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# NUWARD SMR
# Joint Early Review Phase 2
# Summary Report

December, 2025

# NUWARD SMR JOINT EARLY REVIEW PHASE 2 SUMMARY REPORT (DECEMBER 2025)

## 1. INTRODUCTION

From December 2023 to March 2025, six European nuclear safety regulators, ASNR (France), STUK (Finland), SUJB (Czech Republic), PAA (Poland), SSM (Sweden) and ANVS (the Netherlands), and two of their Technical and Scientific Support Organizations (TSO), IRSN from France (now part of ASNR) and SURO from Czech Republic, have conducted the second phase of a Joint Early Review (JER) of the NUWARD SMR design.

The purpose of NUWARD team is to develop a standardised design for its Small Modular Reactor (SMR), suitable for licensing and construction in multiple countries. The JER is one of the initiatives launched by EDF and NUWARD to get from the early stage of the design an international perspective and to embed international expectations into the NUWARD SMR design development.

The pilot phase of the JER was conducted from June 2022 to June 2023 by a more limited group of regulators (ASN/IRSN, STUK and SUJB/SURO). Both the regulators group and NUWARD have published summary reports after this first phase of the JER (see [1], [2]). This new summary report presents the NUWARD team's experience during phase 2 of the JER initiative, which has involved three additional European regulators: PAA, SSM and ANVS. As such, it should be read in conjunction with the combined JER Regulators Group's summary report for phase 2, issued at the same time. The two reports are complementary as they present the two sides of the same JER experience, and in such they offer insights to the whole nuclear community of what was done, how it was done and what was collectively learned.

## 2. CONTEXT AND APPROACH OF THE JOINT EARLY REVIEW

The JER initiative was launched in a challenging global SMR licensing context: The industry needs to be able to propose standardised designs for international deployment without major changes. However, country-specific regulatory frameworks present differences. International harmonisation initiatives are ongoing, making good progress but they take time. The JER initiative offers a pragmatic approach in this global SMR licensing context. At the same time, it allows for early engagement with regulators on main topics for the ongoing design process.

The main objectives of the JER phase 2 remained the same as for phase 1:

- Foster exchanges with several European regulators around NUWARD SMR design and its safety approach.
- Identify key enablers and conditions to meet licensing expectations in the respective countries.
- Enable all participants to increase their respective knowledge of each other's regulatory practices.

The practical approach undertaken, including the selection of topics for engagement and the evolution of the menu for discussion, remained similar to the approach taken for the first phase of the JER. This approach is fully detailed in the Regulators Group JER phase 1 summary report [1], and evolutions of this approach for the second phase of the JER are described in the Regulators Group JER phase 2 summary report [3]. In brief the main topics discussed during the JER phase 2 were:

Topic 7. Design extension conditions management strategies.
Topic 8. Containment and radiological consequences assessment.
Topic 9. Criticality risk management.
Topic 10. Electrical and I&C systems architecture.

They complemented the main topics discussed during the JER phase 1.

The second phase of the JER started with the onboarding of three additional regulators (ANVS, PAA and SSM). In a first step, the design of NUWARD SMR was presented by NUWARD engineers in a dedicated catch-up session. The new regulators were also provided with access to all information exchanged within the JER phase 1. In a second step, dedicated catch-up sessions were organised on each of the six topics of JER phase 1 to address any questions from the new regulators. Topics discussed during the JER phase 1 were:

Topic 1. General safety objectives.
Topic 2. List of design basis conditions and design extension conditions.
Topic 3. Use of passive cooling systems.
Topic 4. Development plan for computer codes.
Topic 5. Integration of two reactor units in a single facility.
Topic 6. Probabilistic Safety Assessment (PSA) approach.

In a third step, the new regulators compiled their contributions on topics 1 to 6 in a report structured in line with the regulator's joint synthesis reports issued for phase 1. The regulators' joint synthesis reports issued for phase 1, together with the new regulators' catch-up report issued for phase 2, reflect the views of the whole Regulators Group on all six topics of JER phase 1.

Following the same process as in JER phase 1, the review of topics 7 to 10 was conducted based on NUWARD SMR information provided in support of the considered topics. This review was performed in the context of each country's national regulation applicable at the time of the review, following WENRA's safety objectives and reference levels, and considering up-to-date knowledge and best practices. For each of the selected topics, NUWARD provided the Regulators Group with a document in advance of the technical meeting(s) where the topic was presented and explored. After each session the Regulators Group produced a joint synthesis report to summarize their findings and views. These joint synthesis reports reflect the views of the Regulators Group on the proposed NUWARD SMR design in terms of technical and legal regulatory expectations and highlight the main areas of convergence and the differences between the approaches and requirements of each country.

