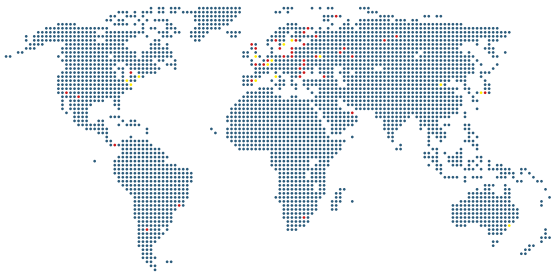

BGE TECHNOLOGY GmbH

ANNUAL REPORT

Income Statement

For the period from January 1 to December 31, 2021

all figures in T€	Notes		2021		2020
1. Turnover	(8)		6,158		5,376
2. Change in inventory of work in progress	(9)		–103		–115
3. Other operating income	(10)		42		41
			6,097		**5,302**
4. Cost of materials	(11)				
a) Cost of raw materials, consumables, and supplies and of purchased merchandise		15		6	
b) Cost of purchased services		1,648		881	
			1,663		887
5. Personnel expenses	(12)				
a) Wages and salaries		3,172		3,106	
b) Social security contributions and expenditures for pensions and similar obligations		814		764	
			3,986		3,870
6. Depreciation and amortisation of intangible and tangible fixed assets			29		32
7. Other operating expenses	(13)		327		316
			92		**197**
8. Other interest and similar income			0		1
9. Interest and similar expenses	(14)		16		24
10. Taxes on income	(15)		36		66
11. Results after taxes			**40**		**108**
12. Other taxes			6		0
13. Net profit for the year			**34**		**108**

Contents

Dear Readers,

Through intensive reflection and discourse alone, the ancient Greeks obviously already thought ahead to many of the questions of our time. Of particular relevance are the thoughts of Heraclitus, who recognised that the world does not stand still but is subject to constant change. "Panta rhei" – everything flows – is the perhaps somewhat abbreviated expression to which his philosophy is usually reduced.

And in 2021, a lot was in flow. Corona directly taught us new ways of working. We now work together online across great distances, and we can work effectively from anywhere, so that family and work can be combined in the best possible way. On the other hand, we now also know that the relaxation of working conditions has its limits and that we very much need certain structures and rules to work effectively and even creatively. Indirectly, Corona has taught us that we also depend on the large global flows of materials and goods on a small scale. This also became clear through the many existing and impending conflicts in the world, which also showed our society that many a villain unfortunately cannot be stopped from his actions by affectionate and friendly coaxing.

There was also a lot in flow in our little world, our BGE TECHNOLOGY GmbH. We finished several major projects and have started several new ones. But in particular, we have reorganised ourselves. We have developed and implemented a structure that allows us to master the generational change that is imminent in our company.

Our organisation focuses on building and maintaining disposal- and repository-relevant knowledge and is divided into the departments "Repository Technologies", "Numerical Modelling", and "Geotechnical Engineering". As the projects themselves, however, are generally based on the entire competence of BGE TECHNOLOGY GmbH, the divisions "Research & Development", "National Projects", and "International Projects" support these departments in order to ensure firm contacts in the organisation.

To maintain the accustomed quality of our daily work and the tasks entrusted to us alongside these major changes and other smaller challenges, it takes a great amount of personal commitment on the part of our colleagues at BGE TECHNOLOGY GmbH.

I would like to take this opportunity to thank everybody involved very much for this. At the same time, I would like to emphasise the trusting and constructive cooperation with our new and long-standing partners and clients both national and international as well as with authorities, ministries, and other companies. Last but not least, our parent company, BGE, is also one of these partners. It is a real pleasure to be able to support their work on the safe disposal of radioactive waste with our knowledge.

We try to share a little of the pleasure we have in our work with you in this annual report. I hope we succeed!

Yours,
Thilo v. Berlepsch
Managing Director

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Our Team

Interview with Dr. Thilo von Berlepsch and Philipp Herold

Interview with Dr. Thilo von Berlepsch, Managing Director, and Philipp Herold, Head of Repository Technologies, about the past business year of BGE TECHNOLOGY GmbH, about the challenges of the coming years, and about how experience in the international field can help.

How successful was the business year 2021 for BGE TECHNOLOGY GmbH? And: How strong is the company by now?

Thilo von Berlepsch (TvB): That really depends on how you look at it! If we look at the mere figures, I have to say that we have had more successful business years. But the figures show only one side of the coin. The other side shows: We have completed quite a number of large projects and have therefore dealt with a large number of tenders. One of them was for Belgium. After an elaborate, multi-stage process, we have now been awarded a contract at the beginning of 2022. This is a five-year framework agreement. In terms of contents, this is very exciting for us. We will continue to support ONDRAF/NIRAS in the development of the Belgian repository concept for long-lived intermediate-level and high-level radioactive waste. It is not just a matter of developing individual systems such as emplacement devices and backfill material; the design of the entire mine workings and the planning of the operation of the repository are required, taking into account both operational and long-term safety. We are of course very happy about this! Another point I can mention is the reorganisation of the company – which has also been very challenging for us. We currently have 36 employees. And we are always looking for more support!

What was the reason for the reorganisation? And of course we are curious to see what it looks like? And when will it start to take effect?

TvB: We are indeed facing a generational change. A large part of the departmental management team will leave in the next one to two years. In the future, we would like to distribute the tasks and responsibilities of the previous department heads across several shoulders and use the opportunity to optimise our processes by orienting them along the fields of knowledge relevant to a repository. These are in particular the departments "Repository Technologies", "Numerical Modelling", and "Geotechnical Engineering". In addition, we will establish project management divisions from the beginning of 2022, in order to be able to continue to meet the different requirements of our clients. The requirements for the projects sometimes differ considerably, and this is exactly what we want to reflect with the project management divisions. In the past, the individual department heads had very many, and recently even too many tasks. They were involved in the day-to-day business, took care of acquisitions, and much more. I actually see this as an opportunity for our young colleagues to take on more responsibility. Another thing that is important to me is that we have stronger networking and exchange among ourselves.

Morsleben repository: Activities in mine working 1a

Which projects are particularly exciting from your point of view at the moment? What do you learn from them? You are also active on an international level.

Philipp Herold (PH): We are currently very busy implementing our knowledge concerning repository concepts in crystalline rock for requirements of our parent company BGE. In this regard, we are involved in the development of waste containers. In recent years, we have already addressed this topic in various research projects. In a consortium with GNS Gesellschaft für Nuklear-Service mbH, we can now also apply this knowledge in a targeted manner. The CHRISTA II project should also be mentioned in this context. This project is about developing safety and safety verification concepts for a repository for high-level radioactive waste in crystalline rock in Germany. This also includes the corresponding repository concepts. On the one hand, the waste container is an essential component of these concepts. On the other hand, we also see that this work can provide a basis for the colleagues from the site selection department, which they can use to develop the repository concepts for the search for a repository site.

Also very fascinating: In Norway, we are working on a completely different type of disposal. Here, the extent to which disposal in deep boreholes is possible is also being examined. This works particularly well because the waste inventory in Norway is significantly lower than in Germany. If we transferred this process to Germany, we would need 30 or even more boreholes, depending on the technical concept! In Norway, a single one would be enough. Nevertheless, the topic is very interesting for us. The question is similar, but in this case, we have to look at it from a completely different angle.

This is a good example of how working in the international projects forces us, on the one hand, to look at questions about disposal from a different angle and, on the other hand, to understand solutions that deviate from the concepts pursued in Germany through active cooperation. This means that our, and in particular BGE's, expertise covers a multitude of fields and that we can provide answers to many questions about disposal.

What are the biggest challenges for BGE TECHNOLOGY GmbH in the coming years?

TvB: I actually see the biggest challenge for the company in the upcoming generational change! Linked to this is the question of how to retain the expertise of the "old hands" within the company. We know: Our issues are so complex that it takes two to three years for someone to become familiar with them – and in some specialised areas even longer. We also have many enquiries – which is very positive on the one hand, but of course, we also want to satisfy them in the usual quality.

It doesn't get boring?

TvB: Definitely not!

The interview was conducted by Martina Schwaldat, Corporate Communications at BGE.

Formwork wall for the construction of a sealing structure, Asse mine

Geotechnical Barriers

Geotechnical Barriers

When selecting a site for a repository for heat-generating, high-level radioactive waste in a mine, rock salt, claystone, and crystalline rock are considered as possible rock formations in Germany. After emplacement of the waste, the repository mine must be backfilled and the transport of radionuclides from the repository must be prevented or limited to negligible levels by a system of technical and geotechnical barriers. This way, the radionuclides remain concentrated in an isolating rock zone.

