July 2014

EUROSAFE TRIBUNE

Towards Convergence of Technical Nuclear Safety Practices in Europe

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Research on **waste processing** and geological disposal

Public participation in low-level waste disposal issues

NUCLEAR ACCIDENTS: COPING WITH UNEXPECTED WASTE

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Radioactive waste: standing the test of time

EUROSAFE Tribune expresses its appreciation to François Besnus (IRSN) and Jörg Mönig (GRS) for the valuable support provided throughout the design and production of the present issue.

To our readers

Though the decision about the energy mix and about radioactive waste management remains with the member states, the European waste directive clearly makes it an ethical obligation for each member state to avoid undue burdens on future generations that result from the use of nuclear energy and especially from radioactive waste. While near-surface disposal is a recognised concept for low- and intermediate-level waste, it is widely accepted in the scientific-technical community that disposal in deep geological formations represents today the safest and most sustainable way of disposing of highly radioactive waste.

In this context, the primary concern of TSOs is to make sure that high-quality, independent expertise is actually made available where and when it is needed. But providing state-of-the art expertise on systems required to remain safe over hundreds of thousands of years obviously is a costly process that involves a great deal of knowledge derived from on-going research, experiments and operating experience feedback.

Above this, where nuclear waste is concerned, particularly high-level and long-lived materials, technical proficiency is still not enough. It requires the trust of society, which in turn can only result from a patient and dedicated dialogue with all stakeholders, a dialogue not only to inform and communicate, but also – and mainly – to discuss at length and progressively narrow down the options available to finally reach a solution that is acceptable to most. International experience shows that the development of the disposal concepts, the verification of the safety case, and the implementation of the repository may take decades. Therefore, the directive recommends, and in fact it is practice, that the national waste management programmes remain flexible to accommodate advanced knowledge about the geological site or about innovative options for waste treatment.

The last EUROSAFE Forum held in Cologne in November 2013 showed that many questions remain open to discussion. The aim of the present issue of the EUROSAFE Tribune is to share some key issues with you.

We wish you pleasant reading.

Frank-Peter Weiß and Jacques Repussard

● The first precondition to any balanced energy policy is that the plans are made available to the public ●

Nadja Železnik,
Nuclear Transparency Watch

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The EUROSAFE Tribune 25

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Coordination
Verena Güllmann (GRS)
Emmanuelle Mur (IRSN)

Writer
Jean-Christophe Hédouin (HIME)

Design and production
Martin Brunner Associés,
Vivian Scheithe (GRS)

Iconographer
Charlotte Heuzé

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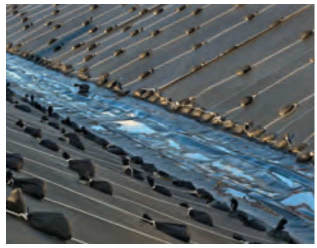


Front cover
When art meets technology. Far from being the masterpiece of some genius artist, this apparently abstract painting is nothing but the surface of sliced concrete encapsulating radioactive waste.

Contents

Kaleidoscope

ON THE WEB

Public Consultation of Revised WENRA Safety Reference Levels
The Reactor Harmonisation Working Group (RHWG) of WENRA reviewed the Safety Reference Levels at the end of 2013. More on:
www.wenra.org > Archives

ANNIVERSARY

This year, the Western European Nuclear Regulators Association (WENRA) is celebrating its 15th anniversary. The association founded in 1999 has now 17 members and is chaired by Hans Wanner, Director General of the Swiss Nuclear Safety Inspectorate (ENSI). More at: www.wenra.org

TSO CONFERENCE

27-31 October 2014
Challenges Faced by TSOs in Enhancing Nuclear Safety and Security: Strengthening Cooperation and Improving Capabilities,
international conference organised in Beijing (China) as part of the IAEA General Conference in co-operation with the European Technical Safety Organisations Network (ETSON). More on:
www-pub.iaea.org/iaeameetings/

ETSON News

ETSON Working Groups
Creation within ETSON on 6 November 2013 of an Expert Group dedicated to radioactive waste management, decommissioning and remediation to issue common views on safety assessment and research programs.

ETSON Award
During the EUROSAFE Forum in Cologne on November 4th, 2013, the ETSON Award was handed by IRSN's Director General Jacques Repussard (left) to Christian Heckötter of GRS (right) and Ari Vepsä (VTT, not in the photo) for their thesis titled *Experimental Investigation and Numerical Analyses of Reinforced Concrete Structures Subjected to External Missile Impact.*

ENSTTI NEWS

The European Nuclear Safety Training and Tutoring Institute (ENSTTI) organises the following one-week training courses:

- **Final Disposal Safety**
on 16-20 June 2014 in Fontenay-aux-Roses (France)
- **Safety Assessment and Regulation of Decommissioning of Nuclear Facilities**
on 06-10 October 2014 in Kaunas (Lithuania). More on: www.enstti.eu

MEETINGS

24-26 June 2014
Geodisposal 2014,
the IGD-TP Conference will take place at the University of Manchester (UK). More at:
www.igdtp.eu > Platform Joint activities > Waste forms and behaviour > Events

15-17 September 2014
Constructing Memory
An international conference and debate on the preservation of records, knowledge and memory of radioactive waste across generations organised by the OECD-NEA in Verdun (France).
More on:
www.oecd-nea.org/rwm/rkm/verdun2014/

25-26 September 2014
Key Topics on deep geological disposal,
symposium on radioactive waste disposal organised in Cologne (Germany) by the German Research Group on Final Disposal (DAEF).
More on: www.igdtp.eu

Stakes
& Goals

If there is one issue that exemplifies complexity for nuclear experts, it is probably radioactive waste. Different definitions, different producers, different classifications, different packaging concepts and different storage and disposal options make it a hard work for international agencies to foster understanding and harmonisation among their members.

Entering the radioactive waste maze

From spent fuel transport casks (right) through to concrete encapsulated waste drums (below), each type of radioactive material requires specific packaging technology.

The initial step of any radioactive waste management policy is the setting of legal and regulatory bases ultimately meant to protect man and the environment from the radiological hazard associated with this particular type of waste. Then, the activities producing waste must be identified, the different types of waste classified, and appropriate management processes specified for each category of waste, based on state-of-the-art scientific and technical knowledge.

Waste or not waste?

When addressing the topic of 'radioactive waste', the first thing that comes up to someone's mind is trying to give a clear-cut definition of this word... And here begins the difficulty, since any definition will be highly dependent on the policy followed respectively by one or another country. In France for instance, where the spent fuel unloaded from the nuclear reactors is reprocessed, final radioactive waste means "*radioactive waste for which no further treatment is possible under existing technical and economic conditions. Treatment particularly entails extracting any part of the waste that can be recycled or reducing any pollutants or hazardous substances it contains.*" (French Environmental Code). But for a country which does not reprocess spent fuel, the definition will be completely different, since the spent fuel assembly itself is considered as a piece of waste to be disposed of once and for all. Waste thus is a relative concept.

>half-life<
means the amount of time required for a given quantity of radioactive substance to fall to half the radioactivity measured at the beginning of the time period.

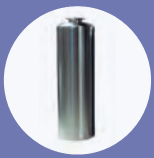
Who generates radioactive waste?

Were this question to be asked as part of a polling survey, it would very likely result in the nuclear power industry coming far ahead of any other answer, as it is true that the highest volumes of radioactive waste and corresponding activities are generated by the nuclear power industry at each step of the nuclear fuel cycle. However, far less visible players contribute to generating significant amounts of radioactive waste, starting with non-nuclear industries that use sealed sources to perform gammagraphy or food sterilisation for instance, but also the medical sector, which uses ionising radiation

Different types of waste packages used in France

Metal drum
contains compacted low level dry radioactive wastes such as clothes, papers, liquid effluents, steels and other organic and non-organic wastes and metallic parts.

Concrete drum
is used for the packaging of most intermediate level waste immobilised in cement-based materials.



Vitrified waste container
Stainless steel canisters are used for the containment of high level liquid incorporated into borosilicate glass.

Compacted waste container
Long-lived intermediate level waste products are compacted and placed in adapted waste container for disposal in near-surface facilities.

for diagnosis and treatment purposes, or yet universities and laboratories. Irrespective of its origin, radioactive waste emits ionising radiation, which makes it a particular hazard for human health and the environment, calling for particular managed procedures from production to final disposal.

How to classify radioactive waste

If radioactive waste is classified according to its activity level and the radioactive >**half-life**< of the radionuclides it contains, classifications vary from one country to another, in spite of the IAEA's efforts to generate greater consistency through the publication of the Radioactive Waste Safety Standards (RADWASS). If we consider the situation in France again, the radioactive waste categories are shown in the diagram on page 8.

The management of radioactive waste

Radioactive waste is extremely varied in terms of physical and chemical form, radioactivity and the half-life of the radioactive elements it contains, as well as in terms of volume. It therefore calls for specific processes by category, from sorting through to final disposal.

- *Sorting:* this consists in separating waste according to its different properties, in particular the half-lives of the radionuclides it contains. It also involves separating waste that can be compacted, incinerated or melted down to reduce the volume.

• *Treatment and conditioning:* different types of waste undergo different types of treatment (incineration, calcination, melting, compacting, cementation, vitrification, etc.). It is then sealed in a container. The result is a radioactive waste package.
• *Storage and disposal:* storage facilities are designed to accommodate waste packages for a limited period of time. Disposal is the final stage of the waste management process and implies that the packages have reached their final destination, meaning that there is no intention of retrieving them, though it may be required that provisions be set so that the possibility of retrieving the waste for a given period of time be ensured.

Different types of packaging provide suitable containment depending on the level of activity and decay period of the radionuclides to be disposed of.

Waste categories in France

VSLW — **Very short-lived**
waste comes mainly from medical applications of radioactivity and contains radioactive elements with a half-life of less than 100 days.

