

Another 30 years to go

The final storage of
high-level radioactive waste

A new yet familiar role



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Where nuclear energy is concerned, we have come a long way since the Oeko-Institut was founded more than 40 years ago. The nuclear phase-out was finally agreed; Germany's remaining reactors are due to be shut down next year. A science-based, transparent, participatory and stepwise procedure is now in place to identify a site for a repository. Our researchers' expertise is therefore still in demand. For more than four decades, they were the first to provide independent scientific analyses that the anti-nuclear energy movement could rely on. Today, they feed their independent expertise into the public participation formats that are part of the site selection process. They also support the process by providing studies of their own, and they help to interpret the statements contained in technical reports. Many of the issues being addressed in this process are far removed from our day-to-day experience, so anyone wishing to engage appropriately needs support and assistance in understanding the science.

We face a monumental task: to set up a repository that can safely store high-level radioactive waste for at least one million years. It is a challenge replete with potential for social conflict. Opposition to the project is already stirring and will undoubtedly increase once the number of potential sites is narrowed down. There is therefore no alternative to this broad-based participation process. It is a process that must prove its worth at every stage, which is why the decision in favour of a self-reflecting learning procedure is so important. It is also essential to manage generational change on this issue efficiently and ensure that there is no loss of knowledge and expertise. We are pleased that at the Oeko-Institut – with our experienced team members and our younger and more recent appointees – we are able to make an important contribution here.

In her article in this issue of *eco@work*, Julia Neles, who took over as Deputy Head of the Oeko-Institut's Nuclear Engineering & Facility Safety Division in March 2021, addresses a topic which, in view of the geological and societal challenges associated with final storage, was sharply criticised early on: the fact that nuclear energy generation began while the legacy issue was still unresolved. It was a mistake that we must not repeat, and it warns us that whenever new technologies are adopted, it is essential to be mindful of their impacts, no matter how clean and sustainable they may, on the face of it, appear to be. This has been the Oeko-Institut's mission for more than 40 years – and will remain so. I hope you will continue to support us!

Yours,
Jan Peter Schemmel

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“You have to try a lot of things and tolerate setbacks”

In Finland construction is already under way, in France a site has been identified, while the USA is still stuck. Countries all over the world are engaged in the search for a final repository. Dr Allison Macfarlane is one of the USA's top nuclear experts. She chaired the Nuclear Regulatory Commission (NRC) and was a member of the Blue Ribbon Commission on America's Nuclear Future. She is now Director of the School of Public Policy and Global Affairs at the University of British Columbia in Vancouver, Canada. In her interview with *eco@work* she talks about the state of the worldwide search for a repository, the factors that contribute to a successful search for a site, and also about where the repository issue has got to in her home country.

Which country has made most progress in setting up a repository?

Definitely Finland. It will probably be the first country to put a final repository into operation. The repository is already under construction on the Olkiluoto peninsula on the west coast; only one more licence will be needed for it to become operational.

What is the position in other countries?

Sweden, too, is relatively far advanced. It has already chosen a site – which is adjacent to the Forsmark nuclear power plant in the east of the country – and the official review is under way. In Sweden, incidentally, they had to try multiple methods to find a site. Initially the search involved looking for an appropriate geologic setting, then they asked for municipalities to volunteer to host a repository on their land. Some came forward, but for geological reasons they turned out not to be suitable. Finally, municipalities that already have nuclear facilities were approached and asked if

they would be prepared to be involved. That paid off: they found two communities where more than 80 percent of the local population was supportive of a repository.

In France – a country with a very large number of nuclear power plants – Bure in Lorraine has been identified as a site. The UK was close to choosing a site, but after considerable opposition the search had to be re-started. And following the accident at Fukushima, Japan has also begun again to look for a suitable site.

What enables the search for a site to succeed?

In my view, one of the key things we have learned from the activities to date is that it is not usually a straightforward process. You have to try something and it probably fails, so you then try something else and perhaps fail again. But eventually you try something and it succeeds.

It also needs a lot of compromises and a lot of negotiating, and you have to cooperate with the local people. You cannot simply go to a municipality and specify it as a site for a final repository without discussion. People must have an opportunity to say no. Of course, this only applies up to a certain point in time. Once formal approval has been granted, it is too late to object. It is also important for the municipality to be given the financial resources needed to carry out its own surveys – or commission independent ones – so that the community doesn't have to rely on the assumption that what the government or the nuclear industry says is correct. Ideally such funds should also be available for those who oppose a final repository as well.

