

PRA Used to Implement LMP for Non-LWR CP Applications Under 10 CFR Part 50

APRIL 18, 2023

Initialisms and Acronyms

ADAMS	Agencywide Documents Access and Management System	DC	design certification	NSRST	non-safety-related special treatment
ANS	American Nuclear Society	DG	draft regulatory guide	NST	no special treatment
AOO	abnormal operating occurrence	DID	defense in depth	OL	operating license
ASME	American Society of Mechanical Engineers	EAB	exclusion area boundary	PDC	principal design criteria
ARCAP	Advanced Reactor Content of Applications	FOAK	first-of-a-kind	POS	plant operating state
ARCOP	Advanced Reactor Construction Oversight Process	FR	<i>Federal Register</i>	PRA	probabilistic risk assessment
BDBE	beyond design-basis event	FSAR	final safety analysis report	PSAR	preliminary safety analysis report
CDC	complementary design criteria	ISG	interim staff guidance	RFDC	required functional design criteria
CFR	<i>Code of Federal Regulations</i>	LBE	licensing basis event	RG	regulatory guide
COL	combined license	LMP	Licensing Modernization Project	RSF	required safety function
CP	construction permit	LPSD	low-power and shutdown	SAR	safety analysis report
DBA	design-basis accident	NEI	Nuclear Energy Institute	SE	supplemental evaluation
DBE	design-basis event	NEIMA	Nuclear Energy Innovation and Modernization Act	SR	safety related
DBEHL	design-basis event hazard level (NEI 18-04)	NLWR or non-LWR	non-light-water reactor	SRM	staff requirements memorandum
DBHL	design-basis hazard level (NEI 21-07)	NPUF	non-power utilization facility	SSC	structure, system, and component
				TEDE	total effective dose equivalent
				TICAP	Technology-Inclusive Content of Applications

Overview

Purpose

Background

Non-LWR CP applications implementing LMP

Discussion of staff views and perspectives

Summary

Next steps

Purpose

To share the staff perspectives on important information related to a PRA used to support implementation of the Licensing Modernization Project methodology for a non-LWR CP applicant under 10 CFR Part 50

Obtain public feedback on staff perspectives

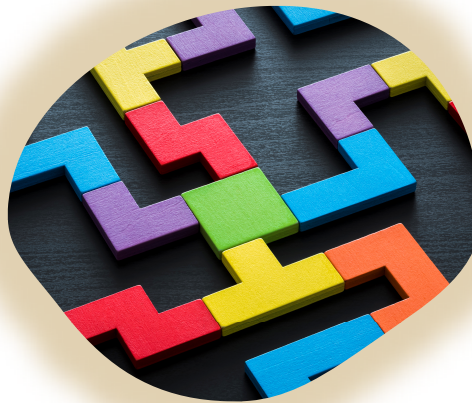
Background: Fitting the Pieces Together

Licensing Modernization Project

- NEI 18-04, Rev. 1
- RG 1.233
- NEI 21-07, Rev. 1 (TICAP)
- DG-1404 (pending)

Consistency with the Underlying Principles of § 50.69 SSC Classification

- NEI 00-04, Rev. 0
- RG 1.201
- Previous approved LARs



NLWR PRA Acceptability

- ASME/ANS-RA-S-1.4–2021
- RG 1.247
- NEI 20-09, NLWR PRA Peer Review

Commission Policies

- Advanced reactor policy statement (2008)
- Safety goal policy statement (1986)
- Severe accident policy statement (1985)
- PRA policy statement (1995)

Relevant Regulations and Guidance Related to Part 50 Construction Permits

- § 50.34(a) – PSAR content
- § 50.35 – Issuance of construction permits
- § 50.40 – Common standards
- § 50.50 – Issuance of licensees and construction permits
- Consistency with DNRL-ISG-2022-01 and coordination with related LWR efforts

