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"Nuclear Waste Management in Europe" Special

Édito

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The scientific challenges of spent fuel and nuclear waste management

The availability of safe and effective solutions for dealing with the nuclear waste is a key concern hampering public acceptance of nuclear energy and applications. This concern is related mainly to the disposal of nuclear waste, but also to decommissioning and, when necessary, remediation of obsolete nuclear facilities and sites.

Facilities for conditioning and disposal of short-lived Low Level and Intermediate Level Waste are operational in Europe. However, no geologic repository for the disposal of long-lived waste, High Level Waste (HLW) or Spent Nuclear Fuel (SNF) is currently in operation. The yearly generation of SNF in Europe is in excess of 2000 tHM (~1200 tHM in France). In France, SNF is reprocessed to recycle uranium and plutonium. Other countries consider SNF as waste form to be directly deposed in a geologic repository.

Some EU countries (Finland, Sweden, France) are nearing the implementation of geologic disposal for HLW/SNF. A geologic repository in these countries, characterized by the presence of redundant barriers sequestering the radioactive species, may start operations in the next decade. Other countries have longer timelines. While waiting for the repository to become operational, SNF has to be kept in dry or wet interim storage.

Past and current R&D efforts in Europe aim at supporting the implementation of geologic disposal. There are no technology gaps blocking the construction and operation of a deep geologic repository; the remaining hurdles are more of administrative and political nature. Nevertheless, there are areas in which R&D contributions are envisaged and/or necessary.

The extension of the timeline for implementing the geologic disposal for instance is causing an extension of the interim storage duration from the originally envisaged few decades to time spans of up to a century or more. Providing scientific evidence to predict the evolution of physical-chemical properties which may affect the integrity of SNF assemblies (fuel, cladding and structural components), and of the containers during and after extended storage (including SNF retrieval, transportation and repackaging for disposal) is very important.

Other than that the optimization of the disposal process is investigated, by enhanced (higher density) repository loading, e.g. by using higher capacity disposal containers, and in terms of waste acceptance criteria.

Concerning the very long term corrosion behaviour of SNF/HLW in the repository, current R&D is focused on reducing uncertainties associated with the mobilization of long-lived, chemically mobile radionuclides. The behaviour of evolutionary and non-standard fuel compounds such as high burnup fuel, mixed U-Pu oxide fuel and fuel with additives is also studied.

Possible future developments in which long-lived radionuclides are burned in fast reactors may reduce the HLW repository footprint and the required repository isolation times of the waste from several hundred thousand years down to several hundred years.

The forthcoming EURATOM funding for Radioactive Waste Management (RWM) is (i) implemented through a European Joint Program (EJP), driven by organizations that are mandated by the respective Governments (Mandated Actors) with their Linked Third Parties), (ii) is expanded into all types of radioactive waste and associated research and strategic study activities important for the Member States in establishing and implementing responsible and safe radioactive waste management programmes, and (iii) has a greater emphasis on all aspects of Knowledge Management (maintaining, using and transferring knowledge).

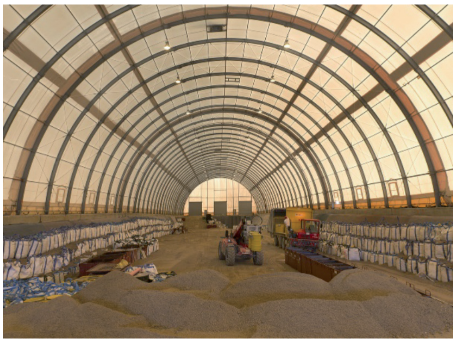
Contents

Make the right choices now

Like any industry, the nuclear sector produces waste, which has to be managed. Nuclear waste is very specific, however, as some of it–fortunately, the smallest proportion–is highly radioactive and has a very long lifespan, exceeding several centuries. Nonetheless, solutions are available or will become available in the future. In this article, Jacques Percebois looks at what has been done so far and the challenges that remain.

We ought to begin by defining this waste. The term "waste" applies to the products obtained after the fission reaction when we do not know how or do not intend to process and recover them. In the "open" cycle, spent fuels and fission products are stored and/or disposed of with no further processing, while in the "closed" cycle some of the waste is recovered for processing and recycling. In France, this is the case for depleted uranium or plutonium used to manufacture MOX. Nonetheless, some "final waste" remains at the end of the recycling process. Some countries, such as the United States, have opted for the "open" cycle, arguing that reprocessing/recycling could lead to these products being distributed for military purposes. France, on the other hand, sees the "closed" cycle as a way of containing demand for natural uranium and reducing the volumes of plutonium to be stored, as this plutonium is used as fuel. Processing and recycling waste is more expensive than disposing of it unprocessed, but it is cost-effective if the price of uranium is high or if there are fears over a shortage. In addition, it slightly reduces the volume of the waste packages to be stored. It is also necessary in encouraging the emergence of fourth-generation reactors (fast neutron reactors), the stance taken by France with its Astrid project.

We then need to specify the nature of the waste. Two criteria are used to define waste type: firstly, its level of radioactivity and secondly, its lifespan. There is thus a broad range of waste, from very low-level waste (VLLW) to high-level, long-lived (HL-LL) waste. In France, nearly 60% of waste volumes come from nuclear power generation and nearly 30% from the research sector (figures from Andra). The remainder (approximately 10%) is attributed to national defence, the non-nuclear electro-industry and the medical sector. A very high proportion of waste volumes (91%) corresponds to low or very low-level (VLL) short-lived waste that can be stored with no further processing on the surface or underground until it reaches its release threshold (natural radioactivity level). In France this waste is contained and stored in the La Manche storage facility (now being closed) and in centres in the Aube *département*.



VLL waste packages stored in cells (aube.andra.fr)

Nearly 6% of waste is qualified as LL-LL: it is low-level waste but has a long or very long lifespan and will be stored below the surface. The biggest issues are with intermediate to high-level radioactive waste (3.5%) because its lifespan is generally very long. IL-LL waste accounts for 3.2% of waste and emits 5.5% of radioactivity. HL-LL represents only 0.3% of waste but it alone accounts for almost 95% of radioactivity (source: Andra).

Storage or disposal. An ethical choice. Storage is a temporary solution, while disposal is permanent. In all cases, the waste must be stored for a certain period of time to bring down radioactivity levels before disposal and to contain the heat it generates. Some countries opt for very long-term disposal (several centuries) of IL-LL and HL-LL because they believe that this is the best way of monitoring sites and, above all, because major scientific progress could lead to ground-breaking technology making it possible to transform long-lived waste into shorter-lived waste or into fuel in the future, or may enable a completely new solution. In this case, an "active" safety policy is required: sites must be monitored, waste packages periodically reconditioned and repositories rehabilitated. This is costly and comes with the risk of a loss of vigilance in monitoring and/or a loss of conditioning expertise (especially if nuclear power is shut down and replaced by another form of energy). In addition, there is the unknown societal element: what will society be like in 300 or 500 years? It is 300 years since Louis XIV died and 500 years since Marignan: French society has certainly changed… What would happen in the event of world war? Should we leave the management of waste produced today to future generations? This is where ethics come into the equation.

More secure "passive" safety. The advantage of a geological repository is that safety is "passive" and no longer requires human intervention: once the site is closed, the geology takes care of safety. Ocean floor disposal is prohibited by international conventions, and disposal in terrestrial magma inconceivable with existing technologies. Hence the deep storage solution (at less than a thousand metres) is recommended by the IAEA, the NEA (OECD), the UN and has been adopted by the highest number of waste-producing countries. Three types of geological layer are considered stable over thousands or even millions of years: clay (or argillite), granite and salt. Some believe it is necessary to retain memory of the repository for centuries after closure, if only to avoid drilling work being undertaken two or three centuries down the line and potentially causing radioactivity to migrate towards the surface faster. For example, a special landmark[1] could be placed at such sites. Others disagree, arguing that this will draw the attention of future generations and encourage them to explore the site without necessarily taking full safety precautions. Wouldn't it simply be better to let it fade from memories?

France, Finland and Sweden out in front. These three countries lead the field when it comes to IL-LL and HL-LL waste disposal. The Forsmark EPR site in Okiluoto, Finland, which is dug into crystalline rock, is expected to be operational by 2025. In Sweden, waste will be deposited in safe granite and mining is expected to begin sometime around 2030. In France, the Bure site is built into clay-rich rock at a depth of 500 metres (Cigéo project).

IL-LL waste disposal should begin in 2040 in France and in 2080 for HL-LL waste. Disposal will remain "reversible" for a century, according to the terms of the 2006 law. This means it will be possible to recover certain waste packages if desired. It should therefore be closed in around 2150. It is difficult to compare the cost of France's disposal system with that implemented in Finland and Sweden because the volume of waste differs significantly (lower volumes in the Nordic countries) and the geological constraints are not the same. France has abandoned granite as cracks became apparent at the sites explored, and the economic factor was deemed secondary to safety requirements.

