



Supplement La Lettre des Entretiens Européens - February 2019

Recommendations for a sustainable and responsible spent fuel and nuclear waste management



Les Entretiens Européens want to contribute to public debate on the issue of spent fuel and nuclear waste management which is a central matter for the future of nuclear power in the European energy mix.

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The 2018 edition **"Spent fuel and nuclear waste management in Europe. Solutions exist, they must be implemented"** takes the perspective of the public debate that is expected to start in France, within the framework of the National Plan for the Management of Radioactive Materials and Waste (NPMRMW)¹, on the proposed solutions, in particular for deep geological disposal of more radioactive waste (high-level activity and long-lived waste - HALLW), with the ambition to give a European dimension to it.

They extend and develop les Entretiens Européens which were organized in October 2015 in Brussels on "the societal appropriation of nuclear waste management in Europe" and in 2016 and 2017 on the challenges of a competitive nuclear industry².

Les Entretiens Européens, which have been organized with the support and

the participation of the European Commission and with partners (EDF, ANDRA, CEA, ENGIE, ORANO, ROSATOM, FORATOM, the BELGIAN NUCLEAR FORUM ...), brought together 60 actors such as political, industrial and institutional representatives, but also scientists and students. 23 high-level speakers from several countries joined the event: Belgium, Czech Republic, Germany, France, Hungary, Japan, Slovakia, Slovenia, Russia.

They debated five major themes: how to promote the implementation of national plans and help countries lagging behind? What solutions for sustainable and efficient spent fuel management? Economic issues: the cost of nuclear waste management. Innovation in the storage and disposal, and recycling industry. European and

international cooperation.

In 2019, Les Entretiens Européens will focus on the following topic: « The new nuclear power to answer the electrical changes in societies ».

This text presents options and recommendations resulting from a fruitful debate that has been reported in Les Cahiers des Entretiens Européens. **They are aimed at institutions, States, actors in the nuclear sector and, more broadly, at civil society and citizens**, with the ambition to improve knowledge of these complex issues and to promote better public policies in France and Europe.

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¹ www.debatpublic.fr - For a complete overview of nuclear waste in France, consult the «National inventory of radioactive materials and waste 2018», on the ANDRA website, www.andra.fr

² - October 2017 in Brussels : The issues of competitiveness of nuclear energy in Europe.

- October 2016 in Brussels : Investments in nuclear energy in Europe. Building a long-term framework to allow the upgrading and financing projects.

- October 2015 in Brussels : The social ownership of nuclear waste management, a safety issue.

► Giving nuclear energy its rightful value in the Energy Union

Nuclear energy is an important part of the European energy mix - it accounts for 30% of electricity in Europe. It does not produce any CO₂, and it is a key of the low-carbon energy policy (more than 50% of the electricity produced in the EU is decarbonised thanks to the nuclear energy when associated with renewable energies) which is **crucial to fight against climate change**. By contributing to the **security of supply in Europe** and the stability of electricity costs, nuclear energy is **an essential element of economic competitiveness and the fight against inequalities**.

Moreover, nuclear generation is the only control (with hydroelectric), and therefore represents an ideal complement of renewable energies, contributing to the decarbonization of electricity, and by extension, to that of the European economy in the perspective electrification of transport and habitat.

A nuclear European industrial policy must be defined, involving operators, regulators and territories. The nuclear industry needs high capital requirements and low operational requirements, and its development needs a stable framework and vision, as shown by all international programs. Governments, by promoting long-term contracts in the market and supporting investments, have an important role to play.

A European nuclear industry could pool costs, create series effects and contribute to a competitive economy. It could thus have a role in countries of the world that are developing a nuclear industry.

► Setting a democratic debate on existing solutions for managing nuclear waste to foster societal ownership of nuclear energy and improve the governance of institutions when implementing

Public perception of the dangers of radioactivity is a major issue for the future of the nuclear industry. These risks are very badly perceived and contribute to delaying the deployment of responsible solutions.

