

GREIFSWALD NPP (GERMANY): SITE CLEANUP, SITE REUSE, CONVERSION & KNOW-HOW UTILIZATION

G. Boehme, H. Glauser, M. Haeger
Energiewerke Nord GmbH Rubenow(EWN GmbH)
P.O. Box 1125, D-17509 Lubmin, Germany

ABSTRACT

Till now approximately half of the complete former nuclear power station area has been cleared from regulatory control. Both half of facilities has been dismantled and half of the area is out of atomic law. Meanwhile our company is involved in national and international decommissioning projects. Many investors are looking for settlement of companies on the site now.

To accelerate site cleanup some certain project changes were carried out. A major one was the decision not to cut the reactor and the internals remotely but the remove these parts into the interim storage for long-term decay. A special challenge will be the dismantling of the reactor pressure vessel of our subsidiary as one part and the 200-km-transport through the north-eastern part of Germany to storage it in our interim storage.

Using trained know-how and mechanical devices, 9 steam generators of our subsidiary were cut and stored in the interim storage of the site. 2 reactor vessels of a research institute have been cut. Now we manage the dismantling of an experimental nuclear facility. Another important project is managing the construction long-term interim storage of Russian nuclear submarines in the north European part of Russia.

The chosen approach shows, that economic reuse seems successful. This concerns both the staff and obtained facilities and the cleaned site land. By means of property sales, performances for third parties, sales of dismantled components and scrap metal etc. it is possible to save money. Site restoration, building a new infrastructure and site advertising/marketing will help to reach investors. A conventional port with entry to the Baltic Sea was built for commercial reuse of the site. By a changed occupation and the prospect of settlement of new businesses greater social problems can be avoided.

Lastly it seems possible too, to save a part of the site as a power plant site with the necessary, already realized nuclear infrastructure.

INTRODUCTION

Following the reunification in Germany all NPP units changed into a post-operation phase. Some decisions were required to reach a higher safety and prepare to dismantle. Spent fuel management became priority. A storage strategy was needed. Dry transport/storage casks in connection with a long-term interim storage seemed to be the best way.

15 years after shut down of the 2200-MW MW_{el} -NPP (5 x 440-MW_{el}) a lot of experience is collected in decommission, waste disposal, cleanup and site marketing.

Following the site inspection and characterization most auxiliary systems and buildings were dismantled. Methods to sample, measure and analyse the ground area and below were suggested and approved, also free measuring of buildings. Earth had to be replaced only partly. Stones made some difficulties due to here own natural radioactivity, the Tshernobyl accident too.

44 CASTOR casks, 24 steam generators and many other parts and casks are stored in the on site interim storage.

Approximately half of the planned project lifetime is over. The financial situation is approximately adequate. If one compares the progress of the dismantling project with the financial situation, one can see a responsibly funds use. This is not a condition, which arises in the self-run. Continuous controlling of the great dismantling project is a tool to react to deviations on time. The adaptation of dismantling technologies to the level of technology guarantees further success.

SITE CLEANUP AND DISMANTLING

With the reunification of Germany all construction activities and assembly work on the not completed nuclear power station units were stopped [1]. The operating units (unit 1 to 4) were shut down; the test operation of unit 5 was also stopped. Immediately started the site cleanup and the demolition of the construction site facilities. A thorough, first site inspection, investigation of the radiological condition of the land, buildings and plants, started before cleanup of other areas of the location. A basis for the characterization, assessment and evaluation of the findings and measurement results, coordinated with the approval authority, was required. The repetition of a number of measurements nevertheless couldn't be avoided just in the first time. The interests of the technical surveillance and authorities were too different at times. Step by step the work was better done.

One can split up the whole site of the former NPP (under construction and operating) in 3 main areas:

- Fenced in area with free access (outer fence, including construction site)
- Monitored area, access by staff and authorized visitors (former operating NPP-units without needed radiation protection restrictions by the staff)
- Restricted access area (primary water circuit, reactor area and its auxiliary systems, radiation protection and monitoring is mandatory).

Accelerating Cleanup

The building demolition and the site cleanup of the freely accessible, fenced in area are described here. Conventional waste disposal, site cleaning and removing of no more needed facilities was carried out by strangers under project management of EWN, the former nuclear power plant operator.

