
Occupational radiation exposure of workers in German NPPs

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Abstract:

In several industries, the personnel are subject to radiation exposure. This contribution will provide an overview of the occupational exposure of personnel in nuclear power plants in operation and also under decommissioning in Germany. Based on recent data, trends in the exposure of personnel will be discussed and some examples will be given on how experiences contribute to improvements concerning the exposure of workers.

The data available show, that with time in general the exposure of the individual worker decreases. This is a result of a manifold effort by all parties involved in the radiation protection in nuclear facilities, which is mainly based on a consequent experience feedback from past operation to improve design and operation and regulations relevant for the nuclear sector.

1 INTRODUCTION

The evaluation of radiation exposure data is an important issue for an experience feedback in the area of radiation protection. Therefore, GRS operates a database (RADAN) which contains data on occupational exposure in German nuclear power plants (NPP) in operation and under decommissioning. These data are obtained from various sources, ranging from annual reports of the German NPPs, specific communications by the NPPs to international databases, like the database of the Information System on Occupational Exposure (ISOE).

This contribution to the 2010 EUROSAFE Conference presents excerpts from RADAN to highlight the long term trends of the occupational exposure in German NPPs, both in operation and under decommissioning. The main emphasis is on the key data, i.e. on the total annual collective effective dose (in person.Sv/a) and the average annual individual effective dose (in mSv/a), but also dose distributions are considered.

2 OCCUPATIONAL EXPOSURE OF PERSONNEL IN GERMAN NUCLEAR POWER PLANTS

Today in Germany 17 nuclear power plants at 12 sites are in operation and 17 nuclear power plants at 13 sites are under decommissioning while 2 nuclear power plants were completely dismantled meanwhile.

2.1 Nuclear Power plants in operation

Fig. 1 and Fig. 2 show the total annual collective effective dose and the average annual individual effective dose to monitored personnel for all German NPPs in operation. Both figures show a clear long term trend of lower total annual collective effective doses and average annual individual effective doses of monitored personnel. In general terms, this

trend is due to a consequent experience feedback and radiation protection work planning process during operation (based on the so called IWRS radiation protection planning) and due to improvements in the design of newer NPPs. For some NPPs, back fitting activities were performed during operation improving also the radiological work conditions. Especially the long term trend for the average annual individual effective dose of monitored personnel indicates that in general the working conditions for the personnel changed and improved. The figures are based on data from the occupational dosimetry systems used by the operators of the NPPs. Thus, contracted personnel are attributed to each single NPP even if they entered two or more NPPs during the year. Accordingly, the number of contracted personnel in the figures is higher than the number of real persons or the related number of the personnel registered in the German statutory dosimetry. As a consequence, the average annual effective individual dose for contracted personnel is lower than in case of using the official data of the statutory dosimetry and should be regarded as an “NPP attributed average annual individual effective dose”.

A further analysis of the distribution of the annual individual effective dose of the monitored personnel in German NPPs confirms that the fraction of personnel with a higher dose decreases (e.g. Fig. 3 and Fig. 4 on the distribution of the fraction of monitored utility and contracted personnel). Since 2001, exposures above the German dose limit (20 mSv per year) did not occur.

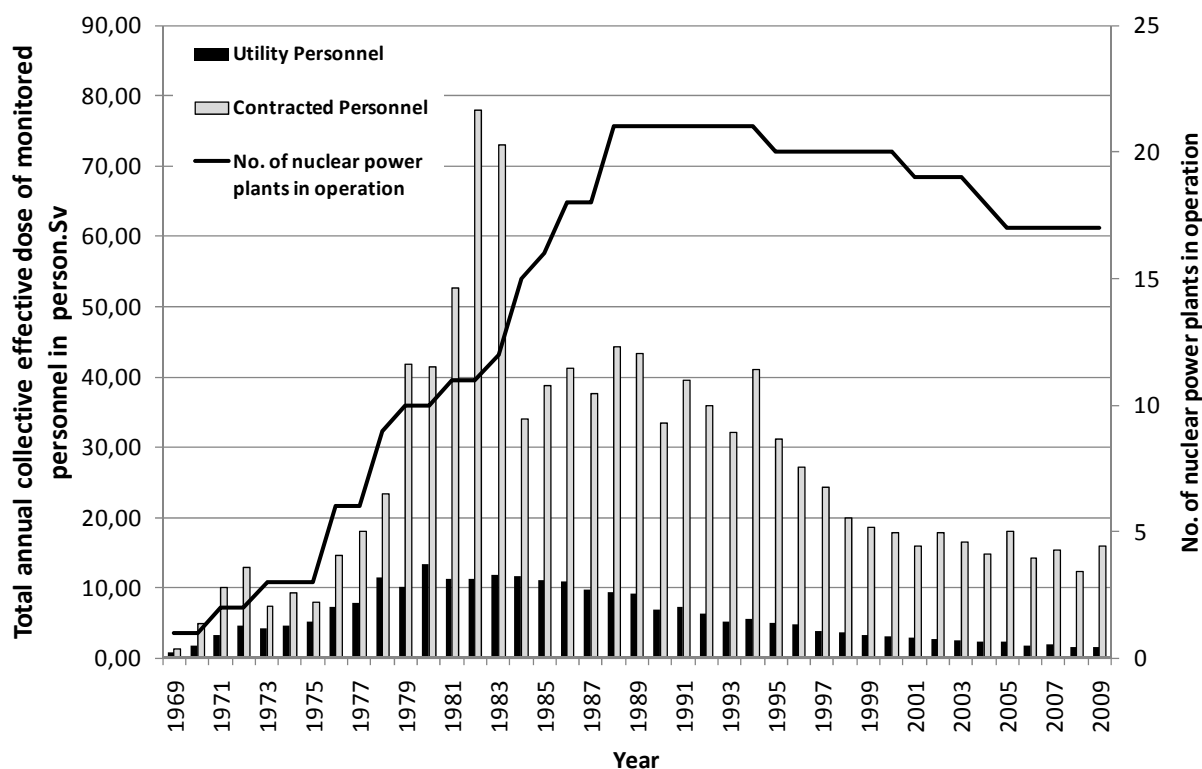


Figure 1: Total annual collective effective dose of monitored personnel for German nuclear power plants in operation