Due to the diversity of geologic and hydro-geologic conditions and possible host rock formations, very different framework conditions have to be taken into account for the respective geotechnical barrier system. The host rock rock salt is tight in its undisturbed state and has only very low moisture contents – it is practically dry. Accordingly, a geotechnical barrier system for rock salt aims at preventing solutions that may penetrate from outside from reaching the radioactive waste and from mobilising radionuclides. Thus, the geotechnical barrier system must also have a high degree of tightness, which must be maintained in the long term. In the case of claystone, a higher moisture content is to be expected; but claystone is characterised by stagnant waters, so that a potential transport of radionuclides will be mainly diffusive and thus very slow. Here, the goal is to design the geotechnical barrier system in such a way that it does not allow faster radionuclide transport than the host rock barrier itself. The hydraulic gradients are thus to be kept so low that diffusive transport dominates. What salt and claystone have in common is that in suitable formations, there is sufficient space for the geotechnical barrier system.

The situation is entirely different in crystalline rock. Given its formation history, water-bearing fissures must be assumed. For this reason, the design of the geotechnical barriers focuses on the vicinity of the emplaced waste containers. In addition to the containment effect of the container itself and of the bentonite buffer surrounding it, a concept is being investigated that aims at improving the rock in the vicinity of the containers by means of injections in such a way that nature-identical, tight fissure fillings are created, thus enclosing the radioactive waste by an additional, crystalline sarcophagus.

Improving the Properties of the Contact Zone of Geotechnical Barriers

In-situ Test STROEFUN

In ensuring the safe containment of radioactive waste in a containment providing rock zone (CRZ) in rock salt, drift seals play an essential role, as they seal the means of access to emplacement fields that penetrate the geologic barrier.

Drift seals consist of a core barrier made of MgO-based concrete, which is sandwiched between abutments. The excavation-damaged zone (EDZ) in the rock, which runs parallel to the core barrier, and the contact zone between the structure of the core barrier and the rock contour are also part of the drift seal, as these three elements are crucial for the functionality of the drift seal. Due to the parallel arrangement of the elements, the element with the lowest hydraulic resistance is decisive for the sealing effect.

As part of the joint project STROEFUN, a measuring method was developed that is capable of capturing the permeability of the contact zone of the entire cross-section. Furthermore, the permeability of the contact zone can be reduced by injection measures, and the injection success can thus be demonstrated by measurements. To test this method, an in-situ test is being carried out at the Teutschenthal mine. For this purpose, the lower half of a sealing structure made of MgO concrete was constructed in a drift stub. Before concreting, temperature and pressure sensors as well as injection hoses for the eventual improvement of the contact zone were installed on the contact zone in addition to the measuring system for permeability measurements. In August 2021, the MgO concrete was placed in layers in five 10-hour shifts. The concreting of the total of 100 m³ of MgO concrete went off without any problem.

The temperature sensors showed the predicted rapid rise in temperature to slightly above 100 °C. Associated with the temperature rise was a pressure build-up, with the pressure sensors showing maximum values between 1.2 MPa and 4.4 MPa. When the temperature cooled down again, the pressures dropped to values close to zero, but remained in the pressure range. After reaching the minimum, the pressure increased again and reached a pressure level of about 1 MPa, which remained constant until the end of the year.

First tests of the measuring system to determine the permeability of the contact zone showed its effectiveness. A typical permeability level in the order of 1E-14 m² to 1E-15 m² was observed, as was also achieved in pneumatic tests before injection and creep of the rock in other in-situ tests. These measurements will be continued in 2022 alongside the injections.

The research project STROEFUN is funded by the Project Management Agency Karlsruhe (PTKA) on behalf of the Federal Ministry for Economic Affairs and Energy. The project is managed by Clausthal University of Technology with BGE TECHNOLOGY GmbH as subcontractor.

»The measuring system for the integral determination of the hydraulic properties of contact zones has proven itself in practical use. This paves the way for systematically investigating this narrow area and for recording its changes over time – an important step towards providing concrete evidence of the safe containment of radioactive waste.«

Dr. Nina Müller-Hoeppe, Civil Engineer

Concreting the lower half of a sealing structure in the Teutschenthal mine

Access tunnel to the Bedretto underground laboratory

Quantifying the Dilatancy and Fluid Pressure Criterion in Crystalline Rock

Project PRECODE

The excavation of mine openings as well as the time-dependent brittle fracturing around drifts can lead to a coherent fracture network (i.e., excavation-damaged zone – EDZ) and thus provide potential pathways for radionuclide migration.

To improve the knowledge about the properties and evolution of the EDZ in brittle rock, Bundesgesellschaft für Endlagerung (BGE) finances the PRECODE project, which RWTH Aachen University has initiated in collaboration with the Swiss Federal Institute of Technology (ETH) and York University. BGE TECHNOLOGY GmbH is also participating in this project. The general project objectives are (i) to improve the understanding of EDZ development in crystalline rock, (ii) to test methods for near-natural fracture filling using injections to reduce rock permeability, and (iii) to develop a method for quantifying the dilatancy and fluid pressure criterion in crystalline host rock. BGE TECHNOLOGY GmbH will focus on the latter two objectives.

Injections for systematic rock improvement have not yet been included in any repository concept. Furthermore, it is of great interest for the German concept of safe containment to examine whether it is possible to create near-natural, long-term stable fissure fillings by injections. The use of such injections has already been investigated for the crystalline rock in Scandinavia, but was not pursued further because the Scandinavian safety concepts differ from the German ones. BGE TECHNOLOGY GmbH has developed injection procedures for the Asse II mine, which is located in rock salt. Here, the injections can now be applied as a standardised process chain (material, technology, analysis), and the hydraulic resistances of the injected areas can be verified according to the requirements. The injection tests are carried out in the Bedretto Underground Lab (Switzerland), where ETH Zurich has set up a new underground research laboratory. The core facility of the URL is located in the Rodondo granite at a depth of approx. 1100 m.

»The research work in the Bedretto underground laboratory gives us the opportunity to demonstrate the technical feasibility of rock injections. Injections in a repository are primarily intended to seal off pathways and thus increase the containment function of the rock.«

Philipp Herold, Mining Engineer

Salt processing plant for the production of sorel concrete, Asse mine

Backfilling Measures

Backfilling Measures

A multi-barrier system of a repository comprises engineered, geotechnical, and geologic barriers. They are to isolate the radionuclides from the biosphere. The successful functioning of these systems requires that the barriers are permanently effective. However, their integrity can be compromised in many ways. To avoid damage to geologic barriers by rock pressure, cavities must be backfilled to stabilise the rock mass. In addition, construction materials are used to protect engineered barriers. Fluids can react with barriers and thus shorten their functional life, and they transport radionuclides. Consequently, their volume and flow in the repository must be minimised by backfilling measures. In addition, it may be necessary to create stable cavities as fluid reservoirs, which can delay and limit pressure build-up.

Backfill materials can also actively contribute to the isolation of radionuclides by binding substances that damage the barriers. There are also many ways to reduce the solubility of radionuclides or to fix the substances, which means there is a wide range of applications as geochemical barrier.

Backfilled repository areas can also act as geotechnical barriers to interrupt flow paths in the long term and thus be an essential component of redundant and diverse sealing systems. Like geotechnical and engineered barriers, backfilling measures must therefore be designed for specific sites and tasks and in the context of the multi-barrier system. This way, the individual elements in combination and as part of an individually designed decommissioning concept contribute optimally to the permanent protection of the biosphere.

The facts that solution is already intruding into the Asse II mine and that the radioactive waste has to be retrieved result in a large number of specific backfilling measures, such as filling cavities with building material. The support effect of old crushed salt backfill is improved by means of injections that reduce the compactable pore space of the backfill. The work carried out by BGE TECHNOLOGY GmbH shows that backfill improved in this way can also act as a geotechnical barrier in the long term.

Extensive work was carried out as part of the KOMPASS I and II research projects with the aim of being able to use the compaction of salt backfill when preparing safety demonstrations. They allow BGE TECHNOLOGY GmbH to reliably model and predict the behaviour of salt backfill up to the range of very low porosities and permeabilities.

However, any application of backfill requires that the materials and the backfill structures meet a wide range of requirements. As the achievement of a defined installation condition is of particular relevance, the development of quality assurance programmes has a long history at BGE TECHNOLOGY GmbH. In the future Konrad repository, different backfill materials have to be used and several material streams and emplacement procedures have to be taken into account. It was thus a great advantage to be able to use our wealth of experience.

The examples illustrate how BGE TECHNOLOGY GmbH is creating an essential framework for the disposal of radioactive waste in deep geologic formations.

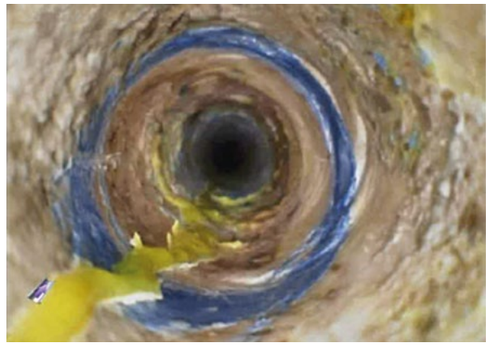
Consolidation and Sealing of Backfill in the Asse II Mine

Asse Mine

Between 1967 and 1978, low- and intermediate-level radioactive waste was emplaced in the Asse II mine. Characteristic of the mine workings is a large number of chambers and drifts, some of which have only a small distance to the adjoining rock. The long operating time of the mine led to damage to the salt barrier, so that salt solution has been intruding since 1988.