Staff was hired about job creation schemes for the work process. 250 persons were employed on average with these cleanup, waste disposal and demolition tasks. During the first cleanup and the dismantling period 1991-1994, the following results were obtained:

- Cleaned areas: 2 000 000 m²
- Scrapped materials: 25 000 Mg

- Dismantled buildings and building workers' huts: 400
- Broken concrete: 200 000 m³

The removal from service and approval for the dismantling of the facilities of the conventional part of the nuclear power station having been carried out step by step. Both the dismantling of auxiliary systems of the conventional part and the building demolition, therefore were carried out in stages. This was and will be done by job creation schemes again. For this 30 workers are employed on average. The time period contains 9 years (1998 to 2006). The main emphasis of the work contains primarily the dismantling of power stations auxiliary systems and the demolition of the corresponding structural plants. The complete size of this work comprises essentially the following performances:

- Areas clean: 100 000 m²
- Materials scrap: 25 000 Mg
- Huts and building demolition: 20 pieces
- Breaking concrete: 120 000 m³

The following has proved useful for an accelerated cleanup and a faster demolition, till now:

- Commitment of numerous workers about job creation schemes for the execution of mainly manual activities
- Use of special equipment engineering for the demolition of the structural facilities
- Commitment of qualified workers about job creation schemes for the execution of special dismantling and for the operation of demolition technology
- Advance performances by our company like design of the demolition projects and the explanation documents, obtaining of the official approvals, realization of the interfaces.

Dismantling

A prerequisite for the dismantling of the facilities was the creation of approval documents based on German Atomic Energy Act. This concerns both components of the restricted access area and the monitored area. This preparatory phase up to the receipt of the first approval to the dismantling lasted for six years. After this, further atom-legal approvals to dismantle were requested and approved. As a rule, this time period lasted approx. 1 to 2 years each.

Both, the requests for approvals to the dismantling and the dismantling of components, were carried out therefore also in technologically useful partial steps.

The dismantling of the components of the monitored area (turbine hall and auxiliary systems) was not influenced by the restrictions, which apply to the restricted access area. The monitored area contains fundamentally higher dismantling mass, than the restricted access area. The dismantling conditions, however, are simpler than in the restricted access area. Due to this fact, the dismantling mass is clearly higher per worker and man-hour. More dismantling staff also could be employed from the beginning. This particularly concerned the use of strange staff. As a rule, the double mass was dismantled in the monitored area in comparison with the restricted access area per annum.

The following essential points especially influenced the job performance of the monitored area:

- Restricted capacity of places to treat and saw restriction free and radioactive material
- Elimination of the insulations containing asbestos before dismantling
- Dismantling of cables. Because of the variety of cables of different systems on the cable run systems it was required to dismantle cables in sections.

The dismantling of components in the restricted access area was dependent on the following other activities:

- Nuclear fuel removal [3],
- Dismantling of activated components,
- Waste management of radioactive operation waste (resins).

Thereby it came to restrictions at the dismantling of components in the respective power plant units. An essential prerequisite for the material flow out of the restricted access area was the installation of material gateways therefore. Investments were required to accelerate the whole process. This concerned mainly the intermediate storage of the nuclear fuel, the activated components to be dismantled and the other parts and their treatment. Important elements of the on site refitting were:

- A corresponding interim storage (ISN^a),
- Free release measuring devices and
- Buffer storage areas.

At first only own staff was employed to the dismantling of the components of the restricted access area. Strange staff was also employed under instructions of the own staff. This happened in the sections of the restricted access area after minimizing of dismantling restrictions.

Accelerated Dismantling

For different reasons require long-term projects like dismantling of NPP-units from time to time a deep concept check. This is caused manly through the long duration of such projects and therefore by the need of really immense money. Compulsorily an accelerated dismantling through technological improvements is a must permanently.

Thus, the required step by step license applications [2] guaranties to change former intentions due to these technological improvements.

Former dismantling concept was:

- Removal of low or not contaminated plant parts like turbine hall devices
- Removal of other auxiliary systems (low or average contaminated) as much and often as possible from lower to higher radiation
- Train remote dismantling in an inactivated environment and transport of an only low activated reactor pressure vessel as the whole to the onsite interim storage
- Dismantling around the other four pressure vessels again from lower to higher radiation

- Remote dismantling of pressure vessels and their activated internals

The essential concept change avoids cutting the pressure vessels and partially the internals at this time. With this change of dismantling strategy one can save approx. 1 and a half years time now. It is a learning process before, to decide this. Such a decision is not possible at or from the beginning of the concept stage. One must train and collect enough know-how to decide this way. On the other hand it is always as useful as important too, to have two or more possibilities, to dismantle complicate devices. Through exercise the transport of a not activated reactor pressure vessel as whole part and train remote dismantling in not activated environment, we got more safety step by step. Essential is the check of the real radiation situation, too. Calculations carried out merely do not suffice alone. It can give a first orientation, however, it doesn't represent the real world. It almost leads to an overvaluation (Table I) of the on-site situation. It is advisable to find out the actual situation by measurements.