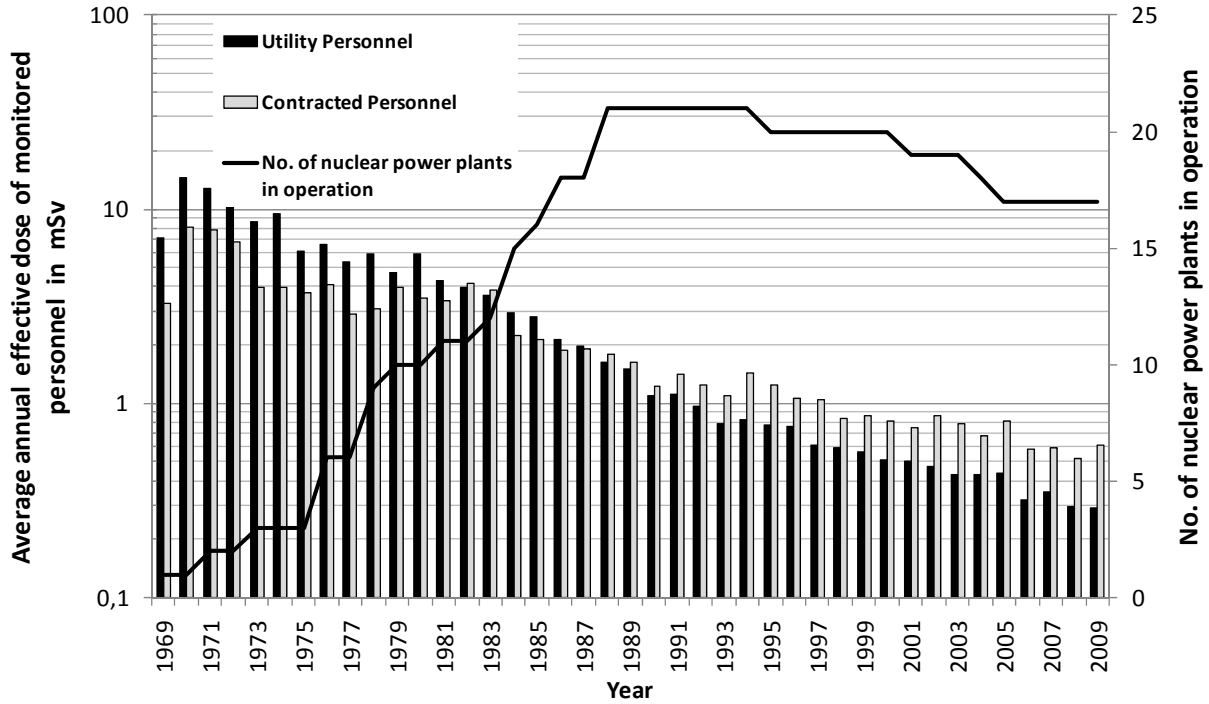


Figure 2: Average annual individual effective dose of monitored personnel for German nuclear power plants in operation

