Acceptability of a PRA Supporting a Non-LWR Construction Permit Application Based on the LMP Methodology

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Public Meeting

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Agenda

- Provide NRC staff views and perspectives on PRA acceptability for non-LWR CP applications that are based on the LMP methodology
- Discuss public feedback on the NRC staff views and perspectives
- Discuss the path forward

Development Approach

- The NRC staff is developing a new Appendix B that supplements DG-1404[1]
  - DG-1404 will endorse the TICAP guidance in NEI 21-07[2]
  - DG-1404 was released for public comment on May 25, 2023 (88 FR 33846); comment period extended to August 10, 2023 (88 FR 41862)
- Appendix B would apply the four interrelated principles of PRA acceptability provided in trial RG 1.247, "Acceptability of Probabilistic Risk Assessment Results for Non-Light-Water Reactor Risk-Informed Activities," published in March 2022 (ML21235A008):
  - PRA scope
  - PRA level of detail
  - PRA elements
  - Plant representation and PRA configuration control
- Appendix B would also address:
  - PRA documentation
  - Demonstrating PRA acceptability (self-assessment or peer review)

[1]DG-1404, "Guidance for a Technology-Inclusive Content-of-Application Methodology to Inform the Licensing Basis and Content of Application for Licenses, Certifications, and Approvals for Non-Light Water Reactors" (ML22076A003)
[2]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 (ML22060A190)

RG 1.247 PRA Acceptability Paradigm

Uses of the PRA

- Demonstrate, in part, that certain regulations are met
- Demonstrate that Commission policy expectations are met
- Risk-informed applications (e.g., LMP)

PRA Scope

- Risk metrics
- Radiological sources
- Plant operating states
- Hazard groups

PRA Level of Detail

- Modeling resolution

PRA Elements

- Fundamental technical analyses (e.g., event trees, human reliability analysis)

Plant Representation and PRA Configuration Control

- PRA should represent the as-designed, as-to-be built, as-to-be-operated plant design described in the PSAR

General Considerations

- Beneficial to engage in pre-application activities with NRC staff
  - Reach alignment on approaches to demonstrating the acceptability of a PRA that supports implementation of the LMP methodology before the CP application is submitted
  - Pre-submittal alignment supports the development of a high-quality application, which could facilitate efficient application acceptance and review
- Consider near-term and long-term uses of the PRA as the PRA is developed
  - Demonstrating that certain regulations are met
  - Demonstrating that Commission policy expectations are met
  - Supporting risk-informed applications

Regulatory Requirements

- No regulation requires the development of a PRA to support a CP application under 10 CFR Parts 50 and 51
- CP applicant may use the PRA to demonstrate, in part, that certain regulations, including the following, are met:
  - 10 CFR 50.34(a)(1)(ii) – "It is expected that reactors will reflect through their design, construction and operation an extremely low probability for accidents that could result in the release of significant quantities of radioactive fission products."
  - 10 CFR 50.34(a)(4) - PSAR to include "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…"
  - 10 CFR 50.34(a)(9) – The applicant is technically qualified
  - 10 CFR 51.50(a) requires CP applicants to prepare an environmental report

Examples of Staff Findings Related to PRA

- 10 CFR 50.35(a), Item 2 – 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
- 10 CFR 50.35(a), Item 4 – There is reasonable assurance that:
  - Safety questions will be satisfactorily resolved at or before the latest date stated in the application for completion of construction of the proposed facility
  - 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

Note: In accordance with 10 CFR 50.35(b), a construction permit will not constitute Commission approval of the safety of any design feature or specification unless the applicant specifically requests such approval and such approval is incorporated in the permit.

Advanced Reactor Policy Statement (73 FR 60612; October 14, 2008)

- Expectation that advanced reactor designs will comply with the Commission’s safety goal policy statement (51 FR 28044; August 4, 1986, as corrected and republished at 51 FR 30028; August 21, 1986)
- Severe accident policy statement (50 FR 32138; August 8, 1985) indicates that new plant designs can be shown to be acceptable for severe accident concerns, in part, by completion of a PRA and consideration of the severe accident vulnerabilities the PRA exposes along with the insights that it may add to the assurance of no undue risk to public health and safety.
- The use of PRA as a design tool is implied by the Commission’s PRA policy statement (60 FR 42622; August 16, 1995)

Note: The LMP methodology may be used to inherently demonstrates that these Commission policy expectations have been met.