Table I. Maximum of on-site γ -radiation [mSv/h] at pressure vessel #1^b (unprotected)

	Calculated value	On-site measurement
Surface distance 0.5m	300	22,1
Surface distance 2.0m	93	6,4

By lifting the reactor pressure vessel remotely controlled these measurements were made possible.

The radiological situation was calculable with that at the transportation. The transport of two undivided pressure vessels from the power plant units to the interim storage was tested. Now had to check how and where to store the undivided pressure vessels. It is a question of the crane load capacity at the right place (not all storage places of the on-site interim storage are equipped with the required load capacity). Therefore the needed place requires removing of other large parts stored there. The question was now, what has to happen with the disturbing components (Figure 1). Can we remove these only or must we saw up these until the needed date? Components concerned were steam generators and reactor pressure vessel closure heads. The radiation situation should make the decision itself.



Fig. 1. Blocked place through steam generators and pressurizers in interim storage

Licensed parameters to saw up such components inside a special caisson of the local interim storage are:

- Radiation in 2 m distance $\leq 10 \mu\text{Sv/h}$
- Activity concentration $(\beta/\gamma) < 100 \text{ Bq/g}$
 $(\text{Co-60}) < 30 \text{ Bq/g}$
- Radiation protection concept to guarantee $< 10 \mu\text{Sv/h}$ as yearly average.

On this time it is possible to saw up steam generators, but not yet reactor pressure vessel closure heads. The reason for this is the high radiation in 2 m distance. In progress is the pressurizer's saw up. We have to prepare cutting of two steam generators only short used.

Lastly had to check how long would it take to saw up it all (Table II). It should be done in the lifetime of the on site interim storage's building.

Table II. Required decay time of larger components

	Pressure vessel #1	Fuel basket (bottom plate)	Protection tube device (bottom plate)	Protection tube device (upper plate)
Today's Co-60-activity	1,5E+12 Bq	4,63E+14 Bq	3,42E+14 Bq	3,056E+12 Bq
Needed decay time ^c to get $< 10 \mu\text{Sv/h}$ in 2 m distance	approx. 50 years	approx. 105 years	approx. 101 years	approx. 64 years
Needed decay time ^d to get	approx. 56 years	approx. 109 years	approx. 106 years	approx. 69 years

≤ 30 Bq/g		years	years	
----------------	--	-------	-------	--

Table II shows that it is useful and serviceable from the radiation point of view to treat the components after a decay period. However, a special radiation protection is required during the decay storage of these components. A 180 mm thick iron protection suffices roughly in the area of the highest activity (Table II) to reach conditions $< 10 \mu\text{Sv/h}$ in 2 m distance. Partly the reactor pressure vessel internals can stay in the reactor vessel. Main sources of the radiation are the fuel basket (Table II) and other parts, which were in the past near the fuel elements. The wall of the reactor vessels then works like a radiation protection shield.

This now chosen technological change accelerates the whole process again. The decay will minimize the staff's dose rate and the need for containers can be minimized. Simplifications are expected by later technological progress to dismantle the more decayed components.

It is clear that the sooner the site has been cleaned up, the sooner it can be reused. Decay storage of components, as large as at all possible, is therefore a real acceleration example.

Other items, to get accelerations in the processes, are such like this:

- Use of special project managers realizing and coordinating main tasks,
- The cessation of technological restrictions,
- Specific use of a proven equipment engineering,
- The optimization of the waste materials flow by use of collected experiences,
- Increased deployment of dismantling staff by acquisition of workers,
- The realization of partial tasks by means of outside staff e.g. for the reduction of the asbestos loaded insulations,
- Use of experienced staff at more complicated dismantling
- Repeated application of approval procedures, standardized application steps

SITE REUSE AND CONVERSION

The economic relationships had changed dramatically with the decision to shut down the nuclear power station. With that in conjunction a considerable restructuring started in the nuclear power station. Single structure units could divide off themselves. From these more or less successful, independent companies were set up and established themselves at the location. This concerned primarily smaller service and industrial branches. That way, some available halls and buildings were in use continuously. To reuse the site extensive, an entirely clean up of outer, fenced in areas (Figure 2.) was carried out.