Background: Applications and Guidance

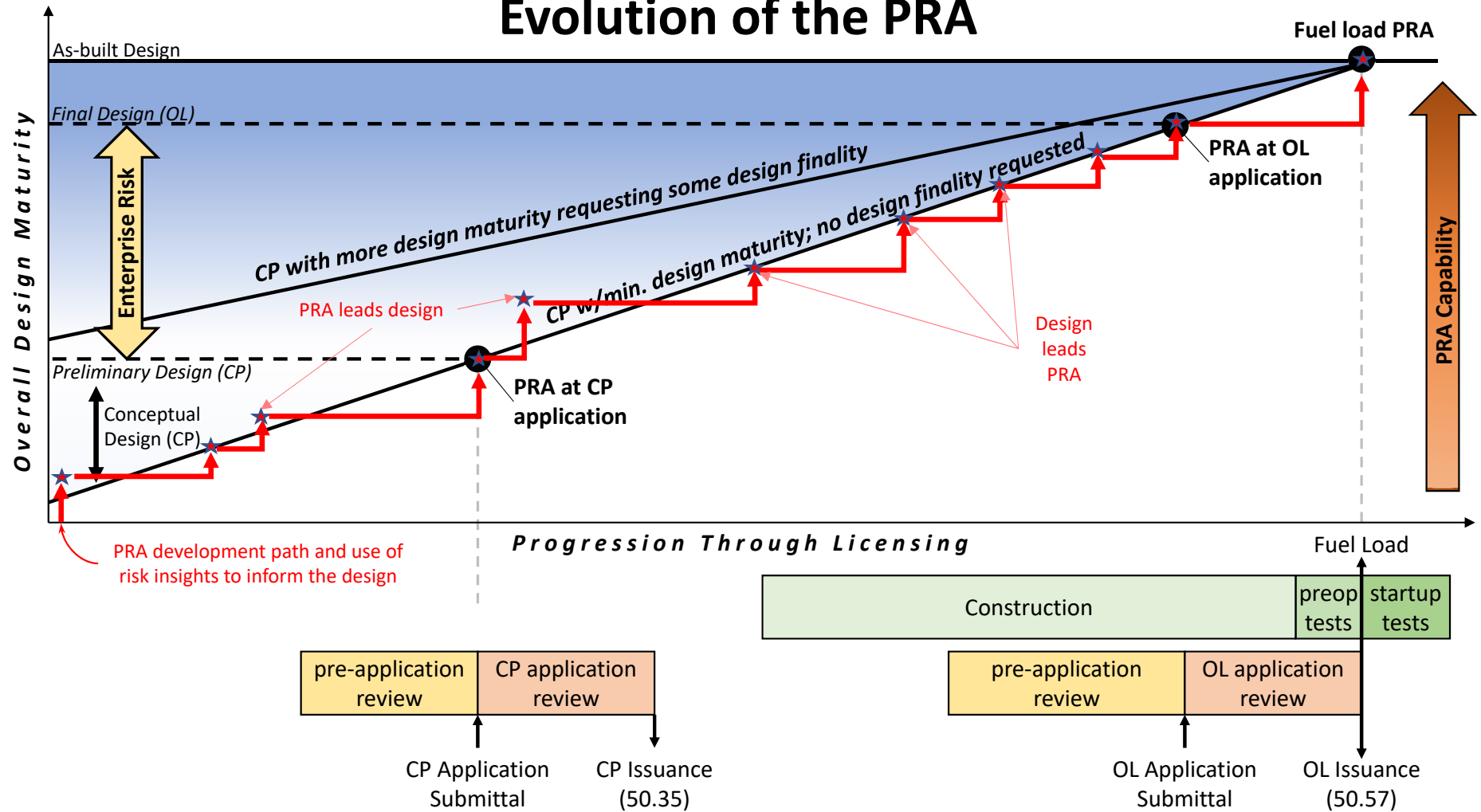
Construction Permit Applications

- Some Non-LWR applicants will be using the two-step licensing process under 10 CFR Part 50.
- The last CP application for a power reactor was in 1978 (Watts Bar).
- NPUF CP applications have been submitted more recently (e.g., SHINE, Kairos Hermes).
- No previous CP applications have been supported by a PRA.

Guidance Development

- **LMP Guidance** - NEI 18-04, Rev. 1, “Modernization of Technical Requirements for Licensing of Advanced Non-Light Water Reactors: Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development,” August 2019.
- **Staff Endorsement of the LMP Guidance** – RG 1.233, Rev. 0, “Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors,” June 2020.
- **TICAP (Technology-Inclusive Content of Application)** – NEI 21-07, Rev. 1, “Technology Inclusive Guidance for Non-Light Water Reactors: Safety Analysis Report Content for Applicants Using the NEI 18-04 Methodology,” February 2022.
- **Staff Endorsement of TICAP** – DG-1404 (proposed new RG 1.253), “Technology Inclusive Content of Application Guidance for Advanced Non-Light Water Reactors,” pending.