As the development of the inflow rate is hardly predictable, it was decided to retrieve the radioactive waste. With the aim of protecting the emplacement chambers, flow barriers are currently being erected. In addition, cavities are being backfilled with magnesia binder to stabilise the mine openings. In the event of uncontrollable inflow rates, an inert salt solution is to be pumped into the underground cavities.

Crushed salt already backfilled into chambers compacted to such an extent that the rock mass was not sufficiently supported, which led to the formation of cavities. With the aim of improving the load-bearing capacity and the tightness of the backfill, BGE TECHNOLOGY GmbH carried out a status analysis that allowed the planning of backfilling measures and backfill injections. A drilling programme provided data on the dimensions and locations of cracks as well as the composition and pore size distribution of the backfill. Thus, backfill and injection materials could be selected and optimised, and new long-term stable construction materials could be developed. Subsequently, the technical equipment was selected and the injection strategy was specified. The results of the building material tests and the data analysis of the injection parameters formed the basis of a customised quality assurance programme.



Borehole camera inspections of the compacted backfill of the Asse II mine

Suspensions were used to grout larger cavities and cracks, and then the pores of the backfill were injected with solutions. The fact that increasingly higher pressures could and had to be applied was a result of the improved load-bearing capacity and impermeability of the backfill. Investigations on drill cores confirmed the success of the work, which could also be visually demonstrated by borehole camera inspections. Once the boreholes had been backfilled to the required quality, all project goals were met.

»Depending on the specific tasks, different injection methods are used. The backfill injections carried out are a combination of rock, pore, and compaction injections and are based on a wide range of different methods. All work, from planning to demonstrating success, is an interactive and iterative process that requires interdisciplinary collaboration of experienced professionals.«

Holger Schmidt, Geotechnical Engineer

Follow-up Project on the Compaction of Crushed Salt for Safe Containment

R&D Project KOMPASS-II

After the first phase of the KOMPASS project had been successfully completed in 2020, the follow-up phase for the compaction of crushed salt for safe containment began in 2021 with the KOMPASS-II project. The project is a joint project of the German project partners GRS gGmbH, BGE TECHNOLOGY GmbH, Federal Institute for Geosciences and Natural Resources (BGR), Institut of Geomechanics GmbH (IfG), and Clausthal University of Technology (TUC) in cooperation with SANDIA (USA) and Utrecht University (Netherlands). The project is scheduled to run from 01.07.2021 to 30.06.2023.

Building on the results of the successful previous project phase, the current project goals are to refine the control parameters during pre-compaction and to broaden the experimental database with regard to THM-controlled tests. Furthermore, in-depth microstructural analyses of the pre-compacted samples with regard to their equivalence to the in-situ compaction process and of samples of the subsequent normal compaction process are to be carried out. In addition, the mechanical and hydromechanical material models are to be further developed.

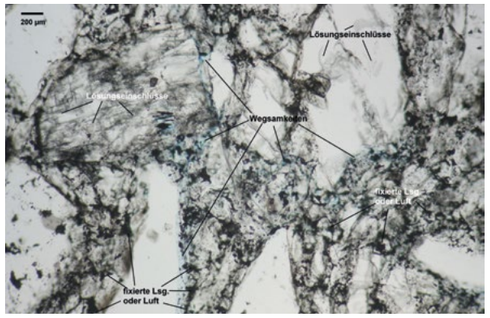


Photo of a thin section of compacted crushed salt

The particular importance of the constitutive models results from the fact that – depending on the state variables of the host rock – the containment efficiency of the granular salt can only be established at a late stage, so that physical demonstrations have to be replaced by numerical verifications. Due to our expertise in numerical modelling, BGE TECHNOLOGY GmbH contributes to the project with the further development of the material model according to Hein, which was already used in earlier projects such as BAMBUS. The main focus of the work is the implementation of deformation processes, which are influenced by changing state variables, as well as of processes that are more pronounced in the case of strongly advanced compaction. The experimental and microstructural findings obtained in the project are the basis and the benchmark for the development of material models. The applicability will be demonstrated by means of a numerical demonstrator.

The project is funded by the German Federal Ministry for Economic Affairs and Energy (BMWi), represented by the Project Management Agency Karlsruhe (PTKA), as well as by the U.S. Department of Energy (DOE) and Centrale Organisatie Voor Radioactief Afval N. V. (COVRA).

»With regard to disposal in rock salt, the long-term development of crushed salt is one of the main knowledge gaps. In the research project KOMPASS, methods and strategies were developed to close this knowledge gap and to improve the prediction of crushed salt compaction in the low-porosity range.«

Christian Lerch, Mechanical Engineer

Quality Assurance Concept for Backfilling the Konrad Repository

Konrad Repository

The former iron ore mine Konrad is currently being converted into a repository for low- and intermediate-level radioactive waste. As part of the disposal operation, chambers and drifts are to be backfilled. After the containers have been stacked and shotcrete walls have been constructed, cement-based material will be pumped into the emplacement chambers.

The cement of the backfill mixture will be pneumatically conveyed from the surface to the underground mixing plant via the shaft. Excavated material will be processed into aggregate for the backfill material and into bulk material backfill. Special purpose vehicles will transport all materials necessary for the backfilling measures.

To ensure a smooth work progress and that the cavities are filled to a high standard of quality, the requirements for the raw materials, the building materials, and the process steps have to be specified. Furthermore, the material properties have to be determined using suitable testing methods.

BGE TECHNOLOGY GmbH is certified according to DIN EN ISO 9001:2015. We cooperate with many certified testing institutes and have extensive experience in the development and application of quality assurance programmes within a wide range of construction measures. We have consequently been commissioned with the demanding task of developing the quality assurance concept for the complex backfilling measures. It is based on established procedures in construction materials technology and takes into account the special framework conditions of the Konrad mine and the disposal of radioactive waste. Optimised for the individual building materials, the concept includes production controls of the technical equipment and conformity controls. The aim of the latter is to demonstrate compliance with the material requirements. In addition to this, in-house and independent third-party inspections will be carried out.

This way, BGE TECHNOLOGY GmbH contributes a key component to the operation and decommissioning of the first repository licensed in Germany under the German Atomic Energy Act.

»Quality means that services and products meet specified requirements. Quality is not a matter of coincidence, but the result of an efficient and systematically structured work process. With the design of the concept, we were able to develop a path for the successful backfilling of the Konrad repository.«

Dr. Hans-Joachim Engelhardt, Geoscientist

Tests with tube viscosimeter

Demonstration test for the borehole emplacement of fuel rod canisters, machine hall in Landesbergen (Nienburg/Weser)

Technological Aspects

Technological Aspects

The area of responsibility of the Repository Technologies Department covers all project phases of radioactive waste disposal, from the design, planning, construction, and operation of a repository to its decommissioning and closure. The tasks are not limited to geological repositories for radioactive waste in different host rocks; near-surface repositories are also in the focus. In addition, issues related to emplacement and disposal technologies, the dismantling of nuclear facilities, and to comparable tasks in conventional mining are addressed. The tasks are distributed across all project areas of BGE TECHNOLOGY GmbH. One focus is the field of research and development projects. The implementation of these R&D projects enables BGE TECHNOLOGY GmbH to make a substantial contribution to the advancement of scientific and technical know-how in the field of radioactive waste disposal. The knowledge generated can also be applied in the other areas. Almost all of the typical sub-tasks of the Repository Technologies Department are implemented in the context of ongoing or recently completed research and development projects.

As an example, the work of BGE TECHNOLOGY GmbH on the subject of deep borehole disposal can be mentioned. The opportunities and risks of this disposal option were examined in the CREATIEF research project. With the decision in favour of deep geological disposal in Germany, the alternative of deep borehole disposal has receded into the background. Nevertheless, for the disposal programmes of other nations with their specific boundary conditions, deep borehole disposal offers advantages that justify further development. Particularly for small waste volumes, deep borehole disposal is a flexible and cost-effective option. This motivation led to our cooperation with CSIRO (Australia). The knowledge on deep borehole disposal and also on emplacement techniques that was initially generated in national research projects can thus be applied and further developed within the framework of international cooperations.

Within the TREND project, for example, it was possible to revise the transport and emplacement technology for high-level radioactive waste and transfer it to a uniform planning basis. Emplacement in horizontal drifts, in vertical boreholes, in horizontal boreholes, or in horizontal short boreholes is basically applicable in each of the three host rocks to be considered in Germany. In addition to taking into account the experience gained from previous demonstration tests, TREND incorporates current technical requirements and a possible adaptation of the geometry and mass of the waste containers. The emplacement and transport devices developed thus form a basis that can be transferred to all host rocks in the future.