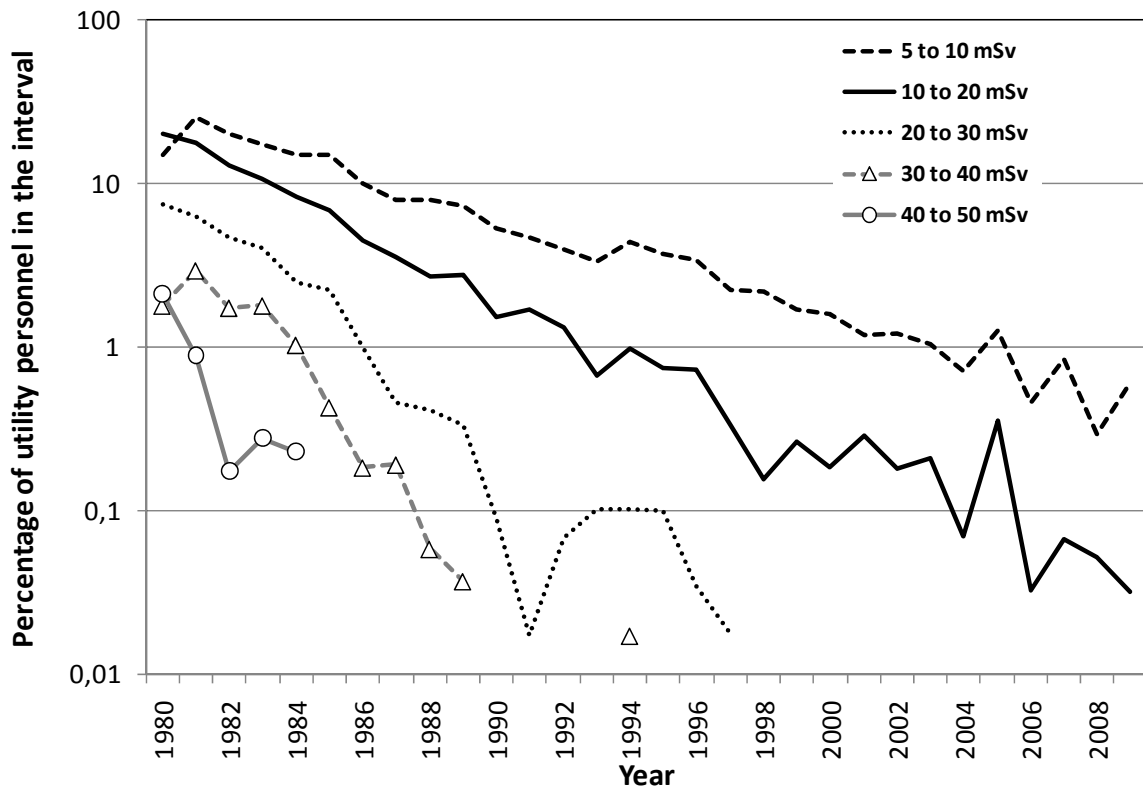


Figure 3: Distribution of the fraction of monitored utility personnel with a specified annual individual effective dose for German nuclear power plants in operation (in %).

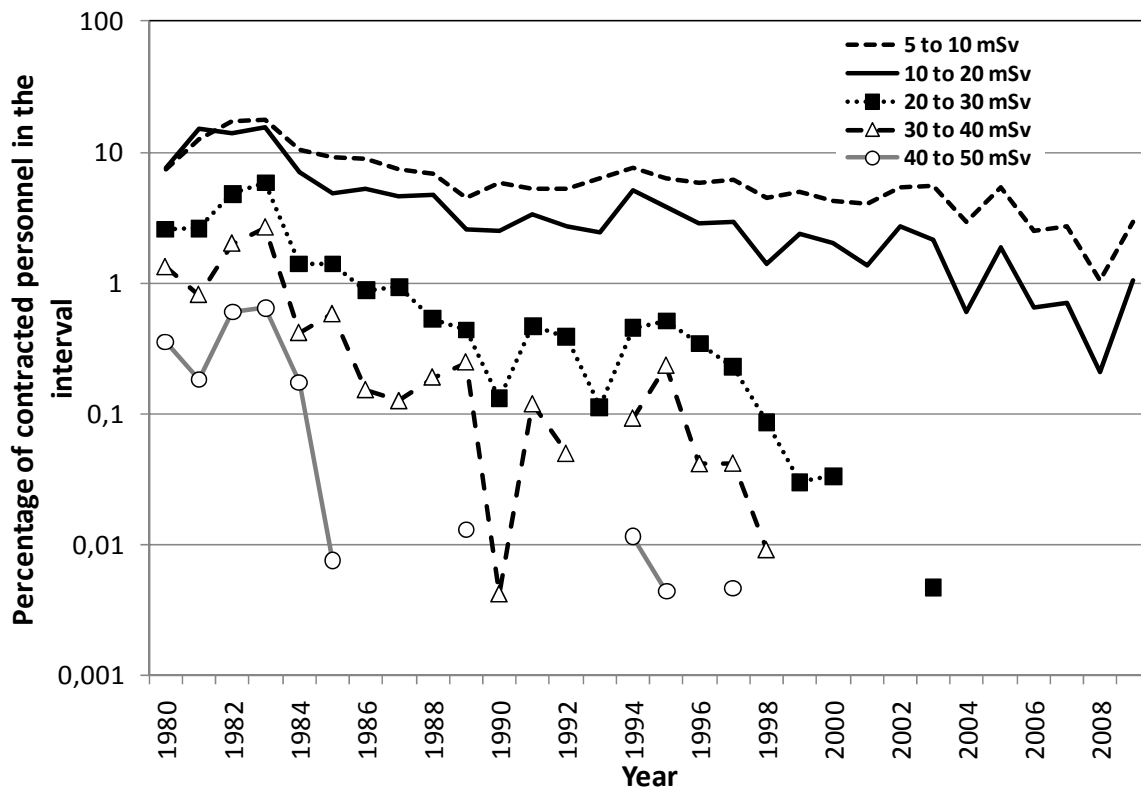


Figure 4: Distribution of the fraction of monitored contracted personnel with a specified NPP attributed annual individual effective dose for German nuclear power plants in operation (in %).

The influence of the design of the German NPPs on the occupational exposure during operation can be easily recognized in Fig. 5 and Fig. 6. In these figures, an average annual collective dose is correlated to the German design generations; the average is calculated from the annual collective effective dose of all NPPs belonging to the same design generation. While the figures consider all commercial NPPs in operation in former West Germany, the six NPPs of the former East Germany are not considered, as they belong to another design generations of Russian design (VVER). The German NPPs of PWR type are divided into 4 design generations (Fig 5); during design of the PWRs of the fourth generation (so called Konvoi reactor) all previously made experiences, esp. from operation of PWRs of the first generation, were considered (e.g. on the use of material with low neutron activation, design of compartments to separate components with high dose rates from those with low dose rates to reduce exposure during later maintenance work, design requirements for low dose rates at frequently accessed locations). As such, the Konvoi reactors offer well improved radiological conditions due to design. Fig. 6 shows the 3 German design generations of BWRs. Generally, for all German design generations the trend decreased significantly in the past. During the recent years, the data are fluctuating on a lower level which is different for the different design generations. These fluctuations are caused by the outage workload which is varying strongly from year to year in the single units.