Where does the USA stand on this issue?

Unfortunately nowhere. So, the decision for or against Yucca Mountain is currently open. And since the Department of Energy dissolved the office that handled nuclear waste disposal in 2010, there is now no national organisation that takes the lead in the handling of radioactive waste.

Why has the USA got stuck in this process?

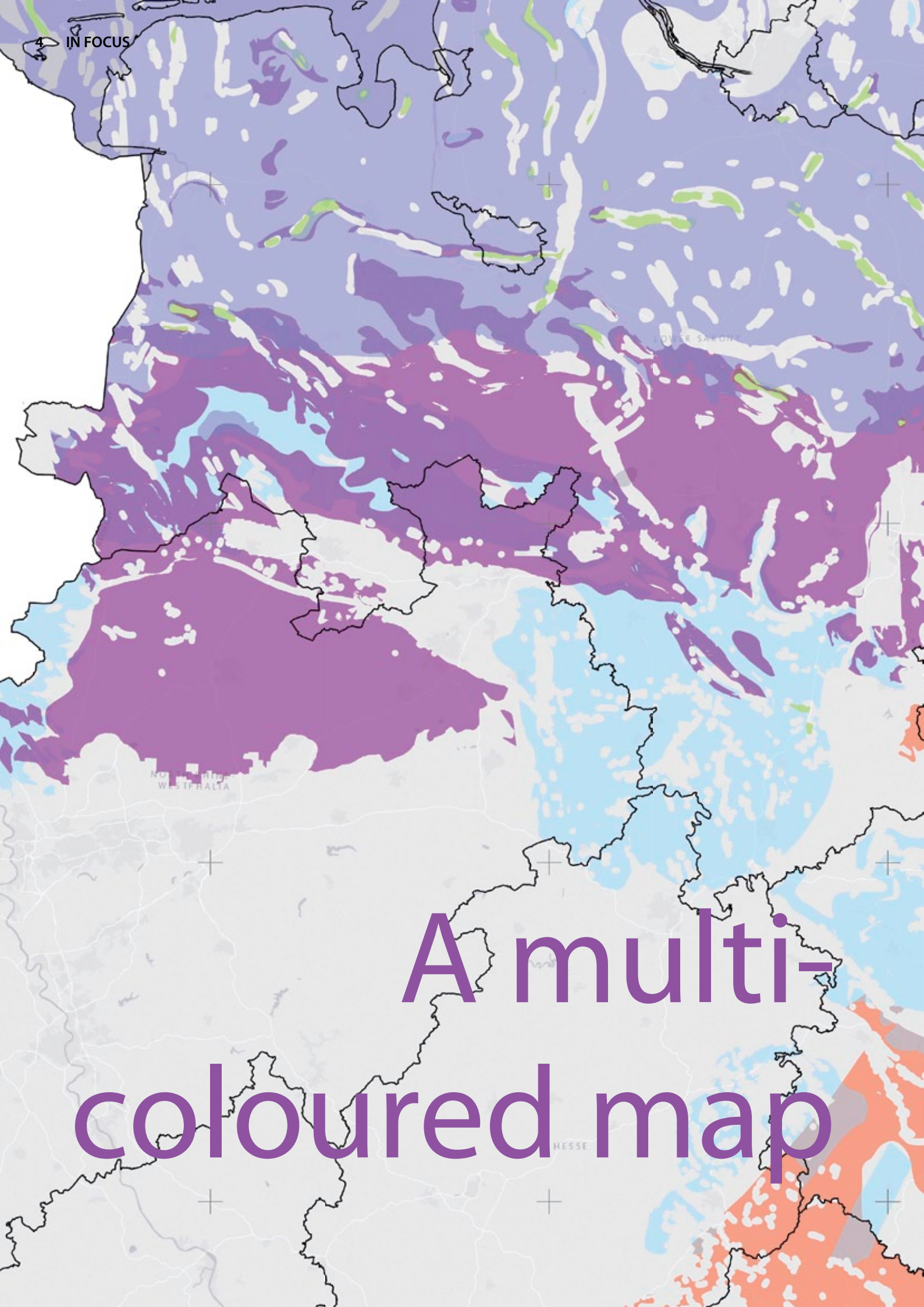
This is partly because the original plan to examine a number of sites was scrapped for reasons of cost. And now there is nobody with an incentive to get things going again. The only people who would have an interest in solving the waste problem are those who live near shutdown nuclear power plants where the high-level radioactive waste is stored. This is already the case at 19 power plants with 21 reactors; by 2025 there will be 24 such power plants. But unfortunately these people do not have a loud voice.