Evolution of the PRA



Regulations

Requirement	Comment
§ 50.34(a)(4) – “A preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents.”	PRA and the LMP process may be used to help demonstrate this requirement is met. Associated policy statements: • Advanced reactor policy statement (2008) • Safety goal policy statement (1986) • Severe accident policy statement (1985) • PRA policy statement (1995)

Regulations

Requirement	Comment
§ 50.35(a) – “When an applicant has not supplied initially all of the technical information ..., the Commission may issue a construction permit if the Commission finds that ... (2) such further technical or design information as may be required to complete the safety analysis, and which can reasonably be left for later consideration, will be supplied in the final safety analysis report ... and that (4) on the basis of the foregoing, there is reasonable assurance that, (i) such safety questions will be satisfactorily resolved at or before the latest date stated in the application for completion of construction of the proposed facility, and (ii) taking into consideration the site criteria contained in part 100 of this chapter, the proposed facility can be constructed and operated at the proposed location without undue risk to the health and safety of the public.”	Allows use of the LMP process after the CP is issued to complete the design. May have less-than-full-scope PRA for the CP application.

Regulations

Requirement	Comment
§ 50.40 Common standards. In determining that a construction permit or operating license in this part, or early site permit, combined license, or manufacturing license in part 52 of this chapter will be issued to an applicant, the Commission will be guided by the following considerations: (a) Except for an early site permit or manufacturing license, the processes to be performed, the operating procedures, the facility and equipment, the use of the facility, and other technical specifications, or the proposals, in regard to any of the foregoing collectively provide reasonable assurance that the applicant will comply with the regulations in this chapter, including the regulations in part 20 of this chapter, and that the health and safety of the public will not be endangered.	Includes the LMP process and its underlying PRA.

Regulations

Requirement	Comment
§ 50.50 – “Upon determination that an application for a license meets the standards and requirements of the act and regulations, and that notifications, if any, to other agencies or bodies have been duly made, the Commission will issue a license, or if appropriate a construction permit, in such form and containing such conditions and limitations including technical specifications, as it deems appropriate and necessary.”	Add conditions to the CP to “lock-in:” • PDC and design bases • LBE selection, SSC classification, and DID adequacy evaluation processes • Plan for finalizing the design and PRA

What is a PRA?