Risk-Informed Applications

- Implementation of the LMP methodology[3,4]
- Risk-informed inservice inspection and inservice testing programs – see DANU-ISG-2022-07 (ML22048B549)
- ASME Code, Section XI, Div. 2, reliability and integrity management (RIM) programs – see RG 1.246 (ML22061A244)
- Risk-informed technical specifications – see DANU-ISG-2022-08 (ML22048B548)
- Risk-informed fire protection programs – see DANU-ISG-2022-09 (ML22048B547)
- Performance-based emergency preparedness – see DG-1350 (draft RG 1.242) (ML18082A044)

[3]NEI 18-04, Rev. 1, G-1404, "Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development" (ML19241A472)
[4]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," February 2022 (ML20091L698)

Risk Metrics

- Event sequence family frequencies and consequences, where the consequence is expressed as the dose calculated at the Exclusion Area Boundary (EAB) for the 30-day period following the onset of the release.
- Three cumulative risk metrics:
  - The total mean frequency of exceeding a site boundary dose of 100 mrem from all licensing basis events (LBEs).
  - The average individual risk of early fatality within 1 mile of the EAB from all LBEs.
  - The average individual risk of latent cancer fatalities within 10 miles of the EAB from all LBEs.

Note: The CP applicant should develop PRA elements to determine these risk metrics.

PRA Scope

- Identify all radiological sources, hazards, and POSs by performing a comprehensive and systematic search.
- Disposition the search results by a combination of:
  - Screening methods
  - PRA logic modeling
  - Risk-informed supplemental evaluations (e.g., PRA-based seismic margins analysis)
  - Crediting design-basis hazard levels (DBHLs).
- As a minimum, the scope of the PRA supporting the CP application should include the internal events hazard for the reactor in the at-power plant operating state:
  - Demonstrates the applicant's ability to develop an acceptable PRA
  - Establishes an acceptable foundation for upgrading the PRA as the design progresses.

Note: A minimally acceptable PRA would not support full implementation of the LMP methodology at the CP stage because it would not address non-core radiological sources, low-power and shutdown plant operating modes, and all internal and external hazards

Identifying PRA Elements

Minimally Acceptable PRA		Additional PRA Elements	
2-IE	Initiating Event Analysis	1-POS	Plant Operating State Analysis
3-ES	Event Sequence Analysis	8-FL	Internal Flood PRA
4-SC	Success Criteria Development	9-F	Internal Fire PRA
5-SY	Systems Analysis	10-S	Seismic PRA
6-HR	Human Reliability Analysis	12-W	High Wind PRA
7-DA	Data Analysis	13-XF	External Flooding PRA
11-HS	Hazard Screening PRA	14-O	Other Hazards PRA
15-ESQ	Event Sequence Quantification		
16-MS	Mechanistic Source Term Analysis		
17-RC	Radiological Consequence Analysis		
18-RI	Risk Integration		

Defining the PRA Level of Detail

Apply the process provided in Section 3, "Risk Assessment Application Process," of the ASME/ANS Non-LWR PRA Standard, ASME/ANS RA-S-1.4-2021, "Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants"

Step1
- Characterize plant design life cycle stage and PRA application

Step 2
- Define site or site characteristics

Step 3
- Select PRA scope, level of detail consistent with design stage and application

