



Bundesministerium
für Umwelt, Naturschutz, nukleare Sicherheit
und Verbraucherschutz

Programme for the responsible and safe management of spent fuel and radioactive waste

(National programme)

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Preface

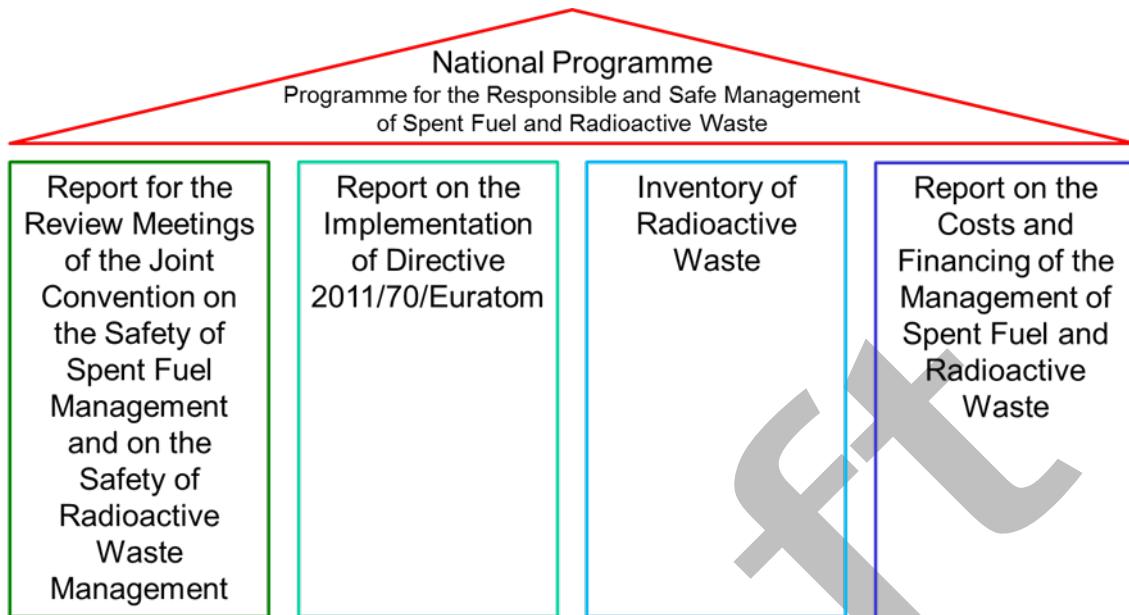
Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste obliges the Member States of the European Union to prepare national programmes and to notify them to the Commission by 23 August 2015; any subsequent significant changes must also be notified. The German Federal Government reviews the national programme on a regular basis, at least every ten years, as required by section 2c (3) of the Atomic Energy Act (*Atomgesetz*).

The Federal Government's national programme is drafted under the lead responsibility of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). The programme lays down the strategy for the responsible and safe management of spent fuel and radioactive waste.

The Federal Government meets its reporting obligation imposed by Directive 2011/70/Euratom by submitting several documents (Figure 0.1). The national programme contains a comprehensive overview of the German waste management policy. The current status of waste management is reported every three years in the *Report for the Review Meetings of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*. Progress made implementing the national programme will also be reported every three years within the framework of the *Report on the Implementation of Directive 2011/70/Euratom* to the European Commission (the first report was submitted on 23 August 2015). In this context, the *Inventory of Radioactive Waste (current inventory and prediction)* will be updated and submitted to the European Commission. This also applies to the *Report on the Costs and Financing of the Management of Spent Fuel and Radioactive Waste*.

The European Commission has previously noted that Member States used different deadlines when reporting on inventories of radioactive waste. As a consequence, the Commission notes that reports under the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) should be submitted as per the deadlines laid down in Directive 2011/70/Euratom. The Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) had therefore decided to amend the deadline for the Inventory of Radioactive Waste to that of the Joint Convention. This amendment was reflected in the 2021 report. However, due to the COVID-19 pandemic, the Joint Convention was postponed by one year, in turn requiring further amendment of the deadlines.

Figure 0.1: Concept of the Federal Government to fulfil its reporting obligation within the framework of Directive 2011/70/Euratom



1 General principles of waste management policy

The utilisation of nuclear fission for the commercial generation of electricity in the Federal Republic of Germany ended on 15 April 2023. The delivery of spent fuel from installations for the fission of nuclear fuels for the commercial generation of electricity (hereinafter referred to as nuclear power plants) to reprocessing plants has been banned since 1 July 2005.

A licence for the export of spent fuel elements from facilities used for the fission of nuclear fuels but not for the commercial generation of electricity (hereinafter referred to as research reactors) may only be granted for serious reasons of non-proliferation of nuclear fuel or for reasons of sufficient supply of fuel elements to German research reactors (cf. section 3 (6) sentence 1 of the Atomic Energy Act (*Atomgesetz*)).

According to the Atomic Energy Act, it is the responsibility of the Federal Government to provide facilities for the safekeeping and disposal of radioactive waste. The Federal Government plans to dispose of all types of radioactive waste in deep geological formations. To this end, the Konrad mine, a former iron ore mine in Salzgitter, is being repurposed as a disposal facility for radioactive waste with negligible heat generation. The site of a disposal facility for high-level radioactive waste will be determined by a selection procedure that started in 2017. This procedure will also investigate whether an additional disposal facility for low- and intermediate-level radioactive waste can be erected at the site (cf. section 1(6) of the Site Selection Act (*Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für hochradioaktive Abfälle - Standortauswahlgesetz, StandAG*)) to dispose of such waste, including the low- and intermediate-level waste to be retrieved from the Asse II mine.

The Federation has transferred its disposal duty to the private-sector company Bundesgesellschaft für Endlagerung mbH (BGE) in shareholding management by the BMUV and whose sole shareholder is the Federation. BGE is the operator and responsible for the operational tasks involved in the search for a site, the construction, operation and closure of disposal facilities and the Asse II mine and in the inspection of the waste designated for disposal. BGE is also responsible for developing disposal containers for high-level radioactive waste and for planning and operating the receiving storage facility and requisite conditioning plant.

As the higher federal authority, the Federal Office for the Safety of Nuclear Waste Management (*Bundesamt für die Sicherheit der nuklearen Entsorgung - BASE*) is the competent approval and supervisory authority for disposal facilities to be established by the Federation. BASE is also responsible for granting licences for the storage and transport of nuclear fuel and for the enforcement of government custody. In addition, BASE supervises the Asse II mine and Morsleben repository for radioactive waste (ERAM) under nuclear and radiation protection law and monitors implementation of the site selection procedure. BASE is also responsible for organising public participation in the site selection procedure.

