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Review of APR1000 and SMART100 Standard Design Approval Experience and Its Implications for i-SMR

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1. Introduction

The Standard Design Approval (SDA) process plays a crucial role in the licensing of new reactor designs, ensuring regulatory compliance before construction and operation.

- APR1000 is a 1000MW-class pressurized water reactor (PWR) that has passed KINS's initial document review and is currently undergoing the main regulatory review.
- SMART100, a 110MWe integral PWR developed by KAERI, obtained its SDA in 2012, submitted a revised SDA application in 2019, and completed final deliberation in 2024 [1].

Additionally, i-SMR, an innovative small modular reactor, incorporates passive safety systems utilizing natural circulation cooling, enhancing its ability to handle station blackout (SBO) and design-basis accidents (DBA). i-SMR aims to obtain SDA by 2028, leveraging lessons from APR1000 and SMART100 while refining its regulatory strategy to meet evolving SMR-specific requirements [2].

This study reviews APR1000 and SMART100's SDA experiences and explores their potential application to i-SMR licensing [1,3].

2. Review of APR1000 and SMART100 SDA Experience

2.1 Comparison of APR1000, SMART100, and i-SMR

Although all three reactors follow PWR principles, their safety approaches and regulatory challenges differ significantly. Table 1 summarizes these differences [1,4].

2.2 SDA Documentation in APR1000 and SMART100

Both APR1000 and SMART100 underwent SDA, but their focus areas differed. Key documents included:

- Standard Safety Analysis Report (SSAR) – Safety assessment covering design, operational limits, and accident scenarios [3].
- Preliminary Accident Management Program (PAMP) – Severe accident mitigation strategies and emergency response plans [1,3].
- Standard Design Specification (SDS) – Core technical specifications for design integrity [1,3].

SMART100's SDA process emphasized passive safety validation, particularly in loss-of-coolant accidents (LOCA) and containment response [1].

Table 1. Comparison of APR1000, SMART100, and i-SMR

Feature	APR1000	SMART100	i-SMR
Reactor Type	Gen III+ PWR	Integral PWR	Integral PWR
Electrical Output	1000MW	110MW	170MW
Safety System	Active safety with backup systems	Passive safety (up to 72 hours)	Passive safety (natural circulation cooling)
Containment Design	Large reinforced concrete containment	Compact integrated containment	High-integrity Integrated Containment Vessel (ICV)
Licensing Basis	EUR, NRC standards for large PWRs	KINS SDA, International PPE study	Emerging SMR-specific regulatory frameworks
Passive Safety Validation	Deterministic safety analysis (DSA)	LOCA & containment integrity tests	Best-estimate and uncertainty analysis (BEAU), incorporating probabilistic safety assessment (PSA) and advanced simulation techniques for passive system validation

3. Application of APR1000 and SMART100 SDA Experience to i-SMR

3.1 Establishing a Structured Licensing Framework

Applying SDA strategies from APR1000 and SMART100 to i-SMR could improve the efficiency of the licensing process. The following steps are recommended:

- Developing a Preliminary Safety Analysis tailored to i-SMR's passive safety features.
- Engaging early with KINS to reduce licensing uncertainties while exploring compatibility with evolving international regulatory frameworks, such as those from CNSC and NRC.

- Ensuring alignment with global safety standards (EUR, IAEA, US NRC).

By adopting a structured licensing roadmap, i-SMR can enhance its regulatory acceptance and minimize potential delays.

3.2 Challenges in Applying SDA to i-SMR and Proposed Solutions

While applying the SDA framework from APR1000 and SMART100 to i-SMR offers significant advantages, several key challenges must be addressed. These challenges stem from differences in reactor design, regulatory expectations, and the evolving nature of SMR-specific licensing frameworks. Table 2 summarizes the primary obstacles and corresponding mitigation strategies.

Table 2. Key Challenges and Mitigation Strategies for i-SMR Licensing

Challenge	Description	Proposed Solution
Regulatory Uncertainty	Evolving SMR regulatory frameworks present licensing challenges.	Early engagement and pre-licensing review
Passive Safety Validation	Limited operational data for SMRs	Use best-estimate and uncertainty analysis (BEAU)
Containment Performance	SMART100 required extensive experimental testing and computational validation of passive safety functions, including LOCA response and long-term cooling performance	Conduct integral system tests and LOCA containment response validation
International Certification	SDA needs to align with international licensing pathways	Develop a harmonized approach for simultaneous approval

These approaches will enhance i-SMR's licensing competitiveness in the global market.

4 . Conclusions

The APR1000, SMART100, and i-SMR SDA processes provide key insights into improving i-SMR's licensing approach. By incorporating:
- Comprehensive documentation strategies.
- Early regulatory engagement.
- Global standard alignment.
- Passive safety validation through advanced analysis methods.

i-SMR can enhance its regulatory preparedness and global market competitiveness. Further research should focus on refining SDA methodologies for modular reactors, emphasizing integrated safety assessment, experimental validation of passive safety systems, and harmonization with international licensing practices.

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