 60-year storage period was mentioned. Pending construction, low- and medium-level wastes continues to be sent to ENRESA's storage facility at El Cabril, Cordoba, which has operated since 1961. Used fuel remains at individual power plants.(*11)

For Jose Maria Saiz, the mayor of Villar de Canas, the financial compensation and the promise of 300 jobs were compelling arguments to get the storage to his place. That doesn't alter the fact that environmental groups and trade unions are against the storage.(*12) And in March 2012 it turned out that promised regional jobs were not materializing and little is left of the initial optimism.(*13)

The General Plan on Radioactive Waste suggests that the operation of a deep repository in Spain would probably start in 2050. Therefore, the period between 2025 and 2040 would be focused on decision-making process and site characterisations, whereas from 2040 to 2050 construction would take place. A programme of activities between 2006 and 2025 to meet the objective of having a repository by 2050 is lacking (Fundación para Estudios sobre la Energía, 2007).

The high level of priority given to the interim storage facility has delayed the interest and the research efforts in deep geological disposal. Furthermore, the construction of the centralised storage facility allows decisions on final management to be postponed.(*14)

SWEDEN

Nr. of reactors	first grid connection	% of total electricity
10	1964-05-01	39.62%

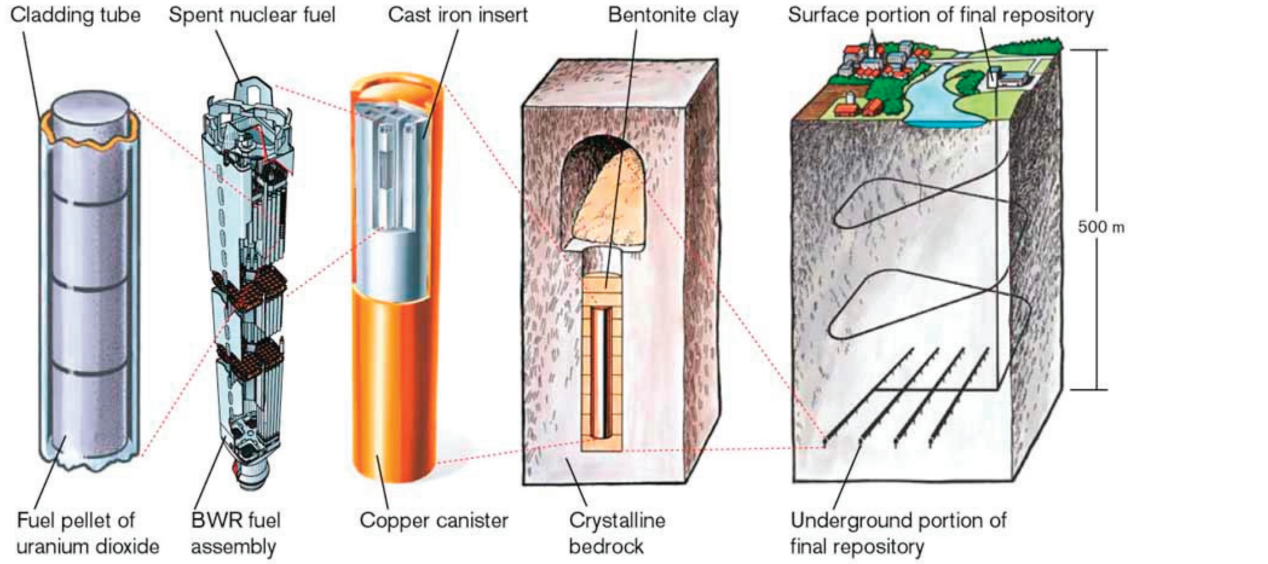
Since the mid-1970s spent nuclear fuel is to be disposed of in a geologic repository. Early plans for reprocessing the spent fuel were abandoned already in the early 1980's. In the 1970's Svensk Kärnbränslehantering AB (Swedish Nuclear Fuel and Waste Management Company), SKB, was established to manage the waste (*01 Sweden once dumped low-level waste in the Atlantic Ocean (in 1969) and twice (1959 and 1961) in the Baltic Sea.(*02)
The country wants to dispose its nuclear waste, packed in copper to ensure long-term safety, in granite from 2023/25 on. But problems with copper and geological stability have been published widely. Awaiting final disposal spent fuel is stored in an interim facility in Oskarshamn, called Clab. Low and intermediate-level waste is currently stored in a final repository 50 meters deep in the crystalline basement near the nuclear power plant in Forsmark.(*03)

Long-lasting search
In Sweden, the Parliament decided to a Nuclear Power Act in 1977, which asked for an "absolutely safe solution" for final disposal of nuclear waste and makes the nuclear industry responsible for the management of the waste. The Swedish government started a procedure, called scientific mediation, to clarify the scientific differences. This was followed by discussions with the public, aimed at participation in the decision-making.(*04)
Research to find a final disposal site has taken place for since 1977. Eleven sites were examined, with extensive work undertaken at 7. Test-drillings was planned in 5, but only two of these allowed SKB to carry out even an initial feasibility study: Storuman and Malaa. Several possible locations for the final disposal have been dropped out after referendums, such as Storuman, Malaa(*05) and Gaellivare.(*06) It was obvious by then that the best chance for a repository would be in a municipality that has a nuclear power plant: Forsmark and Oskarshamn, or at the Studsvik research reactor.(*07) The idea is that in these locations such an initiative will most likely gain sufficient support, and SKB limited themselves to the choice of a site with nuclear power activities. (*Sw08) Municipalities can present themselves voluntarily as a host location, but can also withdraw in a later stage. Although there is a law enabling the government under very specific conditions to overrule such a veto, but this provisions seems very hard to use for any government: this will not happen in practice.(*09)

In 1998, SKB director Peter Nygaards stated that the Swedish government should be prepared to offer financial incentives to a community willing to host the repository. He compared this with the money the government pays to local communities to take in refugees. Similarly, any disposal of nuclear waste must also be reimbursed. Nygaards also said he don't want to fix the moment of permanently sealing a repository. If the repository is full one should consider if closing is not a better option so that "*future generations can open it if they need to?*" Nygaards said: "*It is not wise to make a decision today for 100,000 years from now*".(*10)
Besides the locations with nuclear power plants, only Tierp volunteered to be a host community for the repository. (*11)
In November 2001 the government approved research in Tierp, Forsmark and Oskarshamn,(*12) but in April 2002, the city council of Tierp decided to withdraw.(*13) In June 2009 SKB selected Forsmark.(*14) The repository is proposed to be sited adjacent to the Forsmark nuclear power plant on the Baltic Sea coast. On 16 March 2011, SKB applied for a permit.(*15) It plans to begin site works in 2013, with full construction starting in 2015, and operation after 2020.(*16)

Criticism on safety
The KBS method was developed in the 1970s. The basis is a geologic repository at about 500 meter depth in granite bedrock and the long-term safety is to be guaranteed by artificial barriers – copper canisters surrounded by a bentonite clay buffer.(*17)

There is severe criticism on the disposal method. The nuclear waste is disposed of at 500 meters depth in granite. According to SKB, this is a stable geological formation. But paleo-geophysicist Nils-Axel Mörner states that the stability is not true. Since the end of the last Ice Age the ground went upwards with a rate of one millimeter per day, there were 58 serious earthquakes and 16 tsunamis. As a consequence of these and other factors Mörner finds the repository unstable and not safe.(*18)
In November 2009 another problem arose: the use of copper.



In the final repository several barriers must ensure that the radioactive substances do not harm people or the environment.

The nuclear waste is encased in a copper layer of five centimeters, which has to remain intact for 100,000 years. Copper corrodes in environments where oxygen is present. The process is easy to observe on copper roof materials that turn green from oxidation. When the industry's KBS-method was developed in the 1970's the understanding was that copper does not corrode at all in an anoxic (oxygen-free) environment in the bedrock. During the 1980's a researcher from the Royal Institute of Technology (KTH) in Stockholm, Gunnar Hultquist, presented new findings that showed that copper could corrode in environments without oxygen, as long as there is water present. The new findings were denied by SKB and ignored by the authorities. During the autumn of 2007 Gunnar Hultquist and a colleague Peter Szakálos presented the findings again, this time with more experimental results. (*19) This is noticed by investigation of copper artifacts from the Swedish warship Vasa, which sunk in 1628: the copper had become much thinner than expected.(*20) Copper corrosion has caused a discussion about the KBS method in Sweden as the findings threaten basic assumptions underlying the long-term safety of the KBS method.

A geologic repository in Swedish bedrock at a depth of 500 m. has groundwater flowing through the repository, says Dr. Johan Swahn, Director of the Swedish NGO Office for Nuclear Waste Review (MKG) at a hearing on the management of nuclear waste at the European Parliament's Committee on Industry, Research and Energy.(*21) A repository using the KBS method therefore has to rely on manmade barriers (clay and copper) to isolate the nuclear waste from the environment. The chemical and biological environment will in the long term threaten the artificial barriers of copper and clay in ways that are difficult to foresee. The relatively dry rock (for the KBS method) chosen by SKB in Forsmark puts stress on the clay barrier and opens up for new questions on copper corrosion processes. In Sweden there will be one or more Ice Ages during the next 100,000 years and glaciation will lead to variations in the chemical and biological environment that will affect the man-made barriers.

The safety case for Swedish KBS method is severely questioned and licensing is uncertain. The problems for the KBS method has opened up for questioning whether disposal methods relying on artificial engineered barriers should be implemented at all. The Swedish and Finnish repository programs for spent nuclear are entirely interdependent. If the Swedish program fails, so does automatically the Finnish.(*22)
In short, also in Sweden, nuclear waste disposal is not a fait accompli.

The Swedish Radiation Safety Authority (SSM) has recommended a tripling of the fee paid by the country's nuclear power industry towards paying for management of the country's nuclear waste. Basing its assessment on information gathered from the relevant organizations - including cost estimates from SKB - SSM has recommended to the government that the fee should be set at 3 öre per kWh of nuclear electricity produced. The current level is 1 öre per kWh. (1 öre is worth approximately US$0.001) According to SSM, much of the increase is down to new estimates from SKB indicating that the remaining costs of the country's planned final repository for used nuclear fuel have grown by about SEK 18 billion (US$2.7 billion) from previous estimates made in 2008. SSM also says it believes that SKB has underestimated future costs, and it has adjusted the proposed fee increase to reflect this.(*23)

SWITZERLAND

Nr. of reactors	first grid connection	% of total electricity
5	1968-01-29	40.85%

In 1969, the first Swiss nuclear power plant, Beznau 1, entered service. As of 1 March 2012 this plant is the oldest nuclear plant in the world.(*01) A geological final repository for high level waste will not be available before 2040, at the earliest: 70 years after the first reactor began operation. Switzerland dumped low- and intermediate level radioactive waste in sea 12 times from 1969-1982.(*02) It transported the waste by train to the Netherlands, from where it was dumped in the Atlantic Ocean together with the Dutch radioactive waste.(*03) Spent fuel is temporary stored at the Zwilag central storage facility.

Nagra
In December 1972, the Nationale Genossenschaft für die Lagerung radioaktiver Abfaelle (Swiss organization responsible for the storage of nuclear waste) was created: Nagra:(*04) The operators of the nuclear power plants are 95% owned by Nagra, the government has a share of 5%.(*05) Nagra immediately began investigating the storage of low, intermediate and high-level radioactive waste. This resulted in the project "Gewähr" of 1985. In June 1988 the government decided to take the first steps for low and intermediate radioactive waste, but for high-level waste further research was needed. This was because siting feasibility, i.e. the demonstration that a suitable rock body of sufficient extent could be found at an actual site in Switzerland, had not been demonstrated.(*06)

LLW & ILW: Wellenberg drops out
In 1993, from a 1978 list of originally 100 sites, Nagra chose Wellenberg (in the canton of Nidwalden). Nagra found Wellenberg suitable for safety reasons, but also because there would be sufficient storage available.(*07) In the Wellenberg-debate critics of the repository project articulated new concepts: the disposal should be retrievable and verifiable. The Nagra, however, did not agree with that and the debate culminated in a June 1995 referendum. A majority of the Nidwalden population voted against the storage. Given the distribution of powers in Switzerland, storage at Wellenberg was off.(*08) The Nagra then examined how the people of Nidwalden would have voted if the requirement of retrievability and monitoring would have been granted. It turned out that 60.8 percent would have voted 'yes'.(*09)

But Nagra wanted to hold on to Wellenberg and the government agreed to this. In 1998 the Department of Energy repeated that Wellenberg is suitable for retrievable and verifiable disposal of low and intermediate level waste.(*10) So another referendum was organized and on 22 September 2002, a majority (57.5%, turnout was 71%) of the population voted again against the disposal at WellenbergThe government reacted by saying that with this result disposal plans were canceled. This was a hard blow to the nuclear industry, which has spent 80 million francs (€55 million) for research and to propitiate the population.(*11) But it turned out that Wellenberg was not off the table for ever.

