Expected Waste Streams Originating from the Decommissioning of NPPs: German Situation as Compared to International Standards – 16447

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ABSTRACT

This paper presents an overview of current and future decommissioning projects of NPPs in Germany. The expected amounts of residual radioactive materials are given. Their possible utilization and disposal routes, which are stipulated by the German Radiation Protection Ordinance, are presented and compared to those resulting from the French zoning model.

INTRODUCTION

In Germany, disposal in deep geological formations is intended for all types of radioactive waste. Therefore, every endeavor is being made in order to minimize the amount of radioactive waste, which is generated.

This is of special importance for the decommissioning of nuclear power plants (NPPs) as the amount of residual radioactive material will rise significantly during decommissioning of an NPP compared to the operating phase, especially material arising from demolition of the building structures, which is at the most slightly contaminated and which needs to be utilized without detrimental effects.

First, an overview of current and future decommissioning projects of NPPs in Germany is given. The German regulatory requirements for clearance of residual radioactive material are presented and an estimation of the corresponding waste streams shown. Finally, the German approach to clearance is compared to the zoning model applied in France.

OVERVIEW OF CURRENT AND FUTURE DECOMMISSIONING PROJECTS OF NPPS in Germany

In Germany, 19 NPPs and prototype reactors have been decommissioned since the 1970ies, three of which have been completely dismantled and the sites released from regulatory control. TABLE I presents major decommissioning project being conducted at the moment.

TABLE I. Major decommissioning projects of NPPs presently conducted in Germany

Name	Abbrev.	Reactor type	Power (MW_e)	Decom. started
Greifswald 1-5	KGR 1-5	PWR/WWER	440	1995
Würgassen	KWW	BWR	670	1997
Mülheim-Kärlich	KMK	PWR	1302	2004
Stade	KKS	PWR	672	2005
Obrigheim	KWO	PWR	357	2008

After the events at Japanese NPP Fukushima Daiichi in March 2011 the German government decided to end the use of nuclear energy for the commercial generation of electricity at the earliest possible time by gradually phasing it out. This decision resulted in the 13th Amendment of the German Atomic Energy Act withdrawing the authorization to operate an installation for the fission of nuclear fuel for the commercial production of electricity for the NPPs Biblis A and B, Neckarwestheim 1, Brunsbüttel, Isar 1, Unterweser, Philippsburg 1 and 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.

NPP Grafenrheinfeld was shut down on June 27th, 2015, half a year before its set end-date. In the meantime, the operators of all shutdown NPPs applied for decommissioning licenses, as did NPP Gundremmingen B, which final shutdown is due by the end of 2017. TABLE II summarizes the coming decommissioning projects of shutdown NPPs in Germany, whereas TABLE III present the expected shutdown dates of those NPPs still in operation.

TABLE II. Coming decommissioning projects of shut down NPPs in Germany

Name	Abbrev.	Reactor type	Power MW_e	Date of application
Isar 1	KKI 1	BWR	912	5/4/2012
Unterweser	KKU	BWR	1410	5/4/2012 12/20/2013
Biblis A	KWB A	PWR	1225	8/6/2012
Biblis B	KWB B	PWR	1300	8/6/2012
Brunsbüttel	KKB	BWR	806	11/1/2012 12/19/2014
Neckarwestheim 1	GKN 1	PWR	840	4/24/2013
Philippsburg 1	KKP 1	BWR	926	4/24/2013 1/28/2014
Krümmel	KKK	BWR	1402	8/24/2015
Grafenrheinfeld	KKG	PWR	1345	3/28/2014

TABLE III. NPPs still in operation

Name	Abbrev.	Reactor type	Power MW_e	Date of final shutdown
Gundremmingen B	KRB-II-B	BWR	1344	12/31/2017[a]
Philippsburg 2	KKP 2	PWR	1468	12/31/2019
Grohnde	KWG	PWR	1430	12/31/2021
Gundremmingen C	KRB-II-C	BWR	1344	12/31/2021
Brokdorf	KBR	PWR	1480	12/31/2021
Isar 2	KKI 2	PWR	1485	12/31/2022
Emsland	KKE	PWR	1400	12/31/2022
Neckarwestheim 2	GKN 2	PWR	1400	12/31/2022

[a] *Application for decommission license on 12/11/2014*

It is expected that the first decommissioning licenses are granted in the first half of the year 2016. As a result, a significant number of large decommissioning projects will be conducted in parallel in Germany in the coming years.

