

## ASPECTS OF THE FRG WASTE MANAGEMENT POLICY AND THE ALTERNATIVE FUEL CYCLE EVALUATION

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### THE FRG WASTE MANAGEMENT POLICY

There is a key phrase referring to nuclear energy in the Third Update of the German Federal Government's Energy Program made public in November 1981: "The current contribution of nuclear power and the time involved in proceeding from the planning stage to an operating license for new nuclear facilities are inadequate to meet energy needs". Actually, there is a nuclear capacity of 10 000 MWe in operation and additional 9 000 MWe are under construction. But not a single construction permit for nuclear power plants has been granted since summer 1977 (Philippsburg II, PWR, 1350 MW). The nuclear power plants presently under construction are years behind their schedules. Cost overruns are considerable and investments estimated at \$ 15 billion are held up.<sup>1</sup>

One major reason for the stagnation of the German nuclear industry is seen by many in the continuous tightening of safety requirements as well as the requirement of the German Atomic Energy Act that the "existing scientific knowledge and technology" be the criterion by which the adequacy of prevention of damages and risks is to be judged. These requirements demanded by German licensing authorities make German nuclear power plants much more expensive than those of other countries, with which Germany is competing in the world market. On the other hand, some feel that in the post Three-Mile Island era, these expensive safety features will pay off.

The stagnation of the nuclear industry in the Federal Republic of Germany is also due to economic factors: the growth in electricity consumption has slowed down to about 1 % per year as the result of saturation tendencies in the household sector, successful conservation efforts, and the economic recession in the Western world. Moreover, the argument of direct oil substitution by nuclear energy in the production of electricity is not of particular importance for the FRG because the portion of electric power generated by oil-fired power plants is just about six per-

cent (very much in contrast to countries like France or Italy). But there is a strong incentive to substitute nuclear energy for lignite and natural gas with which a large percentage of Germany's base-load capacity is fueled.

Finally, protests, demonstrations, and citizens' action suits against nuclear energy, especially in connection with siting decisions, have played a decisive role, both directly and indirectly, in bringing about the situation described. As opinion polls conducted in the FRG show, by a vote of 3:2 Germans voted in favor of nuclear energy, with many respondents undecided.

Detailed analyses reveal a host of developments and factors that reciprocally influence each other. But the main problem besetting the nuclear option clearly rests upon issues associated with the back-end of the nuclear fuel cycle. Recovery of uranium and plutonium in fuel-reprocessing plants, recycle in LWR's and later on in LMFBR's, and disposal of radioactive wastes in deep underground repositories have always been the mainstay of the German nuclear energy program. The closing of the LWR fuel cycle has been of increasing concern in German nuclear politics since the second half of the 1960's.

Two phases can be distinguished: In 1965, the Federal Government purchased the then closed-down Asse II salt mine in the State of Lower Saxony and ran it as a test repository for low- and intermediate-level radioactive wastes. From 1967 through 1978 all low- and intermediate-level wastes that were generated in Germany were disposed of in the Asse II mine.<sup>2</sup> In 1967, on the site of KfK, Karlsruhe Nuclear Research Center, construction work was started for the WAK fuel-reprocessing pilot plant. Since that time 115 MT of oxide fuel with burn-ups exceeding 30000 MWD/MT have been successfully reprocessed. Finally, in 1977, the stage was set for realization of the so-called integrated "Entsorgungs" Center (Entsorgung is the German term that comprises all steps at the back-end of the nuclear fuel cycle): It was announced that Gorleben in Lower Saxony was to be the site where a fuel-reprocessing plant (1400 MT/yr), waste treatment facilities, interim storage pools, and a final repository in a salt dome were to be collocated. The licensing procedure was well underway when this first phase of the closing of the LWR fuel cycle was brought to a sudden end in the aftermath of the International Gorleben Hearing. Parallel to the formal licensing procedure for the integrated Entsorgungs Center this expert symposium was organized by the State of Lower Saxony in early 1979 to discuss safety problems of the integrated Entsorgungs Center. The conclusions drawn by the State Government were twofold: As far as safety aspects were concerned, the pro-

ject was judged technically sound; however, large-scale fuel reprocessing was not considered politically attainable at this time. The pursuit of the realization of the Integrated Entsorgung Center at Gorleben was halted in May 1979 by a political decision of the Lower Saxony State Government and this project has not been pursued in its original form since then.