Spent fuel policy
From July 2006 on , there is a 10-year moratorium on the export of spent fuel for reprocessing. Before the moratorium, utilities were free to choose between reprocessing and direct disposal of the spent fuel. The reprocessing took place abroad (France and UK). Dry storage buildings at the Beznau nuclear power plant and at the Zwilag central storage facility have been built for the interim storage of spent fuel and of radioactive waste returned from reprocessing abroad. In addition, a building for the wet storage of spent fuel at the Gösgen nuclear power plant was commissioned in 2008.(*12)

2008: new plan for high-level radioactive waste
On 6 November 2008, the Nagra came with a new waste disposal roadmap: 'Zeit zum handeln'.(*13) Surprisingly, Wellenberg was candidate again for storage of low and intermediate level. In February 2011, for the third time, the population Nidwalden voted against (74.5%) the storage.(*14) But unlike earlier, the district no longer has a right to veto: the government has abolished that in 2002.(*15) Therefore, Wellenberg remains on the list.
In the new roadmap, as a first step, there three regions were chosen: Zürcher Weinland, Nörlich Lägeren and Bözberg. These are three regions in northern Switzerland, where a certain kind of clay (opalinus clay) is found. From 2011 on, regional conferences (attended by 100-200 people) should be held several times per year.(*16) The costs, for each region 1.5 million francs (€1 million) is made available, of which 80% is paid by the Nagra.(*17) Somewhere between 2014 - 2016 two locations in each region should be selected and before 2020 a referendum can take place. After that one site will be chosen for the geological repository. After the repository is constructed and the procedures are completed, the storage can start in 2030 for low- and intermediate-level waste and for high-level waste in 2040 at the earliest. (*18)

The plans raised much protest, as extensively described in the May 2010 issue of Energie und Umwelt (Energy and Environment) of the Swiss Energy Foundation (SES).(*19) In all regions, groups work together to prevent that the nuclear waste goes to the site with the least resistance. Although the government announced it wants to give action groups financial support to make their own studies, this was not settled in May 2010. And while the Nagra asserts that a repository has regional benefits, a study of the canton of Schaffhausen shows the contrary: great regional economic damage is expected. Therefore, SES calls the participation a form of sham democracy.
The government, however, continued the plans and on 1 December, 2011, decided that those sites may remain appropriate on 1 December 2011.(*20) The next four years, further investigation will take place at all sites, and interested parties can participate in regional conferences. After those four years, so in 2016, one site is selected and an application process for a license will start. In 2040, Nagra expects, the actual disposal can start. The Swiss Energy Foundation (SES) together with local groups are protesting the continuation of the process. According to these groups there are 12 unresolved questions about safe disposal of nuclear waste.(*21) These 12 questions should first be resolved before the people can be involved in the disposal. Therefore, these groups are in favor of the suspension of the government's plans.(*22) On March 6, the government, however, sees no reason to stop the procedure and announced that a repository has positive outcomes on the regional economy.(*23)

TAIWAN

Nr. of reactors	first grid connection	% of total electricity
6	1977-11-16	19.02%

Taiwan has adopted the following management strategy for spent nuclear fuel: “storage in spent fuel pools for the near term, onsite dry storage for the mid-term, and final deep geological disposal for the long term".(*01)

The Atomic Energy Council (AEC) was founded in 1955 at the ministerial level under the Executive Yuan as the Competent Authority (regulatory body). FCMA is the unique agency for the supervision of spent fuel and radioactive waste safety management. Radwaste Administration (RWA) was established in January 1981, as an affiliated agency under AEC, to meet the growing need for radioactive waste management. After restructuring RWA was renamed as Fuel Cycle and Materials Administration (FCMA) in early 1996.(*02)

Low-level waste
The Lan-Yu Storage Site provides off-site interim storage for solidified low-level radioactive waste from 1982 to 1996, and has not received any radioactive waste since then. Because of the high temperature, moisture, and salty ambient atmosphere in Orchid Island, many drums stored on site for decades has shown paint scaling or rusted, some waste in drums even presents solification deformation.(*03)

Interim dry storage
Taiwan’s current policy calls for dry storage of spent fuel at the reactor site until final disposal, although it is recognized that additional storage facilities will be needed soon to deal with the growing amount of spent fuel being produced. Taiwan is also looking at sending its fuel overseas for reprocessing. However, U.S. government opposition to Taiwanese reprocessing has so far blocked significant movement on this; since Taiwanese reactors and fuel are of U.S. origin, bilateral agreements require Taiwan to obtain U.S. consent for reprocessing.(*04)

Recognizing the problem of spent fuel storage, the authorities began looking toward cooperation on the development of dry storage technology, with mixed success. China offered to take over Taiwan’s spent fuel inventory in the late 1990’s but Taiwan refused due to fears that Beijing would demand political concessions in exchange.(*05) In 2001, Taiwan also explored the possibility of storing its spent fuel on Russian territory; but dropped negotiations after U.S. objections.(*06) However, this could still be a possibility in the long-term.

Since December 1983, research for final disposal has been carried out. The "Nuclear Materials and Radioactive Waste Management Act" was issued in December 2002. It states that the producer of high-level waste is responsible for the implementation of final disposal and is required to submit a final disposal plan for HLRW within two years after the Act came into effect. In Dec. 2004, TPC submitted the "Spent Nuclear Fuel Final Disposal Plan" to AEC. The plan was approved in July, 2006, and will be carried out in five phases: (1) Potential host rock characterization (2) Candidate site investigation; (3) Detailed site investigation and testing; (4) Repository design and license application; and (5) Repository construction. Finally, a deep geological disposal repository is expected to be operational after 2055.(*07)

UKRAINE

Nr. of reactors	first grid connection	% of total electricity
15	1977-09-26	47.20%

Established in 1996 the State Enterprise National Nuclear Energy Generating Company 'Energoatom' is responsible for everything nuclear in Ukraine, including radioactive waste management. There is no intention for final disposal in Ukraine in the coming decades, though the possibility remains under consideration. In 2008 the National Target Environmental Program of Radioactive Waste Management was approved. Storage of used fuel for at least 50 years before disposal remains the policy.(*01)

Waste management: Interim storage
Before 2005, Ukraine transported annually about 220 tons of spent fuel to Russia.(*02) Because of the rising price of Russia's reprocessing and spent-fuel storage services, however, Energoatom decided in the 1990s to construct dry storage facilities. The first Ukrainian dry-cask interim storage facility came into operation in July 2001 at the Zaporozhe nuclear power plant for storage of fuel from the six reactors.(*03) But since 2005, Ukraine has been shipping spent fuel again to Russia from its other sites: about 150 tons a year from seven VVER-1000s and about 30 tons a year from its two VVER-440s,(*04) at a cost to Ukraine of over US$100 annual.(*05)

In December 2005, Energoatom signed a US$ 150 million agreement with the US-based Holtec International to implement the Central Spent Fuel Storage Project for Ukraine's VVER reactors.(*06) This was projected for completion in 2008, but was held up pending legislation.

Then in October 2011 parliament (and upper house in February 2012) passed a bill on management of spent nuclear fuel. It provides for construction of the dry storage facility within the Chernobyl exclusion area. The storage facility will become a part of the spent nuclear fuel management complex of the state-owned company Chernobyl NPP,(*07) also constructed by Holtec.
The first pond-type spent fuel storage facility (SFSF-1) for RBMK-1000 spent fuel at Chernobyl has been in operation since 1986. Due to the *"unavailability of SFSF-2 and taking into account the future prospects of this project it was decided to withdraw SFSF-1 from the list of facilities, subject to decommissioning."*
SFSF-2 (or Interim Storage Facility-2 as it is often called outside Ukraine) construction started in June 2000 by Framatome (later Areva), financed by EBRD's Nuclear Safety Account, and part of the Shelter Implementation Plan. ISF-2 is designed for long-term storage (100 years) of all Chernobyl spent fuel and is a necessary condition for decommissioning Chernobyl and SFSF-1. At the beginning of April, 2007 the agreement was canceled and in September 2007 a contract for completion was signed also with Holtec.(*08) The design of the new facility was approved by the Ukrainian regulator in late-2010. Work can commence once the contract amendment for the implementation is signed. It is expected that construction work will be finalized by 2014.(*09) Negotiations with Holtec on the construction could be completed in April 2012. Costs, however, have been escalating since the project financing scheme was drawn up before the 2008 financial crisis: some U.S. banks that participated in the financing scheme had ceased to exist.(*10)

High-level wastes from reprocessed spent fuel will be returned from Russia from 2013 onwards and should be stored at the existing repository 'Vektor' 17 km away from Chernobyl where a low-level waste repository has been built.(*11) Preliminary investigations have shortlisted sites for a deep geological repository for high- and intermediate-level wastes including all those arising from Chernobyl decommissioning and clean-up.(*12)

UNITED KINGDOM

Nr. of reactors	first grid connection	% of total electricity
17	1956-08-27	17.82%

In 1981, the government in Britain decided to postpone plans for the disposal of high-level radioactive waste.
In 2010, the NDA came up with a plan that has to lead to final disposal of high-level waste from 2075. The government claims to follow an advisory committee, but the committee thinks the government gives a distorted view of their advice. Nuclear fuel is reprocessed and liquid and glassified waste is stored at Sellafield until a final repository will be opened.

Low- and medium-level radioactive waste
Great Britain dumped solid low and intermediate level radioactive waste in sea from 1949 untill 1982.(*01) A near-surface repository in Drigg (near Sellafield) has operated as a national low-level waste disposal facility since 1959. Wastes are

compacted and placed in containers before being transferred to the facility.(*02)

Investigation from 1978 to 1981 into the disposal of high-level radioactive waste in Caithness led to much opposition. In 1981, the British government therefore decided to postpone a decision on the storage of high-level waste by fifty years.(*03)

Although in 1981 the government decided to postpone the plans for a high-level radioactive waste facility, the search for a storage place for low- and medium-level radioactive waste had to be continued. For this purpose the British nuclear industry created Nirex in 1982. After repeated selections of a number of new sites and abandoning them again, Nirex chose Sellafield in 1991 for detailed studies on a deep repository for long-lived low-level and intermediate level radioactive waste.(*04)

In March 1997, however, the government rejected Sellafield due to the unfavorable geological conditions. The government has also decided that a new choice of location can take place only after the government has adopted new procedures for that purpose, and for that participation is required. It took un til 2001 before new procedures have been settled.(*05) It will take at least 25-30 years before a deep geological disposal facility for low en intermediate level radioactive waste will be in operation.(*06) Large information campaigns for years and years hasn't led to a final repository for nuclear waste.

High-level radioactive waste

After the 1981 postponement of a decision on the storage of high-level, the parliament established a new waste policy in 2001, which led to the foundation of the Nuclear Decommissioning Authority (NDA) in 2002. The government set up the commission on radioactive waste management (CoRWM) in 2003 to consider long-term waste strategy. This committee has to advise the government on all sorts of nuclear waste, of which "inspire public confidence" and "protect people and the environment" have been central principles.(*07)

The CoRWM released an advice in July 2006.(*08) The committee calls robust interim storage (100 years) and geological disposal as the end-point for all high and intermediate level waste. in deep underground after intensive research into the long-term safety of disposal. For the realization of the storage "voluntarism and partnership" is important: the local population should be willing to cooperate. The government adopted the recommendations of the CoRWM in October 2006 and initiated a new round of official consultations that would end in 2008. Nirex was wound up and the government-owned Nuclear Decommissioning Authority was given responsibility for the long-term management of all UK radioactive wastes.

