REPORT

IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

Assessment of dry storage possibilities for MOX or ERU spent fuels

IRSN Report No. 2019-00903

Report prepared in response to a request from the French National Public Debate Commission

French Issue
April 2019

This report is the English translation of the IRSN report n°2019-00265 entitled "*Analyse des possibilités d'entreposage à sec de combustibles nucléaires usés de type MOX ou URE* " issued in April 2019.

REPORT SUMMARY

As part of preparations for the public debate on the 2019-2021 French National Plan for the Management of Radioactive Materials and Waste (2019-2021 PNGMDR), the President of the National Public Debate Commission asked the French Institute for Radiological Protection and Nuclear Safety (IRSN), by letter dated February 15, 2019, to conduct an assessment of the dry storage of spent nuclear fuels containing mixed uranium and plutonium oxide (MOX) or enriched reprocessed uranium oxide (ERU).

The assessment carried out is presented in this report.

The characteristics of the MOX fuel used by EDF have changed over time. In particular, their plutonium content was successively 5.30%, 7.08% and 8.65% (current level). Given the periods during which MOX fuels with the aforementioned plutonium contents have been used, dry storage solutions based on current concepts could now be considered for all spent MOX fuels with a plutonium content of 5.30% and for most of those with a plutonium content of 7.08%, i.e. around 2,500 fuel assemblies. For the first spent MOX fuels with a plutonium content of 8.65%, used since 2007, this type of storage may not be suitable until around 2040. To reduce the duration of wet storage to around ten years, dry storage concepts should first be developed for spent fuels with a residual heat of around 3 kW per fuel assembly.

Approximately 1,150 ERU fuel assemblies were loaded into reactors by EDF between 1994 and 2013. All of the spent ERU fuels currently stored have a residual heat of less than 2 kW and are therefore compatible with current dry storage concepts.

Considering only the safety requirement related to the temperature of the fuel cladding, it is possible to change the load configurations of existing concepts so that spent fuels with a residual heat greater than 2 kW can be stored. Similarly, transport configurations and even cask should be able to be adapted in order to transport fuels with a residual heat exceeding the reference value of 6 kW per fuel assembly. However, in addition to the constraint related to fuel cladding temperature, casks must meet a set of safety and radiation protection requirements, as well as industrial constraints (feasibility, capacity, cost, etc.). A comprehensive analysis integrating all these factors would therefore be required.

Furthermore, the operations to be performed at the end of the spent fuel storage phase, whether wet or dry, must be taken into account from the design stage of the storage facilities. Specific safety requirements will also have to be adopted for these operations, for example concerning the mechanical characteristics of spent fuel after storage. Demonstrating compliance with these requirements, particularly for spent MOX fuel, may require specific developments and the monitoring program for stored fuels must take these requirements into account. The definition and study of all these requirements would impact the time required to construct the first potential spent MOX fuel dry storage facility in France.

In conclusion, the assessment carried out by IRSN did not reveal any factors that would rule out storing in dry conditions some of the MOX and ERU fuels currently stored underwater. Nevertheless, the various possible options should be examined, incorporating the related safety and radiation protection requirements as well as all industrial constraints.

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REFERENCES

[1] Letter of request from the National Public Debate Commission dated February 15, 2019.

[2] IRSN Report No. 2019-00181 “Storage of nuclear spent fuel: concepts and safety issues” - June 2018.

[3] Report by the French High Committee for Transparency and Information on Nuclear Safety, “*Présentation du « Cycle du combustible » français en 2018*” (Presentation of the French ‘Fuel Cycle’ in 2018) - update of September 21, 2018.

1 PRESENTATION OF THE REQUEST

As part of preparations for the public debate on the 2019-2021 French National Plan for the Management of Radioactive Materials and Waste (2019-2021 PNGMDR), the President of the National Public Debate Commission asked the French Institute for Radiological Protection and Nuclear Safety (IRSN), by letter dated February 15, 2019, [1] appended in Appendix 1 of this report, to conduct two assessments to supplement the information contained in the contracting authority[1] file. These assessments focus, firstly, on the dry storage of spent nuclear fuels made from mixed uranium and plutonium oxide (MOX) or enriched reprocessed uranium oxide (ERU) and, secondly, on the current state of international research on alternatives to the deep geological disposal of high-level, long-lived waste.

This report concerns the assessment of dry storage; the second part of the request will be the subject of a dedicated report.

Since the management of spent fuel from French nuclear power reactors, including its storage, is one of the topics covered in the 2019-2021 PNGMDR, the Special Public Debate Commission (CPDP) mandated for the debate on the PNGMDR, in preparing for the debate, considered the IRSN [2] report on concepts and safety issues related to the storage of spent nuclear fuel published in June 2018 in response to a request from the Parliamentary Committee of Inquiry into the Safety and Security of Nuclear Facilities in France. In the report, IRSN details the possible spent fuel storage options based on a residual heat decay curve for two typical fuels, representative of:

- current EDF reactor loads (MOX fuel and fuel made from enriched natural uranium oxide: ENU),
- the characteristics of transport and wet or dry storage concepts currently implemented in France and around the world.

In particular, for transport and dry storage concepts in their current state, IRSN indicates that the residual heat of spent fuels must be below 6 kW for transport and below 2 kW for dry storage.

The CPDP found that these are determining values in defining the minimum cooling time of spent fuels before transport or the implementation of a dry storage solution. It also wanted IRSN to provide further information, firstly on the suitability of dry storage for the MOX and ERU fuels currently stored underwater and, secondly, on potential changes to current transport and dry storage concepts in order to raise the reference residual heat values cited earlier.

These points are the subject of this IRSN report.