The BMUV is consulted on safety-related and generic issues along with operating experience in all types of nuclear installations by its advisory bodies, the Reactor Safety

Commission (*Reaktor-Sicherheitskommission - RSK*), the Nuclear Waste Management Commission (*Entsorgungskommission - ESK*) and the Commission on Radiological Protection (*Strahlenschutzkommission - SSK*).

Against this background, the fundamental elements of the national programme are characterised by the following key points:

- The management of radioactive waste shall as a rule be carried out within German national responsibility. Disposal is to be on German national territory.
- Three disposal facilities are to be constructed: The Konrad disposal facility for radioactive waste with negligible heat generation, a disposal facility for high-level radioactive waste and a disposal facility for low- and intermediate-level radioactive waste that cannot be disposed of at the Konrad disposal facility.
 - The radioactive waste to be retrieved from the Asse II mine produces a negligible amount of heat. The site selection procedure for a disposal facility for high-level radioactive waste will also assess whether an additional facility can be constructed to dispose of the waste to be retrieved from the Asse II mine along with the waste that cannot be disposed of at the Konrad disposal facility. This includes the depleted uranium that has been and will be generated from uranium enrichment (uranium tailings) if it is not reused.
- The site for the disposal facility for high-level radioactive waste is to be determined by the middle of the century. Once the site has been determined, the disposal facility for high-level radioactive waste, a receiving storage facility for the transport and storage casks and a conditioning facility are to be constructed.
- Should there be a dismantling requirement, the dismantling of all nuclear power plants along with other nuclear facilities and installations taken out of operation during the period under consideration is to be carried out early enough so that the negligible heat-generating radioactive waste produced during this process can be emplaced in the Konrad disposal facility.
- Up to 303,000 m³ of negligible heat-generating radioactive waste¹ is to be emplaced in the Konrad disposal facility from the beginning of the 2030s. The emplacement phase of the licensed waste volume of 303,000 m³ is not to exceed 40 years.
- With the first partial licence for the disposal facility for high-level radioactive waste, a receiving storage facility and possibly a conditioning facility are also to be approved at the site for spent fuel and waste from reprocessing, with BGE responsible for both facilities following approval. This provides the conditions needed to start clearing existing spent fuel storage facilities.

¹ This radioactive waste with negligible heat generation corresponds to a partial quantity of low- and intermediate-level radioactive waste.

- Until then, the spent fuel and waste from reprocessing are to be kept at the existing storage facilities.
- Emplacement of low- and intermediate-level radioactive waste in the Morsleben disposal facility for radioactive waste has been concluded. The disposal facility is to be closed and safely sealed for the long term.
- In Germany, naturally occurring radioactive material (NORM) is not typically considered to be radioactive waste.

With regard to the management of radioactive waste, the polluter-pays principle applies until the waste is delivered to a disposal facility or a Land collecting facility. So those handling radioactive material must make provisions to ensure that residual radioactive material and disassembled or dismantled radioactive components are utilised without detrimental effects or are disposed of as radioactive waste in a controlled manner (direct disposal).

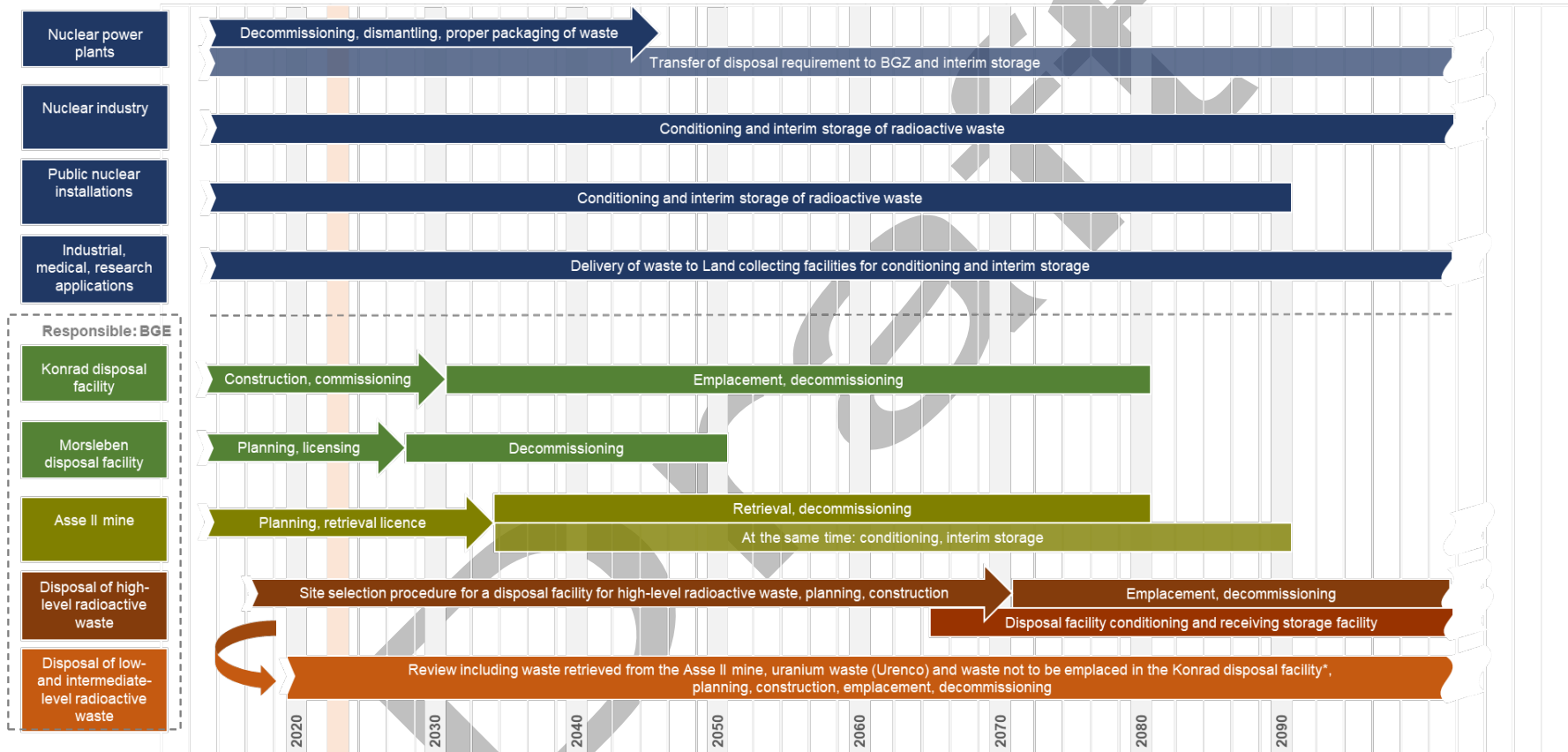
Operators of nuclear power plants² who deliver properly packaged radioactive waste pursuant to the Waste Management Transfer Act (*Gesetz zur Regelung des Übergangs der Finanzierungs- und Handlungspflichten für die Entsorgung radioaktiver Abfälle der Betreiber von Kernkraftwerken - EntsorgÜG*) – upon fulfilment of the requirements – to a third party commissioned by the Federation, i.e. BGZ Gesellschaft für Zwischenlagerung mbH (BGZ), are exempt from this obligation. Upon delivery of properly packaged radioactive waste to BGZ, responsibility for financing passes to the German Nuclear Waste Management Fund (KENFO), while responsibility for the operator's obligation to act in terms of disposing of its radioactive waste is transferred to the Federation. In 2017, operators created a fund under public law (KENFO) for the Federation to use for storage and disposal of radioactive waste.