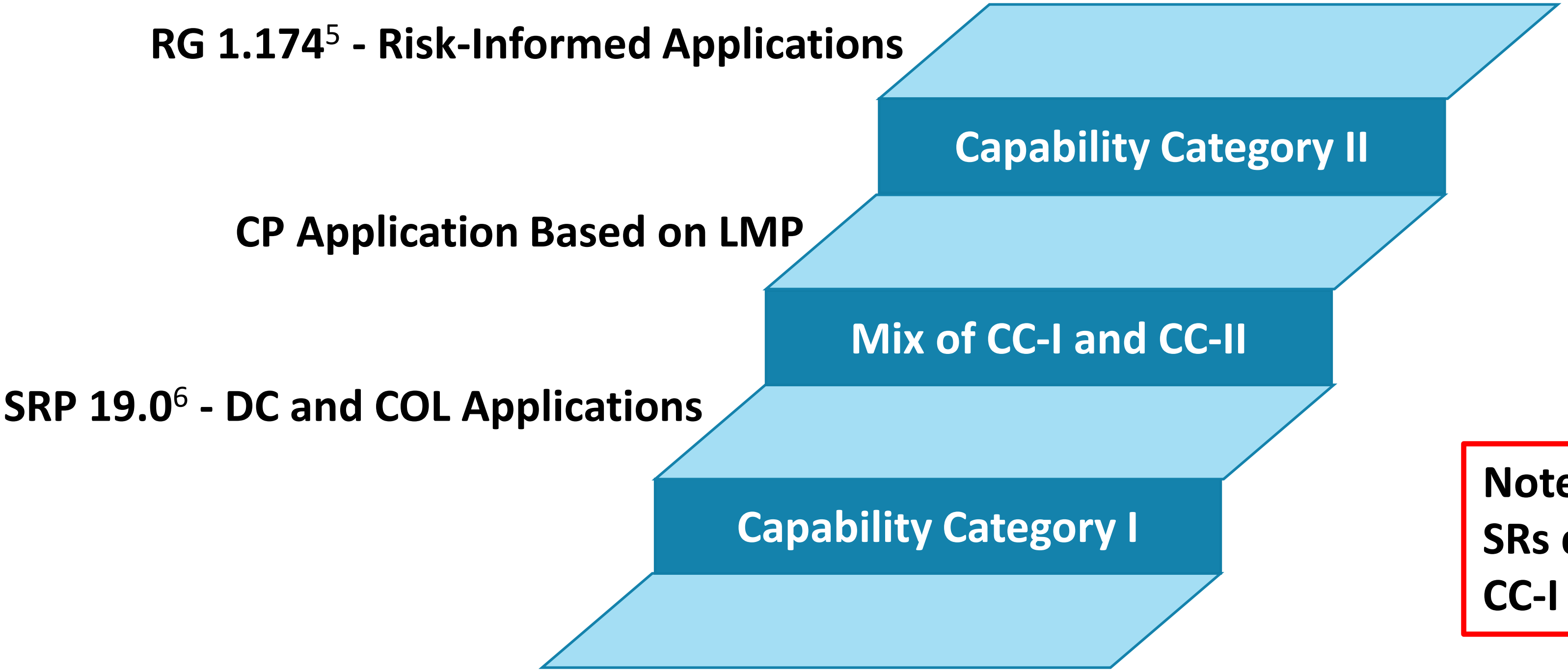
Step 4
- Select the risk significance criteria appropriate for the application

Step 5
- Determine Capability Category needed for each part of the PRA to support application

Capability Categories

PRA Attributes	Capability Category I	Capability Category II
1. Scope and level of detail	Identify relative importance of contributors: • Hazard group • Initiating event group • Functional or systemic event sequence level including associated human failure events, relevant physical phenomena, and release characteristics.	Identify relative importance of contributors: • Hazard group • Initiating event group • Functional or systemic event sequence level and basic event level including associated human failure events, relevant physical phenomena, and release characteristics.
2. Plant-specificity	Use of generic data/models	Use of plant-, site- or design-specific data/models
3. Realism	Departures from realism will have moderate impact on the conclusions and risk insights	Departures from realism will have small impact on the conclusions and risk insights