In phase 2 NUWARD shared its analysis on possible methods to include the feedback from the regulators group into a standardized SMR design. The scope was limited to JER phase 1 main subtopics for which different expectations were identified and which are of main importance for the ongoing design.

In July 2024, as the JER phase 2 reached its halfway point, NUWARD made the decision to shift its product development strategy towards the design of an SMR based on proven technology only. The impact of this decision on the ongoing JER phase 2 was discussed with the regulators group. It was confirmed that, despite this product strategy shift, the JER initiative remained very useful to all participants, and that the foreseen program of work could continue without major changes.

The JER Regulators Group summary report, issued publicly, is a shared consolidation of their overall experience and feedback form this JER phase 2 [3].

## 3. SUMMARY OF NUWARD VIEWS, LEARNINGS AND OUTCOMES

Similarly to the phase 1, the JER phase 2 continued to provide a unique environment for useful and encouraging exchanges, outside of and prior to any formal licensing process, in which the use of a real SMR case study added a substantial vehicle to enable views to be expressed and explored.

This facilitated exchanges on practical applications and interpretations of high-level safety objectives and legal requirements. It also revealed areas of differences in the interpretation or further development into national regulation of IAEA and WENRA international nuclear safety related requirements. These exchanges continued to be key for the learning curve of the NUWARD SMR project, to improve the ability of the design engineers to anticipate the challenges of licensing the same SMR in different European countries and to design a SMR responding to the SMR market needs.

The JER continued to be an opportunity for regulators to raise questions on the design and safety approach and receive answers from the NUWARD team at an early design stage. It also allowed for the NUWARD team to obtain clarifications from the Regulators Group regarding their expectations, fostering discussions that ensured a shared understanding at the source. Also during the JER phase 2, the range, depth of discussion, and insights achieved in a relatively short time has been an amazing success in a challenging international context, mixing different contexts of regulation, nuclear history, and culture. The NUWARD team has noted the regulators great involvement in the plenary meetings and in-between in their own group meetings in a period where the flourishment of nuclear projects is already challenging their own resources.

Based on the experience of both JER phases 1 and 2, key NUWARD learnings on the overall JER initiative and working methodology include the following:

- Confirmation of added value of using a real SMR case study:

  International standards such as IAEA and WENRA provide high-level safety objectives and requirements. When it comes to practical applications and interpretations of these high-level safety objectives and requirements, typically for a country-specific context, exchanges are facilitated when the vendor can provide substantial information from ongoing design activities as a basis for the discussions with the regulators.

- Timing:

  The JER exercise came at the right timing for the NUWARD project. The JER is carried out at a sufficiently advanced stage of the NUWARD SMR design process, ensuring that options are already defined or under discussion on some key aspects, but still early enough to allow the insights to guide the ongoing and next design phases. Engaging early in the design process is an opportunity but also implies that further exchanges may be needed at a later stage and that different statements may then be expressed as the design evolves. This is however in line with the objective of a pre-licensing process, and proper to an iterative design process. The minor impact of the NUWARD product strategy shift on the ongoing JER confirms this finding.

- Duration:

  The pilot phase of the JER was conducted over a period of one year. The second phase of the JER was also intended to last one year. However, given the increased number of involved parties and the busy agenda of each party, this time schedule has shown to be challenging, and phase 2 was extended a bit compared to the initial expectation. However, the constant and professional involvement of all parties made it possible to finalize most of the technical discussions on schedule. The overall finding remained that, as the JER initiative is not intended to issue regulatory binding decisions, this enables to shorten the schedule and provide early and prompt feedback to the vendor compared to official licensing processes in each country. The short duration of the review phase limited to around a year favors continuity in the participating vendor and regulator teams and is compatible with the timeline of an iterative design process. The increased number of participating regulators also impacted the preparation phase of the JER phase 2. Additional discussions were required to establish essential preconditions, such as non-disclosure agreements.

- Choice of topics:

  The topics and underlying selection criteria appeared to be well chosen. The first topics discussed at the beginning of the JER phase 1 allowed for a better understanding of the level of safety that could be expected, and on the approach to meet this level. This served as a necessary basis for addressing more specific topics. Not all topics were design-specific or even SMR-specific but were selected based on the important impact they could have on the potential for design standardisation, the safety demonstration and the timeline of the licensing process. Design standardisation and efficient licensing are key conditions for SMR success.