Meanwhile, it became clear there was a more positive feeling about the construction of nuclear power plants. CoRWM found it necessary to emphasized that its opinion is about nuclear waste that already exists ('legacy waste'): with nuclear waste from new-build power plants other ethical and political aspects play a role than with the present waste. CoRWM states there was no distinction, technically. Both could be accommodated in the same stores and disposal sites. But creating new-build wastes was a choice, and there were alternatives. The political, social and ethical issues surrounding the deliberate creation of new wastes were therefore quite different from those arising from the inevitable need to manage the legacy.(*09) CoRWM argued that the waste implications of any new build proposals would need their own assessment process.

On 10 January 2008, the government announced plans for the construction of new nuclear power plants, followed by a new nuclear waste policy on 12 June 2008.(*10) The government indicated to make no distinction between waste, which is now simply inevitable, and waste from new power plants. The government said that principles of "voluntarism and partnership" are to be used in the selection process and calls on municipalities to present themselves to host a disposal facility. Most of the land in the UK is thought to be geologically suitable for the store.(*11)

Several members of the first CoRWM don't agree with the government. On a November 20, 2009, letter to the Secretary of State for Energy and Climate Change(*12), Ed Miliband, they stated that the government has reproduced the CoRWM report in an incorrect and distorted way. "*In conclusion we reiterate that we do not consider it credible to argue that effective arrangements exist or will exist either at a generic or a site-specific level for the long—term management of highly active radioactive wastes arising from new nuclear build.*" The members also protest against the fact that the government makes no distinction between unavoidable nuclear waste, which has been produced already, and new nuclear waste that can be avoid. "*However, it is clear that government has conflated the issue of new build with legacy wastes and thereby intends the CoRWM proposals to apply to both. No separate process, as suggested by CoRWM1, for new build wastes is contemplated. There will be no opportunity for communities selected for new nuclear power stations to consider whether they wish to volunteer to host a long term radioactive waste facility; it will simply be imposed upon them.*"

On 15 January 2010, the Scottish government said that nuclear waste must be just stored above ground at or close to existing nuclear facilities (in Dounreay, Hunterston, Torness and Chapelcross), reducing the need for waste to be transported long distances. A consultation exercise on the issue has been launched. Underground storage is not eligible because "Having an out of sight, out of mind policy is losing support." The strategy is at odds with the UK government's preferred option of storing nuclear waste deep underground.(*13)

In March 2010, the NDA published a report in which it states that "*a geological disposal facility will be available to receive ILW and LLW in 2040 and HLW and spent fuel in 2075*",(*14) but spending cuts could delay the plans, and community support is vital.(*15)

The government thinks this takes too long, and Energy Minister, Charles Hendry, asked NDA's Radioactive Waste Management Directorate (RWMD) to look at reducing the timescales for first emplacement of high level waste (currently 2075) as well as the dates for spent fuel and waste from new build power stations presently indicated to take place in 2130.(*16)

In a preliminary response to the Minister's request RWMD says: "There are fundamental principles that are critical to the success of the implementation of the geological disposal programme. These are: the vital role of voluntarism and partnership with local communities (…); and, the need for technical and scientific work necessary to underpin the safe disposal of radioactive waste to be done rigorously and to the required high standard."(*17) RWDM will evaluate and "*be in a position* *to consider whether or not changes to the programme would be realistic*" in December 2012. (*18)

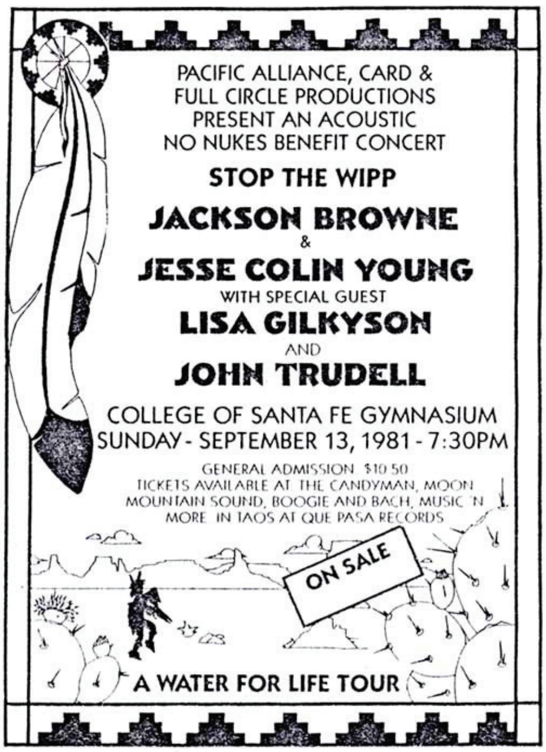
The long and tortuous story of UK radioactive waste policy demonstrates that achieving legitimacy around the management of these wastes is a social process with long time horizons. After 50 years of policies, institutional change and debate, extraordinarily little has been achieved in securing the long-term disposition of wastes.

UNITED STATES OF AMERICA

Nr. of reactors	first grid connection	% of total electricity
104	1957-10-19	19.25%

The U.S. nuclear waste management policy in the 1960s was focused on underground storage in salt. From 1987 on it was all about Yucca Mountain. In 2009 newly elected President Obama thwarted the plan and a commission was founded to study possible disposal: the nuclear waste policy is back to square one. Awaiting a final disposal facility, spent fuel is stored on site of nuclear power plants. U.S. nuclear utilities are eager to demonstrate that the spent fuel will not stay on-site indefinitely. Thus far, however, all efforts to establish central interim storage facilities have been unsuccessful.(*01) The U.S. dumped between 1949 –1967 in an unknown number of operations radioactive waste in the Atlantic Ocean, and between 1946-1970 in the Pacific Ocean. (*02) No commercial reprocessing has taken place.

No high-level radioactive waste in salt
Already in 1957 the National Academy of Sciences (NAS) called storage of nuclear waste in salt the best option.(*03) Also the Atomic Energy Commission developed plans in that direction. In 1963 test drilling in salt began at Lyons, Kansas for a national repository. Because this produced unfavorable results, one went to other places to drill in salt. Also without success.(*04)



Then the eye fell on salt at Carlsbad, New Mexico. The construction of the storage mine (called Waste Isolation Pilot Plant -WIPP) was expected to cost US$ 100 million in 1974,(*05) was cancelled by president Carter in 1980, but Congress restored budget to keep it alive.(*06) The storage would initially begin in 1988, but, although the underground facility was finished by then, because water leaked into the mine (*07) the start of disposal is delayed many times. (*08,09,10) The first waste arrived at WIPP on March 26, 1999. (*11) Construction costs were estimated at US$ 2 billion. (*12)
Around 64,000 m3 of waste – out of the maximum allowed quantity of 175,600 m3 - was stored by the end of 2009. Storage is planned to continue until the end of the 2020s when the maximum allowed capacity will be reached; the mine will be closed in 2038.(*13) It is the world's first geological repository. However, not all nuclear waste can be stored at WIPP. The U.S. government makes a distinction between nuclear waste generated from the production of nuclear weapons and nuclear waste generated by the production of electricity from nuclear power plants. In Carlsbad, the storage of low and high level radioactive waste (including spent fuel) from nuclear power plants for electricity production has been expressly prohibited by the government.(*14) However, one part of the radioactive waste from nuclear weapons production was allowed to go there. Generally, TRU (Transuranic) waste consists of clothing, tools, rags, residues, debris, soil and other items contaminated with radioactive elements, mostly plutonium.(*15)

In 1982, the government established the Nuclear Waste Policy Act. This Act gave states with possible locations an important role in the supervision on the choice of location, including federal funds for its own investigation into the suitability of the site, for an amount of US$10 million per year. States also had the power to prevent the storage. The NWPA mandated that the DOE select three candidate sites for a geological repository for U.S. spent fuel and high-level waste.(*16)
The government adapted the rules. In 1984, the DOE put salt lower on the list and a year later only one salt layer remained on the list: Deaf Smith, Texas.(*17) In 1986, the DOE nominated sites in Texas (salt), Washington state (basalt) and in Nevada's Yucca Mountain (volcanic tuff).(*17)
At the time, two of the most politically powerful members of Congress, the Speaker of the House and the House Majority Leader, represented Texas and Washington state respectively. They opposed siting the repository in their states. By comparison, the delegation from Nevada was politically relatively weak and so Yucca Mountain became the focus of attention.(*19) In 1987, therefore, Congress amended the Nuclear Waste Policy Act to direct that Yucca

Mountain would be the only site to be examined for suitability for the first U.S. Geological repository. (*US20) The 1982 NWPA had mandated that the second repository be in crystalline rock, i.e., in the eastern half of the country, where most of the country's power reactors are located. However, the 1987 amendments also instructed the DOE to "phase out in an orderly manner funding for all research programs … designed to evaluate the suitability of crystalline rock as a potential repository host medium." (*21)
To reassure Nevada that other states would ultimately share the burden of hosting the nation's radioactive waste, Congress also set a legal limit on the amount of radioactive waste that could be emplaced in Yucca Mountain "until such time as a second repository is in operation." The limit was established as "a quantity of spent fuel containing in excess of 70,000 metric tons of heavy metal or a quantity of solidified high level radioactive waste resulting from the reprocessing of such a quantity of spent fuel."(*22)

No high-level radioactive waste at Yucca Mountain
The implementation of the decision to dispose nuclear waste at Yucca Mountain did not go smoothly. "*Yucca Mountain is not selected through a scientific method, but through a political process,*" said Robert Loux. He worked for the government of the state of Nevada as a leader of the real estate developer for radioactive waste. "*The choice of the repository led to much resistance. The governor, congress delegates, local authorities and almost the entire population was against it.*" Yucca Mountain is located in an earthquake zone. Loux: "*There are 32 underground fractures and four young volcanoes. In the summer of 1992, an earthquake occurred with a magnitude of 5.4 on the Richter scale. This led to considerable damage. Therefore Yucca Mountain is unsuitable. The government of Nevada has made laws that prohibit the storage.*"(*23) In March 1998, a survey of the California Institute of Technology found that the risk of earthquakes and volcanic eruptions is larger than hitherto assumed.(*24)
The Yucca Mountain nuclear waste repository would have to come in operation in 2010, according to plans made in the 1980s. But it took until July 2002, when President Bush signed a resolution clearing the way for disposal at Yucca Mountain, (*25) and until June 2008 before the DOE applied for a permit to build the storage.(*26) President Barack Obama stopped the storage at Yucca Mountain, Nevada, in late February 2009,(*27) although DOE had spent US$14 billion (in 2009 dollars) from 1983 through 2008 for the Yucca Mountain repository. The construction of the storage mine and exploitation would have cost between US$41 and US$67 billion (2009 dollars) according to the U.S. Government Accountability Office (GAO).(*28) Obama finds Yucca Mountain unsuitable and unsafe for the disposal of radioactive waste and therefore "no option". A new strategy for the disposal of nuclear waste must be developed and on 29 January 2010, Obama appointed a commission to work out a new policy: the 'Blue Ribbon Commission on America's Nuclear Future'.(*29)

On 27 January 2012, after nearly two years of work, the Blue Ribbon Commission has issued its final recommendations for "creating a safe, long-term solution" for dealing with spent nuclear fuel and high-level radioactive waste. Efforts to develop a waste repository and a central storage facility should start immediately, it says. *"Put simply, this nation's failure to come to grips with the nuclear waste issue has already proved damaging and costly. It will be even more damaging and more costly the longer it continues."* It continued, "*The need for a new strategy is urgent, not just to address these damages and costs but because this generation has a fundamental, ethical obligation to avoid overburdening future generations with the entire task of finding a safe, permanent solution for managing hazardous nuclear materials they had no part in creating.*"(*30) Experience in the U.S. and in other nations suggests that any attempt to force a top down, federally mandated solution over the objections of a state or community - far from being more efficient - will take longer, cost more, and have lower odds of ultimate success. By contrast, the approach the commission recommends is explicitly adaptive, staged, and consent-based. In practical terms, this means encouraging communities to volunteer to be considered to host a new nuclear waste management facility while also allowing for the waste management organization to approach communities that it believes can meet the siting requirements. Siting processes for waste management facilities should include a flexible and substantial incentive program.(*31) On 31 January 2012, Energy Secretary Steven Chu said that the U.S. will likely need more than one permanent repository for commercial nuclear fuel.(*32) The U.S. nuclear waste policy is therefore back to square one. Except that there is no chance of returning to the option of salt domes or layers. This follows from the 2008 "Nuclear waste trust decision" of the U.S. government,(*33) stating: "*Salt formations currently are being considered as hosts only for reprocessed nuclear materials because heat-generating waste, like spent nuclear fuel, exacerbates a process by which salt can rapidly deform. This process could potentially cause problems for keeping drifts stable and open during the operating period of a repository".*

MULTINATIONAL APROACHES

Siting radioactive waste repositories is considered as one of the most difficult to solve problems in waste management, so one could think it would make sense for produces of radioactive waste and waste management organizations to limit the number of repositories. For politicians and waste management authorities, the idea of a shared repository is, at least intuitively, connected more to export than to import of waste. However, it could well be that international (sometimes referred to as 'regional') repositories, could increase the siting problem, in stead of easing it. The few initiatives so far all have had to cope with fierce local opposition, putting an end to those attempts.