Finding the Appropriate Mix of CC-I and CC-II Supporting Requirements

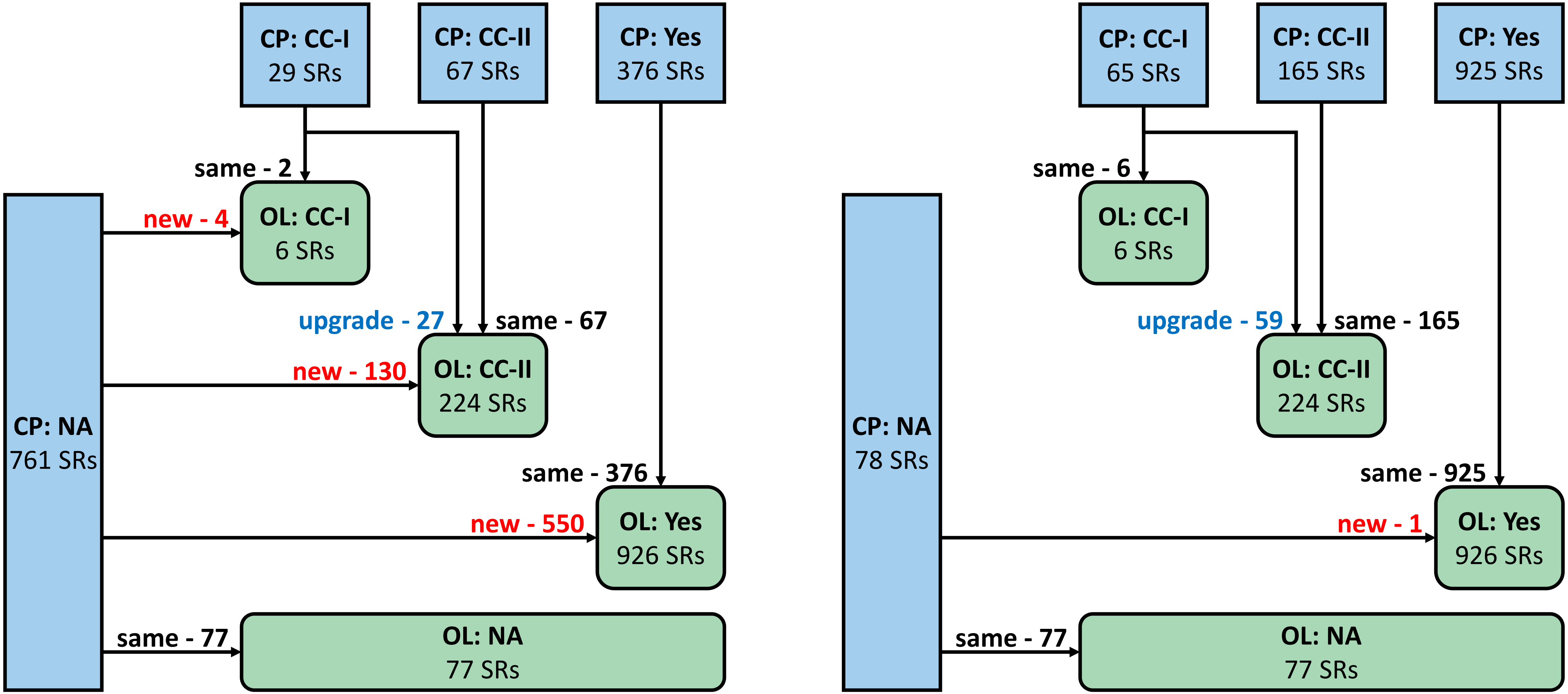


Note: Approximately 80% of the SRs do not differentiate between CC-I and CC-II

[5]RG 1.174, Rev. 3, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," (ML19241A472)