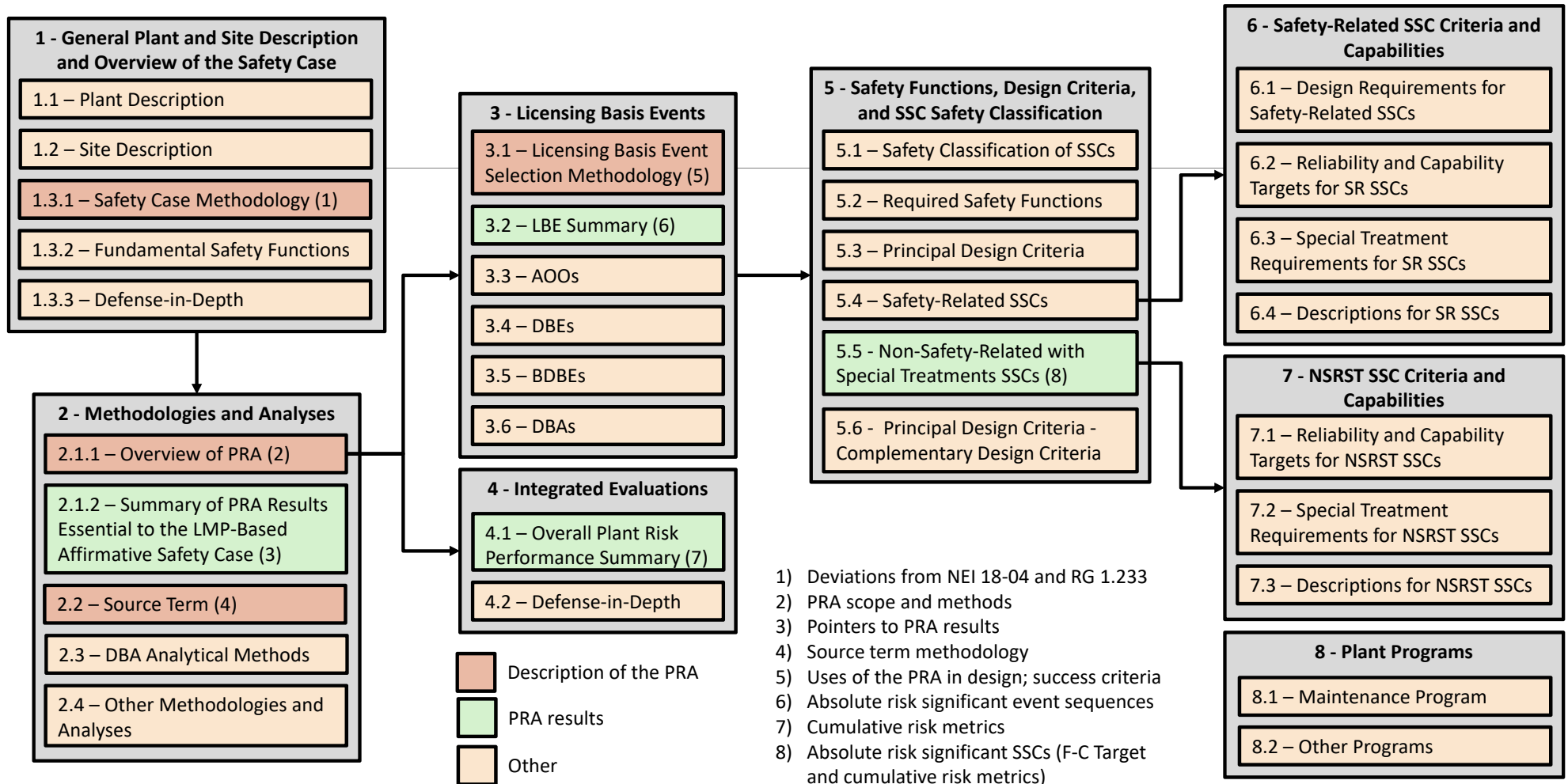
Risk Assessment / Risk Evaluation

- SRM-SECY-98-144 - “A risk assessment is a systematic method for addressing the risk triplet as it relates to the performance of a particular system (which may include a human component) to understand likely outcomes, sensitivities, areas of importance, system interactions and areas of uncertainty. From this assessment the important scenarios can be identified.”
- § 52.47(a)(27) – Provide “A description of the design-specific probabilistic risk assessment (PRA) and its results.”
- SRP Chapter 19.0 (applies to Part 52 DCs and COLs; based on SRM-SECY-93-087):
 - The Commission approved the use of 1.67 times the design-basis SSE for a margin-type assessment of seismic events.
 - The Commission approved the use of simplified probabilistic methods, such as but not limited to the Electric Power Research Institute (EPRI) Fire-Induced Vulnerability Evaluation (FIVE) methodology, to evaluate fire risk.

Probabilistic Risk Assessment

- RG 1.247, Section C.1 - “A risk assessment approach is considered to be a PRA when it (1) provides a quantitative assessment of the identified risk in terms of scenarios that result in undesired consequences (e.g., releases of radioactive material, radiological consequences) and their frequencies and (2) is comprised of specific PRA elements for quantifying risk.”
- Non-LWR PRA Standard: “*Probabilistic risk assessment (PRA)*: a quantitative assessment of the risk associated with plant operation and maintenance that is measured in terms of frequency of occurrence and consequences of *event sequences, event sequence families, or release categories* [also referred to as a probabilistic safety analysis (PSA)].

TICAP: Location of PRA-Related Information in the SAR



NEI 21-07 (TICAP)

Section 2.1.1, “Overview of PRA,” p. 24

At the CP stage, neither the plant design nor the PRA is expected to have the level of maturity that will be necessary to support an OL application.

At the CP application stage, the applicant should describe its ultimate intended approach for qualifying the PRA. If conformance to ASME/ANS RA-S-1.4–2021 is planned, a simple statement to that effect should be sufficient. If the applicant intends to use another PRA methodology, that planned approach for establishing PRA technical adequacy should be described.

In either case, the applicant should address the last **five** items in the Section 2.1.1 list, consistent with the state of the plant design and the PRA at the time of CP application.

- Staff: Change “five” to “six.”

NEI 21-07 (TICAP)

Section 2.1.1, “Overview of PRA,” pp. 22-23

The discussion should include the following items:

A statement that describes how the applicant used the non-LWR PRA Standard ASME/ANS RA-S-1.4-2021 to establish the technical adequacy of the PRA, including the scope of technical requirements that were addressed.

