Decommissioning of NPPs with spent nuclear fuel present - efforts to amend the German regulatory framework to cope with this situation

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ASTRACT

The authorization to operate an installation for the fission of nuclear fuel for the commercial production of electricity was withdrawn for the seven oldest NPPs and NPP Krümmel in Germany on August 6th, 2011after the events at Japanese Nuclear Power Plant (NPP) Fukushima Daiichi in March 2011. In the meantime, all these NPPs applied for decommissioning. One aspect reflected in the applications for these NPPs is the possibility that spent nuclear fuel elements or fuel rods will still be present in the cooling ponds at least during the first stage of decommissioning, i. a. due to limited availability of spent fuel casks. Although considerable decommissioning experiences are available in Germany, the approach "decommissioning with fuel elements present" has been the exceptional case so far. The paper highlights the efforts undertaken to strengthen the regulatory framework with respect to decommissioning in Germany taking into account this changed approach.

The paper presents a short introduction to the legal and regulatory requirements for decommissioning in Germany. Afterwards, the updates to the Decommissioning Guide, which includes proposals for an appropriate procedure for the decommissioning, safe enclosure and dismantling of facilities or parts thereof as defined in § 7 of the German Atomic Energy Act in respect of the application of the technical rules for planning and preparation of decommissioning measures as well as for licensing and supervision, are highlighted. In addition, the amendments to the Guidelines for the Decommissioning of Nuclear Facilities of the Nuclear Waste Management Commission (ESK), which is complementary to the Decommissioning Guide in a technical sense, are reported as well.

Introduction

After the events at Japanese Nuclear Power Plant (NPP) Fukushima Daiichi in March 2011 the German government decided to end the use of nuclear energy for the commercial generation of electricity by gradually phasing it out. This decision resulted in an amendment of the German Atomic Energy Act (AtG) of July 31st, 2011 withdrawing the authorization to operate an installation for the fission of nuclear fuel for the commercial production of electricity for the seven oldest NPPs and NPP Krümmel on August 6th, 2011 and setting end-dates for the authorization for the remaining nine NPPs on a step-by-step-basis until 2022 at the latest.

In the meantime, all eight NPPs, which were shutdown in 2011 and which are now in the post-operational phase (i. e. the phase between final shutdown and granting of the decommissioning license), applied for decommissioning. Additionally, NPP Grafenrheinfeld was shutdown on June 27th, 2015, half a year before its set end-date. An application for decommissioning was posted well in advance, as was done for the NPP Gundremmingen B, which is still in operation and which set end-date is December 31st, 2017.

One aspect reflected in the applications for these NPPs is the fact that spent nuclear fuel elements or fuel rods will possibly still be present in the cooling ponds at least during the first stage of decommissioning, i. a. due to limited availability of spent fuel casks. Table 1 summarizes the present situation at the NPPs being in the post-operational phase.

Table 1: Status of NPPs in post-operational phase

NPP	Date of final shutdown	Applications submitted	Location of fuel	Dismantling with fuel assemblies foreseen
Isar 1	06.08.2011	04.05.2012	cooling pond	yes
Unterweser	06.08.2011	04.05.2012 20.12.2013	cooling pond	yes
Biblis A	06.08.2011	06.08.2012	cooling pond	yes
Biblis B	06.08.2011	06.08.2012	cooling pond	yes
Brunsbüttel	06.08.2011	01.11.2012 19.12.2014	RPV (fuel assembly), cooling pond (defective fuel rods)	no (def. fuel rods)
Neckarwestheim 1	06.08.2011	24.04.2013	cooling pond	yes
Philippsburg 1	06.08.2011	24.04.2013 28.01.2014	cooling pond	yes
Krümmel	06.08.2011	24.08.2015	cooling pond	no (def. fuel rods)
Grafenrheinfeld	27.06.2015	28.03.2014	cooling pond	yes

Although considerable decommissioning experience is available in Germany, the approach "decommissioning with fuel elements present" has been the exceptional case so far. Therefore, efforts have been undertaken to strengthen the regulatory framework with respect to decommissioning in Germany taking into account this changed approach.