Countries on hold. Other countries are waiting to identify a disposal site or are still hesitating between disposal and long-

[1] *See Cécile Massart's contribution opposite.*

term storage. Belgium plans to dispose of its most radioactive waste in the Boom clay formation at Mol, where there is a laboratory some 230 metres underground. In the United States, after setbacks at Yucca Mountain and the accident at the Wipp repository, the federal authorities are still looking for appropriate sites; waste is thus currently stored at production sites (in 39 states). The National Regulatory Commission (NRC) has announced that long-term, dry storage of spent fuel is a reliable, safe solution. In Germany, there are plans to use the former Konrad iron mine to store LL-LL and IL-LL waste, while a site for HL-LL waste is still being sought. In the meantime, it is stored in Gorleben, where the planned salt dome repository was abandoned after issues at the Asse salt mine. The United Kingdom is looking for a site for its repository, which should be operational sometime after 2040. Russia plans to build an underground laboratory in a granite massif, with the ultimate aim of creating an underground repository.

An international storage site one day?
In Canada, China, India, Japan, the Netherlands and Switzerland, studies are underway to identify sites for repositories in clay or granite; meanwhile, waste is stored until a solution is found. Australia, which does not generate nuclear power but exports large quantities of uranium, has suggested that deep storage in the country's deserts could accommodate foreign waste. Every country is required to store its waste on its own soil, but it is certainly worth studying this kind of solution given the size and nature of these desert areas. So will the ultimate solution be an international storage facility?

Jacques Percebois
Professor Emeritus at the University of Montpellier
Director of CREDEN, the French Centre for Research on Energy Economics and Law

A reasonable cost

Cigéo is a unique project, and as such it is not easy to estimate the cost over a long period; any figures should be treated with caution as costs are likely to change. Assessed at between 25 and 33 billion euros (spread over a century), the cost is reasonable if we compare it to the cost of EDF's Grand Carénage programme to refit its nuclear fleet (55 billion euros) or the extra cost for renewable energy, estimated by the French Court of Auditors (report of March 2018) at 121 billion euros for the period 2017-2045 (feed-in tariff agreements already signed). This represents 1 to 2% of the cost of generating a kWh. This figure does not take into account dismantling costs (estimated to be around 20 billion euros for the 58 reactors in France), nor, a fortiori, the costs of reprocessing or recycling the waste. These costs are borne by the nuclear energy generators and are included in the cost of a nuclear kWh (estimated at between 50-60 euros the MWh by the Court of Auditors). This figure covers only the gross cost of the storage facility, investment costs and operating costs over a century. Cigéo's investment for the "pilot phase" (first phase) is estimated at between 5 and 6 billion euros. The Minister (DGEC) quoted the figure of 25 billion euros (which is used as the basis for the generators' provisions for waste) for the total project costs, while Andra (the project manager) initially estimated this total cost to be 33 billion.

J. P.

France (re)opens the public debate on its national plan for radioactive material and waste management

At the request of the Ministry for the Ecological and Inclusive Transition, France's National Commission for Public Debate is to hold a new public debate on the national plan for radioactive materials and waste management (PNGMDR) in December 2018. It is hoped that this debate–the third of its kind–will go off peacefully. We all remember the failure of the public debate held in 2013–2014 following the blitz of actions by opponents to the Bure site.
The Special Committee on Public Debate (CPDP), chaired by Isabelle Harel-Dutirou, discussed the conditions for running the debate, the need for openness on certain subjects and the advisability of suspending certain procedures while the debate goes ahead, particularly as regards CIGEO. The government has thus given in to the flood of criticism from environmental and anti-nuclear campaigners. At dawn on 22 February, 500 gendarmes evacuated the Cigéo site, occupied since 2016 by 15 or so people, who have since promised to make the debate 'explosive'! Against this background, "Les Entretiens Européens" will endeavour to give the debate its full European dimension (see page 16).

C. F-H.

The book of Cécile Massart

On 18 October, Cécile Massart, a major figure in Belgian art and a pioneer on the nuclear issue, will speak at the *Entretiens européens* in Paris. She will present her book *Archive du futur, pour une culture nucléaire* [Archive of the future, for a nuclear culture], published by Editions La Lettre Volée, with the support of ONDRAF. Seeking to raise public awareness on the issue of marking nuclear waste disposal sites for future generations and to get the cultural world to engage in a reflection on our nuclear culture, still widely ignored, Cécile focuses her work on finding a way to pass on the memory of the radioactive waste sites in the landscape.

In 1994, after many trips to nuclearised countries, she presented and published her work under the title *Un site archivé pour alpha, bêta, gamma* [An archived site for alpha, beta, gamma]. In 2008, the artist designed a set of markers and published *Cover*, which we had the pleasure of offering in Budapest during *the Entretiens européens* in 2010.

The aim is to make this archaeological stratum of the 20th and 21st centuries visible on the surface, and appeal to everyone's sense of responsibility. What policy should be adopted for the future? What kind of heritage do we want to pass on? More specifically, when it comes to highly radioactive waste, the artist is opening a new investigative field with the "Laboratory." Located along the perimeter of the site, new public spaces are thus appearing dedicated to creation and reviving the role of the artist for the safety of the living world.

The stage is set for the Entretiens européens in Paris

On 14 September 2018, a meeting was held at FORATOM's offices in Brussels to prepare for the Entretiens européens on the management of spent fuel and nuclear waste, due to take place in Paris on 18 October 2018. On this occasion, ASCPE was delighted to welcome Massimo Garribba, director of "Nuclear energy, safety and ITER" at the European Commission's DG for Energy, Jacques Percebois, professor at the University of Montpellier and member of the French national assessment board for research into the management of nuclear waste (CNE2), and Géraldine Benoît from EDF's Decommissioning and Waste Management Projects division (DP2D). The meeting was moderated by Claude Fischer-Herzog, Director of ASCPE, who opened the debate.

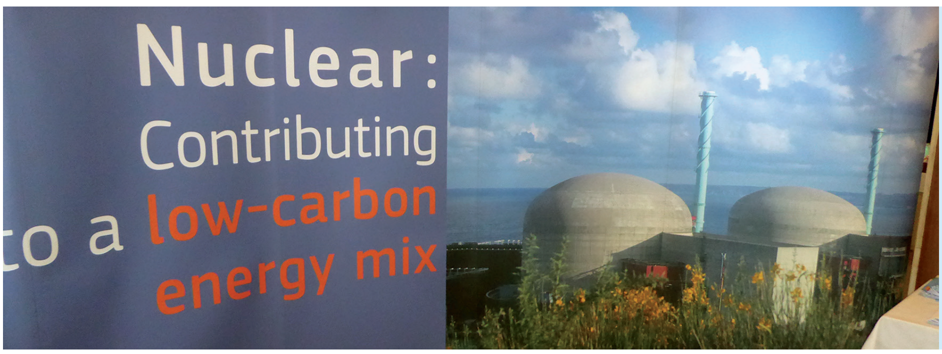
According to Massimo Garribba, the nuclear waste directive – adopted in 2011 – is still a priority for the Commission. He argued that waste management costs must be clarified to satisfy public opinion and counter opposition from the anti-nuclear movement. **Jacques Percebois** observed that the feed-in tariffs applicable to renewable energy in France from 2018-2044 will be five times more expensive. How do we progress from the nuclear waste management objectives set by the Member States to a real waste disposal policy? In answer to Electrabel's **Marc Bayens,** who raised the possibility of revising the directive, Massimo Garribba said that the delay in transposing the directive into national legislations[1] is not due to the directive itself, but to the lack of consistency and harmonisation between states, which have very different nuclear waste classification schemes.

Jacques Percebois and Géraldine Benoît both mentioned the subtle distinction made by the general public and some stakeholders between final waste and reprocessable waste. In France, the Nuclear Safety Authority (ASN) has stated that everything that comes from a nuclear zone must be treated as nuclear waste, including very low-activity radioactive waste. Thus, producers are obliged to sell all their waste, including dismantling waste, to ANDRA (the French National Agency for Radioactive Waste Management) for disposal. As the agency does not reveal the value of its contracts, it is difficult to assess the actual cost of waste management, according to Jacques Percebois. He believes that the best solution would be to define a "clearance level", which would allow the vast majority of dismantling waste to be recycled, as in Finland and Sweden. When **Berta Picamal,** Executive Advisor to the DG of FORATOM asked what would happen if the ASN did not agree with the "clearance level", Géraldine Benoît observed that France's behaviour runs somewhat counter to environmental requirements. She added that treating all waste as radioactive – including waste that is below natural radioactivity levels – reinforces the public belief that radioactivity is necessarily dangerous. **Andrey Rosdestvin,** Director of Rosatom Western Europe, believes that new technologies are needed because, in his opinion, new reactors will change the type of waste produced. He suggests creating a pan-European structure to resolve all the technical and ecological issues, which could be rather complicated considering that French law prohibits the storage of foreign waste in France, and vice versa. **Jacques Percebois** questioned the feasibility of nuclear revival, given that the investment needed for research and development could be undermined by the decision to reduce the share of nuclear energy in power production. **Robert Leclere,** director of the Belgian Nuclear Forum, also thinks it is risky to rely on future technologies to manage nuclear waste, and that it is a way of evading the problem. **Baptiste Buet,** director of Orano's Brussels office, pointed out that France leads the world in recycling spent fuel and in the sustainable storage of waste, which is vitrified after being reprocessed or recycled. This is a well-established European technology, which still sets the standard in other parts of the world.

