DECOMMISSIONING OF NUCLEAR FACILITIES IN GERMANY - STATUS AT BMBF SITES

R. Papp
Forschungszentrum Karlsruhe GmbH
P.O. Box 36 40, D-76021 Karlsruhe

K. Komorowski
Bundesministerium fuer Bildung und Forschung
P.O. Box 20 02 40, D-53170 Bonn

ABSTRACT

In a period of approximately 40 years prior to 1994, the German Federal Government had spent about € 15 billion to promote nuclear technology. These funds were earmarked for R&D projects as well as demonstration facilities which took up operation between 1960 and 1980. These BMBF (Federal Ministry for Research) facilities were mainly located at the sites of the federal research centers at Juelich and Karlsruhe (the research reactors AVR, FR2, FRJ-1, KNK, and MZFR, the pilot reprocessing plant WAK) but included also the pilot plants SNR-300 and THTR-300 for fast breeder and high-temperature gas-cooled reactor development, respectively, and finally the salt mine Asse which had been used for waste emplacement prior to conversion into an underground research laboratory. In the meantime, almost all of these facilities were shut down and are now in a state of decommissioning and dismantling. This is mainly due to the facts that R&D needs are satisfied or do not exist any more and that, secondly, the lack of political consensus led to the cancellation of advanced nuclear technology.

BACKGROUND

Since the announcement of the first nuclear program (Atomprogramm) in 1956, nuclear R&D in Germany has been supported by the Federal Government under four nuclear programs and later on under more general energy R&D programs. The original goal was to help German industry to achieve safe, low-cost generation and self-sufficiency in the various branches of nuclear technology, including the fast breeder reactor and the fuel cycle. Several national research centers were established and prototype plants were built, among them the SNR-300 fast breeder reactor, the THTR-300 thorium reactor, the WAK reprocessing plant and, finally, the Asse salt mine was converted into an R&D facility. From the total construction cost the Federal government's share was slightly above 50%, bringing the total Federal funding spent on nuclear R&D since 1956 to about € 15 billion.

Since about the end of the 1980s nuclear power plants have generated roughly 1/3 of the electricity in Germany. This is still the case even though, after the last Parliamentary Election in 1998, the nuclear policy of the new government has changed drastically. This deserves a brief departure from the main theme. Nuclear policy is now aimed at banning construction of new nuclear power plants and limiting the lifetime of operating ones.

Leaders of Germany's federal government and of the nuclear utility industry in June 2001 formally signed the nuclear energy phase-out accord the two sides had negotiated one year earlier. According to that agreement all power reactors will be shut down after they will have generated a total of about 3000 TWh (which is about the same electric energy as produced since the beginning of nuclear power generation in Gemany approximately 30 years ago). The agreement does not specify a date for shutting any individual reactor or date when the last reactor will close, but entitles the reactor operators to transfer or trade each reactor's allotment to other reactors. Thereby, bigger and newer units may stay on-line beyond the 32-year reactor lifetime the agreement is based on, at the expense of smaller and older units.

This new policy includes the restriction of spent fuel management to direct disposal after 2005. Up to this date, reprocessing in France and Great Britain is permitted. Simultaneously, the utilities are building intermediate storage facilities for spent fuel at the reactor sites, so that by 2005 shipments of spent fuel – either to reprocessing plants or to centralized storage facilities – become superfluous.

Before focussing on the status of decommissioning, one last essential of this new policy should be addressed briefly, the on affecting Gorleben, the proposed repository site. As a reminder, the Gorleben salt dome was explored between 1979 and 2000 with respect to its suitability as a repository for HLW and spent fuel. In October 2000, a moratorium was imposed, halting its exploration for at least 3 years and a maximum of 10 years. In the meantime, the suitability of new sites to accommodate a repository is to be examined. It is the Government's goal to have one single repository for all sorts of radioactive waste operation around the year 2030, without limiting the site selection process to one specific host rock formation (such as formerly rock salt).

