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Sustainable reading from the Oeko-Institut

Nuclear energy – what comes afterwards?

A task for generations to come
Interview with Michael Sailer

One million years

The first time I took part in a panel discussion – in Worms back in 1975 – it dealt with a nuclear power plant. We talked about the Biblis plant. And when the issue of nuclear waste was raised, the operator said: "We'll deal with it." And I answered: "It's not that simple. I'm worried that we will need a clean-up operation in future." The future means today. Germany is now searching for a site that can accommodate 28,100 cubic metres of high-level radioactive waste – a site that offers the best possible safety and security for a period of one million years, in accordance with the law. No building, facility or technology created by human hand can possibly offer safe storage over such long time spans: the forces of nature are simply too strong. Only geological formations are stable enough to store the legacy of half a century of the nuclear industry. Using modern geoscientific techniques, it is possible to predict a safe storage period of around one million years with a very high degree of probability.

The Earth is, after all, more than four billion years old, so on that scale one million years is a manageable timeframe. Let's look back to one million years ago. Broadly speaking, the Earth's continents had already assumed their current form, the Alps and the North Sea looked very much as they do today, and our ancestors were already using tools. Large-scale and recurrent Ice Ages were carving out the landscape. Glaciers – sometimes 3,000 metres thick – towered over Scandinavia and created the plains of Northern Germany. The Baltic Sea came into being after the last glacial period.

But the search for a final storage site is not only about identifying a suitable geological formation which will be secure enough to withstand anything – even another Ice Age. It is also about public acceptance. And in my view, that is the real challenge. Who would rest easy, knowing that radioactive waste is buried nearby?

In this issue of eco@work, we look at this urgent and complex scientific, social and environmental issue. Among other things, we focus on the Oeko-Institut's work on acceptance issues. A site may be entirely suitable from a geological perspective, but it is essential to prepare and involve citizens from an early stage in the site selection process. We also explore the issues surrounding power plant decommissioning in the following pages.

As always, I hope you enjoy this issue of eco@work!

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In Focus

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"We have a responsibility to future generations"

Nuclear energy issues run like a red thread through Michael Sailer's curriculum vitae. Early on in his career, he campaigned for the phasing out of nuclear power. Today, he is the Chairman of the Nuclear Waste Management Commission (ESK) and a member of the Commission on the Storage of Highly Radioactive Materials. Michael Sailer is a critic of nuclear energy and a high-profile expert on the nuclear industry. For the last 35 years, he has put this expertise to good use on behalf of the Oeko-Institut. He has been a member of its Executive Board since 1999. He talks to eco@work about his involvement in the search for a final storage site, the problematical issue of interim storage, and the criteria that must be met by a German repository.

Mr Sailer, why is being involved in the search for a final storage site so important to you?
We are responsible for the nuclear waste produced in Germany, so we need final storage facilities in Germany. To me, that's beyond question. I think it would be immoral simply to leave nuclear energy's difficult legacy for future generations to deal with. So we need to build a safe and secure repository as soon as possible. We should not operate the existing interim storage facilities any longer than necessary.

What risks are posed by the interim storage facilities for spent fuel elements and high-level radioactive waste?
These interim storage facilities are licensed for 40 years. Let's take the Gorleben site as an example: its operating licence is due to expire in 2035. The other 15 interim storage facilities will follow soon afterwards. But Germany won't have a repository for high-level radioactive waste by then. This raises a host of questions. What will happen to the waste that is stored at these sites? What condition will the fuel elements be in? How reliable are the sealing and monitoring systems? These things are impossible to predict. So the Oeko-Institut is demanding continuous monitoring, which must include periodically opening and examining a number of sample storage containers. If we intend to store high-level radioactive waste in a repository, we first need to find an answer to the question whether the condition of the containers and their contents will allow this to take place without any need for additional safeguards.

Do the current interim storage facilities have adequate capacity? Will they be able to cope with the forthcoming decommissioning programmes?
The interim facilities have sufficient capacity to store spent fuel elements and high-level radioactive waste, but not enough to store the low- and intermediate-level radioactive waste that forms the bulk of the waste produced during decommissioning, mainly from power plant buildings and technical components. So we will need additional interim storage facilities at the reactor sites. A repository for this type of waste is now being built at Konrad pit, and it is important that it comes into operation as soon as possible.