2 BACKGROUND

In the report “Storage of spent nuclear fuel: concepts and safety issues” [2], IRSN reviewed the wet and dry storage concepts existing worldwide and in France, as well as the safety issues associated with the different solutions for storing spent fuel underwater or in dry conditions, either on the site where it is produced or at a central facility. To conclude its analysis, IRSN found that decisions about the type of storage to be used for spent fuel must be assessed in the light of the following considerations.

[1] The Directorate-General for Energy and the Climate (DGEC), within the Ministry for the Ecological and Inclusive Transition, and the French Nuclear Safety Authority (ASN) are the contracting authorities.

Wet storage and dry storage of spent fuel do not serve exactly the same needs. Storage in pools is absolutely necessary for fuel leaving the reactor core and that has hardly cooled. Dry storage is suitable for fuel that has cooled substantially.

The type of spent fuel, whether made from enriched natural uranium oxide (ENU), mixed uranium and plutonium oxide (MOX) or enriched reprocessed uranium oxide (ERU), influences the storage devices possible, at least for a certain period of time after unloading. In particular, MOX fuels have a significantly higher residual heat than ENU and ERU fuels, regardless of the cooling period considered.

IRSN also illustrated the suitability of storage solutions in relation to the residual heat of spent fuel in a figure (see figure 1 in report [2]) for two typical fuels representative of those currently used by EDF in 900 MW reactors in the CPY series, namely:

- a fuel made of enriched natural uranium oxide (ENU), initially enriched to 3.7% uranium-235 and irradiated at 50 GWd/t [2];
- a fuel made of mixed uranium and plutonium oxide (MOX), with an average total plutonium content of 8.65% and irradiated at 50 GWd/t.

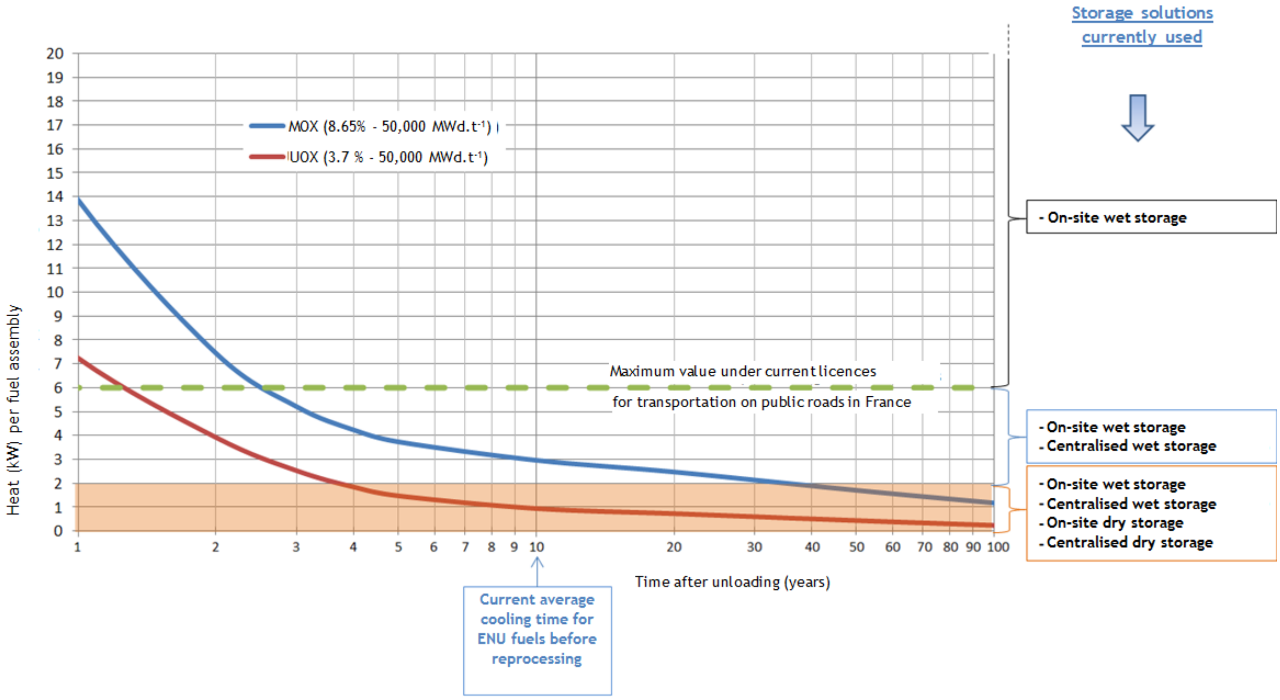

Figure 1: Storage solutions based on the residual heat of the spent fuel

This curve is based in particular on two reference values:

- the maximum residual heat of spent fuel that can be transported on public roads, equal to 6 kW under the transport licenses currently valid in France;
- the highest average residual heat of fuel assemblies, around 2 kW, in current dry storage concepts.

[2] Gigawatt-days per metric ton: fuel burnup unit giving the level of irradiation of fuel assemblies, expressed as energy produced by the assembly in the reactor per ton of initial uranium.

From a safety point of view, regardless of the type of storage, the decisive parameter is the residual heat of the spent fuel to be stored. Wet storage (i.e. in a pool), which generally contains hotter fuel, requires more substantial safety measures than dry storage, for which more passive measures can be implemented. In dry storage, however, cladding (the first containment barrier) is subject to greater thermal stress and is more difficult to inspect.

3 COMPATIBILITY OF MOX OR ERU SPENT FUEL WITH DRY STORAGE

For the record, ERU and MOX fuels are not currently reprocessed and are stored, after cooling in EDF reactor pools, in the pools on the Orano Cycle site in La Hague. This is because EDF's current strategy is to store them underwater and to reprocess them in due course (after 2050), in order to use the plutonium in future generations of reactors, such as fast neutron reactors (FNR) [3]. The storage time of these fuels, their future and therefore their final destination depend on decisions about the development of these new generations of reactors.