Furthermore an assessment of the areas was required with regard to conventional residual wastes. To this appropriate engineering offices were engaged. The findings were explained into reports. The suspicion of existing residual wastes was confirmed in certain areas. These areas were decontaminated into dependence of the necessity with regard to the danger potential and the scheduled reuse.

For settlements of companies, which need larger areas for production, concepts were made. Particularly the local location situation, the situation in the region and the geographical situation

were taken into account. The draft of a development scheme was drawn up. The construction of a port was ideal at the navigable waters (Figure 2.). The prerequisite was created with that to transport larger colliers over sea.



Fig. 2. Reusable properties in the left and new harbour in upper part

The following situation appears today:

- Industrial area of the development scheme 1 200 000 m²
- already sold 320 000 m²
- for the erection of a gas power station 200 000 m²
- as an industry harbour 120 000 m²
- different 20 000 m²

Besides the preparations to the settlement of industrial facilities efforts were made around the possibilities of managing to set up further gas power stations.

Advantages of the location for a use as an energy location and other lines of industry are:

- Existence of water, electricity, warmth, disposal equipments etc. of former power stations auxiliary systems,
- Use of energy infrastructure of the location like cooling water channels, energy release about high-voltage installations (former energy feed in point) etc. for energy generation by the construction of conventional power stations.
- (Now) existing conventional harbour with a depth of 7 meters,

- Available traffic connections (streets and railroad track, railroad tracks are suitable for whole trains till 360 m),
- Company settlements at the location: 30 companies with about 655 employees
- Still sufficient employees at the location with a good training.
- Future connection to European earth gas network

To dismantle the nuclear power station we established some facilities. To keep the project costs lowly, we do some services like the followings now: Container lender service, service center for interim and long-term storage of radwaste, free release measurement service for third parties, treatment and conditioning center for third parties, special waste treatment center (e.g. asbestos), mobile dismantling and special waste service, scaffolding service, education (specialized in site activities).

Items to get accelerations in the processes of creating development scheme and preparations to the settlement of industrial facilities are such like these:

- Examinations of residual waste suspicious areas and preparation of the corresponding reports by commissioning engineering offices,
- Execution of waste disposals,
- Draft of a settlement concept for companies. Checking the financing possibilities by governmental promoting monies,
- Preparation of planning documents for the development scheme area; obtaining of the approval,
- Creation of free space. Reducing the monitored area on the most necessary one.
- Quickest possible leasing of area and halls for companies with the best concepts,

Here must point out that the transformation to commercial/economic reuse is a real difficult business.

KNOW-HOW UTILIZATION

Our company is trying to convert the know how from operation and maintenance of 6 WWER reactors on Greifswald and Rheinsberg site and the presently ongoing decommissioning activities into new long term jobs, especially in the engineering area. Due to the previous socialist structure, it was necessary for the personnel to perform all activities on their own, e.g. planning and execution of modifications, maintenance etc. This means that there is a well-founded engineering know how which now has been mixed with Western experience, rules etc. Thus, we are able to perform engineering work in similar Nuclear Power Plants of previous East European countries, especially in the decommissioning and waste management field, notably in the following specific areas:

- Decommissioning planning and execution,
- Preparation of licensing documents,
- Environment assessment analysis,
- Project implementation and management,

- Waste management and material logistics,
- Remote dismantling planning and execution,
- Development and implementation of software routines,

In this framework we are involved in decommissioning projects in Chernobyl (Ukraine) and Kozloduy (Bulgaria). Other projects our company is/was involved include decommissioning activities for Russian submarines, delivery, education and training courses e.g. Ignalina NPP decommissioning leading personnel and representatives of Lithuanian authorities, R/D-projects for the European Commission, projects and activities for/with the IAEA and cooperation with different companies e.g. JGC (Japan).

The German Federal Government decided to transfer the responsibility for the AVR decommissioning project in Jülich research Centre to EWN. The Jülich reactor is a high temperature pebble bed reactor, which was operated from 1964 to 1988. The takeover was performed in April 2003. This led to a total review of all possibilities and finally to a major change in the decommissioning strategy, which is now in the planning and licensing phase. The basic approach in this new strategy is to construct new interim storage possibilities and to remove the complete reactor (ca. 2000 Mg) in one piece and put it in an interim store together with the major part of the dismantled material. Treatment will only begin when the requirements for final storage are known.

