Redefining international dialog: Invent innovative frameworks for licensing Small Modular Reactors

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**Abstract**

Beyond the sustained efforts of the international nuclear community to promote common safety principles and approaches, nuclear safety regulatory frameworks remain very national specific at the implementation level. While many SMR designs are being considered across borders, with the industrial imperative of minimizing design changes, convergences of regulatory standpoint emerge as crucial. Sharing regulatory views and practices is a first step to streamline regulatory processes, to facilitate assessment of future license applications across jurisdictions and at the same time to promote the highest safety level reasonably achievable. Through the Joint Early Review (JER), six European regulatory bodies have been conducting a synchronized preliminary review of the Nuward SMR, focused on a selection of key topics. This initiative enables the vendor to refine its design in a very early phase but it also raises regulators readiness by considering different regulatory approaches. Maturity of documentation, involvement of the vendor and commitment of regulators have been key conditions for a successful collaboration. The early outcomes of the JER highlight the benefits of such initiatives. It also confirms the need to develop new frameworks to address the challenge of licensing a very large diversity of designs, supported by new applicants, while ensuring the highest standards of safety.

1. **Introduction**

Since the 60’s and the beginning of the industrial nuclear program in France, the French nuclear community has been ruled by the main principles: a fleet of similar large-scaled reactors operated by a well-established licensee focused on the domestic market, being regulated by a regulator, with the support of a state-owned TSO. The French case is not unique and, despite the sustained efforts of the international nuclear community to promote common safety principles and approaches, nuclear regulatory frameworks remain very national specific. The recent EPR licensing confirms this conclusion. The EPR Working Group under the Multinational Design Evaluation Program (MDEP) was a fruitful forum, where regulators could share and discuss regulatory challenges related to EPR licensing. However, this reactor has been independently licensed in each country, according to different regulatory frameworks. As a result, and after a long licensing procedure, each reactor has been customised to comply with national regulatory framework.

While many SMR designs are being considered across borders, with the industrial imperative of minimizing design changes, convergences of regulatory standpoint emerge as crucial. Sharing regulatory views and practices is a first step to streamline regulatory processes, to facilitate efficient licensing procedures across jurisdictions and at the same time to promote the highest safety level reasonably achievable.

1. **The Joint Early Review: a pilot case of innovative framework for international collaboration**
   1. **Motivation and framework of the JER**

In the context of industrial and political support toward SMR technologies and evolution of national regulations, and considering that EDF has approached several European regulatory bodies with the objective to have an early regulatory involvement, in countries where industry has expressed interest for the construction of its NUWARD SMR project, a joint early review of some key topics has been identified as an opportunity.

At an international level, several initiatives have been launched to reflect on the challenges, risks and opportunities presented by SMRs (SMR Regulator’s forum, NHSI, etc.). Despite the very high value of the outcomes and discussions from these forums, these reflections have been usually focused on high level regulatory challenges raised by SMRs.

As a regulator, ASN considered the JER as an opportunity to enable the regulators not only to discuss their regulatory framework (binding or not), but also to engage on their approach and practices in the execution of their framework by reviewing a specific design.

To conduct this work, ASN, STUK and SÚJB have decided to launch an initiative to conduct a joint early review of the NUWARD SMR preliminary design and safety approach, with the support of IRSN and SÚRO, and with a focus on topics with high stakes for safety or for the design. This design-specific forum was established as a complementary tool of other international regulatory initiates addressing SMRs challenges.

This review was based on the current set of each national framework, WENRA’s safety objectives and reference levels, and up to date knowledge and practices. This review was not part of any licensing process, and therefore its results are not binding.

This initiative had for objective to enable participating regulators:

1. to acquaint with a SMR design and identify the potential challenges that it raises prior to the beginning of their respective licensing process.
2. to share their expectations, knowledge and practices about the identified topics.
3. to increase knowledge transfer about regulatory practices and expectations.
4. to provide EDF with early feedback about its design and possible associated regulatory challenges.

Finally, knowing that international cooperation usually requires time and effort, and that the initiative was innovative, the involved regulators found beneficial to limit the scope to topics consensually considered as the most important ones and to set an ambitious pace of work from the beginning. This enabled the working group to complete its work in one year, and to assess, at the end of this phase, the strength and weaknesses of this form of collaboration. Reaching harmonization from regulators’ side was not the objective of this initiative as it requires a lot of time, effort, and often a political commitment.

A proposition of list of topics was proposed, discussed and agreed. The priority was given to the topics having importance on the safety demonstration and having a potential influence on the design.

The review was based on preliminary extracts from the safety options file. This level of details corresponds to the beginning of the basic design phase.

* 1. **Lessons learned from the first phase of the JER**

Here are some of the main lessons learned raised by the members, extract from the report [1]:

* Reviewing a same design together with other regulators helps identifying possible challenges related to this design at a very early stage, as was the case of this JER initiative. This cross-view can enhance nuclear safety, as each regulator may look at a topic from slightly different angles, influenced by their regulatory frameworks, expectations and practices, which have developed over the years and by their own experiences.
* The JER initiative strengthens knowledge sharing and provides valuable inputs to the regulators to review, their national regulatory framework, guides and practices.
* The JER initiative provides substantial room for discussions between the vendor and the regulators. It enables to better understand the design and safety approach of a reactor, as well as each regulator’s national legal requirements, expectations, approaches and experience.
* The JER initiative enables to provide timely feedback to the vendor on topics considered as amongst the riskiest and the most impactful for the project, from a safety or a design point of view, at a stage where design changes are still possible with limited impact on the project. This approach facilitates the development of a standardized design more likely to meet expectations in terms of safety and to be licensed in different countries.