Radioactive waste from industrial, medical and research applications must first be delivered to a Land collecting facility and stored there. The Land collecting facilities deliver the radioactive waste stored within their responsibility to a disposal facility.

² Applies only for installations listed in Annex 1 of the Act on the Waste Management Fund.

Figure 1.1: Overview of radioactive waste accumulated over time and requiring disposal

Stand 02/2024



* Disposal at the disposal facility site for high-level radioactive waste must take place in a separate disposal facility mine that excludes any possibility of negative interactions regarding the long-term safety of the disposal facility for high-level radioactive waste.

2 Current inventory and prediction of radioactive waste

A detailed breakdown of the current inventory of radioactive waste can be found in the report *Inventory of Radioactive Waste*. This inventory is updated every three years.

2.1 Spent fuel and waste from reprocessing³

2.1.1 Current inventory

As at 31 December 2023, about 16,711 Mg HM⁴ have been generated in the form of spent fuel assemblies (FA) from the operation of nuclear power plants in the Federal Republic of Germany. 6,673 Mg HM of spent fuel have already been removed from the nuclear power plants either for reprocessing or for permanent storage abroad. The remaining 10,038 Mg SM⁴ must be disposed of directly in the Federal Republic of Germany. They are currently being stored as set out in Table 2.1.

Table 2.1: Inventory of spent fuel from German nuclear power plants, stored in Germany, as at 31 December 2023

Storage location	Casks	Fuel assemblies	Mass
Nuclear power plant storage pools		5,204 FA	1,896 Mg HM
Dry cask storage in on-site storage facilities	822	23,904 FA	7,463 Mg HM
Dry cask storage in the transport cask storage facilities at Ahaus, Gorleben and Rubenow	76	5,343 FA	675 Mg HM
	Total	34,451 FA	10,038 Mg HM⁴

Vitrified high-level radioactive waste from the reprocessing of spent fuel in other European countries and in Germany is stored in 119 casks in the Gorleben transport cask storage facility, the Zwischenlager Nord transport cask storage facility in Rubenow and the Biblis transport container storage facility.

³ High-level radioactive waste

⁴ Megagrams of heavy metal (Mg HM) is the unit of the mass of heavy metal and thus a measure for the fuel content (uranium, plutonium and thorium) of a fuel assembly. The quantities given are rounded to the nearest whole number. This may result in minor differences in the total compared to other figures published.

The amount of spent fuel originating from research reactors is much lower than the amount of fuel from nuclear power plants requiring disposal. The spent fuel from the non-power reactors is stored at the wet storage facilities of the research reactors in Berlin (102 kg HM), Garching (334 kg HM) and Mainz (764 g uranium) and in 479 casks (11 Mg HM, dry storage) at the spent fuel storage facility in Ahaus, at the AVR cask storage facility in Jülich and at ZLN in Rubenow.

2.1.2 Prediction

Around 10,000 Mg HM accumulated in the form of spent fuel assemblies in nuclear power plants will have to be disposed of. A waste volume of 10 to 12 Mg HM is expected from the research reactors.

The amount of vitrified high-level radioactive waste is provided in Table 2.2.

Table 2.2: Prediction (including current inventory) of the amounts of radioactive waste from reprocessing that must be disposed of in the Federal Republic of Germany (as at 31 December 2023)

	Canisters	Casks
Vitrified high-level radioactive waste from France	3,136	112
Vitrified high-level radioactive waste from the United Kingdom	560	20
Vitrified high-level radioactive waste from reprocessing in Karlsruhe	140	5
Total	3,836	137

As regards the research reactor in Berlin, spent fuel assemblies generated until the year 2016 were shipped back to their country of origin as per the corresponding contracts. The remaining spent fuel assemblies from the research reactors in Berlin, Garching and Mainz are to be stored at an interim facility.

2.2 Other radioactive waste⁵

2.2.1 Current inventory

The current inventory of other radioactive waste is reported annually to BGE in line with the Nuclear Waste Management Ordinance (*Verordnung über Anforderungen und Verfahren zur Entsorgung radioaktiver Abfälle - AtEV*), cf. Table 2.3 The breakdown by originators of the total conditioned radioactive waste volume of around 134,300 m³ existing as at 31 December 2023 is shown in Figure 2.1.

Figure 2.1: Breakdown of the current inventory of other conditioned radioactive waste by originators as at 31 December 2023

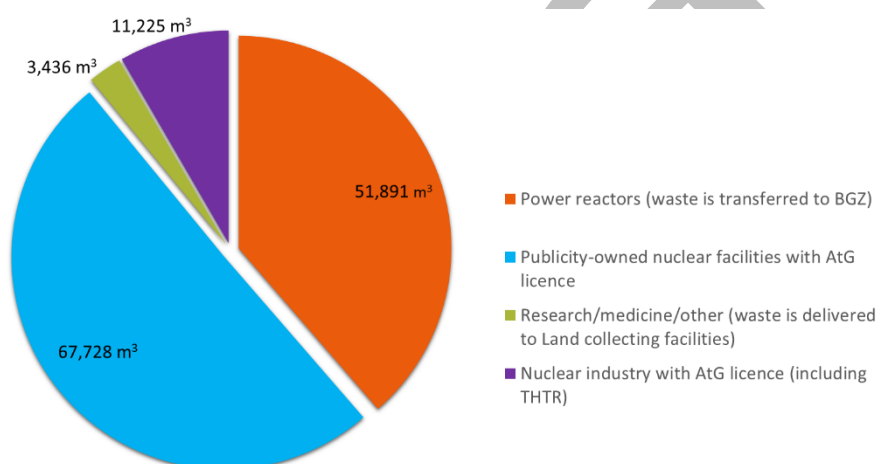


Table 23: Current inventory of other radioactive waste (as at 31 December 2023)

Processing condition	Amount
Primary waste and pre-treated waste	25,460 Mg
Conditioned waste products	23,186 m ³
Waste packages for disposal	111,094 m ³