Claude Fischer-Herzog observed that a huge, multi-billion-euro dismantling market is beginning to emerge. She stressed that, to improve societal ownership of the challenges, we must answer the general public's questions with financial and scientific arguments and show that solutions exist at the European level. She believes that innovation means creating a pan-European structure and developing projects to step up cooperation between government and business. She was delighted with the talks that set the stage for *the Entretiens européens*, which are scheduled to take place on 18 October in Paris within the frame of France's national public debate, and which could result in a set of recommendations for institutions.

Wilfried Nikiema
Project manager, ASCPE

[1] *"Should a dismantling market be created": see the issues addressed by Claude Fischer-Herzog at the round table meeting she chaired on behalf of the ENEF on 27 May 2015.*



National action plans: what is the status on the implementation of the European directive? What can be done to help the countries that are lagging behind?

Implementation of the 'Waste Directive'

There is a common misconception that radioactive waste only concerns countries running nuclear power plants. However, all EU Member States generate radioactive waste, including from research reactors or medical applications, and 21 of them manage spent fuel from nuclear reactors. Due to the potential hazard radioactive material poses to workers and the general public, it is important to ensure its safe management throughout its life-cycle, for the benefit of citizens and the environment. By adopting and transposing the 'Radioactive Waste Directive[1], EU Member States have accepted the responsibility to comply with its requirements and to ensure a high level of safety when managing these materials.

The Directive is a cornerstone of the EU's nuclear legal framework, the most advanced, legally binding and enforceable regional framework in the world.

Member States were required to align their legislation with the Directive by 23 August 2013 and were given two additional years to put in place national programmes for the management of spent fuel and radioactive waste. They were also required to send to the Commission their first national reports on the implementation of the Directive.

Having analysed the relevant national legislations, the Commission concluded that the legislation of over half of the Member States was not fully in line with the provisions of the Directive. Therefore, in May and June 2018, the Commission opened a formal dialogue with these Member States. The main issues at stake are the provisions on the national framework, the competent regulatory authority, licence holders, and expertise and skills.

The national programme is a key instrument under the Directive, by which a Member State demonstrates the way it implements its national policy in practice and how it will implement concrete solutions for the long-term management of all types of radioactive waste and spent fuel. To date, all but three Member States have adopted such national programmes.

Following the assessment of national programmes, the Commission concluded that over half of the Member States had programmes not fully compliant with the Directive's requirements and thus engaged in an exchange with Member States to find the solutions.

Overall, the Commission notes a varying degree of detail in different national programmes. Only a few Member States have national programmes that address all types of spent fuel and radioactive waste and all management steps, the main issue being the disposal step. Clear detailed milestones and timeframes for reaching the objectives are often missing, thus creating the risk of postponing decision-making to the future. One of the main shortcomings is also the insufficient information on the costs of their national programmes and the financing schemes in force. It is essential for Member States to know the overall costs for their programme and the timing at which these costs will materialise. Only in this way can they put in place the corresponding financing mechanisms to make the funds available when needed. Another issue is the lack of clear indicators allowing for monitoring progress of the implementation of the programmes. Additional efforts are needed to address these shortcomings.

Cooperation to facilitate and improve spent fuel and radioactive waste management

In order to support Member States in addressing some of the above challenges, the Commission has undertaken a number of actions to promote cooperation and best practice exchange with Member States and international organisations.

The Commission is supporting the IAEA since 2014 in the development of the self assessment tool and preparation for international peer reviews (ARTEMIS). The aim is to provide a tool for periodic self-assessment and for independent review of the national framework, programme and competent regulatory body, which is available to each Member State.

Reporting on national inventories has been one of the challenges in the national programmes, in particular when providing the future forecasts. Since 2015, the Commission has been working with IAEA, NEA/OECD and ENSREG (the European Nuclear Safety Regulators Group) to develop a harmonised set of data reporting for national inventories. The objective is to facilitate the reporting of EU Member States and enhance reliability of global inventory data in line with the IAEA classification.

The Commission is also making every effort to ensure that all relevant information is publicly available and to enhance transparency. In this regard, it has presented a comprehensive overview of the situation in different Member States in its first report to the Council and European Parliament on the implementation of the Directive, adopted in May 2017.

In November 2017, the Commission organised a workshop with Member States on the implementation of the Directive to present and discuss the outcome of its first report and the way forward.

The Commission is planning to continue this work together with Member States on the basis of the second national reports on the implementation of the Directive that were to be submitted in August 2018. The outcome will be taken into account in the second Commission report to the Council and the European Parliament in 2019.

Massimo Garribba
Director of Nuclear Energy, DG Energy, European Commission

[1] *Council Directive 2011/70/EURATOM of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, OJ L 199, 2.8.2011, pp. 48–56.*

The 2011 Directive
Fingers pointed at three countries

On 19 July 2011, the Council of the European Union adopted the Directive "establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste", two years after adopting the "Safety" Directive.

This directive restates that generators have primary responsibility and each Member State has responsibility as a last resort to manage nuclear waste in its territory. It frames the development of national management policies that each Member State must implement in addition to creating a legislative and regulatory framework (1). This directive should have been transposed within two years by Member states, who were required to formally submit their national management plans no later than 23 August 2015. The date was pushed back to August 2018, but despite the extra time certain Member States, such as Austria, Croatia and Italy, have failed to provide any management plan.

United Kingdom: reluctant political actors

The management of radioactive waste in the UK is one of stark contrasts. The management including disposal of low-level waste (LLW) continues smoothly while that of intermediate- and high-level waste (ILW and HLW) has failed to make progress beyond the storage phase.

According to the Nuclear Decommissioning Authority's (NDA's) latest inventory of waste (2016), the total packaged volume forecast up to 2025 was 4.77 million cubic metres. Over 90% of this was very low-level waste (VLLW) and LLW (2.72 millions and 1.6 million cubic metres respectively). The remainder is made up of ILW (close to 450,000 cubic metres) together with a very small amount (1500 cubic metres or 0.03%) of HLW.

In the past nearly all of the LLW (including VLLW) was disposed of at the LLW Repository (LLWR) near Drigg in Cumbria. However, as that site was starting to fill quite fast, it was decided that the VLLW could be disposed of together with municipal, commercial or industrial wastes to specified landfill sites. Today around 85% of the LLW – in particular things such as construction rubble from decommissioning – is disposed of elsewhere in facilities such as the one at Clifton March in Lancashire and the East Northants Management Facility at Kings Cliff. In addition to the LLWR near Drigg there is also a relatively new, engineered LLW disposal facility at the Dounreay site in Caithness that opened in 2015. This is for waste for the decommissioning of Dounreay and the neighbouring Vulcan nuclear site.

No disposal route yet exists in the UK for the ILW and the HLW. The ILW waste are being stored in at a number of nuclear sites throughout the UK in a variety of ways – in tanks, vaults, silos and drums – many of them at Sellafield in Cumbria The HLW – most of it a product of reprocessing - is also stored at Sellafield where most of it is in vitrified form in canisters in an engineered air-cooled store. The major outstanding issue is finding a site for an ILW and HLW repository. Communities have been invited to volunteer to host a Geological Disposal Facility (GDF). Leading the "consent-based" siting process for the GDF is the responsibility of Radioactive Waste Management Limited (a subsidiary of the NDA). It is hoped that the facility could be ready to accept waste in 15-20 years – but this could be optimistic given the UK's track record on disposal for such wastes and the clear reluctance of many politicians to support it.

Derek Taylor

Professor emeritus in geography-energy, University of Nottingham, The United Kingdom

Dismantling, nuclear waste...
Germany needs cooperation

Today, Germany is building a storage center on the site of the former Konrad mine to house 303,000 cubic meters of waste from the operation and dismantling of power stations, generating very little heat. Its commissioning is planned for 2022, a date which corresponds to the definitive closure of the last German nuclear power station.

But it is the final storage of 30,000 m² of exothermic waste (generating a lot of heat) that has been debated for more than 30 years! After the interruption in 2014 of the project at the Gorleben site, and the stopping of salt storage at the Morsleben and Asse (1) sites following leakage of contaminated water, Germany is now relaunching the search for a site for the disposal of high-level and long-lived waste (irradiated fuel, vitrified waste reprocessing ...). Equipped with resources and a legislative framework, and a safety guide on technical criteria, a new agency, BGE, must engage the process in full transparency. Different host formations must be studied such as granite, salt, or even clay, one of the issues being to create a deep and reversible disposal for about 500 years, which would leave future generations possibility of changing strategy.

