Attachment 9

Experience from Greifswald NPP Decommissioning in Germany (EWN Environmental Impact Register -Summary)

EWN Environmental Impact Register

EXPERIENCE FROM GREIFSWALD NPP DECOMMISSIONING IN GERMANY
(EWN ENVIRONMENTAL IMPACT REGISTER)

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List of abbreviations

AOX	Adsorbable Organic Halides
CASTOR	Cask for dry storage of spent fuel elements
COD	Chemical Oxygen Demand
EDTA	Ethylene Diamine Tetra Acetic acid
FFH	Flora Fauna Habitat areas (EU definition)
ISN	Interim Storage North (storage for radioactive waste with facilities for conditioning and storage for filled CASTOR casks)
KTA	Rules of the committee for nuclear technology
LUNG	Environmental Protection Agency of Mecklenburg – Western Pommerania
NTA	Nitrilo Tri Acetic acid
RPV	Reactor Pressure Vessel
TRGS	Technical Rules for handling hazardous materials
UBA	Federal Environmental Agency
WWER 440 213	Water Water Energy Reactor 440MW$_{el}$ model 213, Russian type with wet condensation (advanced type)
WWER 440 230	Water Water Energy Reactor 440 MW$_{el}$ model$_{l}$ 230, Russian type with hermetically sealed compartment system (first type)
ZAB	Wet storage for spent fuel
ZAW	Central Warm Workshop, facility for dismantling and decontamination of plant parts

1. Introduction

EWN GmbH, Rubenow, has gained much experience with Environmental Impact Assessment (EIA) procedures regarding the decommissioning of the units 1 to 5 of the Greifswald NPP.

Units 1 to 4 (WWER 230) on the Greifswald site were shut down in 1990, first Unit 2 followed by Unit 3, Unit 4 and Unit 1. Unit 5 (type WWER 213) started trial operation 1989 and was shut down at the end of 1989. The construction of Units 6 to 8 was stopped in 1990.

With regards to EIA, Units 1 to 4 of the Greifswald NPP have the same technical design as the Kozloduy NPP Units 1 to 4. Differences to the EWN Units 1 to 4 are existing (see chapter 4.0 of the EIA-Report) but not important.

Another issue which has to be considered regarding EIA is the different approach for treatment and conditioning of operational radioactive waste.

EWN transition stage (1991 – 1995)

The main activities in this post operation phase were:

- Defuelling: that means transport of all spent fuel elements from the Units to the Wet storage for spent fuel (ZAB),
- Treatment of operational waste,
- Decontamination.

In 1992 the dismantling of buildings and plants outside the controlled and monitored area (outside turbine hall and reactor buildings) started.

EWN decommissioning stage (1996 up to present, completion planned for 2013)

The EWN dismantling strategy comprises the removal of all components/equipment (e.g. steam generators and pressurizers) as large as possible for decay storage and their later treatment in the newly constructed Interim Storage Facility North (ISN).

Contaminated plant parts can also be treated in the Central Warm Workshop (ZAW) by cutting and decontamination and other treatments.

At the end of 2008 approx. 75% of the plant parts of the controlled area Units 1-4, approx. 92% of the plant parts of the controlled area Unit 5 and approx. 97% of the monitored area were dismantled.

In the frame of the remote dismantling of the activated components (reactors and internals), new technologies were developed and implemented. In preparation a mock up phase (model dismantling) was performed in Unit 5 with non-activated components of the reactors of Units 7/8.
The RPVs of Units 1 to 5 were stored as complete components in the ISN using special designed Shielding and Transport Devices. The high- activated RPV internals of Units 1 and 2 have been cut on the basis of the mentioned newly developed and tested technology.

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The RPV internals of the reactors 3 - 5 were stored without cutting in shielded casks in the ISN.

The RPV Units 3 and 4 were stored with parts of their internals (reactor shaft). These activities were finished in September 2009.
The spent fuel elements stored in the Wet storage for spent fuel (ZAB) were reloaded into CASTOR casks in the following steps:

- transport from the Wet storage for spent fuel (ZAB) to the reloading facility (Unit 3),
- reloading into CASTOR cask,
- closing, emptying and drying of the CASTOR casks, and
- transport into the ISN (hall 8).

This process started in 1999 and was finished in May 2006.

The treatment of operational and post operational waste is ongoing. After reconstruction of Special Building No. I, the conditioning of mixed operational waste, stored there in concrete pits, was carried out from 1998 until 2002.

Up to the end of 2008 about 90% of all operational waste was conditioned.

