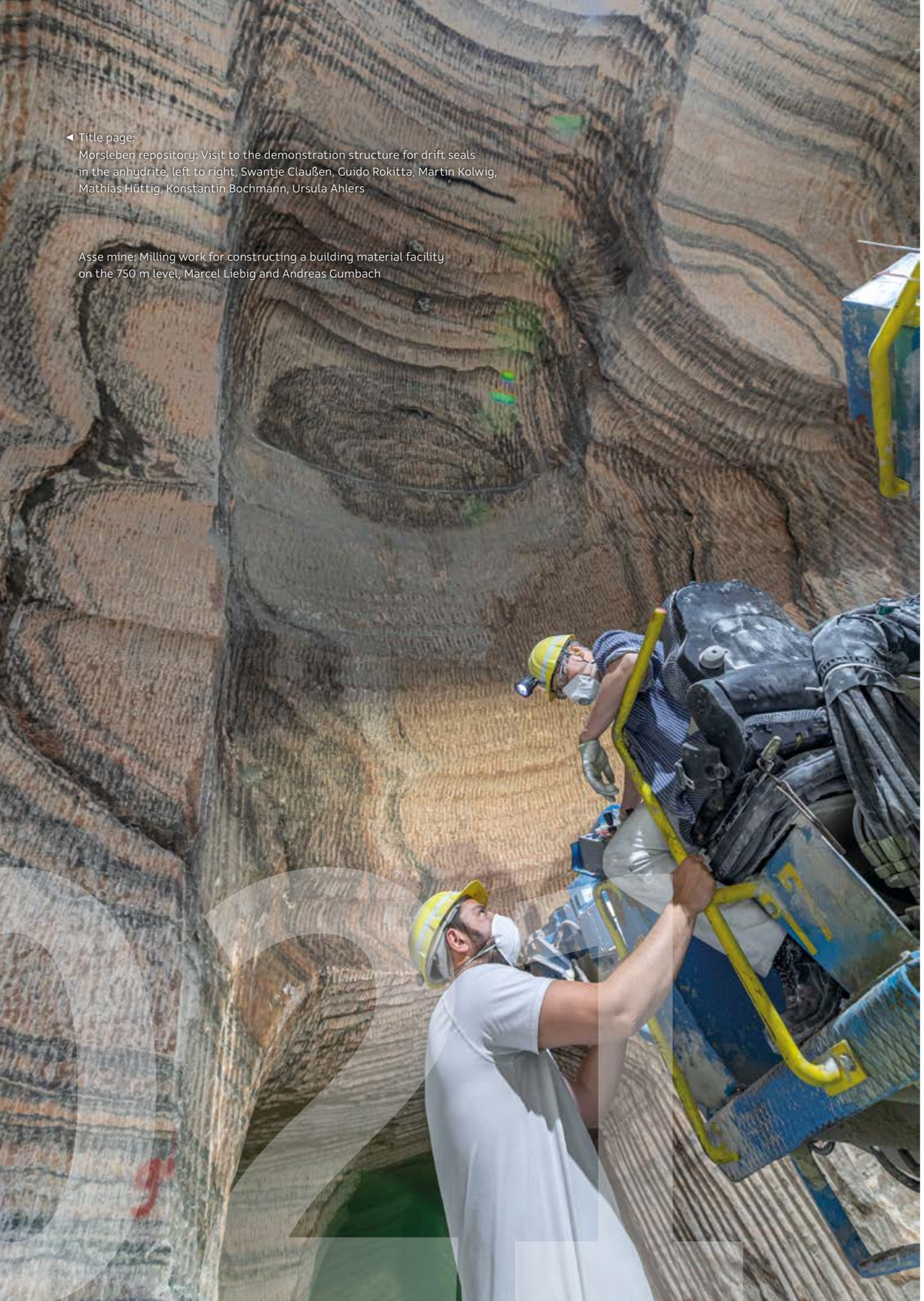
BGE

BUNDESGESELLSCHAFT
FÜR ENDLAGERUNG

ANNUAL REPORT



◄ Title page:
Morsleben repository: Visit to the demonstration structure for drift seals in the anhydrite, left to right, Swantje Claußen, Guido Rokitta, Martin Kolwig, Mathias Hüttig, Konstantin Bochmann, Ursula Ahlers

Asse mine: Milling work for constructing a building material facility on the 750 m level, Marcel Liebig and Andreas Gumbach

Dear Readers,

The coronavirus pandemic has challenged BGE for another financial year. Fortunately, almost all those affected have already returned to work in good health so far. Consistent enforcement of company safety policies and the employees' prudent conduct in this regard have helped BGE, despite the pandemic and with only some delays, to make good progress overall.

In fact, BGE even has a number of positive takeaways from this period of exceptional operations. The IT systems at BGE have played and continue to play an important role in enabling the switch from analogue to digital communication with almost no disruptions. This affects a good half of the workforce. The positive experiences have motivated BGE management and the co-determination representatives together to expand the general works agreement on mobile working and make it much more comprehensive. The push towards digitalisation has also had an effect internally, where many processes have been further optimised. And by now, participating in digital formats has become the norm. Until two years ago, hosting hybrid events was unimaginable.

A crucial part of BGE's success is the progress made in the projects on site. This has been partly complicated and hampered by the pandemic. Our attention is therefore focused on keeping the impact on the time-critical processes as low as possible.

At the Asse mine, things have progressed considerably. With early public participation, BGE has opened up the project to broad participation by all interested parties.

For the implementation of emergency planning, a major milestone was reached with the completion of the surface facility for solution management.

For retrieval, things have come a good way forward with important planning contracts for retrieval technology and waste treatment, initial purchase agreements for future operational areas, and entry into the regional planning procedure.

At Konrad, the excavation of the underground cavities is almost complete. The filling site on the second level has kept us busy for more than two years.

On Konrad 1, construction of the last buildings has begun. In particular, the various construction sites at the Konrad 2 shaft have picked up speed, clearly visible to all. Knowing the cranes are in motion there makes BGE optimistic about the continued progress of this project.

In Morsleben, key questions regarding the approval for decommissioning have been clarified. Regarding the site selection procedure, there has been a great deal of communication on the results of the Sub-Areas Interim Report. Transparency and traceability remain essential goals for us in the site selection procedure. This goes for Step 2 in Phase I of site selection, for example, which has now begun with the development of methods for the first safety assessments. Product control has succeeded – with digitalisation – in significantly increasing the number of notices issued for the future storage licence for the Konrad repository and in accelerating the procedure overall. Last but not least, the press conference held by Supervisory Board Chair Jochen Flasbarth outlined the way forward for the closure of the Gorleben mine.

The BGE management would like to expressly thank the staff for their commitment, loyalty, and support over the past year!

Stefan Studt
Chair of the Management Board

Steffen Kanitz
Deputy Chair of the Management Board

Dr. Thomas Lautsch
Technical Managing Director

Konrad shaft mine: Drift crossing at the crusher plant, 2nd level

Contents

Report of the supervisory board

With the number of employees now permanently exceeding 2,000, management initiated a status procedure and the supervisory board of the Bundesgesellschaft für Endlagerung (BGE) reconstituted itself in the third quarter in accordance with the parity composition regulations of the Co-Determination Act. The supervisory board convened for its constituent meeting in the fourth quarter, with eight board members on the shareholder side and eight provisionally court-appointed board members on the employee side.

The chair of the supervisory board was confirmed in office, and Franz-Gerhard Hörnschemeyer was elected deputy chair. Furthermore, the legally mandated mediation committee was set up, which, in addition to the chair and deputy, includes Dr. Holle Jakob for the shareholder side and Carsten Meyer for the employee representative side.

In 2021, the management board informed the BGE supervisory board orally and in writing about all essential business transactions of the company.

In two meetings, the supervisory board discussed business developments and important individual events, and dealt with the transactions presented for examination and approval as required by law and the articles of association.

Once again, in 2021, the supervisory board met exclusively in digital format due to the ongoing effects of the coronavirus pandemic. At its meeting on 22 June 2020, among other things, the supervisory board accepted the annual financial statements for 2020, informed the general assembly in writing of its appraisal, and proposed its approval.

The annual report on the internal audit for 2020 was also presented and discussed.

In its subsequent meeting on 30/11/2021, the supervisory board proposed to the shareholders' meeting that the auditing / tax consulting firm Ebner Stolz GmbH & Co KG be appointed for auditing the 2021 annual financial statements, and defined two focal points for the audit.

A new version of the rules of procedure for the supervisory board was discussed, with the final resolution to be passed in 2022.

State Secretary Gebers resigned her seat on the supervisory board with effect from 01/02/2021. She was succeeded by Lena Daldrup as representative of the Federal Ministry of Labour and Social Affairs. In the course of the reconstitution of the supervisory board as of 01/09/2021, the employee representatives Gregor van Beesel, Gabriele Theisen, and Peter Wolff also resigned from the board.

The supervisory board expresses its thanks and appreciation to the management board and all BGE employees for the work they did in 2021.

Peine, 30 June 2022

Members of the supervisory board

Jochen Flasbarth
Chair of the Supervisory Board[1]
State Secretary
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Berlin
(05/09/2017 – 01/03/2022)

Dirk Alvermann
Mine Captain
Bundesgesellschaft für Endlagerung mbH, Morsleben Repository (Employee Representative)

Ursula Borak
Head of Division International Affairs, Fossil Fuels and Nuclear Energy
Federal Ministry for Economic Affairs and Energy, Berlin

Dr. Wolfgang Cloosters
Head of Department Nuclear Safety, Radiological Protection
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

Lena Daldrup
Head of Division Basic Occupational Safety and Health Policies, Technical Supervision of the Federal Institute for Occupational Safety and Health
Federal Ministry of Labour and Social Affairs, Berlin (appointed on 13/04/2021)

Leonie Gebers
State Secretary
Federal Ministry of Labour and Social Affairs, Berlin (left on 01/02/2021)

Prof. Dr. Karin Holm-Müller
Head of Chair
Resource and Environmental Economics
Rheinische Friedrich-Wilhelms-Universität, Bonn

Franz-Gerhard Hörnschemeyer
Deputy Chair of the Supervisory Board
(since 30/11/2021)
Trade Union Secretary Energy Sustainability
Mining, Chemical and Energy Trade Union, Hannover (Employee Representative)

Dr. Holle Jakob
Head of Directorate
Strategic management of the customs administration; financial control of undeclared work; customs anti-money laundering measures
Federal Ministry of Finance, Berlin

Dr. Andreas Kerst
Head of Division
General issues of holdings management; Public corporate code; §§ 65 and 68 Federal Budget Code; coordination of international activities
Federal Ministry of Finance, Berlin

Sylvia Kotting-Uhl
Member of the Bundestag (Bündnis 90/Die Grünen parliamentary group) and Chair of the Committee for the Environment, Nature Conservation and Nuclear Safety of the German Bundestag, Berlin
(until 30 October 2021)

Jens Lindner
Shift Supervisor
Bundesgesellschaft für Endlagerung mbH, Konrad mine (Employee Representative)

Appointed as of 01/09/2021

Christina Egelkraut
Legal Assistant
Bundesgesellschaft für Endlagerung mbH, Asse mine (Employee Representative)

Carsten Meyer
Project Engineer
Bundesgesellschaft für Endlagerung mbH, Peine (Employee Representative)

Christina Offermanns
Secretary to the Management
Bundesgesellschaft für Endlagerung mbH, Konrad mine (Employee Representative)

Marike Vornkahl
Trade Union Secretary
Mining, Chemical and Energy Trade Union, Hanover (Employee Representative)

Sebastian Zwetkow-Tobey
Miner
Bundesgesellschaft für Endlagerung mbH, Asse mine (Employee Representative)

Left as of 31/08/2021:

Gregor van Beesel
Deputy Chair of the Supervisory Board
Dipl.-Ing. Kartographie
Bundesgesellschaft für Endlagerung mbH, Peine (Employee Representative)

Gabriele Theisen
Accountant
Bundesgesellschaft für Endlagerung mbH, Asse mine (Employee Representative)

Peter Wolff
System Administrator
Bundesgesellschaft für Endlagerung mbH, Asse mine (Employee Representative)

[1] Jochen Flasbarth was Chair of the Supervisory Board from 05/09/2017 to 01/03/2022. His successor as of 04/04/2022 is Christian Kühn.

"We are advancing the state of the art in science and technology"

An interview with Managing Director Steffen Kanitz

Steffen Kanitz is responsible for site selection within the management of BGE. His responsibilities also include research, product control, information technology, and provisionally commercial matters. He has been on the BGE management board since September 2018. Previously, he represented the interests of BGZ Gesellschaft für Zwischenlagerung mbH. From 2013 to 2017, he was a member of the German Bundestag, and in this capacity he was also a member of the Repository Commission that developed the requirements and path to a final repository for high-level radioactive waste from 2014 to 2016.

Steffen Kanitz

About half of the current research projects in the site selection for a repository for high-level radioactive waste deal with crystalline host rock or with clay rocks. Why is that?

Steffen Kanitz: Our research projects reflect the state of knowledge about the host rocks in Germany. For a very long time, repository research had mainly focused on rock salt. Now we want to catch up, especially through international cooperation and the more advanced research questions being developed from it.

Most of the work in international cooperative research is also on clay and crystalline host rock. For example, in the EURAD research consortium, two large projects are looking at specific properties of clay rock. Are there more cooperative projects?

Last year, BGE participated in the characterisation of opalinus clay in the Mont Terri rock laboratories and of crystalline rock at the Grimsel test site, both in Switzerland. BGE is also involved in some of the very long-standing experiments there, in order to improve the body of knowledge especially with regard to the preliminary safety assessments.

Is that why BGE has initiated the development of containers in crystalline host rock first?

In view of the two possible safety concepts, this is the most demanding type of container. This is because high-level radioactive waste can be sealed either in a confining rock area or, in the case of crystalline rock, also in a technical safety concept in which the container basically performs the main task.

In Scandinavia, there is already a container concept for granite, which are containers with copper sheathing and a protective layer of bentonite. Bentonite has technical properties that are comparable to clay rock. Is that not enough?

The safety requirements in the Site Selection Act stipulate the best possible safety for at least one million years. No one else does that. The Scandinavian container concept has so far been designed for shorter periods. In this case, BGE has to make advancements in the state of the art in science and technology and push the limits of what is feasible. That is why we have made this container development the first thing to work on.

What is the next step in container development?

Next, we also want to find out whether the much-discussed idea of storing Castors directly in the repository could be a possible variant. The challenges in terms of both mining and manageability are enormous, but we have to clarify this question now, once and for all.

There are also important open questions about rock salt. What is BGE's approach, given that the internal structure of a salt dome is so difficult to assess from the outside?

In the current phase regarding this, namely the first preliminary safety assessments, for which we have just presented a method, we are trying to re-evaluate the existing data from previous seismic surveys and explorations around salt domes. We have better evaluation methods now than those at the times when they were done, and we hope that reprocessing will create better images, which would then enable us to draw even more inferences.

Additionally, in cooperation with the Federal Institute for Geosciences and Natural Resources (BGR), we also want to look far back into the past and, taking data from thoroughly explored salt domes into account, to examine whether a more accurate description of the formation of salt domes can help us in our assessment. We are taking a very targeted approach – but with an open mind as to the results. There's a possibility that not much will come out of it. But this openness to results is at the heart of our scientific search for a repository.

What happens if the research project doesn't produce any results?

There is always that risk in research: that either the question was wrongly posed, or that simply no clarity can be achieved.

If a research project doesn't produce any results, we will report that publicly in any case. And then we would have to develop a plan B and find a new strategy to be able to make the most robust, i.e. reliable, statements possible about an area. By the way, this doesn't only apply to salt domes.

Interviewed by Dagmar Dehmer

Why research & development is important for BGE

"In a scientific process like site selection, for which there is no blueprint, identifying and addressing knowledge gaps is essential for robust decision-making. We are currently researching questions of geology, repository mines, and the interactions between different barriers. If you want to guarantee safety for a million years, you have to understand in detail how the various components of a repository system change over the years. In this context, it is important to me that we share the scientific findings with the public and also clearly state which questions we are currently unable to answer."

Steffen Kanitz, 38, Deputy Chair of the Management Board

"In the site selection procedure, the initiation of research projects is very important. From a geoscientific point of view, two important topics are: the systematic collection of characteristic and host-rock-specific rock properties, and the prediction of future processes and consequences of earth processes such as erosion. Since many geoscientific processes and questions cannot be answered by direct observation, modelling can help to analyse the influence of various processes on safety-relevant geological properties. When it comes to site selection, cooperation with scientists from universities and research institutions is very important."

Dr. Sara Fanara, 43, Geoscientist, Site Search, Site Selection Division

"In the unique context of the Asse retrieval project, research and development is an important element of contingency planning. Part of this contingency planning is carrying out various backfilling and sealing measures as a precaution. In this respect, we are continuing to develop building materials as required and are also examining whether R&D projects can bring about an optimisation of the building materials and backfilling or injection procedures. This means we are pursuing the goal of exceeding and continuously optimising the system safety of our underground structures with regard to the defined protection goals. The results have a direct influence on the implementation of our measures."

Jan Hegemann, 34, Head of Contingency Planning, Asse/Contingency Planning

"We want to improve the health of our employees, eliminate emissions from our construction sites and operations, and use autonomous systems in the hazardous areas of our repositories. There is still important research and development needed for this. What will our renewable building materials be? How do I get my machines to see, to hear, to feel and, ultimately, to think? How do we achieve the company's goal of zero accidents? BGE is in an ideal position to conduct research and development in these important fields for the future. We have the repositories, and we have the people to do it."