To this end BMU, the Federal Ministry of the Environment, established AK-End, a group of experts whose mandate it is to develop a comprehensive site selection process within about 4 years, i.e., by the end of 2002. AK-End's major task is to come up with a set of site selection criteria and a step-by-step process in which is specified how to proceed with respect to comparative site selection.

For decommissioning of nuclear facilities in Germany responsibility is three-fold: Firstly, electric utility companies are responsible for the nuclear power plants. Secondly, as laid down in the German Reunification Treaty, the Federal Ministry of Economics is in charge of the decommissioning projects in the former German Democratic Republic (e.g., the Greifswald and the Rheinsberg power plants and the Wismut mine which had formerly provided the uranium for the Soviet nuclear weapons program). Finally, there are the facilities within the responsibility of the Federal Ministry for Education and Research (BMBF), i.e., eight reactors, the Karlsruhe reprocessing plant WAK, the Asse salt mine and several hot cells and laboratories located at the sites of the national research centers. Their various stages of decommissioning are the essence of this presentation. Decommissioning became necessary not primarily due to technical problems but because of various other reasons such as:

- The facilities, especially those in the research centers, became obsolete and there was no more need for further R&D.

- The lack of consensus among the major German players on nuclear policy issues led to a phase-out of three main projects at the end of the 1980s: the prototype reactors SNR-300 and THTR-300 as well as the Wackersdorf reprocessing plant. Consequently, there was no need to operate the respective pilot plants, KNK, AVR, and WAK. As provisions for decommissioning are usually accumulated over the planned service life of a facility, the funds set aside for these facilities were not sufficient to cover the decommissioning costs. The lack of consensus in nuclear policy in some cases necessitated early decommissioning, causing premature financial liabilities.

- Safety concerns voiced by the authorities, e.g. in the case of the Asse underground laboratory. This also applies to the VVER reactors in East Germany which either were shut down during operation or were not completed.

BMBF's decommissioning strategy in some cases consists of a speedy return to green field sites. The rationale behind this approach is based mainly on three concerns, public acceptance, the working personnel, and costs. BMBF is convinced that by way of this strategy public acceptance of nuclear energy will not be further impaired. Additionally, the Ministry is concerned about the so-called "Fadenriss", i.e., the loss of technological capability, in case existing personnel are not assigned to dismantle facilities with which they are familiar.

Cost reductions, finally, have to be pursued without compromising safety and environmental standards. In many cases comparison between safe enclosure and total dismantling of reactors reveals about equal costs. Still, this result cannot totally be generalized as there is a clear dependence on the structure of direct and indirect costs.

FINANCING OF DECOMMISSIONING PROJECTS

Costs which an organization or company is expected to meet in the future as a consequence of current and past activities are generally referred to as future financial liabilities. Beside waste management and disposal, future financial liabilities arising from nuclear activities mainly include decommissioning of facilities. In all the countries that rely on nuclear energy, various schemes have been adopted to guarantee the availability of funds for these liabilities. These schemes differ from country to country depending on whether or not the fund is centrally controlled, and whether or not the responsibility for management of the liabilities rests with a central organisation (1).

For the decommissioning of facilities under the auspices of the German Federal Government no specific funds are generally set aside during their operating life-time. In order to assure financing of decommissioning projects, however, long-term cost commitments are accounted for in the Federal budget. To give an example, for decommissioning of the WAK reprocessing pilot plant at the site of the Karlsruhe Research Center, a special fund has been established into which the electric utility industry paid a lump sum and payments are made regularly by the State (Baden-Wuerttemberg) and BMBF.

This differs from the way liabilities are dealt with by German industry. German commercial law requires that money is set aside annually during the operating life-time of a facility. In addition, Germany is an example of decentralized control with regard to liabilities. Responsibility for the fund is retained by the owner of the facility who has to follow accepted accounting standards when preparing annual accounts. The operator/owner of the facility has to justify the provisions to supervisory boards. For plant decommissioning the provisions are accumulated over 19 years beginning at commercial start-up. At the end of the 1990s German electric utility companies reportedly showed a reserve fund of approximately € 30 billion in their balance sheets for their back-end liabilities, i.e., spent fuel and waste management as well as decommissioning.