2. Direct impacts from EWN decommissioning in comparison to impacts from the operation and post operation phases

General:

- Important reduction of all impacts, after shut down of the operating units, except conventional emissions into the air,
- All impacts are well below under limit values or other legally required values,
- The low level impacts of decommissioning are in the same range as impacts from other activities (e.g. post operation),
- Tthe most relevant impacts are temporary and disappear or are essentially reduced at the end of the decommissioning process (e.g. waste),
- All activities in the controlled area take place in a closed system with effective control, exhaust air cleaning systems according to the best available techniques and a closed water system with waste water treatment plants and control of all outside releases.

2.1 Radiation exposure of personnel

During the operation stage the Collective Effective Dose (CED) was about 10 Sv/year (average 1986 – 1989).
In the post operation stage (1991 – 1995) the CED decreased from 0.56 Sv/year (1991) to 0.23 Sv/year (1995).
In the ongoing dismantling stage the average annual CED (1996 – 2008) was between 0.12 Sv (2001) and 0.26 Sv/year (1998). For this stage the radiation exposure of the annual average CED can be splitted due to activities in the following approximate range:

1. dismantling incl. treatment of waste from dismantling between 30 to 50%
2. Post operation and all other activities (outside 3. – 6.) between 20 to 30%
3. Guarding about 10 to 20%

4. Radiation protection less than 10%
5. Fuel reloading (into CASTOR casks) about 5 to 10% (1999 – 2006)
6. Conditioning of operational waste about 5 to 10%

The annual CEDs are comparable with other NPP decommissioning projects in Germany (Würgassen and Stade). The data show that the exposure during the several phases of decommissioning and dismantling is much lower than during the operation phase [10].

For the dismantling of all facilities and plant parts (without demolition of building structures and activated components) of one unit, the total CED is < 0.5Sv.

For the remote dismantling of activated components (core components without Reactor Pressure Vessel) of one unit, the total CED is < 0.1Sv. The main part of the exposure is caused by preparation activities. The total CED for all activities with all activated components of the units 1 to 5 up to the storage in the ISN was cumulated 270mSv.

The total CED for the whole process of reloading of 4800 spent fuel elements with the total amount of 555.3Mg into Castor Casks was accumulated 148mSv and the collective neutron dose was 190mSv.

The annual CED from all activities in the Interim Storage Facility North has been increased from 1.5mSv in 1998 (start of operation) to 9.2mSv/year until 2008.

The cumulative CED for the whole transition and decommissioning stage can be expected as lower than the CED of one year during operation.

2.2 Release of radioactive nuclides into air

- In comparison between operation and post operation the emission of aerosols is reduced in 1 order of magnitude at the beginning of the post operation (from 28155MBq/year to 2744MBq/year) to 2 orders of magnitude at the end of the post operation (422MBq).
- In comparison of post operation and dismantling stage the emission of aerosols is decreasing to 1 order of magnitude (average 24MBq/year in the dismantling stage).
- The main emitters are the stacks 1-3, the quotas of ZAB, ZAW and ISN are all together in the range of some percents.
- The emissions of aerosols in the decommissioning stage are on a very low level (0.02 – 0.05% of the limited values). ***The effects of dismantling activities regarding the emission of aerosols are existing but not explicitly detectable***. The low level is caused by an effective system of measures for prevention and separation of aerosols (closed dismantling areas with additional exhaust air plants, use of filters with the best available rate of filtration for the exhaust air system).
- An influence of the remote dismantling was not detectable.
- At the stack of the conditioning area of the ISN aerosols are not detectable.
- The aerosol emissions from the ventilation systems of the ISN storage halls are calculated by model of emissions with the assumptions:

- 100% capacity utilization rate, and
- the maximum of contamination of 4 Bq / cm^2 on all surfaces at stored boxes and components

These calculated emissions are 2 orders of magnitude below the aerosol emissions of the whole KGR site and thus to be considered as negligible.

2.3 Release of radioactive nuclides into surface water (Baltic Sea)

- In comparison between operation and post operation and dismantling, the total emissions (without H-3) were reduced in 2 orders of magnitude (28 800 MBq/year by operation to 164 MBq/year in 1996).
- The main source for these emissions is the treatment of operational and post operational waste. All emissions are caused exclusively by the waste water treatment process.
- ***An influence of the dismantling activities is not detectable*** as:
  - All dismantling activities are realized on empty and dry facilities;
  - In case of dismantling activities with water use, band saw and remote dismantling, the waste water is contaminated with solid particles which have very small influence on the quality of evaporator condensate;
  - Waste water from post dismantling decontamination has only a small influence on the quality of evaporator condensate as it is neutralized before evaporation.