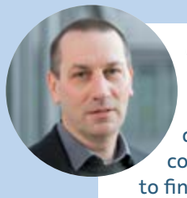
Dr. Thomas Lautsch, 61, Technical Managing Director

"R&D projects provide important impetus for our repository projects, which we carry out on behalf of the federal government. In finance and accounting, the contract modalities, the separate booking of direct and overhead costs, and the relevance to projects are especially important. A distinction also has to be made as to whether we do our own research and development or whether we have R&D done by third parties. The R&D expenses don't have an impact on the balance sheet, as they relate to the federal government's repository projects. But we do present the content and scope in the management report of the annual financial statements – as required by the German Commercial Code. We indicate the given costs for auditing purposes."

Marion Mrozek, 64, Head of Finance and Accounting

"Research and development towards a final repository for high-level radioactive waste is a core task of BGE TECHNOLOGY GmbH, and one that has even occupied me for my entire career. By making continuous developments in the various repository systems, we can provide a basis for ultimately realising the final repository. What is particularly fascinating is the possibility of introducing new technologies or impetus from outside into the world of repositories and of developing solutions for the specific requirements of final disposal. This constantly poses new challenges. Good examples of this are developing technical concepts to ensure retrievability or continuously advancing the transport and emplacement technology."

Philipp Herold, 37, Division Manager for Repository Technologies at BGE TECHNOLOGY GmbH



"The site selection procedure is subject to a variety of requirements, a central one being its scientific character. This search is the first step towards a repository. A good scientific basis from the very beginning is important for achieving the best possible safety as demanded. To this end, we are researching with universities, research institutes, and companies into matters of numerical simulation of complex coupled processes with a view to finding a repository. Be it heat generation, the effect of closures, or many other things. One example to mention here is the OpenWorkFlow project, in cooperation with the Helmholtz Centre for Environmental Research and the Freiberg University of Mining and Technology."

Wolfram Rühaak, 54, Head of Safety Investigations, Site Selection Division

"The commercial use of nuclear energy has been producing radioactive waste for more than 60 years, and there is still no final solution for its safe disposal. With the decision to phase out nuclear power and the Site Selection Act, there is now a clearly outlined decision-making procedure. However, even within this framework for action, BGE is still faced with many technical questions that could not be answered reliably and authoritatively without the involvement of science and research. And of course, our other projects also urgently need constant reflection – be it construction of the Konrad repository, retrieval of the Asse waste, or decommissioning of the Morsleben repository."

Stefan Studt, 60, Chair of the Management Board

"My aha moment in the field of communication research was when I learned how the human brain processes information. Taking this into account often requires a counterintuitive approach to communication – and shows me that we always have to keep at it. This is all the more true when it comes to our repository projects. Our communication must reflect the latest state of our knowledge. That, too, is a part of transparency. One of the things I enjoy most is discussing procedures, new findings, and new research questions with the scientists of BGE and our research partners."

Dagmar Dehmer, 56, Head of Corporate Communications and Public Relations

"We want to increase the operational safety of our repositories as well as the long-term safety for people and the environment. To this end, we are continuously advancing the state of the art in science and technology with our R&D work. Our international cooperative projects are important building blocks in this respect. What technologies and what knowledge do we need now and in the years and decades to come? What competencies must we develop and maintain? These questions guide us in the strategic planning of research and development work."

Dr. Axel Liebscher, 55, Head of Repository R&D, Research Planning

"Final disposal is a task that extends far into the future. Of course, that also applies to product control. The state of science and technology will always move forward, based on research and development. Even if we don't do our own concrete research and development projects in the area of product control, we must always keep these topics in mind. In addition, we can contribute our knowledge, for example on the characterisation of radioactive waste or container development, to projects in other areas."

Dr. Monika Kreienmeyer, 57, Head of Product Control

"Why is research & development important? Without innovations there is no progress. This has always been the case and affects all areas of work and life."

Matthias Unger, 41, Head of Department, ASE / ASE-Bau

Konrad shaft mine: Shaft workers have just finished controlling the ropes, left to right, Noah Appeltauer, Christopher Becke, Björn Siegel

Research for the final disposal of high-level radioactive waste

Dr. Anne Eckhardt has dealt with the disposal of radioactive waste in various positions held in Switzerland – most recently as the Chair of the ENSI Board, Swiss Federal Nuclear Safety Inspectorate. She is the Deputy Spokesperson for the TRANSENS research project and Managing Director of risicare GmbH.

Megaproject: final storage

Storing high-level radioactive waste in a safe manner is an enormous project that takes decades to accomplish. From site selection to construction and operation to decommissioning of the repository, it requires a wide range of competencies. Many people are already making concrete, tangible contributions to this project. Site selection involves, for example, the modelling of radionuclide dispersion, the assessment of safety issues, and the sinking of boreholes. What role does research play in all this? Why is so much research being done on the repository at all, when it seems other 'projects of the century' such as new urban districts, transport, and energy infrastructures can make do without their own research programmes?

More than other large-scale projects, a repository for high-level radioactive waste has a pioneering character. One repository for high-level radioactive waste is being built in Germany. Internationally, there is only a handful of reference projects that can be looked to as role models – such as the repository in Finland or the site selection procedure in Switzerland. Expertise and experience can be drawn from mining or nuclear technology, for example, but many features of a repository for high-level radioactive waste are unique. One prominent example is the exceedingly high safety requirements: compliance with these must be demonstrated over a million years. At the same time, the repository project is exceptionally demanding and complex not only from a scientific and technological perspective; many difficult sociological questions also arise, which have to be answered against a background of differing values and interests of stakeholders, such as: When is the safety convincingly proven? How do we best meet the expectations of future generations?

Research is thus needed to answer specific questions that are unique to repositories and to clarify especially difficult questions that arise in connection with final disposal. In this context, different forms of research complement each other.

Useful and not-so-useful research?

Applied research focuses on those questions whose answers are directly related to the realisation of the repository project: How do you assess the earthquake hazard at a site? How could this hazard threaten the long-term safety of the repository? How do you communicate risks and uncertainties in a clear and comprehensible way? These are all essential contributions for the disposal of high-level radioactive waste on behalf of those involved in the repository project, in particular the project sponsor BGE.

Application-oriented basic research goes more into seeking its own questions. Because of this, at first glance, it may appear less efficient and solution-oriented than applied research. Yet, we are not talking about pure research here, which is done purely for the knowledge gain. "Application-oriented", in our context, means research questions are oriented towards actual, potential, or conceivable questions relating to disposal. In this way, application-oriented basic research represents a useful counterweight to applied research; it allows for changes in perspective and for diversity.

A current example is TRANSENS, the research project "Transdisciplinary research on the disposal of high-level radioactive waste in Germany" funded by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) and the Volkswagen Foundation. TRANSENS works largely independently of other actors in the site selection procedure, tests different approaches from those being pursued in the current repository project, and can thus bring suggestions and alternatives to the table that applied research does not have in its sights. TRANSENS will provide new insights into things like the monitoring of environmental radioactivity by citizens, self-organisation in citizen participation, and the interdisciplinary assessment of uncertainties. These findings shall enrich the discussion on final disposal and address a broad circle of stakeholders, including not only those directly involved in the repository project but also the interested public and the scientific community.

The shortest route between two points

In his epigrams, Erich Kästner mocked progress and science for making the discovery that "the detour is the shortest route between two points".

In fact, research, especially application-oriented research that is expected to or wants to advance a megaproject like final disposal, does not always take the direct route. Sometimes it finds an answer that raises several new questions at the same time. Sometimes it calls long-held beliefs into question and thus necessitates arduous responses and changes of direction. It antagonises, doubts, and errs. And not infrequently, it so happens that the supposed detour reveals a previously unknown shortcut.

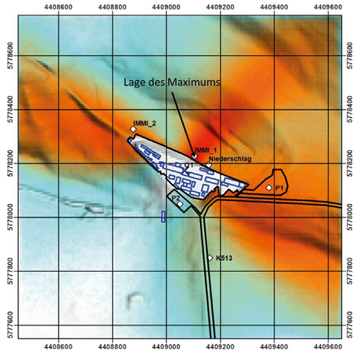
Be it a shortcut, a planned route, or a detour – on the path to a safe repository for high-level radioactive waste, the knowledge, experience, and willingness to experiment are indispensable. Only by including diverse competencies and opinions, by (self-)critical questioning, by open-ended experimentation, and by lively discussions can it be convincingly demonstrated that we are in fact seeking or creating the best possible repository.

Research offers young people a chance to try things out at the cutting edge of science and technology, to gain experience and deepen their knowledge. The project of a final repository for high-level radioactive waste in Germany holds particularly interesting questions, among other things because of the long time dimension, the exceptionally high safety requirements, and the complexity of the questions that can only be answered when there is collaboration between different scientific fields and new research approaches such as transdisciplinarity. Fascinating questions motivate young entrants and open-minded career changers to look deeper into the issue of disposing of high-level radioactive waste.

In this way, research directly promotes what the repository project needs most: well-trained, committed people who will drive the final disposal megaproject forward in the coming decades and ultimately bring it to its goal.

Guaranteeing the best possible safety

BGE has the mandate to put radioactive waste safely underground. One of the most important goals in the construction and operation of a repository is protecting against the dangers of ionising radiation. For this, there are nuclear and radiation protection regulations that must be complied with. It is important to protect the population, the environment and, of course, one's own employees.



Dispersion simulation for radioactive substances with the diffuser emission point at the Asse 2 mine shaft

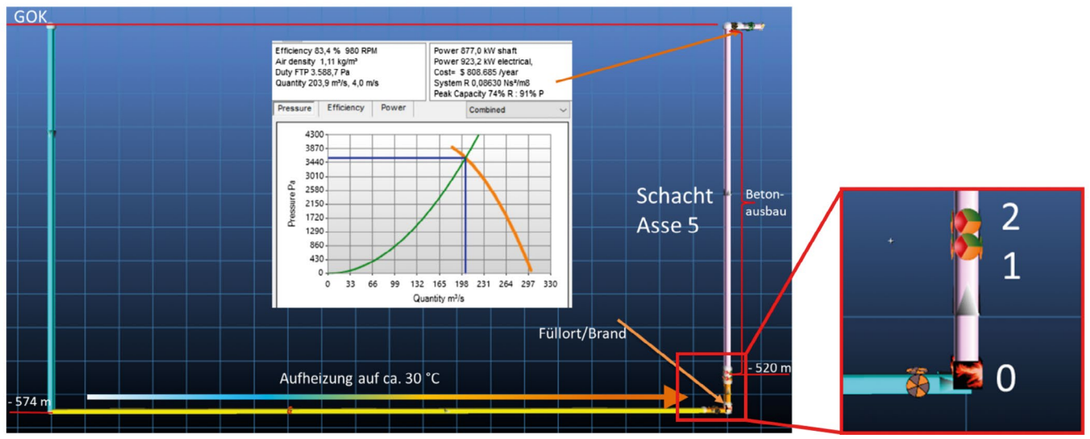
To guarantee compliance with the protection goals, there is a group at BGE for each site that deals with safety analyses. Another department, Repository Safety, also works across projects at all sites and additionally facilitates the technical exchange of experience. What exactly is a safety analysis? It looks closely at factors that can influence safety in any way. These could be problems of a mining or of a nuclear nature. The aim is always to guarantee the best possible safety.

Safety analyses accompany every project. Without them, nothing works. A project can only be approved once it has been proven to be safe.

What questions are considered in safety analyses? One thing is for sure: they are extremely diverse. On the one hand, they relate to occupational safety. This includes classic topics such as fire, explosion, and radiation protection. On the other hand, there is repository safety, where the focus is on topics such as the integrity and stability of mine buildings or the long-term safety of facilities with regard to radiation protection for the population. Potential accidents and precautionary measures are also considered.

Another thing is external impacts: in this respect, issues such as plant safety, aircraft crashes, or earthquakes are given importance.

Just how complex and extensive these safety analyses can be is illustrated by the example of the Asse II mine. In this particular case, the law has mandated that the radioactive waste in it be retrieved – which throws up a plethora of difficult questions.



Simulation of fire in the Asse 5 shaft filling site, in the area of the 574 m level

Firstly, it has to be proven under mining law that the existing mine workings and the new Asse 5 shaft are stable. Secondly, it must be demonstrated that radiation protection for the personnel and the population will be complied with during all sub-steps of the retrieval project.

What processes could result in the release of radioactive substances? How can this be technically prevented? How can the effects be limited, and how can it be monitored that the limit values are complied with? How can the dose of an individual member of the population be measured? These few examples hint at just how complex a safety analysis can be. Many steps are required to calculate the dose received by a single member of the public. After an underground leak of radioactive substances in a controlled area, the radioactivity is first contained by safety systems such as staggered airlocks and exhaust air filter systems. However, if radioactivity still escapes through the exhaust stack, dispersion simulations accounting for climate data (wind direction, wind strength, precipitation) and terrain conditions show where the point of worst impact would be.

Then, the maximum effective dose that an individual could receive is calculated from the type and quantity of the escaped radioactive substances, together with their dispersion behaviour. As the last step of the safety analysis, this exposure can then be compared with the legal limits.

In addition to the safety analyses for the project to retrieve radioactive waste from the Asse II mine, safety considerations are also being made as to a potential beyond-design-basis influx of solution and its consequences. Thus, the long-term consequences of flooding in the mine, should some or all of the radioactive waste remain in the mine workings, are also being considered and specific measures taken to limit the effects in such an event.

All of these safety analyses are thus not only a necessary part of the legal requirements, but sometimes yield surprising findings and play an important role in ensuring that employees at the various BGE sites, as well as the general public, are adequately protected against all possible hazards associated with repositories. (gg/ms)

Knowing what we don't know

Research into uncertainties and their influence on site safety

So far, Germany doesn't have a final repository for high-level radioactive waste, and the search for a site for one is in full swing. In fact, there still isn't a completed and operational repository anywhere in the world.

In trying to find the safest possible site, analyses are currently being carried out for various sub-areas throughout Germany. In evaluating these areas, analogies are being drawn, geoscientific models are being applied, and the corresponding data are being interpreted. Given the enormity of all this, assumptions are also having to be made, and these are fraught with uncertainties. For example, the properties of rocks many hundreds of metres below the earth's surface depend on many factors and therefore often cannot be precisely quantified with a single numerical value. So, ranges (from... to...) are used instead. Such uncertainties can then have an impact, for example, on model simulations done for preliminary safety assessments. In the search for the best possible site for a repository for high-level radioactive waste in Germany, it is therefore important

- to systematically identify and characterise these uncertainties,
- to document how they can be dealt with and how they impact the informative value of preliminary safety assessments and the reliability of safety-oriented investigations,
- to show whether and to what extent they can be reduced by further exploration, research, and development measures.

These binding requirements are laid down in Section 11 of the Ordinance on repository safety assessments (EndlSiUntV). In addition to the aspects listed above, one of the tasks of BGE is to communicate with the public about such uncertainties. In order to identify them, learn to deal with them, and minimise them as much as possible, many different aspects are being investigated in scientific research projects. One of these is the cluster project "Uncertainties and robustness with regard to the safety of a repository for high-level radioactive waste" (URS), in which a total of six research clusters are working together:

- In the cluster "Risk-based assessment of salt domes as disposal sites for nuclear waste", a numerical framework is to be developed. This is to be used to predict events that are detrimental to repository safety, such as the leaking of radioactive materials.
- In the cluster "Uncertainties in THM-coupled integrity calculations", quantification methods are being developed for calculating uncertainties in integrity analyses of geological barriers. THM stands for thermal–hydraulic–mechanical. This considers, for example, things like the effects of rock expansion due to the heat generated by radioactive decay.
- In the cluster "Repository safety: uncertainties and regulatory aspects", recommendations are to be developed for the implementation and communication of safety assessments – as an examination of how the human factor comes in. Accordingly, this research cluster also has a pivotal function for the other research clusters.
- In the cluster "Reduction of scenario uncertainties through climate models", various scenarios for climatic development in Germany are to be developed. This looks not only at uncertainties in climate change but also, on a geological scale, the glaciation of Germany and its effects on a deep geological repository in Germany.
- In the cluster "Improvement of the predictive quality of repository-relevant simulations through optimal data acquisition and smart monitoring", methods for predicting parameters and optimising the acquisition of measurement and observational data for use in modelling are to be further developed. The primary intention is to optimise experimental data collection.
- In the cluster "Building blocks for the quantification of uncertainties in geological models", methods are being derived to allow the quantification of uncertainties in geological models in the context of the repository site search. To achieve this, artificial datasets are being created to systematically analyse the effects of new input data and different modelling approaches in a controllable environment.

In these six research clusters, universities and research institutes as well as the Federal Institute for Geosciences and Natural Resources (BGR) and the Gesellschaft für Anlagen und Reaktorsicherheit gGmbH (GRS) are working to develop various solutions for dealing with uncertainties. In doing so, they are not only working at the state of the art in research, but also advancing it. Through the involvement of doctoral students, a total of up to 13 doctoral theses are expected to emerge from the project. (an)

Project overview

Title: Uncertainties and robustness with regard to the safety of a repository for high-level radioactive waste (URS)
Duration: from 2022 until 2025
Funding volume: about 6 million euros
Project partners by cluster:
(1) Leibniz University Hannover;
(2) Freiberg University of Mining and Technology, Chemnitz University of Technology, Helmholtz Centre for Environmental Research GmbH, Federal Institute for Geosciences and Natural Resources (BGR);
(3) Clausthal University of Technology, University of Kassel;
(4) Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH, Potsdam Institute for Climate Impact Research;
(5) RWTH Aachen, University of Stuttgart;
(6) RWTH Aachen, University of Aberdeen, BGR
Aim: to increase the state of knowledge regarding uncertainties and to develop methods for dealing with uncertainties in order to improve the robustness and thus the safety of a repository for high-level radioactive waste.

Bundle, model, understand

The OpenWorkFlow data synthesis platform

Finding the site in Germany that offers the best possible safety for the final disposal of high-level radioactive waste for a million years – that is one of the goals pursued by BGE, the federal company for radioactive waste disposal. In doing so, many requirements must be met, which are stipulated by the Site Selection Act (StandAG), the Ordinance on Repository Safety Requirements (EndlSiAnfV), and the Ordinance on Repository Safety Assessments (EndlSiUntV).