VLLW — **Very low-level**
waste comes from the nuclear industry, in particular from decommissioning. It consists of very slightly contaminated parts and rubble.

LILW-SL — **Low- and intermediate-level short-lived**
waste comes also mainly from the nuclear industry facilities (reactors, nuclear fuel cycle plants), as well as a few research laboratories.

LLW-LL — **Low-level long-lived**
waste consists for the major part either of waste contaminated by radium (naturally radioactive raw materials, retrieval of radium-bearing objects, cleanup of polluted sites) or graphite waste, which comes from the decommissioning of old gas-cooled reactors.

ILW-LL — **Intermediate-level long-lived**
waste result of spent fuel reprocessing (spent fuel claddings, reprocessing sludge, etc.) and nuclear facility maintenance work.

HLW-LL — **High-level and long-lived**
waste consisting of products resulting from spent fuel reprocessing that cannot be recycled.

3 questions to...

US NRC Commissioner William C. Ostendorff on the safe disposal of radioactive waste

How would you characterise the major issues associated with the management and disposal of nuclear waste in the United States?

Currently, the major issues for the NRC are the storage of spent nuclear fuel at our existing NPPs and the ultimate disposal of high-level nuclear waste. First, the US NRC is addressing our so called Waste Confidence (WC) decision, which is our generic findings on spent nuclear fuel storage, beyond the life of the plant, and high-level waste repository availability. The NRC reviews periodically our WC decision, which goes back to 1984, and updated it most recently in 2010. In 2012, the US District of Appeals directed the NRC to address some technical questions on spent fuel pools such as fires and leaks; and to address what happens if the US never develops a repository. NRC staff is now updating the WC decision, pursuant to the 's direction, and after significant public input, we expect to issue an updated WC decision by the fall of 2014.

Regarding the ultimate disposal of high level waste, the official US policy is to evaluate the Yucca Mountain, Nevada site as a permanent geological repository. However, the US Congress has not provided funds to support this evaluation in recent years so the review has been essentially suspended. A recent court decision directed the NRC to expend remaining funds (approximately $11M) to continue the licensing proceeding but additional funds will be required from Congress to actually complete the licensing proceeding.

Why is the ultimate disposal of nuclear waste such a controversial issue?

I believe it is politically controversial simply because many people do not want to live near waste disposal facilities of any type, the so-called `Not In My Backyard (NIMBY)` phenomenon. The Nuclear Waste Policy Act passed back in 1982 established a process for the Department of Energy (DOE) to approve a site to serve as a geological repository. DOE completed that process in 2002 and the US Congress passed a law certifying Yucca Mountain in Nevada. As allowed by the process, the State of Nevada appealed that decision before Congress; nevertheless, Congress confirmed siting the high-level waste geologic repository at Yucca Mountain. Since the 2002 decision, the DOE submitted and then withdrew its application for a license to construct a high-level geologic repository at Yucca Mountain. Following legal proceedings before the NRC's Atomic Safety and Licensing Board, I voted to affirm that withdrawing the license application was inconsistent with the legal terms of the Nuclear Waste Policy Act. Separately, Congress chose not to provide funding for activities related to the repository and the NRC was forced to suspend its review. In August 2013, the District of Colombia's of Appeals directed the NRC to continue assessing the DOE application to construct a repository at Yucca Mountain, within existing high-level waste funds; and on November 18, 2013, the Commission has provided direction to the staff on the use of the limited funds remaining, though I would note that those remaining funds are insufficient to complete the proceeding.

What is the NRC's position on the final report of the Blue Ribbon Commission on America's Nuclear Future?

First, the repository development and the actions in response to the BRC are not the responsibility of the NRC but of the U.S. Department of Energy (DOE). The BRC did not address Yucca Mountain directly, but did provide several recommendations including: a consent-based process to identify a site; a 'super organisation' separate and distinct from the DOE with responsibilities for developing, constructing, and operating a repository; and for DOE to provide consolidated interim storage for spent nuclear fuel. Any of these recommendations would require amending the Nuclear Waste Policy Act. Whether Congress chooses to amend the Nuclear Waste Policy Act to support the BRC recommendations, or to implement the current Act, the NRC stands ready to implement the law.

Meeting public expectations: the central issue

Beyond science and technology, radioactive waste management is first and foremost a matter of societal expectations. And since social and cultural habits vary from one country to another, there is no universal strategy to meet them. However, a blend of technical excellence and unconditional transparency seems a good way to earn credibility and to grow public confidence and propinquity. A Finnish municipality manager, a French disposal implementer and a Slovenian NGO representative provide insights into this issue.

>Onkalo<
The Onkalo deep geological repository for the final disposal of spent nuclear fuel is under construction by Posiva at the Olkiluoto NPP site in the municipality of Eurajoki.

A Finnish municipality of some 6,000 inhabitants, Eurajoki comprises the island of Olkiluoto, where two of Finland's four nuclear reactors are in operation, an EPR-type unit being under construction. *"We have a more than 40-year long history with nuclear power in Eurajoki,"* municipality manager Harri Hiitiö recalls.

After considering the possibility to send their spent fuel abroad for reprocessing and recycling, the Finns decided in 1983 to opt for final disposal, starting site investigation and selection. This decision was ratified by the parliament in 2001. *"From the very beginning, the idea of fairness and responsibility played a central part in the process,"* Harri Hiitiö stresses, *"we considered that, if we wanted the benefit from nuclear power, we had to take care of the nuclear waste too. And we did not see any important reason to postpone final disposal indefinitely. In Finland we are used to relying upon our officials. If STUK, the Finnish radiation and nuclear safety authority, says something is safe, we believe it, as we know this authority is independent from the nuclear industry, the government and above all, from political decision-making."*

The Finnish laws that rule nuclear investments include provisions aimed to increase transparency and the involvement of local stakeholders, the most important of these provisions being the municipalities' right of veto. *"Unconditional transparency between the Eurajoki municipality and the nuclear industry made confidence grow to a high level,"* Mr. Hiitiö observes, *"it has been a very wise policy."*

Official information and public hearings are organised by the ministry of employment and economy in co-operation with STUK and the Eurajoki municipality, which also meets TVO, the NPP operator, and Posiva, the operator of the **>Onkalo<** disposal facility, on a regular basis. Besides transparency, Harri Hiitiö acknowledges 35 years of NPP operation without a major problem at Olkiluoto as a driver for an increased feeling of safety: *"The Fukushima Daiichi accident made us aware of one major principle of the nuclear industry in Finland: continuous improvement. On the one hand, TVO is eager to learn how to build and run better and better units and, on the other hand, our officials can issue new safety regulations even after a reactor has been licensed."*

A specific feature of the Finnish radwaste disposal

The Aarhus convention is a good instrument to involve stakeholders in nuclear projects, and most signatory countries have transposed its requirements into their national legislation. But its implementation still needs to make progress.

>Cigeo<
is a French project of radioactive waste disposal in deep geological formations. It is designed to receive the LLHLW from all French nuclear facilities and from the reprocessing of spent fuel. After more than twenty years of research conducted mainly in an underground research laboratory, the repository is to be built at the border of the Meuse and Haute-Marne department in the northeast of France.

system is the collocation of nuclear power plants and final disposal facilities. *"The quality relationship of the Eurajoki municipality with Posiva concerning the disposal of nuclear waste facilitated the acceptance of new reactors, such as the EPR under construction at Olkiluoto,"* Harri Hiitiö underlines, *"a fourth unit is at the bidding and engineering phase, with all aspects of nuclear waste management located on the Olkiluoto island. That gives new opportunities to our companies and permanent jobs to our citizens."*

Facing the vicissitudes of public debate

Andra, the French National Radioactive Waste Management Agency, is a public body tasked with finding and implementing safe solutions for the management of all types of radioactive waste. Heading the Agency's risk management division, Fabrice Boissier observes that France was one of the first countries to become aware of the need for establishing a responsible, proactive policy on the management of radioactive waste and to set up a dedicated body, independent from radioactive waste producers. *"Each year, radioactive waste in France is generated primarily at the nuclear power plants and by the defence, industry, healthcare and research sectors,"* Mr. Boissier says. *"Operational solutions already exist for the vast majority of waste categories. Indeed, 90% of the total volume of waste generated in the country is disposed of at Andra's industrial surface facilities."*
Along with the safe operation of its processing and disposal facilities, the Agency's top priority, Andra interacts on a daily basis with local stakeholders, primarily through the Local Information Committees and Commissions: *"Their main concern is to verify the absence of radioactive contamination in the environment and the positive impact of our facilities on the local economic development,"* Mr. Boissier goes on.
Regarding the most highly radioactive and long-lived waste produced in France, Andra is currently designing, in accordance with its mission prescribed by French law, a reversible geological disposal facility called **>Cigeo<**, located in a clay formation in the north-east of France, at the border of Meuse and Haute-Marne departments. Fabrice Boissier recalls that, for more than 20 years, many interactions have been conducted to listen to local stakeholders' expectations on important issues for

the project, as part of the preparatory process: *"To take one example, the option of large storage facilities was rejected by the local stakeholders and therefore abandoned. More recently, in 2013, a public debate was conducted at national level by an independent commission as part of the Cigeo project. The holding of public meetings had to be abandoned because of the vehement intervention of opponents, but the debate continued on the web, giving stakeholders, especially at local level, the possibility to express their views on the project and the conditions for its acceptability."* In this regard, a major challenge for Andra was to factor the outputs from the debate into the design of the Cigeo project.