Fig. 5 and Fig. 6 illustrate also the different contributions from the German NPPs to the total annual collective effective dose of the German NPPs in operation. As an example on the different situation in the different NPPs, for 2009 the average annual individual effective dose for monitored contracted personnel varied between 0,046 mSv and 1,78 mSv. These are doses for single NPPs that are not shown in the figures. The individual contributions of each NPP may change significantly, typically more for the earlier generations, as they are due to the design based height of radiation fields in the workplaces more sensible to changes in workload than the Konvoi reactors.

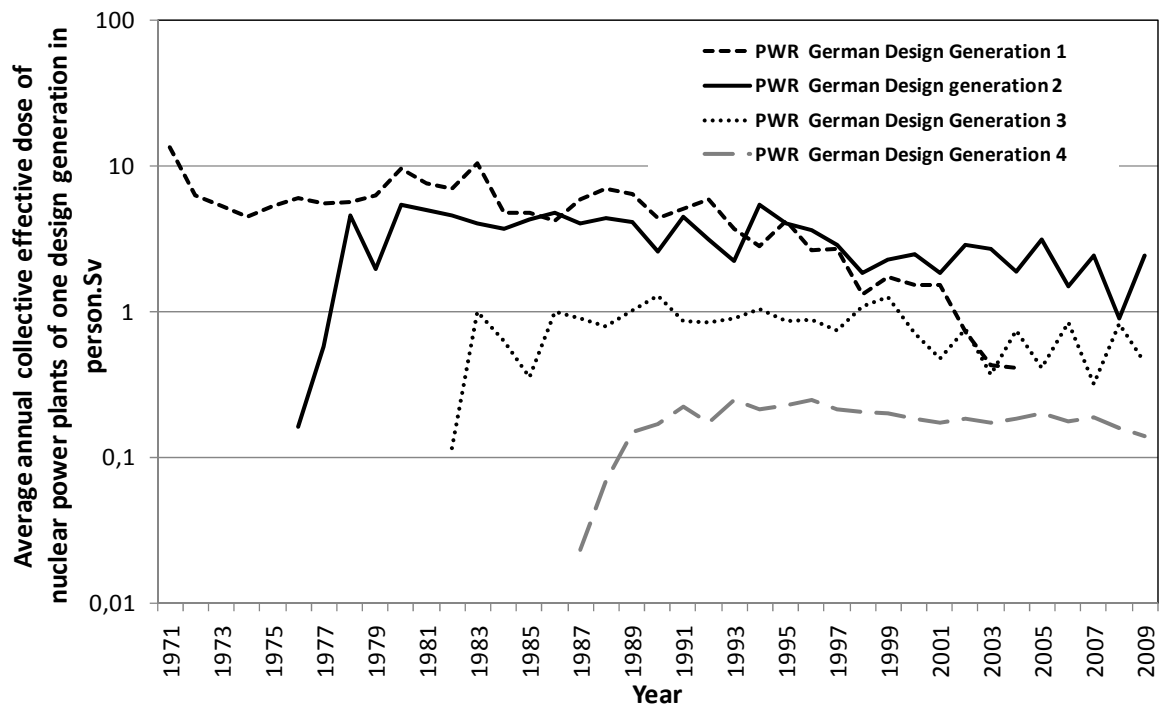


Figure 5: Average annual collective effective dose of the personnel (utility and contracted), averaged for German PWRs of similar design generation.

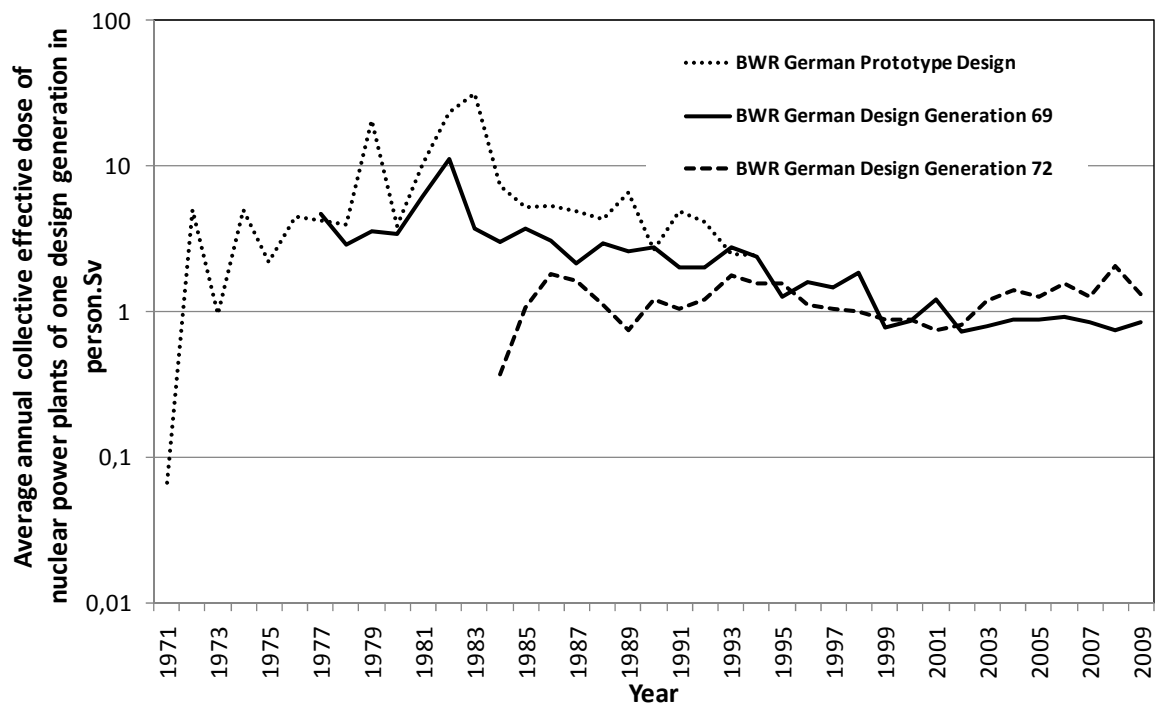


Figure 6: Average annual collective effective dose of the personnel (utility and contracted), averaged for German BWRs of similar design generation.