Past initiatives
International repositories have been discussed at least since the early 1970s,(*01) but in the 1990 a number of initiatives made the headlines. In June 1997, in the openings speech of a IAEA symposium, Director General Blix said that international repositories should be 'examined'.(*02)
In 1995, the President of the Marshall Islands proposed hosting a storage and disposal facility, but the idea ran into strong opposition from other Pacific states and the United States. There was also fierce local opposition.(*03) The idea was dropped when the government changed.(*04)
Also in the mid 1990s, a U.S. based group, U.S. Fuel and Security, with support from the Russian Ministry of Atomic

Energy, initiated a scheme involving fuel storage on a Pacific Island — initially Wake Island and then later Palmyra Island. (*05) The scheme was met with strong opposition and was not pursued further. The Pacific Islands Forum, formerly the South Pacific Forum, a political grouping of sixteen independent and self-governing states in the Pacific, condemned the idea of using Palmyra as a "dumping ground for nuclear waste."(*06)

Pangea
A third project was initiated by organizations in several countries, including Pangea Resources, a British-based company. In November 1998 an anti-nuclear activist was given a video that promoted Australia as a site for an international nuclear waste dump. The video was produced by the US company Pangea Resources. It had been leaked to Friends of the Earth in the UK, and they had passed it on for release in Australia. The video extolled the virtues of a privately run, long term, high-level nuclear waste dump for outback South or Western Australia. The 15-minute video built an argument that nuclear waste is a problem that will not go away, that the best way of dealing with it is putting it somewhere in stable rocks, that these rocks must be away from population centers, in a country with strong democratic institutions, and that there are only a few places in the world where these conditions apply, and ... Australia seemed to be the best choice! Although the proposal had been on the table for several years, discussions had been behind closed doors. Until the "unauthorised" release of the video, Pangea's operations had been "private business."
Political opposition in Australia stopped further progress on the scheme. In 2002, Pangea Resources rebranded itself as ARIUS – the Association for Regional and International Underground Storage – and it is still scheming to build an international high-level nuclear waste dump.(*07)

Mongolia
Shortly after the Fukushima accident it became public that Japan and the United States had discussions with Mongolian officials, just before the March 21 accident, to jointly build a spent nuclear fuel storage facility in Mongolia to "serve customers of their nuclear plant exporters".(*08) This led the Mongolian authorities to issue a statement denying plans to bring nuclear waste to the country and pointing out that "Article 4.1 of Mongolia's law on exporting and banning import and trans-border shipments of dangerous waste unequivocally bans import of dangerous waste for the purpose of exploiting, storing, or depositing."(*09)
On September 13 Mongolian President Elbegdorj, in response to reports of ongoing secret talks with both Japan and the U.S., issued a presidential order banning negotiations and abandoning the plans. On September 21, President Elbegdorj once again affirmed in the United Nations General Assembly that "Construction plans in Mongolia will absolutely not be accepted."(*10)

European Union
For all countries, building a national repository is a major challenge and extremely expensive. Some countries are not even in the process of developing a national repository and are looking for ways to work together to address the common challenges. In Western Europe, one of the first initiatives to explore 'shares solutions' was formed in 1992.(*11) Lately, a number of countries in the European Union consider the option of shared repositories following the experience of the SAPIERR project (Strategic Action Plan for Implementation of European Regional Repositories). Since 2003 the EC has funded SAPIERR I and II.(*12) Based on the SAPIERR findings, a Working Group has been created in early 2009 to enable the establishment of a European Repository Development Organisation (ERDO), which would contribute to develop the concept of a shared repository as a complement to the national facilities being developed. Currently, Austria, The Netherlands, Poland, Slovakia, Italy, Lithuania and Slovenia participate in this Working Group. The ERDO-WG is a project managed by the national waste agency of the Netherlands, Covra, and the Arius Association on behalf of its Members. (*13) Arius, as noted above, was called Pangea until 2002.

In July 2011, the European Commission adopted a directive for disposing of spent fuel, including radioactive wastes from nuclear power plants and from medical and research facilities. It sets compulsory and legally enforceable standards for all European Union member states. It does not specify disposal strategies, but it does permit two or more member states to share a disposal facility and also allows exports of spent fuel and radioactive waste — but not to African, Caribbean, or Pacific countries.(*14)

ERDO model for Gulf states and SE Asia?
Arius has received grants from two charitable foundations in the USA to enable the Association to extend the concept of regional, multinational cooperation to other parts of the world. Arius has explored the feasibility of adapting and applying the ERDO model to other global regions and concluded that, of various possible areas worldwide, the regions that may show the most immediate promise and potential interest are the Arabian Gulf region and South-East Asia.(*15)

Dumping waste on the poor
As long as initiatives for regional repositories exist, opponents point out that it can turn out to be an ethically risky idea. Countries that up until now have indicated some potential interest in being a host, have always been weak states that are in urgent need for money and / or do not have a developed civil society. A connection between poverty and accepting foreign waste is an ethical concern and should not be allowed: the shift from commercial to voluntary cooperation could partly answer this concern, but the debate on compensation needs to be carefully guarded.

REFERENCES

Argentina:
*01- World Nuclear Association: *Nuclear Power in Argentina*, November 2011
*02- Republica Argentina: Third National report Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, 2008, section B-7
*03- Michael Alvarez Kalverkamp: *Argentina: Uncertainty about the nuclear future*, Heinrich Boell Foundation, 18 April 2011
*04- Greenpeace: *Argentina next nuclear dump for the world?,* 8 November 2002
*05- IAEA: *Country profile: Argentina*
*06- Republica Argentina, Section B-1

Armenia
*01- ANRA: *ANRA Regulatory Activity, Installations subject to Regulation and Legal Bases*, website, April 2012.
*02- ANRA: *Convention on Nuclear Safety, Fifth national report of the Republic of Armenia,* September 2010.
*03- ANRA: *Dry Spent Fuel Storage Facility,* website, April 2012

Belgium
*01- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999
*02- NIRAS: *Het beheer van het radioaktieve afval, vouwblad 7: De berging van het radioaktieve afval*, (The management of radioactive waste. Folder 7; the disposal of radioactive waste), Brussels, no date.
*03- Erik van Hove: *Accounting for Socio-economic Effects in Nuclear Waste Disposal Projects*, in: Nuclear Energy Agency, *"Informing the Public about Radioactive Waste Management",* Proceedings of an NEA International Seminar, Rauma, Finland, 13-15 June 1995, Paris, 1996, p 161-171
*04- NIRAS: press release, Brussels, 16 March 1998, p 3
*05- TV België-1: journaal (national TV-channel news) 19.00 hr, 28 June 1998
*06- NIRAS: *Informatiefiche*, Brussels, 2 March 1998
*07- Nuclear Energy Agency: *Radioactive Waste Management Programmes in OECD/NEA Member Countries*, Belgium, Paris, 25 May 1998
*08- NIRAS: *Informatiefiche*, Brussels, 2 March 1998, p. 11
*09- NIRAS: *Partnerschap staat centraal in nieuw werkprogramma van NIRAS*, (Partnership is central issue in new working program of NIRAS), press release, Brussels, 16 March 1998, p. 3-4
*10- NIRAS: *Het langetermijnbeheer van categorie-A afval* (2006) (The long-term management of Category-A waste)
*11- NIRAS: Final report *De berging, op Belgisch grondgebied, van laag- en middelactief afval met korte levensduur*, 2006 (The storage, on Belgian soil, of short lived low and intermediate level waste)
*12- NIRAS: *SAFIR Syntheseverslag* (SAFIR Synthesisreport), Brussels, June 1989, pp. 7 and 8
*13- NIRAS: *Naar een duurzaam beheer van radioactief afval* (Towards a durable management of nuclear waste), SAFIR 2 and it's context, report NIROND-2001-07N, 4 February 2002.
*14- NIRAS: Press release *Afvalplan* (Wasteplan) Brussels, 23 September 2011
*15- ONDRAF/NIRAS, Executive summary *Afvalplan voor het langetermijnbeheer van geconditioneerd hoogradioactief en/of langlevend afval en overzicht van verwante vragen,* September 2011. (Waste plan for long term management of conditioned high-level waste and/or long-living waste and overview of relevant questions) report NIROND 2011-04.
*16- Sigrid Eeckhout (NIRAS), email to Herman Damveld on 8 December 2009, 15.51 hr.

Brazil
*01- IAEA, *Brazil country report: 2006*
*02- we can find no information that suggests a location has been chosen –March 2012
*03- Nuclear Engineering International: *Nuclear power in Brazil,* 1 June 2010
*04- World Nuclear Association, *Nuclear Power in Brazil*, November 2011
*05- CNEN: *National report of Brazil 2011, for the fourth review meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management,* October 2011
*06- Nuclear Engineering International
*07- CNEN, 2011
*08- CNEN, *National report of Brazil 2008, for the third review meeting of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management,* October 2008

Bulgaria
*01- Sofia Echo: *Bulgaria selects consultant for radioactive waste depot*, 26 October 2011
*02- Wolfgang Neumann: *Nuclear Waste Management in the EU*, October 2010, p 35
*03- Republic of Bulgaria: *Fourth national report on fulfillment of the obligations on the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, October 2011, p.8-9
*04- World Nuclear Association: *Nuclear Power in Bulgaria*, March 2012
*05- Republic of Bulgaria, October 2011, p.49
*06- Reuters: *Bulgaria opens dry spent nuclear fuel depot*, 12 May 2011
*05- Republic of Bulgaria, October 2011, p.52, 75