BGE is interested by the French agency's experience in developing the CIGEO project, including its step-by-step process, as well as its scientific and industrial knowledge of clay disposal.

The cooperation between France and Germany must be strengthened so that the dialogue around a sustainable project can develop and the responsibility for the decision is not yet postponed, at the risk that it does not see the day.

C.F-H.

(1) The former Asse salt mine in Lower Saxony was exploited from 1967 to 1978 as an experimental storage facility for the storage of radioactive waste in deep geological layers. Approximately 126,000 low and medium-level packages were stored there.

The national inventory:
a tool for transparency that feeds into public debate

Every three years, Andra, France's national agency for radioactive waste management, conducts and publishes a national inventory of radioactive materials and waste in accordance with the mandate it received from the legislature. The holders of radioactive materials and waste send declarations to Andra, which collects data, carries out consistency checks, analyses the declared waste management chain and confers with declaring parties before synthesising the data in a single document, which is then made public. According to the latest publication, 1,540,000 m³ of radioactive waste was produced in France at the end of December 2016, compared with 1,460,000 m³ at the end of December 2013. The increase in volume is in line with the forecasts in previous publications and corresponds to current production by the various sectors that use radioactivity. The national inventory is a valuable tool for steering public policy on radioactive materials and waste management in that it indicates the estimated quantities of radioactive materials and waste under a range of prospective scenarios: the non-renewal of nuclear power generation plus three scenarios with continued nuclear power generation and different assumptions on the operating life of current reactors and different technology options for future reactors (EPR or FNR). This makes it possible to assess the impact of the different scenarios on the quantity and nature of the waste to be stored. The publication of this inventory, a few weeks before the public debate on the 2019–2021 national plan for radioactive materials and waste management (PNGMDR), ensures transparency for citizens and provides insight into the issues that may be addressed during the debate.

Asking the right questions repeatedly

For very low-level waste (VLLW), the current system is relevant in the context of plant operation but it needs to be reviewed to adapt to the volumes expected at the time of plant decommissioning, and to seek an optimum – not in terms of radiation but for the environment. VLLW waste storage capacities are limited (even when we take into account the creation of a second centre), yet a significant proportion of the waste received shows little or no trace of radioactivity. For future decommissioning operations, we therefore need to ask the right questions from an overall environmental assessment perspective: do we accept waste with no radiation significance being transported hundreds of kilometres from across France to be stored in our facilities? Is in situ storage possible for the waste type and is it compatible with safety requirements, or could a recycling solution be considered? What are the requirement levels? For long-lived low and intermediate level waste (LL and IL-LL), there is no great danger but it has a long lifespan – and therein lies the main problem: it is not dangerous enough to justify storage in a geological layer but lasts too long to be managed in current above-ground storage facilities. The public debate could examine the level of very long-term passive safety requirements that we aim to apply to this waste category while remaining coherent with similar substances.

Shouldering our responsibilities

The stakes are different, however, for the most hazardous waste: high-level waste (HLW) and long-lived intermediate-level waste (IL-LL). For a project such as Cigéo, we need to regularly review the arguments that resulted in deep geological storage and take on board any changes in context. The choice made in 2006 appeared to be the only technical option capable of guaranteeing passive safety over the very long term, but it was also an ethical and political choice, with geology as a guarantee of safety rather than a societal decision to leave future generations to deal with the problem. The current context, with the future of nuclear power being called into question and less certain, suggests erring on the side of caution was the right choice. It would be illusory or indeed downright risky to assume that an alternative option will continue to be sought in the future to attempt to deal with a subject from the past – waste – in a sector that may no longer have a future. In this respect, despite the various stakeholders' positions on the sector's future, it is our responsibility to start building Cigéo today so that future generations will not be left powerless when faced with this waste nor bound by the choices we make. The whole spirit of the 2016 law on reversibility ensures alignment between energy policy and changes in inventory and, more broadly speaking, compels us to come together regularly to reflect on an incremental project like Cigéo.

Pierre-Marie Abadie
CEO of Andra

[1] *In France, a national radioactive waste plan was implemented in 2006, and will be discussed again during the national public debate in December* *(see page 3)*.

Belgian companies have the skills to decommission industrial nuclear installations

This year has seen the end of the decommissioning works of the first Belgian industrial nuclear installation. The decommissioning of the Belgonucleaire Mixed Oxide nuclear fuel plant in Dessel (Belgium) is completed, taking into account the most recent regulatory evolutions of the Federal Agency for Nuclear Control and of the National Office for Nuclear Wastes and Fissile Materials. The facility was shut down in 2006, after 20 years of industrial production for mainly Belgian and European reactors. After a careful assessment of the decommissioning approaches of this complex installation, Belgonucleaire set up a dedicated and integrated project organization with the best skills at the best place. The company, as owner-responsible, took key positions, including safety and waste management. Experts from Tractebel,, SCK•CEN and Tecnubel were put in charge of operational positions.

On the contracting approach, a formula 'at-cost plus incentives' was preferred to the lump sum contracting. The incentives addressed safety, efficiency and waste production and this turned out to be a win-win for owner and contractors: the latter reduced its risks and could gain premiums when performing well, for Belgonucleaire it increased safety performance and efficiency in a transparent way.

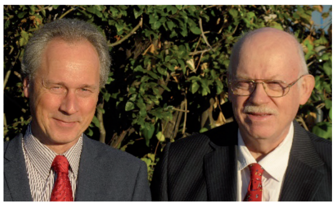
In 2009, after the grant of the decommissioning license, the contracts were executed and the works started after training and qualification of the operators as well as of the necessary techniques. The integrated team included 120 people, including German operators qualified during the decommissioning of the Hanau MOX plant. 80% of the workforce was local.

The radioactive waste was continuously transferred to the National Office for Nuclear Wastes and Fissile Materials, for processing, conditioning and storage: this included about 300 m³ of alpha-contaminated waste and about 80 m³ of other radioactive waste. About 1 200 tons of suspect waste was either recycled through melting, or released after radiological characterization.

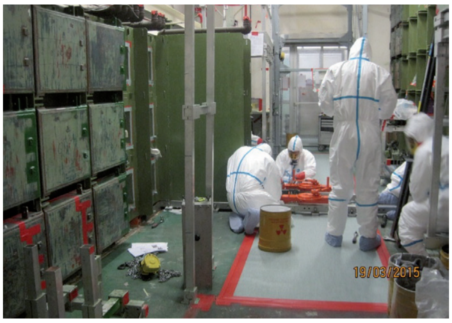
Successful decommissioning and dismantling of the Belgonucleaire MOX fuel factory

Belgonucleaire and its main contractor Tecnubel, are very proud of the outstanding safety record of this decommissioning project: not a single accident with loss of worktime occurred in the decommissioning operations for 9 years and the maximal individual dose did not exceed 8 mSv/year. A thoroughgoing preparation, training and qualification of the workers - lasting several months - the safety incentivized contracting and the detailed preparation of the works are without doubt key elements of this excellent safety result. This project can be considered as the first important industrial size nuclear decommissioning project in Belgium. It ended successfully including thanks to the skills from SCK•CEN and Tractebel, experts and the commitment of Tecnubel operators. Their participation in this project also enhanced their competences, experiences and skills in planning, preparing and executing dismantling and decontamination projects.

The decommissioning market is gearing up in Europe. In Germany most nuclear reactors are shut down due to the political «Energiewende» and several other countries like Belgium have passed laws for nuclear phase-out. All utilities have the same drive to decommission and dismantle their plants as efficiently as possible, safely and minimizing radioactive waste volumes and cost. ENGIE affiliates having participated into the project have gained competence and experience feedback allowing them to position on the D&D market segment including to tackle the challenges of ENGIE future own nuclear power plant decommissioning projects in Belgium.



Jean van Vliet, CEO of Belgonucleaire
Guido Mulier, Managing Director of Tecnubel



Belgium. What are we waiting for?

Belgium is a pioneer in research into the deep geological disposal of intermediate and high-level nuclear waste, a task entrusted jointly to the Belgian National Agency for Radioactive Waste and Enriched Fissile Material (ONDRAF) and the Belgian Nuclear Research Centre (CEN), but which has not yet resulted in the choice of a site for the geological storage of radioactive waste. Despite the advanced studies carried out on the Mol/Dessel site, the final choice will be made only in the later stages of a participatory process involving the population concerned. While transparency is essential in projects covering very long periods, uncertainty remains over the date on which authorisation to operate such a site will be obtained, which does nothing to increase the credibility of nuclear power.