Fig. 7 and Fig. 8, respectively, again illustrate the differences between the reactor design generations. They present the fraction of the personnel (both contracted and utility personnel) that received an NPP attributed annual individual effective dose above 1 mSv, the German dose limit for a member of the public. The fraction of the personnel with doses

> 1 mSv shows a general decreasing trend. In case of the Konvoi reactors, only a few percent exceed the 1 mSv value, nevertheless, the fraction is still decreasing.

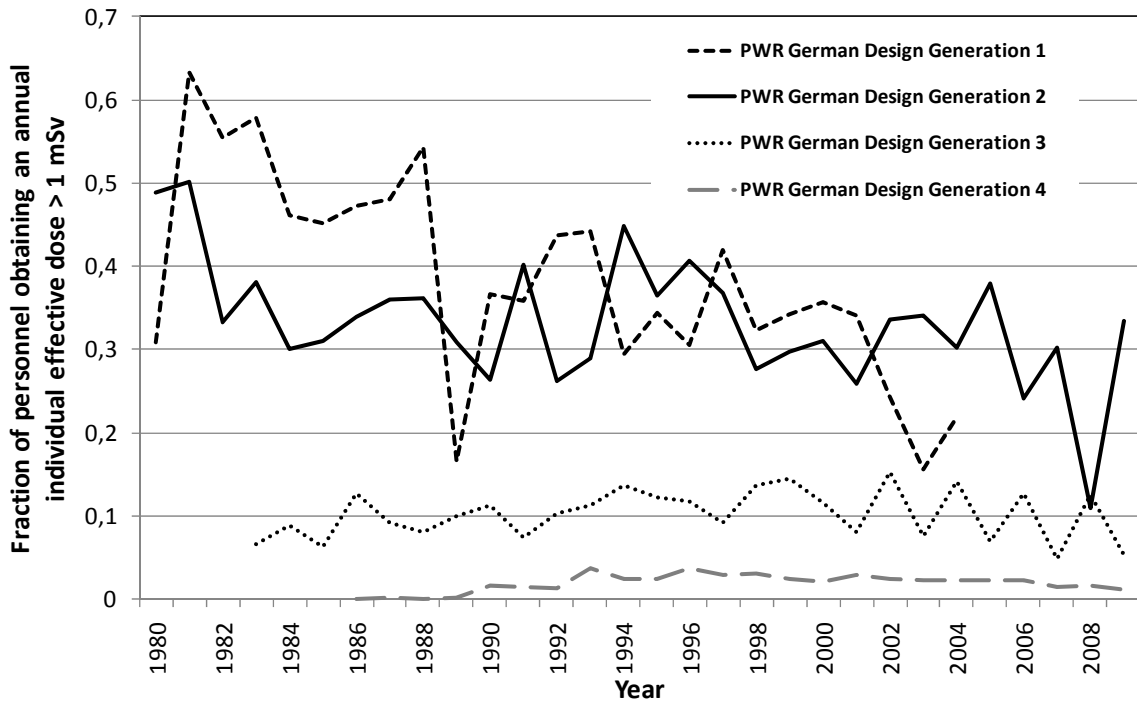


Figure 7: Fraction of the personnel (utility and contracted) that obtained an (NPP attributed) annual individual effective dose > 1 mSv in for German PWRs of similar design generation.