Nuclear Transparency Watch

Information on this new NGO's aim and activities can be found on www.anccli.fr/Europe-International/Nuclear-Transparency-Watch-english-version

Plea for an effective implementation of the Aarhus convention

"The first precondition to any balanced energy policy is that the plans are made available to the public and that the use of nuclear energy can be discussed nationwide. Then it will be clear whether or not public supports nuclear energy, and what is or is not acceptable to the public," stresses Nadja Železnik, Vice-President of **Nuclear Transparency Watch**, a European NGO created in late 2013. *"If there is general consensus on the necessity of nuclear energy, then it will be easier to reach an agreement on new build, on repositories, on the extension of a facility's lifetime, etc."*

If Mrs. Železnik considers the Aarhus convention as a very good instrument to involve stakeholders in nuclear projects, she is far more circumspect about its implementation. *"Most signatory countries to the convention have transposed its requirements into their national legislation,"* she acknowledges, *"but why is it still so difficult to access precise information for example on decommissioning and on radioactive waste management? Or to get documents on new plans for NPPs? Why were the French Local Information Committees and Commissions not invited to discuss the provisions of the new French National Response Plan to a Major Nuclear or Radiological Accident?"* though such stakeholders are natural relays towards the public when it comes to rolling out national plans.

She urges both governments and nuclear facility operators/implementers to establish procedures to fulfil the requirements from the Aarhus convention in terms of access to information, participation in decision-making and access to justice. *"This is still lacking this in the real world"* Mrs. Železnik observes. *"Changing the situation is very difficult, but we will work on informing the media, the politicians, the institutions both at EU level and national levels. The elites need to understand society has changed and is no longer inclined to accept situations such as collusion between regulator and operator for instance,"* she points out, hoping that things will change with time, thanks to the generation shift.

Taking the example of the radioactive waste repository planned for construction in Vrbina, near the Krško NPP in eastern Slovenia, Nadja Železnik observes: *"the future disposal is nothing but a plan at this stage, but a 5 M€/yr. compensation is already paid to the Vrbina municipality. For such a tiny community, it is a powerful financial incentive that will prevent local people from being critical anymore. How can independence of judgment be preserved under such conditions?"* Among other things, Mrs. Železnik claims clear criteria on awarding compensations. ✖

Science
& Technology

Ensuring the stability of the waste – especially long-lived, high-level waste – over thousands or even millions of years is the aim of the research performed in different countries on processing, packaging and disposal technology. The next pages invite you to discover an overview of the situation in different countries.

Waste processing and geological disposal: Where do we stand?

How far are major nuclear countries with their radioactive waste management programmes? The brief outline of the situation in six countries provided below illustrates how diverse the priority concerns and the corresponding technical options are throughout the European continent.

Coping with legacy radioactive waste

After postponing in the past the decisions to be made on waste management, Russia has tackled the issue. The country's new energy policy began in 2006 when the Government declared nuclear power indispensable for Russia and started providing funding accordingly. This paved the way for an in-depth consideration of how to manage radioactive waste appropriately. Before 2006, Russia had started work on the waste generated by the dismantling of its decommissioned nuclear submarines – we are talking about approximately 200 units! – and the management of their spent fuel. In the meantime, the issue has made substantive progress on these aspects, in the frame of international co-operation among countries once in opposite camps. Now coming back to waste from the nuclear electricity sector, Russia has plans to build an underground laboratory at Krasnoyarsk, where the nuclear fuel cycle facilities are located, including spent-fuel pools. The construction of a dry storage facility is in progress with a first part now in operation. The spent fuel from the Russian RBMK-type reactors is transferred to this facility.

Andrei Gagarinski
Kurtchatov Institute (Russia)

Finland

Low- and intermediate-level waste (LILW) processing and disposal are operated at NPP sites: in Olkiluoto from 1992 and in Loviisa from 1998. Finland has gained substantial experience in this now well-established process. Research is currently focussed on getting better understanding of post-closure safety issues, with a view to decreasing related uncertainties. Research projects are going on in areas such as the long-term testing of concrete container performance, the modelling of concrete behaviour and the formation of gas from waste. The development of a spent-fuel disposal facility moved a further step forward after Posiva, the operator, submitted the construction license application of Olkiluoto encapsulation and disposal facility to the Government in late 2012. As safety regulator, STUK plays a central part in the review process. The R&D is oriented primarily towards large-scale tests

From vitrification halls (left) to deep geological disposal (top right) through interim storage facilities (bottom right), different technologies are developed across the Globe to process, package and dispose of radioactive waste.

and demonstrations on the disposal site. Another important research topic is the post-closure performance of engineered barriers and host rock in order to reduce uncertainties in safety assessment.

France

The Programme Act of 28 June 2006 concerning the sustainable management of radioactive materials and waste is behind the set up of the National Radioactive Materials and Waste Management Plan (PNGMDR). Its aim is to provide regularly an updated status of the radioactive substances management policy, to evaluate new requirements and to determine the objectives to be met in the future, particularly with regard to studies and research. Andra, the French National Radioactive Waste Management Agency, is pursuing a project called Cigéo. To study the safety features of a facility designed to accommodate different types of long-lived, high-level and intermediate-level waste 500 m below the surface in a clay layer, Andra operates an underground laboratory located below the town of Bure (north-east of France). As a TSO, IRSN continues on its side with scientific data acquisition based on simulations and experiments in view of the assessment in due time of the radioactive waste disposal facilities.

This simulation shows the emplacement of the proposed Yucca Mountain Nuclear Waste Repository, located about 130 km northwest of the Las Vegas Valley (Nevada).

For more on this subject, see the EUROSAFE Tribune's interview with US NRC Commissioner William C. Ostendorff on page 09.

Germany

The 6th Federal Energy Research Program sets, among other things, the general programmatic frame for R&D on geological disposal of high-level waste (HLW). The Federal ministries of Economy and Energy (BMWi), Education and Research (BMBF) and of the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) are responsible for respective detailed programs providing for basic and applied R&D conducted by national research centres, universities, and private companies. The knowledge on HLW disposal is well advanced as regards salt formations, but remains impro-vable for other host rocks. Of high priority are topics pertaining to engineering, geotechnics, and long-term safety for repository concepts in potential host rocks. A significant aspect regards long-term maintenance skills. An important and valuable part of R&D is the co-operation with international partners, in underground laboratories, and in EC Programmes. No R&D on waste processing and packaging is currently performed.

Russia

Over 90 facilities for the reprocessing of different types of radioactive waste are currently in operation and research on improvement of existing technologies such as cementation, vitrification, incineration of LILW is ongoing. At the moment, no disposal facility for solid radioactive waste is in operation, but there are three disposal sites for the deep-well injection of liquid LILW into geological formations.

Several legacy facilities that were sited, designed and operated as disposal facilities in the former Soviet Union are now licensed for radioactive waste storage and are operated by the Federal State Unitary Enterprises Radon and RosRAO. All legacy waste should be classified into 're-movable' waste and 'special' waste and processed accordingly. Research is performed in view of site selection for future near-surface and deep-geological disposal facilities, as part of the Unified State System for Radioactive Waste Management.

Spain

Tasked with the management of radioactive waste, the public company ENRESA has been developing since the beginning of its activity in 1986, several R&D Programmes organised in five-year plans. The 7th Plan (2014-2018) is currently being launched. R&D activities have been focussed on giving support to the management of all the different types of waste to be taken care of, from low- and intermediate-level waste up to spent-fuel and high-level waste, including both the support to the dismantling of nuclear facilities as well as site restoration activities.

R&D activities are basically organised in four groups:

❶ Waste Technology.
❷ Treatment, conditioning and dismantling.
❸ Isolation and confinement materials and systems.
❹ Performance assessments, safety, radiological protection and modelling. In addition to these four technical areas, a group is devoted to crosscutting issues such as coordination and know-how management.

Ukraine

In accordance with its National Radioactive Waste Management Strategy, Ukraine has implemented a number of projects and measures to develop an overall radioactive waste management system. This includes significant efforts aimed at developing technologies and facilities for radwaste processing at Chernobyl and operating NPPs to produce waste packages that comply with waste acceptance criteria (WAC) for centralised disposal or long-term storage at the Vector site. A number of projects are planed to allow implementation of effective technologies for processing 'problematical' waste such as salt fusion cake and historical waste. Studies are underway towards the development and justification of disposal concepts for each type of waste following the updated classification. The identification of general WAC for each type of waste disposal is planned, and the initial stages of the programme aimed at developing a geological repository are envisaged.

An expert view on the Vector Complex

According to the Strategy and National Program for Radioactive Waste Management in Ukraine, approved by law, the Vector site, located in the Exclusion Zone around the Chernobyl NPP, is considered as the most appropriate site to harbour the National Centre of Radwaste Management – called 'Vector Complex'. The first stage will include centralised near-surface disposal facilities for low level radioactive waste from all producers in the country. Three near-surface disposal facilities have been already constructed on the site. The second stage will include long-term interim storage facilities prior to geological disposal for high level, intermediate level and long lived radwaste such as spent radiation sources, vitrified high-level waste from spent-fuel reprocessing in the Russian Federation, waste to be retrieved from the Chernobyl NPP, etc. Facilities for waste reprocessing are also planned at the Vector Complex site. The centralised storage facility for spent radiation sources is under construction.

As the Ukrainian regulator, SNRIU is paying utmost attention to the safety assessment of all the facilities of the Vector Complex and raised an issue of comprehensive safety assessment of the site's radiological impact. The results of such an assessment could answer the questions about the feasibility of gathering all the country's radwaste, including high-level waste, on one single site. With the assistance of ETSON member TSOs, SNRIU has developed guidance and recommendations to the operator of the Vector Complex. Moreover, we expect the industrial projects carried out under the EC's Instrument for Nuclear Safety Cooperation to contribute to the final decision making through the support provided to the operator in the comprehensive safety assessment of the site.

Nataliia Rybalka
Head of Radioactive Waste Management Safety Division
State Nuclear Inspectorate of Ukraine (SNRIU)

Radioactive alchemy

A new emplacement concept developed in Germany uses a tilting device to swivel the transfer casks containing the spent fuel and place them in vertical boreholes drilled in rock salt.