Thank you for talking to *eco@work*.

The interviewer was Christiane Weihe.



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Talking to *eco@work*:
Dr Allison Macfarlane, Director of the School of Public Policy and Global Affairs at the University of British Columbia (Vancouver, Canada)



A multi-coloured map

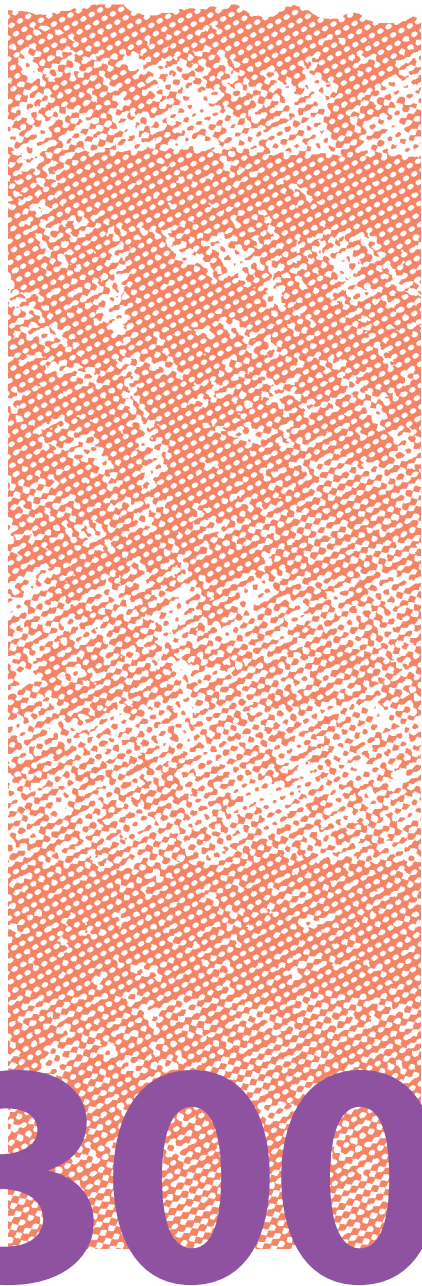
The Sub-areas Interim Report

Large areas of orange, a lot of lilac, a touch of green: the map of Germany on which the Bundesgesellschaft für Endlagerung (BGE) – the Federal Company for Radioactive Waste Disposal – shows possible sub-areas is a colourful one. Its radiant hues show where there are claystone, granite or rock salt formations and, above all, which regions in Germany – according to current knowledge – may be suit-

able as a site for a future repository for high-level radioactive waste. The sub-areas were assessed against legally stipulated criteria and finally made public in the BGE's Sub-areas Interim Report in September 2020. The Oeko-Institut is involved in a number of projects which examine the bases and content of the Interim Report and consider the implications for various regions in Germany.

According to the Interim Report, a total of 90 sub-areas in Germany are suitable in principle for consideration as a repository site; this means that based on current knowledge, they have suitable geological conditions as stipulated in the Repository Site Selection Act (Standortauswahlgesetz – StandAG). They include the Fichtelgebirge mountain range in Bavaria, Alb-Donau-Kreis county in Baden-Württemberg, the Mecklenburg Lake District, and the district of Friesland, as well as cities such as Berlin and Stuttgart.

TO BE CONSIDERED FOR A REPOSITORY, A ROCK FORMATION MUST BE AT LEAST



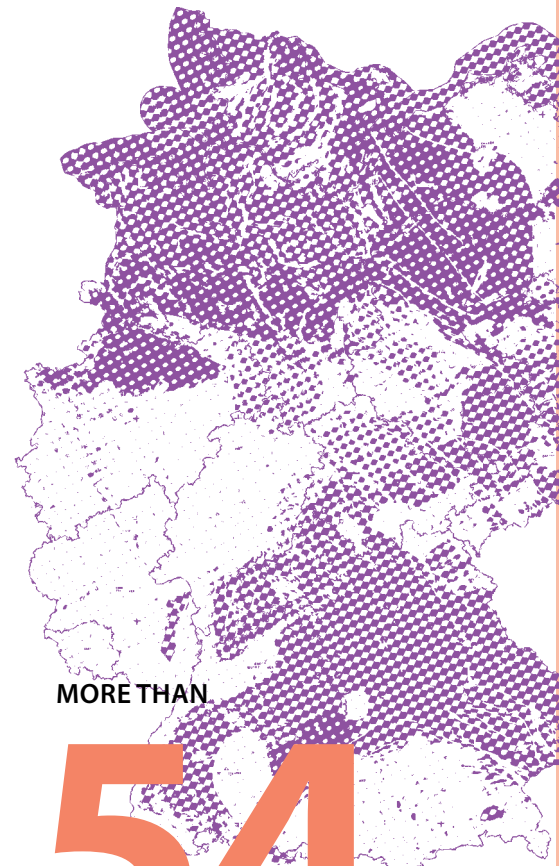
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METRES BELOW GROUND SURFACE.