The storage of intermediate-level waste is not currently foreseeable before 2070, or 2110 for high-level waste. This kind of deferral does not send out a positive signal for nuclear activities in Belgium and the setting up of provisions. The issue of nuclear provisions remains a sensitive one in many countries, both for waste producers and for nuclear power plant operators. The deferral also complicates the technical choices to be made and the related costs, and raises an ethical dilemma as we leave future generations to deal with the consequences of the choices we make today.

The future could feature sites shared by several countries, but that is a whole new chapter yet to be written.

Robert Leclere
President of the Belgian Nuclear Forum

Andra leads the Cigéo project, which focuses on the storage of high-level waste and intermediate-level long-lived waste in a deep geological layer on the border between the départements of Meuse and Haute-Marne, with the aim of protecting human health and the environment over the very long term.
Like a number of countries in Europe and elsewhere, the French Parliament adopted the principle of deep geological disposal over ten years ago, considering it to be the safest solution for this type of waste.
The Cigéo project is the outcome of more than 25 years of regularly reviewed research, three laws (1991, 2006 and 2016) and two public debates held in 2005 and 2013.
Andra intends to apply for a declaration of public utility in early 2019 and for authorisation to set up the facility in late 2019/early 2020.

Reprocessing and recycling of used nuclear fuels: an operating asset to manage used fuels and radioactive waste in Europe

Thanks to nuclear and renewable energies, more than 50% of the electricity produced in the European Union is low-carbon. This advantage means that the European Union can project itself with ambition towards a European carbon-free economy. On the long term, nuclear power will play a key role in the European energy policy by contributing to security of supply and stability of electricity prices, which are crucial for the competitiveness of the EU. Nuclear waste disposal, an ultimate step, whose modalities are being defined, can already count on the solutions offered by the reprocessing-recycling of used fuels to ensure a stable and efficient containment in the very long term.

17,000 vitrified waste containers are safely stored before disposal at La Hague plant

Optimized management of used fuels – an achievable imperative for the European Union

Whatever the importance of their nuclear power programs, it is an imperative for all Member States that responsible solutions for the management of all types of used fuel be implemented at national level.

Since 2011, based on a proposal from the European Commission, the national management of used fuels and radioactive waste has been subject to a European legislation: a European directive (Directive 2011/70/Euratom) requires each Member State to establish a detailed programme until the final stage: deep geological disposal for high-activity waste. This option has been recognized worldwide as the safest and more sustainable solution. However, these national programmes are at different levels of maturity. The medium-term availability of disposal facilities will remain a scarce resource, limited to a few Member States. Thus, the European directive allows the dialogue between States on the question of shared disposal facilities, which has special significance for countries that would not afford such an investment, having few nuclear reactors.

Industrial and public authorities are working together with the communities to develop a sustainable waste management: a transparent process with no impact on people nor on the environment in the long run. Implementing a responsible disposal of a wide variety of high-radioactive materials means optimizing, or better, reducing volumes, radiotoxicity, and disposal spaces.

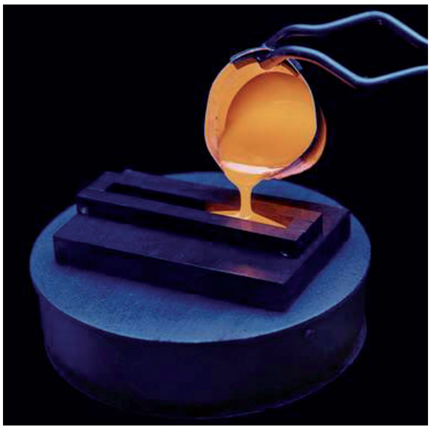
Reprocessing-recycling of used fuels: it reduces waste (radiotoxicity and volume), facilitates long-term storage, and standardizes waste forms to enhance the deployment of disposal facilities, be they shared.

Since 1967, reprocessing-recycling participates in the responsible approach to waste management: this process separates recoverable and valuable materials for reuse in a new fuel. In comparison with direct disposal which considers used fuels as waste, this technology allows to cut volume by five and toxicity of the high and intermediate level waste by ten. La Hague and Melox recycling facilities are the cornerstones of the French approach and benefit to other European countries such as Germany, Switzerland, Italy, Spain, Belgium and the Netherlands.

The very small volume of ultimate waste, in particular high and intermediate level waste (HLW-ILW), is confined within a glass matrix and safely stored for a long period until they are put into final disposal. This technology has been certified by 9 national safety authorities and is recognized as a worldwide reference. Moreover, with no fissile material nor proliferation risk, the obtained packages significantly facilitate long-term interim storage and transport operations and, thus, the serene deployment of disposal facilities. As an example, the Netherlands has opted for reprocessing-recycling and this is an illustration of the advantage of this approach one can benefit from.

Vitrification is the key for this process and brings an unparalleled performance of HLW waste tight containment.

At La Hague plant, approximately 25 000 units of vitrified packages have confined fission products from an uninterrupted and safe industrial activity of approximately 35 000 tons of used fuel. This process allows for the recycling of material, a circular economy of up to 25% of material, and contributes to the security of supply thanks to the spared resources.



Vitrification, a French innovation introduced in 1978

This process has constantly improved thanks to efforts made by Orano and the CEA (the French Alternative Energies and Atomic Energy Commission), as shown by the operational excellence of La Hague's plant[1] and new processes such as the cold crucible. The latter helps to broaden the range of fuels accessible to treatment at industrial pace, while reducing the volume of secondary waste. The CEA and Orano are also working on new vitrification processes such as *Dem'n'Melt*, which will allow on-site vitrification of waste from dismantling operations, thereby widening the scope of standard waste packages.

Used fuel reprocessing and recycling are a solution for a responsible management of radioactive waste: the risks for populations and the environment are reduced, so are industrial and financial uncertainties regardless of the deployment of ultimate waste disposal centres. They can also facilitate the emergence of shared disposal solutions, for which the support of the European Commission will be necessary.

Nathalie Allimann
Executive Vice President
back-end sales, ORANO

orano

[1] *The La Hague plant has been awarded by the Japan Institute of Plant Maintenance the "TPM Excellence - Category A" prize. Internationally renowned, this award distinguishes companies engaged in an industrial performance process known as Total Productive Management (TPM).*

***"Les Entretiens Européens"** will join environmental organizations engaged in the fight against climate change. They will be in the manifestation to support nuclear energy so that it plays its full role in reducing CO2 emissions.*

See you in Munich on October 21st.

Radioactive waste management in Finland

In Finland, nuclear waste is accumulated in the nuclear power plants in Loviisa and Olkiluoto and in the research reactor located in Otaniemi. According to the law, this waste must be managed in Finland, up to and including disposal; the nuclear energy act from 1994 prohibits the import and export of spent nuclear fuel. The responsibility for the preparation, financing and safe execution of nuclear waste management lies with the producers of the waste, i.e. the operators of the nuclear facilities. The Radiation and Nuclear Safety Authority supervises the safety of nuclear waste management. The funds for the final disposal are collected from the plant operators during the lifetime of the plant so that the funds are sufficient at any given time for the final disposal of spent nuclear fuel, as well as decommissioning and dismantling the nuclear power plants. Currently the fund is over 2,5 billion euros.

Solutions adapted to the types of waste

The final disposal of low and intermediate-level waste generated during the use of nuclear power plants is an established activity in Finland and overseas. The power plant sites in Loviisa and Olkiluoto contain the final disposal facilities for the waste generated in these plants. Globally, final disposal is underway at more than 80 final disposal facilities. In Olkiluoto, a disposal facility for low and intermediate-level waste has been in operation since 1992 and a similar facility was commissioned in Loviisa in 1998. Both power companies intend to dispose of low and intermediate-level radioactive waste arising from the dismantling of the nuclear power plants in a similar way by expanding existing disposal facilities.

In Finland, spent nuclear fuel is stored in water storage basins located at the sites of nuclear power plants. The final disposal of spent nuclear fuel or other high-level waste is not yet underway in Finland or anywhere else in the world.

Finland has been running a long-term research and development program aimed at the implementation of high-level nuclear waste disposal. The schedule for preparation of spent nuclear fuel for disposal was defined in a Government decision in 1983, and work has been progressing in schedule. Posiva submitted an application for a construction license concerning an encapsulation and disposal facility for spent nuclear fuel to the Ministry of Economic Affairs and Employment at the end of 2012, and the license was granted by the Government late in 2015. Construction of the repository is

ongoing, and the commissioning of the final repository is expected in the early 2020s.

Encapsulatio and disposal facility

For the disposal of spent fuel, an above-ground encapsulation facility and an underground disposal facility are needed. In the above-ground encapsulation facility, nuclear fuel that has been in interim storage for 30–50 years is received, dried and packed into final disposal canisters.

The disposal facility consists of facilities for the disposal of waste packages (repository) and related underground and above-ground auxiliary facilities. The encapsulation facility (above-ground) and disposal facility (underground) are connected to each other with an elevator shaft and canister transfer shaft as well as a separate access tunnel. In the processing of nuclear waste, mainly equipment operated by remote control is used.