3.1 Spent MOX Fuel

As previously indicated, the residual heat decay curve of spent MOX fuel presented in the June 2018 IRSN report corresponds to the MOX fuel currently used in EDF reactors (CPY series), taking into account bounding characteristics (maximum burnup, for example).

However, it is important to remember that the characteristics of the MOX fuel used by EDF in its reactors have changed over time, with regard to their plutonium content and burnup. Thus, since 1987, the date that MOX fuels were first used, there have been four periods (see Table 1) between which the characteristics of MOX fuel and the number of reactors concerned changed.

Table 1: Changes in the characteristics of MOX fuels and the reactors that use them since 1987

Loading period	**1987 - 1994**	**1994 - 2000**	**2000 - 2007**	**Since 2007 ***
Average plutonium content of MOX fuel	5.30%		7.08%	8.65%
Average burnup	36 GWd/t		39 GWd/t	46 GWd/t
Number of reactors concerned	6	20	20	22
Number of MOX fuel assemblies involved **	around 1,200		around 1,500	more than 2,500

***** It should be noted that, in the future, EDF plans to use MOX fuel with an average plutonium content of 9.08%.

****** The number of fuel assemblies was estimated from Figure 14 - *Record of MOX fuel loaded in reactors in the fleet* in the report by the High Committee for Transparency and Information on Nuclear Safety cited in reference [3].

As shown in figure 2 below, drawn up by considering an average burnup rate for the fuels, the residual heat decay differs according to the type of MOX fuel. The time required for these fuels to cool to the reference value of 2 kW therefore varies significantly. For example, MOX fuel with a 5.30% plutonium content is compatible with dry storage after around 5 years of cooling; on the other hand, MOX fuels with a 7.08% plutonium content and with an 8.65% content require 10 years and 30 years of cooling, respectively.

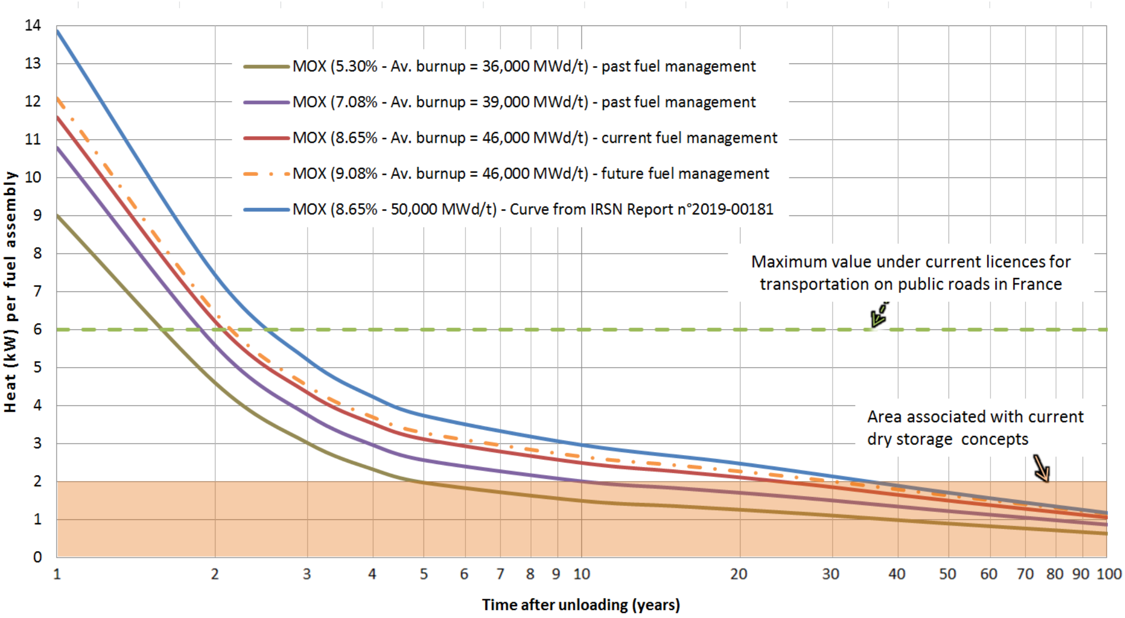

Figure 2: Residual heat decay curves for the different types of MOX fuels used by EDF

Thus, taking into account the dates from which the different types of fuel[3] were used and the reference value of 2 kW, it appears that, from the point of view of residual heat removal, spent MOX fuels with a 5.30% plutonium content and most of those with a 7.08% plutonium content are compatible with certain dry storage concepts (see figure 3). This represents around 2,500 spent fuel assemblies.

However, the first spent MOX fuels with an 8.65% plutonium content may only be compatible with dry storage in around 2040.

In this respect, figure 2 shows that a dry storage solution designed with a maximum residual heat per assembly of around 3 kW would allow spent MOX fuels with an 8.65% plutonium content to be stored after 5 to 10 years of cooling.

In the rest of this report, IRSN uses this 3 kW value as a reference value to analyze the changes in dry storage concepts that would significantly reduce the cooling time required before dry storage could be implemented for the spent MOX fuels currently in use.

[3] Fuels are generally unloaded from reactors after three years of irradiation for MOX fuels with plutonium contents of 5.30% and 7.08% and after four years for MOX fuels with plutonium contents of 8.65%.