But urgency was still attached to the closing of the LWR fuel cycle. The beginning of a second phase in German nuclear politics centering around the back-end of the fuel cycle was marked by a revision of the governmental "Entsorgungs Principles": In September 1979 the heads of both the Federal Government and the States agreed upon the scope within which these principles were to be revised. The essential elements of this governmental decision were the following<sup>3</sup>:

- o Fuel reprocessing, recycling of the recovered fuel, and disposal of wastes conforming to the latest standards of scientific knowledge and technology are suited to the closing of the fuel-cycle, all aspects of safety, economy, and environment considered. Therefore, based upon results obtained in the past and in the light of the outcome of the Gorleben Hearing further efforts are to be devoted to the realization of the "classical" fuel-cycle, i.e., fuel reprocessing, recycling, and disposal of reprocessing wastes. In contrast to the concept of the "Integrated Entsorgung Center" which had prevailed prior to the Gorleben Hearing with all above-ground and underground facilities being collocated at one specific site, the new "Integrated Entsorgung Concept" allowed for decentralized siting.
- o Simultaneously, so-called "other" disposal techniques such as the direct disposal of spent fuel without reprocessing are to be investigated in such a speedy manner that by 1985 results are obtained that will enable a judgement whether or not these "other" disposal techniques may prove superior on the grounds of safety and of safety-related aspects.
- o The Heads of Government welcomed the willingness of the State of Lower Saxony to accept the salt dome near Gorleben as the site of the prospective final repository under the provision that the exploratory mining program certifies the suitability of the site. The decision about the suitability of the Gorleben salt dome is scheduled for the second half of the 1980's.

- o Completion of both the above-ground facilities for either "Entsorgung" technique and the underground repository for radioactive waste - the latter lies within the responsibility of the Federal Government - is scheduled for the end of the 1990's.
- o The Heads of Government agreed upon timely implementation of away-from-reactor storage facilities as an interim solution to "Entsorgung". Extension of the storage capacity in on-site spent fuel basins by means of compact storage techniques is seen as a valuable contribution to the solution of problems surrounding spent fuel management.

Finally, in February 1980, a federal-State review group came up with the revised "Entsorgungs Principles". This policy clearly spells out the licensing requirements for new nuclear power plants with respect to the back-end of the fuel cycle. Pending the grant of the first partial construction license for a new nuclear power plant, evidence of at least preparatory efforts to ensure "Entsorgung" has to be given. Commensurate with progress in construction work, proof has to be furnished of increasingly firm contracts pertaining to Entsorgung. Contracts for fuel-reprocessing in foreign countries (such as France) are one viable option but reprocessing waste has to be returned to Germany in the long run. Other legal requirements comprise the conclusion of preliminary site selection for AFR's and progress made in the repository exploration program for geologic disposal. Beginning January 1, 1985, partial construction licenses of new nuclear power plants will be granted under the stipulation only that the site selection process for facilities of either one of the spent fuel management and waste disposal schemes - i.e., fuel-reprocessing and disposal of high level waste or direct disposal of spent fuel - has been concluded. Besides that, at any given time, spent fuel management has to be substantiated six years in advance, with emphasis on at-reactor and away-from-reactor storage facilities.

With the governmental decision of 1979 and the promulgation of the new "Entsorgungs Principles" in 1980 a clear policy for the management of spent fuel was formulated with a fixed time frame. What steps have been taken in the meantime to implement this new policy? Due to the liberal economic philosophy that dominates the German federal policy, it has been essential for the private sector to take the lead in commercialization of fuel-reprocessing and waste treatment. The German Reprocessing Company (DWK), which is a jointly owned subsidiary of German electricity utilities, has entered into the site selection process for both reprocessing plants and AFR's to meet the Entsorgungs demand

from more than 10 000 MW of power plant capacity. Ever since decisions on DWK's own plan for a 1400 MT/yr integrated reprocessing and waste disposal center at Gorleben were put on ice for political reasons, the company has been looking for additional capacity to ensure that no nuclear power projects are held up by the legal requirement to have firm contracts prior to loading of fuel into the reactor. DWK has picked potential reprocessing sites in Hesse and Bavaria and will start licensing procedures in the near future. It is planned that these two reprocessing plants will have 350 and 700 MT annual capacity, respectively. Besides, DWK also has reprocessing contracts with COGEMA in France. But these will expire for the different power plants between 1986 and 1991. In 1981, preliminary discussions held in the USA indicated DWK's interest in a share of the available capacity in the Barnwell reprocessing plant in South Carolina.<sup>4</sup>

Progress is being made in the preparation of the licensing procedures for two 1500 MT away-from-reactor spent-fuel storage facilities using the German concept of dry storage in cast iron transport canisters. Construction licenses are pending at Ahaus in Northrhine-Westfalia and Gorleben in Lower Saxony.

