Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22-23, 2025

Consideration on Project Management for Performing Design Phase PSA

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***Keywords :** Design Phase PSA, Risk Management, Change Management, Critical Path

1. Introduction

The innovative Small Modular Reactor (i-SMR) project aims to improve both safety and cost-effectiveness by making reactors smaller, modular, and using passive safety systems. Unlike large traditional nuclear plants, this next-generation reactor is being developed with contributions from various organizations, including Korea Hydro & Nuclear Power (KHNP), Korea Electric Power Corporation Engineering and Construction (KEPCO E&C), Korea Atomic Energy Research Institute (KAERI), KEPCO Nuclear Fuel (KNF), Future and Challenge Technology (FNC) and so on. The design phase Probabilistic Safety Assessment (PSA) is progressing alongside the reactor development, with major efforts focused on applying for Standard Design Approval (SDA) in January 2026. This paper discusses key factors in managing the project effectively to ensure the successful execution of design phase PSA.

2. Methods and Results

PSA is conducted and updated continuously throughout the design, construction, and operation of a nuclear power plant. During the design phase, uncertainties are high, and frequent design changes occur. Therefore, a Preliminary PSA is used to estimate risks and guide design improvements. In the construction phase, final design decisions are made, and the PSA model is adjusted to match actual site conditions. During operation, system maintenance, procedure updates, and equipment changes require ongoing updates to the PSA model, creating a Living PSA that reflects real conditions.

2.1 Characteristics of Design Phase PSA

Performing PSA during the design phase presents unique challenges due to incomplete information and frequent modifications. These challenges can be categorized in Table I.

In addition to these challenges, design phase PSA must balance the trade-off between providing timely risk insights and maintaining analytical accuracy. Since PSA serves as a tool for evaluating design alternatives, frequent iterations are required to reflect changes. This means that the PSA team must work closely with designers to ensure that updates are managed systematically.

Moreover, proper documentation of assumptions and design modifications is crucial. Without a clear tracking system, misalignment between PSA results and actual design status can occur, leading to inefficiencies. Establishing a formalized review process, where PSA findings are periodically validated against evolving design data, is essential to maintaining consistency.

By implementing structured change management, communication protocols, and clear documentation practices, design phase PSA can effectively support

Table I: Challenges on Design Phase PSA

Challenges	Descriptions
(1) Uncertain Design Information	- System specifications, structural design, and control logic are not fully defined in the early stages. - PSA is based on assumptions, but if actual designs differ, reanalysis is necessary.
(2) Frequent Design Changes and Rework	- As PSA and design progress together, changes in one area often require modifications in the other. - More frequent changes increase the workload and require additional resources.
(3) Data Exchange Timing Issues	- Different teams complete their tasks at different times and with varying priorities. - If PSA lacks essential information, the overall schedule may be delayed.
(4) Interface Management and Communication Challenges	- If teams do not communicate regularly, PSA input data may be outdated or missing. - Shared platforms, regular meetings, and structured change management help prevent this.
(5) Conflicts in Scope and Prioritization	- Design teams focus on meeting regulatory requirements, while PSA teams evaluate risks. - Limited resources make it difficult to decide which systems or scenarios should be analyzed first.
(6) Complex Change Management and Tracking	- PSA models involve many factors, such as failure rates and human error probabilities. - If design changes are not properly tracked, PSA results may be unreliable.

decision-making while minimizing unnecessary rework. Addressing these issues early helps ensure that PSA results remain relevant and aligned with the overall design process.

2.2 Data Exchange for Design Phase PSA

Design phase PSA (SRP Ch.19) evaluates plant safety using data from other design sections (SRP Ch.1-18). The key data exchanges are illustrated in Fig. 1.