As a regulator already involved in the pre-licensing of Nuward since July 2023, ASN acknowledges the benefit of the JER to get familiar of the design and to raise its readiness in conducting a more effective pre-licensing. It is a very good practical exercise for people to be ready for a more formal assessment. In addition, sharing with other regulators helps to identify and address the most challenging topics.

* 1. **Follow up and perspectives of the JER**

In November 2023, three additional members joined the JER (the Netherlands, Poland and Sweden) and a second phase was initiated. Following on from the first phase, the aim of the second phase will be to identify, the strengths and issues raised by the Nuward SMR in terms of safety on a few selected topics and adaptation to the various national regulatory frameworks. During this new phase, the scope of the review will be extended to new technical issues. In particular, the review will cover containment barriers, review of the radiological consequences of an accident and the architecture of electrical and instrumentation and control systems. Conclusions are expected to be issued early 2025, maintaining the objective to conduct a timely review.

1. **The limits of a JER cooperation due to the emergence of new SMR projects developed by start-ups**

The efforts of the stakeholders and the framework of the JER should of course be credited for the success of the initiative but it should also be noted that such initiative was adapted to the specific case of Nuward. In particular, the combined experience of the different partners involved in Nuward (EDF, CEA, Technicatom, Naval group and Tracetebel) enables a timely development of a mature design and help in having prompt comprehensive answers. In addition, having compatible calendars in the different countries helps a lot to align the interests to support this initiative. All these conditions were necessary to reap full benefits of the framework provided by the JER and to make it a success.

In complement to the development by major historical nuclear companies of SMLWR projects comparable in power to fossil-fuelled power plants, the French government launched in March 2022 a call for projects for innovative nuclear reactors with the objective of fostering the emergence of new private companies in the nuclear sector.

This call for projects, launched as part of the France 2030 plan to decarbonize the economy, aims to develop SMR not only to meet the expected growth or conversion of electricity production for the grid, but also to produce heat at temperatures of several hundred degrees, thus providing an alternative to fossil fuels used by many industrial processes.

This call for projects has led to the emergence of a dozen start-ups in France with a wide scope of reactor technology and power:

TABLE 1. List of ongoing AMR projects in France (as of May 2024)

|  |  |  |
| --- | --- | --- |
| **Reactor technology** | **Start-up** | **Core thermal power** |
| LWR | Calogena | 30 MWth |
| HTR | Jimmy Energy | 20 MWth |
|  | Blue capsule | 150 MWth |
| SFR | Otrera | 300 MWth |
|  | Hexana | 400 MWth |
| LFR | Newcleo | 80 MWth / 400 MWth |
| MSR | Naarea | 80 MWth |
|  | Thorizon | 250 MWth |
|  | Stellaria | 250 MWth |
| LWR | Calogena | 30 MWth |

Since these start-ups are facing the same economic challenge of developing SMRs, which require to design a standardized reactor model that can be licensed in many countries, a JER similar to the one performed on the Nuward project could be seen also as an opportunity for their development.

However, it is important to note that almost all the start-up projects are AMRs. This difference has a significant impact on the objective of an early review. Indeed, the Nuward joint early review had for objective to enable participating nuclear safety authorities with already a strong experience feedback on regulating LWR to share with more details their regulatory practices and expectations on a concrete SMLWR project.

In the case of those AMR projects, the first objective of each early review started by ASN and IRSN has been to identify innovative safety features compared to usual LWR that could challenge the regulatory framework (new definition of a severe accident, new safety criteria for accident studies, new material to withstand high temperature and corrosion….) and hence are more to be seen as preparatory reviews.

Moreover, most of these start-ups have a more gradual development plan than historical big nuclear companies, considering as a first step to get a construction and operating license for a demonstrator in a single country, and afterwards, based on the performance of this demonstrator, hoping to convince more investors to support their growth to be able to build a fleet of reactors in the same country or abroad. This is the case, for example, of Jimmy Energy, which in May 2024 applied for a construction license in France of a 10 to 20 MWth demonstrator of its HTR reactor to produce heat for an industrial distillery.

This gradual development plan within an initial purely national framework may make it difficult for many SMR projects to envisage a synchronized joint JER-type review involving several safety authorities.

1. **The new nuclear landscape calls to rethink regulator’s international collaboration**

It is important to underline that the SMR projects developed by these start-ups, mainly AMRs, are featuring innovations in terms of design, technological choices and safety approaches and also that some of these safety innovative features can be shared by several SMR models, such as the concept of a remote-monitored/operated reactor with no operating staff on site.

Hence, carrying out complete independent safety assessments by several safety authority on innovative safety features on different projects, or on the same reactor project but staggered in time, may result in developing as many different safety approaches and requirements as there are different national assessments, thus going in the wrong way as regards the need for harmonization that is expected to foster standardization.

It seems advisable to work on defining a cooperation between safety authorities in order to compare analyses of innovative provisions and avoid regulators adopting conflicting positions, even if these AMRs projects are not submitted at the same time everywhere. The lessons learned from the Nuward joint evaluation report can serve as a starting point for developing a tailored framework for cooperation on AMRs.

References

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