For any entity involved in radioactive waste management, turning lead into gold means succeeding with minimising the volumes and optimizing the long-term containment of ultimate waste to be disposed of. With this purpose, they perform R&D on different sorting, treatment and disposal technology, as explained by Frédéric Plas from Andra (France), Jan Deckers from Belgoprocess (Belgium) and Wilhelm Bollingerfehr from DBE Technology (Germany).

The radioactive waste disposal capacity of the existing repositories is limited both in terms of disposable volumes and radioactivity. For instance, the management of radionuclides such as chloride 36 is an issue, as it fills the radiological capacity of a repository without filling its volumetric capacity. Moreover, the identification of appropriate sites for the disposal of radioactive waste poses several scientific, technical and societal problems which make it a challenging project. This leads implementers to seek for improvements in the upstream steps – i.e. waste sorting, processing and packaging – of the waste management cycle. The basic concept is to improve radionuclide characterisation and processing with a view to reducing the volumes to be disposed of ultimately.

Graphite, the burden from first-generation reactors

In this context, several projects are either on track or about to be initiated in France. For instance, €20M public funding was allocated to a research programme to be launched by the French National Radioactive Waste Management Agency (Andra), the French Atomic Energy and Alternative Energies Commission (CEA) and the nuclear fuel manufacturer Areva in order to adapt the plasma torch technology to alpha-emitting organic waste. Moreover, with the support of the French National Agency for Research (ANR), Andra is about to launch a call for proposals among innovative SMEs for the characterisation, sorting and processing of waste generated by the dismantling of NPPs. Thirdly,

Andra participates in a programme initiated by the French public utility EDF and dedicated to the processing of graphite waste from first-generation reactors – known as UNGG –, fuelled with natural uranium and using graphite as moderator and carbon dioxide as coolant. The 9 units in operation between the mid-1950s and mid-90s used 23,000 tons of graphite which would result in 90,000 m³ of packaged waste to be disposed of. This volume represents about one fourth of all medium-level, long-lived waste to be disposed of in France.

Studying the feasibility of gasification to separate radionuclides

With a view to optimize graphite waste disposal, research is underway since 2010 to analyse different management options such as sorting the waste to separate e.g. graphite sleeves from graphite piles or processing the entire assemblies for decontamination. Chlorine-36 for instance, a long-lived halide that represents 8 TBq of radioactivity, is assumed to be separable by heat treatment. To verify this assumption, experiments are conducted where the graphite is heated up to 800 to 1,000 °C and different gaseous atmospheres (steam, carbon dioxide...) are tested to

Improve radionuclide processing to reduce the ultimate volumes to be disposed of.

analyse the releases and to establish the feasibility of separating chlorine-36 and carbon-14 without significant disruption of the graphite's structure. For instance, this would allow packaging these radionuclides in the form of small volumes of waste and to dispose of the remaining graphite as lower level waste.

5,000 °C allow plasma furnaces achieving a high volume reduction factor and the long-term stability of different types of radioactive waste.

Industrial treatment of radioactive waste: the plasma tilting furnace

Minimising the ultimate volume to be disposed of and achieving a robust waste form are primary aims of innovation in radioactive waste treatment. By means of the plasma technology, used as a heat source, a plasma flame of approximately 5,000°C allows melting inorganic materials into a glassy slag containing the radioactive isotopes, whereas the organic material is gasified and then

(From top to bottom) Plasma torch operated in Zwilag's plasma plant in Würenlingen (Switzerland). 85t payload composed of a transfer cask and its transport cart, developed for the direct disposal of spent nuclear fuel into deep vertical boreholes (Germany). Tilting device designed to swivel the transfer casks containing the spent fuel and place them in vertical boreholes drilled in rock salt (Germany).

oxidised in an afterburner and purified in an off-gas cleaning system. Once it has reached a sufficient quantity, the slag is poured on a controlled way into a slag-drum which after cooling down is suitable for disposal. The advantages are notably an important volume reduction factor (ranging from 6 for drums containing mostly metals and granulates such as concrete debris, to more than 80 for primarily organic waste) as well as the long-term stability of the end product (similar to vitrified waste). Moreover, the direct radiation exposure and contamination risks to the personnel are minimised thanks to the absence of pre-treatment of the waste and to the possibility to feed waste drums unopened.
A first full-scale plasma system, the ZWILAG facility in Switzerland, was taken into operation beginning in 2004. Iberdrola Ingeniería y Construcción and Belgoprocess are building jointly another full-scale plasma facility at the Kozloduy NPP site (Bulgaria), which will process 250 tons per year.

Innovative technology for the direct disposal of spent fuel in Germany

In the late 1980s, the German Government ordered R&D to be performed on a direct-disposal concept for spent fuel assemblies as an alternative to reprocessing and recycling. In cooperation with the German nuclear industry DBE developed a new spent fuel transport and disposal concept for the horizontal emplacement of a 65-t self-shielding casks called POLLUX® containing the fuel rods of up to 10 disassembled elements in a repository in rock salt formations. An alternative emplacement concept named BSK 3 was developed with a new spent fuel canister which complies with the geometrical requirements for emplacement in deep (up to 330 m) vertical boreholes drilled in rock salt. DBE Technology and GNS were part of programmes launched to demonstrate at full scale as well the feasibility of the safe and reliable transport of a 85-t payload composed of a POLLUX® cask and the transport cart from the surface to the emplacement level by means of a special shaft hoisting system as in 2009 the emplacement of BSK3 canister into deep vertical boreholes. They built test facilities in Landesbergen and Peine (both in Lower Saxony, Germany) were each step of the transport and emplacement process was repeated over a 1,000 times to validate the safety and reliability of the technology and by that creating a new state of the art.

Dismantling of the research reactor FRJ-1 in Jülich, Germany

Waste from dismantling: the German experience

Since the 1970s, Germany has successfully conducted decommissioning projects on 16 prototype or commercial reactors, thereby gaining experience in the management of the associated waste, as explains Boris Brendebach, Chief Expert for Decommissioning at GRS' Radiation and Environmental Protection Division.

>Clearance<
Administrative act by the nuclear regulatory authority that regulates the release of material, buildings or the site of nuclear facilities from regulatory control.

To date, 16 prototype or commercial reactors (boiling water reactors, pressurised water reactors, fast breeders, high-temperature gas-cooled and heavy water gas-cooled reactors) are in different stages of decommissioning in Germany, whereas 3 reactors have been completely dismantled and their sites have been released from regulatory control.

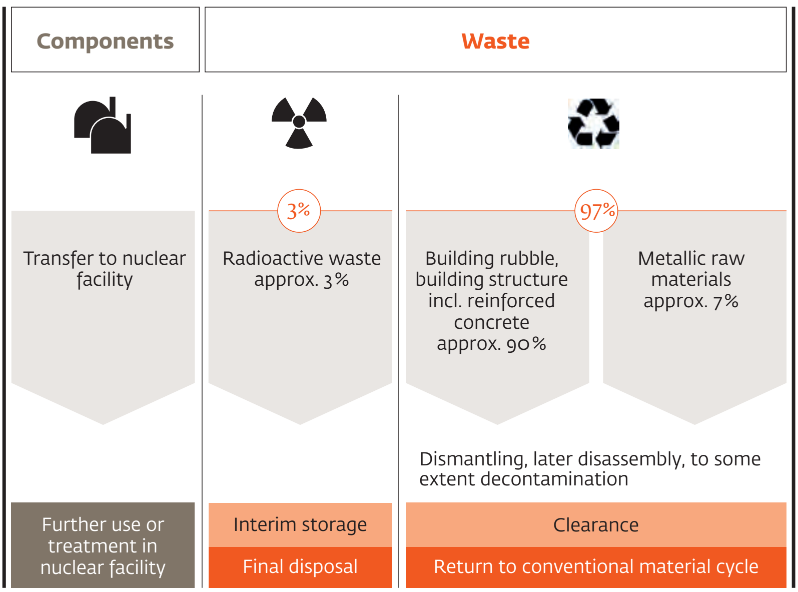
As the amount of radioactive waste and residues generated during the dismantling of structures, systems and components of a nuclear power plant exceeds many times the amount of operational waste per year, logistic planning of the waste streams is key to successful nuclear decommissioning projects. In addition, reducing the amount of material to be declared as radioactive waste is of utmost importance, as disposal in deep-geological formations is the only option for the final storage of radioactive waste in Germany.

Different clearance options defined by law

There are several ways to achieve this aim. Firstly, a small proportion of the material may be passed on to other nuclear facilities for further use. If the activity is demonstrably below a certain level, depending on the radionuclide concerned, **>clearance<** may be granted through a decision by the safety authority. Another way is the set-up of decay storage for activity reduction prior to clearance or further conditioning.

The German Radiation Protection Ordinance defines several clearance options: *unrestricted clearance*, applicable to material that is no longer radioactive in terms of the German Atomic Energy Act and may be re-used for any purpose; *clearance for removal*, applicable to material that has to be passed on to a suitable conventional landfill or an incinerator facility; and finally

Total mass of the >Controlled area< of an NPP: Figures which might be unexpected



>Controlled area<
Spatially separated area of radiation protection in which persons may be exposed to an annual dose of more than 6 mSv. The controlled area may only be entered to perform certain work activities. The controlled area is usually surrounded by a supervised area.

several options of *restricted clearance* exist, e.g., for scrap metal intended for melting down in conventional steelworks or foundries, for large amounts of building rubble and excavated soil, for the buildings of the facility, and for the site. The clearance levels have all been derived in such a way that the additional dose occurring for a member of the public will not exceed a value in the range of 10 µSv per year, consistent with the European Commission's basic safety standards on radiation protection.