WASTE STREAMS RESULTING FROM THE DECOMMISSIONING OF NPPS IN GERMANY

Although the averaged total masses of all buildings of the German pressurized water reactors (PWR) to be decommissioned in the future are significantly higher than those of the respective boiling water reactors (BWR), the masses of buildings being part of the controlled area are comparable. Fig. 1 depicts typical masses of all buildings from radiation protection areas and other areas of an NPP averaged over different sites, 95% of the masses being concrete.

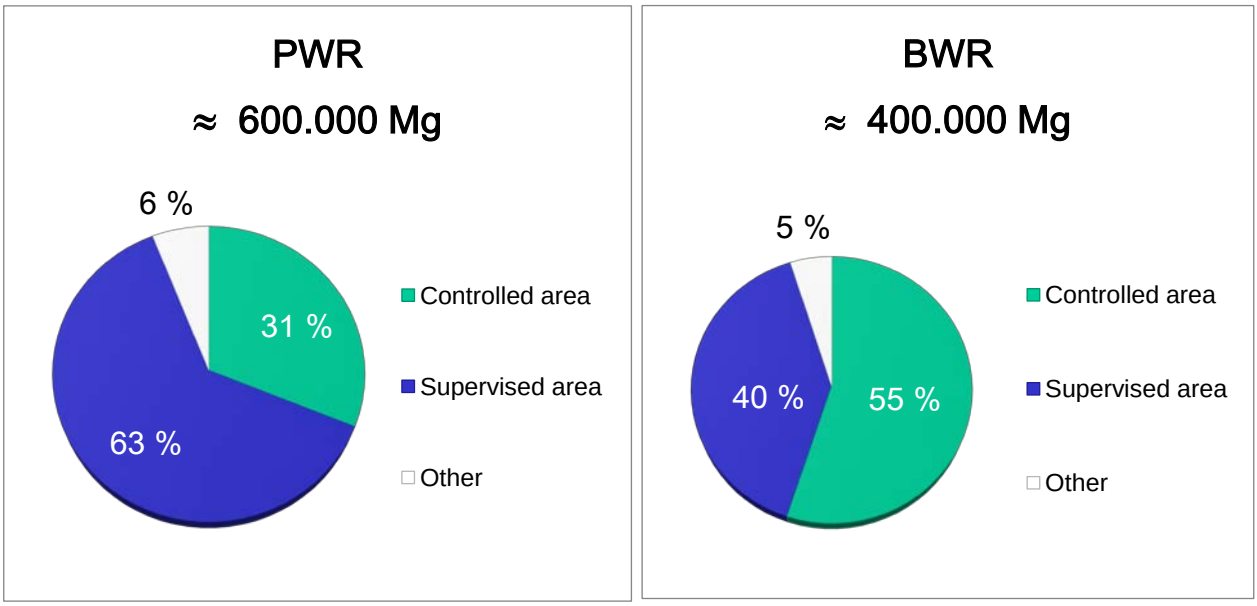

Fig. 1. Total mass of all buildings from radiation protection areas and other areas of an NPP averaged over different sites (as of [1]).

The material stemming from a controlled area is judged as residual radioactive material. Provided the residual radioactive material is proven to comply with the clearance levels stated in Appendix III, Table 1 to § 29 of the German Radiation Protection Ordinance (RPO), it may be cleared and utilized, removed, owned or forwarded to third parties as non-radioactive materials. TABLE IV summarizes the possible clearance options in Germany.

TABLE IV. Summary of possible clearance options stipulated by the German Radiation Protection Ordinance

Unconditional clearance ("use as you like"):	**Conditional clearance ("the use is prescribed"):**
Solid material	Solid material for disposal (100t, 1000t) incineration (100t, 1000t)
Liquids	Liquids for disposal in a waste incineration plant
Building rubble and excavated soil with an expected mass of more than 1,000 t/a	Buildings for demolition
Sites	Scrap metal for recycling
Buildings for reuse and further use	

The compliance with the clearance levels ensures that during the reuse or the disposal on a conventional landfill any noticeable exposure of the general public is precluded, i.e. the additional dose occurring for a member of the public will not exceed 10 µSv per year. There is a range of possibilities for the reuse of residual radioactive materials. Released tools and installations from decommissioned NPPs may be used e.g. in other NPPs or in conventional plants. Metals may be recycled by melting them down. Rubble may be used as raw material in road-building, for backfilling of landfill or for the production of concrete. For electronic scrap, conventional recycling is applied, too.

By making use of the possible clearance options, approximately 97% of the residual radioactive material, which is generated during the decommissioning of an NPP can be cleared (10% unconditionally and 87% conditionally) leaving 3% which has to be disposed of in a deep geological repository (see Fig. 2).