Canada
*01- M.A. Greber, E.R. Frech and J.A. Hillier: *The Disposal of Canada's Nuclear Fuel Waste: Public Involvement and Social Aspects,* AECL Research, Whiteshell Laboratories, Pinawa, Manitoba, July 1994 (AECL-10712 COG-93-2); this report of 260 pages contains a detailed description of the debate in Canada until mid-1994
*02- C.J. Allan and M.A. Greber: *Social and Ethical Issues Surrounding the Disposal of Nuclear Fuel Waste - A Canadian Perspective*, AECL Research, Whiteshell Laboratories, Pinawa, Manitoba, 1995 (Technical Record TR-705 COG-95-405)
*03- Fred Roots: *Radioactive Waste Disposal - Ethical and Environmental Considerations - A Canadian Perspective*, in: Nuclear Energy Agency: *Environmental and ethical aspects of long-lived radioactive waste disposal*, Proceedings of an International Workshop organized by the Nuclear Energy Agency in co-operation with the Environment Directorate, Paris, 1-2 September 1994, p 71-93
*04- Kevin R. Ballard and Richard G. Kuhn: *Developing and Testing a Facility Location Model for Canadian Nuclear Fuel Waste*, in: Risk Analysis, Vol. 16, No. 6, 1996, p 821-832
*05- Robert Morrison and Peter Brown: *Radioactive Waste Management in Canada*, Proceeding of the Uranium Institute Annual Symposium 1991, September 1991, London, 1992
*06- PJ Richardson: *A Review of Benefits Offered to Volunteer Communities for Siting Nuclear Waste Facilities*, prepared for Dr. Olof Soderberg, Swedish National Co-ordinator for Nuclear Waste Disposal, March 1998, p 4
*07- *Nucleonics Week*, 28 September 1995, p 3 en 4
*08- *Nucleonics Week*, 9 January 1997, p 4 en 5
*09- *Nucleonics Week*, 22 January 1998, p 9
*10- Darrin Durant: *Radwaste in Canada: a political economy of uncertainty*, In: Journal of Risk Research, Volume 12, Issue 7 & 8, December 2009, p. 897 – 919.
*11- International Panel on Fissile Materials: *Managing Spent Fuel From Nuclear Power Reactors*, September 2011
*12- A. M. Aikin, J. M. Harrison, and F. K. Hare, *The Management of Canada's Nuclear Wastes, Report of a Study Prepared under Contract for the Minister of Energy, Mines and Resources Canada*, Federal Department of Energy, Mines and Resources, Government of Canada, Ottawa, Ontario, 1977.
*13- *Nucleonics Week*, 19 March 1998, p 8
*14- Report of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel: *Nuclear Fuel Waste Management and Disposal Concept*, Minister of Public Works and Government Services Canada, February 1998; published on 13 March 1998.
*15- Canadian Environmental Assessment Agency, Press release: *Government Releases Report of Panel Studying the Disposal of Nuclear Fuel Waste*, Ottawa, 13 March 1998.
*16- *Nucleonics Week*, 19 March 1998, p 8 en 9.
*17- NWMO: *NWMO 'Learn More' Program*, 13 November 2009. www.nwmo.ca/news?news_id=107&uniqid=2635
*18- World Nuclear News: *Search for Canadian Nuclear Waste Site*, 4 June 2010
*19- NWMO: *NWMO 'Learn More' Program - The Long-Term Management of Used Nuclear Fuel in Canada,* 13 November 2009
*20- The Globe and Mail: *Towns vie to be nuclear waste burial sites*, 14 January 2012

China
*01- World Nuclear Association: *China's Nuclear Fuel Cycle*, March 2012
*02- Hui Zhang: *On China's Commercial Reprocessing Policy*, paper presented at the Institute for Nuclear Materials Management 50th Annual Meeting, Tucson, Arizona, July 12-16, 2009
*03- Nucleonics Week: *EDF, AREVA Finalize Joint Ventures with Chinese Nuclear Companies*, 24 December 2009
*04- People's Republic of China: *National Report for Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, September, 2008, p.13
*05- World Nuclear Association, March 2012 A
*06- Yun Zhou: *China spent fuel management and reprocessing*, Working paper, March 2011
*07- Qiang Wang, China Needing a Cautious Approach to Nuclear Power Strategy, Energy Policy, Vol. 37 (2009)
*08- Nuclear Fuel: CNNC Favors Remote Site for Future Reprocessing Plant, 7 April 2008
*09- Ju Wang: *High-level radioactive waste disposal in China*, update 2010, Journal of Rock Mechanics and Geotechnical Engineering. 2010, 2 (1): 1–11
*10- Zheng Hualing and Ye Guo'an: *The Status and Prospect of Nuclear Fuel Cycle Back–End in China,* paper presented at the Atalante 2000 Conference on Scientific Research on the Back-End of the Fuel Cycle for the 21st Century, October 2000. p.9
*11- People's Republic of China, September, 2008, p.34-38

Czech Republic
*01- RAWRA: *Basic Information*, Company website
*02- Wolfgang Neumann, *Nuclear Waste Management in the EU*, October 2010, p. 38-40
*03- Wolfgang Neumann, October 2010
*04- Czech Republic: *National Report under the Joint Convention on Safety in Spent Fuel Management and Safety of Radioactive Waste Management*, March 2011, p.90

*05 -RAWRA: *Government moratorium ends; RAWRA intends to resume repository siting research*, Press release 17 December 2009
*06- RAWRA: *Working Group for Transparency of the Site Selection Process of a Deep Geological Repository was established in the Czech Republic*, Press release 26 November 2010
*07- Czech Republic, March 2011, p.91
*08- World Nuclear Association: *Nuclear Power in Czech Republic*, March 2012

Finland
*01- Nuclear Monitor, *Russian import of spent fuel imports stalled*, 16 July 2004
*02- Posiva Oy: company website, visited 6 April 2012
*03- Posiva Oy *Selecting the Site: the Final Disposal at Olkiluoto*, company website, April 2012
*04- Mark Elam en Göran Sundqvist: *The Swedish KBS project: a last word in nuclear fuel safety prepares to conquer the world?,* In: Journal of Risk Research**,** Volume 12 Issue 7 & 8 2009, December 2009, p. 969–988
*05- Posiva Oy, *General Time Schedule for Final Disposal*, website, April 2012
*06- NEA/OECD, *Radioactive Waste Management and Decommissioning in Finland*, 2011
*07- YLE (Finnish TV), 19 April 2010 and 25 May 2010.
*08- YLE: *Posiva: No room for Fennovoima waste in nuclear cave*, 4 October 2011
*09- World Nuclear News: *No room at the repository*, 9 March 2012. www.world-nuclear-news.org/WR-No_room_at_the_repository-0903127.html
*10- Swahn quoted in: House of Commons: *Memorandum submitted by the Nuclear Waste Advisory Associates to UK Parliament*, January 2010
*11- Mainpost: *Endlager in Bergstollen statt unter der Erde* (Repository in mountain tunnels, in stead of underground), 25 February 2011
*12- YLE: *Posiva: No room for Fennovoima waste in nuclear cave*, 4 October 2011
*13- IceNews: *Finland set to become long-term nuclear waste dump*, 29 August 2009

France
*01- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999
*02- Greenpeace: *Nuclear Waste Management: The lesson from the CSM disposal site*, 30 May 2006
*03- ANDRA: *The French National Radioactive Waste Management Agency,* May 2010, p.3
*04- International Panel on Fissile Materials: *Managing spent fuel from nuclear reactors*, 2011, p.38
*05- Yannick Barthe: *Framing nuclear waste as a political issue in France*, in: Journal of Risk Research, Volume 12 Issue 7 & 8 2009, p.941 – 954, December 2009.
*06- Republique Francaise: *Law no.91-1318 of December 30, 1991 on Radioactive Waste Management*, 30 December 1991, French version and English translation.
*07- Nuclear Fuel: *French waste negotiator takes up Pilgrim's staff*, 18 January 1993, p.14-15
*08- Nuclear Fuel, Citing pressure, Mayor of potential HLW laboratory site commits suicide, 31 January 1994, p 5 en 6.
*09- Nuclear Fuel: *France okays work on HLW lab sites, ending four year stay*, 17 January 1994, p 15-16
*10- Nuclear Fuel: *French court rejects request aimed at halting search for waste labs*, 29 December 1997, p.9-10
*11- Nuclear Fuel: *Eastern Mayors fight to keep ANDRA from building waste labs*, 22 September 1997, p.10
*12- Nucleonics Week: *French localities' vote vary on nuclear waste lab siting*, 24 April 1997, p. 13-14
*13- Nuclear Fuel: *French government gives itself a year to decide on waste labs*, 22 September 1997, p. 8-9
*14- Nuclear Fuel: *French committee signals shift in approach to long-term storage*, 13 July 1998, p. 11-12
*15- Nuclear Fuel: *ANDRA gets license for waste lab, court challenge from Greens*, 23 August 1999, p.14-15
*16- Nuclear Fuel: *French ministers okay waste lab at Bure but call for new granite site*, 14 December 1998, p.3-4
*17- Email Markus Pflüger to Herman Damveld, 5 December 2009.
*18- Republique Francaise: *The 2006 Programme Act on the Sustainable Management of Radioactive Materials and Wastes,* 28 June 2006
*19- ANDRA, ASN, CEA, IRSN: *Radioactive Waste Management Programmes in OECD/NEA Countries: France*, March 2012, p.16
*20- World Nuclear News, *Next phase for French geological disposal,* 5 January 2012

Germany
*01- International Panel on Fissile Materials, *Managing spent fuel from nuclear power reactors*, 2011, p.43
*02- Bulletin of the Atomic Scientists: *Nuclear Waste Repository Case Studies: Germany*, Michael Sailer, 29 August 2008
*03- IAEA: *Inventory of radioactive waste disposals at sea*, Tecdoc-1105, August 1999, p.34
*04- Nuclear Heritage: *Information about the Research Mine Asse II*, late 2008
*05- Ipsen, Kost, Weichler: *Analyse der Nutzungsgeschichte und der Planungs- und Beteiligungsformen der Schachtanlage Asse II,* University of Kassel, Germany, March 2010 p.17
*06- NRC Handelsblad, *'Opslag kernafval in zoutlagen kan heel goed'*, April 5, 1984.
*07- *Shaft ASSE II – a pilot project for nuclear waste storage in a mine shaft / the research mine for nuclear waste storage*, Chronology 1.11.2007
*08- Bundnis90/Die Grünen: *Asse-Chronik –Vom Umgang mit Atommüll in Niedersachsen*, Hannover, June 2009.
09- BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety): *Mehr Plutonium in Asse als bislang angenommen,* Press release 281/09, 29 August 2009
*10- Erstes Deutsche Fernsehen, Hartaberfair, 19 August 2009
*11- Bundesamt für Strahlenschutz, *Endlager Asse: ein Überblick,* August 2009
*12- Bundesamtes für Strahlenschutz: *Wie soll die Asse stillgelegt werden?,* Press release 29/09, 3 September 2009
*13- Bundesamtes für Strahlenschutz : *BfS stellt Ergebnis des Optionenvergleichs zur Schließung der Asse vor*, Press release 01/10, 15. January 2010:
*14- Frankfurter Rundschau: *Milliardengrab Asse,* 29 January 2010
*15- Umwelt-Panaroma: *Stromkonzerne sollen offenbar für Asse-Sanierung zahlen*, 6 February 2010
*16- Asse Einblicke: *Niemand weiss, wann das erste Fass geborgen wird*, 03/2010, May 2010, p4.
*17- Newsclick, *Lager für Asse-II Müll wird grosser*, 23 februari 2011
*Ge18- Asse Einblicke, *Gemeinsam tragen wir verantwortung*, nr. 13, May 2011, p 1
*19- Asse Einblicke, *Auf dem Prüfstand,* nr. 13, May 2011, p 1.
*20- Asse Einblicke, nr. 13, May 2011, p 2.
*21- Asse Einblicke, nr. 13, May 2011, p 2.
*22- Asse Einblicke, nr. 13, May 2011, p 1.
*23- Handelsblatt: *Atommüllager Asse, Opposition warnt vor Umweltdisaster*, 23 December 2011
*24- ZDF Heute, *Bleibt der Atommüll doch im Asse-Schacht?*, 23 December 2011
*25- Deutsche Bundestag: *Bundesregierung: Noch kein Zeitplan für Rückholung des Atommülls aus der Asse möglich*, 8 February 2012.
*26- Strom Magazin: *Rückholung von Atommüll könnte 40 Jahre dauern*, 13 February 2012
*27- Asse Einblicke: *„Jeder muss für sein Tun geradestehen"*, nr. 16, February 2012, p.1
*28- Deutsche Bundestag; Antwort auf eine Kleine Anfrage der Linksfraktion (16/9935), (answer on parliamentary questions) Bundestag, hib-Meldung, 2008_227/01, 8 August 2008
*29- Bundesamt für Strahlenschutz, *BfS trifft Vorsorge gegen möglichen Löserfall in Morsleben*" press release, 27 augustus 2009.
*30- Deutsche Bundestag; Antwort auf eine Kleine Anfrage der Linksfraktion (16/9935),(answer on parliamentary questions) Bundestag, hib-Meldung, 2008_227/01, 8 August 2008
*31- Elbe Jeetzel Zeitung: *Gorleben per Hand Nachgereicht*, 30 January 2010.
*32- Anselm Tiggemann, *Gorleben als Entsorgungs- und Endlagerstandort*, study commissioned by Lower Saxony ministry for Environment and Climate Protection, May 2010
*33- Jürgen Kreusch, *Ausarbeitung für den 1. Untersuchungsausschuss der 17. Wahlperiode (Gorleben-Ausschuss), Fragen und Antworten in Zusammenhang mit der Festlegung auf den Standort Gorleben und der Begründung zur untertägigen Erkundung (1979 – 1983),* Hannover, 10. June 2010
*34- Detlef Appel en Jürgen Kreusch, *Das Mehrbarrierensystem bei der Endlagerung radioaktiver Abfälle. Warum der Salzstock Gorleben nicht als Endlager geeignet ist*, 14 November 2006
*35- ZDF, Heute Nachrichten, 26 augustus 2009.
*36- CDU, CSU, FDP: *Koalitionsvertrag zwischen CDU, CSU und FPD*, 26 October 2009, p.21
*37- BMU: Bund und Länder einigen sich auf Endlager-Fahrplan, 15 December 2011
*38- ContrAtom: *Ein Jahr Gorleben-Epilog*, 12 February 2012
*39- Dadp, *Suche nach Atommüllendlager weiter offen*, 1 March 2012
*40- Bürgerinitiative Lüchow-Dannenberg: *Gorleben-gegner fordern Bau- und Erkundigungsstopp und den Abbruch der vorlaufigen Sicherheitsanalyse Gorleben ein*, 9 February 2012
*41-Süddeutsche Zeitung, *Debatte um Atom-Endlagerstandorte; Bund will Gorleben einmotten*, 23 March 2012