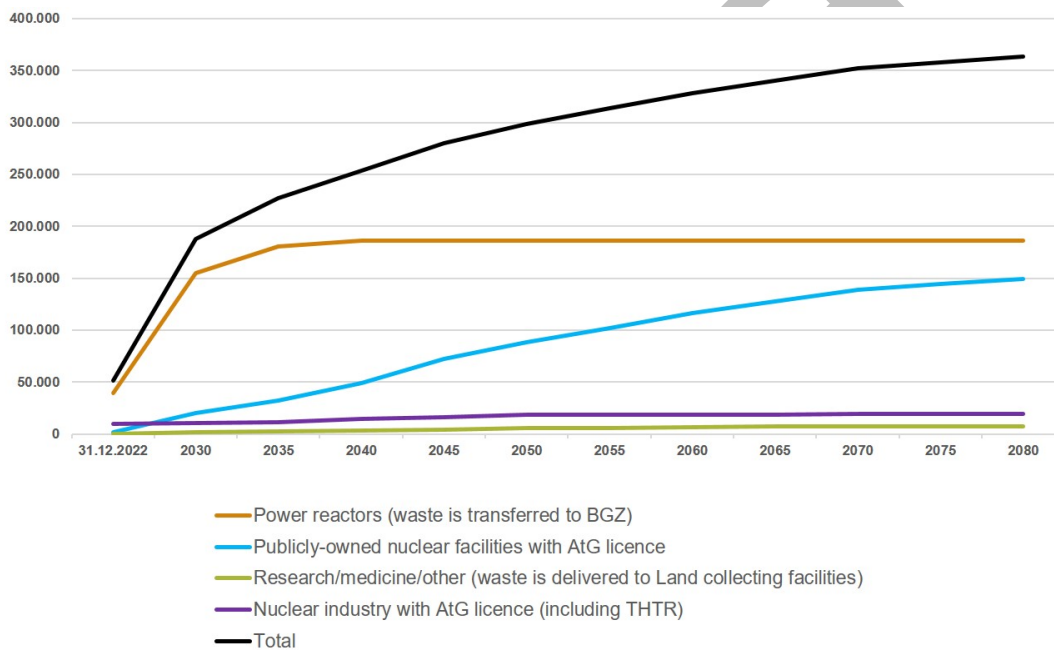
2.2.2 Prediction

The amount of radioactive waste with negligible heat generation that waste originators expect to accumulate over time which – according to the valid plan approval decision – is available for emplacement in the Konrad disposal facility is shown in Figure 2.2.

⁵ Low- and intermediate-level radioactive waste and radioactive waste with negligible heat generation for storage at the Konrad disposal facility

The values predicted differ from the current inventory in section 2.2.1 as the inventory of conditioned waste to be reported each year not only includes packaged waste designated for product control, but also the volume of unpackaged waste products awaiting Konrad-specific packaging prior to emplacement in the Konrad disposal facility along with the volume of conditioned old waste awaiting subsequent declaration and possibly even subsequent conditioning prior to emplacement in the Konrad disposal facility. However, the values predicted in Figure 2.2 only include waste quantities that waste producers deem to have been conditioned and fully documented at that time and that can be released for emplacement after passing all product control inspections.

Figure 2.2: Expected accumulation of radioactive waste to be conditioned and packaged in line with the Konrad disposal facility requirements and registered for product control inspection [m³]



Based on recent surveys, no larger amounts of waste from the decommissioning of nuclear power plants are expected to accrue after 2045. Excluding the waste to be retrieved from the Asse II mine and the uranium tailings, a waste package volume of around 360,000 m³ is assumed.

In the Asse II mine, around 47,000 m³ of low- and intermediate-level radioactive waste have been emplaced. This waste is to be recovered, conditioned and stored until disposal. Current estimates assume a volume of approx. 175,000 to 220,000 m³ of conditioned waste for later disposal.

In the event of no further reutilisation, the waste from uranium enrichment is expected to result in a package volume of up to 100,000 m³ of depleted uranium.

3 Radioactive waste management

3.1 Management of the spent fuel and the waste from reprocessing

3.1.1 Storage

Spent fuel and vitrified radioactive waste from reprocessing is kept in dry transport and storage casks. The individual spent fuel storage facilities at the nuclear power plant sites are accompanied by central spent fuel storage facilities at Gorleben, Ahaus and Zwischenlager Nord. A replacement transport cask storage facility (ESTRAL) is to be constructed at the Zwischenlager Nord site to house the 74 Castor casks currently being stored there in hall 8. In 2017, responsibility for the two central storage facilities at Gorleben and Ahaus was transferred to BGZ under company law, and on 1 January 2019, BGZ also assumed responsibility for the licensed spent fuel storage facilities on the basis of the Waste Management Transfer Act.

Presumably by the year 2027, all fuel assemblies used in the nuclear power plants will have been placed in a total of around 1,050 transport and storage casks and moved to storage facilities. The vitrified radioactive waste to be returned from reprocessing has also been placed in transport and storage casks and is to be stored in on-site and central storage facilities. According to current predictions, a total of 137 transport and storage casks are needed for this waste. An additional 24 empty end used casks (EUC) will be reused, possibly following storage at an interim facility.

The dry storage of spent fuel and vitrified radioactive waste from reprocessing in transport and storage casks has proven effective. In Germany, there are sufficient storage capacities available for accommodating all spent fuel and vitrified radioactive waste from reprocessing.

Nuclear licences for the storage of transport and storage casks are limited to 40 years. Based on the latest information, the storage facilities in Germany can no longer be fully cleared during this period. As a result of this, preparations are already being made to apply for new licences. Technical and legal preparations for extended storage include, in particular, research studies (see also section 3.1.3) and the drafting of regulations for extended storage that meet the state of the art in science and technology.

These storage facilities are not expected to be cleared until the second half of the 21st century because a decision on a site for the high-level radioactive waste disposal facility is not anticipated before the middle of the 21st century and a receiving storage facility for the transport and storage casks would need to be built there. The operators of such facilities are required to ensure safe storage until disposal is possible. Once disposal is possible, operators must ensure that the transport and storage casks meet the requirements for safe transport to the disposal facility.

3.1.2 Disposal

The Act on the search for and selection of a site for a disposal facility for high-level radioactive waste and for the amendment of other laws (Site Selection Act (*Gesetz zur Suche und Auswahl eines Standortes für ein Endlager für hochradioaktive Abfälle - Standortauswahlgesetz, StandAG*)) entered into force in 2013, with the procedure itself starting in 2017 following an amendment to the Act in the same year.

The aim of this amended act is to adopt a participatory, science-based, transparent, introspective and adaptive approach to determine a site where high-level radioactive waste can be disposed of while offering the highest possible levels of safety for one million years. The selection procedure assumes a set of statutory minimum requirements along with exclusion and weighing criteria to be applied throughout the various stages of the procedure to narrow down the number of site options and to support provisional safety analyses that will be refined over time.

The role of implementing agency for the site selection procedure is held by the federally owned company BGE, founded in 2016.

BASE, which is under the authority of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), is responsible for supervising and accompanying the procedure.