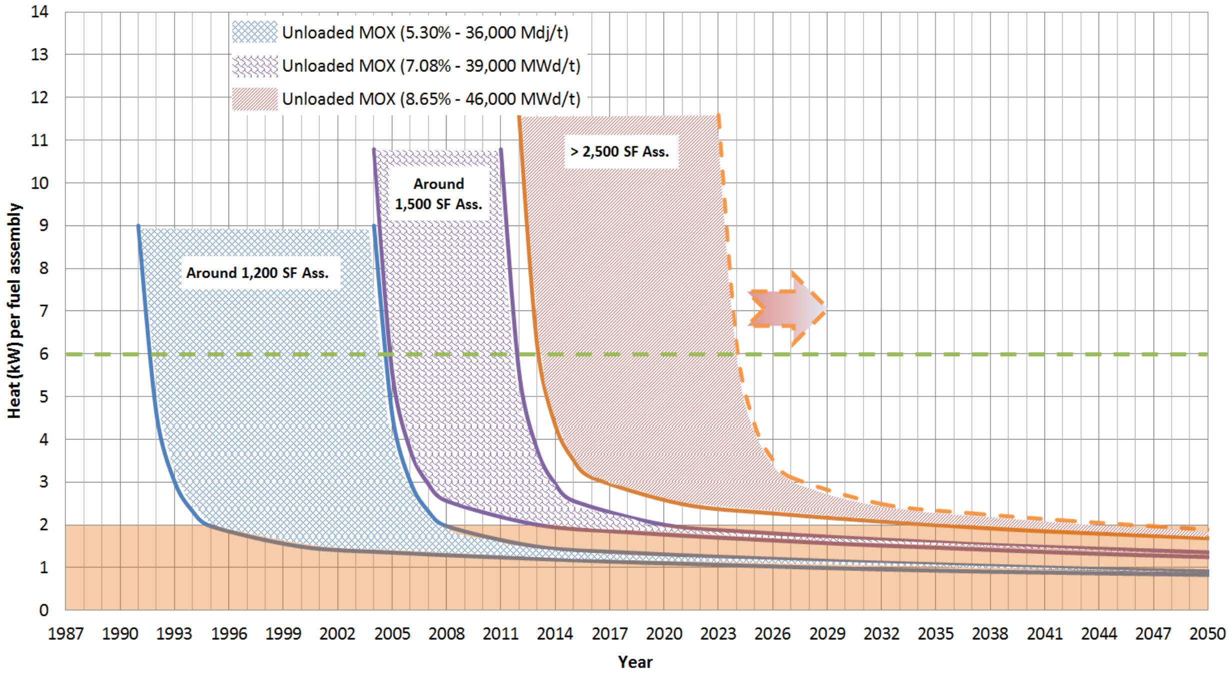

Figure 3: Residual heat decay of the various MOX fuels according to the date of their unloading from the reactor

3.2 Spent ERU fuels

Between 1994 and 2013, ERU fuels were loaded into the 900 MW reactors at the Cruas site. EDF plans to resume the use of this type of fuel in 2023 [3].

As with MOX fuels, the characteristics of ERU fuels used by EDF have changed over time, with regard to uranium-235 enrichment and burnup. This means that since ERU fuel was first used in 1994, there have been three periods (see Table 2) between which the characteristics of this fuel and number of reactors using it changed.

Table 2: Changes in the characteristics of ERU fuel used since 1999

Loading period	1994 - 1999	1999 - 2009	2009 - 2013
^{235}U enrichment	3.70%	4.10%	
Average burnup	46 GWd/t	46 GWd/t	
Number of reactors concerned	2	2	4
Number of ERU fuel assemblies involved *	About 250	About 900	

* The number of fuels was estimated from the figure *Annual quantity of ERU fuel loaded at Cruas between 1994 and 2013* in Appendix 6 of the report by the High Committee for Transparency and Information on Nuclear Security cited in reference [3].

The residual heat characteristics of spent ERU fuels are similar to those of ENU fuels. **As illustrated in figure 4 below[4], all of EDF's spent ERU fuels are currently compatible with current dry storage concepts. This represents around 1,150 spent fuel assemblies.**

[4] ERU fuels are generally unloaded from reactors after three years of irradiation.

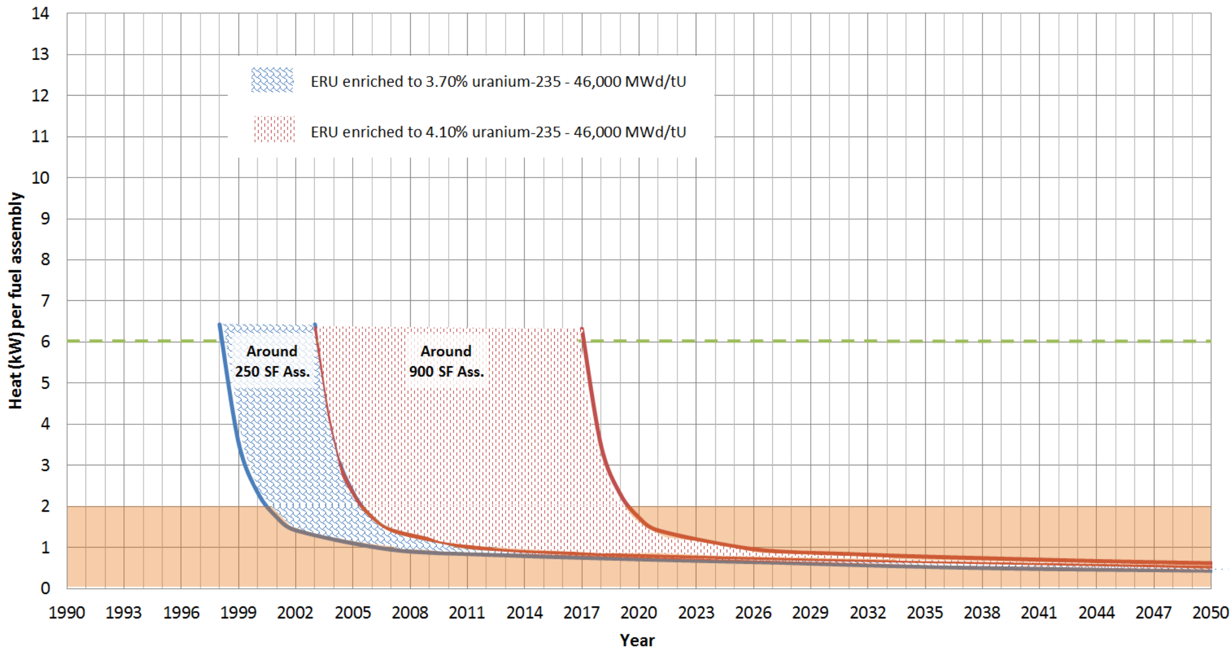

Figure 4: Residual heat decay of the various ERU fuels according to the date of their unloading from the reactor