Hungary
*01- OECD: Radioactive waste management and decommissioning in Hungary, 2009
*02- IAEA: *Country Profile; Hungary*, NEWMDB reports
*03- WNN - Hungary inaugurates permanent waste repository, 9 October 2008
*04- PURAM: *The 11th medium and long-term plan of Puram*, May 2011, p.8
*05- PURAM, May 2011, p.12
*06- Republic of Hungary: *Second Report prepared in the framework of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, 2005, p.13
*07- PURAM, May 2011, p. 35-38

India
*01- World Nuclear Association: *Nuclear Power in India*, March 2012
*02- Upasana Choudhry: *Half life, Radioactive waste in India*, Heinrich Boell Stiftung, March 2009
*03- Deccan Herald: *India keen on having nuclear waste repository*, 14 February 2012
*04- World Nuclear Association, March 2012
*05- The Times of India, *Nuclear waste not an immediate problem for India: Ramesh*, 3 January 2011
*06- Bhabha Atomic Research Centre: BARC Highlights: Nuclear fuel cycle, 2007, ch.17
*07- Daily News and Analysis India, India scouting for sites to store nuclear waste, 14 February 2012
*08- Deccan Herald, 14 February 2012

Iran
*01- Nuclear Threat Initiative – *Country Profile: Iran*
*02- ISIS: Nuclear Iran, website, visited April 2012
*03- Ali Vaez, Charles D. Ferguson: *Towards Enhanced Safeguards for Iran's Nuclear Program*, FAS Special Report No. 2, October 2011, p.25, 28

Italy
*01- Energie e Innovazione: *I risultati dei referendum sull' energia*, November/December 1987
*02- WISE News Communique: *Nuclear power in Italy finished*,15 July 1988
*03- Italy: *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Second Italian National Report*, October 2008, p.5
*04- AFP: *Italy backtracks on nuclear waste decision after mass protests,* 27 November 2003
*05- OECD: *Radioactive waste management and decommissioning in Italy*, 2011, p.13-14
*06- Italy, October 2005
*07- OECD, 2011
*08- Nuclear Monitor: *No to nuclear power – Historic victory Italian referendum*, 17 June 2011 p.1

Japan
*01- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999
*02- World Nuclear Association, *Nuclear Power in Japan*, March 2012
*03- IPFM: *Managing spent fuel from nuclear power reactors*, 2011, p.54
*04- Japan: *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management National Report of Japan for the fourth Review Meeting,* October 2011
*05- Akahata Sunday Edition: *N-related money behind restart of N-waste storage facilities construction*, 2 October 2011
*06- Nuclear Monitor 716: *Two year delay for Rokkasho plant*, 24 September 2010, p.6
*07- Nuke Info Tokyo: *Japan's HLW disposal plan*, CNIC, March/April 1998
*08- Japan, October 2011, p.2
*09- Nuke Info Tokyo, March/April 1998
*10- Nuclear Waste Management Organization of Japan: *Siting Factors for the Selection of Preliminary Investigation Areas*, December 2002
*11- NUMO 2008: *Geological Disposal of Radioactive Waste in Japan,* July 2008, p.8
*12- NUMO: *Toyo town applies as a volunteer area for exploring the feasibility of constructing a repository for high-level radioactive waste*, Press release, 25 January 2007
*13- Aileen Mioko Smith: *The Failures of Japan's Nuclear Fuel Cycle Program 1956 – 2007, Green Action Japan*, May 2007
*14- no further applications are announced at the NUMO website, April 2012
*15- OECD: *National framework for Management and regulation of radioactive waste and decommissioning*, October 2011, p.9
*16- Green Action Japan: *Japanese nuclear power plant waste*, website, visited April 2012

Kazakhstan
*01- Togzhan Kassenova: *Kazakhstan's nuclear ambitions*, Bulletin of the Atomic Scientists, 28 April 2008
*02- T. Zhunussova, O. Romanenko, M. Sneve, A. Kim, I. Tazhibaeva, A.Liland: *Norway-Central Asia cooperation on nuclear safety and radiation protection. Regulations for radioactive waste handling for long-term storage and final disposal in Kazakhstan*, 2009
*03- Embassy of the Republic of Kazakhstan, accredited to Singapore, Australia and New Zealand: *Kazakhstan not to store other countries' nuclear waste - Minister of Ecology N. Ashimov*, 3 May 2011
*04- National Nuclear Security Administration: *Joint Statement By Co-Chairs of the U.S.-Kazakhstan Energy Partnership On Successful Completion of the U.S.-Kazakhstan BN-350 Spent Fuel Program*, 17 November 2010

Korea, Republic of
*01- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999, p.40
*02- OECD: *Radioactive waste management in Republic of Korea*, 2010, p.10
*03- World Nuclear Association, *Nuclear Power in South Korea*, March 2012
*04- OECD, 2010, p.
*05- World Nuclear Association, March 2012
*06- South Korea's nuclear energy development has been made possible by the ROK-U.S. Atomic Energy Agreement signed in 1972. The United States provided nuclear technologies and materials necessary for the peaceful use of nuclear energy; in return, South Korea was specifically prohibited from proliferation-related activities such as the reprocessing of spent fuel and uranium enrichment under the terms of the agreement. After three decades of successful bilateral nuclear cooperation, the two governments are due to renew the accord by 2014. See: Seongho Sheen: *Nuclear Sovereignty versus Nuclear Security: Renewing the ROK-U.S. Atomic Energy Agreement*, in The Korean Journal of Defense Analysis, Vol. 23, No. 2, June 2011, 273–288
*07- Nuclear Fuel: *Reprocessing cost might exceed KHNP's spent fuel management fees*, 13 July 2009, p. 1
*08- see for instance the case of Buan; Nuclear Monitor 591: *Massive actions against proposed South Korean waste dump*, 22 August 2003, p.5
*09- Seong-Kyung Cho and Jooho Whang, "Status and Challenges of Nuclear Power Program and Reflections of Radioactive Waste Management Policy in Korea," *2009 Advanced Summer School of Radioactive Waste Disposal with Social-Scientific Literacy*, Berkeley, CA, 3 — 10 August 2009
*10- Korea Herald: *Gyeongju wins vote for nuclear dump*, 3 November 2005
*11- World Nuclear Association, March 2012
*12- Seong-Kyung Cho and Jooho Whang, August 2009
*13- This is based on several South Korean news items in 2009, quoted in: IPFM, *Managing spent fuel from nuclear power reactors*, 2011, p. 68
*14- Republic of Korea: Korean Third National Report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, October 2008, p.91
*15- OECD, 2010, p.12
*16- Miles Pomper, Ferenc Dalnoki-Veress, Stephanie Lieggi, and Lawrence Scheinman: *Nuclear Power and Spent Fuel in East Asia: Balancing Energy, Politics and Nonproliferation*, Asia-Pacific Journal: 21 June 2010

Lithuania
*01- World Nuclear News: *Lithuania shuts Ignalina plant*, 4 January 2011)
*02- World Nuclear News: *Lithuanian project makes progress*, 30 March 2012
*03- Lithuania: *Joint Convention on the Safety of Spent Fuel and on the Safety of Radioactive Waste Management, Second National Report,* 2008
*04- Algirdas Vaidotas: *Radioactive waste management in Lithuania; implementation and strategies,* Deputy Director Radioactive Waste Management Agency (RATA), 4 November 2011

Mexico
*01- IAEA: *Country Profile Mexico*
*02- World Nuclear Association: *Nuclear Power in Mexico*, March 2012
*03- OECD: *Radioactive waste management programmes in OECD countries: Mexico*, 2005.
*04- Augusto Vera: *Laguna Verde Station approach to nuclear waste*, Comision Federal de Electricidad, 1993

*05- Javier Palacios H.: *Situación de los Desechos Radioactivos en México*, presentation at OLADE, 25-27 February 2010.

Netherlands:
*01- COVRA: *Beleid* (Policy), COVRA website http://www.covra.nl/over-covra/beleid.
*02- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999.
*03- Energie en Milieuspectrum: *Radioactief afval een eeuw onderdak* (Radioactive waste under a shelter for a century), March 1994
*04- Letter Minister Economic Affairs Lubbers and Minister of Public Health and Enviroment Vorrink to Gedeputeerde Staten (Executive Board) of Groningen and Drenthe, 18 June 1976. Reference 376/-II/1055/EEK.
*05- ICK-commissie; *Subcommissie Radioactieve Afvalstoffen (RAS), Eerste interimrapport betreffende de mogelijkheden van opslag van radioactieve afvalstoffen in zoutvoorkomens in Nederland,* (1977).(ICK-Commission Subcommission Radioactive Waste (RAS). First interimreport about possibilities for the disposal of radioactive waste substances in salt formations in the Netherlands.)
*06- *Atoomenergie,* July/August 1974, pp. 175-181.
*07- An anthology of press publications and comments on the disposal proposals can be found in: Meent van der Suis, *Energie en milieu in de Nederlandse krant 1968-1993,* (19933). (Energy and environment in the Dutch newspapers 1968-1993)
*08- Tweede Kamer, session 1979-1980, 15802, nrs. 11-12, p.160.
*09- Tweede Kamer, session 1984-1985, 18343, 6.
*10- Commissie Opberging te Land (OPLA): *Onderzoek inzake geologische opberging van radioactief afval in Nederland, Tweede Tussenrapport over Fase 1* (January 1986-January 1987), 1987. (Commission Storage on Land. Research for geological disposal of radioactive waste in the Netherlands. Second Interim report on Phase 1)
*11- Ministerie of Housing, Spatial Planning and Environment (VROM): *Basisnotitie ten behoeve van de ontwikkeling van een toetsingscriterium voor de ondergrondse opberging van radioactief afval (TOR),* (1987). (Basic notes for development of assessment criteria for the underground disposal of radioactive waste)
*12- Stichting Natuur en Milieu: *Reactie namens de hele Nederlandse milieubeweging op de zogeheten TOR-nota* (26 October 1987). (Reaction for the Dutch Environmental movement on the so-called TOR-notes)
*13- Tweede Kamer, session 1992-1993, 23163, nr 1.
*14- Ministry of VROM, Reference RB/2009040895, 30 June 2009
*15- Ministry of Economic Affairs, Agriculture and Innovation (EL&I): *Advice for guidelines for the Environmental Impact Report for the construction of a second nuclear power plant at Borssele*, 3 December 2009 / reportnumber: 2295-48
*16- COVRA press release: *Start OPERA program*, 5 July 2011
*17- OPERA: *Mutiannual program OPERA*, 5 July 2011.
*18- see picture (greenpeace brochure -blz 5, of website)
*19- Greenpeace campaign website http://www.greenpeace.nl/Nieuwsoverzicht-2012/Actie-roept-minister-Verhagen-op-ga-voor-schone-energie/#a0, (visited February 8, 2012)