During the search for a repository, the safety of each area looked at is thoroughly investigated with many so-called preliminary safety assessments. In the site selection procedure, these are carried out three times, each at increasing complexity. One aspect of these assessments is making quantitative, safety-oriented evaluations of the potential sites. To support the preliminary safety assessments, a system analysis platform is being developed at the Helmholtz Centre for Environmental Research (UFZ) in Leipzig and at Freiberg University of Mining and Technology (TUBAF) as part of the OpenWorkFlow project (OWF). This platform can be used to bundle data, models, process descriptions, and – based on these – estimates of the long-term safety of a repository system in its geological context. The culmination will be complete, quality-tested workflows for the preliminary safety assessments, which will guarantee a seamless flow of data and information as well as the interpretability of the simulations, especially for the more complex preliminary safety assessments.

The platform is based on the open source software OpenGeoSys (OGS), which is well established in the geoscientific community and at universities and is being continuously developed by the UFZ. This software can be used to carry out numerical simulations of thermal–hydraulic–mechanical–chemical (THMC) processes in porous and fractured media such as rock or artificial geotechnical barriers. It is essential to consider these processes in combination because each process influences the other. For example, temperature has an influence on the properties that control hydrogeological transport behaviour. To make this feasible, OGS relies on the finite element method, which reduces the complex, real-world environment to a calculable set of individual elements. The programme can then be used to carry out various simulations in which changes in individual variables can be targetedly investigated. These could be, for example, the mechanical behaviour of geological units such as the host rock that is to safely contain the radioactive waste, or the simulation of groundwater flows, or the heat distribution in the subsurface. But it is also possible to carry out a simulation that combines all of these at once.

For use in site selection, OGS is being developed further to meet the special challenges of the safety assessments. This includes, for example, the consideration of all relevant flow and transport processes in repository systems. This must account, at various levels of complexity, for things like multiphase flows with phase changes – where an aggregate state changes between liquid and gas – in media that have pores and are deformable under pressure.

For verifying the integrity of geological and geotechnical barriers, focus is on advancing the mechanics or, more specifically, coupling mechanical processes with other processes. One example is coupling the heat generation due to the radioactive decay of the waste. The heat generated by the radiation causes the surrounding rock to expand. This in turn can lead to changes in the mechanical stresses, which can create expansion gaps and cracks in the so-called near field – the space within a few metres surrounding the repository.

The OWF project will provide a comprehensive and efficient system analysis platform along with extensive documentation. Other aspects being taken into account are the robustness and efficiency of the workflows, including a certain amount of workflow automation. This applies, for example, to the preparation of structural models for numerical simulation with visually supporting analytical methods using virtual reality concepts. Above all, however, this platform addresses all the requirements of StandAG as well as EndlSiAnfV and EndlSiUntV in the context of preliminary safety assessments. The open-source nature of the project plays a special role here. For one thing, it ensures continuity in development, and for another, it enables the greatest possible transparency and traceability. Thus, the internal quality assurance will be complemented by constant, independent, and scientific quality control (in the form of peer review), for example with international benchmarking initiatives. In addition, the platform and all documentation will be published in the spirit of open source. In this way, anyone who is interested can carry out repository safety simulations or look at existing simulation results for themselves. (an)

Project overview

Title: Synthesis platform for safety assessment in the site selection procedure (OpenWorkFlow)
Duration: from 7/2021 until 12/2024
Funding volume: just under 5 million euros
Project partners: Helmholtz Centre for Environmental Research, Freiberg University of Mining and Technology
Aim: a unified platform to bring together different data and models and make them accessible to all interested parties.

Learning from the past: Erosion in Germany's future

Quantification and prediction of erosion processes in Germany

The repository for high-level radioactive waste that BGE will build and operate must provide safety for the period of one million years. Such a long period of time is far beyond everyday human experience; even agriculture and animal husbandry are "only" about 12,000 years old. To help find the best possible repository site in the coming years, the project "Quantification and prediction of erosion processes in Germany" takes a look into the past:

Various methods are used to trace how erosion has changed the landscape over the past ten million years and in greater detail over the past one million years. Based on these findings, computer models can simulate the effects of certain factors to find out how they led to the appearance of regions today. These factors influence how the land erodes and so how the landscape develops. They include, for example, the resistance of rocks to erosion, climatic factors, the reorganisation of river networks, and the large-scale uplift or subsidence of the earth's surface.

All of these factors act simultaneously and influence each other to varying degrees, depending on the location. By varying the factors thousands of times in repeated model simulations on the computer, it is possible to determine which combinations led up to a landscape that most closely resembles the real landscape in its current form. This knowledge can then be extrapolated to simulate many different future scenarios and their effects on the safety of a repository system.

Safety is only given if the radionuclides – i.e. the particles that emit radiation – remain safely contained for at least one million years. The effective containment zone (ECZ) must not lose its barrier function over the entire period of proof. However, various natural processes can weaken the barrier function of the underground rock layers if, for example, the rock becomes more permeable or less thick. This can happen if erosion processes wear down the overburden, the upper layers of earth that overlie the rocks in which the repository is built. Not only does this bring the stored waste closer to the surface, but the loss of pressure from above can also allow the rock as a whole to expand, resulting in cracks or expansion gaps (decompaction). Such erosion processes can begin or intensify, for example, when the earth's surface itself rises or when less vegetation protects the soil surface from erosion due to climatic changes. Changes in the equilibrium state of the drainage system due to river tapping and river reversal can also lead to a sharp increase in linear erosion (fluviatile deepening): the river cuts deep into the earth in a relatively confined space. Such reorganisations in river networks can even occur in relatively short periods of time (less than a million years). This can lead to a sharp increase in linear erosion and denudation, i.e. large-scale erosion of the earth's surface and potential exposure of the repository.

Information on such erosion and landscape development processes in Germany is so far only available to a limited extent in the form of regional studies. In this research project, the available data on relevant processes and rates of erosion over the last one to ten million years will be compiled and discussed, and maps will be created. The resulting extrapolations over the next one million years should then form the technical basis for BGE to define the site-specific depth requirements of the ECZ relative to the terrain surface. Also, areas that could potentially be affected by decompaction of the rock mass are to be identified. In order to model erosion processes, the landscape evolution model needs to be fed information on how the rocks of the subsurface were exposed by erosion processes in the past. This information will be provided by two different measurement methods: collecting thermochronological data for long periods of time, and quantifying cosmogenic nuclides for the recent past.

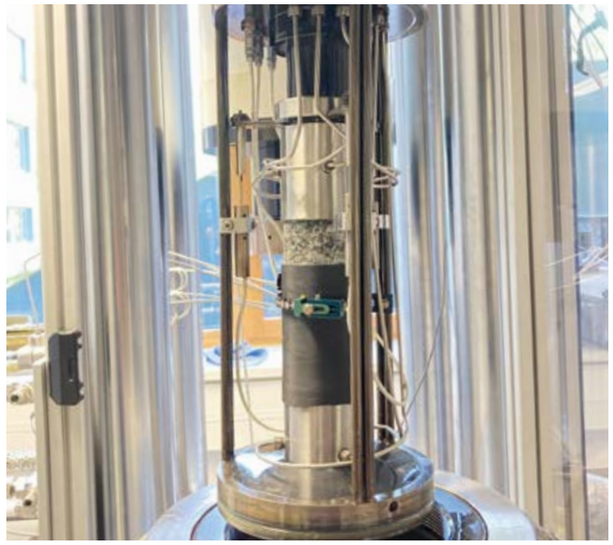
The first method exploits the fact that temperature increases at great depths – by about 30 °C per kilometre – and that rocks have their own, natural radioactivity. When uranium decays, fission products such as helium are formed in certain minerals of the rock. In addition, cracks form in the crystal lattice of the mineral, which grow in numbers at low rock temperatures of less than 60 or 110 °C, depending on the mineral. At higher temperatures, these cracks would close again and the helium would escape from the mineral. Since the rate at which the fission products are formed is known, it is possible to calculate how long a rock has stayed at a relatively cool temperature by measuring the uranium content and counting the cracks. Knowing that the temperature increases underground, the temperature information can be converted to depth information and the path of the rock from deep down to the earth's surface can be reconstructed.

The second method makes use of cosmic radiation, which produces certain beryllium isotopes with a half-life of 1.51 million years down to a depth of 60 cm in the ground. By measuring the quantity of this isotope, it can be calculated how long the ground layers have been exposed and at what rate the earth's surface is being eroded.

All this data is then used to run computer simulations that model how the landscape changed from one million years ago to the landscape we know today. Running the simulation further, we can then make predictions for the next million years, where specific factors such as climatic influences can also be adjusted in the models. Exactly how the climate will change over geological periods of time is not certain. For example, we do not know whether there will be any more ice ages – and if so, how many – or whether a temperate climate will continue to prevail in Germany. By researching the erosion processes and with the help of modelling in this project, simulations can be made for very different scenarios. This will help allow a better assessment of the safety of the future repository over the very long periods of geological time. (an)

Project overview

Title: Quantification and prediction of erosion processes in Germany
Duration: from 2022 until 2023
Funding volume: about 1.15 million euros
Project partner: University of Tübingen
Aim: area-wide quantification of erosion rates in Germany since the Miocene. Various analytical methods will be used to represent erosion processes over different time scales.



Such rock samples – whether from stock or newly taken – are tested for their behaviour under high pressures.

A profile of crystalline host rocks

A detailed description of magmatic and metamorphic German rocks

At this stage in the site selection procedure, slightly more than half of Germany's surface area remains to be investigated. Crystalline host rocks are found on one third of this area. The project "Atlas of mineralogical and petrophysical properties of German crystalline host rocks (AMPEDEK)" is creating a database that will provide an exhaustive overview of rock properties. The investigation is limited to the igneous (e.g. granites, granodiorites, gabbros, and diorites) and metamorphic rocks (e.g. ortho- and paragneisses, amphibolites, and granulites), which are most frequently represented in Germany.

As the initial rough delimitation for the Sub-Areas Interim Report, the areas were assessed on the basis of existing data. However, this also revealed that in some areas there is not enough information available or the quality is not sufficient to make a proper assessment. In such cases, reference data sets for crystalline rocks were used. These represent a collection of known properties that can be referred to and which describe a normal state. In a generic approach, it was assumed that a potential emplacement area or effective containment zone could be identified in each of the large-scale subareas, in the crystalline host rock in a homogeneous crystalline rock body with little or no fracturing.

For further delimitation, all available information on the properties of the crystalline host rocks is now being collected. There are existing databases covering rock types from all over the world. However, important detailed information about the rocks occurring in Germany is lacking. This project focuses more on the specific needs of BGE and will thus help to make an initial assessment of subsurface rock properties.

When going through the existing data collections, such as scientific literature, public reports from industry and authorities, or unpublished data, special attention must be paid to the quality of the measurement results. This will be complemented by new rock sampling campaigns and new laboratory experiments. At the end of the project in four years, about twice as much data will be available as at the beginning.

Specifically, the chemical and physical properties of rocks are being studied, such as their chemical and mineralogical composition, density, porosity, and gas or liquid permeability. Thermal properties such as the ability to conduct and store heat are also being taken into account. In addition, the mechanical properties of rocks are being tested; for example, how does a rock behave when it is subjected to a compressive or upsetting force? In this case, special apparatuses are being used that can reproduce the pressure and temperature to which the samples are exposed.

In this way, even conditions at great depths in the earth's crust can be replicated. All this information is associated with a specific rock type based on the mineral composition. Thanks to the diversity of samples, the collection will allow representative inferences to be made.

With the AMPEDEK database, all information about the crystalline host rocks will be digitally available and complemented by relevant meta-information for each measured value, such as the sampling location and the age of the rock-bearing layer, among other things. In addition, information about the procedure and execution of the measurements will be included.

A second, indirect, result of this project is the preparation and presentation of a distribution of physical parameters on a local to regional scale on a 2D map.

The compilation and aggregation of all this data will allow for better planning of necessary future explorations. With more information, it will also be possible to make more accurate and realistic models of areas. A better understanding of the different crystalline rocks and their physical properties will also be made possible by this database. Inferences about the suitability or unsuitability of different rocks will become possible, as will the evaluation of differences in the same type of rock from different regions. Not only will this help BGE in making an initial assessment of the underground rock properties in the further course of the site selection procedure; the results and the experiences gained in building the database will also be published in relevant scientific journals as well as open access platforms. (an)

Project overview

Title: Atlas of mineralogical and petrophysical properties of German crystalline host rocks (AMPEDEK)
Duration: from 2021 until 2023 (possibly 2025)
Funding volume: about 208,600 euros
Project partner: Darmstadt University of Technology
Aim: a functional database in which petrophysical, mineralogical, mechanical and thermophysical data for crystalline host rocks in Germany are available.

Bringing light into the darkness – Exploring the Asse mine

An interview with Dr. Ralf Holländer

The decommissioning of the Asse II mine is the legal mandate of BGE. This is to take place after the radioactive waste has been retrieved. Both of these processes will have to have extensive planning and licensing steps with complex verification procedures completed beforehand. What does this require? First of all, a reliable and comprehensible data basis. Because only then is it possible to understand and explain the geological and hydrogeological knowledge.

The 3D seismic surveys that BGE initiated between 2019 and 2020 represent an important building block. They served to obtain reliable data on the structure of the overburden and the geological structure of the Asse mountain range. This is an important step along the way to retrieving the radioactive waste. Only with the help of the data obtained can the planning and subsequently also the licensing documents for retrieval and subsequent decommissioning be drawn up with the necessary precision. In addition, there have been several surface and underground (exploratory) drillings, and there are more to come. Why does more exploration have to be done? Dr. Ralf Holländer provides information about this. He is head of the geology group and has been employed by BGE since 2019. The 53-year-old geologist has more than 20 years of professional experience in a German potash and rock salt mining company.

Why do we need to explore at all? And what other explorations are planned?

Ralf Holländer: Because the data situation for Asse has been classified as insufficient and/or not very reliable in the past, the aim of exploration is to improve the starting situation for the upcoming planning and licensing steps for the various tasks in BGE. And we want to ensure safe operation. This applies to emergency preparedness, retrieval and decommissioning, equally. Notwithstanding this, the more recent explorations to the east of the Asse II mine have already shown that the geological picture of the underground of Asse is more complex than previously assumed.

Now that we have obtained a good picture of the situation in the overburden and the location of the salt envelope from the 3D seismic surveys, we will be drilling boreholes primarily from the surface, but also from underground. The planned borehole surveys will further consolidate the database, and the cores obtained will offer even more laboratory data.

How many boreholes are planned in total and where will they be drilled?

At present, we are in the process of coordinating with the colleagues involved in retrieval planning, emergency planning, and long-term safety to determine what further geological information we need as a basis for planning for the next respective tasks. Then we will determine drill approach and target points based on the findings from the 3D seismic surveys. A number is difficult to determine – roughly speaking: probably more than one, but certainly less than ten. At present, the focus is on underground exploration to the east of the Asse II mine, where the retrieval mine is to be built, including the new shaft through which the radioactive waste will later be retrieved to the surface. But also in the central area of the asbestos structure as well as underground, there are still unanswered questions that need to be clarified and assumptions that need to be justified.

Dr. Ralf Holländer

We read everywhere about R10, R11, R15, or R18. What does the "R" stand for?

The "R" stands for the town of Remlingen. Historically, exploratory wells would be named typically after the next largest town in the area. This naming convention is used to this day for the deep boreholes, and the counting continues. In daily use, rather than always saying the full name "Remlingen", we just use the abbreviation "R".

Like 3D seismics, boreholes also serve for developing the geological model of the geology of the Asse salt dome. What else can BGE learn from drilling?

The drillings primarily serve to obtain information – rock-solid findings, we geologists might say – and to determine the site-specific properties of the rocks. Appropriate measurement methods in the borehole and in the laboratory can be used to determine hydrogeological, geomechanical, geochemical, and mineralogical parameters. This knowledge is incorporated in combination with the geometric and structural geological information from the 3D seismics into the various models. Based on the model calculations, inferences can be drawn for the various safety considerations within the framework of the verification and licensing procedures for retrieval and decommissioning.

For example, 3D seismic surveys provide us with information on the spatial location and course of layers and faults. By doing targeted drilling and making corresponding borehole measurements and core examinations, we then know concrete properties about these elements, for example, their permeability and other characteristics. In the next step, conclusions can be drawn about the transport of groundwater and other substances, e.g. how fast the transport takes place, and what happens to the rock or groundwater during this transport.

Who carries out the drillings? And what are the immediate effects on nature?

The drillings are carried out by specialised drilling companies – steered by BGE. The aim is to drill the boreholes safely and with as much knowledge as possible. One thing must be clear: In the end, it is of no use if we have produced a deep hole but the investigation programme has fallen by the wayside. In this respect, it is important to develop a common understanding of the exploration task at hand.

As far as the impact on the environment is concerned, we try to keep the influence as low as possible, since in most cases we are operating in a protected area. In the run-up to the approvals, environmental assessments are prepared and the

nature and scope of them are agreed with the approving authorities. As part of the approval process for drilling, it is specified in great detail how the drilling site is to be set up and how it is to be renatured afterwards. The permits specify what substances may be used at the drilling site and in the borehole. The work is also overseen by ecological monitoring.

This year's annual report is all about research and development. Do the exploration measures also fall into this spectrum?

Research and development is above all about establishing a scientific basis or about developing new procedures that can then be translated into standard procedures. Our task in drilling is to fill knowledge gaps reliably with the help of proven procedures according to the state of the art. We refer to this as exploration. To do this, we measure and test in the borehole as comprehensively as possible in order to maximise the knowledge gain. But we may very well also use methods that are not yet standard or whose practical suitability we are only just now proving. Also, we try to break new ground in the evaluation of data and to make our data available for people doing their master's theses and research. So there are indeed several bridges to research and development.