The Repository Site Selection Act defines three groups of criteria. In a first step, exclusion criteria were applied in order to identify areas that cannot be considered. Characteristics that put a site out of the running for a future repository are seismic or volcanic activity and large-scale vertical movements. "These are caused by very gradual processes, such as plate tectonics, within the Earth," says Dr Saleem Chaudry, a geologist from the Oeko-Institut's Nuclear Engineering & Facility Safety Division. "Areas that have active geological fault zones where there are fractures in the rock strata, for example, and areas with young groundwater in direct exchange with the biosphere are also excluded." The Act also stipulates minimum requirements for a possible final repository, which were applied in the second step for the Interim Report. "For example, the host rock must have very low-level permeability, the rock formation must have a thickness of at least 100 metres and be located at least 300 metres below ground surface, and it must be large enough for a repository that can accommodate all of Germany's nuclear waste," Dr Chaudry explains. In a third step in this part of the process, the identified areas were evaluated according to 11 geoscientific weighing criteria, including the rock's temperature compatibility, protection of the effective containment zone by the overburden, and hydrochemical conditions.

ONE MILLION YEARS

All these criteria are intended to ensure that the high-level radioactive waste – mainly consisting of spent fuel elements and vitrified fission products from reprocessing – remains safely contained in the future repository for a period of at least one million years. "From a scientific perspective, there is currently no alternative to underground storage of this waste. Over the long term, geological barriers can prevent the radioactive materials from reaching the surface again," says Dr Chaudry. "They will of course be reinforced by technical and geotechnical barriers, including those created when the repository is sealed."



MORE THAN

54

PER CENT OF GERMANY'S NATIONAL TERRITORY CAN CURRENTLY BE CONSIDERED FOR THE SITING OF A REPOSITORY.

Even after the application of these criteria and requirements, that still leaves a total of 54 per cent of Germany's national territory as a designated sub-area; the details are published in the Interim Report. In a self-funded project, the Oeko-Institut is tracking the process from a scientific perspective, for example by producing analyses and participating in the relevant sub-areas conferences (*for more details, see "An ongoing task" on p. 8*). "We also publish statements and articles about the Interim Report in order to address current issues, and we provide background information for all interested parties," says Dr Chaudry. Overall, the researchers regard the Interim Report as an important step in keeping the public informed and offer-

ing them an opportunity to participate in the process early on. "Many elements of the report have been handled well; the criteria were applied sensibly and addressed in a transparent manner." Elsewhere, however, the experts are critical of the Interim Report's methodology. "For example, before making any predictions on volcanic activity in a given region, the indicators need to be reviewed as there are differences in scientific opinion here." Dr Chaudry is also critical of the fact that much of the available data relating to previous drilling was not utilised in the production of the report. "This is due to the principle of comparability, because the data may have been available for one region but not for another. However, in the further process, this information should be used for site-specific evaluation."

In addition, the Oeko-Institut considers the very detailed report to be insufficiently structured, especially given the complexity of its content. "A non-professional would find it almost impossible to navigate," says Dr Chaudry. "And there are many sections where even scientists working on this topic on a daily basis find it difficult to follow the decisions that the report documents." In his view, this is partly due to the short timeframe for the production of the report. "However, it is neither necessary nor sensible for the persons responsible to be working under time pressure here."