Pakistan
*01- World Nuclear Association: *Nuclear Power in Pakistan*, March 2012
*02- Director General Nuclear Power Waste, PAEC: *Radioactive Waste Management Policy & Strategy of Pakistan*, September 2007
*03- Tariq Bin Tahir, September 2007
*04- Bymanzur Hussain, Directorate General National Repository PAEC: *Status of Radioactive Waste Disposal in Pakistan*, April 2008
*05- Pakistan Nuclear Regulatory Authority (PNRA): *Convention on Nuclear Safety, Report by the Government of the Islamic Republic of Pakistan for the Fifth Review Meeting, 2011*, September 2010

Romania
*01- Nuclear Agency & Radioactive Waste (AN&DR): *Romania Nuclear Power Sector Reverse Trade Mission September 6 - 16, 2010 United States of America*. Powerpoint presentation.
*02- European Commission: *Radioactive Waste and Spent Fuel Management in the European Union, Seventh Situation Report*, 22 August 2011, p.58
*03- Nuclear Agency & Radioactive Waste (AN&DR), September 2010
*04- Romania: *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, First National Report, March 2005

Russian Federation
*01- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999
*02- RIA Novosti, *National Operator for radioactive waste management has been appointed*, 2 April 2012
*03- Nuclear Fuel: *Russia on track to complete spent fuel facility by 2015*, 6 February 2012, 5
*04- World Nuclear News: *Russia commissions fuel storage facility,* 30 January 2012
*05- Nuclear Fuel, 6 February 2012
*06- World Nuclear Association: *Russia's Nuclear Fuel Cycle*, March 2012
*07- Tatyana A. Gupalo: *Creation of Underground Laboratories at the Mining-Chemical Complex and at Mayak to Study the Suitability of Sites for Underground Isolation of Radioactive Wastes*, published in: *An International Spent Nuclear Fuel Storage Facility*, The National Academies Press, 2005. p.240-247
*08- World Nuclear Association: *Russia's Nuclear Fuel Cycle*, March 2012
*09- Russian Federation: *The National Report of the Russian Federation on Compliance with the obligations on the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management*, October 2008, p.97-98
*10- International Panel on Fissile Materials: *Managing nuclear spent fuel from nuclear power reactors*, 2011, p.73
*11- Bulletin of the Atomic Scientists, *Managing nuclear spent fuel: Policy lessons from a 10-country study*, 27 June 2011

Slovak Republic
*01- UJD: *UJD SR established*, company website
*02- OECD: *Radioactive waste management programmes in OECD/NEA member countries*: Slovak Republic, 2005, p. 5
*03- Slovak Republic: *National Report of the Slovak Republic compiled in terms of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radwaste Management,* August 2011
*04- Slovak Republic: *Answers on questions on the National Report of the Slovak Republic*, April 2009
*05- Wolfgang Neumann, *Nuclear Waste Management in the EU*, October 2010, p. 72
*06- Slovak Republic, August 2011, p.95
*07- Slovak Republic, April 2009
*08- Wolfgang Neumann, October 2010

Slovenia
*01- Republic of Slovenia: *Fourth Slovenian Report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, October 2011*
*02- World Nuclear News: *Permanent store for Slovenian waste,* 15 January 2010
*03- Republic of Slovenia:, October 2011, p.14
*04- Wolfgang Neumann: *Nuclear Waste Management in the EU*, October 2010, p 75

South Africa
*01- World Nuclear Association: *Nuclear Power in South Africa*, December 2011
*02- Nesca: *South African National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, First National Report, October 2008, p.14
*03- Nesca, p.90
*04- Idaho Samizdat: SouthAfrica to reprocess spent nuclear fuel, 28 August 2008
*05- Engineering News: *High-level nuclear waste may be disposed of at Vaalputs*, 25 March 2009

Spain
*01- COWAM: *Nuclear Waste Management in Spain : El Cabril and on site storage*, COWAM European Concerted Action, February 2005
*02- Damveld/Van den Berg: *Discussion on nuclear waste: A Survey on Public Participation, Decision-making and Discussions in Eight Countries; Spain,* January 2000, p.65
*03: ENRESA: *Who we are*, company website, April 2012
*04- J.L. Santiago, J. Alonso, et al: *Geological disposal strategy for high level waste in Spain*, in: *Distec Proceedings, Conference on Disposal Technology*, Hamburg, September 1998, p. 206-211
*05- P. Richardson: *The Virtual Repository of Radwaste Information: Spain*, July 1997 (currently pay site).
*06- J.L. Santiago, J. Alonso, et al.
*07: WISE News Communique: *Spain: protests against possible radwaste storage site*, Nr. 489, 3 April 1998
*08- J.L. Santiago, J. Alonso, et al.
*09- OECD/NEA: *Radioactive waste management programmes in OECD/NEA Member countries: Spain*, 2005, p.4-5
*10- World Nuclear News: *Spain selects site for waste storage*, 3 January 2012

*11- World Nuclear Association: *Nuclear Power in Spain*, Update April 2012
*12- Deutschlandradio: *Ein spanisches Dorf jubelt, weil es Atommüll lagern darf* (A spanish town rejoices, because it can store nuclear waste), 16 February 2012
*13- Ee-news: *Spanien: Atommüll-Lager bringt den Fortschritt nicht* (Spain: nuclear waste storage does not bring progress), 21 March 2012
*14- Meritxell Martell Lamolla: *Identifying remaining socio-technical challenges at the national level: Spain*, InSOTEC Working Paper (Draft), 1 March 2012

Sweden
*01- See for an extensive historical overview of the waste problem in Sweden: Miles Goldstick et.al.: *Nuclear waste in Sweden –The problem is not solved!*, FMKK, August 1988
*02- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999
*03- SKB: *Our current facilities*, company website, visited April 2012
*04- Matthijs Hissemöller and Cees J.H. Midden, *Technological Risk, Policy Theories and Public Perception in Connection with the Siting of Hazardous Facilities*, Charles Vlek and George Cvetkovitch (eds), Social Decision Methodology for Technological Projects, Kluwer Academic Publishers, 1989, p. 173-194
*05- PJ Richardson, *Public Involvement in the Siting of Contentious Facilities; Lessons from the radioactive waste repository siting programs in Canada and the United States, with special reference to the Swedish Repository Siting Process*, Swedish Radiation Protection Institute, August 1997, p 26-27
*06- Nuclear Fuel: *Another Swedish community rejects repository*, 16 June 1997, p.17
*07- Nucleonics Week: Malaa voter rejection turns SKB back to plant sites for repository, 25 September 1997, p.15
*08- Marianne Löwgren: *Nuclear Waste Management in Sweden: Balancing Risk Perceptions and Developing Community Consensus*, in: Eric B. Herzik and Alvin H. Mushkatel, *Problems and Prospects for Nuclear Waste Disposal Policy*, Greenwood Press, Westport, Connecticut / London, 1993, p. 105-121
*09- Olof Söderberg: *Who Makes Which Decisions When?,* in Proceedings DisTec'98, Disposal Technologies and Concepts 1998, International Conference on Radioactive Waste Disposal, 9-11 September, Hamburg, pp. 633-639
*10- Nuclear Fuel: *New SKB head endorses cash incentives for repository host*, 9 March 1998, p. 8-9
*11- Mark Elam and Göran Sundqvist, *The Swedish KBS project: a last word in nuclear fuel safety prepares to conquer the world?*, In: Journal of Risk Research**,** Volume 12 Issue 7 & 8 2009, December 2009, p. 969–988
*12- Nuclear Fuel: Swedisch government gives SKB approval to study 3 sites for possible repository, 12 November 2001, p. 8
*13- Nuclear Fuel: *Tierp town council votes against site testing for Swedish repository*, 15 April 2002, p.10-11
*14: SKB: *SKB selects Forsmark for the final repository for spent nuclear fuel*, press release 3 June 2009
*15: SKB: *SKB turns in application for permit to build a final repository in Forsmark*, press release 17 March 2011
*16- World Nuclear Association: *Nuclear Power in Sweden*, February 2012
*17- SKB: *Our method of final disposal*, company website,
*18- Nils-Axel Mörner: *The Shameful Nuclear Power*, presentation 16 April 2008. See also: The uplift of Fennoscandia at: http://www.pog.nu/01research/1-2_fennoscandia.htm
*19- MKG: Copper corrosion, website MKG (Swedish NGO Office for Nuclear Waste Review)
*20- Technisch Weekblad, 21 November 2009
*21- Dr. Johan Swahn: *Considerations on nuclear waste management in Sweden*, presentation at the European Parliament's Committee on Industry, Research and Energy public hearing on management of nuclear waste, 1 December 2010
*22- Johan Swahn: *The Scandinavian Nuclear Waste Strategies*, MKG, Expert Hearing Greens in het European Parliament, 8 juni 2010, p.10
*23- World Nuclear News: *Swedish waste fees rise to reflect repository cost*, 10 October 2011

Switzerland
*01- ee News: *Beznau: Aeltestes AKW der Welt wird sichergerechnet*, 29 February 2012
*02– IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999, p.50
*03- Dutch Minister of Health and Environmental sanitation: *Zwitsers radioactief afval in IJmuiden* (Swiss radioactive waste in IJmuiden), Tweede Kamer 15 676 nr 2, 20 July 1979
*04- Nagra: *Entwicklung der Nagra 1972 bis 1980* (Development of Nagra 1972-1980), company website, visited April 2012-04-09
*05- Damveld/Van den berg: *Discussions on nuclear waste*, Laka Foundation, 2000, p.103
*06- Nagra: *Opalinus Clay Project. Demonstration of feasibility of disposal ("Entsorgungsnachweis") for spent fuel, vitrified high-level waste and long-lived intermediate-level waste,* December 2002, p.7
*07- M. Fritschi: *Standortwahl*, (Site selection) in: Nagra Informiert, Nr. 24, June 1994, p.6-12
*08-Luzerner Neuste Nachrichten: *Nagra scheitert am Wellenberg*, (Nagra fails at Wellenberg) 26 June 1995
*09- Nagra Report: *Was halten die Nidwaldner von Wellenberg?* (What does population of Nidwalden think of Wellenberg?), Nr. 1/1996, p. 2-3
*10- Nucleonics Week: *New Wellenberg studies confirm its safety and feasibility,* 24 September 1998, p. 9-10
*11- Nagra News: *Sondierstollen in Wellenberg abgelehnt –Wie geht es weiter?* (Exploratory tunnels in Wellenberg rejected –How to continue?), December 2002, p.1
*12- NEA/OECD: *The control of safety of radioactive waste management and decommissioning in Switzerland*, 2011
*13- Nagra: *Zeit zum Handeln*, (Time to act), November 2008
*14- Allianz Nein zu neuen AKW: *Nidwalden will keinen Atommüll – Atomstrom schon* (Nidwalden does not want nuclear waste, but nuclear electricity), 14 February 2011
*15: Das Schweizer Parlament: *Curia Vista, Zusammenfassung: 01.022; "MoratoriumPlus" und "Strom ohne Atom". Volksinitiativen und Kernenergiegesetz*
*16- Neue Zürcher Zeitung, "Das nationale Endlager wird zur lokalen Frage; Neuartiges Partizipationsverfahren zur Atommüll-Tiefenlagerung"; 10 december 2009
*17- Tagesanzeiger, "Nagra zahlt für Endlager-Regionen", 5 december 2010
*18- Nagra: *Zeit zum Handeln*, November 2008
*19- Energie & Umwelt: *Das Atommuellproblem ist nicht geloest* (The nuclear waste problem has not been solved), Schweizerische Energie Stiftung, 3/20, May 2010
*20- Bundesrat: *Standortsuche für geologische Tiefenlager: Bundesrat legt sechs Gebiete fest und startet Etappe 2* (Search for geological disposal sites: Federal Council sets six sites and starts Stage 2), 1 December 2011
*21- Schweizerische Energie Stiftung: *Die 12 ungelösten Fragen der Schweizer Atommüllentsorgung*, (The 12 unanswered questions about the Swiss radioactive waste disposal), December 2011
*22- Schweizerische Energie Stiftung: *Atommüll-Fragen müssen jetzt geklärt werden* (Radioactive waste questions must be answered now), 9 January 2012
*23- Neue Zürcher Zeitung: *Endlager-Standorte haben keine Garantie auf Entschädigung* (Final disposal sites have no right for compensation), 6 March 2012