Further Development of the Transport and Emplacement Technology

R&D Project TREND

From January 2019 to February 2021, BGE TECHNOLOGY GmbH worked on the further development of the technology for the transport and emplacement of high-level radioactive waste in a repository mine within the scope of the TREND research project. For this purpose, the existing concepts of transport and emplacement technology for different waste packages and different emplacement options were brought to a comparable level of development. This was achieved in particular across the various combinations of emplacement concepts, waste containers, and host rock formations.

The already existing concepts for the direct emplacement of transport and storage containers as well as for vertical borehole emplacement were further developed taking into account the state of the art and current regulations. One major adjustment was equipping the emplacement device for vertical borehole disposal with a second hoisting rope. The driving factor behind this decision was not so much operational safety but the requirement of retrievability of all waste containers during the operating phase of a repository. As a crash of a waste container into a vertical borehole would make retrieval extremely difficult, the emplacement device was classified as a device to which "additional requirements" apply according to regulation no. 3902 for nuclear facilities (KTA 3902). For emplacement in crystalline rock, a technical concept was developed that allows waste containers to be emplaced in vertical boreholes without having to cut a borehole cellar into the rock, as

Concept of an emplacement device

was required in the previous emplacement concept. A completely new approach based on compressed air was investigated for disposal in horizontal boreholes. This solution does not require any mechanical or hydraulic means for pushing waste containers into the horizontal borehole. These could fail, resulting in a complex operational malfunction that could expose personnel to high levels of radioactivity. The update of the emplacement technology in drifts was based on the state of the art of self-propelled gantry cranes in the industry. The new technology facilitates especially adaptability to different types of waste containers and eliminates the need for track construction in the emplacement drifts. All machines considered were designed with CAD, and the operational processes were also animated. The illustration shows a screenshot from the animated emplacement process in drifts.

The project was funded by the Federal Ministry for Economic Affairs and Energy (BMWi), represented by the Project Management Agency Karlsruhe (PTKA).

»It is necessary to adapt the emplacement and disposal technology to the current potential of machine development. As a mechanical engineer, I am happy to develop compact and partly autonomous machines for different emplacement processes. It is fun to use the technical possibilities and to now be able to show: We can work reliably and efficiently in a repository.«

Dr. Ulla Marggraf, Mechanical Engineer

Renovation of Shaft 1 of the HADES Underground Laboratory

Underground Laboratory HADES

From 2017 to 2021, BGE TECHNOLOGY GmbH and Tractebel Engie (Belgium) advised ESV EURIDICE GIE on the rehabilitation of the shaft hoisting system of Shaft 1 of the HADES underground research laboratory in Belgium.

After developing specifications for the rehabilitation works in close cooperation with the client, BGE TECHNOLOGY GmbH assisted in the management of the tendering process for Lot 3 of the project (detailed design and construction of the shaft hoisting system) and in the selection of a contractor. During the construction phase, we continued to accompany the work in Lot 3 and provided administrative and technical advice to Euridice. The focus was on monitoring the work with regard to compliance with the specifications.

The construction site was set up at the end of 2019. The old shaft installations were removed by means of a temporary hoisting system. Before the new shaft fittings were installed, the concrete of the shaft was inspected and repaired in places. Above ground, two drum conveyors were set up in floor position and the hoist frame was erected. The recommissioning of the shaft and the handover to the operator ESV Euridice GIE took place in autumn 2021.

Renovation of the shaft hoisting system of the HADES underground laboratory (Mol, Belgium)

»The renovation of the shaft hoisting system at HADES was a special opportunity to accompany all construction phases from concept development to commissioning. The coordination of the different works and the lack of a Belgian set of rules were major challenges. Despite Corona-related delays, the project budget was undercut.«

Niklas Bertrams, Mining Engineer

Deep Borehole Disposal of Radioactive Waste in Australia

Commonwealth Scientific and Industrial Research Organisation (CSIRO)

An increasing number of countries are considering deep borehole disposal of small volumes of radioactive waste because this technology can easily be adapted to the characteristics of the waste inventory and the geologic setting. This makes it possible to isolate the radionuclides in deep rock formations over the long term in a relatively short time and at low cost.

In Australia, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is responsible for the development of repository concepts and thus, also for borehole disposal. Igneous complexes, metamorphic rocks, clayey sediments, and rock salt are considered as host rocks. Designs are available for 2-km- and 3-km-deep boreholes. Technical barriers and backfill sections are to separate the deep emplacement areas from the biosphere.

BGE TECHNOLOGY GmbH has extensive experience in the design of waste containers. For deep borehole disposal in mines, ready-for-use emplacement technologies have been developed up to long-term stable borehole backfill and borehole seals. We also have comprehensive expertise in deep drilling technology, including flushing technology, and in borehole investigation methods. This makes us a competent partner when it comes to developing concepts for borehole disposal.

For CSIRO, our consulting services focused on the selection of gentle methods for drilling large-calibre vertical boreholes and on the evaluation of their stability in different host rocks. We also answered questions about the removal of the casings and about cementation, which are a prerequisite for the construction of technical barriers. This way, BGE TECHNOLOGY GmbH was able to successfully support CSIRO on its way to small- and large-scale demonstration tests.

»In Australia, only small amounts of radioactive waste are present, making deep borehole disposal an interesting option. We have developed a respective basic concept and pointed out where there is still need for research and development. It is an interesting and challenging task, which can provide a disposal solution for many countries in the future.«

Tilman Fischer, Deep Drilling Engineer

Deep drilling rig in Helsinki (Finland)

Konrad mine: Support in the area of the backfill processing plant on the 3rd level

Operational Safetu

Operational Safety

The focus of research and development on the disposal of radioactive waste is usually on long-term safety. This focus results from the goal of disposal: To concentrate and contain radioactive substances in a geologic formation for a very long time. For successful disposal, however, the safe operation of the repository mine is a basic prerequisite. For its analysis, the operation is often divided into mining activities and emplacement operations. Depending on the disposal concept, these activities are carried out in succession or in parallel. In both cases, the impacts of nuclear requirements on mining operations pose a major challenge to research, planning, and implementation.

In 2021, BGE TECHNOLOGY GmbH was primarily involved with issues relating to operational safety at the Konrad and Asse sites. In both cases, the focus was on investigations of planned long-lived support systems that are to be constructed to prepare the respective site for emplacement or retrieval operations.

In addition, operational safety and the methods of its analysis become increasingly significant as the repository concepts for a HLW repository become more concrete. Section 12 of the "Ordinance on Safety Requirements for the Disposal of High-Level Radioactive Waste" requires that both the safety concept and the technical design of the repository be optimised. The measures to achieve the two optimisation goals of long-term safety and operational safety should be in balance with each other. Thus, in terms of its significance, operational safety is already equated with long-term safety by the regulations.

In order to implement the requirements, new methodological ground must be broken in order to comprehensively analyse the interactions between mining and emplacement. The application of nuclear safety principles such as the phasing of safety measures ("defence in depth") to the excavation operation of a HLW repository, which is closely related in space and time to the parallel emplacement operation, is, for example, still largely unexplored.

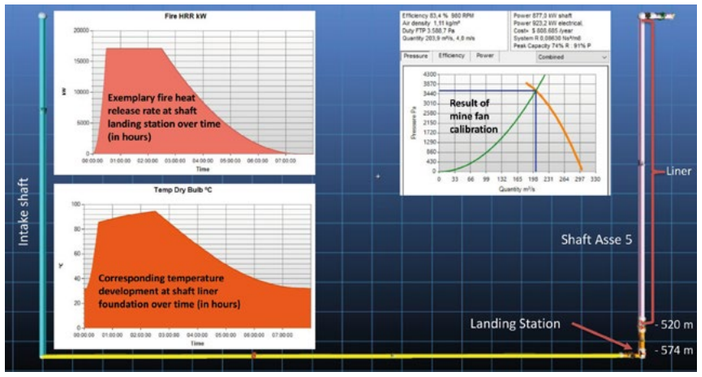
Fire Analysis for the Retrieval Shaft of the Asse Mine

Asse Mine

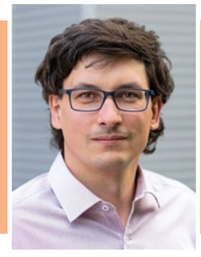
One of the tasks of our parent company, BGE, is the retrieval of low- and intermediate-level radioactive waste from the Asse II mine. For this purpose, a new shaft is to be sunk that will serve as a transport shaft for the waste from underground to the surface. BGE's department for the retrieval of radioactive waste has commissioned employees of BGE TECHNOLOGY GmbH with investigating the thermal effects of a fire at the shaft landing station on the concrete lining of the new shaft.

In close cooperation with the BGE experts for retrieval operations and safety analyses, various simulations with the mine ventilation software VentSim were thus carried out, taking into account realistic model parameters and assumptions. The figure shows the model in VentSim with exemplary results on the course of the thermal power, the temperature development, and the calibration of the mine fan.