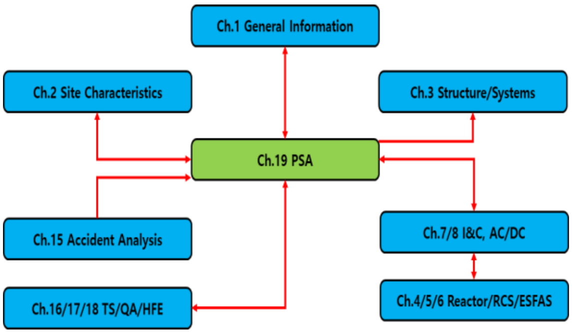

Fig. 1. Relationship between PSA and other parts

Ch. 1 provides project details to set PSA goals, Ch. 2 includes site conditions (e.g., seismic hazards) for external event PSA, Ch. 3 offers structural and system designs for reliability analysis, Ch. 4-6 provide reactor, primary system, and safety system details for PSA modeling, Ch. 7-8 include control and electrical system designs for PSA logic models, Ch. 15 provides accident analysis results for scenario development. Ch. 16-18 contribute to PSA by detailing operation procedures and human-machine interfaces. Since PSA and design progress together, design data often becomes available in later stages. To ensure smooth progress, teams must define when specific data will be ready and document agreements clearly. PSA milestones should align with key design changes to ensure necessary input data is available on time.

2.3 Strategies for Meeting PSA Schedule

To stay on schedule, it is essential to maintain active communication with design teams. Assigning dedicated PSA engineers to each design team helps track data exchange progress and resolve issues quickly. If delays occur, PSA teams should have predefined responses and assess the impact on deadlines.

Since PSA is continuously updated throughout the design phase, simplified models can be used in early stages to compare design options. As design details become clearer, PSA models should be gradually refined. This approach ensures that PSA results are ready on time for regulatory approval.

PSA requires expertise in various areas, such as system reliability and human factors. A well-planned staffing strategy ensures that experts are available when needed. Additional personnel should be considered to handle unexpected analysis demands or design changes.

2.4 Identifying the Project's Critical Path

The Critical Path consists of tasks that directly affect the total project duration. In a project where PSA and design progress simultaneously, identifying key dependencies is crucial. For example: Chapter 15 accident analysis must be completed before PSA can finalize risk assessments. Delays in Chapter 7 control system design may prevent PSA from modeling system reliability on time. By mapping critical design decisions and dependencies, teams can identify high-risk delays that could affect PSA progress.

2.5 Key Factors for Successfully Performing Design Phase PSA

Four key factors are crucial for successful PSA execution:
(1) Structured Communication and Decision-Making
- Design changes, analysis results, and additional requirements must be shared with PSA teams immediately.
- A project-wide scheduling system is needed to coordinate different team priorities.
(2) Effective Change Management and Tracking
- PSA input variables, assumptions, and methodologies should be clearly recorded and updated systematically.
- Poor change management can lead to confusion about which PSA version is being used.
(3) Adequate Contingency and Risk Management
- Frequent design changes require flexible schedules and additional resources.
- Uncertainties should be planned for by securing extra time and manpower.
(4) Early Regulatory Coordination
- PSA reports are key regulatory documents, so early discussions with authorities help streamline approvals.

3. Conclusions

Design phase PSA is a critical part of SMR development, conducted under conditions of uncertainty and frequent changes. This study reviewed its characteristics, data exchange process, scheduling strategies, critical path analysis, and key success factors.

To execute PSA successfully, structured communication, efficient change management, proper resource allocation, and proactive regulatory coordination are essential. Ensuring PSA does not become a bottleneck in the overall project schedule is crucial. These findings provide useful insights for SMR projects and other next-generation reactor designs.

Acknowledgment

This paper was supported by the Innovative Small Modular Reactor Development Agency grant funded by Korea Government (MOTIE) (NO.RS-2023-00258118).

REFERENCES

[1] **U.S. Nuclear Regulatory Commission (NRC).** *Standard Review Plan for Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors (NUREG-0800, Chapter 19).* U.S. NRC, Washington, D.C., 2018.
[2] **U.S. Nuclear Regulatory Commission.** *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition – Section 17.4: Reliability Assurance Program.* NUREG-0800, 2007.
[3] **Electric Power Research Institute.** *Design Reliability Assurance Program Implementation Guidance.* EPRI, 2011.