4 POSSIBLE CHANGES TO DRY STORAGE CONCEPTS

4.1 Reminder about current dry storage concepts

In countries that do not reprocess spent fuel, the fuels unloaded from reactors (mainly ENU fuels) are generally placed in dry storage after a period of cooling in a pool of several years. These storage facilities are specifically designed to guarantee a maximum spent fuel cladding temperature of around 400°C. For the storage devices currently in use, this leads to the maximum residual heat of the fuels stored being defined, depending on the concept, between around 1 kW and 2 kW. These values mean that the dry storage of ENU spent fuels is possible in any case before 10 years of cooling.

As detailed in the IRSN report cited in reference [2], three main dry storage concepts for spent fuel have been developed around the world:

- vault storage[5];
- silo storage;
- cask storage.

Dry storage, whether at the reactor site or at a centralized site, requires the spent fuel to first be conditioned, depending on the case, by placing it:

- in a basket placed in a cask with a screwed closure system;
- in a container, first fitted, where necessary, with a basket, onto which the lid is then welded to make it leaktight; the whole system is then placed in a storage module (pit, horizontal or vertical concrete structure).

5 In French, '*entreposage en casemates ou puits*'.

4.2 Analysis of possible changes to current dry storage concepts

At the request of the CPDP, IRSN studied the possible changes to current transport and dry storage concepts that would make it possible to change the above-mentioned reference values for the residual heat of spent fuel assemblies (2 kW for dry storage and 6 kW for transport).

For this analysis, IRSN conducted sensitivity studies for a dry storage concept in a metal cask for which it had sufficient data (geometry, materials, etc.) to quickly prepare a computational model. The selected cask consists of a thick steel shell covered with a resin to limit the dose rate around it. Its outer layer is not fitted with a specific system (cooling fins), intended to increase the surface area for exchange with the outside air and therefore the heat dissipation of the cask. The basket placed inside the cask contains 24 compartments to hold spent fuel assemblies. The maximum residual heat of spent fuel stored in this cask, assuming a complete and uniform load (reference case), is just less than 1.5 kW.

At first glance, IRSN considers that the conclusions of its study could be extended to all concepts. However, the increases in the residual heat of spent fuel concluded from this study should be considered as orders of magnitude, since these may vary depending on the storage concept.

IRSN mainly studied different load configurations of the cask selected for storage. In particular, the following were analyzed:

- incomplete loads: one or more compartments were left empty and the used compartments contained spent fuels with the same residual heat;
- non-uniform loads: the cask was loaded with two types of spent fuel with different residual heat levels.

The parameters of the alternative configurations (number and residual heat of spent fuel assemblies) studied were defined such that the maximum temperature of the spent fuel cladding in the reference case was respected (below 400°C).

In the configurations with incomplete loads, there were significant gains in the maximum admissible residual heat of the spent fuel assemblies stored.

Figure 5 shows, for a given number of empty compartments in the cask, the different incomplete load configurations that present the greatest possible gain in the maximum residual heat per fuel assembly compared to the reference case cited.

However, they lead to a significant decrease in storage density. This would entail an increase in the number of casks required, the surface area of the storage units and, potentially, the buildings housing them. These changes would lead to a significant increase in the cost of storage.

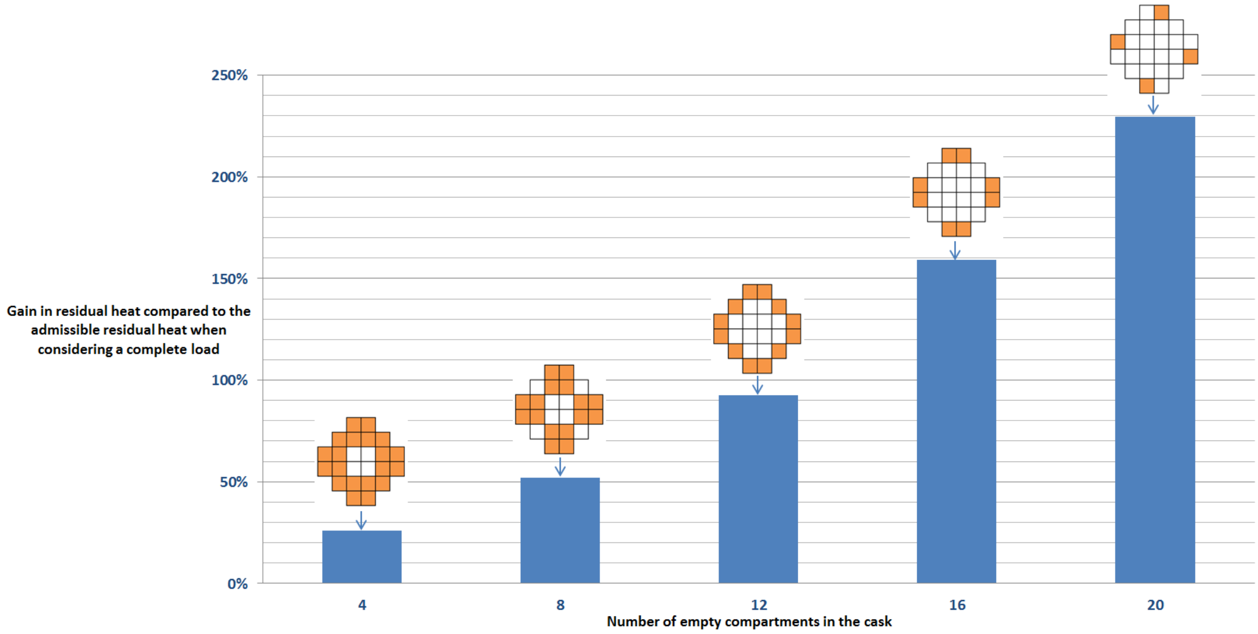

Figure 5: Admissible residual heat of fuel assemblies according to the number of empty compartments in the packaging