First, fires were modelled based on different design fire curves from tunnel engineering. The results showed extremely high heat release rates and temperatures. In a next step, BGE provided estimates for realistic fire loads corresponding to the use of machinery in the planned excavation and retrieval operations. The then calibrated design fires were simulated in the otherwise same model as before, which led to much more realistic results of heat release from underground fires. To take into account uncertainties, several sensitivity analyses were carried out, for example, by varying the duration of the fire development stages and burning rates or the amount of ventilation. The results of the analyses suggest that the thermal effects of a fire at the shaft landing station on the shaft liner will not exceed 300 °C.



Visual representation of the model for the fire simulations with exemplary results

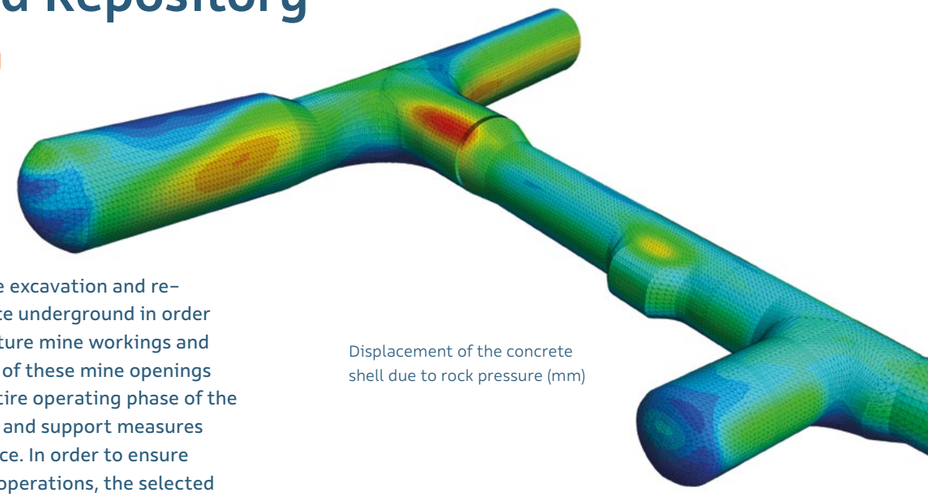


»The plans for retrieving the waste from the Asse mine are progressing. Safety in the retrieval shaft is a top priority, especially in the event of a fire. With the work of the team of BGE TECHNOLOGY GmbH, the parameters for the fire engineering design of the shaft could be identified.«

David Seidel, Mechanical Engineer

Rock Mechanics Calculations for the Konrad Repository

Konrad Repository



Displacement of the concrete shell due to rock pressure (mm)

The Konrad mine is currently being converted into a repository for low- and intermediate-level radioactive waste. For this purpose, extensive excavation and recutting work is taking place underground in order to excavate the infrastructure mine workings and transport routes. As some of these mine openings will be used during the entire operating phase of the repository, the protection and support measures are of particular importance. In order to ensure continuous emplacement operations, the selected anchor/shotcrete lining of these mine openings must be designed to be free of renovation/refurbishment or maintenance, and stability for several decades has to be demonstrated.

For the design of the lining, static numerical calculations are carried out by BGE TECHNOLOGY GmbH, which will be followed by more detailed planning for implementation by a subcontractor of BGE. These analyses comprise the Ramp 380, which connects the infrastructure rooms for backfill processing and the workshop, the radiation protection room, and the e-truck service room. For this purpose, several large 3-dimensional numerical models are used that take into account the excavation process, the local geologic situation, and the heterogeneous and anisotropic rock properties.

The simulation of the drift lining up to diameters of 8 m to 9 m shows sufficient stability during the states of construction. Until the concrete lining is finished, fully bonded anchors with lengths between 4 m to 6 m in drifts and up to 8 m in junctions are used as securing means.

Due to the irregular rock movements, the load on the concrete lining also varies locally, e.g. when cross-sections change or in bends. In these cases, an iterative process between planning and numerical calculations has succeeded in optimising the material use of concrete and reinforcing steel and thus also the future construction process.

»"You never stop learning ..." This saying is especially true for projects in which we work together with the specialist departments of BGE as well as with external companies. Their views and approaches to solving interdisciplinary tasks are often very instructive and fascinating for me«

Mirko Polster, Geotechnical Engineer

Drill cores from exploration work in the Bedretto underground laboratory (Switzerland)

Site Selection

Site Selection

The selection of a suitable site is a fundamental prerequisite for the safe operation of a repository mine and for the long-term safe containment of radioactive waste after the repository's decommissioning. During the search for a site, one or more preferred potential sites in different host rocks are selected after unsuitable sites have been excluded and after the other sites have been reviewed and compared. In addition to geologic criteria, socio-political factors are also important (e.g. demographic conditions, transport infrastructure, existing land use). The verification of suitability of a site is carried out by means of safety assessments that are based on site-specific models of local conditions and properties and are validated by means of laboratory tests and large-scale experiments.

In Germany, the "Site Selection Act" (StandAG) came into force in 2013. The aim of the site selection procedure is to find a site for a geological repository for heat-generating radioactive waste in a science-based and transparent process.

Based on the findings of an expert commission, the StandAG was amended in March 2017 and now stipulates a multi-phase search for a site with the best possible safety and with comprehensive public participation, particularly in the affected siting regions. Among other things, exclusion criteria, minimum requirements, and weighing criteria for the site and the potential host rock are defined.

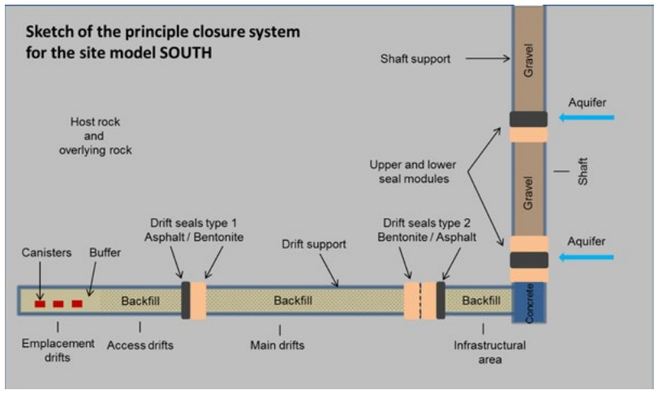
BGE is responsible for the site selection procedure in Germany. BGE TECHNOLOGY GmbH assists BGE in this complex task with its extensive know-how. Of particular importance are BGE TECHNOLOGY GmbH's experience in research projects and contracts in various host rocks as well as the extensive exchange of experience with international waste management organisations. BGE TECHNOLOGY GmbH also makes this know-how available to the waste management organisations of other countries, e.g. on behalf of the International Atomic Energy Agency (IAEA) to the Chinese research institute BRIUG, in this case for site investigations.

Workshops for the Site Selection Department of BGE

BGE

In March 2021, BGE TECHNOLOGY GmbH organised a workshop for the site selection department of BGE. The topic: Repository concepts for the disposal of high-level radioactive waste (HLW) in different host rock formations.

The workshop was divided into several blocks, each taking place on a different day. The first three blocks focused on one host rock each (salt, clay, and crystalline rock) and the current state of scientific and technical knowledge with regard to corresponding HLW repository concepts. Another workshop was held in May 2021 on the topics FEP catalogue and scenario development. These two aspects cover the description and development of a repository system, which form the basis for the safety assessments. In both workshops, BGE TECHNOLOGY GmbH could draw on its extensive expertise in the areas of safety concepts, waste containers, repository planning and technology, backfilling and sealing concepts, and safety demonstration methods. Each presentation was thoroughly discussed with the participants of BGE. The workshops started with outlines of the national geologic conditions and safety and repository concepts as well as of the regulatory requirements. Subsequently, the international approaches were presented and discussed. The continuous involvement in international projects allowed BGE TECHNOLOGY GmbH to illustrate the repository concepts in salt in the USA, in claystone in Belgium, Switzerland and France, and in crystalline rock in Sweden, Finland, Canada, the Czech Republic, and Russia. Particularly interesting and profitable for both sides of the workshop participants was the discussion about the reasons for the differences in international approaches and the influences of new legal requirements that have to be taken into account during the site selection steps in Germany. BGE and BGE TECHNOLOGY GmbH recorded all presentations for future use.



Example of a sealing concept in claystone

»In addition to site selection, the technical concept of a repository is of particular importance when it comes to assessing safety. I am happy that our colleagues at BGE are interested in our experience gained in research projects and international projects and that we have been able to share and discuss our work with them.«

Ansgar Wunderlich, Mechanical Engineer

Development of a Research Programme for the Chinese Underground Laboratory

Chinese Research Institute BRIUG

China plans the disposal of high-level radioactive waste in a deep geological repository. Thus, the Beijing Research Institute of Uranium Geology (BRIUG) has been commissioned with setting up an underground laboratory in crystalline rock in the Beishan region (NW China), which could possibly become part of a future repository.

