POLICY ISSUE
(Notation Vote)

December 2, 2019 SECY-19-0117

FOR: The Commissioners

FROM: Margaret M. Doane
Executive Director for Operations

SUBJECT: 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

PURPOSE:

The purpose of this paper is to request that the Commission find that the U.S. Nuclear Regulatory Commission (NRC) staff's use of the technology-inclusive, risk-informed, and performance-based methodology described in this paper is a reasonable approach to establish key parts of the licensing basis and content of applications for licenses, certifications, and approvals for non-light-water reactors (non-LWRs). Related industry guidance was developed as part of the Licensing Modernization Project (LMP), a cost-shared initiative led by nuclear utilities and supported by the U.S. Department of Energy (DOE). This paper does not address any new commitments or resource implications.

SUMMARY:

The staff recommends that the Commission find that the use of the technology-inclusive, risk-informed, and performance-based methodology described in this paper is a reasonable approach for establishing key parts of the licensing basis for non-LWRs. The major elements of

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the methodology are identifying licensing basis events (LBEs); classifying structures, systems, and components (SSCs); and assessing the adequacy of defense in depth (DID).

The staff has identified policy issues and brought matters to the attention of the Commission in previous papers, and the Commission has made important decisions to support the licensing of non-LWR designs. However, the circumstances related to the development of non-LWR technologies in the United States have resulted in long gaps between Commission decisions. Recent activities are consistent with past Commission decisions and provide an opportunity to demonstrate the integration of those decisions and give guidance to non-LWR developers. Specifically, the Nuclear Energy Institute (NEI) has submitted industry guidance in NEI 18-04, Revision 1, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19241A472). The staff has developed the related Draft Regulatory Guide (DG)-1353, "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" (ADAMS Accession No. ML18312A242) and requests Commission agreement on the use of the methodology, as summarized in this paper, to support the design and licensing of non-LWRs.[1]

The development and approval of the methodology described in this paper will also be part of the NRC's response to Section 103, "Advanced Nuclear Reactor Program," of the Nuclear Energy Innovation and Modernization Act (Public Law No: 115-439), which requires the NRC to (1) within 2 years develop and implement, where appropriate, strategies for the increased use of risk-informed, performance-based licensing evaluation techniques and guidance for commercial advanced nuclear reactors within the existing regulatory framework; and (2) complete a rulemaking by December 31, 2027, to establish a technology-inclusive, regulatory framework for optional use by commercial advanced nuclear reactor applicants for new reactor license applications. The staff is requesting Commission agreement on the use of the methodology at this time to ensure that a solid foundation is provided for the regulatory infrastructure being prepared and planned for advanced nuclear reactors.

Important aspects of the methodology described in NEI 18-04 and DG-1353 that are consistent with previous Commission decisions include:

- Using a probabilistic approach to identifying events,
- replacing the single-failure criterion with a probabilistic (reliability) criterion; and
- using a probabilistic approach for the safety classification of SSCs.

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[1] This paper provides a higher-level description of the methodology, including how several Commission decisions from previous papers are being applied and several implementation details that may be of special interest to the Commission. The staff's request for a Commission finding on the methodology relates to the level of detail provided in this paper which would, in turn, support the staff finalizing the regulatory guidance in DG-1353 using typical agency processes. Under this approach, the staff would maintain responsibility for the detailed guidance and have the flexibility to issue revisions provided no new policy issues were identified.

The processes described in NEI 18-04 and DG-1353 also include implementation details for a risk-informed, performance-based approach to the regulation of non-LWRs that may be of special interest to the Commission. These items include:

- A defined lower bound for event sequence frequencies to be considered, in combination with other factors, in the identification of licensing basis events.
- An assessment of the adequacy of design features and programmatic controls in providing defense in depth.
- Use of the methodology to inform the appropriate scope and level of detail to be provided in non-LWR applications for licenses, certifications, and approvals.