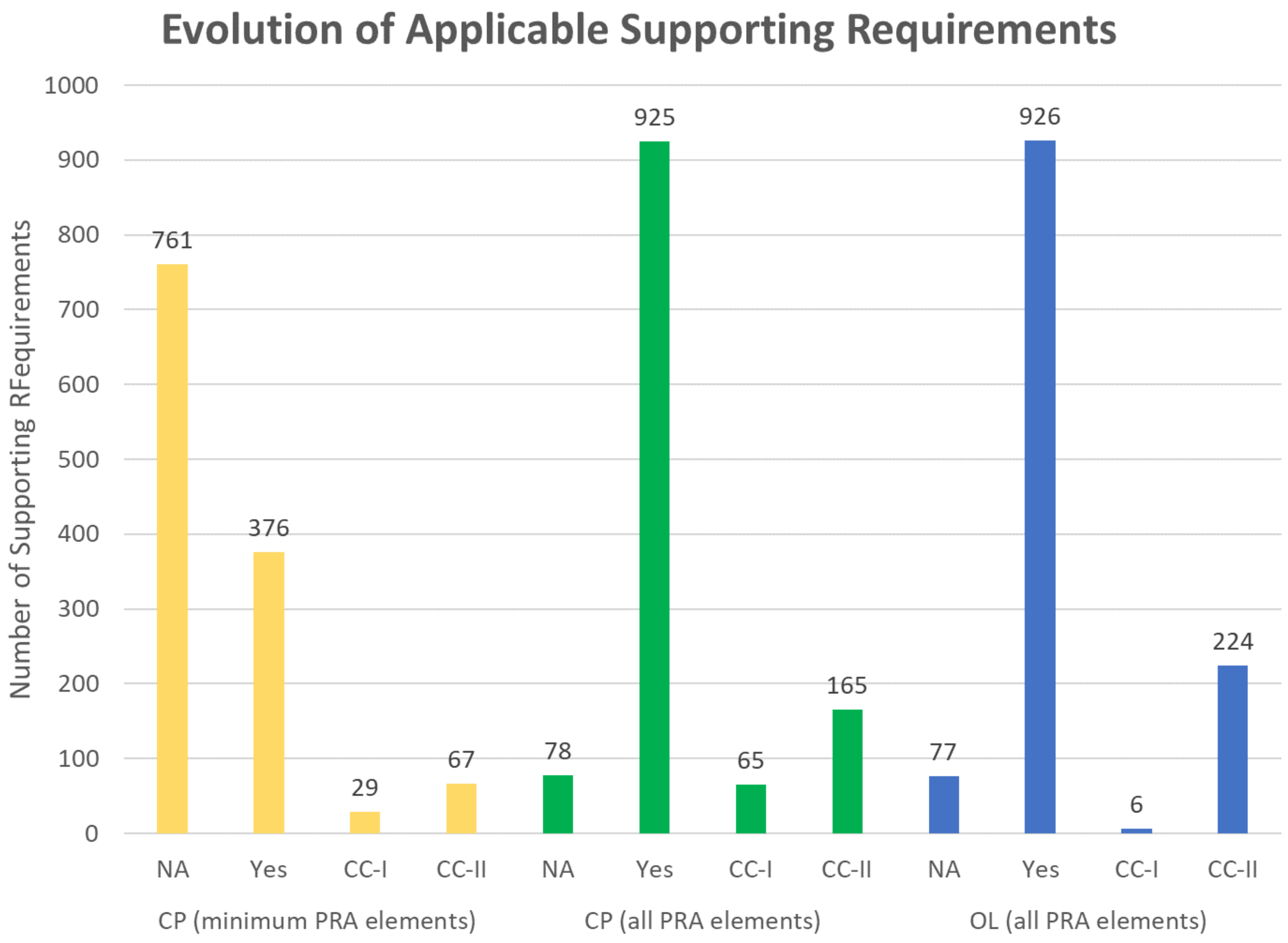
[6]NUREG-0800, Chapter 19.0, Rev. 0, "Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors," (ML15089A068).

Implications of PRA Scope at the CP Stage



Minimally Acceptable PRA at CP Application

All PRA Elements at CP Application


Evolution of Applicable Supporting Requirements
Number of Supporting RFequirements
1000
900
800
700
600
500
400
300
200
100
0
761
376
29
67
78
925
65
165
77
926
6
224
NA
Yes
CC-I
CC-II
NA
Yes
CC-I
CC-II
NA
Yes
CC-I
CC-II
CP (minimum PRA elements)
CP (all PRA elements)
OL (all PRA elements)

Plant Representation and PRA Configuration Control

- Establish a PRA configuration control program to ensure that:
  - The CP PRA represents the preliminary plant design and site characteristics described in the PSAR
  - The PRA will continue to represent the plant design as it is finalized and the plant is constructed.
- Section 5 of the non-LWR PRA standard, which is endorsed in trial RG 1.247 with no objection, provides one acceptable approach
- The PRA configuration control program may be a stand-alone program or included within the quality assurance program required by 10 CFR 50.34(a)(7)

PRA Documentation

- The TICAP guidance in NEI 21-07, Rev. 1, provides an acceptable approach and format for providing PRA submittal information
  - The staff recognizes that PRA results and key assumptions will be provided in the sections of the PSAR to which they apply
- Staff Position C.4.1 in RG 1.247 provides an acceptable approach for developing and preserving PRA archival information
  - PRA archival information may be controlled by a stand-alone program or the quality assurance program required by 10 CFR 50.34(a)(7)