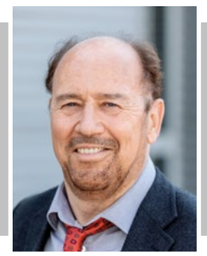
In the past few years, the International Atomic Energy Agency (IAEA) has assisted BRIUG in identifying research activities that can be carried out during the construction of the underground laboratory. BRIUG has started the construction of the underground laboratory in July 2021.

Because of open questions, IAEA initiated a virtual workshop, which took place between February 25 and April 9, 2021. For this workshop, BRIUG had indicated a number of topics and information needs to be discussed by an international team of experts and their Chinese counterparts. Two experts from BGE TECHNOLOGY GmbH participated for the topics "Mining technology" and "Methods for long-term safety demonstration during the construction of the underground laboratory". BRIUG's open questions were first discussed within corresponding expert working groups, with a direct exchange with the Chinese contact persons. In a next step, the results were then comprehensively discussed in three plenary meetings.


Beishan exploration tunnel (China)

In the closing session, the experts provided their observations and recommendations. The "Mining technology" group intensively discussed preparatory measurements and model calculations, the testing of mining technology during the excavation of the ramp, the planning of ventilation, an analysis of the required cementing work, and the characterisation of the excavation damaged zone. The "Long-term safety demonstration" group focused on the issues in the implementation of a safety concept, the use of a FEP catalogue as the basis for the investigation programme, the importance of the site characterisation model, the adaptations of the repository design to the geology, and the implementation of a data management system.

Both BRIUG and the IAEA were satisfied with the progress and the results of the workshop. A continuation of the cooperation is intended.



»In 2019, I was able to visit the planned site of the underground laboratory in Beishan. In 2021, I discussed a variety of issues with regard to the construction and commissioning of the underground laboratory at an IAEA workshop with an international team of experts. The exchange in the expert team and with the Chinese colleagues was very interesting.«

Dr. Andree Lommerzheim, Geologist

Management Report for the Financial Year 2021

Sphere of Activities

The main business areas of BGE TECHNOLOGY GmbH (BGE TEC), Peine, – a 100% subsidiary of Bundesgesellschaft für Endlagerung mbH (BGE) – as a highly specialised engineering company operating at both national and international level continue to be in the field of engineering and consulting services for the disposal of radioactive waste. This includes national and international research and development projects for the safe disposal of these wastes, in particular of high-level waste and spent fuel elements. International projects on various aspects of the disposal of radioactive waste, especially in deep geologic formations and in various host rocks (claystone in Belgium and Switzerland, rock salt in the UK as well as magmatic host rock in Norway, Canada, South Korea, and Ukraine) are of particular importance.

The company gives advice and support to its clients in the special field of radioactive waste management in various repository-specific areas. The tasks range from the identification of waste classes and their disposal paths to the development of repository concepts for different host rocks in general and, in particular, of technologies, for example, for the transport and emplacement of waste packages or for the improvement and stabilisation of the host rock, to the implementation of mining activities such as the routine construction of flow barriers at the Asse mine. The company carries out safety assessments, develops the necessary basic and coupled material models, and implements these in existing simulation tools for the performance of safety assessments.

Furthermore, the company supports in particular international clients in their waste management and repository project activities in accordance with international safety standards. In this context, projects and activities for clients in Australia and Norway as well as for the International Atomic Energy Agency (IAEA), in which concepts and technologies for the disposal of radioactive waste in deep boreholes are being developed, are particularly worth mentioning.

Of particular importance for developing know-how and in support of future tasks in Germany are the management of and participation in joint cooperation projects with other leading research institutions involved in radioactive waste disposal, in particular concerning safety and safety demonstration concepts for repositories in various deep rock formations, transport and emplacement technologies, the development of material models in the relevant host rocks crystalline rock, rock salt, and claystone, and in particular concerning the compaction of crushed salt.

The knowledge and experience gained in the joint projects, but also in other interactions with various waste management organisations, are made directly available to our parent company Bundesgesellschaft für Endlagerung mbH (BGE); e.g. within the framework of training courses on repository concepts in relevant host rocks and in the implementation of research projects. Furthermore, employees of BGE TEC support BGE by means of assignments in the handling of licensing requirements related to the decommissioning procedure of the Morsleben repository and in the implementation of the recommendations of the Nuclear Waste Management Commission, ESK. For instance, in addition to the integrity analyses carried out for the geologic barrier, the associated uncertainties are analysed and evaluated. Within the scope of the construction of the Konrad repository, BGE TEC is also working on rock mechanics tasks. In addition to providing technical support to BGE's subcontractors, BGE TEC itself carries out numerical calculations to assess the stability of the mine workings and their support structures. The company also provides services for the Asse II mine concerning several major tasks related to hazard prevention and emergency planning activities. In addition, BGE TEC is involved in the design and construction of sealing structures and the assessment of their functionality.

BGE TEC's knowledge and experience gained in national and international activities are also in demand internationally, beyond specific projects. Experts from the company are represented in advisory bodies of the Dutch and Norwegian waste management organisations, in working and advisory bodies of the IAEA and the Organisation for Economic Cooperation and Development / Nuclear Energy Agency (OECD/NEA) as well as in programme committees of international conferences.

A particular focus in 2021 was on adapting the company's internal processes to the mandatory Federation's Public Corporate Governance Code (PCGK). The application of the PCGK, the decision to optimise personnel management and development, and the consideration of current customer requirements led to the decision to change the organisational structure of the company to a matrix structure. This ensures that the knowledge and resources available in the company can be made available in a project-specific and customer-oriented manner.

The requirements of environmentally responsible action are taken into account by the company's activities, which specifically focus on protecting the environment.

MANAGEMENT

The company uses the annual results as financial performance indicator to manage the company. Further performance indicators are outlined in the business development, results of operations, and net assets and financial position sections.

RESEARCH & DEVELOPMENT

A high priority is the processing of research and development projects (R&D). The R&D projects carried out by BGE TEC are divided into site-independent work, which is financed within the framework of the research programme funded by the budget of the Federal Ministry for Economic Affairs and Energy (BMWi), and into additional work contributed to R&D projects of BGE. In conjunction with BGE, BGE TEC thus ensures that the expertise for the planning, construction, operation, and closure of radioactive waste repositories is preserved and further developed based on the state of the art in science and technology. In the reporting period, the company was involved in a total of 15 national and international research and development projects. The related expenditures amounted to T€ 1,179 (previous year T€ 1,750).

Financial Report

BUSINESS DEVELOPMENT

According to the Federal Statistical Office (Destatis), the gross domestic product (GDP) of bn* € 3.57 in 2021 increased compared with 2020 (bn € 3.37). Adjusted for price and calendar effects, there is a change of +2.9%. The result is thus still below the value of 2019. Due to the company's business model, the overall economic development in Germany has neither a short-term nor an immediate decisive influence on BGE TEC. Nationally and internationally, BGE TEC is active in very long-term, partly independently financed programmes with large planning horizons. In addition, R&D projects are financed via the federal budget within the framework of multi-year funding programmes. This considerably reduces the risk that a company can be subjected to due to economic fluctuations.

The impact of the pandemic caused by Covid-19 remained of particular importance in the financial year 2021. BGE TEC implemented the respective directives of the crisis team set up at BGE. In addition to hygiene rules, this essentially meant almost completely stopping business trips and allowing mobile working to a large extent. None of the employees of BGE TEC was infected with Covid-19, thus, BGE TEC was able to provide all services owed.

The Covid-19 pandemic affected BGE TEC's business activities in 2021 mainly in terms of administrative processes and project management. The more difficult cooperation with partners and clients had already been taken into account in 2019 for the planning of

* In accordance with Destatis 1bn = 10^{12}

tasks and projects. No services had to be postponed or work stopped completely. Overall, the targeted values were largely adhered to despite the uncertain environment. Overall, the projected business result of T€ 50 was offset by a real business result of T€ 34.

Although several larger projects were completed in 2021 and the acquisition of new projects was intensified, 2021 can also be said to be another stable business year with a turnover of T€ 6,158 (previous year T€ 5,376). As of December 31, 2021, the company had orders on hand amounting to T€ 6,044.

RESULTS OF OPERATIONS

Compared with the previous year, turnover increased by T€ 782 to T€ 6,158 due to the final invoicing of several orders.

Other operating income of T€ 42 (previous year T€ 41) remained virtually unchanged. The main items included in other operating income are the release of accruals in the amount of T€ 15 (previous year: T€ 2), the non-cash benefits in 2021 in the amount of T€ 10 (previous year: T€ 9), as well as reimbursements of the ancillary costs 2020 for the rented office space in the amount of T€ 8 (previous year: T€ 5).

Within the cost of materials, the expenses increased mainly for purchased services for project assistance by third parties and the parent company BGE. The item also includes energy and fuel costs as well as expenses for repairs and maintenance work.

Compared with the previous year, personnel expenses increased by T€ 116 to T€ 3,986.