Non-uniform load configurations also present significant gains with regard to the maximum admissible residual heat of the spent fuel assemblies stored compared to the reference case. figure 6 shows, for three non-uniform load cases, the gain[6] in residual heat of the hottest fuel assemblies compared to the decrease[6] in residual heat of the coldest fuel assemblies (see the example in Figure 6 below). Moreover, they do not lead to a reduction in storage density. However, they require spent fuel assemblies with a lower residual heat to ensure that the cask is fully loaded. The French strategy of reprocessing spent ENU fuel limits the possibility of using this alternative.

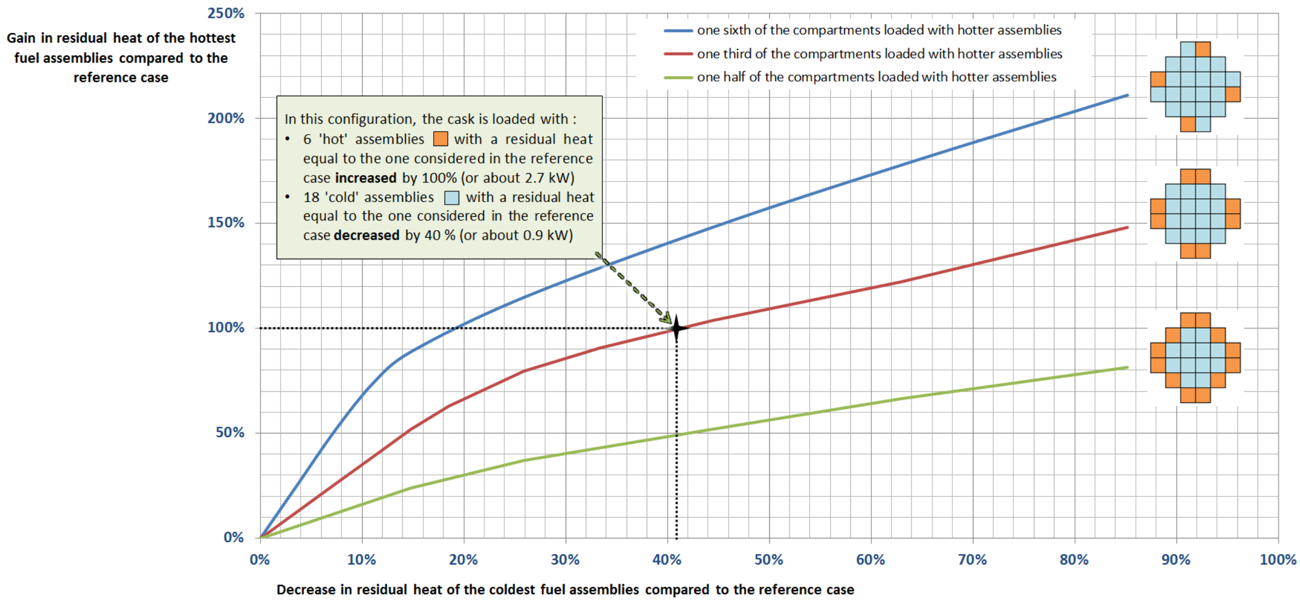

Figure 6: For three non-uniform load configurations, the relationship between the residual heat of the hottest and the coldest fuel assemblies in order to ensure a maximum fuel temperature of less than 400°C

[6] Gain and decrease compared to the residual heat of fuel assemblies in the reference case.

In conclusion, the results obtained show that, by considering only the criterion of the maximum cladding temperature for the spent fuels stored, it would be possible to store, in the cask considered for the study, a limited number of spent fuel assemblies with a residual heat of two to three times that of the maximum in the reference case (complete and uniform cask load). This significantly reduces the underwater cooling time required before implementing dry storage. In this respect, the reference value of 3 kW, introduced in paragraph 3.1 of the report, appears achievable.

Nonetheless, the industrial implementation of the configurations studied should be the subject of analyses (on safety and technical and economic aspects), particularly in the French context. This is because they lead to a significant decrease in storage density or require the availability of a large number of spent fuel assemblies with 'low' residual heat.

Furthermore, some cask design choices promote heat exchange between spent fuels and the external environment (cooling fins, for example). These measures would increase the admissible residual heat of the spent fuel assemblies stored. By way of example, installing cooling fins around the packaging modeled by IRSN would increase the maximum admissible residual heat of fuels by several tens of percent. However, this could make the cask manufacturing process, and even storage facility construction, more complex in order to promote heat exchange.

Finally, in addition to the requirement regarding the maximum spent fuel cladding temperature, casks must meet radiation protection requirements, particularly when they are used for both transport and storage operations. In this respect, the results presented above do not take into account either radiation protection requirements (in particular those related to transport on public roads) or the maximum admissible temperature of the resin commonly used for this type of cask.

Taking these constraints into account could reduce the estimated gains. For example, in the case studied by IRSN, the greatest gains in residual heat were obtained by placing the hottest fuel assemblies in the outer compartments of the baskets. However, this configuration is the least favorable in regard to dose rate value for storage devices, particularly given the neutron fluence rates[7], which increase with the initial plutonium content in the fuel.