The general public is to be given the opportunity to participate intensively in the site selection procedure at national and regional level. BASE is also the organiser and coordinator of public participation.

The main priority of the site selection procedure is the construction of a disposal facility for high-level radioactive waste, i.e. spent fuel and vitrified radioactive waste from reprocessing. The additional disposal of low- and intermediate-level radioactive waste at a second disposal facility at the same site must not have any negative effect on the safety of the high-level radioactive waste, nor should sites be excluded from the procedure due to a lack of space for low- and intermediate-level waste.

The Site Selection Act mentions rock salt, clay and crystalline rock as possible host rock types. National and international research and development activities regarding all three host rock types have already been carried out and are still ongoing. BGE uses the available research results in the exploration, assessment and designation of regions in Germany with potentially suitable host rock formations.

Once a disposal facility site has been determined in line with the Site Selection Act, a receiving storage facility and conditioning plant is to be constructed at the same site. The time needed to actually emplace the waste depends on the disposal facility design.

3.1.3 Research

According to section 9a (3) sentence 1 of the Atomic Energy Act, the Federal Government is responsible for providing disposal facilities for radioactive waste. This

means that, besides the provision of the scientific and technical basis for the construction of a disposal facility, the Federation also has to make provisions to continuously further the state of the art in science and technology through corresponding research and development, while contributing substantially to building up, developing and maintaining the scientific and technical competence and promoting young experts in this field. It is imperative to ensure provision of the requisite mining and nuclear engineering competence, at least until the decommissioning⁶ of the disposal facilities; suitable measures for maintaining competence must therefore be taken.

The Federation promotes nuclear safety and waste management research. The funding programmes for research and development in the relevant ministries define the framework and set out the research priorities for the funding period. In this context, international cooperation plays an important role.

In December 2021, responsibility for the project funding programme for nuclear facilities 2021-2025 passed from the Federal Ministry for Economic Affairs and Climate Action (*Bundesministerium für Wirtschaft und Klimaschutz - BMWK*) to the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). As part of the associated project funding programme, the BMUV specifically promotes national application-oriented basic research and the development of nuclear safety expertise and the next generation of experts, in particular with a view to extended storage, high-level radioactive waste management and disposal. In addition, the BMUV funds international collaboration on joint research projects (e.g. OECD/NEA, EURATOM) covering these fields.

Further details of the project funding programme are published in the Project funding programme of the Federal Ministry for Economic Affairs and Climate Action related to nuclear safety research 2021-2025 (current version: Federal Gazette AT 22 November 2023 B6).

Moreover, the BMUV funds ministry-dependent research into the safety of nuclear facilities, nuclear fuel supply and waste management and radiation protection.

Furthermore, in pursuit of its duties, BASE conducts scientific research into the safekeeping and disposal of radioactive waste, radioactive waste management, transport and storage of radioactive substances and waste, nuclear safety and socio-technical aspects of nuclear waste management.

In addition, BGE and BGZ are responsible for conducting research and development work in their role as implementing agencies.

The Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung - BMBF*) runs a funding programme that includes research on the dismantling of nuclear installations (FORKA) to improve the protection of people and the environment

⁶ Decommissioning comprises all measures taken after the termination of emplacement, including the closure of the disposal facility, to establish a maintenance-free condition that ensures the long-term safety of the disposal facility.

in connection with nuclear dismantling and radioactive waste management and to increase the efficiency of the procedures and methods used. Another important aim is to maintain nuclear expertise and support training of the next generation of scientists.

Research projects that are being or have been carried out or monitored with the involvement of Gesellschaft für Reaktorsicherheit (GRS) gGmbH and BGZ deal with aspects such as the current state of dry storage facilities in Germany and compared with other countries, technical and non-technical ageing management, long-term behaviour of containers and emplaced inventories, issues pertaining specifically to storage in Germany and the exchange of experience. These aspects form the basis for demonstrating the safety of storage beyond the currently licensed period.

3.2 Management of low- and intermediate-level radioactive waste

3.2.1 Dismantling of nuclear facilities and installations

Where prescribed by law, nuclear facilities and installations are to be dismantled and released from nuclear supervision following the end of their operational use if substances legally defined as radioactive are no longer present.

According to the operators' plans, the decommissioning and dismantling of installations to be decommissioned and dismantled immediately pursuant to section 7 (3) sentence 4 of the Atomic Energy Act is due for completion by 2045.

The plant operator must present his chosen dismantling plan to the competent authority as part of his application for decommissioning and dismantling. On the basis of experience thus far, full dismantling of a nuclear power plant is estimated to take an average of 15-20 years per reactor unit. According to the Nuclear Waste Management Commission (ESK)⁷, a total mass of around 600,000 Mg (approx. 30% from the controlled area, approx. 65% from the supervised area and approx. 5% from other areas) is expected for a pressurised water reactor and around 400,000 Mg (approx. 55% from the controlled area, approx. 40% from the supervised area and approx. 5% from other areas) for a boiling water reactor. Around 2% of the mass from the controlled area (approx. 4,000 Mg) of both reactor types is to be disposed of as radioactive waste.

Public-sector installations were shut down many years ago, with dismantling already at an advanced stage. Such installations include the nuclear power plants located in the former German Democratic Republic (Greifswald, Rheinsberg), which now belong to the federally owned company EWN, and the former federal nuclear research pilot plants in Karlsruhe (WAK, KNK, MZFR) and Jülich (AVR, FRJ-2).

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https://www.entsorgungskommission.de/sites/default/files/reports/ESK_Praesentation_Vergleich_Masse_nstroeme_bei_Stilllegung_ESK99_15062022_EN.pdf

The radioactive waste with negligible heat generation produced during dismantling can be delivered to the Konrad disposal facility during its operating period until such time that the facility's disposal limit of 303,000 m³ is reached as defined in the plan approval decision.

The Federal Government is working to ensure that the radioactive waste with negligible heat generation from these plants in safe enclosure (Hamm-Uentrop Thorium High-Temperature Reactor, Research Reactor Neuherberg, Research Reactor 2 in Karlsruhe) is conditioned soon enough so that it can be emplaced during the designated disposal facility's operating period.

3.2.2 Conditioning and storage of waste

The radioactive waste delivered to the Konrad disposal facility must comply with the waste acceptance requirements for disposal that apply to this disposal facility according to the plan approval decision. To this end, the radioactive waste must first be conditioned and undergo BGE product control to ensure compliance with the waste acceptance requirements for disposal.

Product control includes radiological and material composition inspections, waste container type approvals, random sampling of waste packages and the evaluation of conditioning measures.

Until delivery to the Konrad disposal facility, the radioactive waste with negligible heat generation remains in storage facilities, Land collecting facilities or a collecting facility of the armed forces, each of which has its own waste acceptance requirements for storage.