Society's acceptance of nuclear energy is closely linked to the existence of solutions for managing spent fuel and

nuclear waste. Especially since waste inventories exist, and the different types of solutions are the subject of consensus among international experts.

In order to clarify the terms of the debate, we must redouble our efforts to inform the public and explain that safe, responsible and sustainable solutions exist and that they can be implemented from now on.

Transparency and accessibility of information on these solutions need to be strengthened and the scientific community has a major responsibility to this regard.

The role of cultural actors is essential to raise thoughts on nuclear culture, as shown by the initiatives of the Belgian artist Cécile Massart who wants to create markers to maintain and transmit the memory of nuclear waste management sites.

This debate concerns the countries that have decided to continue or even develop nuclear energy production on their territory, **but also those who have decided to stop** their production like Germany and Italy, and those who are looking for regional solutions.

The training of civil society experts is necessary to get rid of the recurring question « for or against nuclear power », what is not the subject. The goal is set a stable political course and vision that promotes stakeholder dynamics through enlightened public participation in the evaluation of safe and sustainable solutions and their implementation.

The training of political elites is a fundamental issue. Management solutions require implementation over very long times (several hundred years), but political mandates are short (of a few years), and alternations should not be allowed to call into question decisions or legislations under the pressure of a part of public opinion.

Moreover, **the institutions - states, safety authorities and national courts - must better cooperate** with each other and respect EU legislations and their transposition.

► Implement existing solutions without delay

Safe solutions exist with a range of options concerning spent fuel and waste management. In Europe, facilities for the conditioning and management of low-

level waste or short-lived waste are operational. Deep geological disposal for long-lived waste, high-level waste or spent fuel is about to be implemented in countries such as Finland, Sweden and France.

These solutions have reached a consensus in the international community. We must deploy them without delay. The investments would make it possible to settle the issue of existing waste in the very long term and to avoid the accumulation of future inventories linked to dismantling (as is the case in the United States where 80 000 tons of spent fuel are stored on site).

Postponing solutions, while waiting for hypothetical technologies, involves several risks: the increase of the volume of waste; the weakening of responsible projects worsening of the doubts maintained by the opponents of nuclear power over the lack of solutions.

Furthermore, it raises **an ethical question with regards to the future generations**: our responsibility is not to let them manage tomorrow the consequences of our choices today (reversibility will allow them to change our choices if they wish).

► Creating the conditions for a active search on the nuclear power of the future

Europe has an advance in the management of nuclear waste that ambitious research programs could increase, including by federating them at European level. These will open up new horizons of volume reduction and toxicity.

Research must remain active on the deployment of the future reactors, in particular those with fast neutrons of the so-called 4th generation sector which would constitute the next step of the development of the nuclear industry in the world. This sector makes it possible to drastically reduce or even cancel the use of natural uranium and to value plutonium and waste.

International cooperation, with partnerships between the main actors of the sector, must be strengthened to lead those R & D projects that require long term investments. **Pooling resources**, sharing tools, creating of joint R & D programs and even **common research platforms** are actions to promote.

A regulatory framework adapted to research should be created because established rules - especially for waste - are standards for industrials producing electricity.

► Promoting European regional cooperation

The 2011 European Framework Directive on Radioactive Waste was a major step towards a strong EU framework for safe management of spent fuel and radioactive waste. It is the most advanced body of laws in the world.

The transposition of the Framework Directive will have to be completed in states which have spent fuel and waste. Its implementation should result in the definition of national waste management programs which are tools for the implementation of management plans in the Member States and for monitoring progress. But nowadays, sixteen States have not transposed the Directive yet and they have been notified by the Commission.

We must build a European know-how to help the States to find the best solutions, with the help of Finland, France and Sweden.

The directive paves the way for regional waste management solutions that should be facilitated. For this purpose, the clarification of responsibilities between the States and the different partners is necessary.