IMPACT IN THE REGIONS

From Dr Saleem Chaudry's perspective, the Interim Report requires interpretation as a matter of urgency for anyone who is not an expert but will be using it in their work. "Sooner or later, local government representatives in particular will need the capability to deal with this topic." The Oeko-Institut has already provided this service for Bevensen-Ebstorf municipality in Lower Saxony by "unpacking" the report and providing short-term consultancy. "The municipality wanted to know why it was being considered as a site for a repository, so we looked at the reasons for this decision." Two salt domes and a claystone distribution area were designated as sub-areas in the Interim Report. "In our analysis, we found that with regard to

the weighing criteria, for example, only very general information about the rock formations, their location, scale and thickness had been used," says Saleem Chaudry. "In our view, detailed information from the municipal area was left out of the assessment."

The Oeko-Institut has already provided advice to Emsland as well. "In total, there are 10 possible sub-areas across this rural district, including three salt domes, which lie adjacent to each other," says Dr Chaudry. "The officials responsible for dealing with this issue wanted to know whether these domes were likely to be considered for a repository. We also helped them set up their own advisory panel." In its report, entitled "Specialised Consultancy for Emsland Rural District on the Findings of the Sub-areas Interim Report as Part of the Process for the Selection of a Repository Site" (*Fachliche Beratung des Landkreises Emsland zu den Ergebnissen des Zwischenberichts Teilgebiete im Standortauswahlverfahren für ein Endlager*), the Oeko-Institut notes that the methodology that led to the selection of the salt domes was transparent. However, the report also identifies a need for additional information and review on certain points. "For example, pre-existing site-specific data from prospection drilling by the oil industry were not used in the assessment – that needs to change as the process continues," says Dr Chaudry. "There also need to be further checks on which active fault zones exist in the salt domes and how this influences their suitability as a sub-area." The report further notes that the minimum requirements pertaining to the size of the future repository – three square kilometres for rock salt, six for crystalline rock and 10 for claystone – should be reviewed, "also with a view to establishing whether the stated area is sufficient to guarantee retrievability of the high-level radioactive waste, if desired."

On behalf of the Citizens' Initiative for Environmental Protection Lüchow-Dannenberg (*Bürgerinitiative Umweltschutz Lüchow-Dannenberg*), the researchers also produced a "Short Report on the Implementation of the Criteria pursuant to Sections 22-24 of the Repository Site Selection Act: Methodology for the Application of the Criteria by the Federal Company for Radioactive Waste

Disposal (BGE)" (*Kurzgutachten zur Umsetzung der Kriterien nach den §§ 22-24 StandAG in Methoden zur Kriterienanwendung durch die Bundesgesellschaft für Endlagerung mbH*). "The Citizens' Initiative had already commissioned us to assess the suitability of the criteria applied in the Interim Report prior to its publication," the geologist explains. "We concluded that for the most part, the requirements and criteria defined in the Repository Site Selection Act were translated into a methodology in a transparent and appropriate manner."

LOSING COLOUR

The search for a repository site will soon enter the next phase. For the BGE, this will involve conducting surface explorations in potential siting regions and narrowing the choice further, based on analyses of seismic activity, for example. This will be followed by subsurface explorations in a third phase and a site proposal, which is subject to final approval by the German Bundestag. The aim is to have identified a site by 2031. So instead of its current broad sweep, the BGE's map of Germany will gradually become focused on individual areas – and will become much less colourful in the process.

Christiane Weihe



Geologist Dr Saleem Chaudry works on various aspects of radioactive waste management. Based in the Oeko-Institut's Nuclear Engineering & Facility Safety Division, his specialist areas include the geochemistry of marine evaporites and inter- and transdisciplinary research in the field of radioactive waste management. s.chaudry@oeko.de

An ongoing task

Public participation in repository site selection: a once-in-a-lifetime project

A repository right on my doorstep? For many people, that's impossible to imagine. They have fears and concerns that can spark major opposition to the facility. So in the search for a suitable site, it is important to consider not only technical and geoscientific issues but also society's needs and

expectations. The early and active involvement of the public is therefore key. How can citizen participation work, and which challenges can already be identified in this once-in-a-lifetime process? These issues are among those being addressed by the Oeko-Institut.

"The search for a repository site faces a monumental task, namely that its outcome has to be accepted and tolerated by the whole of society – including, above all, the people who will be directly affected," says Dr Bettina Brohmann, Research Coordinator for Transdisciplinary Studies at the Oeko-Institut. "This can only be achieved in a transparent, stepwise and consensus-oriented process that actively involves citizens and facilitates co-design." What is needed is citizen participation that goes beyond information and consultation: there must be open dialogue with scope for participants to shape the process, she says. The foundations have already been laid. "With the reform of the Repository Site Selection Act, a new form of public participation was established: a self-reflecting and learning process. This is a particular challenge but also a great opportunity."