Other operating expenses amounting to T€ 327 (previous year: T€ 316) mainly include rental expenses for office space, insurance costs, postal and transport costs, and ancillary personnel costs.

Income taxes are divided into T€ 17 for trade tax and T€ 19 for corporate income tax (including solidarity surcharge).

NET ASSETS AND FINANCIAL POSITION

Compared with the previous year, the balance sheet total has decreased by T€ 144 and amounts to T€ 4,029.

On the assets side, inventories decreased by a total of T€ 547 to T€ 360, in particular due to the decrease in advance payments made for ongoing projects.

Receivables and other assets increased by T€ 1,423 to T€ 2,345 compared with the previous year due to higher receivables from affiliated companies. They include, in particular, claims against BGE from the intercompany invoicing of services.

The bank balances decreased by T€ 1,021 to T€ 1,286 compared with the previous year's balance sheet date.

On the liabilities side, equity decreased to T€ 2,647. The net income for 2021 amounts to T€ 34; the net income of 2020 amounting of T€ 108 was distributed to BGE in 2021.

The provisions mainly comprise pension obligations (T€ 443; previous year T€ 391) and other provisions amounting to T€ 299 (previous year T€ 315). The other provisions were set aside in particular for personnel expenses. Overall, the level of provisions increased from T€ 706 to T€ 742.

Liabilities decreased by T€ 106 to T€ 640. The largest single item, T€ 267, relates to trade payables.

Compared with the previous year, the equity ratio increased from 65.2 % to 65.7 % due to the decrease in liabilities. The equity capital continues to completely finance the fixed assets and inventories.

The company is solvent at all times, as current liabilities are fully covered by cash and cash equivalents.

Personnel and Social Report

As of December 31, 2021, the company's workforce consisted of 35 employees. The proportion of women is 28.6 %. The handling of the tasks of the company is supported by employees of BGE under the terms of an agency and service agreement with BGE. This primarily involves the provision of commercial services. The Company is integrated into the industrial safety concept and compliance organisation of BGE.

Forecast, Risk, and Opportunity Report

Risks from order processing are controlled promptly by means of controls accompanying the order. There is adequate insurance cover for risks that the company can usually expect to encounter. There are no risks threatening the company's continued existence.

Although BGE TEC has business relations with Russia and Ukraine, the Ukraine war currently has only a minor impact. In 2021, two projects were completed for Ukraine. In the existing scientific and technical cooperation between the Russian Federation and the Federal Republic of Germany in the fields of reactor safety research and waste disposal and repository research, BGE TEC participates in joint projects with independent work packages and thus only in indirect relation to Russian partners. There are no offers for projects in Russia or Ukraine, and current acquisition activities do not indicate any short-term orders from these countries, so that no direct effects on planned turnover and results can be expected. The rising prices that can be observed are also not expected to have a significant impact. Some expenses such as travel costs and laboratory materials can be settled via clients. Individual planned trips for acquisition purposes will not be carried out this year due to the current crisis. Overall, the impact for BGE TEC can thus be minimised through appropriate cost control.

Several large contracts were completed in 2021. However, there are various new contracts and promising offers, so that the company's capacity utilisation is almost fully secured for 2022 and partially secured for 2023. Against this background, the order volume as of December 31, 2021, amounting to T€ 6,044 continues to be at a solid level. The increased acquisition activity in 2021, with due consideration of the probabilities of winning outstanding bids, leads us to expect a result of more than T€ 200 for 2022.

The Company's activities continue to focus on developing and expanding the core competence of the BGE/BGE TECHNOLOGY GmbH group in order to be able to offer high-quality services on a national and international level. In 2022, it is intended to expand and intensify activities to further attractive and interesting markets. In addition, the transfer of knowledge to and as support for BGE is to be intensified by making available scientific and technical personnel. This concerns the site selection for a repository for heat-generating waste, safety analyses by means of numerical calculations, and the further development of construction materials for the existing repository projects. In the future, it is expected that there will be a growing need for the project management agency to carry out R&D work in the area of site selection for a repository, especially for heat-generating waste.

The constraints imposed by the Covid-19 pandemic have also been taken into account in the project work in 2022. In addition, the measures of the crisis management team are being implemented. As a result, the probability that services cannot be provided due to personnel shortfalls is considered to be low. However, the company's acquisition activities remain difficult under Corona conditions. Thus, the company will cultivate its established network in the field of waste management particularly intensively. Irrespective of this, the company will continue to participate in tenders in 2022, as a large part of the contracts in the field of radioactive waste management are awarded via tender procedures.

Annex to the Financial Year 2021

General Information

BGE TECHNOLOGY GmbH has its registered office in 31224 Peine, Eschenstraße 55, and is registered with the commercial register at the Local Court of Hildesheim, HRB no. 101385.

The company is a small corporation within the meaning of Section 267 (1) HGB. The annual financial statements of BGE TEC are prepared voluntarily in accordance with the regulations applicable for large corporations.

To improve the overall clarity of presentation, individual items have been combined in the balance sheet and income statement and are shown separately in the notes to the financial statements.

The accounting and valuation methods have remained unchanged as against the previous year.

The income statement was prepared according to the total expenditure format.

Accounting and Valuation Methods

Figures shown in the balance sheet for intangible assets and tangible assets are based on the cost of purchase. Intangible assets – consisting exclusively of software – are written off by straight-line method over a period of three to five years, and tangible assets are written off by straight-line method over their expected useful life (three to fifteen years). Minor value assets with acquisition or production costs of more than € 250 but not more than € 1,000 are combined into an annual collective item and written off uniformly over a period of five years.

Orders that have been commenced (work in progress) are valued at the directly attributable production costs in accordance with the minimum valuation threshold under commercial law.

Advance payments are recognised at nominal value.

Receivables, other assets, and cash and cash equivalents are reported at their nominal value.

Identifiable individual risks are taken into account by value adjustments on receivables. Other assets are reported at nominal value.

Prepaid expenses and deferred income consist of payments made before the balance sheet date insofar as they relate to a specific period after that point in time.

Subscribed capital is reported at nominal value.

Provisions are reported at the amount deemed necessary for the fulfilment thereof according to sound business judgment.

Provisions for pensions are calculated on the basis of actuarial calculations using the projected unit credit method, taking into account the "Mortality Tables 2018 G" of Prof. Dr. Klaus Heubeck, Cologne. The reported pension obligations for individual commitments are governed by the benefit regulations and the contribution-based pension scheme of Bochumer Verband (Bochum Association). Provisions for pensions are discounted at the average market interest rate of the past ten financial years as published by Deutsche Bundesbank (Section 253 (2) HGB), which corresponds to 1.87 % (previous year 2.31 %). Salary dynamics remain unchanged at 2.5 % p.a., while pension dynamics continue to be taken into account at 1.0 % p.a.

The difference resulting from the valuation of the pension provisions at the 7- or 10-year discount rate amounts to T€ 47. Due to sufficient reserves in accordance with Section 272 (2) Clause 4 HGB, the amount is not subject to a distribution block.

Other provisions with a term of more than one year are discounted at the average market interest rate prevailing over the past seven financial years corresponding to their remaining term.

Provisions for archiving costs serve to fulfil legal and contractual archiving obligations for business documents and records. The provisions are calculated based on an average remaining archiving period of ten years and an estimated cost increase of an unchanged 2.5 % p.a. The provisions are discounted at the corresponding average market interest rate of 1.04 % (previous year 1.26 %).

The other provisions take into account all identifiable risks and contingent liabilities.

Liabilities are reported at the settlement amount.

The deferred tax asset surplus was not reported. The valuation of deferred taxes is based on a tax rate of 29.3 % (15.82 % for corporate income tax including solidarity surcharge and 13.48 % for trade tax). Differences between commercial law and fiscal law arise in particular with regard to pension provisions.

Receivables and liabilities in foreign currency are valued at the mean exchange rate applicable at the time of the business transaction. The valuation on the balance sheet date is based on the mean spot exchange rate. If the remaining term is one year or less, Section 253 (1) Clause 1 and Section 252 (1) Clause 4 Subclause 2 HGB are not applied.

Asse mine: Team of BGE/BGE TEC responsible for injection work

Balance Sheet as of December 31, 2021

Assets

all figures in T€	Notes	As of 31. 12.2021	As of 31. 12.2020
A. Fixed assets	(1)		
I. Intangible Assets			
Industrial property rights and similar rights and assets acquired against payment		14	1
II. Tangible assets			
Other equipment, operating, and office equipment		24	36
		38	**37**
B. Current assets			
I. Inventories			
1. Work in progress		360	463
2. Advance payments		0	444
		360	**907**
II. Receivables and other assets	(2)		
1. Trade accounts receivable		732	202
2. Receivables from affiliated companies		1,419	688
3. Other assets		194	32
		2,345	**922**
III. Bank balances		1,286	2,307
		4,029	**4,173**

Equity and Liabilities

all figures in T€	Notes	As of 31. 12.2021	As of 31. 12.2020
A. Equity			
I. Subscribed capital	(3)	511	511
II. Capital reserves	(4)	179	179
III. Revenue reserves			
Other revenue reserves	(5)	1,923	1,923
IV. Net profit for the year		34	108
		2,647	**2,721**
B. Provisions			
1. Provisions for pensions and similar obligations		443	391
2. Other provisions	(6)	299	315
		742	**706**
C. Liabilities	(7)		
1. Advance payments received on orders		119	421
2. Trade payables		267	49
3. Payables to affiliated companies		173	122
4. Other liabilities		81	154
		640	**746**
		4,029	**4,173**

Notes to the Balance Sheet

Assets

1. Fixed assets

Movements of individual items of fixed assets are shown in the fixed assets movement schedule.

