A Study on EUR Technical Requirements to Enhance Export Competitiveness of SMR

Soyoung Kim [a*], Seungyeob Ryu [a], Yunbum Park [a]
[a]*Korea Atomic Energy Research Institute, 111, Daedeok-Daero 989 beon-gil, Yuseong-Gu, Daejeon,, S. Korea*
[*]*Corresponding author: sykim21@kaeri.re.kr*

1. Introduction

The European Utility Requirements (EUR) framework serves as a common technical reference for new nuclear power plant deployment across Europe. With increasing policy emphasis on carbon neutrality and energy security, Small Modular Reactors (SMRs) are gaining strategic importance as flexible and scalable nuclear energy solutions.

EUR Revision E (2016) reinforced post-Fukushima safety provisions, strengthening defence-in-depth, Design Extension Conditions (DEC), and severe accident mitigation requirements. Subsequently, Revision E2 (2021) introduced 26 Key Positions for Small and Medium Light Water Reactors (SMLWRs), marking a structural expansion of the EUR framework toward SMR inclusion.

However, these Key Positions remain primarily at a high-level policy layer within Volume 1 and are not yet fully embedded within the detailed technical requirements of Volume 2. As EUR is preparing the next revision (Rev.F), it is expected that SMR-specific principles will be structurally integrated into the technical requirement framework.

This study analyzes the revision from Rev.E to Rev.E2 and anticipates the integration mechanism likely to be adopted in Rev.F. Through systematic mapping of the 26 Key Positions to Volume 2 chapters, the study derives potential integration pathways and proposes proactive design response strategies to enhance SMR export competitiveness.

2. Current Revision Status of EUR

2.1 Revision Progress from Rev.E to Rev.E2

The European Utility Requirements (EUR) framework serves as a common technical reference developed by European utilities for new nuclear power plant deployment. Historically, it has been structured primarily around large Generation III light water reactors (LWRs).

Revision E (2016) represented a major consolidation of post-Fukushima safety reinforcement measures. Key revisions included:

- Strengthening of Defence-in-Depth (DiD) provisions
- Clarification of Design Extension Conditions (DEC)
- Enhanced severe accident mitigation requirements
- Prevention of Large Early Release (LER) scenarios
- Reinforcement of resilience against external hazards and prolonged station blackout

At this stage, the EUR framework achieved technical maturity for large LWR assessment.

Revision E2 (2021) introduced a structural expansion to accommodate Small and Medium Light Water Reactors (SMLWRs). Instead of directly modifying Volume 2 technical requirements, EUR incorporated 26 SMR Key Positions within Volume 1.

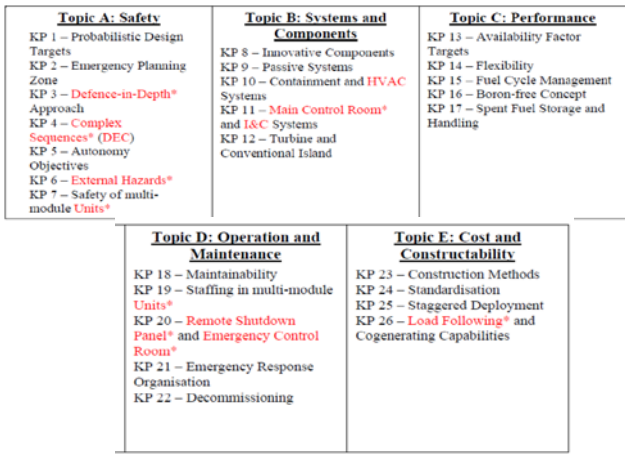

Fig 1. EUR Key Positions on SMLWR

These Key Positions provide high-level principles addressing:

- Passive safety characteristics
- Integral reactor configurations
- Multi-module site deployment
- Potential reduction of emergency planning considerations

However, these principles were not formally embedded within the detailed “shall”-based technical requirements of Volume 2.