PROJECT STATUS

Concerning the decommissioning projects under BMBF's responsibility mentioned above, € 100-150 Mill per year from the federal budget in addition to the payments from private industry will have to be allocated to these projects in future years in order to ensure that progress will be made. In Table I details are given for these facilities where BMBF is the lead agency. Although it is widely known, it deserves mentioning that the cost data contain some uncertainty which, not the least, are attributable to licensing problems. It was not until 1976 that legislation regulating nuclear energy was amended in order to become applicable to decommissioning. By this time nuclear power in Germany was only at one third of the current level and the new law brought in regulations that were strongly biased by the construction and operation aspects of the existing nuclear facilities. These regulations

Table I. BMBF's Decommissiong Projects

	Facility	Reason for Shutdown	Decommissioning Goal, Year	BMBF Funding	
				€ Mill.	% of Total
Karlsruhe	WAK reprocessing	national reprocessing given up	Total Removal, 2009	900	50
	FR2 reactor	end of operating life time	Safe Enclosure, 1997	50	90
	KNK reactor	FBR development given up	Total Removal, 2005	210	90
	MZFR reactor	end of operating life time	Total Removal, 2005	230	100
	HDB waste cond., storage	end of operating life time	Total Removal, 2015	90	90
Juelich	AVR reactor	termination of HTR experiments	Safe Enclosure, 2003	140	90
	FRJ-1 et al. reactor	end of operating life time	Total Removal, 2010	30	90
Other Sites	KKN reactor	technology not promising	Green Field, 1996	130	100
	HDR reactor	technology not promising	Green Field, 1999	40	100
	SNR-300 reactor	FBR development given up	Fuel Removal	80	100
	THTR-300 reactor	no licence to resume operation	Safe Enclosure, 1997	45	50
	ASSE mine	stability of mine	Backfilling, 2004	150	100

even tend to overlook the reduced nuclear inventory and, consequently, the reduced hazard potential of a given dismantling project after the fuel has been removed. Current regulations seem to offer sufficient maneuverability so that adjustments, long overdue, will better serve the real needs of decommissioning projects.

Concerning labor as an important cost factor, utility companies strongly rely on their own staff and in-house capabilities. For the national research centers, on the other hand, which have tended to hire outside contractors, ways should be found which enable them to employ their own personnel for onsite decommissioning projects.

The costs for the individual projects in Table I add up to about € 3 billion, € 2 billion of which are BMBF's share.

Closure of the **Asse-mine**: This mine will be decommissioned and sealed in a 2-step process. First, at an estimated cost of more than € 150 Mill the large rooms excavated during the mining phase prior to 1964 will be backfilled with salt from the neighboring salt dump at Ronnenberg (near Hanover). This will last until 2004 and aims at increasing the stability of the mine. By this time all R&D activities in the Asse which have been carried out concurrently with the exploration of the Gorleben site will be terminated. In a second step, scheduled for the period from 2004 until about 2013, remaining cavities will be backfilled and the shafts will be sealed.

Prototype reactors **THTR-300** and **SNR-300**: The purpose of the 300 MWe prototype reactor THTR-300 was to demonstrate the viability of pebble bed technology, a high-temperature, gas-cooled reactor featuring spherical graphite fuel elements containing coated fuel particles. After three years of satisfactory performance the competent authority of the State (Northrhine-Westfalia) refused to issue the license to resume operation. Safe enclosure has been achieved in early 1997 and will be up for review 20 years later.

The SNR-300 prototype fast breeder reactor was completed but never took up operation. The entire project came to an end in 1991 and the property was sold to a private investor in 1995. The 205 fuel assemblies are stored in Hanau and Dounreay and the electric utility company RWE has assumed the responsibility for the fuel.

Facilities at **Research Center Juelich**: In the heyday of advanced reactor development, responsibility for the accompanying R&D was split among the research centers. While Karlsruhe pursued fast breeder R&D, Juelich focused on the high-temperature, gas-cooled pebble bed reactor line. The **AVR** was the experimental facility that preceded the THTR-300. It was operated successfully for 20 years until its final shutdown in 1988. It is now Juelich's largest decommissioning project. Safe enclosure will be attained in 2003. Due to the longevity of the fission products involved, e.g. Sr-90, long-term safe enclosure is deemed critical by some experts. Further negotiations will show whether complete dismantling can be financed.