5 POSSIBLE CHANGES TO TRANSPORT CONCEPTS

As the storage concept studied above is similar to that of the transport casks, the results obtained can be transposed to spent fuel transport configurations (increase in the maximum admissible residual heat of spent fuels for incomplete or non-uniform load configurations). However, in this case, radiation protection requirements could become more restrictive than residual heat removal requirements.

Transport configurations and even conditioning must therefore be able to be adapted in order to transport fuels with a residual heat higher than the reference value of 6 kW per fuel assembly. However, depending on the configuration chosen, this could lead to an increase in the number of related shipments (particularly for incomplete loads).

As with storage, the industrial implementation of such changes should be the subject of analyses (on safety and technical and economic aspects).

[7] The fluence rate corresponds to the neutron flux density.

6 CONCLUSION

The fuel used in French nuclear power plant reactors contains enriched natural uranium oxide (ENU) or mixed uranium and plutonium oxide (MOX). In the past, fuel made from enriched reprocessed uranium oxide (ERU) was used. Unlike ENU fuels, ERU and MOX fuels are not currently reprocessed. They are stored for cooling in EDF reactor pools and then in those at the Orano Cycle plant in La Hague.

The characteristics of the MOX and ERU fuel used by EDF have changed over time. In particular, the plutonium content of MOX fuels was successively 5.30%, 7.08% and 8.65% (content of fuel currently loaded in EDF reactors).

The residual heat of spent MOX fuels depends on this content and their burnup rate. Thus, the cooling time required for the residual heat of these fuels to be reduced to less than 2 kW per fuel assembly, the reference value adopted by IRSN to consider the possible implementation of current dry storage concepts, is around 5 years, 10 years and 30 years respectively, considering the average burnup rate per assembly.

Consequently, **given the periods during which MOX fuels with the above-mentioned plutonium contents have been used, dry storage solutions based on current concepts could now be considered for all spent MOX fuels with a plutonium content of 5.30% and for most of those with a plutonium content of 7.08%, i.e. around 2,500 fuel assemblies.**

For the first spent MOX fuels with a plutonium content of 8.65%, used since 2007, this type of storage may not be suitable until around 2040. In any case, for this type of spent MOX fuel, wet storage solutions are required over a period of nearly 30 years after the end of their irradiation, taking into account the reference value of 2 kW associated with current dry storage concepts. To reduce this time to around ten years, dry storage concepts should first be developed for spent fuels with a residual heat of around 3 kW per fuel assembly.

Approximately 1,150 ERU fuel assemblies were loaded into reactors by EDF between 1994 and 2013. All of the spent ERU fuels currently stored have a residual heat of less than 2 kW and are therefore compatible with current dry storage concepts.

The 2 kW reference value chosen by IRSN for the implementation of dry storage is based on a bibliographic analysis of the average residual heat of spent fuels chosen for dry storage concepts currently in use around the world. These values, which vary between approximately 1 kW and 2 kW, correspond to compromises between safety requirements (maximum temperature of the spent fuel cladding, radiation protection, etc.), storage capacity (number of fuel assemblies per storage device), the characteristics of the spent fuels to be stored (residual heat and therefore required cooling time) and costs.

Considering only the safety requirement related to the temperature of the fuel cladding, it is possible to change the load configurations of existing concepts so that spent fuels with a residual heat greater than 2 kW can be stored.

Therefore, by reducing, for example, the number of spent fuel assemblies per storage device or by storing fuels with varying residual heats (significantly higher and lower than the average value) in the same device, spent fuels with residual heats two to three times higher than the average value associated with the devices currently in use could be stored. This would significantly reduce the underwater cooling time required before implementing dry storage. Moreover, changes in the design of storage devices (to increase heat dissipation, etc.) could be developed.

However, the reduction in the number of spent fuel assemblies per storage device proportionally reduces the storage density (a half-loaded cask requires twice as much conditioning and storage space for the same number of fuel assemblies as a full cask). Similarly, while non-uniform loads do not lead to a decrease in storage density, they require the availability of spent fuel assemblies with 'low' residual heat. The French strategy of reprocessing spent ENU fuel limits the possibility of using this alternative.

A similar analysis can be carried out for transport casks. Therefore, with the suggestions provided above, it should be possible to adapt transport configurations and even conditioning in order to transport fuels with a residual heat higher than the reference value of 6 kW per fuel assembly. However, depending on the configuration chosen, this could lead to an increase in the number of related shipments (particularly for incomplete loads).

More generally, in addition to the constraint related to fuel cladding temperature, casks must meet a set of safety and radiation protection requirements, as well as industrial constraints (feasibility, capacity, cost, etc.). A comprehensive analysis integrating all these factors would therefore be required to consolidate the gains mentioned above while taking into account both storage and, where applicable, transport operations.

Furthermore, the operations to be performed at the end of the spent fuel storage phase, whether wet or dry, must be taken into account from the design stage of the storage facilities. For instance, it must be possible to unload the fuels for either reprocessing or reconditioning with a view to disposal. In an industrial dry storage project, the facilities required for these operations should be identified from the outset. Specific safety requirements will also have to be adopted for these operations, for example concerning the mechanical characteristics of spent fuel after storage.

Demonstrating compliance with these requirements, particularly for spent MOX fuel, may require specific developments and the monitoring program for stored fuels must take these requirements into account. The definition and study of all these requirements would impact the time required to construct the first potential spent MOX fuel dry storage facility in France.

In conclusion, the assessment carried out by IRSN did not reveal any factors that would rule out storing in dry conditions some of the MOX and ERU fuels currently stored underwater. Nevertheless, the various possible options should be examined, incorporating the related safety and radiation protection requirements as well as all industrial constraints.