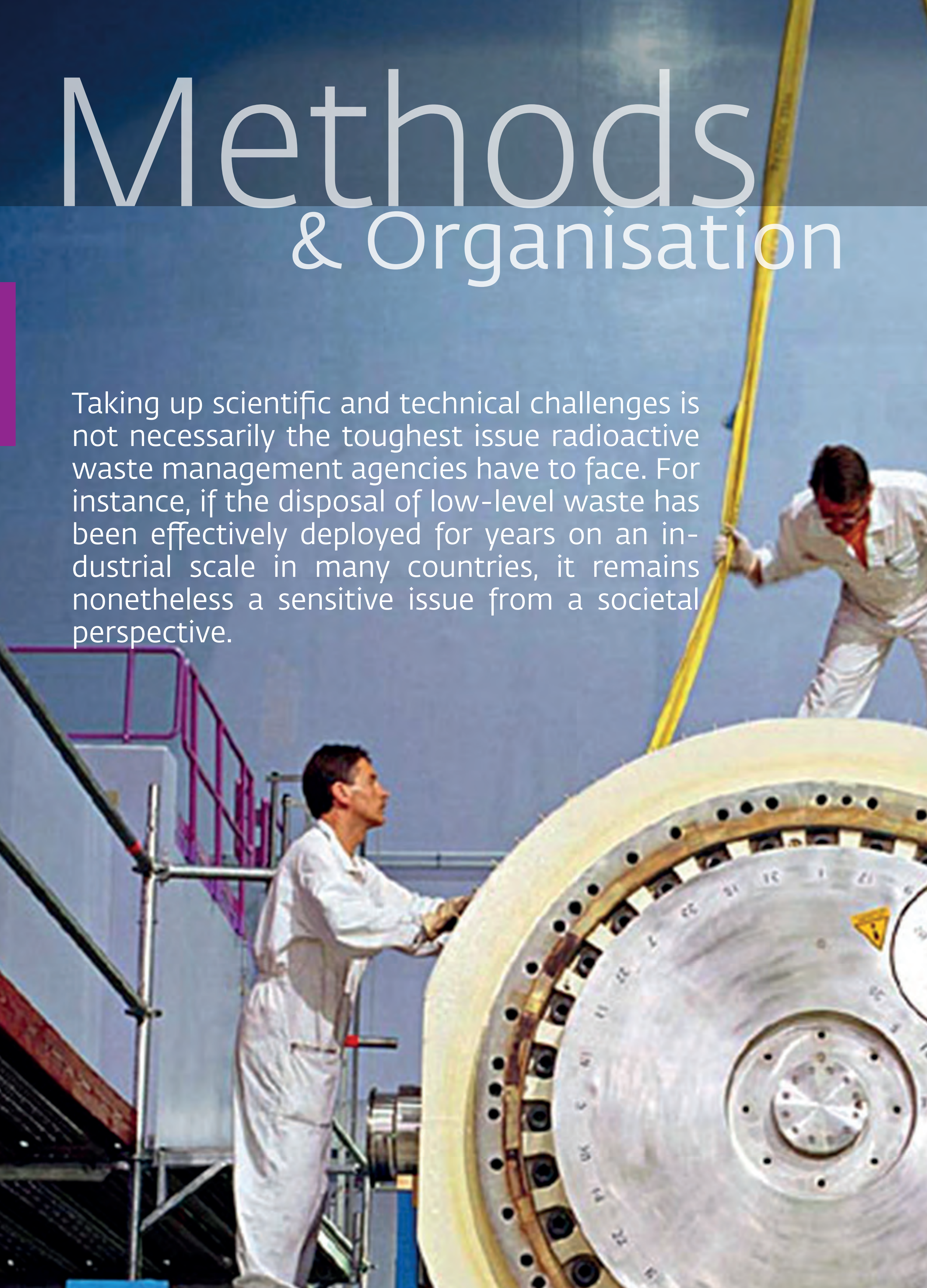
The case of buildings

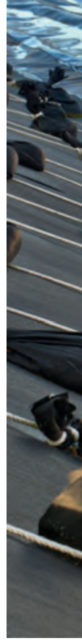
Decommissioned buildings that are not to be demolished but to be used further after decommissioning are subject to unrestricted clearance, requiring compliance with particularly low clearance values. The soil areas at the site of a nuclear facility will also be checked for contamination during dismantling of the facility and cleared by the competent authority.

For radioactive material with an activity above the clearance levels even after decontamination or for structures that have been activated by neutrons, the radionuclides are distributed over the volume and cannot be removed by decontamination; in this case, decay storage may be taken into consideration. With this approach, the material is stored over several years or decades prior to further disassembly and conditioning until the existing activity is sufficiently reduced to reach the clearance levels.

Methods
& Organisation

Taking up scientific and technical challenges is not necessarily the toughest issue radioactive waste management agencies have to face. For instance, if the disposal of low-level waste has been effectively deployed for years on an industrial scale in many countries, it remains nonetheless a sensitive issue from a societal perspective.





Low-level waste disposal: a technical or a societal challenge?

In several countries, millions of cubic meters of low- and intermediate-level radioactive waste (LILW) are disposed of in repositories. The technology seems well established, so why does the planned construction of a repository still raise worries about a negative impact on people's health or welfare? Representatives from a NGO, a TSO, an implementer and a NRA exchange views on that crucial issue.

Nadja Železnik

Country Office Director Regional Environmental Centre for Central and Eastern Europe

My first observation is that, for experts, building a repository for LILW is not particularly complex in terms of engineering: safe solutions are at hand; the project is fairly easy to manage; and the radiological impact is limited. For lay people, nuclear facilities – including LILW repositories – are connected with anxiety. They are perceived as something very dangerous, with major impacts on health and the environment, and something that decreases the value of properties. Now, one of questions is *"why are views so different?"* The answer is multi-facetted: firstly, the public has a much broader perception of risks linked to nuclear facilities than people in the know. Moreover, the military origin of nuclear technology, decades of technocratic approaches and non-transparent attitudes from the industry and from organisations combine to lead to mistrust of the public. And last but not least, nuclear safety issues are intrinsically a complex topic and the communication is usually not adjusted to the public.

Ludivine Gilli

Department of Openness to Society Strategy, Development & Partnerships Division IRSN

If I picture myself as a layperson concerned with a radioactive waste disposal project, I want to be absolutely sure that there is no technical challenge. So, the problem is not to know whether or not there is a technical challenge, but to understand the public's perception on this particular point. Therefore, talking to the public is actually a delicate matter. At IRSN, in our capacity as independent experts, we don't come with ready-made answers, but with our listening skills and our ability to trigger questions from the public. Most issues are far from being 'yes-or-no'-types of questions; and it takes several meetings to address the issues at hand. Therefore, one key aspect of stakeholder involvement is undeniably *time*. You need to be open and to give the process time to build up mutual understanding. You also need to understand that, for the local stakeholders, a repository is not just a technical concept, but something that is going to end up in their backyard! To them, this is no concept, but reality.

When one cell of this near-surface, very low-level waste repository operated by Andra (France) is full, it is covered with soil and revegetated.

Peter De Preter

Senior Advisor to the General Manager ONDRAF/NIRAS

You are right! And this is the reason why you must be able to make people confident in the ability of safety barriers to provide containment integrity of over time. This means you must be able to demonstrate that best practices, state-of-the art techniques, the best understanding of the containment materials, and so on are factored into your safety assessment. Our experience in Belgium is that people discuss a lot the technicalities of how to assess this or that type of concrete barrier, how to assess the design of the facilities so that it can withstand earthquakes, etc. Then you must really evidence that you are using the best available knowledge and technology to deal with issues.

Ludivine Gilli

And to do that, you need more than nuclear experts only. In IRSN, we have experts trained to apply their expertise to nuclear issues, but they bring their broad view on things as structural engineers, economists, etc. They bring different competences which you can combine to conduct valid and solid assessments. Other essential resources are research and experience feedback. You have to start with research and go on with research all along the project to ensure the robustness of the disposal concept. On the other hand, experience feedback is necessary to strengthen the basis you are building drawing upon research and to meet the public demand for independent information and assessment.

Nadja Železnik

Clearly, such demand grew after the Chernobyl and the Fukushima Daiichi accidents. However, we are not yet up to the point where we

“A layperson concerned with a radioactive waste disposal project wants to be absolutely sure that there is no technical challenge. So, the problem is not to know whether or not there is a technical challenge, but to understand the public's perception on this particular point.”

Ludivine Gilli
Department of Openness to Society Strategy, Development & Partnerships Division, IRSN

have a strong, empowered society, able to really take care of the aspirations expressed by the public at large. You can see NGOs performing a considerable job to gain expert knowledge, preparing reports, etc. But there are not a lot of structures that have the time and means to do that.

Ludivine Gilli

I happened to be asked about what should be done or conversely avoided in a decision-making process that involves stakeholders. Based on my own experience, I would say that there is no 'recipe', since stakeholder involvement is very closely related to the culture of each country. Thus, one approach that proves successful in one country could definitely fail in another one. Having said that, I think one thing that should be avoided in any case is going to the public with a pre-packaged solution and saying *"look, this is technically OK, this is going to work and this is why you should accept it."* Because in this case, what you are looking for is no longer stakeholder involvement but public acceptance. And this is not the right way to get the public involved.

Peter De Preter

I agree! There is nothing worse than a 'take-it-or-leave-it' approach! The people you talk to must feel that you are honest with them, that there is no secret agenda, that they can challenge with other experts the information you share with them, etc. These are basic principles of public dialogue.