What are the criteria that should be met by a future final storage facility?
The key criterion is that no water should penetrate the facility, so the host rock must be as watertight as possible. The containers and backfilling must be constructed in such a way that the waste is stored securely, with no leaks, until the surrounding rock closes the gap. So the construction of the containers must be very solid. They should not corrode easily and they should not react with the stored materials. In order to protect the repository from water penetration, the entire facility must also be closed and filled with effective barrier materials. We also need a clearly structured emplacement geometry and clear documentation of the facility. If the repository needs to be reopened again at any stage – for example, if the waste needs to be removed from the facility, which is not something we expect to happen – it must be clear which type of waste is being stored and precisely where it is located at the site.

How can a balance be achieved between integrity and recoverability?
The best approach – should it be necessary to remove the waste from the facility in future – is to build a new facility directly adjacent to the sealed repository from which storage containers are to be removed. This approach allows safe, secure and timely sealing of the repository while allowing possible access at a later stage, if necessary. This also has implications for the search for a site: there needs to be enough space not only for the repository itself but also for the possible future construction of a back-up facility in the host rock.

Thank you for talking to eco@work.
The interviewer was Christiane Weihe.

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Michael Sailer, the Oeko-Institut's CEO, talks to eco@work

Decision-making for the future

Public participation in the search for a final storage site

Germany is looking for a final storage site for its nuclear waste. The 2013 Repository Site Selection Act (Standortauswahlgesetz) created the framework for a multi-stage process which began with the establishment of the Commission on the Storage of Highly Radioactive Materials in 2014. The process of selecting a suitable site for the long-term storage of high-level radioactive waste (HLW) will start in 2016. According to researchers at the Oeko-Institut, however, it could be decades before the facility comes into operation – and next century before it is finally sealed. In other words, even for today's schoolchildren – and their descendants – the problem won't go away. That's one of the reasons why the process to identify a final storage site must involve the general public, especially the young generations.

Germany will complete its nuclear phase-out within the next few years. For low- and intermediate-level radioactive waste, Schacht Konrad (Konrad pit) has been designated as a repository site. However, a solution has yet to be found for waste from uranium enrichment and waste from the at-risk Asse nuclear waste storage facility. And there is still no suitable site for the final storage of the nuclear age's most dangerous legacy: "By the time nuclear power is phased out, there will be an estimated volume of around 28,100 cubic metres of high-level heat-generating radioactive waste, which will need to be stored safely and securely," says Julia Neles, a researcher at the Oeko-Institut. This waste consists of spent fuel elements and radioactive waste from reprocessing.

"We can't duck the issue: we have to make a decision on a final storage site. We can make a well-informed decision by weighing up the various options and choosing the safest solution," says Julia Neles. But this creates major challenges, for nuclear waste poses a threat to human health and the environment over extremely long time periods. The period during which the site must be able to contain radiation has been set at one million years – "a time span for which it is feasible to make firm predictions from a geoscientific but not from a technical safety perspective". According to Julia Neles, deep and stable geological formations are required. "Suitable types of host rock available for consideration in Germany, broadly speaking, are rock salt, clay shale and crystalline rocks such as granite. The site must offer security from attacks or misuse and withstand climatic changes," she says. The repository may be monitored for a time after sealing and the waste could be removed from the facility if necessary, but continued safe storage should not depend on the adoption of active safeguard measures for an indefinite period, as the time spans involved are simply too long.

Since May 2014, the Commission on the Storage of Highly Radioactive Materials has been working on the first stage of the search for a site. It is evaluating the Repository Site Selection Act and drawing up recommendations on selection criteria. A key goal is to ensure that the site selection process is clear and transparent. The Commission consists of 16 political representatives with no voting rights and 16 members with voting rights: eight of the latter group are scientists, while the other eight are appointed by environmental NGOs, the trade unions, the churches and the business community, which each send two representatives. Next, there is a three-stage process to identify a site. First, unsuitable areas will be excluded, and then a multi-day exploratory visit to potential sites that meet minimum criteria will take place. "And finally, the third stage involves an underground inspection of the potential sites, a comparative analysis, and the selection of a site for the repository," Julia Neles explains. The aim is to identify, by 2031, a repository site for high-level radioactive waste and spent fuel elements, which are currently being stored in 16 interim storage facilities in Gorleben, Ahaus, Greifswald and Jülich and at the nuclear power plants themselves.

Consultation and information

Expert Julia Neles emphasises the importance of public participation in this decision. The site selection process will affect specific regions and the people who live there. At the end of the process, one region will face the very real prospect of a repository, and one community will host the facility. "It is crucially important to prepare people and involve them in the site selection process before they are actually confronted with the reality," says Julia Neles. "They need information so that they can respond when the time comes and take part in the consultation process." In her view, the phase in which a repository site is determined will be crucial to the success of the process as a whole.