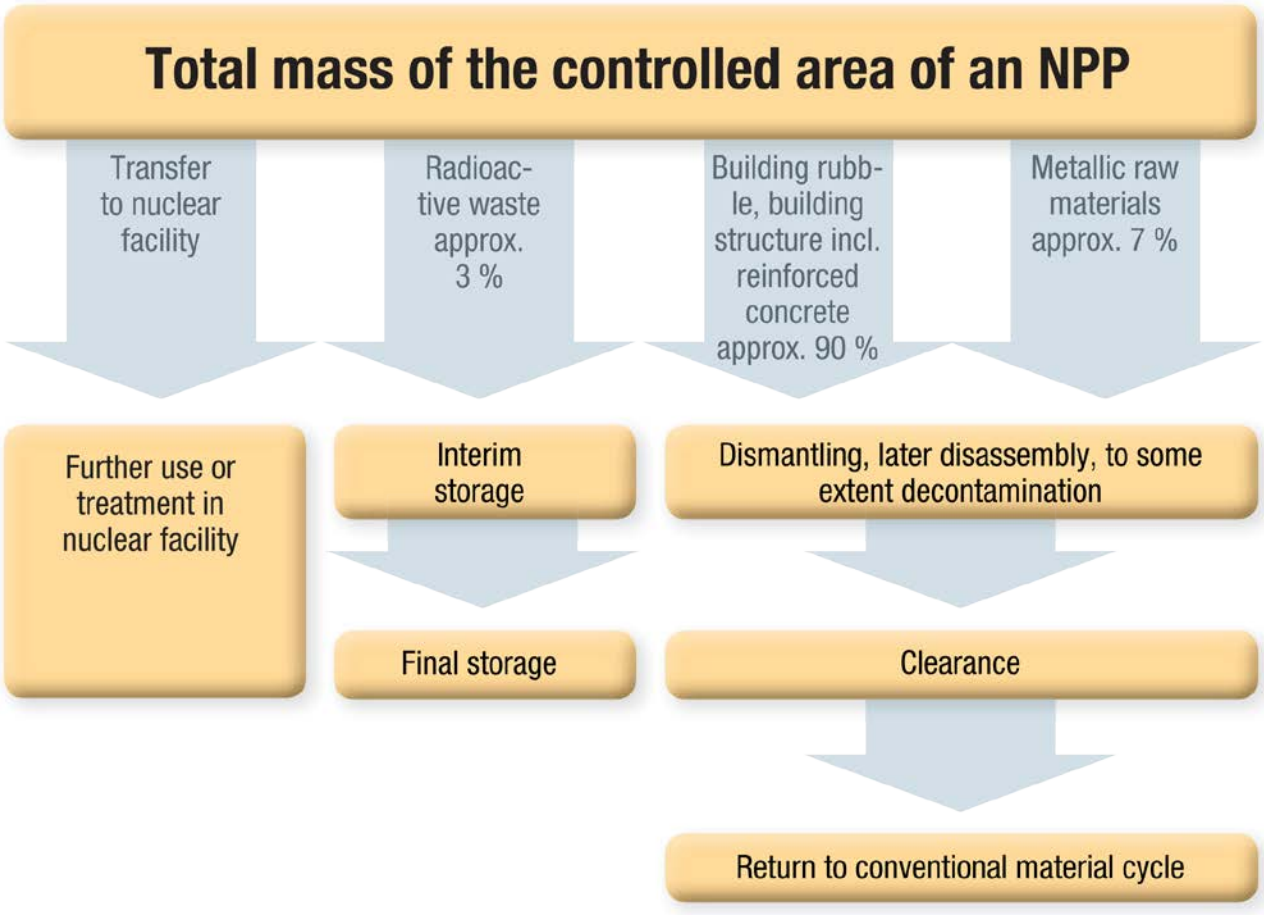

Fig. 2. Typical waste streams from the demolishing of the controlled area of an NPP.

COMPARISON OF THE GERMAN CLEARANCE APPROACH WITH THE FRENCH ZONING MODEL

In France, an NPP is divided into areas of possible production of radioactive waste, in other words areas in which the waste produced is contaminated, activated or liable to be so, and areas known as conventional waste zones. For the later one, solely control measures are performed to verify the classification.

A fraction of 7% of the total mass of an NPP being decommissioned in France is categorized as very low level waste (VLLW) and is disposed of in the near surface repository Centre Morvilliers. Approximately 6% are categorized as low and intermediate level waste (LLW/ILW), which is disposed of the near surface repository at Centre de l´Aube. A majority of 87% of the total masses is assigned to the conventional zone according to the zoning model applied and is conventionally used or utilized. A comparison of the waste streams and respective categories in France and Germany is shown in Fig. 3.