Jussi Heinonen

Section head
Nuclear Waste Facilities
Nuclear Waste and Material Regulation
STUK

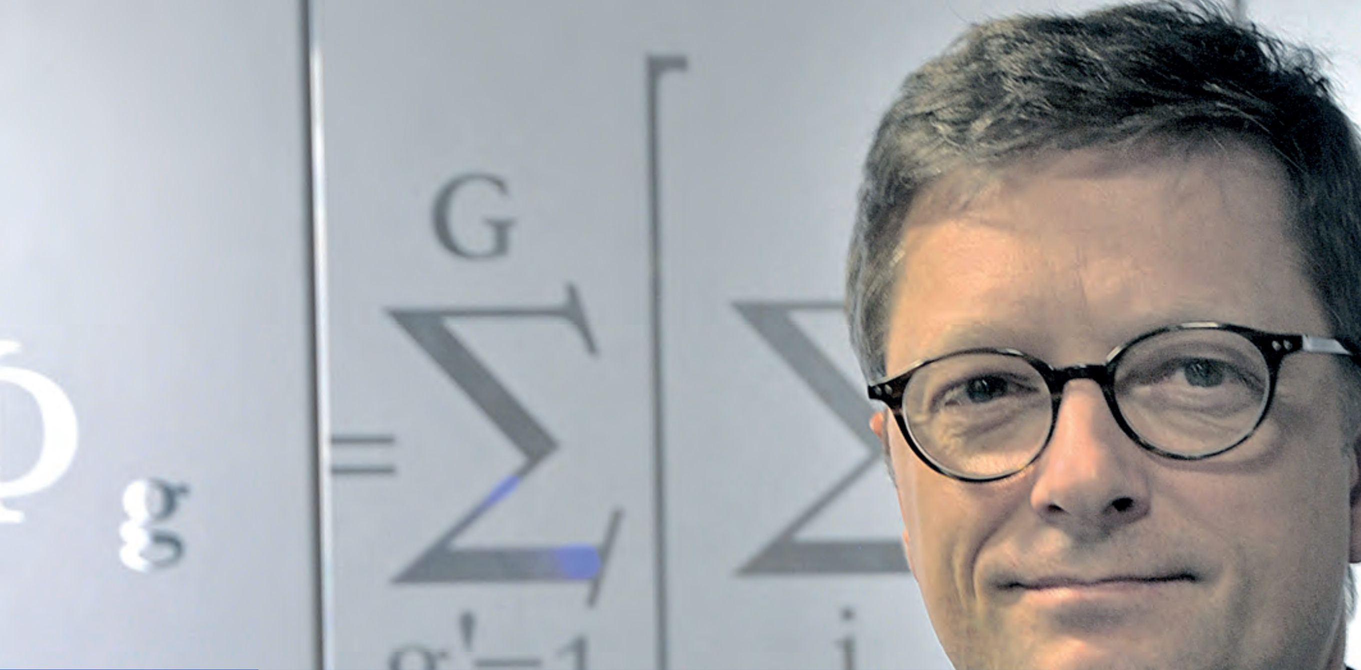
In Finland, it appears that the public trusts STUK, the regulator, very much, as people know that we make safety our top priority in any circumstance. Building such confidence took us time. Since the early 1980s, STUK shows open to the people and proactive in giving accurate and unbiased, safety-oriented information. We are also very open to the media: we have interviews with journalists; we provide them with accurate information on nuclear safety for their background. In one word, I would say we consider we are here for the people, and for the media who inform them.

Nadja Železnik

An interesting point is pertaining to the drivers of the acceptability of LILW repositories among the public. Studies show that, if the repository is to be located in a local municipality, the most important factors are the perception of the risk associated with the nuclear power plants, the fairness of compensation, the perception of the risk associated with the LILW repository, the credibility of the implementer, the knowledge gained on the subject as well as the gender and age of the person concerned.Conversely, if the repository is to be located farther in the region, the knowledge gained becomes the most important factor regarding the acceptability. In other words, the acceptability of a LILW repository is driven far more by cognitive factors than emotional factors in case the repository's location is not affecting the person's life.

Peter De Preter

Another frequently asked question pertains to the lead-time of a public involvement process. My answer is very simple: it just takes the time it takes and no one can calibrate it! Setting the rules for dialogue alone may take some time. Providing people from the public with enough information to answer their questions takes variable time too. At the beginning, people usually have questions on a thousand things: the types of waste, the associated radiological and chemical risks, the processing options, the technology, the safety assessments, etc. All these questions must be answered before any discussion can effectively start. And then, at a certain point, the stakeholders say: *"OK, we are informed, we have a certain understanding of what is at hand, we can think*



3 questions to... Michael Siemann

on the NEA's contribution to radwaste management

Dr. Michael Siemann is Head of the Radiological Protection and Radioactive Waste Management Division at the Nuclear Energy Agency of the Organisation for the Economical Cooperation and Development (OECD-NEA) in Paris.

What is your assessment, as the head of the RWMC, of the major radwaste management issues most OECD-NEA's member countries are faced with?

At the 2012 International Conference on Geological Repositories in Toronto, our member countries agreed that there is no alternative to the geological disposal of high-level radioactive waste – as it is technically feasible and provides unparalleled protection – and that storage can only be a temporary solution. Postponing work on geological disposal is unethical as this transfers undue burdens to future generations. These are also key considerations of the 2011/70/Euratom directive. Among the NEA member countries, we can observe a variety of paths and statuses towards implementing national disposal solutions, caused by cultural, societal, and geographical specificities. However, even if geological disposal is known to be technically feasible, societal support is a critical factor for the siting and implementation of disposal facilities. Unfortunately, due to the variety of cultures and societies, no standard recipe for successful national radioactive waste management programmes can be given. Each country, region or society should learn the best practice from international programmes and find their own successful way by learning from the failures and successes of others.

What kinds of initiatives are taken by the NEA to foster the exchange of experience feedback and the co-operation in the radwaste processing and disposal area?

Being an intergovernmental organisation founded and funded by the governments of our 31 member countries, the RWMC assists them in developing safe, sustainable and societally acceptable strategies for the management of all types of radioactive materials. The RWMC, its working parties and experts groups act as an integration platform promoting dialogue and co-operation and distilling best practices and lessons learned for all. We are also looking for future needs for research, development and innovation in all parts of radioactive waste management, including the decommissioning of nuclear facilities, deep geological disposal and the sustainable integration of national projects in society. In the field of RWMC, about 15 different groups are working on issues from waste management policy to specific technical or scientific questions for different potential host rocks.

What do you consider as key achievements of the RWMC and as key challenges to be tackled in the future?

Major issues for international organisations are to provide their members with overviews about the global status in radioactive waste management, or R&D and innovation, or solutions for specific problems or questions. They can also organise data collection in fields such as nuclear decommissioning, thermodynamic modelling, occupational exposure and scenarios for operational or long-term safety or economic questions. Such data can be analysed in benchmarks from a neutral international viewpoint and be used for the optimisation of processes to the use of member countries. Moreover, the RWMC and its groups are tackling a number of projects such as the operational safety of underground repositories, occupational exposure of nuclear installations under decommissioning, the methodology for peer-reviewing cost estimates for decommissioning and the associated uncertainties as well as the question of how to manage knowledge, memory and records on repositories over generations.

The 2013 EUROSAFE Forum held in Cologne (Germany) on November 4th and 5th brought together about 400 experts from nearly 30 countries for a 2-day exchange on the management of radioactive waste.

••• *about what we can agree with, and what we want to change, etc."* During this process, access to expertise is really crucial.

Jussi Heinonen Absolutely! And this is the reason why there is no time to waste, even if the licensing process for a repository takes years. In Finland for instance, the procedure starts with a decision in principle made by the Government and ratified by the Parliament. The public has to be involved at this stage, to have time for discussion, for debate, notably in public hearings where everybody has his/her say, the statements being collected and integrated into the decision-making process. Then the Government makes a go-decision and STUK performs the safety review of the forthcoming repository. From then on, the public and the NGOs have the possibility to give their opinion, but they do not play any major part anymore, and there is no more possibility for a veto. ✖

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About final disposal in salt rock formations

Over the last decades, salt was regarded as the preferred rock formation for the disposal of high-level radioactive waste in Germany. Salt offers many advantages for the disposal of radioactive waste. For instance, salt has a high temperature tolerance and it offers good elastoplastic behaviour, providing complete containment without any release. Furthermore, Germany has century-long experience of salt mining for conventional use. However, uncertainties remain as regards the hydraulic and geomechanical properties of highly compacted backfill salt, important for its sealing properties. In-depth research is being performed as well as a series of in-situ tests with a view to providing answers to the pending questions. Depending on the decision of the future German commission for site selection, we might have to perform research on clay stone as well. This would mean developing in parallel two containment concepts with, notably, the appropriate canisters and referring emplacement technologies. In order to minimise the effort of time and money, exchanges of experience feedback with countries such as France or Switzerland, which operate underground laboratories in clay formations, would certainly help. Differences exist in the legislation in these countries and in Germany, regarding notably the explicit reference or not to a 1-million-year reference period for compliance demonstration or the type of protection goals – dose-related vs. risk-based – to be adopted depending on the probability of occurrence of different scenarios. Therefore, a direct transposition of the results obtained is not possible. Nevertheless, we could draw upon their experience to develop concepts adapted to our legal framework. This is where ETSON plays an irreplaceable role.

Klaus Fischer-Appelt, Head of the Final Disposal Department Radiation and Environmental Protection Division, GRS

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IAEA: fostering international co-operation

Quite often a transboundary matter, the transport of radioactive waste requires close international cooperation.

Assisting its Member States reaching a high level of safety through the development of internationally agreed safety standards, and the provision for the application of these standards... The IAEA plays a key role in enhancing Nuclear Safety and Security, as explains Gérard Bruno, from the Agency's Radioactive Waste and Spent Fuel Management Unit.

The IAEA's Department of Nuclear Safety and Security develops safety standards in the form of safety requirements and safety guides which obey a strict and comprehensive development, review and approval process.

"This is a first major facet of the Agency's activity in the field of safety of radioactive waste management, as it is authorised by its statutes to develop safety standards," Gérard Bruno stresses, *"a second one is the assistance provided to the Member States in their application."* Furthermore, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management aims at assisting the contracting parties in reaching a high level of safety worldwide in these fields. Its review meetings every three years allow each contracting party to submit national reports to the review by all other contracting parties.