A statement that a peer review was completed following the non-LWR PRA Standard and the guidance in NEI 20-09, Rev. 1, “Performance of PRA Peer Reviews Using the ASME/ANS Advanced Non-LWR PRA Standard”

A summary of the peer review scope and approach relative to the scope of the PRA. Peer review findings and associated actions are to be documented consistent with the non-LWR PRA Standard requirements for PRA configuration control and available in plant records. The findings and associated actions are not required for inclusion in the SAR.

Discussion of how the NRC regulatory guide that endorses the non-LWR PRA standard was implemented (pending finalization of the regulatory guide)

First 4 items;
Only apply to
OL application

NEI 21-07 (TICAP)

Section 2.1.1, “Overview of PRA,” pp. 22-23

Identification of the sources of radionuclides **addressed** and the sources of radionuclides that were screened out

Discussion of how multi-reactor scenarios were **addressed**, if applicable

What does it mean to “address” or “include” in the PRA?

Identification of the internal and external hazards that were **included** and the ones that were screened out

Identification of the plant operating states that were **included** and those that were screened out

Discussion of the software and analytical tools that were used to perform the event sequence modeling and quantification, determine the mechanistic source terms, and perform radiological consequence evaluations, reported in the SAR as stated below:

- All non-DBA LBEs in Chapter 3 that involved a 30-day EAB dose of 2.5 mrem TEDE or greater radiological consequences to the public
- The cumulative dose and risk calculations in Section 4.1

The discussion should include identification of the methods and a high-level description of how they are applied to the radiological consequence evaluation.

Description of the site characteristics modeled or assumed in the radiological consequence evaluations covered by the previous bullet.

**Last 6 items;
Apply to CP
and OL**

NEI 21-07 (TICAP)

Chapter 3, “Licensing Basis Events,” p. 38

For a CP application, Chapter 3 should mirror the COL guidance but will reflect the preliminary nature of the design information. The PSAR should describe the methodology to be used in determining the initial set of LBEs and specifically address the conservative DBA calculation used to demonstrate that the 25 rem TEDE dose limit in 10 CFR 50.34 is met to support the site suitability requirements. The structure of the chapter and sections should follow the structure for the COL guidance. The discussions should be sufficiently robust so the reader can clearly see how the methodology will lead to a final set of LBEs to be used in developing the final design, safety margins, operational program content, and FSAR content. The discussion should clearly describe the role of the PRA in determining the initial set of DBEs. The PRA methodology described in Chapter 2 should be used to determine the preliminary assessments of the Licensing Basis Events, as described in the COL guidance for Sections 3.3 through 3.6 above. (Note that ASME/ANS RA-S-1.4-2021 includes guidance on the performance of PRAs at various design stages.)

The discussions in the various sections of this chapter should provide preliminary assessments of the AOOs, DBEs, and BDBEs, and the basis for those preliminary assessments. Any analyses performed and the methods used in those analyses should be described. The methods and analytical tools (if different from those described in Chapter 2) to be used in deriving the DBAs from the DBEs should be described in Section 3.6.

To the extent tests, experiments, or analytical enhancements are planned to support the FSAR LBE evaluations, those plans should be described in Chapter 2 or Chapter 3 of the PSAR, as applicable.

DNRL-ISG-2022-01, App. A., p. 3: “It is essential that all credible design-basis transients and accidents be considered and evaluated during the CP application stage.”

NEI 18-04, Rev. 1, p. 14: “In many cases, it is expected that the initial selection of SR SSCs and selection of the DBAs will be based on a PRA that includes internal events but has not yet been expanded to address external hazards. With the understanding that SR SSCs are required to be capable of performing their RSFs in response to external events within the DBEHL, there will be no new DBAs introduced by external hazards.”

NEI 21-07 (TICAP)

Chapter 5, “Safety Functions, Design Criteria, and SSC Safety Classification,”
p. 56

For a CP application, Chapter 5 includes preliminary determination of the RSFs and PDC (which include a quality assurance criterion, the RFDC, and the CDC), safety classification of SR and NSRST SSCs, and specific NSRST SSC design requirements. The LMP methodology for assessing safety functions, design criteria, and SSC safety classification, as described in Chapter 5 of the COL guidance, draws on results from the initial PRA. The PRA methodology described in Chapter 2 should be used in the preliminary determination of RSFs, determination of RFDC, CDC, and SSC safety classification.

