



Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Report on the cost and financing of the disposal of spent fuel and radioactive waste

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In the event of discrepancies between this translation
and the original German version, the latter shall prevail.

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Preamble

Responsibility for the decommissioning of nuclear facilities rests with the plant operators. As waste producers, the utilities that operate power plants, as well as the producers of radioactive waste of the public sector and private operators of other nuclear facilities, must bear the full costs of decommissioning (including dismantling) of their nuclear facilities and equipment, and disposing of the radioactive waste.

§ 9a, paragraph (3) of Atomic Energy Act (AtG) requires the Länder to establish Land collecting facilities for the storage of radioactive waste incurred in their region. Under this provision, the Federal Government is tasked with constructing and operating the disposal facilities for radioactive waste. The waste producers are responsible for delivering radioactive waste to the appropriate facilities. § 21 ff. of the AtG states that they must bear the costs in accordance with the polluter-pays principle.

Under § 6 of the Ordinance on Advance Payments for the Establishment of Federal Facilities for the Secure Storage and Disposal of Radioactive Waste (EndlagerVIV), expenditure is currently distributed among the relevant parties as follows (as at: 31/12/2012):

1. For a disposal facility for low-level and intermediate-level radioactive wastes (with negligible heat generation):
 - a) 64.4 % by the nuclear power plants
 - b) 6.0 % by the Karlsruhe reprocessing plant
 - c) 29.6 % by other nuclear facilities (industry, medicine and research).
2. For a disposal facility for (high-level radioactive) especially heat-generating wastes:
 - a) 96.5 % by the nuclear power plants
 - b) 0.7 % by the Karlsruhe reprocessing plant
 - c) 2.8 % by other nuclear facilities (industry, medicine and research).

1 Public sector

1.1 Cost

There are twelve operators in the area of the public sector:

- Arbeitsgemeinschaft Versuchsreaktor GmbH, Jülich (AVR)
- Energiewerke Nord GmbH, Rubenow (EWN)
- Forschungszentrum Jülich GmbH (FZJ)
- Helmholtz-Zentrum Berlin für Materialien und Energie GmbH (HZB)
- Helmholtz-Zentrum Geesthacht, Zentrum für Material- und Küstenforschung GmbH (HZG)
- Institut für Transurane, Karlsruhe (ITU)
- Physikalisch-Technische Bundesanstalt, Braunschweig (PTB)
- Technische Universität München, Garching (TUM)
- VKTA-Strahlenschutz, Analytik & Entsorgung Rossendorf e.V., Dresden (VKTA)
- Wiederaufarbeitungsanlage Karlsruhe Rückbau- und Entsorgungs-GmbH, Karlsruhe (WAK)
- Zentrale Sammelstelle für radioaktive Abfälle der Bundeswehr, Munster (ZESAM)
- Universität Mainz (TRIGA research reactor Mainz, FRMZ).

These operators are responsible for the decommissioning and dismantling of their facilities and for the conditioning and storage of their waste through to delivery to a Federal Government disposal facility.

There are also eleven Land collecting facilities (LSSts):

- LSSt **Baden-Württemberg**, Karlsruhe
- LSSt **Bavaria**, Mitterteich
- LSSt **Berlin**, Berlin
- LSSt **Mecklenburg-West Pomerania**, Rubenow (also responsible for **Brandenburg**)
- LSSt for Germany's four coastal Länder, Geesthacht (responsible for **Bremen**, **Hamburg**, **Lower Saxony** and **Schleswig-Holstein**, whereby Lower Saxony's allocation has been used up)

- LSSt **Hesse**, Ebsdorfgrund
- LSSt **Lower Saxony**, Jülich (acceptance and conditioning of raw waste in Jülich; conditioned waste suitable for disposal and legacy waste is stored at the Leese storage facility)
- LSSt **North Rhine-Westphalia**, Jülich
- LSSt **Rhineland-Palatinate**, Ellweiler
- LSSt **Saarland**, Elm-Derlen
- LSSt **Saxony**, Dresden-Rosendorf (also responsible for **Saxony-Anhalt** and **Thuringia**).

These Land collecting facilities are responsible for the conditioning and storage of wastes received by them until delivery to a Federal Government disposal facility. The delivery of all public-sector radioactive waste to a Federal Government disposal facility is coordinated by a central agency.

The total costs arising in the area of the public sector for dismantling and waste management (excluding the costs of site selection, construction, operation and closure of disposal facilities) from the beginning of 2013 until 2080 are estimated at € 6 billion (based on 2012 prices), including:

- Around € 2.0 billion for dismantling¹,
- Around € 3.7 billion for the management of low-level and intermediate-level radioactive waste (conditioning, storage and transport to the disposal facility)² and
- Around € 0.3 billion for the management of spent fuel and reprocessing waste³.