The harmonisation of safety approaches

Safety standards application encompasses several aspects, starting with international projects aimed, as fora of exchanges, to encourage the sharing of experience among Member States on the predisposal management and the disposal of all types of radioactive waste with a view to harmonising safety approaches. GEOSAF for instance is one of these international harmonisation projects devoted to the safety demonstration of geological disposal, while PRISM is dedicated to the safety demonstration of near-surface disposal facilities. Additionally, cross-cutting topics are dealt with, such as the consequences of potential human intrusion on the safety of disposal facilities.

Helping Member States implement the standards

The second aspect of safety standards application is the assistance provided to Member States with the support of the IAEA's Department of Technical Cooperation in the form of training, workshops, expert missions, or fellowships.

Another aspect of assistance can be provided through the organisation of independent peer reviews. *"Upon request of a Member State, the IAEA can set up a team of internationally recognised experts for a peer review of some parts or all of a waste management programme from the perspective of the safety standards,"* Mr. Bruno observes.

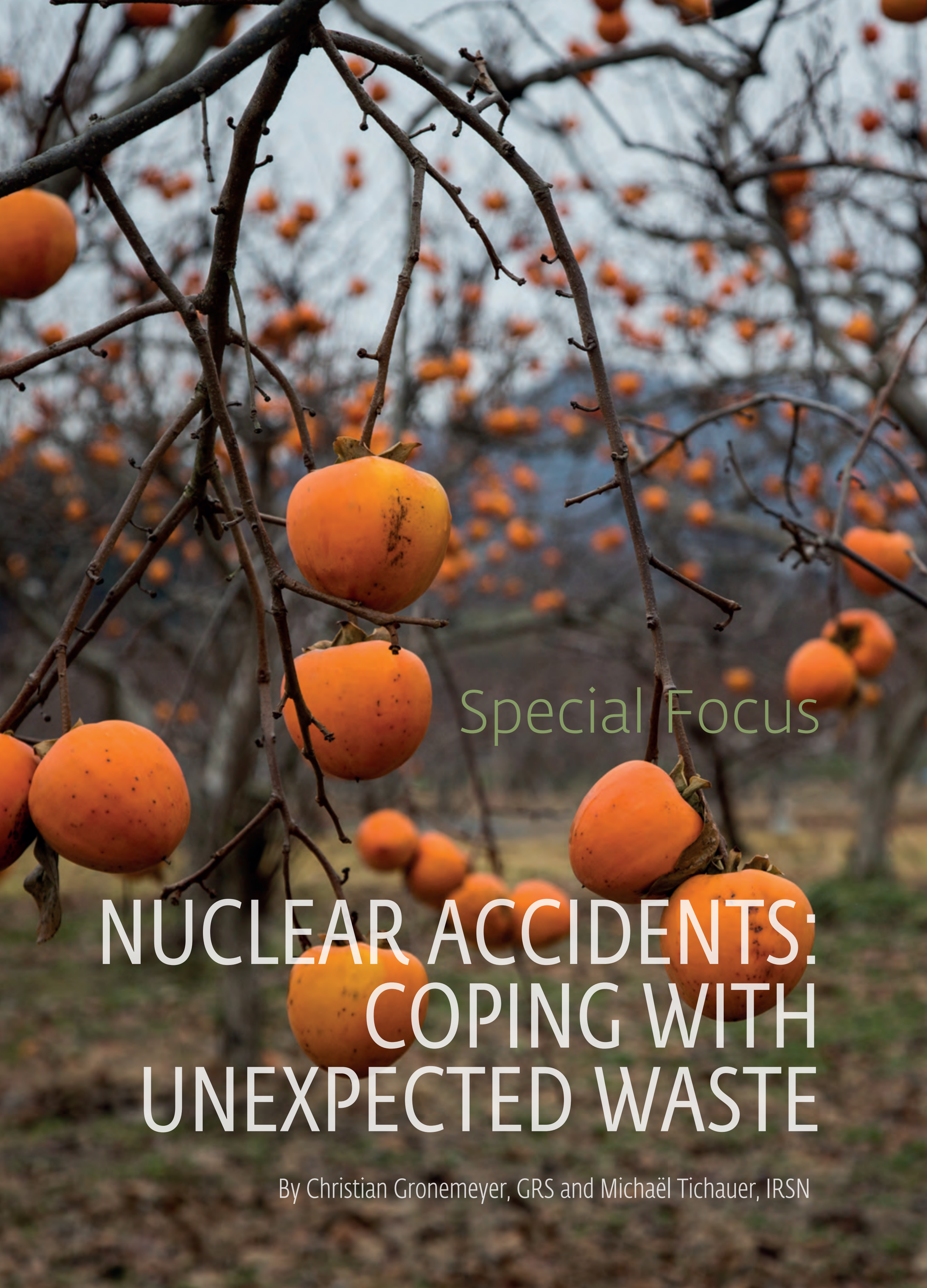
Internationally recognised positions

The work performed by the IAEA allowed reaching international consensus on several principles in the field of radioactive waste management, as recalled by Gérard Bruno: *"As examples, storage cannot be considered as the ultimate solution, but as an interim situation towards the implementation of disposal solutions. As well, if substantive progress was achieved in the near-surface disposal of radioactive waste and valuable experience feedback is available, more work remains to be performed in the field of safety of geological disposal even if several Member States are well advanced and are progressing towards implementing this solutions."*

Learn more

Safety standards

They are drafted by Member states' experts and reviewed and approved by Member States, Safety Standard Committees, the Commission of Safety Standards and the Board of Governors or the IAEA Director General for safety requirements and safety guides respectively. Such a development process aims at guaranteeing the development of consensual, internationally agreed documents.



Special Focus

NUCLEAR ACCIDENTS: COPING WITH UNEXPECTED WASTE

By Christian Gronemeyer, GRS and Michaël Tichauer, IRSN

Chernobyl: Disposal capacity issues

Centralised waste disposal

Ukraine's double challenge: sorting waste and creating additional disposal capacity.

Ddesigned as a near-surface repository and built right after the Chernobyl accident in April 1986, the radioactive waste disposal facility (RWDF) named Buryakovka was commissioned in February 1987 and is still in operation. Located approximately 13 km southwest of the Chernobyl NPP, the 90-hectare facility is primarily intended for the disposal of low- and intermediate-level waste generated by the decontamination work within the exclusion zone. The overall objective is to collect the radioactive waste that is scattered in the numerous dumps ("landfills") of the Exclusion Zone for safe disposal in Buryakovka. The Buryakovka RWDF is the only repository in operation in the exclusion zone and in the Ukraine as a whole.

Fukushima Daiichi: Hardly assessable efficiency

Scattered waste storage

Japan's major challenge: Reclaim land in a densely populated country

The March 11th, 2011 Fukushima Daiichi accident triggered a series of releases from the plant to the environment, resulting in a mixed contamination mainly related to the deposition of caesium 134 and 137 in areas extending tens of kilometres away from the damaged plant. Right after the accident, the Japanese government's policy pursued two objectives: the protection of the population through sheltering and evacuation; and the remediation of contaminated territories. Let us consider this second aspect, with a focus on areas where the population either remained or returned after the evacuation orders were lifted, mainly in the Fukushima prefecture.

●●● Forced by the lack of suitable disposal options, the Ukrainian government permitted the disposal of radioactive waste, initially with dose rates up to 10 mSv/h, this limit being increased up to 50 mSv/h, for a limited period of time. Therefore, the facility receives waste it was not originally designed for. Moreover, the measurement and characterisation of the waste in the exclusion zone are still associated with difficulties, especially due to limited possibilities to determine the radionuclide composition of the waste delivered for disposal. Particularly problematic is the lack of means for verifying that the waste characteristics comply with the RWDF's acceptance criteria.

A disposal facility nearing saturation, but further waste volumes to come

After dredging of the trenches, these are lined with an insulating layer of clay. The waste – mainly composed of contaminated sand, earth, wood, concrete, bricks, metal structures and other

The decontamination of land in Fukushima generated thousands of temporary storage sites for very low volumes of waste, sometimes right next to private dwellings.

●●● The Japanese Government's recovery strategy

The issues associated with the recovery of wide contaminated areas are not only radiological; they include land use (human activities, wildlife...), society (socio-economic and psychological aspects), as well as the time and resources allocated to securing a future for those territories. The Japanese Government passed in August 2011 an *Act on Special Measures Concerning the Handling of Radioactive Materials by Environmental Pollution Discharged by the Nuclear Power Station Accident Associated with the Tohoku District – Off the Pacific Ocean Earthquake That Occurred on March 11, 2011*. This act formalises a decontamination strategy and a waste management strategy for those territories, as well as other provisions such as the sharing of responsibilities between the government, the prefectures and the municipalities, an initial identification of waste in these areas, and the definition of management channels for part of this waste.

After two years, the Fukushima prefecture experience shows that decontamination strategies have a direct impact on waste management strategies: categories and volumes of waste, conditions for implementing the waste management channels, sorting and packaging of the waste resulting from decontamination operations are strongly influenced by the decontamination strategy that was selected. In the Fukushima Prefecture (and ten others), waste primarily consists of soil, branches, plants... In addition, approximately 140,000 t of waste per year result from human activity: garbage, green waste from gardens and parks, sewage sludge, ash from incineration... And on top of that, 500,000 tonnes of tsunami-related debris (rubble, houses, furnishings...) pile up in the coastal zone of the material – is placed in bulk in trenches with a design capacity of 20,000 to 35,000 m³ of compressed radioactive waste. To seal each trench at the end, levelling layers of local soil, protective walls of clay and a layer of soil, on which grass is grown, are put on top of the radioactive waste, up to 6 meters high. To date, 28 of the 30 trenches in the Buryakovka RWDF are filled with more than 886,000 m³ of compacted radioactive waste and a total activity of 2.51×10^{15} Bq. Based on the current rate of waste disposal and the low residual capacity, the last trench will be full in 2014, whereas considerable volumes of accumulated radioactive waste, including operational waste from the Chernobyl NPP, create further need for additional disposal capacity. One option that is being investigated is the extension of the capacity of Buryakovka: filling low-level waste between the existing trenches thus would provide an additional volume of 120,000 m³. Should this option be abandoned, the RWDF would enter the post-operational phase. As each disposal

Learn more about...