Finally, a word about 3D seismic surveying. What happens with the data obtained from it? And when can you report more on this?

The 3D seismic surveys have generated a data set that is unique in terms of its resolution, and which is currently being processed in multi-stage calculations so that it can serve as the basis for 3D modelling of the geological overburden of the Asse range.

The goal is to combine the models of the overburden and the repository, i.e. the folded layers in the salt dome itself, into an overall 3D geological model of the Asse salt dome by the end of the year. This model will then serve as the basis for a variety of tasks in the context of retrieval, emergency planning, and decommissioning. These tasks are, for example, groundwater flow models that require concrete geometry of the overburden layers, or geomechanical models that enable stability simulations based on the geological structures. The retrieval planners also get important information on the geological structure. This information is needed for planning the underground cavity, for determining the starting point of the Asse 5 shaft, and for sinking the shaft.

Interviewed by Martina Schwaldat (ms)

"The goal is to combine the models of the overburden and the repository, i.e. the folded layers in the salt dome itself, into an overall 3D geological model of the Asse salt dome by the end of the year."

Asse mine: A new device for measuring flow rate, density, and temperature at the main intake point on the 658 m level

At the Morsleben repository, it’s all about decommissioning

Research call sent out for a demonstration structure

The Morsleben repository stores almost 37,000 cubic metres of low- and intermediate-level radioactive waste. It is the first German repository set to be decommissioned under nuclear law. The extensive decommissioning concept shows there is much to be done to accomplish this. After all, the measures have to work together for a long time to come.

The decommissioning concept envisages four central measures: extensive backfilling of the mine, the construction of sealing structures in drifts, the sealing of underground boreholes, and the closure of the Marie and Bartensleben shafts. This is accompanied by extensive investigation programmes that must provide both computational assessments and structural engineering evidence in favour of the planned measures.

The common aim of all the measures is to isolate the radioactive waste and thus keep it away from the environment in the long term.

The extensive backfilling of the mine is intended to protect the repository and the overlying rock from deformation and thus reduce the risk of water ingress. The shaft seals are to ensure that no relevant quantities of solution can penetrate the repository for long periods of time via this route, and that no potentially existing gas or solutions can escape.

The objective is: the drift seals in the rock salt and anhydrite should impede any movements of solution or gas. This applies both into and out of the waste storage areas. The sealing of underground safety-relevant boreholes has the same objective.

For the development of drift seals, a separate development project for a sealing structure made of mass concrete in rock salt has already been running on the 2nd level of the Bartensleben mine since 2010. The question here is: is it feasible to produce a structure from salt concrete that is quality-assured and fully functional?

The results: a highly impermeable seal can be built. However, it also became clear that there is a need for further adaptation in the selection and placement of the building material. As the salt concrete that had been used set, unintended cracks had formed in the structure. As a result, corrosion processes would have to be expected along the cracks if these cement-based building materials ever came into contact with solution. These processes could have an impact on the long-term impermeability.

To increase the reliability of predicting the properties of the drift seals, the expected solution composition in the mine areas of the drift seals was assessed in more detail. Which building materials are more resistant to corrosion? These currently include magnesia construction materials as well as bitumen, possibly with aggregates in the form of asphalt. Production technologies that come into question are mass concrete and shotcrete.

Morsleben repository: View from the excavated, 40 m long drift for the demonstration structure before re-cutting the contour

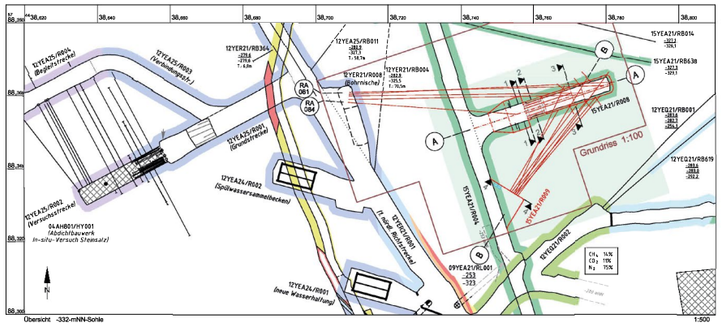
This much is already certain: drift seals in the anhydrite rock will consist of multiple segments. In a sketch developed by BGE, these sealing segments consist of magnesia construction material in the form of mass concrete and/or shotcrete as well as bitumen/asphalt. The final arrangement of the components and design of this sealing system has not yet been decided. The properties of a sealing system made of magnesia construction material in the form of mass concrete are being investigated at a demonstration structure in the Morsleben repository.

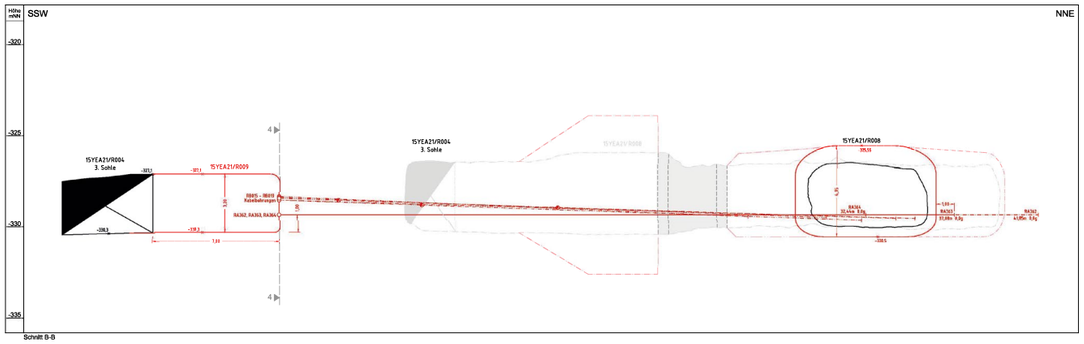
For the technological details and determining the properties of a seal made of shotcrete and of bitumen/asphalt, BGE currently has research and development projects underway for such a demonstration structure. Partners from science and research are being sought for this. Their task would be to develop one or more demonstration structures for drift sealing segments in the anhydrite rock, made of shotcrete and bitumen/asphalt. The construction components will be erected in other salt mines. The advantage is that this work will run simultaneously to BGE’s own development activities for mass concrete.

With the research results, BGE will build up fundamental knowledge about the suitability and applicability of magnesia construction materials in the form of shotcrete in combination with bitumen or asphalt. The focus here is on the connection of the building materials to the rock and thus on evaluating their sealing effect shortly after construction. In the case of anhydrite rock, unlike salt rock, there are no creep properties to support the sealing effect. The contact surface between rock and backfill material must therefore be as tight as possible from the outset.

Morsleben:
Demonstration structure
"Drift seal segment with abutment made of magnesia construction material in the main anhydrite" –332 mNN level

Planning of drift drivages and drillings





Further questions of the research and development project entitled "Demonstration structure for drift sealing in anhydrite made of magnesia construction material in the form of shotcrete and bitumen/asphalt (DeSpriBi)" are: How can individual segments be optimally positioned in the drift seal? What about the manageability of bitumen concepts for construction in the mine?

Dr. Antje Carstensen

Geologist Dr. Antje Carstensen, responsible for the planning of the decommissioning measures, knows the repository like the back of her hand: "We have been observing the development of magnesia construction materials in the field of R&D for many years and have a very good level of knowledge at BGE due to the planning of the precautionary measures at Asse. We are also well positioned with knowledge about bitumen for our shaft closures. Thus we expect that, for the anhydrite rock as well, the best possible sealing effect with a high level of robustness will be achieved by appropriately introducing an optimal combination of sealing elements with different construction material properties."

Carstensen continues, "People often ask how we even get the idea of building a drift seal in anhydrite, anyway, saying it's not very clever. That's true, but our emplacement area in the East Field is where it is, and is connected to the rest of the mine via two drifts. One of those drifts happens to be 100% in anhydrite. So we have to deal with that and build an optimal seal."

The project plans call for the main work on the demonstration structures to be completed by the end of 2024. By then, the project partners should have evaluated and documented the tests. The results will be incorporated into the revision of the planning documents for the decommissioning of the Morsleben repository. In 2026, BGE will submit the final revised planning documents to the licensing authority.

Where the demonstration structure(s) of the R&D project will actually be built has not yet been determined. What is clear is that the site needs to be selected in such a way that the results are transferable to the Morsleben repository. (ms)

What a luggage scanner has to do with radioactive waste

Looking at the construction site at the Konrad mine, you can see: Work is going on everywhere, great strides are being made, many cranes are in motion. Everyone has their sights set firmly on the goal – namely, to get the storage of non-heat-generating radioactive waste started in 2027.

It is not only the construction and operation of repositories themselves that have to satisfy high demands. The same goes for the waste packages that are to be stored there. For the Konrad mine, we are talking about a total of 303,000 cubic metres of non-heat-generating radioactive waste. This waste is left over, among other things, from the dismantling of decommissioned nuclear power plants used for industry or research.

BGE's Product Control department is responsible for ensuring that this nuclear waste is stored in safe and specially designed containers. The requirements that the containers must fulfil are set out in the Conditions for Final Storage. These are part of the licence for the Konrad repository. Ultimately, the experts from Product Control check to ensure everything is safely packed.

And work is already being done on this. One of the conditions for the final storage of waste, as a fundamental requirement, is that only waste that contains less than one percent of its volume in free liquids may be stored. For a 200 litre waste drum, for example, this means that it must contain less than two litres of liquid.

One of the product control experts, Dr. Stefan Thränert, explains: "One must not confuse this requirement with the concept of residual moisture. The product itself does not have to be completely dry. The point is that the product stored in the containers must not release any liquid into its environment." His colleague Dr. Matthias Reiners likens this to a sponge: "The sponge itself can be moist, but it is not allowed to lose any of that moisture or liquid."

So, how big of an issue is this for storing waste? Not especially big, say the two experts, and describe the problem as more academic than real. But there is one real-world situation where it is more of an issue. In the operation of nuclear power plants, so-called ion-exchange resins are used for treating the water. These clean the water radiologically and then have to be disposed of and stored as radioactive waste. Old ion-exchange resins in particular are known to sometimes no longer be able to hold the water in them, and instead release it into the environment. The question is, how can it be ensured that the resins contained in the waste containers – especially after long interim storage – will actually not release any liquid, i.e. that the ion-exchange resins ultimately remain intact?

To answer this, the experts of BGE, together with TÜV Süd, investigated the question of whether and how it is possible to determine the content of free liquids in containers after very long interim storage, without necessarily having to open them. In this way, BGE is also laying the groundwork for all wastes subject to mandatory surrender, given that proof of the free liquid content must be furnished again after long periods of interim storage. BGE is working on finalising a strategy on how such proof can be furnished. The solution is as amazing as it is simple: Using digital radiography – a kind of computer-assisted X-ray machine much like a luggage scanner – it is possible to check whether and how much liquid is present inside a container. Stefan Thränert explains, "Anyone who has been through a baggage check at the airport knows the procedure! The suitcases are screened and if something conspicuous is seen, it is opened."

It works the same way with the containers. They are placed on a kind of turntable, and moved in all directions to detect any liquid that may be present. If there is anything conspicuous, they are opened, the liquid is drained and then they are closed again. That's it for the theory. The procedure has also been tested in practice already. Together with Radiochemistry Munich, a business unit of the Technical University of Munich, and TÜV Süd, a random sample of 48 containers from a batch of 1,000 drums from the Mitterteich interim storage facility in Bavaria was tested. Stefan Thränert gives the following explanation as to why not all the drums are tested: "We always have to weigh up the safety concerns while doing this, as well! The radiation exposure should not be underestimated. That's why only spot checks are being carried out for the time being."

The project will be completed in the course of 2022. Testing of the drums has since finished. The task now is to determine the quantities of so-called free liquids present. Inferences will also be drawn from the spot sample about the entire batch of drums after their long term in interim storage. A small portion of the sample – namely 3 drums among the sample of 48 drums – were drilled, drained and sealed again in a qualified manner. These three drums are sufficient to calibrate the measuring system with the quantities of liquid measured. Subsequently, the amount of liquid in each of the remaining 45 drums can be determined directly from the available radiographs, and a concrete need for action can then be derived.

Once the investigations are complete, the drums will be transported back to the interim storage facility and then wait to be packed into containers and transported to the Konrad repository. (ms)

Research & development as a supporting pillar

Dr. Thilo von Berlepsch, Managing Director, and Philipp Herold, Division Manager Repository Technology, both BGE TECHNOLOGY GmbH

The work of BGE TECHNOLOGY GmbH is divided into the main focal areas of repository technology, numerics, and geotechnical barriers. Together, these areas cover the knowledge that the company requires for dealing with the many, often highly specialised tasks in the field of final disposal of radioactive materials. The tasks range from the planning to the closure of repositories, and are not limited to mine-based repositories in deep geological formations with different host rocks, but also tackle questions of boundary conditions that necessitate solutions other than those that are being pursued in Germany.

The Department of Repository Technology, like the other departments, generates knowledge and skills through research and development projects and develops them to application maturity. Accordingly, the activities span across all project phases from the conception, planning, construction, and operation of repositories for radioactive waste to the closure of repositories. Developing and participating in research projects is therefore an elementary pillar of the division. Managing Director Dr. Thilo von Berlepsch and Repository Technology Division Manager Philipp Herold talk about the main research areas in which BGE TECHNOLOGY GmbH is involved, which host rocks it focuses on, and how it gets into contact with its national and international customers.

How does BGE TECHNOLOGY get its orders? How do you approach your customers?

Dr. Thilo von Berlepsch (TvB): On the one hand, we are very well networked in the community and follow national and international events very closely. And we regularly publish information about the topics that are currently on our minds. Our newsletter, which appears four times a year, is available online and is very sought after. Also, we have observed that business has changed a lot in recent years. This has also affected research and development.

Changed in what way?

Philipp Herold (PH): Today it is more about developing project ideas with foresight, anticipating trends and picking up on them. What issues might become relevant? With the site selection underway in Germany, the questions have become much more concrete – including those regarding the individual host rocks.

Which ones do you have in mind in particular?

PH: There is one very interesting development! In the 1990s, the national focus was on salt. However, BGE TEC started looking at clay as a suitable host rock in Germany at an early stage, and since then we have looked more into the option of clay. Also, almost ten years ago, crystalline host rock came into our focus. But at present, we are also dealing with open questions about salt.

Speaking of site selection…what points of contact do you have there?

PH: As I said before, the questions in this area especially have become much more concrete. We work very closely with BGE, whose mandate is laid out very clearly in the Site Selection Act. Our tasks for BGE in this area have increased significantly. The basis for this support was provided by federal research projects that provided suitable tools for the development of a repository for high-level waste. So far, these projects have been funded through the Federal Ministry of Economics and Technology (BMWK). And then, of course, there are the repository organisations of the other countries.

Can you tell us specifically about a few of your projects?

TvB: The project PRECODE is about practical experiments in crystalline rock. We are pursuing the idea of using injection measures to achieve a targeted reinforcement of rock areas. This could facilitate the designation of effective containment zones around emplacement boreholes, for example. We are well acquainted with injection technology, from our injection work at Asse. Now, we have to translate the standardised process chain (materials, technology, evaluation) to crystalline rock and, at the same time, develop suitable injection materials.

The PIONIER project deals with the development and implementation of material models for clay rock and bentonite. Thus, at the same time, we are doing the legwork for BGE for the EURAD research consortium and specifically the technical sub-projects HITEC and GAS.

Are you also active internationally?

TvB: Yes, we are also in demand internationally. We currently have projects going on in Belgium, Great Britain, Japan, Canada, Norway, and South Korea, for example. And although almost half the work we do is, of course, for BGE, both federal research and development projects and orders from abroad are a very important basis for our company. Overall, we notice time and again that the knowledge we generate is also applied in other domains. Our international customers benefit from this. In fact, we really see ourselves as an important link between research and application – that is our central role!

Interviewed by Martina Schwaldat (ms)

BGE TECHNOLOGY GmbH is a subsidiary of BGE. Founded in 2001, the company currently employs 36 people.

BGE TECHNOLOGY GmbH develops concepts for the final disposal of radioactive wastes and, among other activities, tests new technologies and processes for this purpose. They investigate and run trials with new materials for backfilling and sealing repositories and mines.

Customers include worldwide repository organisations, energy suppliers, ministries and authorities, as well as international organisations and research institutions. The tasks they perform range from generic research projects to specific, detailed solutions for concrete applications in repository projects.

BGE TECHNOLOGY GmbH operates both nationally and internationally. They are currently involved in 15 research & development projects.