- Documentation:

  The NUWARD SMR information provided to the regulators in support of the considered topics was largely based on the safety options file prepared in the frame of the French pre-licensing process. For efficient pre-licensing processes in different countries, it is beneficial to use a common basis. This could be further enhanced by systematically including reference to relevant IAEA and WENRA standards. The regulators joint synthesis reports, together with clarifications through Q&A, provide a clear and structured overview of common approaches and differences between countries, highlighting the underlying rationale when available. Even though these reports do not commit the parties to any positions taken for future official licensing exchanges, they do provide clear and focused valuable feedback that NUWARD can feed back into its iterative design process. The modified structure adopted for JER phase 2 regulators joint synthesis reports, facilitated further their use. Topics were further subdivided in subtopics for which a synthesis and conclusion is given in the main document, with more detailed national contributions attached in appendixes.

- Involvement of experts:

  On one hand, for the sake of efficiency, continuity, and direction of discussions, it is important to involve a limited number of people, including a coordinator from each participating regulator and from the vendor, who attend all meetings and their preparation.
  On the other hand, for each topic of discussion, the involvement of experts on either side is essential to share clear and relevant information, grasp the subtleties of the intents and implications, and produce valuable insights through the discussions. Another benefit of the involvement of several experts from the vendor side is to broaden the view of the NUWARD design team. The JER initiative has challenged NUWARD team's ways of thinking and working, and it has fostered a mindset encouraging agility in the design and anticipation of the possible different approaches in other regulatory contexts.

- Speaking the same language:

  Among the JER’s challenges, participants come from multiple European countries with different national languages. The use of English language was a natural choice for JER documentation, communications, and during meetings. Nevertheless, early in the discussions for any of the topics it was necessary to make sure that everyone had the same understanding of specific terms and to

agree on standard notions and definitions. This finding from the JER phase 1 was confirmed and enhanced, given that more countries joined for the JER phase 2. All participants were eager to require further explanation and exact meaning throughout the process. The IAEA safety glossary was generally acknowledged as a shared basis. It was confirmed that identical English terms could have different meanings recognising that they are issued from a specific national framework forming a consistent and relevant whole set of documents, generally developed in another language.

Based on the experience of both JER phases 1 and 2, key NUWARD learnings on safety requirements differences include the following:

- Legal status of requirements:

  There are differences between countries on how safety requirements are distributed across the different levels of the regulatory framework, determining the binding character of requirements. For example, some requirements may be set out in decrees in one country, and thus are binding requirements, but may be part of non-binding guides in other countries. This has a significant impact on the possibility to deviate from such country-specific requirements and on the expected justification.

- Plant states and dose boundaries (DiD matrix):

  A matrix display of the plant states, as well as their respective frequency of occurrence and radiological consequences limitation objectives is often used as a basis for design principles (so-called “Defence-in-Depth matrix” or “DiD matrix”). It was observed that in general, the frequencies and dose boundaries associated with the different categories of plant states are not all the same in the different regulatory frameworks. It was also observed that the terminology used for the plant states can differ from one country to another. For example, the definition of DEC (design extension conditions) without significant fuel degradation in one country contains a further division into three subgroups with national specificities compared to other countries. It was also observed that the approaches for the identification and categorisation of events in either design basis or design extension conditions can differ (based on either deterministic or probabilistic grounds, or a mix of both). Given that the implementation in the design of such a matrix involves other requirements, such as safety classification of structures, systems and components, or the study rules to be applied, a little difference may have significant implications on the plant design. Examples of

potential impact include the number of redundancies to be implemented, a different level of requirements associated to a different level of safety classification or even a different implementation of a piece of equipment in the buildings to accommodate a separation for independence.

- Study rules for the safety demonstration:

  Key examples of study rules that can differ between countries include the application of the single failure criterion and the need to consider or the way to apply a loss of off-site power as an additional independent failure. The modalities for application of a study rule can differ between countries, for example the time at which the single failure must be considered, or the need to consider or not the failure of a passive component. It should be noted that, even if the way to apply a study rule would be similar for several countries, the set of study rules to be applied to an event is generally dependent on the plant state category in which this particular event has been categorised. Applying a different category means then applying a different set of study rules. This can have a significant impact on the design, for example in the number of redundancies that need to be implemented.

- Safety classification:

  The safety classification approach was not initially part of the program of work. However, it was agreed to have some preliminary exchanges on the safety classification approach. Even if overall the high-level safety classification principles are similar between countries, it was confirmed that, at a lower more detailed level and for the associated requirements, regulators' practices and regulatory requirements regarding safety classification present major differences that impact the design. Examples include the numbering of safety classes which can be different between countries, the consideration of a time bound factor in the safety classification, and the categorisation of functions providing a backup for safety category 1 functions and that are required to control design extension conditions.