Since 1 January 2020, BGZ has successively assumed responsibility for the electric power utilities' storage facilities on the basis of and as listed in the Waste Management Transfer Act. The industry also operates storage facilities, while public-sector companies operate storage facilities such as those in Jülich, Karlsruhe, Rossendorf and Rubenow.

Depending on when the Konrad disposal facility is commissioned and the specific arrangements of the retrieval regime, it must be expected that even waste packages that have been conditioned to meet the waste acceptance requirements for disposal and have undergone product control will still have to be stored over longer periods of time. To accommodate this, storage capacities for radioactive waste with negligible heat generation at various sites have been and will be adapted accordingly.

3.2.3 Konrad disposal facility

The Konrad disposal facility, which is currently under construction, has a plan approval to take in up to 303,000 m³ of radioactive waste with negligible heat-generation. The emplacement operation for the licensed waste volume is not to exceed a period of 40 years.

The Konrad disposal facility is intended for the emplacement of radioactive waste from the operation and dismantling of nuclear power plants and public nuclear installations, along with waste from industrial, medical and research applications. As stipulated in the plan approval decision, concrete verification has to be provided prior to approval of the final operational plan, i.e. towards the end of disposal facility operation, showing that the protection of third parties will be ensured in accordance with the state of the art in science and technology also after ceasing operation at the facility. After closure, no special official control and monitoring programme is intended. The plan approval decision requires routine environmental measurements of the air, water and soil to be carried out for the disposal facility site.

3.2.4 Asse II mine

The Asse II mine is a former potassium and rock salt mine. Between 1967 and 1978, the mine was used to emplace about 47,000 m³ of low- and intermediate-level radioactive waste.

The saline solutions entering the underground structure of the mine and the stability problems caused in the mine by the extensive mine workings led to the decision to decommission the Asse II mine immediately as prescribed in section 57b of the Atomic Energy Act (Lex Asse). The radioactive waste emplaced in the mine is to be retrieved prior to decommissioning.

Work with regard to planning and obtaining licences for retrieving the waste is already in progress. The waste is to be conditioned on-site and stored until its disposal in an on-site storage facility that is to be newly constructed. BGE is responsible for conditioning and storing the radioactive waste retrieved from the Asse II mine.

3.2.5 Morsleben disposal facility for radioactive waste

Emplacement in the Morsleben disposal facility for radioactive waste, where around 37,000 m³ of low- and intermediate-level radioactive waste was emplaced until 1998, has been concluded. The disposal facility is to be closed and safely sealed for the long term. To this end, a plan approval procedure is being carried out, with decommissioning measures set to end around the mid-2040s.

3.2.6 Repository for low- and intermediate-level radioactive waste according to the Site Selection Act

The site selection procedure includes an ongoing review as to whether an additional repository for low- and intermediate-level radioactive waste can be constructed at the same site. This facility would be used to dispose of low- and intermediate-level radioactive waste that cannot be disposed of at the Konrad disposal facility due to its nuclide inventory and/or chemical composition, time of generation or the volume limit

stipulated in the plan approval decision applicable to the Konrad disposal facility. This also applies to radioactive waste to be retrieved from the Asse II mine and to the depleted uranium that has been and will be generated from uranium enrichment in the event that it is not reutilised. It will only be possible to reach a final decision on the location of the disposal facility site for this waste – taking into account all technical, economic and political aspects – once sufficient information is available on the volume and properties of the radioactive waste to be retrieved from the Asse II mine and the time of this waste's generation.

The disposal of low- and intermediate-level radioactive waste at a site for high-level radioactive waste yet to be selected is only permissible in a sufficiently distant, unconnected host rock area if there will be no negative interactions between the two disposal facilities.

If it is not possible to build an additional disposal facility for larger quantities of low- and intermediate-level radioactive waste at the site of the disposal facility for high-level radioactive waste, a separate site must be designated for this disposal facility. It is assumed that at the end of the site selection procedure, a solid geoscientific database will be available for this purpose. The disposal facility required for this waste should be constructed at a site offering the most favourable conditions for the disposal of low- and intermediate-level radioactive waste. The suitability of a given site must be determined by way of a planning approval procedure under nuclear law.

4 Legal framework of nuclear waste management in Germany

The legal basis of nuclear waste management in Germany is formed by the German Constitution, German atomic energy and radiation protection law including the Site Selection Act, the Waste Management Transfer Act and ancillary legal ordinances. This legal framework governs all areas of nuclear waste management with a clear allocation of responsibilities.

For the purpose of protection against the hazards posed by radioactive material and for the control of the utilisation of radioactive material, German atomic energy and radiation protection law generally makes the construction and operation of nuclear waste management installations as well as other facts and circumstances, such as the handling of radioactive material, subject to an official permit, usually a licence. Depending on the type of installation and activity, the licensing requirements are defined in different provisions of atomic energy and radiation protection law. The essential licences in the area of nuclear waste management are:

- Section 4 of the Atomic Energy Act (nuclear fuel transport)
- Section 6 of the Atomic Energy Act (nuclear fuel storage)
- Section 7 of the Atomic Energy Act (e.g. conditioning plant for spent fuel assemblies)
- Section 9 of the Atomic Energy Act (treatment, processing or other uses of nuclear fuel outside the installations referred to in section 7 of the Atomic Energy Act)
- Section 9b of the Atomic Energy Act (construction and operation of installations for the safekeeping and disposal of radioactive waste)
- Section 12 of the Radiation Protection Act (handling of other radioactive material containing no or only small amounts of nuclear fuel).

The federal and Länder authorities dealing with affairs in the area of nuclear waste management have adequate measures for enforcement and sanctioning at their disposal, allowing them to control nuclear waste management and sanction any contraventions of granted permissions and nuclear and radiation protection regulations. The operation of a nuclear installation without a licence and the unlicensed handling of radioactive material are furthermore an offence under regulatory and criminal law.

The legal framework governing nuclear waste management in Germany is explained in detail in the *Reports for the Review Meetings of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*.

5 Public participation

5.1 National programme

As part of the drafting of the national programme and in case of essential future changes to this programme, a strategic environmental assessment in line with the Environmental Impact Assessment Act has been and will be carried out. Here, the impacts of the national programme, including the alternatives considered, on the environment have been and will be assessed with public participation. Consultations with neighbouring countries form part of this strategic environmental assessment.

Should measures be implemented in border areas while implementing this programme, the bordering countries concerned will be offered consultations in accordance with binding international provisions.

5.2 Site Selection Act

To uphold the fundamental objective of transparency with a view to nuclear waste management in Germany, the Site Selection Act sets boundary conditions in terms of informing and involving the public.