¹ As well as the inherent costs of dismantling, the “dismantling costs” also include the costs of experts, license and clearance measurement.

² “Management of low-level and intermediate-level radioactive waste” covers all the costs associated with existing and future waste, including conditioning of the waste and casks, documentation and surveyor costs, storage, and transport to the disposal facility. In estimating the costs of storage, we have assumed that the Konrad disposal facility will remain operational until 2060.

³ The cost of the “management of spent fuel and reprocessing waste” includes currently foreseeable projected costs for the storage and management of the spent fuel and reprocessing waste. Costs are incurred e.g. for the management/recovery of the spent fuel, for transport (either to the country of origin or to the disposal facility), for casks, for storage, and for permits and surveyors. This estimate includes storage costs until 2060 (commissioning in around 2050, plus transitional period).

The projected total costs of around € 6 billion may increase further over the next few years, since the underlying assumptions contain a number of significant unknown factors.

Figure 1.1 illustrates the anticipated development over time (based on 2012 prices, excluding cost increase) of the cost of dismantling and waste management of nuclear facilities and equipment by publicly funded operators and the Land collecting facilities, excluding the cost of disposal, from 1 January 2013 onwards:

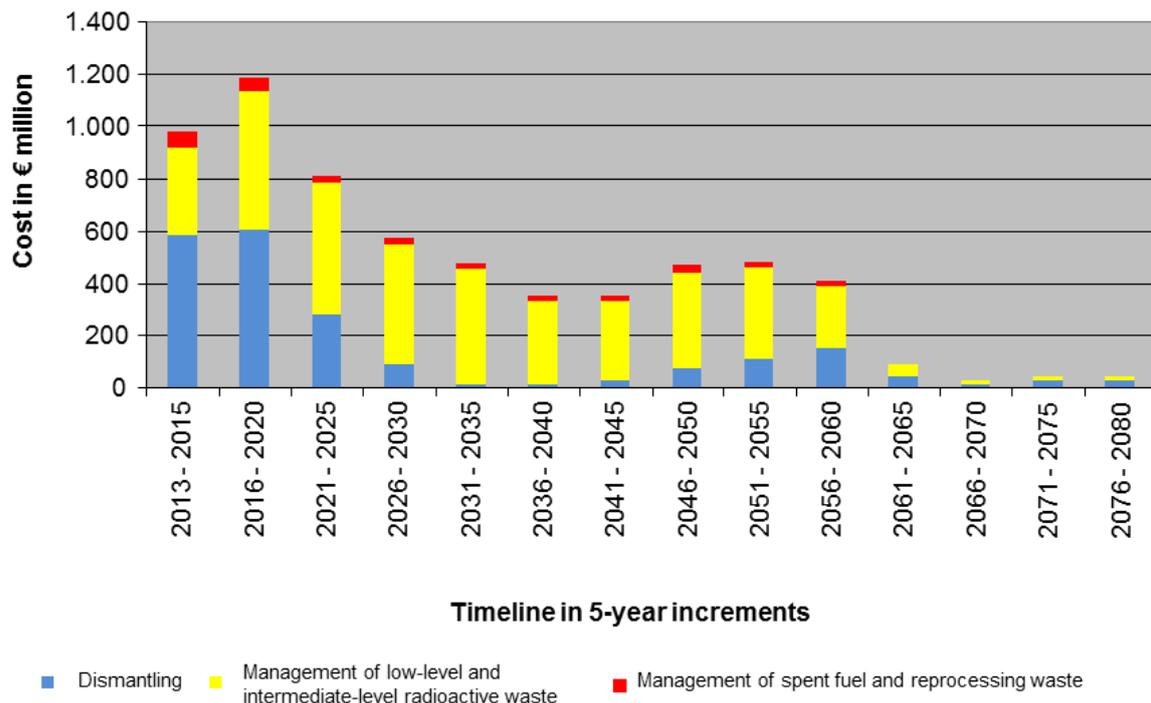


Figure 1.1: Costs in the area of the Public sector for the decommissioning and dismantling of nuclear facilities and installations and the management of radioactive waste from 1 January 2013, excluding the construction, operation and decommissioning of the disposal facilities (based on 2012 prices, excluding cost increase).