The "Guide to the decommissioning, the safe enclosure and the dismantling of facilities or parts thereof as defined in § 7 of the Atomic Energy Act" (Decommissioning Guide) [1], which includes proposals for an appropriate procedure for the decommissioning, safe enclosure and dismantling of facilities or parts thereof as defined in § 7 AtG in respect of the application of the technical rules for planning and preparation of decommissioning measures as well as for licensing and supervision was updated by representatives of the Federal Government and the Länder (states) ministries. Although the amendments are not yet set into force, the main outcomes of the updating process are highlighted.

In addition, the "Guidelines for the decommissioning of nuclear facilities" (Decommissioning Guidelines) of the Nuclear Waste Management Commission (ESK) [2], which is complementary to the Decommissioning Guide in a technical sense, was updated. The amendments of the Decommissioning Guidelines are reported.

Legal and regulatory requirements for decommissioning in Germany

Under the terms of § 7, para. 3 AtG, decommissioning, safe enclosure and dismantling of a facility or parts of a facility are subject to licensing. At the same time it is the only provision of the AtG which relates specifically to decommissioning for nuclear facilities.

According to the Act on the Environmental Impact Assessment (UVPG), Appendix 1, no. 11, an environmental impact assessment must be carried out for decommissioning, safe enclosure or the dismantling of stationary facilities for fission of nuclear fuel exceeding 1 kW continuous thermal load.

The licensing procedure for decommissioning, safe enclosure and dismantling of nuclear facilities or parts of facilities according to § 7 AtG is based on the Nuclear Licensing Procedures Ordinance (AtVfV). It contains provisions which are specific to decommissioning, in particular for the involvement of third parties and for the environmental impact assessment in § 4, para. 4 and § 19b AtVfV. In order to check the other provisions that are subject to public law related to the project, reference is made to § 14 of the AtVfV and for projects that are subject to an environmental impact assessment also to § 14a of the AtVfV. Other regulations in the AtVfV which are relevant here relate to the documents which must be submitted for radioactive residues (§ 3, para. 1 subpara. 8 of the AtVfV).

The Radiation Protection Ordinance (StrlSchV) is of particular relevance for the decommissioning measures. Its provisions contained in § 2, para. 1, subpara. 1 (c) apply to decommissioning, safe enclosure of a facility and the dismantling of a facility or parts of a facility as defined in § 7 AtG, and therefore it determines to a large extent the technical and operational measures, procedures and precautions for protection against damage from ionising radiation. In particular § 29 StrlSchV regulates the clearance unless existing regulations are maintained according to the transitional provisions of § 117, para. 10 StrlSchV.

§ 12 of the Nuclear Financial Security Ordinance (AtDeckV) represents a specific provision for decommissioning. If there is no more nuclear fuel in the facility, the standard limit can be specified by means of the residual activity in the facility as multiple of the exemption values defined in Appendix III Table 1 Column 2 StrlSchV in conjunction with the column for open radioactive materials of Annex 2 AtDeckV.

Other nuclear ordinances which are also applicable in the decommissioning procedure are:

- Cost Ordinance under the Atomic Energy Act (AtKostV);
- Nuclear Safety Officer and Reporting Ordinance (AtSMV);
- Nuclear Reliability Verification Ordinance (AtZüV).

The technical rules which exist for nuclear facilities were primarily created for the construction and operation of these facilities. These rules are i. a.:

- Safety Requirements for Nuclear Power Plants;
- Regulatory Guidelines by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB);
- Guidelines and Recommendations of the ESK, the Reactor Safety Commission (RSK), and the Commission on Radiological Protection (SSK);
- Safety Standards of the Nuclear Safety Standards Commission (KTA).

Where there are no special nuclear safety requirements or radiation protection requirements, the general technical standards can be applied instead.

There are only few standards which are explicitly applicable to decommissioning, safe enclosure and dismantling of nuclear facilities. DIN standards which are specific to nuclear technology cover various areas such as: basic requirements, terms and symbols; construction, operation and inspection of individual components or whole systems; radiological measurement technology, dosimetry; measuring techniques for contamination, discharges and for the clearance of radioactive substances; operation of equipment etc. These standards are to be applied, as far as applicable to facilities to be decommissioned. Deviations from the technical standards may be allowed in individual cases if the necessary level of safety can be guaranteed to a comparable degree in another way.