As a result, Rev.E2 created a dual-layer structure:

- Volume 1: Policy-level SMR principles
- Volume 2: Technical requirements largely centered on large LWR designs

This indicates that while SMRs were strategically acknowledged, they were not yet fully institutionalized within the technical requirement framework.

2.2 Mapping Characteristics of the SMR Key Positions

A systematic mapping analysis was conducted between the 26 SMR Key Positions and the chapters of Volume 2.

Table 1. Structural Mapping Between Key Positions and Volume 2 Chapters

Volume 2 Chapter	Related KPs	Related KPs (Functional Group)	Likelihood of Rev.F Integration	Design Impact
Ch.1 Safety	KP 1–3, 5–10	Safety objectives, DiD, EPZ, Severe Accident response	Very High	Very High
Ch.3 Layout	KP 4, 12, 23	Multi-module configuration, shared system separation	Very High	Very High
Ch.5 RCS	KP 6–8	Integral reactor, passive heat removal	Very High	Very High
Ch.6 Containment	KP 9–10	Containment performance retention, release mitigation	Very High	Very High
Ch.7 I&C	KP 15, 18	Multi-unit integrated control, diversity	Very High	Very High
Ch.15 Constructability	KP 19–21	Factory fabrication, module transportation	Very High	Very High
Ch.17 PSA	KP 1–4, 9, 24	Multi-unit PSA, site-level risk	Very High	Very High
Ch.20 Environmental	KP 2, 24, 25	Off-site impact, EPZ justification	High	High

The results indicate that the Key Positions do not correspond to a single technical chapter on a one-to-one basis.

Instead, they are distributed across multiple technical domains, including:

- Safety and Design Basis (Ch.1, Ch.4)
- Reactor Systems and Containment (Ch.5, Ch.6)
- Plant Layout and Multi-Module Configuration (Ch.3)
- Digital Instrumentation and Control (Ch.7)
- Probabilistic Safety Assessment (Ch.17)
- Constructability and Commissioning (Ch.13, Ch.15)
- Environmental Impact (Ch.20)

This distributed mapping characteristic demonstrates that SMR-related requirements are inherently cross-cutting and interact with multiple technical domains.

Therefore, SMR integration cannot be effectively achieved through the creation of a standalone chapter. Instead, it requires structural integration throughout the existing technical framework.

2.3 Outlook for Rev.F Integration

Based on the observed revision progression from Rev.E to Rev.E2, it is reasonable to anticipate that Revision F will move beyond policy-level acknowledgment and formally integrate SMR-specific principles into Volume 2 technical requirements.

Rather than establishing a separate SMR-exclusive chapter, Rev.F is expected to adopt a distributed integration approach, characterized by:

- Quantitative refinement of safety performance criteria
- Formalization of multi-module risk interaction requirementsClarification of site-level PSA aggregation methodologies
- Reinforcement of digital system independence and cybersecurity provisions
- Codification of factory fabrication and lifecycle management considerations

Such structural integration would signify the transition of SMRs from an “accommodated technology” to a formally institutionalized design category within the EUR framework.

3. Technical Impact Analysis and Design Response Strategy

The anticipated integration of SMR requirements in Rev.F is expected to embed high-level Key Positions into Volume 2 technical criteria.

First, safety and design basis requirements may be quantitatively reinforced, particularly in relation to DEC, containment performance, and probabilistic safety expectations.

Second, multi-module deployment will require formal consideration of site-level risk and shared system independence.

Third, digital I&C systems must demonstrate enhanced independence and cybersecurity robustness.

Finally, constructability and factory fabrication quality assurance may become formal assessment elements.

Proactive development of site-level PSA models, DEC-based analysis, digital independence validation, and factory QA documentation will therefore be essential to ensure alignment with the anticipated Rev.F framework.

4. Conclusion

Revision F is expected to structurally integrate SMR-specific principles into the core technical framework of EUR Volume 2. This shift represents a transition from policy-level accommodation to institutionalized technical embedding. Proactive preparation in safety quantification, site-level PSA, and multi-module independence will be essential to enhance SMR export readiness under the anticipated Rev.F framework.

Acknowledgement

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