A SUCCESSFUL PROCESS

How can the formal and informal types of citizen participation be optimally designed? This question was explored by the Oeko-Institut on behalf of the German Federal Office for the Safety of Nuclear Waste Management (BASE) in the project "Public Participation in the Siting Procedure for a Final Repository: Challenges of a Cross-generational, Self-reflecting and Learning Procedure". Together with the Institute for Technology Assessment and Systems Analysis (ITAS) at the Karlsruhe Institute of Technology (KIT) and team ewen GbR, the researchers began by carrying out a comprehensive review of the current research literature and analysing lessons learned from various other participation processes. "On this basis, we then sketched out what good public partici-

pation in the site selection procedure might look like and how much scope the Repository Site Selection Act offers here," says Dr Brohmann. It is important, she says, to allow for diverse forms of participation which can be added to over time and continuously reviewed and modified if necessary. "In addition, all stakeholders should be involved in the process from the start, and sufficient time and financial resources must be made available for this, along with appropriate structures. The objectives and the scope for participation should always be clearly communicated."

Other factors that contribute to successful participation are openness and interest in the outcomes of citizen involvement – and, of course, systematic consideration of these outcomes in the further process. Here, reflection and learning are important, not only within the institutions but also among



stakeholders. "This is the only way to ensure that this is genuinely a learning procedure. And that means accepting that there may well be changes – after all, this is a long process," says Dr Brohmann. "At the same time, the process must remain robust and stable, even if the broader societal conditions change." Close cooperation among all participants from politics, the public authorities and civil society is also essential, she says. "We need a shared knowledge basis and joint input to the present and future processes." Furthermore, as the process continues, the regions that are being considered in more detail as a repository site must be monitored and supported, with a focus on regional disparities in the resources and capacities needed to make a genuine contribution to the process.

FORMS OF PARTICIPATION

The Repository Site Selection Act provides for various types and forums for public participation. A launch event in October 2020 marked the start of preparations for the three subsequent discussion meetings of the sub-areas conference. The meetings are a forum for discussion of the BGE's results, which are set out in the Sub-areas Interim Report and serve as a basis for the selection of siting regions and, ultimately, of a repository site (*for more details, see "A multi-coloured map" on p. 4*). The sub-areas conferences will be followed by regional conferences. "These will be held wherever surface exploration is carried

out. Their purpose is to provide information and facilitate the involvement of local people, who can then demand further reviews via the regional conferences," Dr Brohmann explains. The Council of Regions, composed of representatives of the regional conferences and the municipalities with interim storage facilities, will also monitor the process from a transregional perspective and assist in weighing the interests of the possible siting regions. "In addition, there are other more informal forms of public participation, such as workshops to promote youth involvement, online consultations and digital dialogue forums. Another key element is an information platform which, among other things, provides updates about the status of the search and makes key documents available."

A LEARNING PROCESS IS DESIRED

Many formats are emerging and are, in some cases, already being critically reviewed. Rightly so, according to the Oeko-Institut's expert. "At the moment, the process is not working as well as it could," she says. "This is undoubtedly due to the fact that we are dealing with new institutions and structures." The sub-areas conference in February 2021 was very well-attended, with more than a thousand participants, but was held entirely online, which posed particular challenges. "It made it difficult to enable all groups to have a say and be heard to an adequate extent." One criticism was

that the events held to date have left too little scope for dialogue and discussion and that the learning process is still too slow. "It is also still unclear how recommendations are to be reviewed and then genuinely accommodated in the process." Better access to scientific knowledge is also needed, she says, perhaps via a scientific body that can provide assessments and expert appraisals as required. "There also needs to be more representative participation and communication with the public. So we need to motivate other groups, such as youth associations and the churches, to participate in the events." As an expert in citizen participation, she would also like to see more media engagement. "The work with the media should be expanded; among other things, there should be more emphasis on the innovative character of the selection procedure."

A repository right on my doorstep? Ensuring that Germany's final storage facility can be tolerated by its future neighbours is a multi-generational, whole-of-society task. It also poses a challenge for the new procedure, which will have to adapt and prove itself again and again over the coming months and years. Last but not least, from Bettina Brohmann's perspective, a further success factor is genuine recognition of the future siting region, possibly in the form of compensation as a mark of appreciation of the very significant, unique contribution that it will be making to the whole of society.

Christiane Weihe



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