DNRL-ISG-2022-01, App. A., p. 4: “A CP should identify the safety categorization and design classification of the proposed facility SSCs.”

ASME/ANS RA-S-1.4–2021 (NLWR PRA Standard)

Section 3, “Risk Assessment Application Process”

Provides a five-stage process to establish the capability of a PRA to support a particular risk-informed application.

- Stage A: The plant life cycle stage is characterized as well as the PRA application or applications to be supported in this stage.
- Stage B: The relevant portions of the PRA are examined to determine whether the PRA scope and level of detail and the risk metrics calculated by the PRA are sufficient for the application.
- Stage C: An evaluation is performed to determine whether the capability requirements for the SRs from this Standard for each relevant portion of the PRA are sufficient to support the application.
- Stage D: Each relevant portion of the PRA is compared to the appropriate SRs in this Standard for the Capability Category needed to support the application as determined in Stage A.
- Stage E: The relevant portions of the PRA, supplemented by additional analyses if necessary, are used to support the application. This activity is outside the scope of this Standard.

10 CFR 50.69

Risk-informed categorization and treatment of structures, systems and components for nuclear power reactors

§ 50.69(b)(2) - A licensee voluntarily choosing to implement this section shall submit an application for license amendment under § 50.90 that contains the following information:

- (ii) A description of the measures taken to assure that the quality and level of detail of the systematic processes that evaluate the plant for internal and external events during normal operation, low power, and shutdown (including the plant-specific probabilistic risk assessment (PRA), margins-type approaches, or other systematic evaluation techniques used to evaluate severe accident vulnerabilities) are adequate for the categorization of SSCs.

§ 50.69(c) *SSC Categorization Process*. (1) SSCs must be categorized as RISC-1, RISC-2, RISC-3, or RISC-4 SSCs using a categorization process that determines if an SSC performs one or more safety significant functions and identifies those functions. The process must:

- (i) Consider results and insights from the plant-specific PRA. This PRA must at a minimum model severe accident scenarios resulting from internal initiating events occurring at full power operation. The PRA must be of sufficient quality and level of detail to support the categorization process, and must be subjected to a peer review process assessed against a standard or set of acceptance criteria that is endorsed by the NRC.
- (ii) Determine SSC functional importance using an integrated, systematic process for addressing initiating events (internal and external), SSCs, and plant operating modes, including those not modeled in the plant-specific PRA. The functions to be identified and considered include design bases functions and functions credited for mitigation and prevention of severe accidents. All aspects of the integrated, systematic process used to characterize SSC importance must reasonably reflect the current plant configuration and operating practices, and applicable plant and industry operational experience.

RG 1.247

“TRIAL - Acceptability of Probabilistic Risk Assessment Results for Non-Light Water Reactor Risk-Informed Activities”

FROM SECTION C.1 – An Acceptable PRA:

Scope of a PRA: The scope of a PRA is defined in terms of (1) the metrics used to characterize risk, (2) the POSs for which the risk is to be evaluated, and (3) the causes of initiating events (hazard groups) that can potentially challenge and disrupt the normal operation of the plant and, if not prevented or mitigated, would eventually result in a radioactive release. The scope of a PRA is determined by its intended use for representing the as-built and as-operated plant or the as-designed, as-to-be-built, and as-to-be-operated plant. 5

Level of detail of a PRA: The level of detail of a PRA is defined in terms of the resolution of the modeling used to represent the behavior and operations of the plant. A minimal level of detail is necessary to ensure that the impacts of designed-in dependencies (e.g., support system dependencies, functional dependencies, and dependencies on operator actions) are correctly represented. This minimal level of detail is implicit in the elements comprising the PRA and their associated characteristics and attributes.

Elements of a PRA: The PRA elements are defined in terms of the fundamental technical analyses needed to develop and quantify the PRA model for its intended purpose (e.g., determination of a specific risk metric). The characteristics and attributes of the PRA elements define specific criteria for successfully performing those technical analyses and achieving a defined objective.

Plant representation and PRA configuration control: Plant representation is defined in terms of how closely the PRA represents the plant as it is designed, built, and operated. In general, PRA results used to support applications after a certificate, approval, permit, or license has been issued should be derived from a PRA model that represents the as-designed, as-to-be-built, or as-to-be-operated plant or as-built, as-operated plant. Consequently, the PRA should be maintained and upgraded, where necessary, to ensure it represents the as-built and as-operated plant through an acceptable configuration control process. Regulatory Position C.1.4 provides guidance on plant representation in the PRA.