In the frame of the G8 Global Partnership, Germany has pledged financial support for the destruction of chemical weapons and the decommissioning of nuclear submarines. The first bilateral major project (cost frame 300 Mio €) is concerned with the decommissioning and the safe storage (Figure 3) of Russian nuclear submarines in the Murmansk area and EWN is responsible for the project management.



Fig. 3. Russian submarines' storage concept (radiation field sections)

The main parts of this project can be summarized as follows:

- Erection of a land-based long-term interim storage facility (Figure 3) for submarine reactor sections in the Sayda Bay including the corresponding infrastructure,

- Optimization of the material and technical conditions and equipment of Russian enterprises to accelerate the utilization of the nuclear submarines,
- Establishing conditions for safe handling of waste being produced during the utilization of the nuclear submarines in the northern region of the Russian Federation,
- Establishing an ecologically harmless state of the Sayda Bay environment

Beside continuation of above-mentioned activities EWN currently plans the participation on new EC-R/D (sixth framework programme) and IAEA projects and expressed the interest for participation in the preparation of the decommissioning project of Bohunice NPP (Slovak Republic).

Also in future, EWN has an interest to utilize the accumulated know-how in the frame of national and international projects. The decommissioning experience will be presented on international conferences, workshops and training courses.

CONCLUSION

Start clean up of the site and demolition of the construction site facilities immediately after the shut down was right and useful. One needs a common base for the characterization and assignment of the findings coordinated with the approval authority also as soon as possible. The former power station operator should do the project management because there is the most knowledge of all the site problems etc. Useful for most conventional tasks is hiring staff about job creation schemes. Further strange staff working under instruction of own staff is helpful, too. The former operator should do advance performances, like design of the demolition projects and the explanation documents, obtaining of the official approvals, realization of the interfaces. Special equipment engineering for demolition of concrete structure is required. Component dismantling and drafts of approval applications in technologically meaningful partial steps are helpful. It takes approx. 1 to 2 years from the draft start till the approval.

The dismantling of components in the restricted access area depends on other activities like nuclear fuel removal, dismantling of activated components and the waste management of radioactive operation waste. Useful for the dismantled material flow out of the restricted access area are installations of material gateway. A corresponding interim storage, free release measuring devices and buffer storage areas are a must.

Long-term projects like dismantling of NPP-units require from time to time a deep concept check. To decide changes with consequences, know-how is necessary.

It is always as useful as important too, to have at least two possibilities to dismantle complicate devices. Radiological calculations for dismantling processes merely do not suffice alone. It can give a first orientation, however, it doesn't represent the real world. It almost leads to an overvaluation of the on-site situation. It is advisable to find the actual situation by measurements out.

The faster dismantling of the NPP-units shut down is suitable to get an earlier cleanup and reuse of this site. Also, the decay storage of components as big as at all possible is helpful for that. For the reuse after cleanup one needs a draft concept to the settlement of companies and the design of a development scheme.

WM'05 Conference, February 27 – March 3, 2005, Tucson, AZ

By the done work and as a social effect, EWN now has the background to perform engineering work in similar Nuclear Power Plants, especially in the decommissioning and waste management field, too.

REFERENCES

- [1] D. RITTSCHER, D. F. LEUSHACKE and R. MEYER "Decommissioning and Dismantling of the Greifswald Nuclear Power Plant" VGB KraftwerksTechnik (...) 03/1998
- [2] UMWELTMINISTERIUM MECKLENBURG-VORPOMMERN "Genehmigungsbescheid für das Kernkraftwerk Lubmin/Greifswald, 28.Änderungsgenehmigung zur Genehmigung vom 30.06.1995 (G01) zur Stilllegung der Gesamtanlage und zum Abbau von Anlagenteilen des Kernkraftwerkes Lubmin/Greifswald vom 19.07.2004"
- [3] G. BOEHME, J. GRIEP, S. SCHWEITZER "157·10⁶ MWh (electric) with 6217 Fuel Elements – Intact, Leaky, Damaged and Experimental. And now?" Proc. Waste Management Conference, Tucson 2000

FOOTNOTES

- ^a ISN: Interim Storage North (the onsite interim storage)
- ^b Used 27 years (normal operation time), 1375 MWth, 440 MWe (type VVER-440)
- ^c Results by using calculator program "MicroShield v.5.05"
- ^d Results by using calculator program "Strahlenschutz Informations-System SISy 1.69"