1.2 Financing

In the area of the public sector, predominant companies that receive public funding, the decommissioning (including dismantling) of the nuclear facilities and installations and the management of radioactive waste is financed from Federal Government and Länder budgets. The same applies to the cost of disposal. The Federal Government

generally bears around 90% of the cost, while the remaining 10% is the responsibility of the respective Land. Exceptions to this rule are the AVR, where the Federal Government share is only 70%; TUM and VKTA, which are 100% funded from the respective Land budget; and the EWN sites Lubmin and Rheinsberg, which are 100% financed from the Federal Government budget as a result of the unification treaty. Additionally, ITU receives 100% EU funding. The experimental and demonstration reactor THTR-300 in Hamm-Uentrop is another special case; for historical reasons, special financing agreements were made between the Federal Government, the government of North Rhine-Westphalia, the operator company Hochtemperatur-Kernkraftwerk GmbH (HK) and its shareholders for controlled completion of the project.

The Land collecting facilities (LSSt) charge for the acceptance of radioactive waste shipments. Upon acceptance of the waste, ownership is transferred to the respective LSSt. For disposal, a proportion of the fees levied by the LSSts is paid over to the Federal Government. As a general principle, § 21a, paragraph (2), sentence 2 of the Atomic Energy Act requires the LSSts to charge fees which will cover their costs (cost recovery principle).

Additionally, companies under private law that receive government financing are subject to the same provisions under commercial and fiscal law (such as the requirement to include adequate provisions in the balance sheet) as private operators (see chapter 2.2).

2 Private operators

2.1 Cost

The cost to the utilities and the fuel cycle industry of the decommissioning and disposal of nuclear facilities is made up primarily of the dismantling of all nuclear installations and the management of the spent fuel and radioactive waste including their disposal. The principal cost-relevant stages in the waste management process are the fuel casks (CASTOR), the loading of the casks, transfer of the casks to the on-site storage facility at the power plant, and storage (construction, operation, dismantling). This calculation is based on existing agreements, with due regard for future transportation to a suitable disposal site to be selected by the Federal Government, and appropriate conditioning

of the spent fuel based on industry-typical data. The costing also assumes that the disposal of conditioned spent fuel will take place in POLLUX casks (around 2,000 in number) which are emplaced in the disposal facility drifts.

Figure 1.2 shows the anticipated development of nominal costs in 5-year increments as projected by the power utilities. The approximate costs **total some € 34 billion** for the decommissioning and waste management (excluding disposal) of nuclear facilities within the remit of private operators (prices based on 2013, excluding cost increases and excluding the cost of disposal).

Until around 2045, decommissioning and dismantling measures account for the bulk of costs; after that, the cost of storage of the spent fuel and reprocessing waste and its preparation for disposal is the major cost factor.