Demonstrating PRA Acceptability

- The guidance in DANU-ISG-2022-05, “Organization and Human-System Considerations,” (ML22048B542) provides an acceptable approach for describing:
    - Key management responsibilities for developing the PRA
    - Ability of the CP applicant’s technical staff to develop the PRA
- The CP applicant should demonstrate the acceptability of the PRA by conducting a self-assessment or a peer review

PRA Self-Assessment

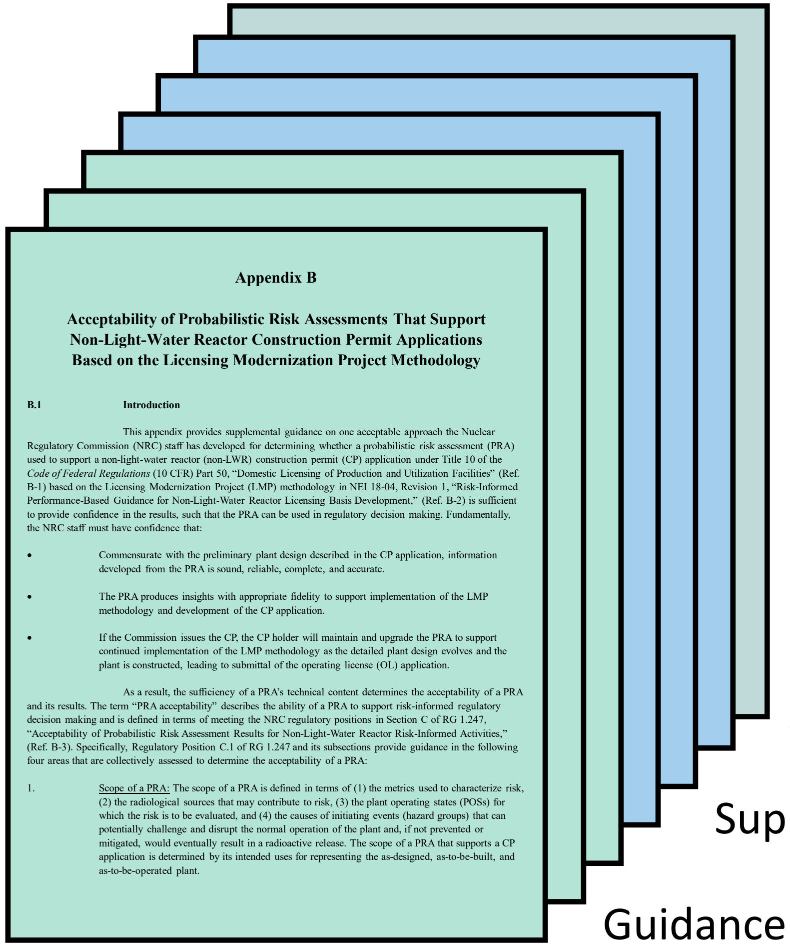
- Results of a self-assessment should:
  - Indicate the extent to which the relevant HLRs and associated SRs are met
  - Reveal the PRA's strengths and limitations
  - Provide a basis for asserting that the PRA is acceptable
- The results of the self-assessment should also demonstrate:
  - The PRA's current scope, level of detail, elements, plant representation, and configuration control are consistent with the maturity of the design and acceptable for implementing the LMP methodology leading up to submittal of the CP application
  - The PRA has been developed and used in a technically acceptable manner, including the appropriateness of the assumptions and approximations used in developing the PRA
  - Preliminary, incomplete, or missing portions of the PRA may reasonably be left for further development as the detailed plant design evolves and the plant is constructed, leading to submittal of the OL application
- NEI 20-09, Revision 1, "Performance of Peer Reviews Using the ASME/ANS Advanced Non-LWR PRA Standard" (ML21125A284), Sections 3.2, A.3.1, and A.3.2, as endorsed in RG 1.247 with no exceptions, provides an acceptable approach for performing a self-assessment.
- The NRC staff will perform a review of the PRA during its licensing review to confirm the results of the self-assessment.