This European cooperation can result in the exchange of good practices, pooling expertise (e.g. for the optimized management of spent fuel stored for long periods) between Member States and with international organizations, or even in storage sites and / or common geological disposal facilities to different States.

Policies could be defined at European level to develop the treatment and recycling of spent fuels. The purpose of the « closed » cycle is to recover part of them and then process and recycle them in a new fuel. This is the case for spent uranium or plutonium used to manufacture MOX (mixed oxide fuel) in France. Combined with the benefits of the 4th generation, this is a solution for limiting the need for natural uranium, reducing the toxicity and volume of waste, and facilitating long-term disposal of the ultimate stabilized waste. This solution provides great flexibility in the storage of associated waste because they have not fissile materials and are fixed in glass matrices whose robustness is certified over the very long term. The containers being standardized, they are independent of the original fuel nature. They are fungible and allow for an optimized landfill program, especially for countries that would be interested in shared programs.

Should we build a European sector of spent fuel management? Must we associate Russia who already have fast neutron reactors in operation? What would be the value of this option in the context of diminution of nuclear facilities?

France, Finland and Sweden³ need to strengthen their cooperation with other European nuclear waste producers to share their knowledge, experiences, skills and to build a European know-how.

Responsibility towards future generations responds to start today the construction of geological disposal sites. Programs on the implementation of this solution must be launched in Europe, with competent human resources capacity and significant funding.

The reversibility of disposal is essential to leave future generations the possibility to make projects evolve if new technologies are available.

The periodic evaluation of projects (e.g. Cigeo in France), which are very long-term projects, is an essential point and the provisional inventory of radioactive waste is a major tool for steering public waste management policy.

The thinking must address the construction of shared sites, especially for countries where isolated investments would be too costly, or even a common European project and sustainable geological waste disposal.

Bilateral cooperation must be undertaken between the waste management agencies, for example in France and Germany, which is re-launching a research process for the disposal of high activity and long life waste.

► Building a European industrial nuclear waste chain

In France and in Europe, the decommissioning and renewal of the nuclear fleet currently in operation will produce a large amount of radioactive waste, mainly very short-lived (VSL) or low to intermediate-level (LIL) waste (e.g. 300 000 tonnes in Germany in the next 20 years). And the storage capacities of these wastes are already limited.

The development of a European industrial sector of fusion-recovery of the metal waste that are produced by the exploitation and the deconstruction of the reactors is an option we should look at in order to reach an economic and

► Favouring deep geological disposal for responsible management of high-level and long-lived activity waste

Deep geological disposal is the reference solution for high and intermediate level, long-lived waste (HAVL and LLWA) contained in spent fuel. It is recommended by the IAEA, the NEA (OECD) and the UN. In Europe, several countries (France, Finland, Sweden) are well advanced on the topic and pave the way.



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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 for public acceptance of nuclear energy and applications. This concern is related mostly 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 specific facility for the disposal of long-lived waste, High Level Waste (HLW) or Spent Nuclear Fuel (SNF) is currently in operation. The newly generated SNF in Europe is around 2000 t/year (1200 t/year in France). In France, SNF is reprocessed to recycle uranium and plutonium. Other countries consider SNF waste form to be deeply conditioned in geological repository. The existing SNF in Europe (Finland, Sweden, France) are nearing the implementation of geological disposal for HLW/SNF. A geological repository in these countries, characterized by the presence of abundant barriers sequestering the radioactive species, may start operations in the next decades. 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 geological disposal. There are no technology gaps blocking the construction and operation of a deep geological 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 geological disposal for instance is causing an extension of the interim storage duration from the originally envisaged few decades to the scale of up to a century or more. Providing scientific evidence to predict the evolution of physicochemical parameters 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 consistent 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 isolatory and nonisolatory fuel components such as high burn-up fuel, mixed oxide fuel and fuel with additives is also studied. Resilient development in which long-lived radionuclides are burned in fast reactors may reduce the HLW repository footprint and the required repository storage times of the waste from several hundred thousand years down to several hundred years. The forthcoming EURATOM funding for Radioactive Waste Management (RWM) is implemented through a European Joint Program (EJP), which is organized around the repository development and associated research and strategic study projects for the Member States. The RWM development plan for the next decade will be developed in the context of the joint program, and (ii) has a greater emphasis on all aspects of knowledge management (maintaining, using and transferring knowledge).