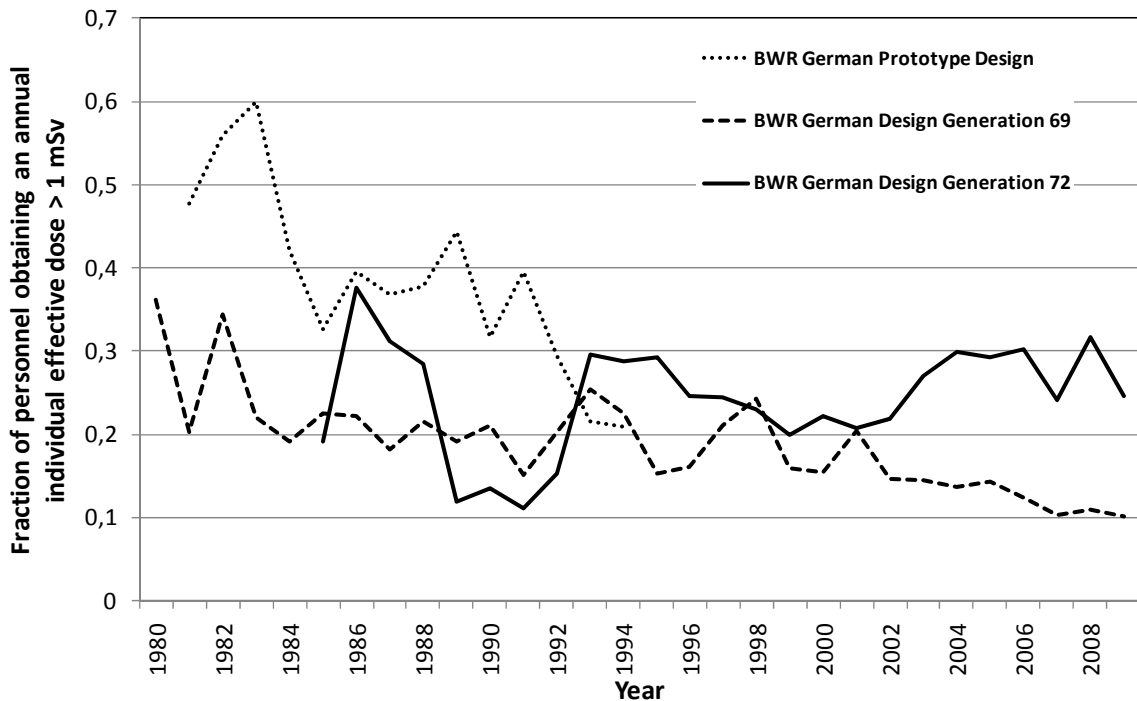


Figure 8: Fraction of the personnel (utility and contracted) that obtained an (NPP attributed) annual individual effective dose > 1 mSv in for German BWRs of similar design generation.

2.2 Nuclear Power plants under decommissioning

The RADAN database contains also data on the occupational exposure at NPPs under decommissioning. Fig. 9 shows the total annual collective effective dose for nuclear power plants under decommissioning. A simple trend similar to that of Fig. 1 can not be recognized. This is due to the fact that the annual collective effective dose for each nuclear power plant strongly depends on the decommissioning work and the related radiological conditions. Especially, the work activities change from year to year, following the overall work planning and decommissioning strategy for the NPP. Obviously, the type, inventory and operational history of the NPP influence the radiological conditions. As such no trends can be expected. Improvements e.g. due to experience feedback take place, but they can only be identified on the level of an individual NPP and only if the radiological conditions and the performed works are analyzed in detail.

Fig. 10 shows the NPP attributed average annual individual effective dose of utility and contracted personnel and the number of the related reporting NPPs under decommissioning in Germany. The evolution of the NPP attributed average annual individual effective dose with time may be interpreted as a decreasing trend. In fact, such a plain interpretation is not valid, as – different to the operation of a NPP – the exposure strongly depends on kind and amount of decommissioning work of a year which change during progress of a decommissioning project dramatically. Thus, similar to the data of the total annual collective effective dose of the decommissioning NPPs (see Fig. 9), there is no trend in the data.

Comparing the data of German NPPs under decommissioning with the data from the operational phase, it turns out as a rule of thumb that the decommissioning related average annual individual effective dose of monitored personnel is about 10% to 20% of that for operating, but this ratio depends on the NPP and – as mentioned – the work to be performed.

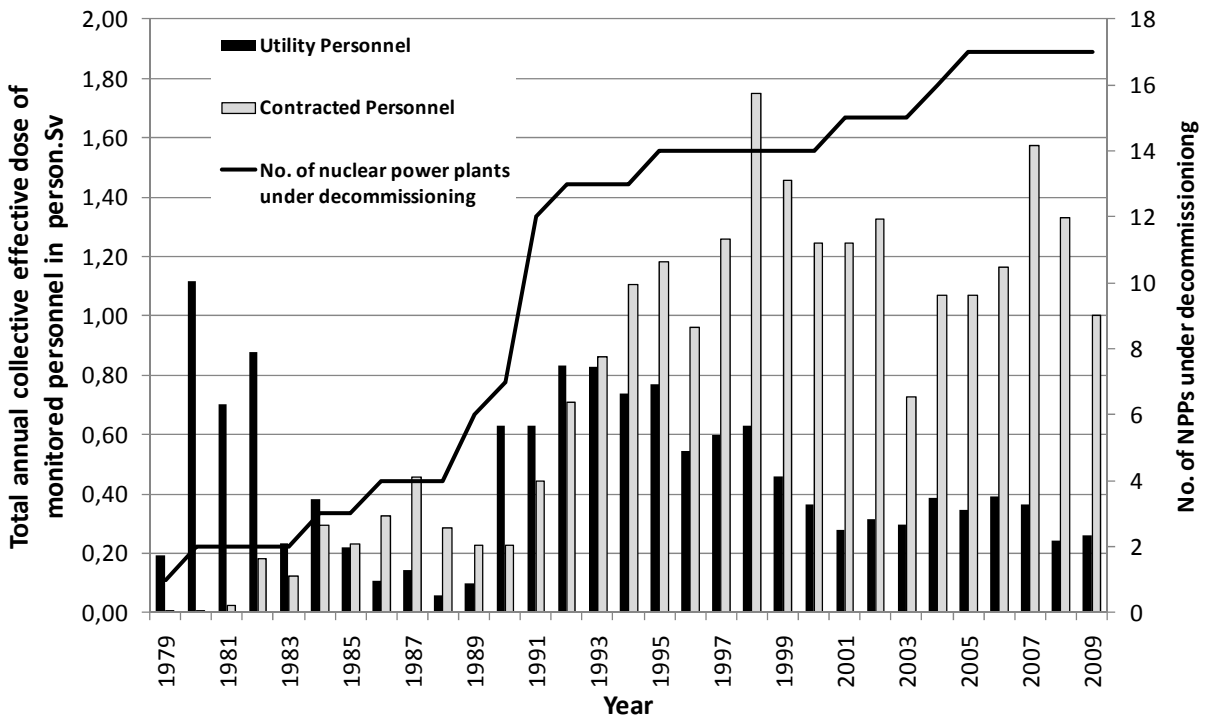


Figure 9: Total annual collective effective dose of monitored personnel for German nuclear power plants under decommissioning.