In the licenses which have so far been issued under the terms of § 7, para. 3 AtG, the licensing authorities stipulated the requirements for decommissioning and safe enclosure or the dismantling of facilities or parts thereof, in some cases with analogous application of the rules and guidelines which exist for construction and operation of the facilities. Relevant parts of the requirements were tailored to suit the specific conditions with regard to the decommissioning and safe enclosure or the dismantling of the facility.

Decommissioning Guide

The Decommissioning Guide was published in the year 2009 as a Regulatory Guideline by BMUB and includes proposals for an appropriate procedure for the decommissioning, safe enclosure and

dismantling of facilities or parts thereof as defined in § 7 AtG in respect of the application of the technical rules for the planning and preparation of decommissioning measures as well as for licensing and supervision [1].

In view of the large number of decommissioning projects which are to be carried out in the future, the aim of the guide is

- to summarise the aspects of licensing and supervision which are relevant in the decommissioning procedure,
- to achieve a common understanding between the Federal Government and the Länder to ensure that decommissioning is done appropriately, and
- to harmonise the existing interpretations and procedures where possible.

As part of the Decommissioning Guide, all Regulatory Guidelines by BMUB and the KTA Safety Standards that were primarily written for construction and operation, were assessed for their applicability to the decommissioning of nuclear facilities and were divided into the following three categories:

- Category 1: The rule is generally applicable and must therefore be taken into account in the decommissioning procedure.
- Category 2: The rule is not relevant to decommissioning procedures. However, in case of construction measures that might be performed within the framework of decommissioning or significant changes of use it can be applied adapted to protection objectives in terms of Category 3.
- Category 3: The rule is applicable after adaptation to the protection objectives or is partially applicable to decommissioning procedures, taking account of the changed, in many respects reduced, potential hazard and the modified requirements relative to construction and operation.

In Annex 2, the rules are assigned to the different categories and Annex 3 contains comments on adaptations of the regulations to the protection objectives or the partial application of the rules assigned to Category 3.

An amendment process of the Decommissioning Guide was commenced in the year 2015, amongst others in order to better reflect the approach “decommissioning with fuel elements or fuel rods present” as foreseen within the applications for decommissioning of the NPPs in the post-operational phase.

In addition to the appraisal of amendments to the regulatory framework and international conventions, the following main topics were reworked in the update of the Decommissioning Guide:

- Preparation for decommissioning after final shutdown and before granting of the decommissioning license;
- Safety assessment for decommissioning;

- Categorisation of Regulatory Guidelines of BMUB and KTA Safety Standards.

Foreseen preparatory activities during the transition period after final shutdown and before granting of the decommissioning license must be commensurate with the provisions of the operating license or must not represent essential modifications. These activities may include the following:

- Unloading of fuel elements and removal of nuclear fuel as early as possible;
- (Full) system decontamination;
- Taking material samples from systems and components for the purpose of a radiological characterisation expected for the license application for decommissioning;
- Inventory-taking for hazardous substances (combustible, toxic, water-endangering etc.);
- Amendment of the operating rules;
- Utilisation of residual radioactive material and disposal of radioactive waste from the operating phase;
- Taking installations out of operation that are no longer needed for the current state of the facility and for decommissioning;
- Establishing areas for logistics (areas for buffer storage of residual radioactive material, transport routes).

As long as there is still nuclear fuel inside the facility, compliance with the safety functions

- reactivity control and
- fuel cooling

has to be ensured all the time. Therefore, key aspect of the respective safety assessment is to demonstrate that the planned dismantling measures do not impermissibly impact the structures, systems and components, which are required to fulfil these safety functions. The following categories of events are relevant with nuclear fuel still present:

- Reduced heat removal from the spent fuel pool;
- Loss of coolant from the spent fuel pool;
- Reactivity changes in the spent fuel pool and criticality incidence;
- Events during handling and storage of fuel assemblies.

Mainly for the following Regulatory Guidelines of BMUB and KTA Safety Standards the categorisation and/or comments were adapted in the context of the update:

- Safety Requirements for Nuclear Power Plants;
- Guidelines Concerning the Proof of the Technical Qualification of Personnel;
- Requirements for the Emergency Manual;

- Integrated Management Systems for the Safe Operation of Nuclear Power Plants;
- Ageing Management in Nuclear Power Plants;
- Instrumentation and Reactor Protection;
- Energy and Media Supply.