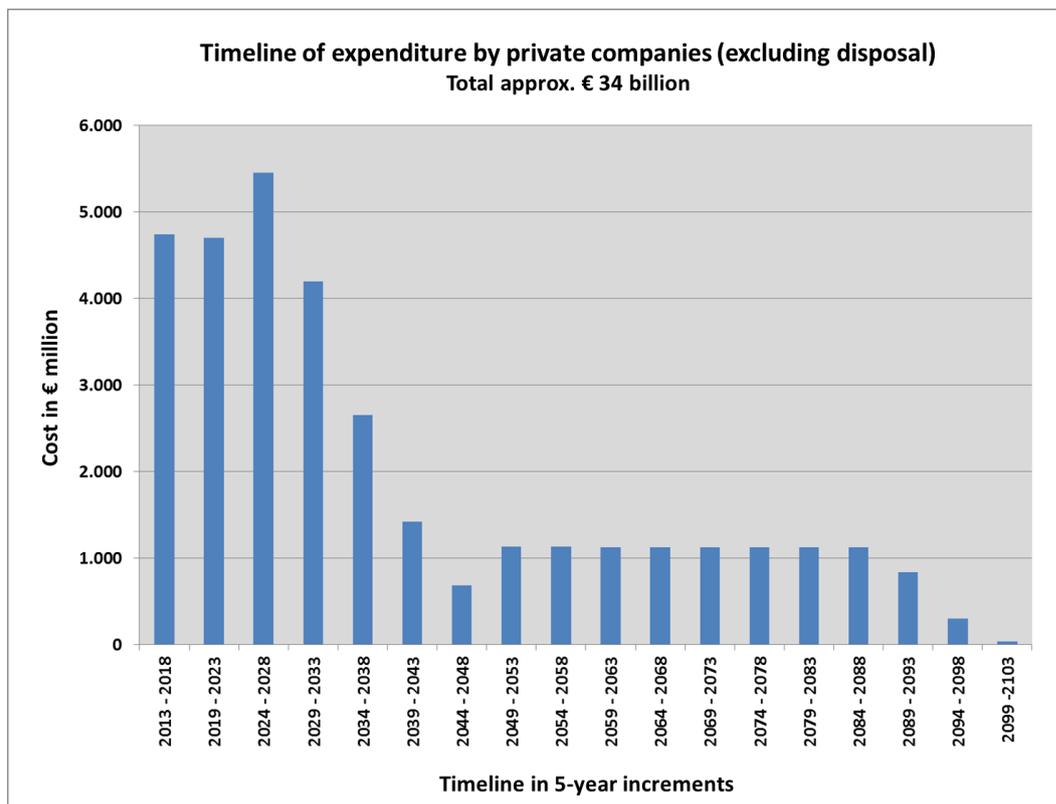


Figure 1.2: Cost of decommissioning private nuclear facilities in Germany and management of radioactive waste in 5-year increments (based on 2013 prices, excluding cost increases and excluding disposal costs).

2.2 Financing

§ 9a, paragraph (1) of the Atomic Energy Act (AtG) requires operators of nuclear power plants and other nuclear facilities to safely recover all radioactive residues and dismantled parts or properly dispose of as radioactive waste. Under the Act's "user pays" principle, in particular, the plant operators are responsible for financing these obligations.

As such, the precise amount and timing of the operators' financial obligations has not yet been fixed. Commercial (particularly § 249 of the German Commercial Code (HGB)) and fiscal regulations therefore require them to form adequate provisions in the balance sheet. In order to meet this requirement, they are also responsible for making the relevant cost calculations and estimates. In calculating the cost of disposal, they are reliant on the estimates provided by the competent Federal Government authority.

These provisions are regularly reviewed by auditors within the context of account auditing. The companies' fiscal balance sheets are also reviewed by the tax authorities.

It is vital to ensure that adequate funds are available in case they are needed.

Provisions must be formed to cover all future waste management stages, including disposal.

3 Cost of disposal

The Federal Government, as the constructor and operator of disposal facilities, is responsible for estimating the cost of disposal.

3.1 Konrad disposal facility

The Konrad project is comprise of four phases: planning and exploration, construction, emplacement operation, and decommissioning. The cost of each phase is indicated below:

- a) Total costs for planning and exploration from 1977 to the end of 2007 approximately € 930 million.

- b) The cost of the Konrad disposal facility construction phase, which began in 2008 and is currently due for completion in 2022, totals approximately € 2.9 billion. Costs have essentially been calculated on the basis of the 2013 project cost estimate by Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH (DBE), which was commissioned by the Federal Office for Radiation Protection (BfS).
- c) During the emplacement phase, the operating costs are currently estimated at € 81.6 million per annum (2012 prices).
- d) To date, the closure costs have been estimated at 10% of the total cost of building the disposal facility, i.e. around € 290 million.

The costs incurred to date for planning and exploration, and the projected costs of construction, emplacement operation and closure, of the Konrad repository are in the region of € 7.5 billion. The total costs are distributed according to the “user pays” principle.

3.2 Morsleben disposal facility

The cost to date of the Morsleben radioactive waste disposal facility (ERAM) is estimated to be in the region of € 2.4 billion (excluding ongoing maintenance operation).

The total costs are distributed as follows:

- a) Total cost to date from 1990 to the end of 2013: € 1.1 billion
- b) Cost of ongoing maintenance operation (2014: € 48 million, 2015: € 47 million, 2016: € 50 million)
- c) The remaining operating and closure costs for ERAM (backfill material, sealing measures, facility costs, operating costs, infrastructure above and below ground etc.) have been provisionally estimated at € 1.2 billion ± 30%. This does not include the cost of dismantling the installations above ground and the cost of compensatory and substitute measures, which are difficult to quantify at present.

The Federal Government will bear the cost of decommissioning ERAM.

3.3 Asse II mine

There is no empirical data available on the recovery of radioactive waste from a shaft mine such as Asse II, and mining industry experiences (excavation of shafts and tunnels, overground equipment, mechanical engineering) are only transferable to a limited extent. There are currently no technical plans available for the envisaged waste recovery project which would allow a reliable estimate of the costs. The cost of recovering the radioactive waste, and of decommissioning and making safe the Asse II mine, will be borne by the Federal Government.

To date, the total expenditure by the BfS since it assumed responsibility on 1 January 2009 up until the end of 2013 has been in the region of € 417.5 million. In 2014, € 114.1 million was spent on operating and decommissioning the Asse II mine . It is impossible at present to give a reliable projection of the total project costs for decommissioning the Asse II mine, since they are based on a range of assumptions which have yet to be defined.