Les Entretiens Européens

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The management of spent fuel and nuclear waste in Europe. Solutions exist: they must be implemented

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³ Deep geological storage should be implemented in Finland and Sweden by 2020. In France, it was the subject of the law of 28 June 2006 for implementation in 2025 with the opening of Cigeo. It must be the subject of a new public debate.

environmental optimum. The products resulting from this treatment (ingots) can indeed be reused in the metallurgical industry.

In this perspective, the French approach deserves to be re-examined: **France must define a "threshold of liberation"**⁴, as provided for by the European Directive 2013/59/Euratom, to allow the recycling of the vast majority of waste resulting from plants dismantling, as it is the case in Sweden.

We could imagine the construction of recycling companies that would host waste from dismantling: should we build a joint venture for several countries? Or on the contrary decentralize them to avoid transport problems?

A convergence of standards is necessary to promote the emergence of this sector and new technologies. This implies **better coordination of nuclear safety authorities** at European level. Why not create **an European safety authority**?

► Training for nuclear jobs and making young people aware of the challenges

The training and in-depth qualification are key elements for the future of the nuclear industry and sustainable management of nuclear waste. **To maintain skills in the future**, especially in this very long-term field, we must **continue to train engineers, managers and technicians**.

Young people need to be made aware of nuclear energy as part of their initial training, at secondary school level, to help them take ownership of the nuclear issue and its challenges for the future.

It is necessary to **attract students to the nuclear professions and scientists to this sector**. The creation of mainstream events, such as the « Nuclear days » in the Czech Republic, or the « Nuclear Pride Fest » (the first edition was held in Munich on October 21, 2018) is desirable in this regard.

Why not **create a European label for employee mobility** and create **European training centers**, financed by mixed public and private funds?

From this point of view, why not **make Cigeo a center of international cooperation** where young people can be trained and where the actors of the sector could exchange their experiences?

► Clarifying costs and funding of waste management

The public does not know that funding for nuclear waste management has been funded since the beginning of nuclear programs. In many countries, it already covers part of the costs.

In terms of deep geological disposal, however, it appears that **the cost remains reasonable**. According to the economist Jacques Percebois, director of CREDES⁵, the cost of the Cigeo project is estimated at between 25 and 33 billion euros over a century. This represents 1 to 2% of the production cost of a « central output » kWh. This cost does not take into account the cost of decommissioning (estimated at around € 20 billion in France for the 58 reactors), nor waste treatment and recycling. These costs are borne by nuclear power producers and result in the cost of nuclear kWh (estimated at 50-60 euros per MWh by the Court of Auditors). It is therefore only the raw cost of the disposal facility, installation cost and operating cost for a century. **So**

it is a « reasonable » cost compared to the additional cost of 121 billion euros for renewable energies over the period 2017-2045 (contracts « feed-in tariffs » already signed) estimated by the Court of Auditors in its report of March 2018.

To implement appropriate funding mechanisms, **clarification of costs information** for national waste programs is needed.

The **creation of public-private partnerships** is an option to consider when financing the human and productive investments necessary for the formation, the creation of laboratories and storage or disposal centers.

The issue of discounting rates is fundamental in a cost/benefit perspective. Arbitrations must be in favor of known and short-term technological solutions, which will mobilize fundings for other social expenditures, such as education, health or the fight against inequalities...

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⁵ See his article in La Lettre des Entretiens Européens in October 2019, and his speech at the Entretiens de Paris in Les Cahiers, January 2019: www.entretiens-europeens.org

⁴ The release threshold allows some very low-level radioactive waste, e.g. rubble or metals, to be reused, recycled or simply stored outside the nuclear industry.

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