As of October 2015, the amendment process of the Decommissioning Guide is in an advanced stage but has not formally completed.

Decommissioning Guidelines of the ESK

The ESK was established in 2008 to advise BMUB in technical/scientific matters of nuclear waste management (conditioning, storage and transport of radioactive materials and waste, the decommissioning and dismantling of nuclear facilities, and disposal in deep geological formations).

In 2010, ESK published its Decommissioning Guidelines, which present the technical requirements and processes to be applied for the decommissioning of facilities and parts thereof licensed under § 7 AtG. These guidelines take into account the recommendations of the international standards and regulations and complement the requirements and specifications of the Decommissioning Guide from a technical point of view.

In 2014, ESK decided to update the Decommissioning Guidelines. The latest version was published in March 2015 [2].

To address issues in relation to the approach "decommissioning with fuel elements present" the Decommissioning Guidelines were amended mainly in the following areas:

- Requirements concerning decommissioning operating rules;
- Dismantling activities;
- Safety classification of systems and components.

The operating rules have to take into account, among other things, the following:

- Operating organisation and safety management including description of safety-relevant processes;
- The procedure for the classification and re-classification of installations;
- The procedure for modifications, including the change of use of facility rooms;
- The procedure for radioactive waste management as well as for clearance/removal of materials, of soil areas and of buildings or parts thereof;
- The work permit procedures;

- The measures provided for radiation protection, occupational health and safety and fire protection.

The dismantling is to be planned and performed such that the safety-relevant measures required to comply with the main safety functions will not be affected in their function and availability. As long as the facility is not yet free from nuclear fuel, compliance with the safety functions

- maintenance of subcriticality, and
- residual heat removal

is to be ensured. The installations required to fulfil the safety functions must be available with the necessary effectiveness and reliability. To what extent installations are required in detail results from the safety analyses which must include considerations for the decommissioning operation as well as for abnormal occurrences and accidents. The measures for dismantling of the installation are to be designed such that there will be no impermissible impacts on the respective installations still necessary for maintaining decommissioning operation.

Classification, reclassification and adaptations of safety-relevant systems and components to the changed conditions of dismantling require the performance of safety assessments and approvals by the supervisory authority. Here, potential releases of existing radioactive material during disassembly of individual facility components or systems and the potential concentration of radioactive material in containers or in the form of packages in individual room areas are to be considered with a view to the confinement of radioactive material and the avoidance of unnecessary radiation exposure. As long as the facility is not yet free from nuclear fuel, the systems and components for cooling and for the criticality-proof storage of fuel elements are safety relevant. Basically, for these systems and components the requirements from the operational phase persist.

Conclusion

One aspect reflected in several applications for the coming decommissioning projects of NPPs in Germany is the fact that spent nuclear fuel elements or fuel rods will still be present in the cooling ponds at least during the first stage of decommissioning, i. a. due to limited availability of spent fuel casks. Although considerable decommissioning experience is available in Germany, the approach "decommissioning with fuel elements present" has been the exceptional case so far. Therefore, efforts have been undertaken to strengthen the regulatory framework with respect to decommissioning in Germany taking into account this changed approach.

The Decommissioning Guide was update especially with respect to the following topical areas:

- Preparation for decommissioning after final shutdown and before granting of the decommissioning license;
- Safety assessment for decommissioning;
- Applicability of Regulatory Guidelines of BMUB and KTA Safety Standards primarily created for the construction and operation of nuclear facilities to the outlined decommissioning approach.

To address issues in relation to the approach "decommissioning with fuel elements present" the Decommissioning Guidelines of the ESK were amended mainly in the following areas:

- Requirements concerning decommissioning operating rules;
- Dismantling activities;
- Safety classification of systems and components.

Both documents were updated in the light of the challenges resulting from the increasing number of NPP decommissioning projects in Germany, including the expectation that start of dismantling measures with spent fuel elements or fuel rods in the cooling ponds will become common practice.

References

[1] Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, "Guide to the decommissioning, the safe enclosure and the dismantling of facilities or parts thereof as defined in § 7 of the Atomic Energy Act", 12.08.2009.

[2] Nuclear Waste Management Commission, "Guidelines for the decommissioning of nuclear facilities", 16.03.2015.