RG 1.247

“TRIAL - Acceptability of Probabilistic Risk Assessment Results for Non-Light Water Reactor Risk-Informed Activities”

FROM SECTION C.1.1 – Scope of a PRA:

All radiological sources at the plant (e.g., reactor cores, spent fuel, fuel reprocessing facilities for molten salt reactors) should be addressed, including accident scenarios that lead to a radioactive release from multiple radiological sources.

All internal and external hazards should be addressed. For licensing activities, a PRA for the seismic hazard group must always be developed; other hazards should also be included if they cannot be screened out with appropriate justification. Appendix B to this RG lists hazards to consider when developing the PRA.

All POSs (e.g., at-power and low-power and shutdown (LPSD) types of POSs) should be addressed.

The frequencies of event sequences should be developed based on the occurrence of an initiating event, evaluation of plant response, evaluation of releases of radioactive material, and the consequences that result from those releases (i.e., an NLWR PRA should address all levels of PRA analysis, analogous to Level 1, 2, and 3 PRAs for LWRs).

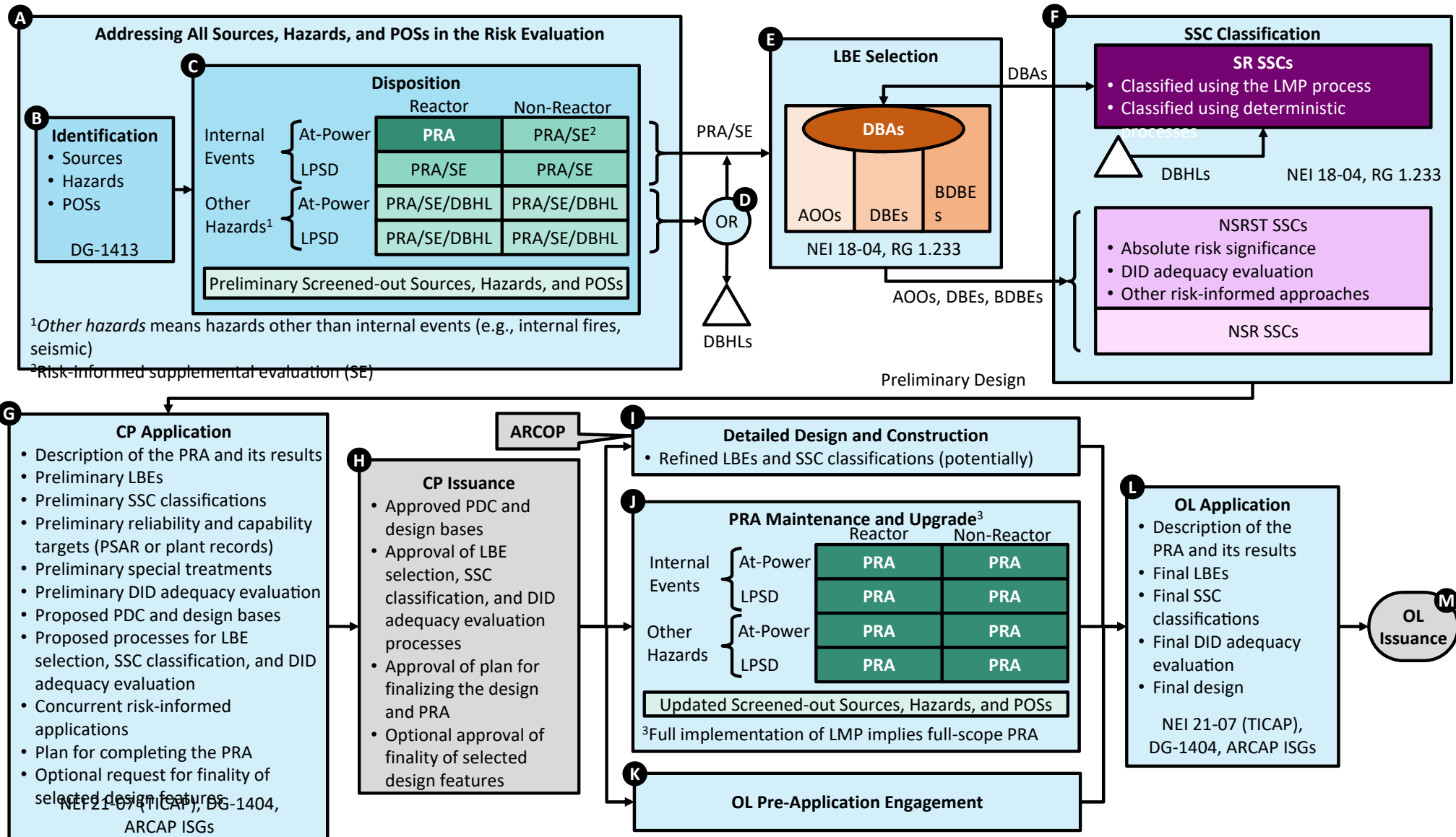
RG 1.247

“TRIAL - Acceptability of Probabilistic Risk Assessment Results for Non-Light Water Reactor Risk-Informed Activities”

FROM SECTION C.3.1 – PRA Scope, Level of Detail, and Degree of Plant Representation (PRA Acceptability for an Application):

The scope of a PRA needed to support an application will depend on the application-specific regulatory requirements, and the acceptability of the scope will be measured in terms of whether the applicant or holder of a license, certification, or permit meets those requirements. Application-specific guidance documents are expected to provide direction on meeting such requirements.

For plants in the preoperational stages of the plant life cycle, the PRA and its results used to support an application are expected to reflect the as-designed, as-to-be-built, or as-to-be-operated plant. For operating plants, the PRA should reflect the as-built and as-operated plant. When used for risk-informed decision-making, the PRA should always reflect the best available information for the plant. For most applications, an applicant or holder of a license, certification, or permit should address all radiological sources, all hazards, all POSs, and all levels of analysis, as discussed in Regulatory Position C.1.1 of this RG. The staff will assess the appropriateness of the justification for any deviations from this scope.



Recent License Amendment to Use 10 CFR 50.69 (ANO-1, 6/23/2022, ML22138A431)