2.4 Waste

The whole mass of the site is about **1 800 000 t.**

This mass is divided into 3 Categories. Category 1 is defined as unrestricted material and the part of the whole mass is about 1 235 000 t. This material is conventional waste. Material of Category 2 is defined as suspected material, i.e. material with possible contamination. Material of Category 3 is defined as contaminated material. The materials of Categories 2 and 3 are radioactive waste (The definition ”radioactive residual material“ is used in Germany for all interim stages before final storage).Their part of the whole mass is about 565 000 t.

They can be exempted from the Atomic Law after free release measurement procedure (measurement and decision of the radiation protection authority when the values are below defined limit values) and possible previous decontamination.

Another type of Category 3 material is operational waste from operation and post operation.

2.4.1 Radioactive waste

The treatment or conditioning of operational- and dismantling waste according to the requirements for final disposal leads to an important decrease of the emergency potential.

On the other hand, the total amount of radioactive waste is reduced by treatment, and the release as conventional waste is possible.

These aspects are to be considered by the assessment of the low environmental impacts by treatment and conditioning of waste.

At the end of 2008, 54 442 t (approx. 80%) of the plant parts, categorized as Categorie 2 and 3 material, was dismantled.

88.4% of this amount of plant parts was disposed as conventional waste (unrestricted release and release with restrictions) after free release measurement and possible previous decontamination:

- Out of that 9.1% (8.3% from it are large components) were stored for decay in the ISN.
- Out of that 1.1% was for reuse or utilization in nuclear facilities.
- Out of that 1.4% was disposed as radioactive waste, with 0.4 % in the final storage Morsleben (closed 1998).

At the end of 2008 the net inventory of stored material in the ISN was 18 786 t with a total activity of 2.463E+16 Bq.

2.4.2 Conventional waste

Besides the waste from the NPP dismantling (Category 1 material and Categories 2 and 3 material after free release), important amounts of the disposed waste are generated by other dismantling activities on the EWN site.
In the years with the highest mass of conventional waste (2001, 2003, 2004 and 2007) in the range of annually < 50 000 t, the main part (about 75%) was concrete and other mineral building materials. More than 10% are scrap metals. About 90% of this conventional waste was recovered (e.g. by recycling).
For the assessment of the impacts from waste recovering it has also to be taken into account that the use of natural resources is reduced and thus environmental impacts (e.g. by ore processing) are prevented.
The quota of about 10% not recoverable waste is disposed environmental friendly by deposition in landfills (dumps) or burning in waste incineration plants.
All subcontractors for treatment, disposal and recovery of waste are regularly audited.
The transport emissions are an important impact of the conventional waste management (see 2.6) as secondary temporary impact.

2.5 Thermal output (cooling water)

The thermal output with the cooling water was important during operation but is insignificant after shut down.

2.6 Conventional emissions into air

Conventional emissions were increased by operation of the thermal power station, but this station was a necessary prerequisite for shut down the NPP units. In 2008, 14 t N-oxides and 1.5 t CO were emitted. With the decreasing energy consumption during the progress of decommissioning, these emissions are reduced.
Steady emissions arise from the emergency diesel engines. The annual emissions between 1988 and 2001 were about 3400kg N-oxides, 130kg SO_2, 115kg VOC (Volatile Organic Compounds) and 230kg PM10 (Particulate Matter < 10µm). Since 2002 these emissions have been stepwise reduced due to the replacement by smaller emergency diesel engines.
The emissions from decommissioning activities:

- Dismantling and cutting of facilities and facility parts,
- Removal of insulation,
- Removal of asbestos materials,
- Waste conditioning,
- Cutting of concrete structures,

- Demolition of buildings, and
- Demolition of plants for utilization of concrete and other mineral building materials

are reduced also by mitigation measures (e.g. filtration plants, band saw facilities), and present significant emissions are only limited to the working area.
The emissions from the transport of waste are more important. The range of these emissions is (worst estimated) about 300g NO_x and 10g PM10 per ton of waste.

2.7 Emissions of nutrients and water pollutants into surface water (Baltic Sea)
In comparison to the operation stage the annual emissions of nutrients, particularly N-compounds, were reduced from 6 930 t to 860 t at the end of the post operation stage. During the dismantling stage, the annual emissions were reduced to 130 t in 2000 and are approximately constant since then.
The emission of water pollutants, e.g. Chemical Oxygen Demand or heavy metals, was similar.
Impacts from the decommissioning process are not detectable. With the progress of decommissioning further decrease of the amount of waste water and the load of nutrients and water pollutants is expected.