BACKGROUND:

The NRC staff has developed guidance on using key aspects of the reactor design process to inform the content of applications for licenses, certifications, and approvals for non-LWRs. The staff plans to endorse industry guidance in NEI 18-04, which was developed as part of the LMP. The guidance focuses on the selection of LBEs; classification of SSCs; and assessment of DID—which are important activities when designing a nuclear power plant. These same activities support identifying the appropriate scope and depth of information provided in applications for licenses, certifications, and approvals required by Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," and 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

On October 14, 2008, the Commission issued its Policy Statement on the Regulation of Advanced Reactors in Volume 73 of the *Federal Register* (FR), page 60612 (73 FR 60612; ADAMS Accession No. ML082750370), which included items to be considered in advanced nuclear power reactor designs. This document reinforced and updated the policy statements on advanced reactors previously published in 1986 (51 FR 24643, ADAMS Accession No. ML051660651), and 1994 (59 FR 35461, ADAMS Accession No. ML051740661). The policy statement identifies attributes that could affect the review of a proposed advanced reactor design, including reliable and less complex shutdown heat removal systems; longer time constants before reaching safety system challenges; simplified safety systems that, where possible, reduce required operator actions; reduced potential for severe accidents; and considerations for safety and security requirements together in the design process. The policy statement goes on to state the following:

> If specific advanced reactor designs with some or all of the previously mentioned attributes are brought to the NRC for comment and/or evaluation, the Commission can develop preliminary design safety evaluation and licensing criteria for their safety-related and security-related aspects. Incorporating the above attributes may promote more efficient and effective design reviews. However, the listing of a particular attribute does not necessarily mean that specific licensing criteria will attach to that attribute. Designs with some or all of these attributes are also likely to be more readily understood by the general public. Indeed, the number and nature of the regulatory requirements may depend on the extent to which an individual advanced reactor design incorporates general attributes such as those listed previously.

The NRC interacted with DOE and reactor developers in the late 1980s and early 1990s on the potential licensing of non-LWR designs. These activities resulted in the publication of assessments for several non-LWR designs. During the preliminary review of these designs, the staff identified issues that required policy direction from the Commission and presented them in SECY-93-092, "Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and CANDU 3 Designs and their Relationship to Current Regulatory Requirements," dated April 8, 1993 (ADAMS Accession No. ML040210725). In the 2000s, the staff continued interactions with stakeholders on policy issues related to advanced reactors. The staff provided the Commission with recommendations in SECY-03-0047, "Policy Issues Related to Licensing Non-Light-Water Reactor Designs," dated March 28, 2003 (ADAMS Accession No. ML030160002), that are important to the methodology described in NEI 18-04 and DG-1353. These key licensing issues include selecting LBEs, classifying SSCs, using probabilistic risk assessments, and providing appropriate DID in non-LWR designs and programmatic controls. The Commission's staff requirements memorandum (SRM) for SECY-03-0047, dated June 26, 2003 (ADAMS Accession No. ML031770124), approved the staff's recommendation to allow the use of risk insights to identify events, classify SSCs, and provide an alternative to the single-failure criterion for designing and licensing non-LWRs.

In subsequent papers, the staff updated the Commission on the development of a technology-neutral framework. The NRC addressed advanced reactor issues, such as event categories and assessing DID, in the advanced notice of proposed rulemaking (ANPR) "Approaches to Risk-Informed and Performance-Based Requirements for Nuclear Power Reactors" published in the FR on May 4, 2006 (71 FR 26267). In December 2007, the NRC staff published NUREG-1860, "Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing" (ADAMS Accession No. ML073400763), which further explored the feasibility of developing a risk-informed and performance-based regulatory structure for the licensing of future nuclear power plants. In August 2008, the NRC and DOE jointly issued to Congress the Next Generation Nuclear Plant (NGNP) Licensing Strategy Report (ADAMS Accession No. ML082290017). As described in SECY-16-0021, "Discontinuation of Rulemaking Activities," dated February 29, 2016 (ADAMS Accession No. ML15336A324), subsequent changes to the NGNP project ultimately led to the rulemaking activities being discontinued. Although the NRC did not pursue a rulemaking as envisioned in the ANPR, the staff continued interactions with DOE, industry, and other stakeholders on policy issues related to advanced reactors. These interactions centered on the NGNP project and a series of white papers intended to further define approaches for key licensing topics, including those specifically addressed in NEI 18-04 and DG-1353.