Section 5 of the Site Selection Act requires BASE to comprehensively and systematically inform the public early on and for the duration of the site selection procedure with regard to its aims, funding, current status and projected effects and intended forms of participation. In particular, this concerned and concerns the following steps:

- Determination of partial areas BGE deems relevant for the subsequent step in the procedure
- Determination and proposal of site regions to be considered for surface exploration
- Proposal of programmes for surface exploration
- Determination and proposal of underground sites to be explored and proposal of programmes for underground exploration
- Final site comparison and proposal

In addition, section 38 of the Site Selection Act requires BASE to permanently store data and documents which are or may become relevant to the storage and disposal of radioactive waste. At the national level, the National Citizens' Oversight Committee (*Nationales Begleitgremium - NBG*) was formed in December 2016 and consists of 18 members, 12 of whom are nominated and appointed by members of the German Bundestag and Bundesrat. The other six members are citizens selected from a nationwide random sample according to a qualified selection procedure and appointed by the Federal Environment Minister, including two representatives of the young generation, i.e. under the age of 30. The central task of the National Citizens' Oversight

Committee is to accompany the site selection procedure as a mediating and independent body until reaching a decision on a site, in particular with regard to public participation. To aid with this, the National Citizens' Oversight Committee can call upon scientific expertise from outside and commission scientific surveys. In addition, the National Citizens' Oversight Committee has an extensive right of access to BGE and BASE files.

The Sub-areas Interim Report was presented and discussed at a public Sub-areas Conference as per section 9 of the Site Selection Act. The conference was held on four occasions – an inaugural event in October 2020 followed by three further events held between February and August 2021. The conference was attended by citizens, representatives from science, local authorities and other groups within society. The results of the Sub-areas Conference were documented and submitted to BGE which is obliged to take them into consideration when determining site regions for surface exploration.

Following the BGE proposal to limit the search to site regions involving surface exploration, BASE will hold a Regional Conference, including the secretariat, as per section 10 of the Site Selection Act in each of the site regions. These conferences will be attended by residents whose local authorities are in the site region as well as residents whose local authorities have an immediate border with the site region. Other attendees include representatives of the site region's local authorities as well as other groups within society. Regions bordering a site region will be represented equally.

Regional Conferences will be held as the site selection procedure progresses and, in the event that a region is ruled out of the selection procedure, the corresponding Regional Conference will be discontinued. From a supra-regional perspective, the Regional Conference processes will be accompanied by the Council of the Regions Conference involving Regional Conference representatives and local authorities where storage facilities are currently located. Information is published regularly on a supra-regional level via the information platform as per section 6 of the Site Selection Act⁸. The Regional Conferences and the Council of the Regions will also be able to publish documents on the information platform.

The repository search forum was developed as an additional participation format to comply with the legal requirement to continue developing the public participation procedure. The repository search forum is linked to the Sub-areas Conference and forms the core of public participation until the Regional Conferences have been set up. To date, meetings have been held once per year, while the forum can also organise smaller sessions. The content of the repository search forum is devised and prepared by a planning team consisting of citizens, representatives from science, local authorities and other groups within society, along with BASE, BGE and the National Citizens' Oversight Committee. As the organiser and coordinator of public participation, BASE is responsible for meeting all of the organisational and financial support requirements.

⁸ https://www.endlagersuche-infoplattform.de/webs/Endlagersuche/EN/home/home_node.html;jsessionid=38EC3B184129B4C09B535F8F16ECDA62.internet981

Besides public involvement, the Site Selection Act also provides for the involvement of Länder authorities, communal head associations, local authorities and public agencies at all three stages of the procedure as part of the respective consultation procedure depending on whether and to what extent they are affected. This also includes participation by the authorities and the public in the strategic environmental assessment provided for in the first two stages and in the environmental impact assessment provided for in the third stage.

The licensing procedure according to section 9b of the Atomic Energy Act, which follows the decision for a particular site, also contains participatory elements, albeit limited to citizens who are affected by the project (usually local residents) and authorities whose area of responsibility is affected by the project.

5.3 Licensing procedure for waste management installations and facilities

Within the framework of the licensing procedures for nuclear facilities and installations as well as within the framework of plan approval and licensing procedures for disposal facilities and the Asse II mine, the general public is involved by the respective competent federal or Länder authority to the extent that such involvement, especially for conducting an environmental impact assessment, is required. In nuclear licensing procedures where public participation is envisaged, the manner of public participation is regulated in the Nuclear Licensing Procedure Ordinance (*Atomrechtliche Verfahrensverordnung - AtVfV*).

Furthermore, pursuant to the legal regulations of the Federation and the Länder concerning free access to environmental information, the nuclear authorities, BGE and BGZ are obliged to pursue a policy of comprehensive and active information.

Information is also supplied at many sites of nuclear facilities and installations by the operators themselves. BGE informs and involves the public early on as required by section 25 (3) of the Administrative Procedure Act (*Verwaltungsverfahrensgesetz - VwVfG*) with regard to its plans to decommission the Asse II mine as per section 57b of the Atomic Energy Act.

6 Cost and funding

In general, funding for the disposal of spent fuel and radioactive waste and for decommissioning nuclear installations is based on the polluter-pays principle.

The expenses incurred for the planning, construction and operation of facilities for the safekeeping and disposal of radioactive waste are principally borne by the waste producers through fees and contributions together with advance payments according to sections 21 et seq. of the Atomic Energy Act in conjunction with the Repository Prepayment Ordinance (*Endlagervorausleistungsverordnung*). According to the Waste Management Transfer Act in conjunction with the Act on the Waste Management Fund, operators of the nuclear power plants covered by the law⁹ are relieved of their financial obligations once the pertinent financial resources have been transferred to the fund for nuclear waste management, meaning that the fund is then obliged to provide advance payments rather than the nuclear power plant operators. This applies equally to the site selection procedure refinanced by way of cost allocation in accordance with section 28 et seq. of the Site Selection Act. Other waste producers (public nuclear installations and the nuclear industry licensed under the Atomic Energy Act, Radiation Protection Act and Radiation Protection Ordinance) continue to be liable to make advance payments or pay allocated costs.

According to section 9a (3) sentence 1 of the Atomic Energy Act, the Länder are required to establish Land collecting facilities to store the radioactive waste generated on their territory. This includes, in particular, radioactive waste from handling licences granted under the Radiation Protection Act (e.g. medicine, industry and research). These facilities store their radioactive waste until it is delivered to a disposal facility, passing on the cost of waste disposal to the Federation. Land collecting facilities are refinanced via costs (fees and charges) to be borne by the radioactive waste producers.

The costs of each dismantling step and the conditioning, storage and disposal of spent fuel, vitrified waste from reprocessing and other radioactive waste are compiled in the *Report on the Cost and Funding of the Management of Spent Fuel and Radioactive Waste*.

6.1 Costs to be borne by the public sector and their funding

In the public sector, the operators are responsible for the dismantling of their installations and for the conditioning and storage of their waste until the latter is delivered to a federal disposal facility. Moreover, there are eleven Land collecting facilities that are responsible for the conditioning and storage of the waste submitted to them until its delivery to a federal disposal facility.