PRA Peer Review

- A peer review determines whether the relevant HLRs and associated SRs established in the non-LWR PRA standard, as endorsed by the NRC in RG 1.247 with clarifications and exceptions, have been met.
- The peer review should confirm that:
  - The technical aspects of the PRA have been developed in a technically correct manner
  - Assess the appropriateness of assumptions and approximations used in the PRA
- A peer review reduces the level of staff review of the CP PRA
- Section 6 of the non-LWR PRA standard and NEI 20-09, Revision 1, which are endorsed in RG 1.247 with no objection, provide an acceptable approach for performing a peer review.

Next Steps

- Internal NRC review
- Publish proposed draft for public comment
- Resolve public comments
- Finalize draft consistent with NRC processes for RG development



Appendix B

Acceptability of Probabilistic Risk Assessments That Support Non-Light-Water Reactor Construction Permit Applications Based on the Licensing Modernization Project Methodology

B.1 Introduction

This appendix provides supplemental guidance on one acceptable approach the Nuclear Regulatory Commission (NRC) staff has developed for determining whether a probabilistic risk assessment (PRA) used to support a non-light-water reactor (non-LWR) construction permit (CP) application under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. B-1) based on the Licensing Modernization Project (LMP) methodology in NEI 18-04, Revision 1, "Risk-Informed Performance-Based Guidance for Non-Light-Water Reactor Licensing Basis Development," (Ref. B-2) is sufficient to provide confidence in the results, such that the PRA can be used in regulatory decision making. Fundamentally, the NRC staff must have confidence that:

- Commensurate with the preliminary plant design described in the CP application, information developed from the PRA is sound, reliable, complete, and accurate.
- The PRA produces insights with appropriate fidelity to support implementation of the LMP methodology and development of the CP application.
- If the Commission issues the CP, the CP holder will maintain and upgrade the PRA to support continued implementation of the LMP methodology as the detailed plant design evolves and the plant is constructed, leading to submittal of the operating license (OL) application.

As a result, the sufficiency of a PRA's technical content determines the acceptability of a PRA and its results. The term "PRA acceptability" describes the ability of a PRA to support risk-informed regulatory decision making and is defined in terms of meeting the NRC regulatory positions in Section C of RG 1.247, "Acceptability of Probabilistic Risk Assessment Results for Non-Light-Water Reactor Risk-Informed Activities," (Ref. B-3). Specifically, Regulatory Position C.1 of RG 1.247 and its subsections provide guidance in the following four areas that are collectively assessed to determine the acceptability of a PRA:

1. Scope of a PRA: The scope of a PRA is defined in terms of (1) the metrics used to characterize risk, (2) the radiological sources that may contribute to risk, (3) the plant operating states (POSs) for which the risk is to be evaluated, and (4) 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 that supports a CP application is determined by its intended uses for representing the as-designed, as-to-be-built, and as-to-be-operated plant.

Proposed Appendix B to DG-1404

Abbreviation/references - 3 pages

Supporting requirement tables - 10 pages

Guidance text - 8 pages

Abbreviations

ALWR	advanced light-water reactor
ASME	American Society of Mechanical Engineers
ANS	American Nuclear Society
CC	Capability Category
CFR	*Code of Federal Regulations*
COL	combined license
CP	construction permit
DANU	Division of Advanced Reactors and Non-Power Production and Utilization Facilities
DBHL	design-basis hazard level
DC	design certification
DG	Draft Guide
DRA	Division of Risk Assessment
EAB	exclusion area boundary
FR	*Federal Register*
HLR	high-level requirement
ISG	Interim Staff Guidance
LBE	licensing basis event
LERF	large early release frequency
LMP	Licensing Modernization Project
LPSD	low-power and shutdown
LWR	light-water reactor
NEI	Nuclear Energy Institute
non-LWR	non-light-water reactor
OL	operating license
POS	plant operating state
PRA	probabilistic risk assessment
PSAR	preliminary safety analysis report
RG	Regulatory Guide
RIM	Reliability Integrity Management
SR	supporting requirement
SRP	Standard Review Plan
TICAP	Technology-Inclusive Content of Application Project
TUPA	trial use and pilot application