The financial assets consist of a cooperative share acquired in 2012.

2. Receivables and other assets

As in the previous year, all receivables and other assets have a remaining term of less than one year.

Receivables and other assets include receivables from affiliated companies (T€ 1,419; previous year T€ 688) arising from claims for project work and of the final settlement of orders with foreign customers. The other assets also include tax refund claims.

Equity and Liabilities

3. Subscribed capital

Subscribed capital remains unchanged at T€ 511. It is fully paid up and is held to 100 % by BGE.

4. Capital reserves

The capital reserves amounting to T€ 179 originate from other contributions according to Section 272 (2) Clause 4 HGB.

5. Revenue reserves

Revenue reserves amount to T€ 1,923. Of this amount, T€ 1,794 consist of retained earnings from previous financial years and T€ 129 from a change in accounting method resulting from the German Accounting Law Modernisation Act (BilMoG) as of January 1, 2010.

6. Other provisions

all figures in T€	31.12.2021	31.12.2020
Employee-related provisions	270	287
Archiving costs	22	21
Other obligations	7	7
	299	**315**

Employee-related provisions amounted to T€ 270 and include costs for special compensations and vacation remunerations.

7. Liabilities

The final settlement of orders with foreign customers led to a reduction in advance payments received to T€ 119 (previous year T€ 421).

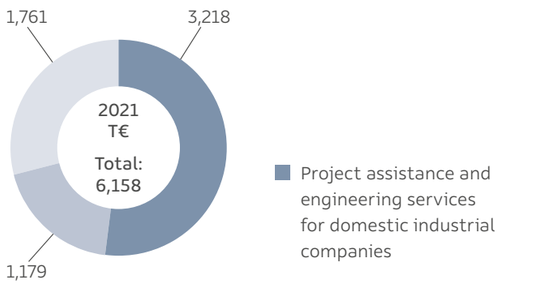
Liabilities to affiliated companies amounting to T€ 173 (previous year T€ 122) are attributable in full to the sole shareholder and result from trade payables.

Other liabilities (T€ 81; previous year T€ 154) consist primarily of value-added tax and wage tax obligations, which are still outstanding to an amount of T€ 79.

As in the previous year, all liabilities amounting to T€ 640 have a remaining term of less than one year and are unsecured.

Notes to the Income Statement

8. Turnover



Revenues from project assistance and engineering services for domestic industrial companies were generated exclusively in Germany. Revenues from international contracts were generated by engineering services.

9. Change in inventory of work in progress

The decrease in inventories of T€ 103 results from orders settled as of the balance sheet date.

10. Other operating income

Other operating income has remained constant compared with the previous year and includes income unrelated to the accounting period in the amount of T€ 23 (previous year T€ 27). This results from the release of provisions (T€ 15; previous year T€ 2) as well as credit notes for the 2020 ancillary cost settlement for rented office space (T€ 8; previous year T€ 5). Furthermore, this item includes in particular remuneration in kind (T€ 10; previous year T€ 9).

11. Cost of materials

The cost of materials includes expenses for purchased services from project work by third parties and the parent company BGE (T€ 1,629; previous year T€ 868), energy and fuel costs (T€ 3; previous year T€ 3) as well as expenses for repairs and maintenance work (T€ 16; previous year T€ 10).

12. Personnel expenses

Personnel expenses include expenses for pensions in the amount of T€ 57 (previous year T€ 66).

13. Other operating expenses

Other operating expenses (T€ 327; previous year T€ 316) are mainly attributable to rents (T€ 133; previous year T€ 123), insurance expenses (T€ 90; previous year T€ 65), postal and transport costs (T€ 21; previous year T€ 21) ancillary personnel costs (T€ 16; previous year T€ 40), and other general administrative expenses amounting to T€ 67; previous year T€ 67. As in the previous year, they do not include any expenses unrelated to the accounting period.

14. Interest and similar expenses

all figures in T€	2021	2020
Interest from the interest accrued on pension obligations	9	9
Interest and similar expenses	7	15
	16	**24**

15. Taxes on income

Taxes on income include trade tax (T€ 17) and corporate income tax (incl. solidarity surcharge) at T€ 1 for the current financial year.

Contingent Liabilities and Other Financial Obligations

The company conducts its business operations in rented office premises. This results in payment obligations in the amount of T€ 70.

As of the balance sheet date, there are no other significant contingent liabilities or other financial obligations.

Other Disclosures

Corporate bodies

In 2021, the company was managed by the following managing directors:

- Dr. Thilo von Berlepsch, Niedernwöhren, Managing Director
- Dr. Thomas Lautsch, Peine, Technical Managing Director of Bundesgesellschaft für Endlagerung mbH (BGE), Peine

Deviating from section 5.2.5 of the Public Corporate Governance Code (PCGK) of the Federal Republic of Germany, no age limit has been set for the management of BGE TECHNOLOGY GmbH so far. The contracts of the current management are limited in time so that no member of the management will reach the legal age limit before expiry of the contract.

The remuneration of the Management Board in the reporting year 2021 comprises the fixed salary payments including ancillary benefits. Performance-related remuneration bonuses are paid.

Managing Director

all figures in T€	Base salary	Retirement pension indemnity	Others	Total remuneration 2021
Dr. Thilo von Berlepsch	166	0	27	**193**
Dr. Thomas Lautsch	0	0	0	**0**
Total	**166**	**0**	**27**	**193**

Pension obligations to former members of the management are accrued in the total amount of T€ 216; their current remuneration amounted to T€ 10 in 2021.

Auditor's fees

The total auditor's fees charged for the financial year are presented in the consolidated financial statements of BGE.

Annual average number of employees

The average number of employees during the year was 36 (previous year 36). Pursuant to Section 267 (5) HGB, the company had 34 employees. Of these, 10 are female and 24 male.

Appropriation of net income

Subject to the approval of the sole shareholder, the net profit for the year of T€ 34 is to be allocated to the revenue reserves.

Group affiliation

BGE TECHNOLOGY GmbH is a 100% subsidiary of BGE. As parent company, the latter prepares consolidated financial statements for the smallest and largest group of companies, in which the annual financial statements of BGE TEC are included. The consolidated financial statements are submitted to the operator of the Electronic Federal Gazette (Bundesanzeiger) and are published in the Electronic Federal Gazette.

Public Corporate Governance Kodex

The company submitted and published the compliance declaration 2020 in accordance with the Public Corporate Governance Code of the Federal Republic of Germany on June 24, 2021. The compliance declaration for 2021 will be published on the company's website in June 2022.

Peine, March 31, 2022

Dr. Thilo von Berlepsch
Managing Director

Dr. Thomas Lautsch
Managing Director

Fixed Assets Movement Schedule

all figures in T€	Acquisition and Production Costs					Value Adjustments					Net Book Values	
	As of 01.01.2021	Additions	Disposals	Re-transfers	As of 31.12.2021	Accumulated depreciation 01.01.2021	Additions	Disposals	Re-transfers	Accumulated depreciation 31.12.2021	As of 31.12.2021	As of 31.12.2020
I. Intangible Assets												
1. Purchased concessions, industrial property and similar rights and assets, and licenses to such rights and assets	140	17	0	0	157	139	4	0	0	143	14	1
	140	**17**	**0**	**0**	**157**	**139**	**4**	**0**	**0**	**143**	**14**	**1**
II. Tangible assets												
1. Other equipment, operating, and office equipment	260	13	10	0	263	224	25	10	0	239	24	36
	260	**13**	**10**	**0**	**263**	**224**	**25**	**10**	**0**	**239**	**24**	**36**
Sub-total	**400**	**30**	**10**	**0**	**420**	**363**	**29**	**10**	**0**	**382**	**38**	**37**
III. Financial assets												
1. Other loans	(250 €)	0	0	0	(250 €)	0	0	0	0	0	(250 €)	(250 €)
	(250 €)	0	0	0	(250 €)	0	0	0	0	0	(250 €)	(250 €)
Total fixed assets	**400**	**30**	**10**	**0**	**420**	**363**	**29**	**10**	**0**	**382**	**38**	**37**

Konrad mine: Drift intersection at the primary crusher plant, 2nd level

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Konrad mine: Shaft Konrad 2, shaft landing station 2nd level