For the years 2015 and 2016, the following amounts have been set aside in the Federal budget for this purpose.

2015: € 110.0 million

2016: € 120.0 million

Assuming a cost of around € 25,000 per m³ of waste package volume for the Konrad disposal facility (2014 prices), and a waste volume of around 200,000 m³, the disposal costs of the waste recovered from the Asse II mine are estimated to be in the region of € 5 billion. These costs are likewise to be borne by the Federal Government.

3.4 Disposal facility for especially heat-generating radioactive waste

3.4.1 Procedure under the Site Selection Act

3.4.1.1 Procedure for identifying and selecting a disposal facility site

The Site Selection Act (StandAG) provides the framework for a future procedure, divided into multiple stages, for identifying and selecting a disposal facility site for especially heat-generating radioactive waste.

The actual identification and selection process is preceded by the work of the “Commission on Storage of High-Level Radioactive Waste” (“the Commission”), the results of which form the basis for the initial legislative process. The Commission is tasked with drafting recommendations on fundamental issues relating to disposal, and the scientific search for a disposal facility site. The results of the Commission’s work will also have an impact on costs. Factors that will help to determine the overall cost of the site selection procedure include how long the process takes (particularly with regard to the need for extended storage, maintenance of the existing exploration site and the public participation process), the cost of exploration, and in particular the number of sites requiring underground investigation. Other unquantifiable factors are inevitable as a result of the site-specific exploration programmes and still-to-be-defined inspection criteria for the investigations above and below ground. The more the procedure advances, the more accurately experts will be able to quantify the expenditure involved in the aforementioned cost-intensive measures.

The legislative process associated with the Site Selection Act (StandAG) projected a cost of around € 2 billion for site selection. This estimate was based on the wording of the Act as formulated by the German Government at that time, and included certain assumptions regarding the anticipated procedural development based on current knowledge at the time. As cost-relevant amendments to the Act may arise as a result of the Commission’s work, it is impossible at present to give a reliable, updated cost estimate.

§§ 21 ff. of the Act states that the costs of the site selection procedure are to be divided into apportionable and non-apportionable costs. The apportionable costs are to be

borne by the waste producer, and the non-apportionable costs by the Federal Government.

Costs are distributed according to the “polluter pays” principle.

3.4.1.2 Maintenance operation of the Gorleben mine

One of the provisions of the StandAG is that the exploration mine in the Gorleben salt dome should be kept open until a site decision has been reached, while guaranteeing all the legal requirements and the necessary maintenance work, for as long as and provided that the site has not been eliminated from the selection procedure. When the StandAG entered into force, mining exploration of the Gorleben salt dome was discontinued. Exploration at the Gorleben salt dome had previously been suspended since November 2012. The planning framework for carrying out the work needed for longer-term maintenance operation is outlined in the current main operating plan (dated December 2014).

The main operating plan is based on the following cornerstones:

- Exploration area 1 will be shut down. All equipment, components and systems will be removed from this exploration area, and the zone will be shut off.
- Only the two shafts and the parts of the infrastructure operation required for technical reasons to ensure ventilation and escape routes will continue to operate in this phase. This includes maintaining a walkable connection between the shafts.
- The safety systems will be downgraded to the status of a normal industrial plant.
- Operation of the installations above ground will be adjusted in line with operation to keep the mine open.
- Before entering this phase, transition work must be carried out to decommission the exploration area and parts of the infrastructure; this will take approximately two years.

Visitor tours of the mine as part of its public relations work will be discontinued.

The cost of keeping the mine open will be distributed according to the “polluter pays” principle. The cost of the transition work is estimated at around € 40 million in 2015 and € 30 million in 2016 (based on 2014 prices). Once it enters maintenance operation, the costs should be reduced.

3.4.2 Construction and operation of a disposal facility for especially heat-generating radioactive waste

Based on a 1997 BfS cost estimate for the former Gorleben disposal project, in the past private operators have given the following cost projections for a disposal facility for especially heat-generating radioactive waste (based on 2012 prices, excluding cost increases):

- Investment costs: € 3,900 million
- Decommissioning costs: € 389 million
- Operating costs: € 3,369 million

The total costs of building, operating and decommissioning a disposal facility for especially heat-generating radioactive waste is therefore estimated at approximately € 7.7 billion. Deviations and cost increases may arise due to the required site selection procedure under the StandAG.

The costs are distributed according to the “polluter pays” principle.