The disposal facility consists of an access tunnel that reaches a depth of approximately 450 meters, technical facilities located at a depth of 437 meters and central tunnels and disposal tunnels to be built in phases during the facility's use. Since 2004, Posiva has been building an underground research facility, called Onkalo, the premises of which are designed to function as part of the disposal facility.

The disposal system is composed of a tightly sealed iron-copper canister, a bentonite buffer enclosing the canister, a tunnel backfilling material made of expansive clay, the sealing structures for the tunnels and premises and the enclosing rock.

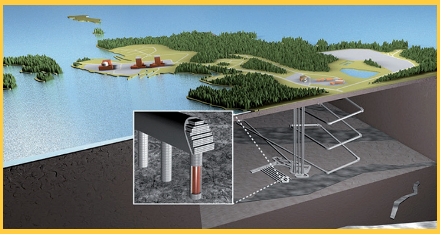
Tuomo Huttunen
Senior Adviser, Nuclear Energy,
FINNISH ENERGY

Sources: Finnish Energy, Radiation and nuclear safety authority STUK, Posiva, TVO.

Onkalo consensus

In November 2016, the Finnish nuclear safety authority authorised the construction of a deep storage facility for spent nuclear fuel in Onkalo. Posiva, which is Finland's equivalent to Andra, is heading the project. Excavation work began in December 2016 and operation of Onkalo, which will begin by 2023, is expected to continue for about 100 years. It is located near the Olkiluoto nuclear power plant and its EPR reactor, currently being built 300 km northwest of Helsinki. Onkalo will be built at a depth of 400 m with a network of galleries drilled into the granite. It will store 9,000 metric tons of spent nuclear fuel from the four existing and future reactors. Like Sweden, Finland will store its spent fuel directly. The Finnish Parliament made its decision after a public debate that resulted in remarkable political and economic consensus.

The project includes two facilities, an above-ground spent fuel conditioning plant and underground storage, consisting of a network of galleries built as



and when required. The galleries lead to shafts about ten metres deep, where the packages will be placed.

Granite is a crystalline rock so measures will be necessary to prevent the risks of fracturing and water infiltration. The waste will be placed in large Swedish-designed steel casks that will then be covered with a thick layer of copper, before being surrounded by an impermeable expansive clay (bentonite) shell. These packages will prevent the release and subsequent migration of radioactive atoms into the environment.

Source: CIGEOMag

Towards global energy sustainability: closing the nuclear fuel together

The vision of the future energy mix as a duet of nuclear power and renewables is nowadays shared by many policymakers and environmentalists in Europe and all over the world. But the issues of spent nuclear fuel (SNF) and radioactive waste (RW) remain the major perceived issue associated with nuclear power, despite the availability of solutions at industrial scale, including the operating fast neutron reactors. These solutions allow us today to return most of the fission material back into the nuclear fuel cycle (NFC), as well as to provide safe conditioning and long-term storage for the rest.

Strengthen international cooperation

In the meanwhile, the industry professionals admit that SNF and RW management is still a challenging field. The primary issue which underlies here is not a technical challenge, but an organisational one. But in the spheres of SNF and RW, we are still far away from having a complete and shared vision, and we probably lack the level of international cooperation needed to handle the challenges in an environmentally, socially and commercially viable way. In fact, not every nation operating nuclear power plants require a reprocessing plant, a mixed oxide (MOX) fuel production plant, or a fast neutron reactor. The respective issues can be handled by the joint efforts of countries with the developed NFC infrastructure. If grouped together, the world's NFC facilities can burn most of the accumulated material, e.g. reprocessed uranium and plutonium, and safely vitrify the residues. Furthermore, this could also lay the groundwork for the improved non-proliferation.

Innovative experiments

In ROSATOM, we believe that NFC closure is the next step for the global nuclear industry development, and probably one of the unexplored areas for global partnerships. Today ROSATOM is working to continually develop the technological base to provide a practical solution for the closure of the NFC.

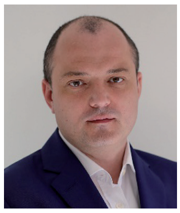
We see fast neutron reactors as the cornerstone of the NFC closure. Russia is the only country that commercially operates two fast reactors of large capacity at Beloyarsk NPP. At this power plant, both BN-600 and BN-800 reactors can be fuelled with either highly-enriched uranium dioxide or MOX fuel consisting of plutonium blended with uranium. The BN-800 reactor of 885 MW capacity is using MOX fuel from the time of its commissioning in 2016.

Another key element of the NFC closure activities in Russia is the reprocessing infrastructure, including Mining and Chemical Combine (MCC) at Zheleznogorsk. The facility has undergone significant evolution over the past ten years. MCC has been recently equipped with a new dry SNF storage facility, which has numerous advantages in comparison to wet storages, and it has also been extended with Pilot Demonstration Center (Phase 1) for SNF reprocessing.

Develop joint research

Furthermore, Russia continues the testing of REMIX fuel that can be reprocessed several times and can significantly increase the effectiveness of uranium usage in light-water reactors and reduce the fissile inventory.

Finally, the NFC closure activities in Russia are reinforced by the ongoing R&D projects, such as MBIR, the world's most powerful multipurpose sodium-cooled fast neutron research reactor, capable of testing lead, lead-bismuth and gas coolants and running on MOX fuel. International cooperation among the leading industry players within such R&D projects as MBIR will contribute greatly to the sustainable future of the NFC. The missions to create the closed NFC and to develop the technologies for minor actinides burning should not belong to a particular nation, but become a common objective. Remaining commercially attractive, NFC closure may become a new global endeavour of the nuclear energy industry that would make it unarguably sustainable.



Andrey Rozhdestvin
Director, Rosatom Western Europe

A two-way approach for national back-end programs

In 2014, nuclear power plants produced 250,000 tonnes of spent fuel, including 36,000 tonnes from more than half of the countries with small nuclear programs. High-level radioactive waste (HAVL) will require storage in a geological repository and over the long term in the producing country. Indeed, under the Joint Convention on the Safety of Spent Fuel and Radioactive Waste Management, the Contracting Parties have agreed that the country benefiting from the benefits of nuclear energy and producing spent fuel is responsible for its management.

A national back-end program based on a two-way approach

Some countries such as Finland, Sweden and France are continuing a program for the closure of a geological repository. Other countries have a «dual track approach»: a program to develop a national track on the one hand, and participation in thinking for a multinational track with shared solutions on the other hand. The key question for each country is how to proceed, given the geological, financial and social acceptability conditions that require a number of countries to work together to develop a multinational option.

Encouraging cooperation and strengthening national programs

The two-way approach is not a wait-and-see approach. It does not exonerate countries from developing their national agenda, and the growing cooperation between a group of countries interested in finding shared solutions will enhance the capacity and credibility of its final program.

IFNEC - The International Framework For Nuclear Energy Cooperation

For more information: https://www.ifnec.org/ifnec/jcms/g_10234/2016-ifnec-practical-considerations-to-begin-resolving-the-final-spent-fuel-disposal-pathway-for-countries -with-small-nuclear-programs

The role of the Nuclear Regulatory Authority of the Slovak Republic in the authorization processes of radioactive waste management.

The Nuclear Regulatory Authority of the Slovak Republic (NRA SR) is a central government authority of the Slovak Republic for nuclear regulation and is responsible directly to the Government and Parliament of the Slovak Republic. The authority executes state supervision over nuclear safety of nuclear installations, including radioactive waste management, spent fuel management and other stages of the fuel cycle, over nuclear materials, including their inspection and registration, as well as over physical protection of nuclear installations and nuclear materials provided by the relevant license holder. The national strategy and basic concept for radioactive waste (RAW) management is defined by the National Policy and National Programme for the Management of Spent Fuel and Radioactive Waste with following characteristics:

- 1. RAW Generation Minimization Program.
- 2. Maximal use of the current technology equipment for treatment and conditioning of RAW – Technologies for Treatment and Conditioning of RAW (Jaslovské Bohunice site) and Facility for Final Treatment and Conditioning of Liquid RAW (Mochovce site).
- 3. Basic methods for solidification of liquid RAW, radioactive sludge and spent ion exchange resins into a form for final disposal are the following technologies: cementation, bituminization and solidification in a matrix SIAL (geopolymer) and incineration.
- 4. The volume of solid RAW is minimized by compacting, incineration and preventive measures.
- 5. Treated liquid or solid RAW is placed into fibre-concrete containers covered with active sealing, made of cement mixture and concentrates. These containers are suitable for transport and storage, as well as for disposal in the National Repository for RAW.
- 6. For treatment of intermediate level RAW or RAW with high trans-uranium content (specific liquid radwaste from storage of spent fuel from NPP A1) there is a vitrification technology.
- 7. Very low level RAW is disposed of at the Mochovce site in the premises of the National Repository of RAW.
- 8. Available technology (high pressure compacting, cementation, etc.) is used for treatment and conditioning of metal RAW. Low level metal waste is treated by fragmentation and decontamination, followed by release of decontaminated material into the environment. Facility for melting of metal RAW is currently under construction.
- 9. Materials contaminated with radioactive substances meeting the criteria for release to the environment (in particular construction materials) are separated and treated prior to release (by crushing) with subsequent use.
- 10. Institutional RAW and disused sealed sources (ZRAM) are safely stored in the „Facility for the management of IRAW and ZRAM"at Mochovce site until their final treatment, conditioning and disposal.
- 11. Conditioned RAW from operation and decommissioning of NPP, as well as conditioned institutional RAW meeting the acceptance criteria are disposed in the National Repository at Mochovce site.
- 12. RAW that does not meet the criteria for disposal in the National Repository is stored long-term at the site of the nuclear power plants. The Integral storage facility for RAW is built at Jaslovské Bohunice site for storage of RAW that cannot be disposed in the National Repository.
- 13. RAW that does not meet the storage criteria for surface type of repository, will be disposed in the deep repository.
- 14. The RAW transports are realized exclusively using approved transport means.
- 15. The costs of transporting and management of RAW from decommissioned nuclear installations and the costs of shipment and management of SNF from the decommissioned NPPs are covered by National Nuclear Fund and BIDSF funds. The costs of shipments and management of RAW and SNF from the NPP operation are covered from the operational costs of producers of radioactive waste and SNF.

The national management plan according to the legislation

Legislative requirements and procedures for the design and construction of RAW management facilities are defined by the Act No. 50/1976 Coll. (Building Act) and Act No. 541/2004 Coll. (Atomic Act) and relevant Regulator´s decrees. Authorization for commissioning of nuclear installation and operation of nuclear installation is issued by the Regulator in compliance with the Atomic Act. The Regulator issues the approval for trial operation after evaluation of nuclear installation commissioning. After positive evaluation of the trial operation, the Regulator issues the approval for permanent operation. During operation of facilities for RAW management the Regulator executes the state regulation of nuclear safety according to the Atomic Act. All RAW management facilities mentioned above have a valid approval of the Regulator for their operation issued under valid legislation.

Eva Hižová
Nuclear Safety Inspector, UJD

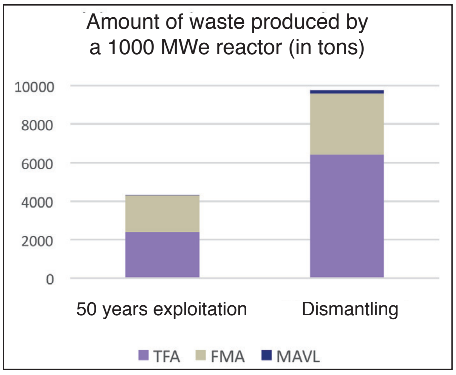
WENRA : moving towards more convergence

The Western European Nuclear Regulators' Association (WENRA) is made up of representatives of nuclear surveillance authorities from European countries in 19 Member States, including Switzerland. Independent, it is in particular responsible for the harmonization of the safety of nuclear reactors in the Member States; the control of nuclear safety in the candidate countries; to promote the exchange of experience on major safety issues. Waste and Decommissioning Working Group (WGWD) compares national regulatory approaches with IAEA safety standards, and proposes harmonization of solutions, based on best practices for nuclear waste facilities. What role does Wenra play for a more harmonious transposition of the directive adopted in 2011? The Commission recognizes that the Directive is not correctly transposed by the Member States, and even if 25 programs have been written and submitted, there are many problems of harmonization. Indeed, some programs do not take into account the type of radioactive waste, others do not take into account the management steps in the process, or say nothing about the costs and who will pay. How to remove short-term barriers, move towards a certain convergence and help states to develop their programs to implement solutions - national and / or multinational - for a nuclear waste management?

C.F-H.

Decommissioning: the prospects of a pan-European waste recycling sector

In France, 9 reactors have been shut down and are being decommissioned, and 58 PWR reactors are in operation, with an installed capacity of 63 GWe. EDF is responsible for running and decommissioning all of these reactors, and managing the waste they produce. The graph below shows the amount of waste generated over 50 years of operation, and during the decommissioning of a 1,000 MWe reactor (excluding waste in the spent fuel).



The waste from the operation and decommissioning of nuclear reactors consists mainly of very low-level (VLL) waste or low- and intermediate-level (LIL) waste. Up until now, the majority of waste evacuated has come from operational processes. However, with decommissioning activity expected to rise in the coming years, dismantling waste will increase significantly and, overall, will make up the majority of the waste generated by EDF. The dismantling of the present reactor population has produced 400,000 tonnes of VLL waste, including 265,000 tonnes of VLL metal waste.

A precautionary principle unique in Europe

In France, VLL and LIL wastes go into separate waste management streams. Ultimately, waste is stored above ground at the CIRES (industrial disposal facility for VLL waste) or the CSA (Aube disposal facility for LIL waste). It may also be melt-processed or incinerated to reduce the volumes placed in storage. The CIRES came into operation in 2003 and has a storage capacity of 650,000 cubic metres. By the end of 2017, it was over half full and was filling up faster than expected. Most of the waste stored there does not require any radiation protection measures: over half of it has a specific activity below 1 Bq/g (lower than the average natural radioactivity rate). Furthermore, 30 to 50% of this waste is not really "radioactive", but comes from a zone à production potentielle de déchets nucléaires (an area that could potentially produce nuclear waste). Yet under French regulations, it must, as a precaution, go through the same specific management process as truly radioactive waste. In the early 2000s, France opted for the "prudential" approach of zoning nuclear installations, rather than adopting "clearance levels" like other European countries. Meanwhile, the CSA, which opened in 1992, is now one third full. Under these circumstances, further consideration is being given to the management of VLL waste in France, bearing in mind the volume of final waste that is produced. The question of whether melt-processing should be used more systematically for metal waste is at the centre of the discussions.

Rethinking the zoning of nuclear facilities

SOCODEI, a subsidiary of EDF, uses a smelting furnace. Eligible metal waste is sorted, size adjusted, then melted in the four-tonne induction furnace. As there are no clearance levels in France, the resulting ingots are then placed in above-ground storage centres as final waste. In all, melt-processing reduces the volume of waste by a factor of around 4 to 6, compared with direct storage. It also homogenises waste, ensuring that the ingots sent to storage have exactly the same physical, chemical and radiological properties. In Sweden, Cyclife – another EDF subsidiary – also has a smelting furnace. The process is similar to that used in France, except that all ingots with radiological values below the clearance levels set out in the European Directive are recoverable in the conventional domain and sold on to the metal industry. In fact, only dairy waste is stored in a facility intended specifically for radioactive waste. The reduction factor thus obtained is close to 20, and valuable materials can be reused according to the principles of the circular economy. EDF and other independent organisations (CNE, IRSN, OPECST, parliamentary commission) believe that the French approach based on "zoning of nuclear installations" needs to be reviewed in light of feedback and the expected rise in VLL waste volumes due to increased decommissioning activity. For example, it does not allow for the recovery of valuable materials in equivalent safety conditions, particularly where those materials have no health impact. Neither does it enable the modest and responsible consumption of the natural resources placed in storage, or of raw materials such as metal ores.

Building a European melt-processing and recovery sector

Standardising regulations on VLL waste management and aligning France's regulatory framework with those of other European countries would enable the development of a European melt-processing and recovery sector to meet the needs of the nuclear industry in France and Europe, particularly Germany where almost 300,000 tons of metal dismantling waste will be generated over the next 20 years.

Sylvain Granger
Director of Decommissioning and Waste Management Projects (DP2D), EDF

The nuclear revival in Japan

Seven years after the accident of Fukushima, Japan is preparing to resume the nuclear path. While the previous government made a commitment to shut down all of the country's power plants by 2039, a stimulus package was approved by the Shinzo Abe government with the goal of achieving 20 Nuclear energy accounted for about 30% of nuclear energy by 2030. It was about 30% before Fukushima, and 2% by the end of 2017. Of the 54 reactors in the country, only nine are currently producing electricity.

To respond to needs...

Since Fukushima and the shutdown of

Japan's nuclear fleet, Japan is massively producing electricity from coal and gas to respond to needs of its population. Japan is the world's largest importer of liquefied natural gas (LNG), particularly from Qatar.

... and commitments to fight global warming

Whereas at the time of the Kyoto agreements in 1990, Japan was at the forefront in the fight against global warming, it is today one of the worst students among the developed countries. With this new plan, the country is committed to reducing its greenhouse gas emissions by 80% between 2013 and 2050. The government considers that nuclear, which does not emit CO2, is «an indispensable resource» for renewable energies.