Reliable information is the basis for effective participation – and the Oeko-Institut's researchers have a wealth of expertise on final storage issues. "This is expertise that we are keen to share," says Julia Neles. "We can offer the public a politically independent assessment of the challenges, processes and decisions." In fact, the researchers are already playing an active role: they are available as panellists and resource persons for events focusing on final storage issues. "We have already given a number of presentations and welcome every opportunity to provide information and promote debate by sharing our expertise."

A new generation

For the experts, the young generation is a particular focus of interest. "Today's young people are tomorrow's decision-makers. They are the people who may well be directly affected by a final storage facility," says Julia Neles. "So it's very important to ensure that they are fully informed today – also about their opportunities to participate." Together with the Independent Institute for Environmental Issues (UfU) and with support from the Legacy for the Future Foundation, the Oeko-Institut has therefore produced teaching materials for schools, including a guide for teachers on lesson planning, a glossary of final storage terms, and a presentation that teachers can use to introduce the topic. "We have also produced a comprehensive set of information cards that present the topic in more detail. They cover five different aspects of the search for a final storage site, including radiological protection and nuclear industry legislation," explains Julia Neles. The teaching materials focus on the young generation's own concerns about the final storage of nuclear waste. The aim

Nuclear waste facilities in Germany

Overview of all sites where radioactive waste is stored

Source: Oeko-Institut (2014)

is to encourage them to engage in the consultations from an early stage, despite the complexity of the issue.

A dialogue of equals

In the Oeko-Institut's view, it is now vital to offer further services, awaken interest in the subject, and restore faith in the people who are committed to finding a solution to the final storage issue now and in future. "Young people in particular must be given the opportunity to engage with this issue," says Julia Neles. "We want to reach as many young people as possible and give them the skills they need to tackle the challenges that lie ahead."

The Oeko-Institut's experts want to see a critical public which challenges and questions, draws on its own expertise and demands compliance with the criteria. The Repository Site Selection Act includes provisions on public consultation mechanisms, such as public meetings and citizens' affairs offices in regions that may be candidates to host the facility. The refinement of these mechanisms is built into what Julia Neles describes as "a learning system". In her expert view, this is a key element of effective consultation, not least because the mechanisms may well vary from region to region. "Many issues will have to be left to local decision-makers. It will be for them to decide how they wish to proceed," says Julia Neles. "So they will need adequate resources – both staff and funding – in order to carry out this work." The search for a repository site is a project which will preoccupy many future generations as well, and that needs to be considered in the public consultation process. "Of course, it is quite possible that future generations won't understand our decisions or will, perhaps, have gained new knowledge about final storage. These are factors which we need to consider today, both in the consultation processes and in the search for a suitable site."

Taking account of citizen participation outside organised structures, such as public protest, is a particular challenge. "Conflicts of this type must be considered in the consultation process today, and finding practical ways of doing so is a major challenge," says Julia Neles. Public participation in processes such as the search for a final storage site is often based on representative mechanisms: in other words, public opinion is articulated by politicians or NGOs. "That's part of our representative democracy," says Julia Neles. "But it sometimes makes it difficult to involve members of the public who are not organised." And that applies particularly to the young generations.

Christiane Weihe

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Fading out of the landscape

Decommissioning nuclear power plants

The last kilowatt hour has been fed into the grid. What happens now? Unlike Berlin's Tegel Airport or the Gasometer in Oberhausen, finding an alternative use for disused nuclear power plants is not an appealing prospect. Decommissioning is therefore the only option and is already under way at several sites. It's a complex process, costing around three quarters of a billion euros for each reactor, and it takes time – 20 years and more from planning to completion. The expertise of power plant staff and external consultants has a vital role to play in this context, along with effective technical supervision by the relevant authorities.

A nuclear power plant is dismantled piece by piece. Radiation levels are considerably reduced when the fuel elements are removed from the storage pond and contaminated primary circuit piping is cleaned. Nonetheless, some radiation remains in every reactor. In some parts of the reactor, it is highly concentrated; in others, there are various levels of contamination across systems and surfaces. "That's why it's important to plan and carry out decommissioning operations with great care; otherwise, inadvertent contamination can occur, which means that radiation is dispersed in dust or liquids to previously uncontaminated areas," explains Christian Küppers, Deputy Head of the Nuclear Engineering and Facility Safety Division at the Oeko-Institut. So what happens to the individual components of a decommissioned nuclear power plant? Stringent rules apply: "Decommissioning a reactor produces various