2.8 Groundwater consumption
An approximately constant quantity of groundwater consumption is caused by groundwater lowering for keeping a constant groundwater level on the EWN site. This quantity is independent from the stages operation, post operation and dismantling and on a level of about 940 Tm^3 per year.
Another part of the groundwater consumption is the drinking water. This annual consumption depends on the number of personnel and was decreasing from 1996 to 2005 from $312Tm^3$ to $99Tm^3$.
The annual technological groundwater demand, primarily for the production of demineralized water is decreasing ($214Tm^3$ 1996 to $46Tm^3$ 2005). ***Significant impacts from the decommissioning process are not detectable.***

2.9 Energy consumption
The annual **electrical** energy demand for the whole site decreased almost continuously after shut down, except the period of the ISN construction. The demand in 1991 was 80 606MWh and in 2008 55 905MWh.
The most important consumers of electrical energy are the pumps of the cooling systems, the ventilation systems, lighting and the ISN.
The annual **thermal** energy demand for the whole site decreased from 403 000MWh after shut down in 1990 until the year 2000 when reached the value 138 580MWh and is approximately constant since this year.
There are no significant impacts from the decommissioning process.
With the progress of decommissioning, further decrease of the energy consumption can be expected.
Another part of energy demand is caused by the transport processes for decommissioning, primarily for the internal and external transport of decommissioning waste. This amount of primary energy is in worst cases estimated in the range of about 150kWh per ton of waste.

2.10 Noise

According to our experience from demolition of buildings outside the controlled or monitored area (area not concerned by operation license) the acoustic sources with the highest noise level are the activities ramming of spile walls and operation of hydraulic chisels. Noise levels above the limit values of the German Technical Instruction for Noise in the nearest residential areas were not measured or calculated for planning.
For the demolition of concrete structures of the hermetic compartments in the controlled area, band saw facilities with a low noise level will be used.
Thus, ***the temporary noise impacts of the whole decommissioning process are below the legally required limit values.***

2.11 Land use

The construction of the ISN was a necessary prerequisite for the decommissioning process.
Land consumption outside the EWN site was not necessary.

3. Evaluation of the impacts to the protected goods

3.1 Characteristics of EWN site

The EWN site is surrounded by the FFH areas “Greifswalder Bodden”and “Struck”, by a bird protection area, by the community Lubmin, a seaside resort, and large woodlands.

3.2 Immission of radioactive nuclides

Small amounts of nuclides were detected in sediments of a sewer which flowed into the cooling water outlet channel and in sediments of the closed part of the cooling water outlet channel inside the EWN territory.
In the environment outside the EWN territory only artificial radionuclide from the Chernobyl disaster were found. ***Impacts from decommissioning are not detectable.***

3.3 Immission of air pollutants (FFH areas)

The immission state was slightly deteriorated by the operation of the thermal power station. This deterioration was below a detectable level.
Impacts from decommissioning are not detectable.

3.4 Surface water (Greifswalder Bodden)

The important impacts from the operation phase (thermal, transport of dirty river water, nutrients and water pollutants) were reduced after shut down to a very low level.
Impacts from decommissioning are not detectable.

3.5 Groundwater (hydrogeology)

Impacts from decommissioning are not detectable.

3.6 Socio – economic impacts

The shut down caused an important reduction of the personnel to about 1/3 of the initial staff. The decision to use own personnel for decommissioning resulted in a personnel need of about 1000 for the decommissioning period.
The social impacts are essentially mitigated by decommissioning.

4. Classification of impacts

With the shut down of all units and the beginning of the post operation stage, the following impacts were reduced in comparison with the operation stage:

- Important reduction of the thermal output,
- Important reduction of personal radiation exposure (almost 2 orders of magnitude),
- Important reduction of the release of radioactive nuclides into air (almost 1 order of magnitude),
- Important reduction of the release of radioactive nuclides into water,
- Important reduction of the release of nutrients and water pollutants into water,
- Important reduction of the groundwater consumption for the production of demineralised water,
- Reduction of the electrical energy consumption,
- Reduction of the thermal energy consumption.

Additional impacts

- Emissions of conventional air pollutants generated by the thermal heating station,
- Social impacts (reduction of personnel).