The use of MOX

Japan's Kansai Electric Power (Kepco), which did not have a functional reprocessing plant or MOX manufacturing plant in Japan, asked the French group Areva in 2008 to take over the spent fuel for the transform. A first shipment of MOX was due to return to Japan in 2011, but its transport was postponed following Fukushima in March 2011. The repatriation of fuel was negotiated between this year the various stakeholders because of the desire of France to do not store this fuel in the long term. The MOX is intended for reactor 3 of the Takahama nuclear power plant, a site that is still stationary, and whose restart depends on the safety diagnosis of the regulatory authority on the basis of strengthened standards that came into force in July.

C.F-H.

Cooperation from China as it aims for ever more autonomy

China is presently developing its electronuclear programme. A major milestone will be the connection of the first operational EPR, Taishan-1 (photo below), to the grid. There are already 38 reactors in operation, and another 19 under construction will be added over the next few years. That makes a total of 57, one less than EDF's 58 for 63 GW of installed power. However, the Chinese government has already decided to go much further to decarbonise its electricity supply, which is currently coal-fired for nearly 70%, and is targeting 120–130 GW of installed capacity by 2030. Along with the emergence of what will soon be the world's largest nuclear reactor fleet, China is focused on the very long term. Its strategy is inspired by the French model, i.e. reprocessed spent fuel, use of MOX (plutonium blended with depleted uranium) and development of 'fast' reactors given the as-yet distant prospect of a natural uranium scarcity.

China is cooperating with the CEA (the French alternative energies and atomic energy commission) and ORANO to manage the waste reprocessing and vitrification chain from start to end. It has begun negotiations for the transfer of two technologies: firstly, reprocessing at a plant similar to the UP3 in La Hague, with capacity of 800 metric tons of fuel per year and secondly, MOX fuel production at a plant similar to the Melox site in Marcoule. There has been an agreement in principle and negotiations are now focused on the timetable, technical details and price. A deal could be reached in 2018 for completion around 2030.

A very long-term vision

The Chinese nuclear programme has a very long-term vision, which necessarily means honing expertise in 'fast' reactor technology. This differs from that used in the current generating fleet as it significantly enlarges the useful supply of mineral resources for several centuries. In fact, when compared to 'slow' reactors, it multiplies the volume of electricity generated from the same amount of natural uranium by at least 50. This is a key consideration

for the Chinese, who can only produce a third of the uranium they need. In 2011, China commissioned a 20 MW experimental fast reactor constructed with Russian assistance, and it is now building a 600 MW fast reactor similar to the Phénix and Superphénix fast reactors at Marcoule and Creys-Malville. This avenue is one of the preferred routes for international cooperation on future reactors, the industrial deployment of which is not expected before 2050. However, the Chinese roadmap includes a more powerful 1,000 MW fast reactor that could be built in the 2030s. ***C. F-H.***

The CEA's R&D in this field and its Astrid reactor project are guided by this same objective – overcoming the problem of limited resources. Just the stock of depleted uranium stored in France (300,000 metric tons) would be enough to generate the country's electricity supply for more than a thousand years. The second benefit of this kind of reactor is that fast neutrons break down the nuclei of minor actinides into nuclei with a much shorter half-life, dramatically reducing the time it takes to bring radioactive materials down to safe levels.

2017 EEN on competitiveness

With which energy to develop an industry without CO2, a clean agriculture, clean transport? At a time when Commission favors RE, "Les Entretiens Européens" questioned competitiveness nuclear power at a meeting on October 19, 2017, in Brussels. The debate took contrary to often irrational arguments of those who fight technology in the name of ecology ... and the decay! Because companies want them two: ecology AND growth! In Europe And in the world.

This 15th edition of the Entretiens Européenne - supported by the European Commission - brought together actors from eight countries of the European Union and Russia. It allowed us to return to our history recent, when the nuclear industry revolutionized our production methods, creating growth and jobs without pollute or emit greenhouse gases!

Since 1958, the date of the Euratom Treaty, we have learned to control the risks associated with nuclear power, manage the waste it produces, to develop the security that makes Europe the safest area in the world. Why should he deprives himself of it? Too expensive ?

Mutualize costs in a European sector in France, generation 2, amortized, can be extended by 10 years, or even 20 years, with a profitability of 20% ... The challenge is to pass to the 3rd generation. Economists present, as Jan Keppler or Graham Wheale, have proved that, organized in the sector, it would be competitive, even compared

to wind sources and whose costs, if we integrate those the storage they will need to offset the reduction of the base, will explode. A European sector would allow pool costs, create effects

series, and to the European play his card in the world that knows a nuclear renaissance. In Asia and in Latin America, many countries develop the technology to meet at the consumer demand of their populations. Africa also wonders who, facing climate and demographic challenges huge, must be industrialized if it wants to develop.

Should Europe be an exception and break his nuclear industry? The States have adopted a climate package that has created perverse effects going against security and competitiveness objectives that they had also fixed themselves! We destroy gas and nuclear capabilities, but we increase the production of fossils. The German experience must us

to make people think, but the Commission is looking to adapt the market to produce further

more RE at the expense of nuclear power which would only represent 20% of the production electricity in 2050 against 50% of renewable energy.

Defending our market and our industry

«Liberalized» nuclear power is in competition by a planned nuclear, complained industrials. But the Russians, present at symposium, have assumed the public support nuclear power and the protection of their market. What is preventing the European Union to defend his market and his industry? The dogma of liberalization? Energy, and moreover nuclear, is not

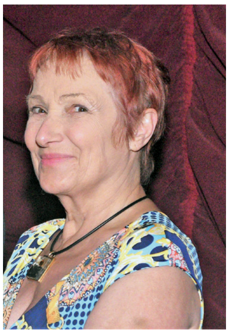
not a commodity like the others, it is a public good that must be defended and regulated! The Commission knows how to find the means when it comes to adapting the market

to encourage investment in the REs, they must be applied to nuclear power: give a price signal, encourage incentives and public guarantees for investment. This one needs a reform of the market with long-term contracts, and an industrial policy that associates the operators, regulators and territories.

This must enable them to cooperate in the context of public relations /private smart homes internally, fostering partnerships of European investors and International.

C.F-H.

Les Entretiens européens in Paris: the European dimension of the debate in France



With this new edition of Les Entretiens Européens, we want to contribute to the public debate on spent fuel and radioactive waste management in Europe. This question is at the heart of the interrogations on the future of nuclear power in the European energy mix. Therefore, we wish to bring together stakeholders from several European countries for a debate among them, with other actors of the civil society, and with the institutions .

This edition of Les Entretiens Européens extends and develops those we organized in Brussels in October 2015 on the societal appropriation of nuclear waste management in Europe, and in 2016 and 2017 on the challenges of a competitive nuclear industry. They respond to the need to give a European dimension to the public debate in France, while the French government itself has just proposed to open a debate on the national plan for the management of radioactive materials and of radioactive waste.

A scientific issue at the heart of international cooperation

We want to raise awareness on the fact that spent fuel and radioactive waste management are scientific issues, at the heart of international cooperation, and that the solutions for responsible management are sustainable. We will analyse the progress made on the national management plans which the Member States have pledged to communicate to the European Commission in the 2011 directive.

Based on the proposed solutions, we will also seek to clarify the truth of the costs for spent fuel and radioactive waste management and what they represent in the electricity price. We want to have a debate with the countries that have decided to maintain, or even to develop nuclear energy production on their territory, with those like Germany which have decided to stop their production, and those that are looking for regional solutions like the Eastern Europe countries or Italy. Some facilities are planned or under construction: these are high value-added constructions that require skilled workers. What are the latest innovations for sustainable and safe waste management? Finally, we will examine the issues related to the decommissioning of power plants and the management of the least radioactive waste: should we store them or develop a new recycling industry?

The European Union brings together on its territory experiences and skills.The excellence of certain European countries is an asset for the transfer of solutions in the less advanced countries towards the safe management of spent fuel and the transfer of nuclear waste, adapted according to the types of waste and the territories. It is an asset for a sustainable nuclear power and the decarbonated energy mix, as well as for the competitiveness of nuclear power in the world.They must be made known and thus enable public opinion to appropriate the subject and solutions, as well as to all stakeholders to assume their responsibilities.

Claude Fischer-Herzog
Director of *Entretiens européens*

ASCPE Les Entretiens Européens & Eurafricains

"Les Entretiens Européens" were created in 2003 with the first edition on the scientific issues of nuclear waste management in Nogent in Haute-Marne. They had gathered representatives of 15 European countries and Japan for a dialogue between them and with the European Commission.

Entretiens Européens

October 2018 – Paris

The management of spent fuel and nuclear waste in Europe. Solutions existe, they must be implemanted

- The science and the atom. The scientific challenges of nuclear waste management in Europe
- How to promote the implementation of national plans and help countries lagging behind?
- What solutions for a responsible and optimized management of used fuels?
- The costs of nuclear waste management. Realities according to the types of waste and their impact on the price of energy.
- Innovation in the dismantling waste storage and recycling industry
- European and international cooperation
- The European dimension of the public debate and memory duty

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