Financial statements

for the fiscal year from 1 January to 31 December 2021

Balance as of 31 December 2021

Assets

in thousands of euros	As of 31/12/2021	As of 31/12/2020
A. Fixed assets		
I. Property, plant, and equipment		
Freehold and equivalent real estate rights and buildings including buildings on third-party land	4,045	0
	4,045	0
II. Financial assets		
1. Shares in affiliated companies	690	690
2. Other loans	0	4,423
	690	5,113
	4,735	**5,113**
B. Current assets		
I. Stock	13,837	5,840
	13,837	5,840
II. Receivables and other assets		
1. Accounts receivable	172	0
2. Receivables from the shareholder	122,535	111,000
3. Receivables from affiliated companies	173	122
4. Other assets	11,762	4,035
	134,642	115,157
III. Bank balances	515	670
	148,994	**121,667**
C. Accruals and deferrals	**295**	**396**
	154,024	**127,176**
Total assets	**3,384**	**3,409**

Liabilities

in thousands of euros	As of 31/12/2021	As of 31/12/2020
A. Equity		
I. Subscribed capital	2,825	2,825
II. Capital reserve	37	37
III. Retained earnings	1,942	1,942
IV. Annual net profit	108	197
	4,912	**5,001**
B. Provisions		
1. Provisions for pensions and similar obligations	16,906	16,404
2. Tax provisions	0	1,389
3. Other provisions	60,355	49,513
	77,261	**67,306**
C. Liabilities		
1. Trade payables	48,879	35,302
2. Liabilities towards the shareholder	3,652	3,312
3. Liabilities towards affiliated companies	1,419	688
4. Other liabilities	17,901	15,567
	71,851	**54,869**
	154,024	**127,176**
Total liabilities	**3,384**	**3,409**

Profit and loss statement

for the period from 1 January to 31 December 2021

in thousands of euros	As of 2021	As of 2020
1. Revenue	476,003	445,890
2. Other operating income	12,069	3,226
	488,072	449,116
3. Material expenses		
a) Cost of raw materials, consumables, supplies, and purchased goods	30,399	29,727
b) Cost of purchased services	229,875	206,517
	260,274	236,244
4. Personnel costs		
a) Salaries and wages	157,898	142,470
b) Social security contributions and expenditure on pensions and other benefits	39,846	35,368
	197,744	177,838
5. Depreciation of property, plant, and equipment	28	0
6. Other operating expenses	27,670	23,214
	485,716	437,296
	2,356	11,820
7. Income from investments	108	197
8. Income from loans under financial assets	85	140
9. Interest and similar expenses	2,171	7,185
10. Taxes on income and earnings	216	4,726
11. Profit after taxes	**162**	**246**
12. Other taxes	54	49
13. Annual net profit	**108**	**197**

Asse mine: Injection work – adjusting the parameters for injecting a particle-reinforced injection medium to create a seal at the flow barrier SB-750-7 (750 m level); Horst Mentzel and Astrid Hofschlag (BGE TECHNOLOGY GmbH)

Annex for the fiscal year 2021

General information

The financial statement of Bundesgesellschaft für Endlagerung mbH (BGE) for the fiscal year from 1 January 2021 to 31 December 2021 was prepared on the basis of the accounting provisions in the German Commercial Code (HGB). In addition to these regulations, the provisions of the GmbH Act and the articles of association were observed. According to the size classes specified in § 267 HGB, BGE is a large corporation.

The profit and loss statement was prepared in accordance with the total cost method pursuant to § 275 (2) HGB.

BGE is entered in the Commercial Register of the Hildesheim Local Court under HRB 204918. The sole shareholder is the Federal Republic of Germany, represented by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV). The company's registered office is located in Peine.

Information on accounting and valuation methods

The company fundamentally does not own any tangible fixed assets to be capitalised, since BGE transfers to the BMUV ownership or rights to movable assets procured for the purpose of operation and financed by the BMUV at the time when BGE itself acquires these rights.

The property, plant, and equipment reported is the balance for the administration building (including land) in Peine, acquired in 2021. This was primarily funded with the capital of the predecessor company Deutsche Gesellschaft zum Bau und Betrieb von Endlagern mbH (DBE). The balance is drawn up under fixed assets at acquisition cost and has been offset against the tenant's loan that was granted to PALEA in the same amount. Fixed assets are being depreciated on a straight-line basis over their useful life (administrative building over 33 years, outdoor facilities over 10 years).

Other fixed assets relating to the Peine property were also valued at acquisition cost less investment grants, so the respective asset is shown in the balance sheet with a book value of zero. Accordingly, there is no depreciation for this asset.

The shares in affiliated companies shown under assets are valued at acquisition cost. Loans are shown at their nominal value.

Advance payments are stated at their nominal value.

Stock, receivables and other assets are valued at their nominal value. Value adjustments are made where necessary.

Cash and cash equivalents are stated at their nominal value.

Prepaid expenses relate to expenses prior to the balance sheet date, representing expenses for a specific period after that date.

Subscribed capital is carried at nominal value.

Provisions are recognised at the amount required to settle the obligation in accordance with reasonable commercial judgement.

Provisions with a remaining term of more than one year, with the exception of provisions for pensions, are discounted at the average market interest rate of the past seven years corresponding to their remaining term.

Provisions for pensions are measured on the basis of actuarial calculations using the projected unit credit method taking into account the "2018 G Mortality Tables" of Prof. Dr. Klaus Heubeck, Cologne. The pension obligations carried as liabilities are based exclusively on the benefit regulations and the defined contribution pension plan of Bochumer Verband for individual commitments. Provisions for pensions are measured at the average market interest rate of the past ten years published by the Deutsche Bundesbank (§ 253 (2) HGB). With an assumed remaining term of 15 years, this corresponds to 1.87% (previous year 2.31%). The salary trend remains unchanged at 2.5%, and the pension trend unchanged at 2.0% and 1.0% for commitments with an adjustment guarantee. Age- and gender-dependent probabilities are used for the expected employee development (fluctuation).

The difference resulting from the different valuation of pension provisions at the 7-year or 10-year discount rate (€1.042 million) is not subject to a distribution block in accordance with § 253 (6) sentence 2 HGB due to sufficient free reserves.

In addition, provisions are formed for uncertain liabilities from pension claims. The provisions are generally discounted in accordance with their term (§ 253 (2) HGB). As the remaining term is less than one year, the provisions have not been discounted. Provisions for anniversary bonuses within other provisions are also measured on the basis of actuarial calculations using the projected unit credit method, taking into account the "2018 G Mortality Tables" of Prof. Dr. Klaus Heubeck, Cologne. The current discount rate is 1.35% (previous year 1.60%).

In the reporting year, provisions for death benefits have been made for the first time. Provisions for tariff obligations are also measured on the basis of actuarial calculations using the projected unit credit method, taking into account the "2018 G Mortality Tables" of Prof. Dr. Klaus Heubeck, Cologne. The current discount rate is 1.35%.

Other provisions include amounts payable for services rendered by subcontractors, fees for the ongoing application procedure for decommissioning the Morsleben radioactive waste repository and the Asse II mine, and provisions for VAT risks. The other provisions take into account all identifiable risks and contingent liabilities.

Liabilities are stated at the settlement amount.

The excess of deferred tax assets over liabilities is not reported. The valuation of deferred taxes is based on a tax rate of 29.3% (15.82% for corporation tax, including solidarity surcharge, and 13.48% for trade tax). Differences between commercial law and tax law arise in particular with regard to pension provisions and procedural costs for decommissioning the Morsleben repository and the Asse II mine.

With the exception of the introduction of provisions for death benefits, the accounting and valuation methods have not changed compared to the previous year and have been applied consistently.

Annex for the fiscal year 2021

Notes on the balance sheet

The fixed assets include property, plant, and equipment as well as shares in the subsidiary BGE TEC. For information on developments in the reporting year, please refer to the statement of changes.

The receivables from the shareholder (€122.535 million; previous year €111.000 million) result from the settlement of BGE's provision of services. Receivables from affiliated companies (€173,000; previous year €122,000) relate exclusively to BGE TEC and result from the invoicing of services in the scope of the agency and service agreement. All receivables, with the exception of receivables concerning long-term provisions (€28.376 million; previous year €27.949 million), and other assets have a remaining term of up to one year.

Other assets (€11.762 million; previous year €4.035 million) relate to receivables from the transfer of invoices to the applicant in the scope of product control as well as tax receivables and have a remaining term of up to one year.

Cash and cash equivalents (€515,000; previous year €670,000) mainly consist of short-term bank balances.

The capital reserve in the amount of €37,000 is made up of capital shares of the predecessor companies DBE and Asse-GmbH that were not used to increase the subscribed capital.

BGE has made use of the option under Art. 67 (1) sentence 1 of the Introductory Act to the Commercial Code (EGHGB) to distribute the conversion expenses of pension provisions from the introduction of the Accounting Law Modernisation Act (BilMoG) as of 1 January 2010 on a straight-line basis over a maximum period of up to 15 years. The annual amount of €214,000 is reported under other operating expenses. As of the balance sheet date, the shortfall in pension provisions thus amounted to €644,000. After the rate for the interest on overdue tax was declared to be unconstitutional, this is expected to be amended from the 2019 assessment period onwards (to 1.8% instead of 6.0% p.a., as drafted by the BMF on 14 February 2022), and this necessitated an adjustment to the provisions previously made for VAT risks (-€6.819 million). This correction results in less tax owed. Taxes on income will therefore not be due for the fiscal year 2021.

Other provisions

Other provisions include the following items:

in thousands of euros	As of 31/12/2021	As of 31/12/2020
Provisions for outstanding invoices	36,108	20,049
Provisions for personnel obligations	7,662	6,634
Provision for procedural costs for decommissioning the Morsleben repository for radioactive waste	6,934	7,368
Value-added tax (VAT) risks	5,983	11,833
Provision for procedural costs for decommissioning the Asse II mine	3,600	3,556
Financial statement costs	68	73
Total	**60,355**	**49,513**

Annex for the fiscal year 2021

The personnel-related provisions include in particular obligations from vacation and time credits.

Liabilities to affiliated companies result entirely from the service relationships with BGE TEC. Liabilities to the shareholder consist entirely of trade accounts payable.

Other liabilities in the amount of €17.901 million (previous year €15.567 million) include obligations from VAT and wage tax payable (€17.796 million; previous year €13.755 million) for the months of November and December as well as other payment obligations towards personnel (€92,000; previous year €79,000). The item furthermore includes liabilities under social security in the amount of €13,000 (previous year €23,000).

All liabilities have a remaining term of up to one year.

There are no liabilities secured by liens or similar rights.

The €3.384 million reported in the balance sheet relates to security deposits held in trust for obligations under the Lower Saxony Nature Conservation Act for compensation and replacement measures in the Gorleben area. The trust assets are accordingly matched by trust obligations in the same amount.

Morsleben repository: Marcus Eggestein, foreman for the construction of the new administration building

Notes on the profit and loss statement

Revenue

Revenue is broken down by activity as follows:

in thousands of euros	As of 2021	As of 2020
Konrad	250,547	227,425
Asse	127,890	127,266
Morsleben	48,693	46,233
Gorleben	12,647	16,891
Product control	15,711	12,808
Site selection	20,116	14,903
Other revenue	399	364
Total	**476,003**	**445,890**

Annex for the fiscal year 2021

Other revenue comprises the services for the subsidiary BGE TEC (€333,000; previous year €306,000) and revenue from the canteen business (€66,000; previous year €58,000). All revenue was generated domestically in Germany.

Other operating income (€12.069 million; previous year €3.226 million) includes income from other periods in the amount of €11.223 million (previous year €2.571 million). Of this, €6.819 million is attributable to the correction of provisions already made for VAT risks, provisions no longer required for outstanding contractor invoices (€4.301 million; previous year €636,000), and recourse and damage compensation claims against contractors and reimbursements of the trade union IG BCE (€103,000; previous year €853,000).

The material expenses reported show the cost of raw materials, consumables, and supplies (€30.399 million; previous year €29.727 million) and the cost of purchased services (€229.875 million; previous year €206.517 million). The cost of purchased services mainly includes work and other service contracts, temporary employment, energy costs, guard services, and maintenance measures.

Costs of pensions amounting to €1.363 million (previous year €1.395 million) are shown under personnel costs.

Depreciation in the amount of €28,000 relates to the acquisition of the administration building with outdoor facilities in 2021 in the company's own name.

The other operating expenses (€27.670 million; previous year €23.214 million) mainly comprise general administrative expenses, including rental costs, expert opinion and external consulting services, incidental personnel expenses, and fees relating to supervision under nuclear legislation. This item also includes the annual pro rata conversion expense in the amount of €214,000 resulting from the introduction of BilMoG relating to the underfunding of pension provisions as of 1 January 2010.

Income from shareholdings results entirely from affiliated companies, to the sum of €108,000.

Income from loans from financial assets in the amount of €85,000 results from the tenant loan to PALEA.

Interest expenses of €2.171 million (previous year €7.185 million) mainly relate to expenses from provisions for VAT risks (€1.106 million; previous year €5.773 million) and the compounding of provisions (€1.052 million; previous year €1.406 million) as well as fees relating to payment transactions (€13,000; previous year €6,000).

Taxes on income and earnings to the sum of €216,000 result from subsequent charges for previous years. Correcting for the anticipated amendment to the interest rate for interest on overdue tax, from 6.0% to 1.8% starting from 1 January 2019, has resulted in less tax owed. Taxes on income will therefore not be due for the fiscal year 2021.

Contingent liabilities and other financial obligations

The company conducts its business operations in Peine. It acquired the building there in its own name in 2021. In order to achieve its goals, the company has rented additional space in buildings and storage areas and has further obligations amounting to €4.073 million. Financial obligations from other existing rental, tenancy, or leasing contracts amount to €1.548 million for the agreed terms on the balance sheet date. Altogether, the existing contracts result in financial obligations totalling €5.621 million.

To secure existing and future claims of Volksbank eG Braunschweig Wolfsburg from BGE TEC, there is a "guarantee for individual claims" in the amount of €750,000. It is not assumed that this will be used because BGE TEC has sufficient liquidity.

Konrad shaft mine: The Konrad Mine Rescue Team's specialist group for rescue at height, from left to right: Jan-Lukas Hanke, Melvin Schniedermeier, Jan Lindner

Annex for the fiscal year 2021

Other information

Members

Management board

The company was managed in 2021 by the following managing directors:

Stefan Studt, Rickert,
Chair of the Management Board

Steffen Kanitz, Dortmund,
Deputy Chair of the Management Board

Beate Kallenbach-Herbert, Braunschweig,
Commercial Managing Director until 1 July 2021

Dr. Thomas Lautsch, Peine,
Technical Managing Director

Para. 5.2.5 of the Public Corporate Governance Code (PCGK) notwithstanding, no age limit has been set for occupying a position in BGE management. The contracts of the current management are fixed in term such that no member of the management will reach the legal retirement age before the end of the term.

Management remuneration in the 2021 reporting year comprises fixed salary payments including fringe benefits. Performance-related remuneration components are not paid.

Management board remuneration in 2021

in thousands of euros Managing director	Base salary	Pension scheme	Other	Total remuneration 2021
Stefan Studt	295	0	9	304
Steffen Kanitz	275	0	21	296
Beate Kallenbach-Herbert	160	0	51	211
Dr. Thomas Lautsch	275	0	2	277
Total amount	**1,005**	**0**	**83**	**1,088**

Upon Beate Kallenbach-Herbert's early departure from the board, a termination benefit of €50,000 was paid in accordance with the contract, which is included under 'Other'. A total of €7.648 million was set aside to cover pension obligations to former members of the management of a merged legal entity; their current emoluments amounted to €594,000 in 2021.

Annex for the fiscal year 2021

Supervisory board

Since the number of 2,000 employees was exceeded and the status procedure was initiated by the management board, the company is now within the purview of the Codetermination Act (MitbestG) and a supervisory board with equal representation and 16 members was constituted in the third quarter of 2021. It held its constituent meeting in the fourth quarter of 2021. The State Secretary of BMU, Jochen Flasbarth, was re-elected Chair of the Supervisory Board; Franz-Gerhard Hörnschemeyer was elected Deputy Chair. Furthermore, the legally mandated mediation committee was set up, which, in addition to the chair and the deputy, also includes Dr. Holle Jakob for the shareholder's side and Carsten Meyer for the employee representatives' side.

The following are members of the supervisory board:

Dirk Alvermann
Employee Representative of BGE

Ursula Borak
Head of Division, Federal Ministry for Economic Affairs and Climate Action

Dr. Wolfgang Cloosters
Head of Department, BMUV, until 31 December 2021

Lena Daldrup
Head of Division, BMAS, since 13 April 2021

Christina Egelkraut
Employee Representative of BGE since 1 September 2021

Jochen Flasbarth
State Secretary, BMU, until 8 December 2021 (Chair of the Supervisory Board)

Prof. Dr. Karin Holm-Müller
Head of Chair, Resource and Environmental Economics, University of Bonn

Franz-Gerhard Hörnschemeyer
Trade Union Secretary for Energy Sustainability at IG BCE (Deputy Chair of the Supervisory Board since 30 November 2021)

Dr. Holle Jakob
Head of Directorate Strategic management of the customs administration; financial control of undeclared work; customs anti-money laundering measures, Federal Ministry of Finance

Dr. Andreas Kerst
Head of Division, Federal Ministry of Finance

Sylvia Kotting-Uhl
Member of the Federal Parliament (MdB) until 30 October 2021, Bündnis 90/Die Grünen

Jens Lindner
Employee Representative of BGE

Carsten Meyer
Employee Representative of BGE since 1 September 2021

Christina Offermanns
Employee Representative of BGE since 1 September 2021

Marike Vornkahl
Trade Union Secretary of IG BCE since 1 September 2021

Sebastian Zwetkow-Tobey
Employee Representative of BGE since 1 September 2021

Members who left are:

Gregor van Beesel
Employee Representative of BGE (Deputy Chair of the Supervisory Board), on 31 August 2021

Leonie Gebers
State Secretary, Federal Ministry of Labour and Social Affairs, on 1 February 2021

Gabriele Theisen
Employee Representative of BGE, on 31 August 2021

Peter Wolff
Employee Representative of BGE, on 31 August 2021

Para. 6.2.2 of PCGK notwithstanding, no age limit has been set for occupying a member seat on the BGE supervisory board, in order to ensure that additional specific skills and experience can be introduced to the benefit of the company.

Management reports to the supervisory board in accordance with § 90 of the German Stock Corporation Act (AktG). In addition, reservations of approval in favour of the supervisory board are laid down in BGE's articles of association for transactions of fundamental importance. These are, in particular, decisions and measures that could lead to a significant change in the business activity within the framework of the articles of association or to a fundamental change in the Company's net assets, financial position, operational results, or risk structure.

By resolution of the shareholders' meeting on 23 August 2017, the attendance fee for supervisory board members who are neither members of the German Bundestag or federal government, nor are in a service or employment relationship with the Federal Republic of Germany, was set at €4,000 per year. These members of the supervisory board were paid attendance fees totalling €31,000 in 2021.