Finally, considerable progress has been made in the field of vitrification of high-level waste. Germany's own solidification process has been developed in the past but so far it has been operated on a laboratory scale only. In 1981, construction work was started on the German prototype vitrification plant PAMELA on the site of the Eurochemic facility in Mol, Belgium. Conditioning of other types of waste, especially fixation in cement or bitumen, are proven technology. Retention of iodine and krypton have been successfully demonstrated on a technical or laboratory scale; it is planned to inject tritium waste in deep geologic strata.

Timely implementation of a repository development program is an essential part of the German nuclear policy. Disposal of radioactive wastes in the FRG will be exclusively in deep underground mines with rock salt having highest priority as a disposal medium. Only the iron ore mine KONRAD is being explored with respect to its suitability for low-active waste. The construction of a repository for all types of radioactive waste is actually planned in the Gorleben salt dome. An extensive geological and hydrological investigation program is underway. Four deep drillings 2000 m down into the periphery of the salt dome and additional drillings for hydrological purposes have been carried out. These drillings have yielded, among other things, a profile of the salt dome. Drilling of an exploratory borehole in the center of the salt dome will be started in the near future in order to select the site of the two final shafts. After completion of these two shafts the potential emplacement area will be explored.<sup>5</sup>

## THE ALTERNATIVE FUEL CYCLE EVALUATION

While work on the "classical" waste management scheme with fuel-reprocessing and recycle will be continued as a matter of priority, so-called "other" disposal techniques such as the direct disposal of spent fuel without reprocessing ought to be investigated according to the governmental decision of 1979 so that by 1985 results are obtained that will enable a judgment to be made as to whether or not these "other" disposal techniques may prove advantageous on the grounds of safety and of safety-related aspects. The decision to deal with direct disposal of spent fuel came into being not the least through the active development of this concept in the United States in the late 1970's. In fulfillment of the governmental decision, a project group at Karlsruhe Nuclear Research Center has been commissioned by the Federal Ministry of Research and Technology to manage the ensuing R&D effort. About DM 60 Mio of federal funds are foreseen for engineering, hardware development, and technology assessment activities.

Well-established companies of the German nuclear industry have become involved in the conceptual design of the direct disposal option, beginning at the point where spent fuel is shipped to an encapsulation station and extending through all steps up to and including the geologic repository. Nukem Corporation and DWK are collaborating on spent fuel treatment and encapsulation techniques. Up to now, three study cases of spent fuel treatment have been sorted out:

- the unmodified fuel element
- disassembling the fuel element into fuel pins
- shortened fuel pins
  - . folded or rolled
  - . pins cut into pieces.

Three concepts of canisters for encapsulation are being investigated:

- metal canister (with gray cast iron, nodular iron, and titanium overpack as candidate materials promising high corrosion resistance)
- graphite monolith
- ceramic (e.g.,  $Al_2O_3$ ).

DBE, a federally owned but privately organized company was commissioned to plan, build, and operate the German geologic repository in Gorleben.

This company will also conduct the adaptation of existing plans for a repository to the specific requirements of disposal of spent fuel. As a first step, emplacement of different package sizes has been analyzed. The following study cases of emplacement are under investigation:

- vertical and horizontal boreholes
- disposal in corridors (self-shielded concept)
- (- disposal from the surface into very deep boreholes).

The goal is to select a single reference concept by mid-1982 from among the aforementioned encapsulation techniques, canisters, and emplacement options. Safety, economics, and technical performance will serve as selection criteria. In a second phase, further engineering efforts will be dedicated to the development of the reference concept. Parallel to that task, the Karlsruhe project group will organize a comparative assessment study in which the Integrated Entsorgung Concept with fuel-reprocessing as its centerpiece will be contrasted to the spent fuel disposal concept. This evaluation will be based on an extended list of assessment criteria where safety and safety-related aspects will remain of major concern. In compliance with the governmental decision of 1979 completion of this comparative study is scheduled for the end of 1984 so that the judgement by political authorities can be made in 1985.

This political judgement will most probably be influenced by aspects such as fast breeder and plutonium policies, international nuclear programs, balance of payment and the export situation, in short, the overall economic situation at that time. In my considered opinion this decision will provide for the continuation of both of the following policies: implementation of the integrated concept and further development of direct disposal techniques.

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