types of waste, and of course some of it is so highly radioactive that it has to be sent to an interim and later a final storage facility," Küppers explains. "This applies mainly to the reactor pressure vessel and its components." However, some materials and surfaces can be decontaminated during decommissioning operations, "for instance by ablation or sandblasting". Below certain contamination thresholds, known as clearance levels, the materials no longer qualify as radioactive and can be disposed of by conventional methods. Most of the waste produced during decommissioning falls into this category. In order to minimise possible radiation exposure and risks as far as possible, various clearance categories are defined. "One is unrestricted safety clearance for building rubble, which can be re-used in road construction, for example," says Christian Küppers. For some types of waste, the Radiological Protection Ordinance allows limited safety clearance, which means that it is subject to certain conditions. This applies to scrap metal, which can be melted down, and disposal of some solid and liquid waste. "For example, some of these materials can be disposed of at landfill sites which meet certain criteria as regards size and the sealing of the base of the landfill facility."

Oeko-Institut researchers are currently working on a project on behalf of AWN, the waste management company in Neckar-Odenwald county, which focuses on the clearance of waste produced in the decommissioning of Obrigheim nuclear power plant and its disposal at the Buchen-Sansenhecken landfill facility. "AWN commissioned us to produce an expert opinion on clearance issues and to conduct follow-up checks at the nuclear plant itself," Christian Küppers explains. The expert opinion deals with basic clearance criteria, analyses the rules applicable to the plant, and discusses monitoring of the clearance process. It also reviews and evaluates the disposal strategy. "Buchen-Sansenhecken landfill site complies with the criteria defined by the Radiological Protection Ordinance for landfill facilities that dispose of waste which has undergone clearance," says Christian Küppers. And as he explains, the clearance levels are based on pessimistic assumptions that overestimate the expected radiological impacts. "The guidance issued by the Association of Counties in Baden-Württemberg for waste producers and landfill operators further reduces possible radiation exposure," says Christian Küppers. As soon as disposal at Buchen-Sansenhecken begins, the Oeko-Institut's experts will carry out checks at the Obrigheim nuclear site. "It is essential to ensure that the only materials disposed of at the landfill facility are those which have been cleared for this purpose," he says.

What does decommissioning mean for people and the environment? Oeko-Institut experts are investigating this question as part of their many environmental impact assessments (EIAs) for decommissioning programmes, including the Jülich experimental reactor in 2008. On behalf of the Ministry of Economic Affairs, Energy and Industry of the State of North Rhine-Westphalia, the Oeko-Institut investigated the possible impacts of radioactive substances and wastewater, air pollution and noise on human health, fauna and flora, water resources and soil, etc. As part of the EIA, the researchers proposed criteria for the decommissioning of the plant, which aimed, for example, to minimise dust and noise during demolition of the buildings. "Demolition rarely forms part of the decommissioning application, because the operator argues that the buildings may ultimately be used for other purposes," explains Christian Küppers. "But as a rule, there is no interest in any post-use of these buildings. But unless the application includes demolition, there is no scope, legally speaking, to include an assessment of its impacts in an EIA."

The researchers are currently conducting two EIAs on the decommissioning of Philippsburg 1 and Neckarwestheim 1 nuclear plants on behalf of TÜV Süd safety standards authority. "In summer 2015, various public consultations will be held on the two decommissioning programmes, which we will attend as experts in order to answer questions about environmental impacts," says Christian Küppers. At present, five preliminary environmental impact assessments are also being conducted. "They are needed because new facilities for waste storage and treatment, for example, are due to be constructed as part of the decommissioning process." The preliminary assessment investigates whether an EIA is needed in these specific cases.

At least another 25 years

The decommissioning of nuclear plants is an issue which is likely to preoccupy Germany for a long time to come. Germany's last reactor is due to be shut down in 2022, but according to Christian Küppers, it will take at least another 25 years to complete all the decommissioning programmes. "But that only applies to nuclear power plants whose decommissioning starts immediately after shutdown," he explains. "There is also the Hamm-Uentrop reactor, which is undergoing a procedure known as safe enclosure: the fuel elements are removed, the radioactive components are gathered together in one area, and as many of the non-radioactive materials and buildings are disposed of as possible." Christian Küppers is critical of this procedure. "Safe enclosure can last up to 40 years. By then, there will no longer be any staff available who are familiar with the plant. But time and again, experience has shown that knowledge of the plant, acquired during construction and operation, is extremely important when planning and carrying out decommissioning," he says. So once the last kilowatt hour has been fed into the grid, decommissioning – in Christian Küppers' view – should start as soon as possible. "Any other option simply delays the process and is likely to add to the problems."

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