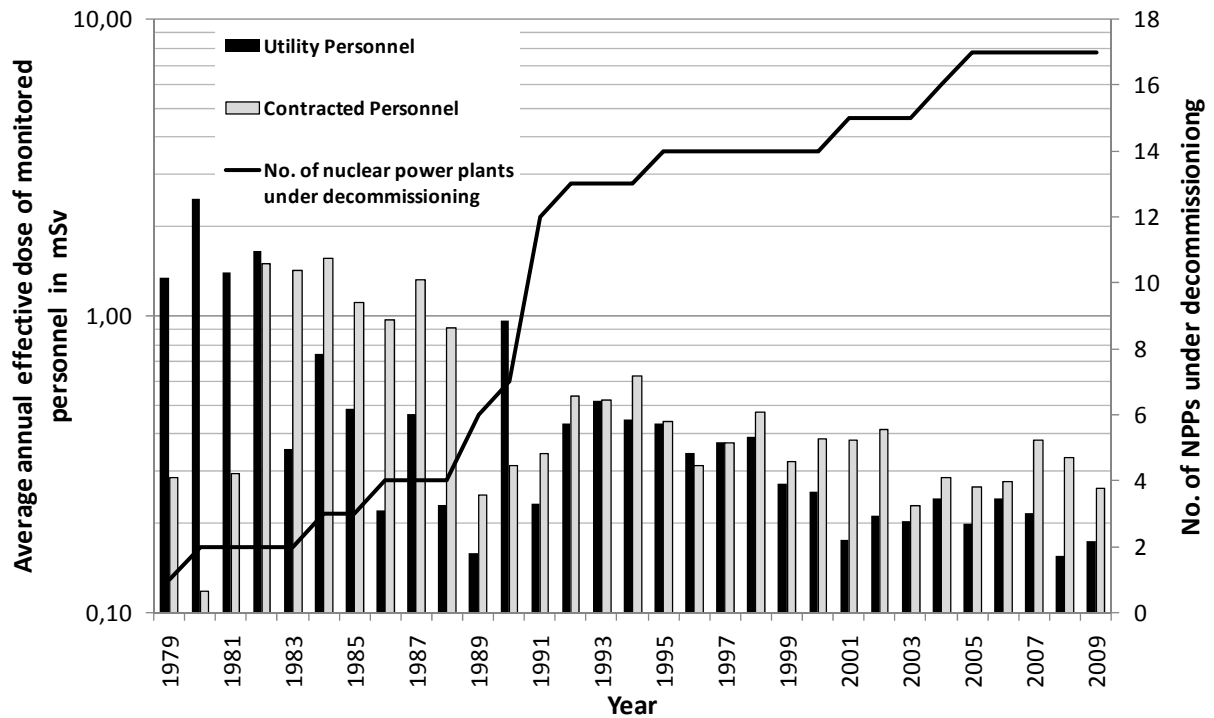


Figure 10: NPP attributed average annual individual effective dose of monitored personnel for German nuclear power plants under decommissioning.

2.3 Nuclear Power plants in transition between operation and decommissioning

Fig. 11 and 12 show the data of an individual NPP for the annual collective effective dose and the NPP attributed average annual individual effective dose to monitored personnel during the whole lifecycle of a NPP. The aspects previously mentioned about the occupational exposure for personnel during the phase of decommissioning of a NPP can be clearly seen: At first, the annual collective effective dose and also the (NPP attributed) average annual individual effective dose are reduced by a factor between 5 and 10. It can also be seen that the reduction of the annual collective effective dose and also the average annual individual effective dose begins some years before the end of operation. Typically, such decreases are due to reduced workload during the last outages e.g. as some periodic inspection will not be needed any more or less improvement activities will be performed.

Secondly, during the decommissioning both entities are changing from year to year, depending on the performed work. Those variations can not be interpreted without detailed knowledge about the decommissioning plan; doses may decrease at first and rise again, for example when works at highly activated components starts. Nevertheless, the dose values are still lower than during the operational phase.

The fact that also the (NPP attributed) average annual individual effective dose is reduced and not only the collective effective dose, indicates that the main cause for the reduction are the changed radiological conditions.