Entergy is approved to implement 10 CFR 50.69 using the processes for categorization of Risk-Informed Safety Class (RISC)-1, RISC-2, RISC-3, and RISC-4 Structures, Systems, and Components (SSCs) using: Probabilistic Risk Assessment (PRA) models to evaluate risk associated with internal events, including internal flooding, and internal fire; the shutdown safety assessment process to assess shutdown risk; the Arkansas Nuclear One, Unit 2 (ANO-2) passive categorization method to assess passive component risk for Class 2 and Class 3 SSCs and their associated supports; the results of the non-PRA evaluations that are based on the IPEEE Screening Assessment for External Hazards updated using the external hazard screening significance process identified in ASME/ANS PRA Standard RA-Sa-2009 for other external hazards except wind-generated missiles and seismic; the tornado safe shutdown equipment list for wind-generated missiles; and the alternative seismic approach as described in the Entergy submittal letter dated May 26, 2021, and all its subsequent associated supplements, as specified in License Amendment No. 277 dated June 23, 2022.

Prior NRC approval, under 10 CFR 50.90, is required for a change to the categorization process specified above (e.g., change from a seismic margins approach to a seismic PRA approach).

The specific evaluation methods (PRA and non-PRA-type) used to support SSC classification are identified as a license condition.

Changes to approved methods require a license amendment.

Summary

All sources, hazards, and POSs should be identified and dispositioned in the CP application:

- Modeled in the PRA, or
- Addressed using risk-informed supplemental evaluations, or
- Dispositioned using design-basis hazard levels (DBHLs) for hazards other than internal events, or
- Screened out.

As a minimum, the CP application should be based on an internal events, reactor at-power PRA model.

The acceptability of the CP PRA must be demonstrated; however, a peer review is not necessary.

The CP application should provide a preliminary, yet complete, set of LBEs.

The CP application should provide a preliminary, yet complete, SSC classifications.

The CP application should provide a plan for maintaining and upgrading the PRA during construction.

- Example: Replacing a seismic DBHL with a seismic PRA
- CP holders are encouraged keep the staff advised of changes to the PRA completion plan that significantly affect the design.

The TICAP guidance implies the PRA will be full-scope (i.e., all sources, all hazards, all POSs) and peer reviewed in support of the OL application.

Next Steps

Staff will consider public feedback from this meeting

- General concepts and approach
- Clarifications and interpretations of the LMP guidance and TICAP
- Editorial comments (with emphasis on the diagrams)

Staff will develop guidance to complement DG-1404 (proposed new RG 1.253, which will endorse TICAP – NEI 21-07, Rev. 1)

Potential workshops