The discussions on JER phase 1 and 2 topics also led to the identification of topics of interest that would be good candidates for a potential next phase of the JER initiative. They include new topics as well as topics that were briefly addressed but would deserve more in-depth discussions.

## 4. CONCLUSION AND NEXT STEPS

Within NUWARD SMR Joint Early Review phase 2, the use of a real SMR case study continued to enable views to be expressed and explored by the regulators. This continued to facilitate exchanges on practical applications and interpretations of high-level safety objectives and revealed some areas of difference in such interpretations. The Joint Early Review is a unique "bottom-up" collective consideration of a real SMR design prior to any (pre)-licensing process in various countries, which supports the nuclear community with a tangible SMR concept experience.

It should be acknowledged that the very fruitful insights offered by the JER initiative are the product of a significant collective investment of time and resources of all those involved. NUWARD and EDF are grateful to all participants for their significant contribution to the continuation of this successful initiative.

On the designer side, in relation to the main objectives of the JER initiative, the following conclusions can be drawn regarding the JER phase 2:

- Exchanges on the NUWARD SMR design and its safety approach were successfully continued addressing new topics and including new regulators in the initiative. Expanding the regulators' group from three to six members required additional time and workload; however, this planning challenge was successfully addressed thanks to the regulators' strong engagement and a slightly adjusted timeline. The exchanges confirmed the phase 1 finding that, although being members of WENRA, and thus having the objective to develop a common approach for safety of nuclear reactors, participating countries have different regulatory frameworks in general.
- The limited impact of NUWARD's strategy shift at the midpoint of JER phase 2 demonstrated that only a few of the ten main topics addressed during JER phases 1 and 2 are design-specific – or even SMR-specific. This confirms that challenges to developing a standardized design also arise from topics that are not unique to SMRs.
- There has been a successful continuation of the identification of key enablers and conditions to meet licensing expectations in participating countries. The purpose of the NUWARD team remains to develop a standardised design, suitable and licensable in multiple contexts. One way of considering JER findings in the design could be through a standard design meeting all the expectations of different countries. However, as already raised through phase 1 of the JER, NUWARD remains convinced that it would not be desirable, or even possible in some cases, to consider the inclusion of all the country-specific requirements in the standard design. The way of

considering JER findings could therefore follow two routes. Where possible, relevant and accommodable requirements would be considered, whereas for others, deviations to country-specific requirements would be justified. The justification should reference and explain the underlying rationale and take a step back to get the whole plant picture demonstrating that despite the deviation, an appropriate level of safety is achieved.

- All participants successfully continued to increase their respective knowledge of each other's regulatory practices. Opportunities for collaboration as well as increased mutual understanding and appreciation of different country contexts have been achieved by the JER. It was recognised that sharing between regulators could motivate regulatory changes and increase harmonisation on a voluntary basis. In that way, the JER contributes to create enabling conditions for increased harmonisation. This in turn makes it easier for leveraging other regulators' reviews, which will be key for efficient Nth-of-a-kind licensing of a standardised design in different countries.

The next key steps identified for the NUWARD team, capitalising on the feedback from the JER, include:

- Further considering the outputs of the JER to inform the NUWARD SMR design choices and safety approach, to include where relevant and appropriate most of the expectations from key European countries in the ongoing design process.
- Further explaining the design choices, and underlying safety rationale, so that they can be communicated in a straightforward and accessible manner, beyond a single national context.
- Further sharing the insights and experience feedback with the international nuclear community, in view of moving towards a more harmonised set of expectations in the future, identified as a success factor for the emergence of the SMR market. This includes NUWARD's active participation to the European Industrial Alliance on SMRs.

The NUWARD team remains committed to continuing the JER initiative, fostering mutual learning and strengthening collaboration with the Regulators' Group from key European countries to support the future development of the NUWARD SMR.

Through a better understanding of the variety of European regulation expectations and sharing the designer's set of constraints, NUWARD wishes to provide the market with a standardised SMR solution achieving a very high safety level while maintaining design simplicity and cost-efficiency.

## 5. REFERENCES

[1] ASN, STUK, SUJB (with the technical support of IRSN and SURO): NUWARD SMR Joint Early Review Pilot Phase Closure Report (September, 2023)

[2] NUWARD Report: NUWARD SMR Joint Early Review Summary Report (September, 2023)

[3] NUWARD JOINT EARLY REVIEW – CLOSURE REPORT PHASE 2 – Main lessons learned from the phase 2 of the NUWARD JER – Regulators' perspectives