The following general conclusions can be drawn for the waste streams resulting from the decommissioning of NPPs in France and Germany when comparing the different approaches:

• The conventional disposal in France is comparable to clearance in Germany.

• Unconditional clearance in Germany is significantly different than the disposal of VLLW in France. This finding holds also for the wastes being cleared to be disposed of on landfills in Germany, as the respective nuclide-specific limits of the specific activities are partially several orders of magnitude lower than the acceptance limits for VLLW-repositories in France.

• Part of the VLLW disposed of in a near-surface repository in France would have to be disposed of in a deep-geological repository for waste with negligible heat generation in Germany.

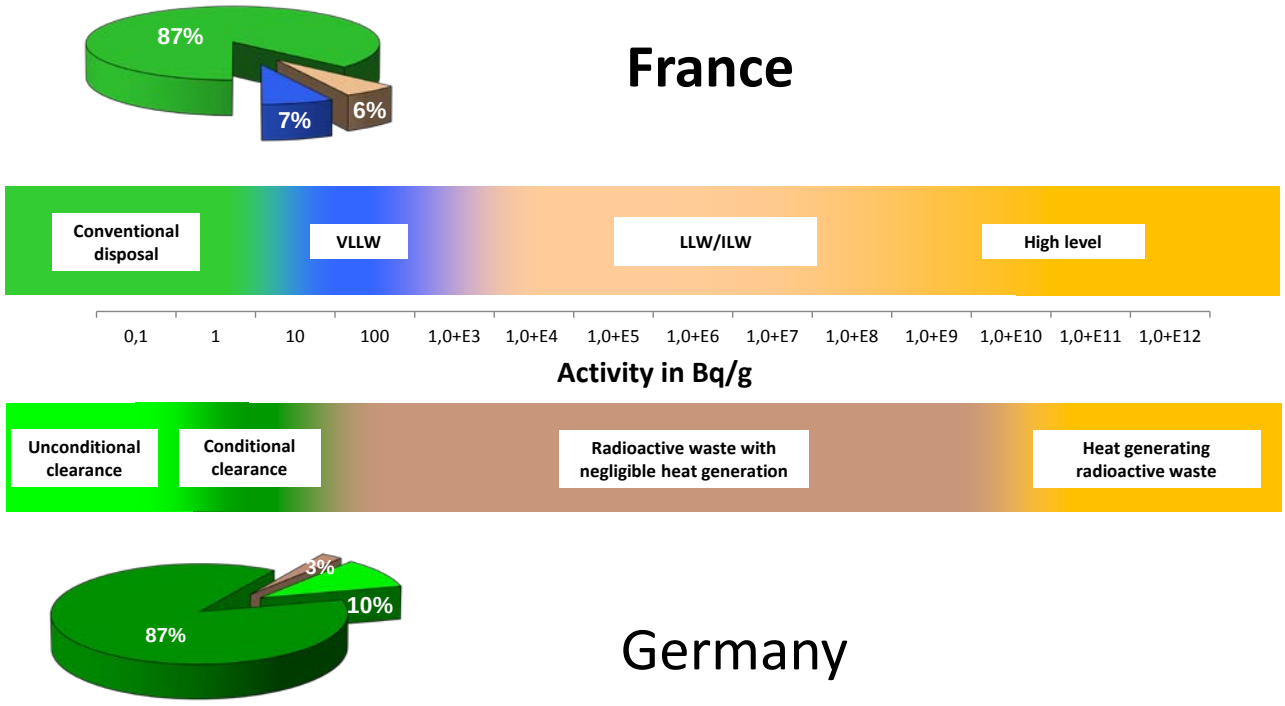

Fig. 3. Waste streams and respective categories in France and Germany (as of [1]).

CONCLUSIONS

A significant number of large decommissioning projects will be conducted in parallel in Germany in the coming years, resulting in a significant increase in waste streams compared to the operating phase.

By making use of the possible clearance options, approximately 97% of the residual radioactive material, which is generated during the decommissioning of an NPP can be cleared (10% unconditionally and 87% conditionally) leaving 3% which has to be disposed of in a deep geological repository.

When comparing the German clearance approach and the French zoning model, the main difference lies rather in the fundamental philosophy applied but impacts on resulting waste streams are comparable.

REFERENCES

1. Nuclear Waste Management Commission, “Comparison of the mass flows from decommissioning of nuclear facilities Germany / France” (2014)

ACKNOWLEDGEMENTS

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