Appendix 1 **LETTER OF REQUEST**

cndp Commission nationale du **débat public**

LA PRÉSIDENTE

Paris, le 15 FEV. 2019

Monsieur le Directeur général,

Pour faire suite aux échanges que vous avez eu avec Madame Isabelle HAREL-DUTIROU, Présidente de la Commission particulière du débat public PNGMDR, je vous confirme la demande de mise en place d'un partenariat avec l'IRSN. Afin de compléter l'information du dossier du maître d'ouvrage, il s'agirait de réaliser deux expertises :

1. Expertise relative à l'analyse des possibilités d'entreposage à sec des combustibles radioactifs

A la demande de la Commission d'enquête parlementaire sur la sûreté et la sécurité des installations nucléaires, vous avez réalisé, en juin 2018, un rapport sur « l'entreposage du combustible nucléaire usé : concepts et enjeux de sûreté ». Dans ce rapport, vous illustrez les modes possibles d'entreposage des combustibles usés sur la base d'une courbe de décroissance de la puissance thermique de deux combustibles types, représentatifs des gestions de combustibles actuelles d'EDF, et des caractéristiques des concepts de transport et d'entreposage, sous eau ou à sec, actuellement mis en œuvre en France et de par le monde. En particulier, vous faites état, pour les entreposages à sec, d'une puissance maximale de 2 kW par assemblage combustible. Cette valeur est déterminante pour définir la durée minimale de refroidissement des assemblages combustibles usés avant mise en œuvre d'un tel mode d'entreposage.

En complément de ce rapport, et dans le cadre du débat public PNGMDR, nous souhaiterions disposer, pour début avril 2019, de votre analyse concernant :

-l'éventuelle compatibilité de certains combustibles usés MOX et URE actuellement entreposés sous eau avec un entreposage à sec ;

-les évolutions envisageables des concepts actuels de transport et d'entreposage à sec qui permettraient de revoir les valeurs repères de puissance thermique des assemblages combustibles usés mentionnées dans le rapport IRSN de juin 2018 (6 kW pour le transport et 2 kW pour l'entreposage à sec)".

Monsieur Jean-Christophe NIEL
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2. Expertise relative à l'état des lieux au niveau international des recherches sur les alternatives au stockage géologique des déchets HA-VL

Avec la loi de 2006, la France a décidé de retenir le stockage géologique profond comme solution de référence pour gérer sur le très long terme les déchets radioactifs les plus dangereux (déchets de haute activité et moyenne activité à vie longue ou déchets HA-MAVL). Cette décision est intervenue à l'issue d'un processus d'évaluation de plusieurs options envisageables. Trois axes définis par la loi de 1991 ont été plus précisément explorés :

– la recherche de solutions permettant la séparation et la transmutation des éléments radioactifs à vie longue présents dans les déchets de haute activité ;
– l'étude des possibilités de stockage réversible ou irréversible dans les formations géologiques ;
– l'étude de procédés de conditionnement et d'entreposage de longue durée en surface de ces déchets.

Les résultats obtenus pour ces trois axes et les fondements du choix retenu dans la loi de 2006 sont présentés dans le dossier du maitre d'ouvrage pour le débat public sur le plan national de gestion des déchets et des matières radioactives.

Le dossier du maître d'ouvrage indique : « le déploiement d'un stockage géologique profond présente des enjeux exceptionnels, de par sa durée qui s'étale sur quatre générations (un siècle environ). Un tel projet doit donc être conçu de façon à pouvoir intégrer, d'une part, les progrès technologiques et les évolutions de politique énergétique et, d'autre part, de répondre aux attentes de la société civile tout au long de sa vie. »

Afin de répondre à ces enjeux, le législateur a instauré un principe de réversibilité du stockage pour une durée d'au moins cent ans. La récupérabilité constitue l'une des formes prévues pour l'application de ce principe. Elle offre aux générations futures la possibilité de revenir sur le choix du stockage géologique profond comme mode de gestion des déchets radioactifs, en permettant de récupérer des colis de déchets déjà stockés et de mettre en œuvre une éventuelle solution alternative.

Afin de compléter l'information contenue dans le dossier du maître d'ouvrage et d'apprécier la vraisemblance d'une telle éventualité, il parait important de disposer d'un panorama des différentes alternatives qu'il est aujourd'hui possible d'imaginer. Nous souhaiterions pour cela que vous rassembliez dans un document une description sommaire des principales options qui ont pu être explorées dans le passé au niveau international, ainsi qu'un état des recherches qui se poursuivent aujourd'hui dans le monde pour mettre au point des solutions de gestion des déchets HAVL alternatives au stockage géologique profond. Nous souhaiterions disposer de ce document pour début avril.

Je vous remercie à l'avance de l'engagement de votre institut dans cette démarche au service de la démocratie participative et de la transparence de l'information, valeurs communes à nos deux institutions.

Je vous prie de croire, Monsieur le Directeur général, à l'assurance de ma considération distinguée.

Bien cordialement.

Jouanno.

Chantal JOUANNO

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LIST OF ABBREVIATIONS USED IN THE REPORT

ASN	French Nuclear Safety Authority
CNDP	*Commission nationale du débat public* (French National Public Debate Commission)
CPDP	*Commission particulière du débat public* (Special Public Debate Commission)
DGEC	Directorate-General for Energy and Climate
EDF	*Electricité de France* (the French national electric utility)
ENU	Enriched natural uranium
ERU	Enriched reprocessed uranium
FNR	Fast neutron reactor
HCTISN	French High Committee for Transparency and Information on Nuclear Safety
IRSN	French Institute for Radiological Protection and Nuclear Safety
MOX	Mixed uranium and plutonium oxide
MW	Megawatt electric.
NPP	Nuclear power plant
PNGMDR	National Plan for the Management of Radioactive Materials and Waste
PWR	Pressurized water reactor