In addition to the AVR, decommissioning projects at Juelich include the Merlin reactor (FRJ-I) and the so-called fuel cell laboratory. Some € 30 Mill of federal funds will have to be spent for these two projects.

Decommissioning projects at **Research Center Karlsruhe**: Five reactors and one reprocessing facility are being decommissioned in Karlsruhe. The **KNK**-reactor, the counterpart to Juelich's AVR, was run with two reactor cores; one in which safe handling of Na-coolant was demonstrated, while the second was a "fast" core. The operation of this second core was conceived to pave the way for the SNR-300.

After shutdown in 1991, the sodium and the fuel assemblies had to be removed in a speedy manner in order to make use of CEA's fuel reprocessing service at Marcoule. The contaminated sodium has been treated in a joint effort with UKAEA. The dismantling work advances according to schedule, eventually leading to "green field" in 2005.

FR-2 was Germany's first homemade reactor after World War II, running on D_2O and, in a later phase, slightly enriched uranium. It was used as a neutron source for scientific purposes. After shutdown in 1981, decommissioning work was directed towards safe enclosure, a stage which was finally reached at the end of 1996. An exhibition in the remaining reactor building is open to the public since 1997, featuring showpieces which tell the story of Karlsruhe's contribution to the peaceful use of nuclear energy.

The multi-purpose research reactor **MZFR** was a heavy-water reactor fueled with slightly enriched uranium. It served, among other things, as a prototype for the 340-MWe Atucha power plant in Argentina. The decommissioning goal and schedule correspond to those of KNK, in other words, "green field" should be accomplished in

2005. The invitation to bid for the dismantling of MZFR's reactor pressure vessel revealed that strong competition has emerged in the market.

Other than the aforementioned three reactors, the two additional reactors operated by FZK are not on its premises near Karlsruhe: the Heißdampfreaktor **HDR** at Karlstein and the power plant **KKN** at Niederaichbach in Bavaria. HDR, after suffering severe fuel damage, was shut down for good in 1971, converted into a test facility and used for reactor safety (accident simulation) experiments. "Green field" was reached in 1999.

The case of Niederaichbach (KKN) is another example of a type of reactor which did not come to fruition. It did become, however, the first decommissioning project to reach green field stage (1995).

Finally, the reprocessing pilot plant **WAK** was an R&D facility for the commercial reprocessing project at Wackersdorf. Due to the cancellation of Wackersdorf in 1989, WAK was terminated likewise, after having reprocessed some 200 t of LWR fuel in 20 years. Now vitrification of some 80 m^3 of high-level liquid waste (HLLW) stored at WAK is the most crucial item. As shipment to the vitrification plant in Mol appeared too risky from the political point of view, a decision was taken to build a vitrification plant on-site.

Apart from concerns about the feasibility and public acceptance of HLLW-shipments, the revision of the concept is also due to the successful development of vitrification techniques at Karlsruhe. Since the PAMELA plant at Mol would have required some extensive retrofitting, on-site vitrification was the obvious alternative.

Construction of VEK (Karlsruhe Vitrification Plant) was started in 2000 and vitrification should be completed by 2005. Subsequently, the vitrification and the remaining plants of the reprocessing facility will be totally dismantled and the WAK site restored to green field conditions by 2009.

In addition to these decommissioning projects BMBF has promoted R&D in this field by allocating on the average € 3 Mill per year. Spending went into most areas of concern for dismantling techniques with special emphasis on cutting techniques and measurement for free release.

CONCLUSION

BMBF assumes that efficient decommissioning of nuclear installations will help stabilize the credibility of nuclear energy. Critics of nuclear energy kept insisting that a return to green field sites would not be possible. The successful completion of decommissioning projects, especially the two green field stages, has refuted these opinions.

REFERENCE

1. Future Financial Liabilities of Nuclear Activities, OECD/NEA (1996).