The supervisory board had previously formed a presidium made up of four supervisory board members who could prepare supervisory board decisions; the final decision remained the responsibility of the supervisory board.

PCGK – Public Corporate Governance Code

The company issued a declaration of conformity in accordance with the Federal Public Corporate Governance Code for 2020 in July 2021 and published this on the company's website. The declaration of conformity for 2021 is to be published in June 2022.

German Sustainability Code

In 2022, BGE is creating a sustainability code report for 2021. This does not replace the financial declaration pursuant to § 289b ff. of the Commercial Code (HGB).

Auditor's fee

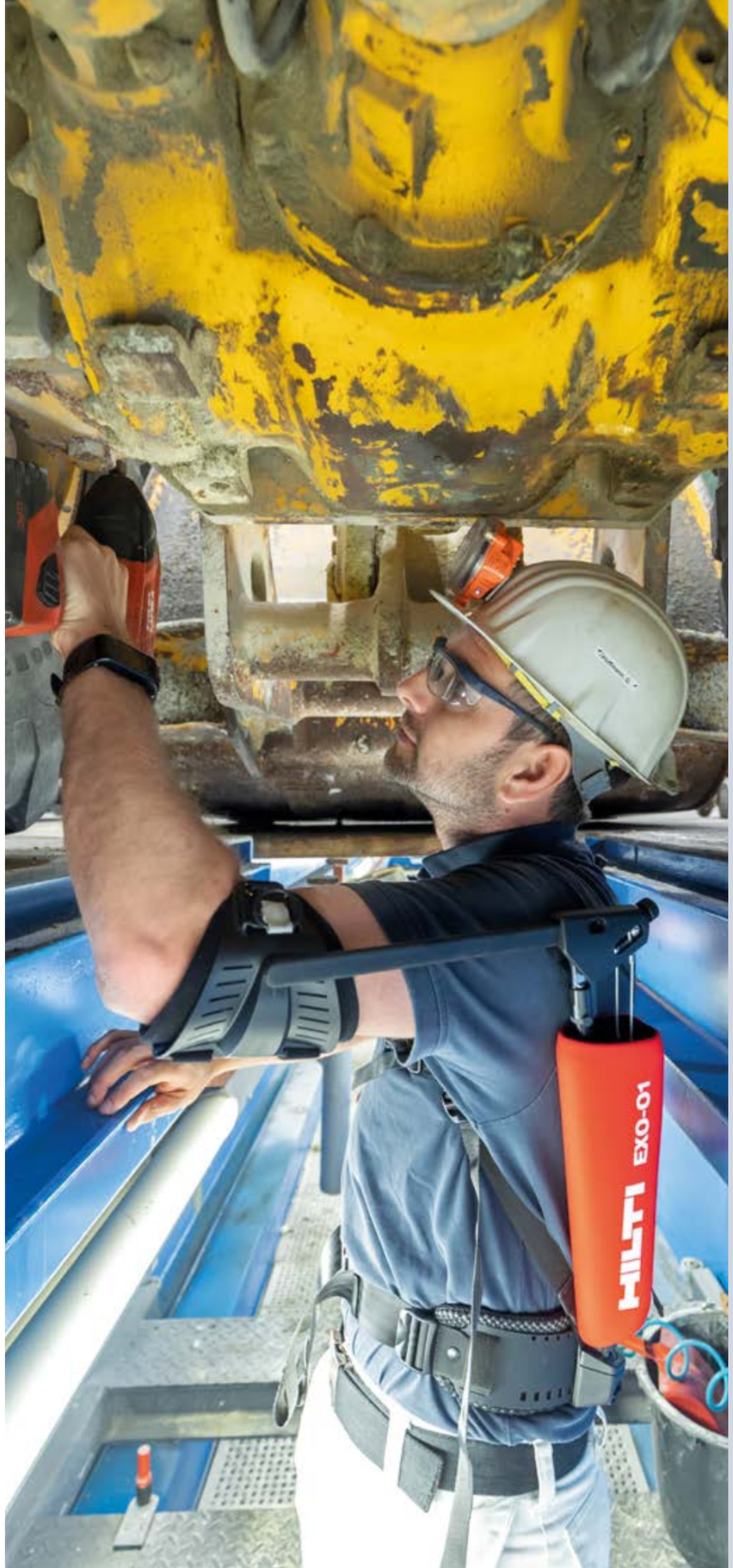
The total fee for the auditor calculated for the fiscal year is shown in the BGE consolidated financial statements.

Annex for the fiscal year 2021

Number of people employed

On an annual average, there were 1,941 people in the company's employ in the sense of § 267 (5) HGB.

Sites	Annual average employees	Of which women
Salzgitter	98	48
Wolfenbüttel/Remlingen (Asse)	579	111
Peine/Berlin	610	252
Gorleben	31	1
Morsleben	153	23
Konrad	470	36
Total employees	**1,941**	**471**



Distribution of profit

The net profit for the year in the amount of €108,000 is to be distributed with the discretionary approval of the shareholder.

Shareholding

One shareholder owns 100% of the interest in BGE TEC, Peine.

As of 31 December 2021, the equity of BGE TEC amounted to €2.647 million. In fiscal 2021, the company generated a net profit of €34,000.

Peine, 31 March 2022

Stefan Studt
Chair of the Management Board

Steffen Kanitz
Deputy Chair of the Management Board

Dr. Thomas Lautsch
Technical Managing Director

Morsleben repository: Dennis Hoffmann tests an overhead exoskeleton, which serves to relieve the physical strain on arms and shoulders during overhead work.

Development of fixed assets

01 January 2021 to 31 December 2021

Acquisition and manufacturing costs

Value adjustments

Carrying amounts

in thousands of euros	As of 01/01/2021	Additions	Investment grants	Retirements	As of 31/12/2021	Accumulated Value adjustments 01/01/2021	Additions, depreciation	Retirements	Accumulated value adjustments 31/12/2021	As of 31/12/2021	As of 31/12/2020
Property, plant, and equipment											
1. Freehold and equivalent real estate rights and buildings including buildings on third-party land	0	5,669	-1,596	0	4,073	0	28	0	28	4,045	0
Financial assets											
1. Shares in affiliated companies	690	0	0	0	690	0	0	0	0	690	690
2. Other loans	4,423	0	0	4,423	(€250)	0	0	0	0	(€ 250)	4,423
	5,113	**0**	**0**	**4,423**	**690**	**0**	**0**	**0**	**0**	**690**	**5,113**
Total fixed assets	**5,113**	**5,669**	**-1,596**	**4,423**	**4,763**	**0**	**28**	**0**	**28**	**4,735**	**5,113**

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Company basics

When Germany passed the Act to reform the organisational structure in matters of final disposal of nuclear waste on 30 July 2016, there was a shift in responsibilities among the institutions concerned. The federal government established the Bundesgesellschaft für Endlagerung mbH (BGE) to perform the tasks of final disposal in accordance with the Act on the peaceful use of nuclear energy and on the protection against its risks (Atomic Energy Act, AtG) and to see the site selection procedure carried out in accordance with the Site Selection Act (StandAG). BGE is organised as a company under private law and is wholly owned by the German federal government. The sole shareholder is the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV).

By a decision dated 24 April 2017, last amended in the decision dated 31 July 2020, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) conferred upon BGE the duties of the federal government, pursuant to § 9a (3) sentence 1 AtG, and the sovereign powers required for this purpose, pursuant to § 9a (3) sentence 3 (first half) AtG.

Duties conferred include:

1. the construction, operation, and decommissioning of repositories as well as the operation and decommissioning of the Asse II mine in accordance with § 57b AtG with all associated duties pursuant to § 9a (3) sentence 1 AtG,
2. the sovereign powers to issue administrative acts in accordance with
   a. § 3 (1) sentence 2 of the Nuclear Waste Disposal Regulation (AtEV), confirming the suitability of waste packages for final storage,
   b. § 2 (5) sentence 1 number 1 in conjunction with sentences 2 and 3 of the Act reorganising responsibility for nuclear waste management (EntsorgÜG), which establish the eligibility of waste packages containing radioactive waste with negligible heat generation to be handed over to the third party under § 2 (1) sentence 1 EntsorgÜG,
   c. § 7 (2) AtEV, by which the waste is retrieved for emplacement in a repository, and
   d. § 34 (1) or (2) in conjunction with § 35 (1) of the Geological Data Act (GeolDG), deciding on the public provision of non-governmental technical or assessment data

in accordance with the provisions laid down in the formal notice of the transfer of tasks (Übertragungsbescheid).

Having been conferred the duties of the federal government pursuant to § 9a (3) sentence 1 AtG, BGE also became the project sponsor within the sense of StandAG.

BGE is additionally deemed a building owner for matters governed by building regulations, with the exception of the Konrad project. Building owner status for the Konrad project was transferred to the federal government with effect from the end of June 2019. In order to fulfil its tasks, the federal government has set up a building authority ("privileged construction" in accordance with § 74 of the Lower Saxony Building Code and supervision of the construction work) at the Federal Environment Agency (UBA); BGE has also been authorised to fulfil all building owner's tasks/ duties not incumbent on the UBA in the Konrad project on behalf of the federal government.

Furthermore, in a letter dated 13 September 2019, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) conferred full exclusive responsibility for developing repositories for high-level radioactive waste to BGE.

With the number of employees permanently exceeding 2,000, the company now comes within the purview of the Codetermination Act, for which the management has initiated a status procedure. Accordingly, in the third quarter of 2021, the supervisory board was reconstituted with equal representation. The board met for its constituent meeting in the fourth quarter of 2021, with eight shareholder board members and eight provisionally court-appointed employee representative board members. This meeting was also used to amend the articles of association.

BGE employs personnel who have been appointed or provided by the Federal Office for Radiation Protection (BfS).

The company's contracts with third parties are awarded in accordance with public procurement law.

BGE has a wholly owned subsidiary, BGE TECHNOLOGY GmbH. Its field of activity includes the provision of consulting and engineering services as well as operational services for the construction, operation, and disposal of nuclear and conventional facilities.

Control system

BGE's mission is to guarantee the safe disposal of radioactive waste. In this way, it contributes to the protection of humanity and the environment and to solving a socio-political problem.

In fulfilling this mission, the company pledges to the responsible and transparent implementation of the projects entrusted to it. These include constructing and operating the Konrad repository, retrieving the radioactive waste from and decommissioning the Asse II mine, keeping the Morsleben repository open until it is decommissioned, and implementing the measures scheduled in the current mining operation plan for the Gorleben mine. Further duties include product control, which ensures that only approved waste packages are emplaced in the Konrad repository, and selection of the site that guarantees the best possible safety for final disposal of high-level radioactive waste.

Safety is the top priority in the fulfilment of all duties. This includes occupational safety, health protection, and operational and long-term safety.

The company is equally committed to the responsible use of the financial resources made available to it for these duties, and to compliance with all legal requirements and burdens of proof relating to the award of contracts and the use of funds by a public-sector enterprise. In particular, the principles of economy and efficiency must be observed. Profitmaking is not the goal of the company. It furthermore abides by the special guiding norms under nuclear and mining law.

The mission statement and corporate goals form the guidelines for carrying out the corporate duties. These guidelines are supplemented by the articles of association, the rules of procedure for management, the financial statute (set out by the shareholder) on economic management and financial and asset management within BGE, the internal regulations based on this statute, and the economic plan approved by the shareholder as well as the schedules and progress plans of the projects.

The integrated management system incorporates the essential tools such as the risk, safety, quality, energy, and environmental management systems

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at their respective levels of maturity, as a means of ensuring that the company's goals are met. These tools are being successively developed and assessed in the course of annual management review. In preparation for certification of the integrated management system, an audit was initiated to confirm its compliance with the requirements of ISO 9001 (International Organization for Standardization), KTA 1402 (Nuclear Safety Standards Commission), and the guideline for safety management in repository organisations of the Nuclear Waste Management Commission (ESK). The energy management system was certified in 2021.

The company uses various financial and non-financial performance indicators to manage its activities in the interests of the corporate goals and implementation of the corporate strategy. These are continually reviewed on the basis of the internal regulation 'Building Blocks of Corporate Management' and presented in the reporting system.

Key financial performance indicators are the costs of the projects and associated general overheads. The 2021 budget anticipated net costs of €518.275 million. In contrast to this, the actual costs amounted to €483.601 million.

Project costs

in thousands of euros	2020	2021	Budget 2021	Deviation 2021	Forecast 2022
Konrad	229,468	253,218	248,847	4,371	271,826
Asse	127,158	132,797	147,401	-14,604	137,611
Morsleben	46,233	49,112	56,167	-7,055	56,165
Gorleben	16,891	12,647	11,929	718	14,667
Site selection	14,903	20,116	34,857	-14,741	31,014
Product control	12,808	15,711	19,074	-3,363	22.114
Total	**447,461**	**483,601**	**518,275**	**-34,674**	**533,397**

The difference between the costs amounting to €483.601 million and revenues amounting to €476.003 million declared in the profit and loss statement (see annex) results from the balance of advance payments paid and reversed. In addition, these costs include the transfer of invoices to BGE TEC and sales revenue from reclassifications due to the German Accounting Directive Implementation Act (BilRUG) as well as the Asse canteen business in the projects.

Among the reasons for deviations from the plan were the various constraints to business operations caused by the Covid-19 pandemic in 2021. This affected planning, approval, and procurement procedures as well as work in the underground and surface mines. Furthermore, the tense market situation owing to the pandemic led to considerable delivery delays and price increases. Maintenance costs were nevertheless low due to the plants, systems, and components being in good condition. The company countered the constraints by implementing streamlining measures, such as expediting market approaches (Konrad: civil engineering tender for the reloading hall and the fan building at Konrad 2), as well as by working on Sundays and public holidays in the Konrad 1 and 2 shafts since 2020.

The following chapters explain the trends in the performance indicators, especially those in the business performance and in the earnings, financial position, and net assets.

The 2022 budget forecasts net costs of €533.397 million for 2022. The respective milestones and tasks to be achieved are presented in the forecast report.

The company's activities are under the scrutiny and supervision of the shareholder, the supervisory board, the Federal Office for the Safety of Nuclear Waste Management (BASE) as well as other authorities, and equally importantly in the focus of the public. BGE therefore provides regular and event-related information about its projects and seeks professional dialogue with experts and the public. Important developments and decisions for the projects are documented and made public as a rule.

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Research and development

The main focus of research and development (R&D) activities in 2021 was on carrying out the site selection process. R&D tasks relevant to site selection have been and are being identified and compiled in a research agenda. Concerns addressed include geoscientific issues, repository planning and preliminary safety assessments, and the radio- and chemotoxic effects of radioactive waste in the repository. The topics and timings of the projects are presented in a research roadmap.

In 2021, the following 18 research and development projects were concluded (C), ongoing (O), and initiated (N) for the site selection procedure.

Project	Purpose	Status
Forecast of volcanic activity in Germany	Application of the exclusion criteria	C
IGD-TP Technical aspects of retrievability	Options and approaches for retrieving radioactive wastes	C
IGD-TP Seismic hazards assessment	Options and approaches for assessing the seismic hazards of repositories	N
IGD-TP Climate change in the safety case	Importance of climatic trends in the safety assessment of repositories	N
Thermal integrity of clay and clay stones – THMC simulations[1]	Determining temperature limits specific to host rock	O
THMC implementation and further development of material models for the simulation of THM-coupled processes within the framework of safety-analytical investigations in clay rock and bentonite (PIONIER)	Demonstrating barrier system integrity	O
Research programme of the European Union on the disposal and management of radioactive waste (EURAD)	Ascertaining and advancing the international state of the art in science	O
Compilation and evaluation of geophysical methods for surface exploration	Basis for the surface exploration programme (proposal in Phase I, implementation in Phase II)	O
Compilation and evaluation of geoscientific methods and programmes for surface site exploration	Basis for the surface exploration programme (proposal in Phase I, implementation in Phase II)	O
Calculation of the depth-dependent area requirement for a repository for high-level radioactive waste	Application of the assessment criterion and minimum requirement; basis for repository layout and design	C
Synthesis platform for safety assessment in the site selection procedure	Supporting evidence management in the scope of the preliminary safety assessments	N
Investigation of the effects of mining activities at great depths on the integrity of crystalline rock in the context of the final disposal of high-level radioactive waste (Precode)	Basis for repository planning and repository layout & design	N
Atlas of mineralogical and petrophysical properties of German crystalline host rocks (AMPEDEK)	Application of weighing criteria	N
Influence of thermal maturity on the coupled hydromechanical properties of low-permeability clay stones – field & laboratory scale (Maturity)	Characterisation and safety analysis of clay rock	N
Effects of cyclical glaciation on salt domes as a potential repository site for high-level radioactive waste (smart tectonics)	Effects and safety-related climatic long-term trends	N
Neotectonic activity in Central and Southern Germany	Safety-oriented application of the exclusion criteria	N
Michigan International Copper Analogue Project (MICA)	Long-term integrity of containers	N
Subglacial erosion processes	Effects and safety-related climatic long-term trends	N

[1] Experiment and simulation of coupled thermal–hydraulic–mechanical–chemical (THMC) processes

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In addition to these projects, there are other in-situ investigations and experiments being carried out in various underground laboratories. After joining the Mont Terri Rock Laboratory in Switzerland in 2020, participation commenced in eight further experiments in Mont Terri in 2021 for the hydrogeological, geochemical, and geotechnical characterisation of a clay formation under in-situ conditions. Similarly, the hydrogeological, geochemical, and geotechnical characterisation of a crystalline formation is being pursued in the rock laboratory of the Grimsel Test Site in Switzerland with the two ongoing experiments CFM investigating the migration of radionuclides and HotBENT investigating the effects of high temperatures on bentonite barriers.

In the Asse project, the subproject 'Development of an optimised, combined and high-resolution seismic imaging method for the site exploration of radioactive repositories, 3D Seismics' was initiated with the aim of achieving higher-detail and higher-precision assessments of seismic surface measurements in exploration.