Taiwan
*01- Atomic Energy Council: *High Level Radioactive Waste Final Disposal,* 1 April 2011
*02- Taiwan: *National Report under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management,* June 2007
*03- Atomic Energy Council: *Lan-yu Storage Site status*, February 2012
*04- Nuclear Fuel: Long-Term Spent Fuel Dilemma at Issue in Taiwan-U.S. Renegotiation, Nuclear Fuels, June 1, 2009.
*05- Nuclear Fuel: *Taiwan Rejected Chinese Offer of Fresh Fuel for Waste Disposal*, 20 April 1998
*06- Nuclear Fuel: *Taiwan to Wait on U.S.-Russian Deal Before Taking Spent Fuel Initiative*, 9 July 2001
*07- Atomic Energy Council, 1 April 2012

Ukraine
*01- World Nuclear Association, *Nuclear Power in Ukraine*, February 2012
*02- K.G. Kudinov: *Creating an Infrastructure for Managing Spent Nuclear Fuel*, in Glenn E. Schweitzer and A. Chelsea Sharber, ed., *An International Spent Nuclear Fuel Storage Facility-Exploring a Russian Site as a Prototype*, National Academies Press, 2005, pp. 145-151
*03- David G. Marcelli and Tommy B. Smith: *The Zaporozhye ISFS*, Radwaste solutions, Jan/Febr 2002
*04- International Panel of Fissile Materials: *Managing spent fuel from nuclear power reactors*, 2011
*05- World Nuclear Association, February 2012
*06- Business wire: *Energoatom and Holtec International Formalize the Contract to Build a Central Storage Facility in Ukraine*, 30 December 2005
*07- World Nuclear Association, February 2012
*08- Ukraine: *Ukraine National Report on Compliance with the Obligations under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management,* September 2008, p.48-49
*09- EBRD: *Chernobyl: New Safe Confinement and Spent Fuel*

Storage Facility, March 2011
*10- Ukrinform: *Talks on construction of storage facility for spent nuclear fuel to be completed in April*, 28 March 2012
*11- Foratom: *Ukrainian Nuclear Forum Association*, 28 February 2012
www.foratom.org/associate-members/ukraine.html
*12- World Nuclear Association, February 2012

United Kingdom
*01- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999, p53
*02- Low Level Waste Repository Ltd: http://www.llwrsite.com
*03- Gordon MacKerron and Frans Berkhout: *Learning to listen: institutional change and legitimation in UK radioactive waste policy*; in: Journal of Risk Research**,** Volume 12 Issue 7 & 8 2009, December 2009, p. 989 – 1008.
*04- John Knill: *Radioactive Waste Management: Key Issues for the Future*, in: F. Barker (ed), *Management of Radioactive Wastes. Issues for Local Authorities*. Proceedings of the UK Nuclear Free Local Authorities Annual Conference 1997 held in Town House, Kirkcaldy, Fife, on 23 October 1997, Publisher Thomas Telford, London, 1998, p 1 - 17.
*05- Gordon MacKerron and Frans Berkhout
*06- NDA: *Strategy for the management of solid low-level radioactive waste from the nuclear industry*, August 2010
*07- Department for Trade and Industry (DTI): *Managing the Nuclear Legacy: a Strategy for Action,* CM 5552, HMSO, London, July 2002.
*08- The Committee on Radioactive Waste Management: *Managing our Radioactive Waste Safely,* CoRWM's recommendations to Government, Doc 700, HMSO, London, July 2006
*09- The Committee on Radioactive Waste Management: *Reiteration of CoRWM's Position on Nuclear New Build,* Doc 2162.2, HMSO, London, September 2007
*10- Defra/BERR: *Managing Radioactive Waste Safely: A Framework for Implementing Geological Disposal,* Cm 7386, HMSO, London, June 2008.
*11- World Nuclear News: *Waste Plan Revealed*, 12 June 2008
*12- Blowers, MacKerron, Allan, Wilkinson, Pitt and Pickard: *New Nuclear Build and the Management of Radioactive Wastes*, Letter to Secretary of State from Former Members of CoRWM, 20 November, 2009
*13- BBC News: *Nuclear waste storage options examined*, 15 January 2010
*14- NDA: *Geological Disposal, Steps towards implementation*, March 2010 p.24
*15- BBC News on line: *Budget cuts caution on UK nuclear waste plan*, 7 July 2010
*16- NDA, *Review of timescales for geological disposal of higher activity radioactive waste*, 22 December 2011
*17- NDA: *Geological Disposal. Review of Options for Accelerating Implementation of the Geological Disposal Programme*, December 2011
*18- NDA, *Review of timescales for geological disposal of higher activity radioactive waste*

United States of America
*01- IPFM: *Managing spent fuel from nuclear power reactors,* 2011, p.106
*S02- IAEA: *Inventory of radioactive waste disposals at sea*, IAEA-Tecdoc-1105, August 1999
*03- Department of Energy: *WIPP Chronology,* 5 February 2007
*04- For a detailed discussion on the history of the plans for the storage of nuclear waste in the U.S. we refer to: 1- Ronnie Lipschutz: *Radioactive Waste: Politics, Technology and Risk*, Cambrigde USA, 1980; 2- A.A. Albert de la Bruhèze, *Political Construction of Technology. Nuclear Waste disposal in the United States, 1945-1972*, WMW-publication 10, Faculteit Wijsbegeerte en Maatschappijwetenschappen Universiteit Twente, Netherlands, 1992; 3- Roger E. Kasperson, *Social Issues in Radioactive Waste Management: The National Experience*, in: Roger E. Kasperson (ed), Equity Issues in Radioactive Waste Management, Oelgeschlager, Gunn & Hain Publishers, Cambridge, Massachusetts, 1983, chapter 2.
*05-World Watch: *WIPP-Lash: nuclear burial plan assailed*, Vol 4, No 6 , Nov/Dec 1991, p.7
*06- Science: *Radwaste dump WIPPs up a controversy*,19 March 1982
*07- US Guardian weekly: *Pilot waste dump is already in trouble*, 12 October 1988
*08- Nucleonics Week: *WIPP moves toward 1993 waste tests, senate okays bill in 11th hour*, 15 October 1992. p 8
*09- WISE News Communique: *US DOE delays (abandons?) giant waste projects*, no 389, 19 November 1993, p 6
*10- WISE News Communique, *US: WIPP is delayed again and again…*, no. 496, 21 August 1998, p 2
*11- WISE News Communique: *First waste at WIPP, but problem not solved,* no 508, 9 April 1999
*12- Nuclear Fuel: *After two decades and $2billion, DOE targets spring for WIPP operations*, 9 March 1998, p 6-7
*13- Waste Isolation Pilot Plant: *Renewal Application Chapter 1, Closure Plan*, May 2009
*14- WIPP: Why WIPP, 5 February 2007
*15- Luther. J. Carter, *Waste Management; Current Controversies over the Waste Isolation Pilot Plant*; in: Environment, Vol. 31, no. 7, September 1989, p 5, 40-41
*16- Ralph. L. Keeney and Detlof von Winterfeldt: *Managing Waste from Power Plants*, in: Risk Analysis, Vol. 14, No. 1, 1994, pp 107-130.
*17- Department of Energy: *Mission Plan for the Civilian Radioactive Waste Management Program*, June 1985, Volume 1, p 41
*18- Department of Energy: *A Multi-attribute utility analysis of sites nominated for characterization for the first radioactive waste repository – A decision aiding methodology*, DOE/RW-0074, 1986
*19- IPFM: *Managing spent nuclear fuel from power reactors*, 2011, p.109
*20- United States of America Congress: Nuclear Waste Policy Act of 1982, The Act was extensively amended on 22 December 1987, Sec. 160
*21- NWPA, Sec. 161
*22- NWPA, Sec. 114, d
*23- Interview Robert Loux by Herman Damveld, in: Herman Damveld, Steef van Duin en Dirk Bannink: *Kernafval in zee of zout? Nee fout!* (Nuclear waste in sea or salt? No wrong!), Greenpeace Netherlands, 1994, p. 29-30
*24- Nuclear Fuel: 6 April 1998, p 13.
*25- Reuters: *Bush clears way for Yucca Mountain nuclear waste dump*, 23 July 2002
*26- Barry D. Solomon: *High-level radioactive waste management in the USA*, in: Journal of Risk Research, Volume 12 Issue 7 & 8 2009, p. 1009–1024
*27- World Nuclear News: *Obama dumps Yucca Mountain*, 27 February 2009
*28- Government Accountability Office: *Nuclear Waste Management. Key attributes, challenges, and costs for the Yucca Mountain repository and two potential Alternatives*, GAO-10-48, November 2009. p.19
*29- World Nuclear News: *Post-Yucca nuclear waste strategy group*, 1 February 2010. One issue that will not be on the table is the exact location of any eventual waste facilities. The 'Blue Ribbon Commission on America's Nuclear Future' is only to consider strategy, not implementation
*30- World Nuclear News: *Immediate action needed on US waste policy*, 27 January 2012
*31- Blue Ribbon Commission: *Report to the Secretary of Energy*, 26 January 2012
*32- Platts: *More than one permanent US nuclear repository likely needed: Chu*, 31 January 2012
*33- Nuclear Regulatory Commission: *Waste Confidence Decision Update*, 9 October 2008, p. 59555

Multination approaches
*01- Bulletin Of The Atomic Scientists: *Putting Radioactive Waste on Ice: A Proposal for an International Radionuclide Depository in Antarctica*, January 1973
*02- Nuclear Fuel: *Examine international repositories, Blix urges fuel cycle symposium*, 16 June 1997, p.15-16
*03- Pacific News Bulletin: *Marshall Islands: Nuke waste dump concerns*, June 1997
*04- Giff Johnson: *Marshalls put a freeze on N-waste plans*, Marshall Islands Journal, June 1997
*05- Der Spiegel: *Ab auf die Insel* (Away, on the island), 15 July 1996
*06- Ken Silverstein: *Nuclear Burial in the Pacific*, The Progressive, Vol. 61, No. 11, November 1997, pp. 32-34.
*07- More information, and the video, is available at: www.foe.org.au/anti-nuclear/issues/oz/import-waste
*08- Reuters: *Japan, U.S. plan nuclear waste storage in Mongolia –paper*, 8 May 2011
*09- Embassy of Mongolia in Vienna, Press release, 10 May 2011, www.embassymon.at/news/emb_news_53.html
*10- News Watch 145: *Mongolian government drops nuclear disposal site plans*, CNIC, Nov/Dec 2011
*11- Nuclear Fuel: *Groups in western-Europe looking at idea of regional waste solutions*, 28 September 1992, p.3-4
*12- E. Verhoef, C. McCombie, N. Chapman: *Shared, regional repositories: developing a practical implementation strategy*, 2009
*13- ERDO Website: www.erdo-wg.eu
*14- European Council: *Council Directive 2011/70/Euratom establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste*, Brussels, 19 July 2011
*15- Arius website: www.arius-world.org/

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As the authors describe in this worldwide overview, non of the roughly 34 countries with spent fuel (reprocessed or not) from nuclear power reactors have a final disposal facility, be it in deep geological formations or (near) surface. A very large majority of those countries are not even close. Some postpone the need for final disposal by long term interim storage of up to 100 years; and other countries use (the future option of) reprocessing as an alibi for postponing that decision. However, fact is that the problem of final disposal of high-level radioactive waste and/or spent fuel has not been solved, more than half a century after the first commercial nuclear power plants entered into operation and used fuel was unloaded from the reactors.

As this worldwide overview of the state of affairs shows, siting radioactive waste repositories is seen as one of the main problems due to socio-political circumstances. Almost without exception, all radioactive waste management programs state that this generation must solve its own problems and not lay the burden of solving the waste problem on the next generations. But those same programs propose, again almost without exception, to postpone a decision on final disposal and/or reprocessing into the far-future, and consider interim storage.

The experiences of Asse in Germany or La Manche in France show that even low and intermediate-level radioactive waste disposal for a few decennia is not without trouble; imagine the 'challenges' of disposal of much more dangerous high-level waste for many millennia.

What will be obvious after reading this unique overview of (the lack of) waste management programs in 34 countries, is that the problem of permanent disposal of nuclear fuel is not solved!

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