Funding for the decommissioning and waste management of the nuclear facilities and installations in the public sector, primarily companies receiving government financing, is

⁹ Section 2 (1) of the Act on the Waste Management Fund

ensured by the Federation and the Länder from public budgets. This also applies to the cost of disposal. In general, the Federation assumes around 90% of the costs, with the Länder covering the remaining 10%. The following exceptions apply here: MZFR in Karlsruhe, which is 100%-financed by the Federation; the storage and disposal of AVR fuel elements in Jülich, where the federal share is 70%; the Technical University of Munich (TUM) and VKTA - Radiation Protection, Analytic & Disposal Inc. (VKTA-Strahlenschutz, Analytik & Entsorgung Rossendorf e. V.), both of which are 100%-financed from the budget of the respective Land; the Lubmin and Rheinsberg sites of Energiewerke Nord GmbH, which in accordance with the German Unification Treaty are 100%-financed from the federal budget; the Joint Research Center Karlsruhe (Institute for Transuranium Elements - ITU), which is 100%-financed from EU funds.

The Land collecting facilities charge the waste producers fees for accepting radioactive waste. Upon acceptance, ownership of the waste is transferred. The Land collecting facilities in turn transfer the fees collected for subsequent disposal to the Federation. In accordance with section 21a (2) sentence 2 of the Atomic Energy Act, the Land collecting facilities must charge cost-covering fees (cost-covering principle).

6.2 Special case of THTR

The Thorium High-Temperature Reactor (THTR-300) is a special case. For historical reasons, special arrangements for the funding of the orderly settlement of the project were made between the Federation, the Land of North Rhine-Westphalia, the operating company Hochtemperatur-Kernkraftwerk GmbH (HKG) and its shareholders.

6.3 Costs of decommissioning nuclear power plants and their funding

The main cost-relevant substeps involved in the decommissioning and waste management of nuclear power plants are the dismantling of the nuclear installations and the management of spent fuel and radioactive waste including its disposal.

In accordance with the Act on the Organisational Restructuring in the Field of Radioactive Waste Management, operators of nuclear power plants remain responsible for the entire management and financing of decommissioning, dismantling and proper packaging of radioactive waste. As a precaution against increasing costs in the future, private operators are required under commercial law (specifically section 249 of the German Commercial Code (*Handelsgesetzbuch*)) and tax law to classify as a liability in their balances of accounts provisions for nuclear asset retirement in adequate amounts, i.e. to ensure future financing of the above-mentioned nuclear liabilities in connection with the decommissioning of the nuclear power plants and the management of their radioactive waste.

As an additional provision to ensure that operators meet their financing obligations, the legislator passed the Follow-up Liability Act (*Nachhaftungsgesetz*). The operators of the nuclear power plants are integrated into corporate groups under company law and are largely subject to control and profit transfer agreements within the group in such a way

that the group's assets are liable for the costs of decommissioning, dismantling and disposal. Under company law, companies have restructuring options that pose a risk of insolvency. To counter this, the Follow-up Liability Act imposes a statutory follow-up liability upon the parent companies to assume the cost of decommissioning nuclear power plants run by their operating companies. For the operating and parent companies, the Follow-up Liability Act represents an extension of liability over the limited liability applicable under company law.

6.4 Setup of the German Nuclear Waste Management Fund (KENFO)

In October 2015, the Federal Government tasked the Commission to Review the Financing for the Phase-out of Nuclear Energy (KFK) with drawing up a proposal on how to phase out nuclear power in Germany. Subsequently, the Commission proposed an organisational restructuring of radioactive waste management, agreeing on a fund-based solution to finance the storage and disposal of radioactive waste from nuclear power plants.

The Waste Management Transfer Act governs the transfer of responsibility for managing the storage of spent fuel and radioactive waste from nuclear power plants to BGZ and, in conjunction with the Act on the Waste Management Fund, the transfer of responsibility for funding the storage and disposal of this waste to the German Nuclear Waste Management Fund (KENFO). BGE assumes responsibility for the Federation's duty to set up disposal facilities. The storage and disposal of radioactive waste from commercial power reactors is financed by the federal budget, with the corresponding fees reimbursed each year by KENFO.

KENFO assumed responsibility for financing when the operators of nuclear power plants paid KENFO around 24.1 billion euros on the basis of the amount determined by the Act on the Waste Management Fund. This amount includes a basic amount and a risk premium of around 35.47% (around 6.3 billion euros) to cover cost and interest rate risks beyond the calculated waste management costs.

From a statutory standpoint, KENFO's purpose is to ensure sufficient funding is available to cover the costs of safely disposing of current and future radioactive waste generated from nuclear energy for commercial generation of electricity in Germany. To this end, KENFO uses the funds paid in by the operators of nuclear power plants to invest in safe yet high-yield investments in pursuit of the sustainability strategy and reimburses the Federation for costs incurred as a result of storage and disposal.

6.5 Costs of disposal and their funding

6.5.1 Konrad disposal facility (radioactive waste with negligible heat-generation)

BGE is constructing the Konrad disposal facility, with financing provided from the federal budget. The Federation is reimbursed these costs each year by way of advance payments made by waste producers to fund disposal facilities. To this end, KENFO is responsible for collecting funds from German energy companies for the waste produced by their commercial nuclear power plants. The Repository Prepayment Ordinance is to be replaced by a financing agreement or fee schedule at the latest once the disposal facility commences operation.

6.5.2 Site selection

BGE is responsible for the search for a site for a disposal facility for high-level radioactive waste, i.e. spent fuel and vitrified waste from reprocessing. The process involved in this search is described in the Site Selection Act. Once the site has been determined, the disposal facility for high-level radioactive waste, a receiving storage facility for the transport and storage casks and a conditioning facility are to be constructed and operated. The BGE's work is financed from the federal budget. KENFO reimburses the Federation annually through payment contributions of waste producers (nuclear power plant operators).

The cost of dismantling the Gorleben mine, previously explored as an option for storing high-level radioactive waste, is financed from the federal budget and reimbursed to the federal government annually through payment contributions of the relevant waste producers. Here, too, KENFO is responsible for collecting financing from German energy companies for the waste produced in their commercial nuclear power plants.

The search for a site for a disposal facility for high-level radioactive waste includes provisional safety analyses and an assessment as to whether an additional disposal facility for large quantities of low- and intermediate-level radioactive waste can also be constructed in the prospective area. The cost of conducting such analyses and assessment forms an integral part of the cost allocations imposed upon the waste producers.

6.5.3 Morsleben disposal facility

BGE is decommissioning the Morsleben disposal facility, with the incurred costs borne by the Federation.

6.5.4 Asse II mine

Pursuant to section 57b of the Atomic Energy Act (Lex Asse), the radioactive waste in the Asse II mine is to be retrieved prior to decommissioning. BGE holds the role of implementing agency, with the incurred costs borne by the Federation.

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