In the Konrad, Morsleben, Asse, and Site Selection projects, the joint project 'Thermodynamic Reference Database (THEREDA)' was continued in 2021 for the creation of an internally consistent database for geochemical model calculations.

The net costs for R&D activities in these projects in 2021 were €5.472 million (previous year €3.020 million). These are included in the costs of the projects.

The research, development, and demonstration (RD&D) activities relevant to the tasks for 2022 are being identified and will be compiled and published in a BGE research programme. The existing projects are expected to be continued in their full scope in 2022.

Aerial views of the Konrad 1 and 2 shaft mines

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Economic report

Business development

The articles of association, the transfer of exercise of duties, the budget, and the resolutions of the supervisory board and the shareholder form the basis for the business management of BGE. The details of business management are regulated in the financial statute, which was updated in 2021.

General

The goal of business development – to guarantee efficient project management and to enable effective organisation and control of the company – was achieved to a significant extent. Noteworthy here is the creation of the concept, organisational structure, and basic approach for the project of migrating to the SAP S/4HANA ERP software. Regarding structures of organisation and tasks, an analysis of cooperation between projects and between central divisions was made in 2021, beginning with a self-assessment and a beneficiary assessment.

The work on consolidating the archives and standardising the documentation systems of the various predecessor organisations was finalised in 2021, to the extent where implementation of the integrated document management system with electronic case processing can go ahead in 2022. Work with text analysis software began as part of setting up the knowledge management system. For business process management, the business processes were captured and modelled with the introduction of the software Aeneis.

The demands on data security and IT capacities are constantly increasing: data centre capacities were therefore expanded, new security concepts developed, and guidelines for their application created.

The increasing number of employees necessitates the optimisation of organisational structures and poses challenges in onboarding, i.e. in providing workplaces. This includes the preparation for renting additional office workspace and the development of flexible and sustainable working times and desk sharing models.

In July 2021, BASE announced an audit of the company in accordance with section 58(4) of the Atomic Energy Act. Pursuant to § 58(4) AtG, it must be checked that a third party (BGE) guarantees the continuation of the erection, the operation, and the decommissioning of installations pursuant to § 9(3), first sentence, of AtG by organisational measures and the provision of material and human resources. On 6 December 2021, BASE named 14 audit complexes in the auditable areas of personnel equipment, technical equipment, and their application and organisation.

Construction of the Konrad repository

The Konrad mine is being converted into a repository for low- and intermediate-level waste. Once complete, up to 303,000 cubic metres of low- and intermediate-level radioactive waste will be emplaced in it. It is the first repository in Germany to be licensed under nuclear law. The nuclear licence for the construction and operation of the repository was given in 2002 in the form of the plan-approval decision.

Preparation of the Konrad repository in 2021 was characterised by extensive construction and planning measures.

Shaft mine Konrad 1

Construction of the guard building and heating centre commenced at the shaft mine Konrad 1. Construction of the temporary workshop was completed. Construction of the new workshop on the land area of the old workshop began in the fourth quarter. The temporary workshop will be operated until the new workshop is ready for use.

The company gave the go-ahead for manufacturing the new guide frame for the new shaft hoisting system. The old work platform was removed from the shaft and dismantled. The new mobile work platform was assembled and put into operation. It has been optimised for the anticipated work and, when unfolded, spans the entire cross section of the shaft.

Shaft mine Konrad 2

Preparation of the pit for the reloading hall commenced at the shaft mine Konrad 2. The reloading hall is the central building for surface activities at the Konrad 2 shaft mine. This is where the delivery and repackaging for transporting the waste packages underground takes place. The awarding of contracts for constructing the reloading hall/buffer hall and the technical building equipment was postponed to 2022, as recalculations of the structural analysis and supporting structure had to be made beforehand, working from current soil dynamic parameters. The pit for the mine water transfer station was dug and structural work commenced. The mine water transfer station is where the mine water accumulating underground during final repository operation will be collected and radiologically controlled. Manufacture of the -16 m platform below the surface commenced as planned in 2021. The small cable-driving system was installed and put into operation on the -16 m platform at the beginning of 2022. Both together are needed for man haulage to be possible while the new winding tower is being constructed.

Underground on the 2nd level, the excavation of the filling site was completed. Thus, the cavity for constructing the reloading station has been completely excavated. This is located between the Konrad 2 shaft and the emplacement transport drift. The filling site is the underground area of the future repository where the waste will arrive through the shaft and be transferred to the transport trucks with the help of a straddle carrier. These will then transport the packages via the emplacement transport drifts into the emplacement chambers.

Overall, slightly higher costs were incurred in 2021 than originally planned. The increase in costs resulted from increased external support services for seismic surveys in the context of the Konrad 2 opencast facilities and additional services for the planning of the Konrad 2 winding tower. Furthermore, as part of the preparation of the repository, the revisions planned for 2022 for KTA compliant identification of plants, systems, and components were brought forward to 2021. Due to delivery delays, lower costs were incurred for vehicle procurement and technical equipment.

Pit

At the pit, the installation of the inner shells in the emplacement transport drift and in the backfill preparation area commenced with the wet spraying of fibre shotcrete. The wet spraying method results in a lower dust load. Another reason for using fibre shotcrete is to accelerate the installation of the inner shells. The fibres partially replace steel bar reinforcement. The contract was awarded for constructing the air control and guidance system for targeted distribution of the air in the mine cavities. 25 plateau cars have been completely manufactured and accepted by the authority's expert and will be stored until the final commissioning. Once the repository has been commissioned, they will transport the radioactive waste within the operational control area.

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Decommissioning of the Asse II mine

Between 1967 and 1978, around 47,000 cubic metres of low- and intermediate-level radioactive waste were emplaced in the mine. Retrieval has been a legal mandate since 2013 and is scheduled to begin in 2033.

In 2021, in connection with the amendment of the Lower Saxony spatial planning programme, BGE asked the Lower Saxony Ministry of Food, Agriculture and Consumer Protection (NML) to include the spatially significant Asse retrieval project in the state spatial planning programme. A spatial planning notification was prepared and submitted to the NML in March 2022.

In the nuclear licensing procedure, the document structure for the application for ventilation conversion was coordinated with the Lower Saxony Ministry for the Environment, Energy, Construction and Climate Protection (NMU). The background to the ventilation conversion is that the new Asse 5 shaft will create a new ventilation situation in the mine. A consultation conference was requested for the licensing procedure for the waste treatment plant with interim storage. After the decision was made in October for the small-scale retrieval procedure on the 750 m level, which will involve retrieval in several partial areas, the further steps towards the licensing procedure were initiated. The decisive factor in favour of this retrieval option is the procedure's flexibility for dealing with geotechnical instabilities and uncertainties regarding the condition of the waste. For this retrieval, important contracts were concluded for developing the retrieval technology for the 511 m and 725 m levels as well as for licence planning for the waste treatment plant with interim storage. The retrieval technology includes tools for the direct uncovering, loosening, and loading of salt grit or packages or parts of packages. In addition, technical solutions have to be developed for avoiding or limiting dust formation and damage to packages, for remotely securing the working areas, and for supplying and storing the actual tools.

In the reporting year, the Remlingen 11 borehole was completed and the findings for boreholes 10, 11, and 15 as well as for parts of the 3D seismic survey were entered into the geological model. The purpose of these boreholes is to gather information about the geological and hydrogeological situation, about the structure of the overburden, and about the transition area to the salt rock. The decision for the location of shaft 5 was supported by the new findings. On behalf of the BMU and in agreement with all parties involved, the decision on the location of a near-site interim storage facility was examined within the framework of the licence application by a team of experts coordinated by the NMU, and the corresponding report was presented in October. In November, a consultation took place on how things will proceed from here.

Participants were the Lower Saxony Minister of the Environment, Olaf Lies, representatives of the Wolfenbüttel district, the citizen advisory group Asse 2 Begleitgruppe (A2B), the NMU, the BMU, BGE, and the experts in the 'enlightenment process' (Beleuchtungsprozess). As an outcome, the NMU declared its willingness to initiate deliberations on an extended clarification of the siting issue, and there was agreement that the company can go ahead with its planning for the interim storage facility as long as it does not create irreversible situations. BGE will deepen its reasoning for the feasibility of a near-site interim storage facility and provide further reasoning in the licensing process. Another in-depth report on the site feasibility is to be prepared in 2022. The waste treatment plant includes all the equipment needed to convert radioactive waste into a state suitable for transport and/or storage. The waste treatment process comprises the steps: buffering, characterisation, and conditioning. The buffer store enables uninterrupted retrieval of the waste and its treatment. Conditioning is where the conditions are created for interim storage and transport to a final repository. For this, the facilities for waste treatment and interim storage must be constructed above ground on site and directly connected to the operating area of the mine.

The company has concluded an initial purchase agreement for land for the new retrieval mine in the name and on behalf of the Federal Republic of Germany. Part of the land for the buildings above ground and the area required for the infrastructure for operating the shaft have thus been acquired.

There was another partial success in the land negotiations at the end of 2021 with the notarisation of the purchase of areas of the access roads to the R18 drilling site. These are required for the execution of subsoil investigations, for which the preparatory work has begun. The contractor for these subsoil investigations has been appointed. In October, the company initiated a dispute resolution procedure against the private owner in the area of the planned retrieval mine shaft 5. The aim is to obtain access rights for the planned exploratory borehole R18 and the associated subsoil investigations. Since the subsoil investigations could not take place in 2021 as planned, no costs were incurred.

The purchase of additional land has been delayed due to difficult negotiations with the owners. The land is needed for shaft 5, the waste treatment plant, the interim storage facility, and the infrastructure facilities for retrieval.

The old 1910 traction sheave hoisting machine for shaft 2 will be replaced by a new drum hoisting machine. This will ensure that spare and maintenance parts can be procured in the long term and thus retrieval operations will be relatively undisrupted.

The concept of characterisation as a milestone was not achieved until January 2022. By means of radiological and material characterisation, the retrieved waste is being characterised for further handling and later final disposal.

Overall, the costs incurred in 2021 were lower than planned. Underground services such as maintenance work had to be postponed due to rescheduling during the construction of flow barriers. Furthermore, the installation and commissioning of the main pit ventilator will not take place until 2022 due to a long planning phase. Another deviation results from the as yet unrealised land acquisitions for the compensation and replacement measures, which are dependent on the planning and implementation status of the retrieval. The planned backfilling measures and their costs, among others for blind shaft 3a, could not be carried out to the planned extent. This was due to changes in planning, exceptional operations due to Covid-19, and the continuation of revising the licensing documents with limited resources. Owing to prioritisation of other measures, the necessary personnel resources were also not available to initiate the procurement of the mixing and pumping plant or the conversion of the salt plant.

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Decommissioning of the Morsleben radioactive waste repository and procedure for the Gorleben mine

Decommissioning of the Morsleben repository for radioactive waste

Between 1971 and 1991 and from 1994 to 1998, a total of around 37,000 cubic metres of low- and intermediate-level radioactive waste was disposed of permanently in the Morsleben repository. Radioactive waste was also stored there temporarily. The tasks in connection with the Morsleben repository for radioactive waste include keeping the repository ready for decommissioning and approving the plans for its decommissioning.

Morsleben plan-approval procedure

The application documents in the plan-approval procedure are expected to be completed and submitted in 2026. The plan-approval decision for decommissioning is expected to come in 2028.

Preparation for decommissioning

As part of the plan-approval procedure for decommissioning, the properties of the geotechnical barriers have to be evaluated. In this context, laboratory tests and planning for demonstration structures were carried out. Planning and preparatory work was carried out for the construction of the demonstration structure in the main anhydrite at the Morsleben repository. The semi-mobile building material facility was procured and the drift bunker built. The integrity calculations for the modified repository model will be postponed until 2022, as further detailed geological sections have to be prepared by the Federal Institute for Geosciences and Natural Resources. Further activities were additionally carried out in preparation for decommissioning. These include awarding the contract for commencing construction of the new administration building and dismantling the above-ground building material facility for the ash placement carried out for filling the residual cavities of the emplacement chambers.

In addition, an operations management department was set up to prepare for decommissioning, with the further essential tasks of dismantling the surface control area and converting the Marie shaft hoisting system.

Within the framework of the decommissioning procedure, it was not possible to submit documents as planned, due to a lengthy coordination procedure and demands from the licensing authority. In 2021, lower costs were incurred than originally planned. This is due to delays in award procedures, e.g. for the construction of the new Bartensleben administration building or for consulting services for building materials testing. Vehicle procurements could not be realised to the planned extent due to supply chain disruptions.

Gorleben

The Sub-Areas Interim Report for the site selection procedure for a repository for highly radioactive waste, published on 28 September 2020, does not include the Gorleben-Rambow salt dome as a designated sub-area. The Gorleben-Rambow salt dome was thus excluded from the further site selection procedure. The Gorleben mine is therefore no longer to be kept open pursuant to Section 36 (2) sentence 2 StandAG. BGE thereupon presented the shareholder with decision options for how to proceed with the Gorleben mine, and proposed its closure.

Keeping the mine open

The structural measures for changing operations to merely keeping the mine open only were completed in 2021.

The basic intention to close the Gorleben mine was announced by the State Secretary of the BMU, Jochen Flasbarth, in a joint press conference with the Lower Saxony Ministry for the Environment, Energy, Construction and Climate Protection (NMU), the Federal Office for the Safety of Nuclear Waste Disposal (BASE), and BGE in September 2021. BGE has started planning this closure. The process of closure is expected to last until the early 2030s. As one of the first measures, the salt dump is to be brought back underground. The first possible solutions for the extraction and placement of the stockpiled salt have been assessed. Preparation of the specifications has begun for bringing the salt dump back underground and backfilling the mine workings. A first rough cost estimate has been made for the closure of the mine.

Site selection procedure

The implementation of Step 2 of Phase I concludes with the milestone "Proposal for the siting regions and surface exploration programmes".

The planning of work involved in implementing the milestone "Proposal for siting regions and surface exploration programmes" started in 2020 and was elaborated further in 2021.

The work for preparing and accompanying the first, second, and third consultations of the sub-areas conference concluded with the end of the third consultation on 7 August 2021. The documents and results of the sub-area conference were handed over on 7 September 2021.

Significant work was done in 2021 for preparing the concept for the development of site-specific exploration programmes for surface exploration and for recording the accompanying processes. Furthermore, important progress was made towards the milestones "Presentation and discussion of the status of the refined method for applying the geoscientific weighing criteria pursuant to § 24 of StandAG", "Planning scientific weighing criteria pursuant to § 25 of StandAG" and "Presentation and discussion of the method for conducting the representative preliminary safety assessment pursuant to § 27 of StandAG".

Due to the concentration of personnel resources on the milestones for timely publication of the Sub-Areas Interim Report in 2020, certain R&D projects (see Research & Development) and other contracts planned for 2021 could only be initiated after a delay. Furthermore, due to the restrictions of the Covid-19 pandemic, many events were held in an online format, as in the previous year. This led to lower costs overall.

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Product control measures

In 2021, once again, the main tasks of product control were the qualification of conditioning processes, examination and approval of flow charts, change requests for existing flow charts and waste packages, and container type testing. For 2021, the intention had been to place 590 applications for product control measures based on the annual plan agreed with the applicants. A total of 492 applications were actually submitted. This equates to a variance of approx. 17% between planned and submitted applications. Experts were brought in for technical assessments in the scope of product control of radioactive wastes and container type testing. These experts were commissioned for a total of 486 test procedures and presented 458 test results and appraisals. In the same period, 343 notices were issued by the Product Control department within the scope of radiological examination. 41 applications relating to container type testing received a decision. In total, Product Control issued 384 decisions in 2021. This is about twice that of 2020.

Implementation of the incidental provisions of the water resources law is a crucial factor for ensuring suitability as a final repository according to the plan-approval decision (nuclear licence) for Konrad. In 2021, expert services for the implementation of approvals for the incidental water law provisions for Konrad (plan-approval decision Annex 4) were newly put out to tender, and work began in September 2021. Also in 2021, development and implementation of the NWL tool (Nuclear Waste Logistics tool) commenced as part of the NWL project for introducing a digital approval request management system. The two project sub-steps 'requirements engineering & process modelling' and 'platform architecture' were also completed on schedule. The milestone 'introduction of a pilot system' was reached on 15 December 2021.

The introduction of a new cost-covering and fair invoicing system for product control will be postponed due to the need for further coordination of the invoicing modalities under tax and accounting law. This milestone could not be reached in 2021.

As part of the standardisation of digitalisation, the successive review of the inventory documentation for completeness as well as its final filing in combination with complete digitalisation was continued in 2021. A further milestone was reached in 2021 with the complete transfer of the documents on container type testing and HAW (High Active Waste).

Technical notes explaining and specifying the requirements arising from the final storage conditions and the product control reports were prepared and issued by BGE. These documents serve, among other things, to illustrate appropriate procedures for carrying out the product control process. Regular technical meetings and special technical and status discussions were held in 2021 to targetedly coordinate the work relating to product control and type testing. Energy supply companies, container manufacturers, experts, and supervisory authorities participated in these to discuss current issues, to identify and schedule time-critical tasks, and to monitor their execution.

Gorleben mine: Hartmut Preuß driving through the approx. 600 ha area for compensation and replacement measures in the district of Lüchow-Dannenberg. A brooding swan has taken up residence at the "Garte Teichen" ponds. Donkeys and sheep assist with landscape management.

Earnings, financial position, and net assets

Earnings

The company's revenues increased by €30.113 million compared to the previous year, from €445.890 million to €476.003 million. Of this, €475.604 million (previous year €445.525 million) are attributable to the shareholder. Revenues additionally include the invoicing of services to the subsidiary BGE TEC in the amount of €333,000 (previous year €306,000) as part of the agency and service agreement, as well as revenue from the canteen business (€66,000; previous year €58,000).