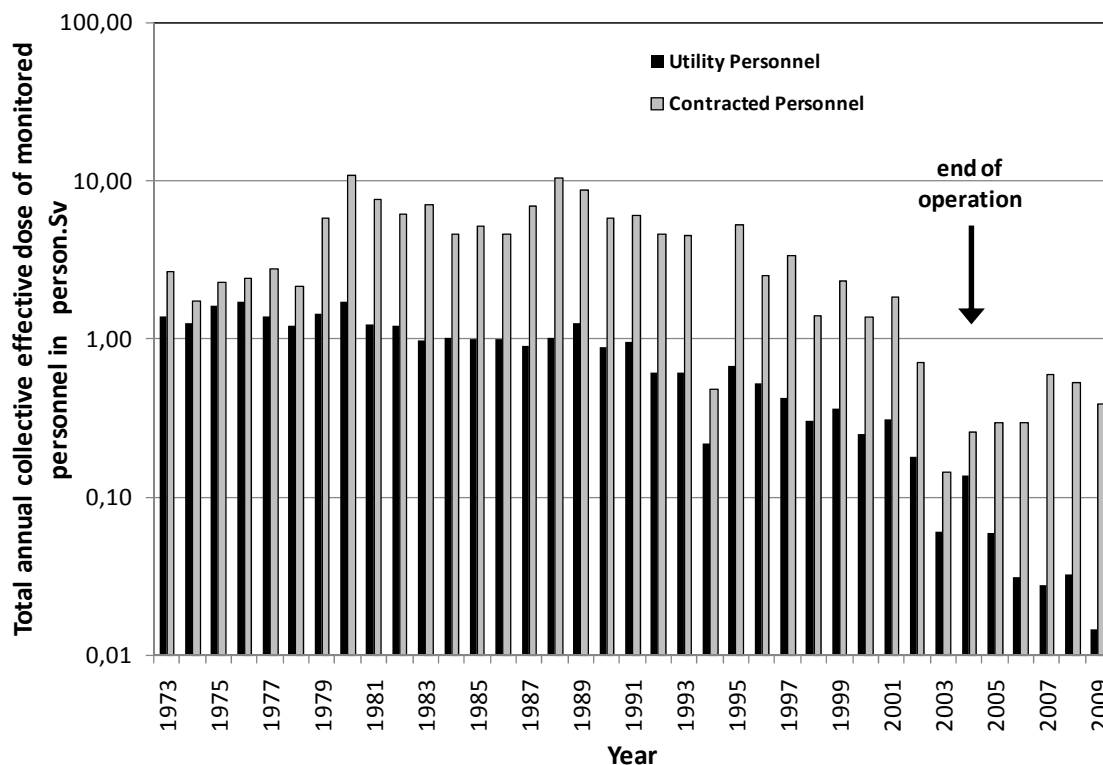


Figure 11: Annual collective effective dose of monitored personnel for a German nuclear power plant during transition from operation to decommissioning

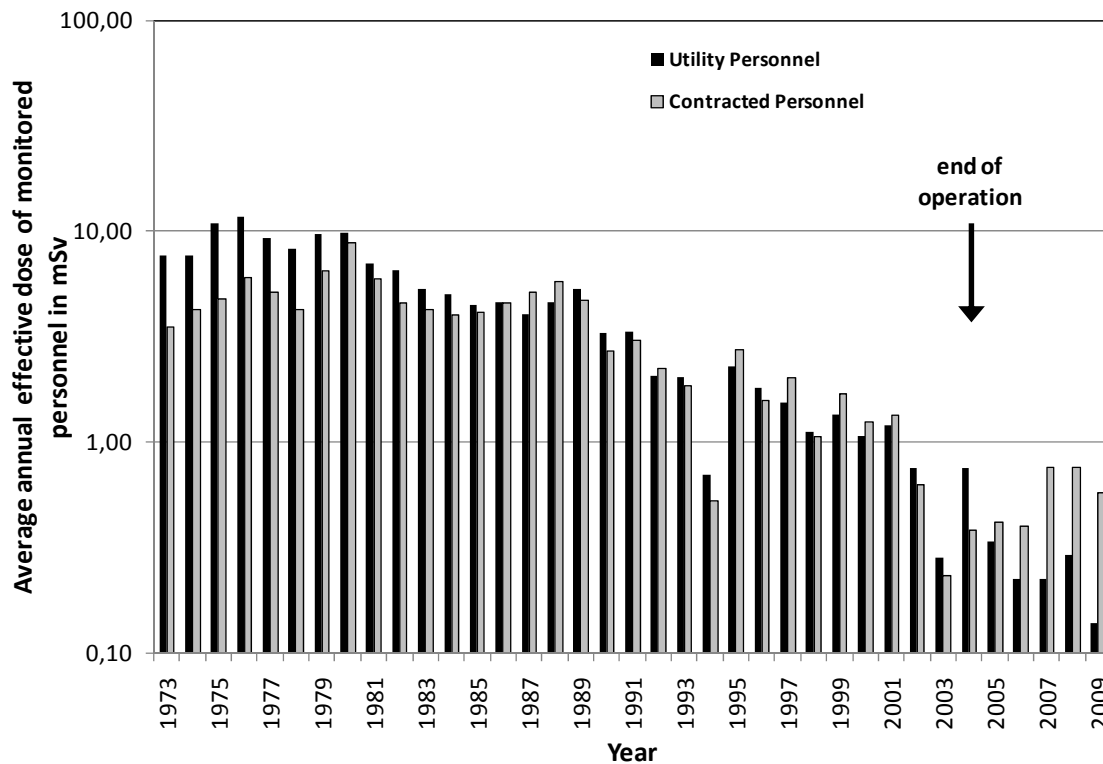


Figure 12: NPP attributed average annual individual effective dose of monitored personnel for a German nuclear power plant during transition from operation to decommissioning

3 CONCLUSION

Best insight can be obtained by analysis of national data allowing a high degree of differentiation. As such an example, the data on the occupational exposure in German NPPs show a decreasing trend for the total annual collective effective dose of German NPPs in operation and for the average annual individual effective dose of the monitored personnel. Depending on the type and design generation of the NPP, the improvements during operation are different due to the radiological conditions and work to be performed. Improvements can be observed for all NPPs but the extent of improvement, e.g. expressed in terms of dose savings, depends strongly on the radiological conditions defined by the design – as such typically savings are higher in NPPs of the first design generations.

Concerning the occupational exposure in NPPs under decommissioning, the available data and their trend are dominated by the specific situation during decommissioning; different to operation, the annual work for a NPP under decommissioning changes essentially with completely different radiological conditions. As such, the annual collective effective dose of a NPP under decommissioning changes significantly due to the nature of work from year to year. As a consequence, no trends in the annual data can be expected which allow an easy conclusion on radiation protection improvements. To account for such improvements on the base of only the dose data is impossible without detailed knowledge about the individual projects, the performed works and the radiological conditions. However, experiences show, that such improvements take place, resulting e.g. in a much lower real exposure of monitored personnel than was expected during planning of the decommissioning.