Additional information on the improvement of the infrastructure for radioactive waste management in the Chernobyl Exclusion Zone is accessible in the ´Preliminary Safety Assessment Report for the Extended Buryakovka Disposal Facility (May 2012)´ at http://gnssn.iaea.org (search: Buryakovka)

evacuated area alone. In total, 16 to over 45 million m³ of waste are expected for storage and final disposal.

The main features of the waste management plans

The implementation of the Government's waste management strategy draws upon:

- the existence of hundreds of temporary storage sites (called 'kariokiba' in Japanese) next to the places where decontamination operations were performed;
- the existence of thousands (over 13,000 in the Fukushima Prefecture alone) of temporary storages for very low volumes of waste, right next to private dwellings (called 'gembaoka' in Japanese);
- the incineration and reduction of waste volumes (a major challenge) through the use of existing municipal incinerators (2 in Fukushima city. Pilot projects are planned to extend the incineration capacity);
- the creation of 3 to 6 huge interim storage facilities (ISFs) in the evacuated area;
- the characterisation, transport (a critical issue), repackaging if necessary, prior to storage in these ISFs of millions of cubic meters of waste currently scattered throughout the Fukushima prefecture and stored in 'kariokiba' or 'gembaoka';
- their final disposal (no formal decision made at this stage).

What can be inferred from the experience feedback from decontamination in Fukushima?

The Japanese government and particularly the municipalities of the Fukushima Prefecture show a very proactive attitude in looking after the decontamination issue, because of its primary importance for the population and the challenges of remediation that are at stake. This massive, on-going effort is a core issue in the residents' day-to-day life and gets increasing coverage, yet at a level lower than the recovery operations carried out at the plant's site. The first experience feedback from decontamination initiatives in the

886,000 m³ of compacted radioactive waste have been disposed of in the Buryakovka RWDF to date.

trench is closed immediately after filling, no major technical closure measures are planned at the end of disposal operations. A 100-year period of active institutional control will follow the repository closure including not only the surveillance of human activity in the area, but also maintenance and environmental monitoring activities. In a further period of 200 years of passive (institutional) control, maintenance activities are carried out. However, during this period all restrictions on human activities in the region should be kept.

Restricted access over an indefinite period of time

Ideally, a near-surface repository would be released from any active and passive institutional control after 300 years. The activity of the waste would be sufficiently reduced by natural decay after this period, so that no further hazard to man and the environment is expected. Due to the content of alpha-emitting long-lived radionuclides, however, this option will not be possible in Chernobyl. Accordingly, access to the repository site will have to be restricted for times significantly longer than the period of institutional control. For this reason, the present solution cannot be regarded at this stage as definitive.

Feedback from the implementation of the decontamination strategy in the Fukushima region

Tamura City

- **228,249 m² of residential areas inside the 20 km exclusion zone,**
- **120,000 man-days of decontamination work.**

Efficiency (reduction of ambient dose after decontamination)

- **residential areas: 24 to 56% of dose reduction;**
- **forests (in a 20m circle around houses): 1 to 32%;**
- **agricultural areas: from 8 to 31%;**
- **roads: up to 28%.**

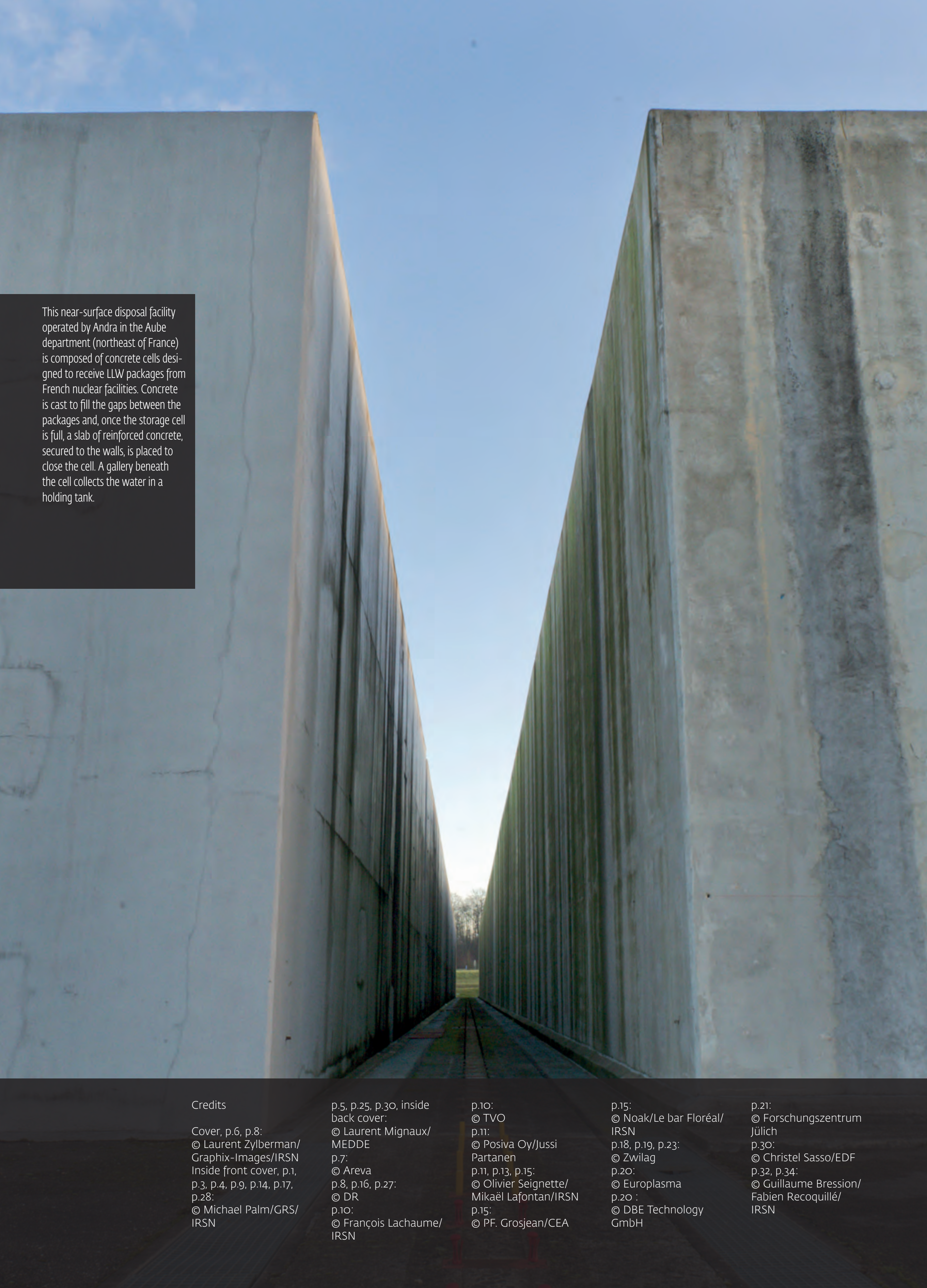
These figures suggest a very significant logistical, financial and human effort, yet effectiveness of decontamination activities does not always show striking results. Decontamination shall nevertheless be understood as a 'contract' between the decision-makers and the population: on one hand, the political level tackles the radiological issue; on the other hand, the population supports the progress. This relative efficiency is to be compared with the volume of waste generated and with the dose 'saved' by setting aside a portion of the contamination in the form of waste. A more comprehensive assessment of the overall benefit of such a strategy will be possible when the forthcoming steps envisioned in the national strategy will be implemented.

Fukushima area shows mixed results, raising the question of 'radiological' efficiency in regard to the amount of resources deployed, as well as the question of restoration of social confidence in the implemented solutions.

Indeed a major and growing problem concerns public acceptance regarding large amounts of waste stored in temporary facilities, in the immediate vicinity of the areas where residents dwell and live. Temporary... until when? Hence, waste management will likely take several decades, given the complexity of implementing waste management plans, from production to disposal through 'pragmatic', safe and accepted channels.

In conclusion: in a post-accidental context, radioactive waste is one issue that is at the intersection of essential considerations for the sustainable recovery of contaminated territories. The 'radwaste' approach of post-accidental situations raises per se essential questions on several aspects such as public decision-making, technology, safety, radiological efficiency and the actual ability to recover durably contaminated territories.

About the authors: Christian Gronemeyer is Senior Expert, Waste Management, GRS and Michaël Tichauer is Senior Expert, Head of the Safety Assessment and Research Section for Radioactive Waste Disposal Facilities, IRSN.



This near-surface disposal facility operated by Andra in the Aube department (northeast of France) is composed of concrete cells designed to receive LLW packages from French nuclear facilities. Concrete is cast to fill the gaps between the packages and, once the storage cell is full, a slab of reinforced concrete, secured to the walls, is placed to close the cell. A gallery beneath the cell collects the water in a holding tank.

COMING NEXT...

Thriving ETSON

As new challenges arise notably in relation to the upsurge of accessing countries and to the necessary preparedness to severe reactor accident prevention and mitigation, the EUROSAFE Tribune 26 highlights the benefits from networking among TSOs to share experience, pool resources, align approaches and, ultimately, put safety first in nuclear projects. These topics will be addressed at the next IAEA TSO Conference to be held from 27th to 31st of October 2014 in Beijing, China. More on: www.eurosafe-forum.org

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Towards Convergence of
Technical Nuclear Safety Practices in Europe