Other operating income (€12.069 million; previous year €3.226 million) mainly includes income for the correction of provisions already made in previous years for VAT risks (€6.819 million) as well as provisions no longer required for expected service settlements in 2020 (€4.301 million; previous year €636,000). Other operating income of total €949,000 (previous year €2.590 million) includes recourse and compensation claims against contractors, the reimbursement of the trade union IG BCE, offset remuneration in kind, credit notes from contractors, and a reimbursement of costs for a research contract.

The costs of operational management in the amount of €488.157 million (previous year €449.256 million) break down as follows:

Gorleben mine with salt dump

Costs of operational management

in thousands of euros	2021	2020
Material expenses	260,274	236,244
Cost of raw materials, consumables, and supplies	30,399	29,727
Cost of purchased services	229,875	206,517
Personnel costs	197,744	177,838
Depreciations	28	0
Other operating expenses	27,670	23,214
Interest and similar expenses	2,171	7,185
Taxes on income and earnings	216	4,726
Other taxes	54	49
Total	**488,157**	**449,256**

Management report for the fiscal year 2021

The cost of purchased services mainly includes work and other service contracts, temporary employment, energy costs, guard services, and maintenance measures.

Personnel costs include all wages and salaries, social security contributions, and costs for pension schemes.

The €27.670 million (previous year: €23.413 million) in other operating expenses mainly comprise general administrative expenses, including rental costs, expert appraisals and external consulting services, incidental personnel expenses, and fees relating to nuclear supervision.

Assets and financial situation

The total assets increased by €26.848 million compared to the previous year and now amount to €154.024 million (previous year €127.176 million). This is mainly attributable to the increase in receivables from the shareholder for provisions that have yet to become effective as well as trade payables as of the balance sheet date.

Fixed assets amounting to €4.735 million (previous year: €5.113 million) include €4.045 million (previous year: €0 million) in tangible assets and €690,000 (previous year: €5.113 million) in financial assets.

The reported property, plant, and equipment (acquisition of property in Peine) was recognised at acquisition or production cost and offset against the loan granted to PALEA in the same amount. Other tangible fixed assets in connection with the Peine property were recognised at acquisition or production cost and offset against an investment grant in the same amount (net method), so that the respective asset is recognised with a book value of zero. Accordingly, there is no depreciation for this asset.

In addition to receivables from the shareholder amounting to €122.535 million (previous year €111.000 million), current assets include advance payments made to contractors (€13.837 million; previous year €5.840 million) and credit balances with banks.

On the liabilities side, current assets are mainly offset by debt capital in the form of project-related trade payables and provisions.

The provisions increased to €77.261 million (previous year €67.306 million) and result from the following: Pension provisions and similar obligations (€16.906 million; previous year €16.404 million), outstanding invoices (€36.108 million; previous year €20.049 million), procedural costs for decommissioning the Morsleben repository for radioactive waste (€6.934 million; previous year €7.368 million) and for decommissioning the Asse II mine (€3.600 million; previous year €3.556 million), VAT risks (€5.983 million; previous year €11.833 million), personnel obligations (€7.662 million; previous year €6.634 million), income taxes (€0 million; previous year €1.389 million), and financial statement costs (€68,000; previous year €73,000).

Within liabilities (€71.851 million; previous year €54.869 million), trade payables predominate at €48.879 million (previous year €35.302 million). Other liabilities (€17.901 million; previous year €15.567 million) essentially comprise value-added tax (VAT) and wage tax payable. Another €5.071 million (previous year €4.000 million) was recognised for liabilities to the shareholder and the subsidiary.

Equity decreased in 2021 by €89,000 from €5.001 million to €4.912 million. The equity ratio is 3.2% (previous year 3.9%).

The financial situation is secured at all times through financing from federal budget funds in the scope of the commissioning by the shareholder. For this reason, separate lines of credit from banks are not required and are therefore not held.

Personnel and social report

As of 31 December 2021, BGE had a total of 2,203 employees working at eight locations, divided into 2,044 company employees (annual average 1,941), 79 BfS-appointed civil servants and public sector employees, and 80 temporary workers.

In 2021, in response to job advertisements, 17 temporary workers were taken on, most in fixed-term contracts; 33 formerly temporary employees were made permanent. As of 31 December 2021, there were a total of 167 fixed-term contracts.

The family-friendliness of BGE was audited, which concluded with its certification in 2021. A project team has been set up to coordinate and monitor the implementation of the agreed measures from the 'berufundfamilie' audit and certification process. They have started, for example, with the creation and design of a separate section on the intranet for information about this topic.

As of the balance sheet date, eight of the sixteen supervisory board mandates are held by women (50%). Since the departure of Beate Kallenbach-Herbert, the proportion of women on the executive board has been 0%. According to the Equal Opportunities Plan, a women's quota of 30% in the management levels F1–F3 is to be achieved by the end of 2023. At the end of 2021, this quota was 20.6%.

As part of employer marketing, a company presentation was given to students of the geosciences faculty of RWTH Aachen University. BGE was able to present itself as an attractive employer for the future, not only for direct career entry but also for internships and master's theses.

One focus in 2021 was the continuation of the project to introduce SAP Human Capital Management (HCM) and to prepare for the go-live date of 1 January 2022. This was the first step towards standardising the time management system within BGE. The necessary measures for going live were initially prepared and tested at the administrative locations in Salzgitter, Peine, and Berlin. With its introduction, employees at the administrative locations now have a platform at their disposal which, among other things, enables the electronic recording of working hours and holiday applications, provides time booking overviews, and supports various change notifications on the system side. The plan for 2022 is to connect the various company sites by the middle of the year.

Various company and works agreements were revised, redesigned and negotiated, and the company regulations manual was transferred to Aeneis and adapted.

Management report for the fiscal year 2021

Training and continuing education

In 2021, as part of the internal measures for continuing education, 3,737 training courses were organised for the company, serving essentially to maintain or develop/expand the expertise and qualifications of the employees. Among them were nine employees who completed their qualification measures in the reporting period: Four of them successfully completed the technical school to become state-certified technicians and five successfully completed the senior class to become mining engineers. As of 31 December 2021, there were 52 trainees employed at four locations. 14 trainees passed their final exams, ten of whom were taken on as temporary employees and three as permanent employees.

Occupational health and safety

Covid-19

The measures taken in response to the Covid-19 pandemic within the joint crisis team of BGE and BGE TEC (general emergency plan, framework plan, coronavirus risk assessment, operational instructions, and concept for implementing the '3G rule' as a pandemic containment measure) were continuously updated in 2021.

These measures followed the resolutions and regulations adopted at federal and state level and were implemented in accordance with the warning levels applicable in each case. In addition to the ongoing implementation of the hygiene and testing concept, BGE continued its own vaccination campaign. In 2021, a total of 1,693 SARS-CoV2 vaccinations, 500 of which were booster vaccinations, were carried out, in some cases along with influenza vaccination. In this context, a back-up plan was established for a potential response to any demands for company medical resources arising at short notice (commissioning of fee-based physicians to support the vaccination campaign).

The disruptions caused by the Covid-19 pandemic (including travel restrictions, resource scarcity, supply chain issues, etc.) continue to affect all projects to varying degrees. The work in the underground and surface mines requires the presence of a large number of employees and

Asse mine: Trainee electronics technicians for industrial engineering, from left to right: Mika Gakenholz, Finn-Luca Hasse, Tim Steinke, Joans Schmidel, Justus Hoffeyer

is associated with spatial confinement for some activities. In order to prevent chains of infection at the workplace, the processes were spread out spatially and temporally over the year, in some cases – if not otherwise possible – even to the detriment of productivity and economic efficiency. In this way, it has so far been possible to avoid having to partially or completely close operations.

Public relations work, which was initially severely affected by Covid-19-related restrictions, were able to be ramped up from the middle of the year in compliance with hygiene concepts and the 3G rule, including the opening of the information points for the Asse, Konrad, and Morsleben projects. Public tours are still suspended; 3D visualisations are offered to give insights into current underground operations at each respective plant.

Occupational safety

Occupational safety has the highest priority in the planning and execution of all work. At BGE, there were a total of nine reportable work accidents among external and in-house personnel in 2021. This is two work accidents less than in 2020. Continuous awareness-raising and training measures are key tasks in this context. In 2021, the occupational health and safety programmes were further expanded with the support of the growing occupational health service. These include the company health day, the project for developing a health and safety culture, participation in the trainee competition 'Sicherheit von Anfang an' ('Safety from the Start') of the German Social Accident Insurance Institution for the Raw Materials and Chemical Industry (BG RCI), and the offer of occupational psychology services.

Management report for the fiscal year 2021

Forecast, opportunity, and risk report

Opportunity and risk report

Internal reporting and comprehensive controlling ensure that the management is promptly informed of potential opportunities and risks and can swiftly initiate appropriate measures and countermeasures.

There are no existential financial risks, since the costs of economic management are reimbursed by the BMUV upon notification of resource requirements through the call-for-funds procedure. The BMUV reimburses the costs incurred at cost price.

With uniform corporate risk management, the relevant risks of all corporate divisions are identified, analysed and evaluated, and necessary measures for risk management are determined and their implementation monitored. In the quarterly cycle, reports are issued on the priority risk situation of the respective departments. In addition to discussing the overall risk situation and the priority project risks, the four quarterly risk committee meetings in 2021 also focused on security and reputation risks. In 2021, the risk management system was developed further in order to aggregate risks that would affect deadlines of the major construction projects as well as to identify potential critical paths and the associated risks for the project schedule at an early stage and to manage these as a priority.

In 2021, as a part of compliance management, essential parts of a tax compliance management system were created with a tax guideline, and the controls were linked to the processes. Processing of the payroll tax and social security contributions started in 2021 and will be completed in 2022. The key controls defined there and those of eight other organisational units were recorded centrally in risk control matrices with a uniform system in the company-wide internal control system. In 2022, this recording will be completed and the first reviews of the controls will begin.

Forecast report

Regarding the forecast costs, please refer to the table in the 'Control system' section.

Currently, the war in Ukraine has no direct impact on the company. Also, BGE does not have any supply relationships with Russia, so no direct repercussions from the EU sanctions against Russia are to be expected. However, the supply chains, which are already fragile due to the Covid-19 pandemic, could be even more strained by the war and have an impact on the projects. Further price increases are also to be expected. At present, it can be assumed that the funds made available by the BMUV from the budget for 2022 are sufficient.

General

Various options for the Peine site expansion are being considered in 2022. These include planning for the expansion of the main administrative building in Peine or the leasing of additional properties. In addition, planning for the expansion of the transport infrastructure at the Peine site shall continue.

The information events, the conceptual further development of the internet presence, the management of the social media channels, and the press monitoring including preparation of the daily press review are all continuing.

The further expansion, ongoing maintenance, and optimisation of the integrated document management system are continuing.

The recording and modelling of corporate processes in Aeneis, which began in 2021, is continuing in 2022. In addition, the measurement of the process quality of priority processes shall start.

In 2022, the IT security concept is being expanded and updated, the expansion of company-wide Wi-Fi availability is continuing, and mobile maintenance is being expanded. Preparatory workshops on system architecture shall be initiated and the creation of technical requirements will continue for upgrading the relevant business processes by migrating to the new ERP software version SAP S/4HANA, a modern user-oriented IT solution as a measure for systematically improving business processes.

The digitalisation projects are continuing, including the expansion of the WLAN infrastructure for implementing 'Industry 4.0 applications', the control of traffic technology to minimise accident risks and in preparation for remote/autonomous operation of vehicles and working machines, as well as the presentation of the Open Platform Communications Unified Architecture.

Within the framework of the review procedure agreed in 2021 by BASE pursuant to Section 58 para. 4 of the Atomic Energy Act, it was agreed that, in addition to the review areas, the organisational and procedural set-up in the area of site selection would also be presented in a supplementary report. The documents are to be submitted to BASE by 30 April 2022.

Construction of the Konrad repository

The main focus of work in the Konrad area in 2022 is on the construction of the shaft cellar, depot, mine water transfer station, fan building, and reloading hall at Konrad 2, as well as on the construction of the workshop, guard building, and heating centre at Konrad 1.

At the Konrad 1 mine, the qualification of the northern shaft is being continued. This includes the construction of the new shaft chairs.

At the Konrad 2 shaft, the planning of the winding tower with shaft cellar is being finalised, applying the input values from the Konrad 2 shaft winding system. The preliminary review process und nuclear and mining law is ongoing for the shaft hoisting system and the winding tower with shaft cellar.

The planning documents for the three construction phases of the reloading hall are being prepared. The reloading hall is the central building at the Konrad 2 mine, where the waste packages will be delivered and prepared for transport underground during the subsequent emplacement operation. The respective licensing procedures under building and nuclear law are being finalised. Parts of the inner lining will be placed in the 2nd level and at the shaft collar. Underground, the expansion of the pit side rooms is continuing, among other things, with the installation of the inner shells. The expansion work in ramp 350 is continuing.

Management report for the fiscal year 2021

Decommissioning of the Asse II mine

As the concrete implementation of the precautionary measures, ridge gaps and remaining cavities in unused mine workings are being backfilled and geotechnical structures (sealing structures and flow barriers) are being constructed for sealing purposes. This is being done in particular in the medium active waste area (MAW area), in blind shafts and sinks, in parallel roads and side drifts, and in deep excavations.

Based on the technical, economic and licensing suitability assessment, preparations are being made for procuring a means of storage (caverns) for the counter-flooding solution (MgCl2 solution). This counter-flooding solution would be required in the event of a beyond-design-basis ingress of solution.

In preparation for retrieval, concept planning is commencing for retrieval of the waste from the 750 m level. The concept planning for retrieval of the waste from the 511 m and 725 m levels and the planning and development of the retrieval methods (salvage equipment) are being continued.

At the future site of Asse 5 shaft, the exploratory drilling R18 is being prepared in 2022. A new drilling site is to be planned and set up for this purpose. The design and licensing planning for the new shaft, including the facilities for ventilation and man haulage, are being continued. In addition, planning will begin for sinking the shaft and constructing the shaft pipe.

Various (partial) permits will be required for the retrieval in the coming years. With the submission of the planning notification to the NMU, the early start of the licensing procedure was initiated in 2020.

Preparation is continuing for an infrastructure concept geared to retrieval (buildings, transport and storage areas, media supply). The design and licensing planning for the waste treatment facilities and the interim storage facility is being continued.

The acquisition of land for shaft 5, including surface facilities and for the interim storage/ waste treatment plant, was planned for 2020 and 2021. Based on the experience gained so far from the difficult negotiations with the owners, some plots of land will probably not be acquired until 2022.

Decommissioning of the Morsleben repository for radioactive waste

For the planning approval procedure for decommissioning, the location reports, geological sections, and reports on the methodology for long-term safety verifications are to be prepared in 2022. Also, the demonstration structure is to be built in the main anhydrite to evaluate the properties of drift sealing with magnesia clay.

In addition, in-situ and laboratory tests are being carried out to evaluate closures of safety-relevant boreholes as well as investigations on backfill and closure materials. Work continues on procedural documents, e.g. the reports on the general site description and on the methodology for creating the repository model.

The optimised decommissioning plan provides for further drift sealing to separate the solution access point at Storage H. For carrying out the exploration measures at the sealing sites, the plans for 2022 include preparation of the drifts, among other things.

The dismantling of the surface control area, relocation of the control area transition to underground, and dismantling of the active laboratory are being continued. The underground fire alarm systems are being renewed. The awarding of the design planning for construction of the Marie shaft hoisting system is starting. Construction work is to begin on the new Bartensleben office and administration building and the rehabilitation of roads, paths, and cable shafts is to continue.

Gorleben

In Gorleben, maintenance measures and replacements will be carried out to continue safe operation and enable safe decommissioning. The planning and execution tasks for closing the Gorleben mine, bringing the salt dump back underground, and backfilling the mine workings are to be partially contracted out.

Site selection procedure

In addition to developing methods for carrying out the representative preliminary safety assessment and its validation, the work in 2022 will also focus on the start of actually carrying out this assessment. Furthermore, the methods for applying the geoscientific weighing criteria (geoWK) in accordance with § 24 StandAG and the planning scientific weighing criteria (planWK) are continuing, and development of the exploration programmes for surface exploration are being elaborated.

With the public presentation and discussion of methods for applying the representative preliminary safety assessment in the first quarter of 2022, this is to be validated and subsequently carried out for each subarea. This will also allow the time required to determine the siting regions to be estimated and a corresponding schedule to be drawn up. The presentation and discussion of a working status of the elaborated method for applying the geoWK and a working status of the method for applying the planWK are planned for the beginning of the third quarter of 2022.

It is still open as to how further participation formats will be designed in Step 2 of Phase I and how strongly the area of site selection will be tied in here.

Product control measures

As already in 2021, in 2022, the qualification of conditioning processes, examination and approval of flow charts, change requests for existing flow charts and waste packages, and container type testing were the main tasks relating to product control. Based on the 2022 annual planning carried out with the applicants, Product Control expects a further increase in product control measures. To be able to work on the continually large number of application procedures and to accelerate the processing of application procedures, the increase in personnel is continuing in 2022. The Product Control department will also continue to be supported by independent expert organisations and will hold technical discussions with all parties involved in order to coordinate the topics of product control, type testing, and exercise of the qualified permission issued under water law.

In addition to the product control measures, the full implementation and further development of the digital application management system will be at the forefront in 2022.

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After the presentation of the NWL pilot system on 15 December 2021, processing is planned for 2022 as part of the third and final project sub-step 'Project Implementation'. Go live is scheduled for 1 April 2022. In addition, the completion and digitalisation of the entire procedural documentation is being continued in 2022.

The introduction of a new cost-covering and cause-related accounting system for product control will probably be changed in 2022 after the final assessment and coordination of the tax and accounting effects for the company.

Peine, 31 March 2022

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Chair of the Management Board

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Deputy Chair of the Management Board

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