1. Impacts caused by post operation, independent of NPP dismantling activities:
   - Groundwater consumption for the production of demineralised water,
   - Release of nutrients and water pollutants into water,
   - Release of radioactive nuclides into water,
   - Thermal energy consumption,
   - Electrical energy consumption,
   - Quota of release of radioactive nuclides into air (post operation, fuel reloading, treatment of operational- and post operational waste),
   - Quota of radiation exposure of personnel (post operation, guarding, radiation protection),
   - Quota of radioactive waste (operational and post operational waste),
   - Quota of impacts from ISN operation,
   - Quota of conventional waste (post operation waste, dismantling of facilities and buildings outside the controlled and monitored area).

2. Impacts caused by decommissioning

   a) Low level impacts
   - Quota of radiation exposure,
   - Quota of release of radioactive nuclides into air,
   - Quota of emission of conventional air pollutants by dismantling activities,
   - Quota of impacts from ISN operation,
   - Small quota of electrical energy demand,
   - Small quota of thermal energy demand.

b) Important impacts

- Radioactive waste, but on the other hand reduction of the emergency potential,
- Mitigation/reduction of social impacts

c) Important impacts but independent from other decommissioning options

- Conventional waste,
- Emissions into air by transport of waste.

3. Impacts independent from operation, post operation and decommissioning
   - Emissions from the emergency diesel engines,
   - Groundwater demand from groundwater lowering of the site.

The experience of EWN shows that the impacts on the protected goods from decommissioning/dismantling are on a significant low level, independent from chosen options.

5 Impact mitigation measures

5.1 Organisational measures

Additional to the legally required documents as the operational manual, the industrial safety instructions and radiation protection instructions, an environmental manual according to the EMAS and ISO 14000 requirements has been issued. As an important tool for supervision and control of all environmental impacts and environmental related activities, an Environmental Information System in the company´s intranet was developed.

EWN is certified as “Company specialised for plants with water harmful substances”. The responsible department for conventional waste management is certified as “Specialised Waste Management Department”.

5.2 Technical measures

5.2.1 EWN dismantling strategy

This strategy comprises the removal of all components/equipment Category 3 (e.g. steam generators, pressurizers and RPVs) as large as possible for decay storage and their later treatment in the ISN.

New dismantling technologies are tested with components without contamination.

Another part of this strategy is the decontamination of plant parts before dismantling. This decontamination measures were realized as soon as possible.

5.2.2 Reduction of the radioactive waste amount

The main strategy is the decontamination of plant parts after cutting and other preparation measures with different technologies, depending on material, form and contamination.

A main condition for this strategy is the use of the effective mass flow tracking system and the free release complex with buffer storages.

5.2.3 Minimisation of conventional and radioactive emissions

In the exhaust air systems of the controlled area, the Petrjanow filters were changed in 1997/98 to filters with the best available technique.

For all activities with the potential of aerosol formation, additional mobile systems for capturing and filtering are used. In case of thermal cutting, non-inflammable ceramic filters were used.

For the removal of asbestos materials in the controlled and monitored areas tight rooms with additional filtration systems and airlocks for personnel and material were used. Components with asbestos parts were dismantled as whole parts, the removal took place in an asbestos workshop under optimised conditions.

On all cutting places in the turbine hall, capturing and filtration systems are installed. The cutting of armoured concrete structures is realised by diamond wire saw systems. Advantages of these systems are:

- High cutting performance (1 – 2m^2/h),
- Low aerosol / dust release (water cooling),
- Low noise level (73dB(A)), and
- Possible automatic operation.

The removal of insulation of piping and plant equipment in the turbine hall was done by implementing a mobile suction system with separation of the insulation material in big bags. Advantages of this system are:

- High performance of removal of insulation,
- Low release of stone fibres,
- Only one worker is needed for operation of the suction system, and
- No direct handling of the insulation material.

5.2.4 Waste water treatment

For the purification of waste water from pickling activities in the operation stage (pickling of steam generators secondary side); and pickling of turbine condensers cooling water side resulting in the water pollutants high concentrations of heavy metals, small contamination with radioactive nuclides and high concentrations of complexones (EDTA and NTA), a treatment procedure with the steps UV radiation exposure, precipitation and filtration was developed and implemented.

5.2.5 Reduction of groundwater demand

The high capacity demineralisation plant (planned for 8 NPP units) was oversized for post operation and decommissioning purposes. Caused by the lower consumption of demineralised water, the internal water consumption rate of this plant was about 44%. With the erection and operation of a smaller demineralisation plant according to the best available techniques the internal water consumption rate was reduced to 3.5%.

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