The NRC described efforts to prepare for possible licensing of non-LWR technologies in "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness" (ADAMS Accession No. ML16356A670), issued in December 2016. The staff developed implementation action plans (ADAMS Accession Nos. ML17165A069 and ML17164A173), to support meeting the goals outlined in the vision and strategy document. Strategy 3 within the implementation action plans called for the development of guidance for a flexible non-LWR regulatory review process within the bounds of existing regulations. The staff coordinated its activities related to Strategy 3 with the LMP, a cost-shared initiative led by Southern Company, coordinated by NEI, and supported by DOE. The LMP developed a technology-inclusive, risk-informed, and performance-based methodology to support the design and licensing of non-LWRs. The LMP proposals built upon the accepted higher-level approaches outlined in SECY-03-0047 by refining the methodologies described in the NGNP white papers to reflect interactions with the NRC, feedback from industry, and broadening of the scope to ensure applicability to various non-LWR technologies. The LMP activities were

incorporated into NEI 18-04, which the staff plans to endorse through finalizing the regulatory guidance in DG-1353. The enclosure and the following discussion further describe the consolidation of the guidance into NEI 18-04 and DG-1353.

DISCUSSION:

Integrated Approach

The overall objective of the guidance in NEI 18-04 and DG-1353 is to describe a systematic and reproducible process for selecting LBEs, classifying SSCs, and assessing the adequacy of DID for a non-LWR design. The Commission's SRM for SECY-03-0047 addressed these three topics and the related topic of improving how the agency uses risk-informed and performance-based approaches (e.g., the Commission's policy statement, "Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities," dated August 16, 1995 (60 FR 42622)). In its SRM, the Commission approved the following recommendations:

(1) Greater emphasis can be placed on the use of risk information by allowing the use of a probabilistic approach in the identification of events to be considered in the design, provided there is sufficient understanding of plant and fuel performance and deterministic engineering judgment is used to bound uncertainties.[2]

(2) A probabilistic approach for the safety classification of SSCs is allowed.

(3) The single-failure criterion can be replaced with a probabilistic (reliability) criterion.

Identification and Analyses of Licensing-Basis Events

NEI 18-04 describes a systematic process for identifying and categorizing event sequences as anticipated operational occurrences (AOOs), design-basis events (DBEs), or beyond-design-basis events (BDBEs).[3] The primary determinant for categorizing events is the estimated frequency of the event sequence, as shown in Figure 1, "Frequency-Consequence [F-C] Target." NEI 18-04 acknowledges and the staff emphasizes in DG-1353 that the F-C target does not correspond to actual regulatory acceptance criteria but is instead a vehicle to assess a range of events within a risk-informed structure to determine risk significance, support SSC classification, determine special treatment requirements, identify appropriate programmatic controls, and confirm the adequacy of DID. As discussed in the enclosure, the anchor points used for the F-C target figure are expressed in different units, timescales, and distances than those used in NRC regulations and policy statements. Design-basis accidents are derived from DBEs by assuming that only safety-related SSCs are available to mitigate the events. DG-1353 accepts the definitions of the event categories in NEI 18-04 as well as the demarcations shown in Figure 1.

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[2] The content of applications is discussed in the enclosure and a later section of this paper. Those discussions go to the information that applicants need to provide to demonstrate a sufficient understanding of plant and fuel performance to support both probabilistic and deterministic assessments of plant safety and related uncertainties.

[3] The definitions of some phrases used in NEI 18-04 are different from the same phrases used in NRC regulations and guidance developed for LWRs. The terms AOO and DBE are examples of similar terms having different definitions. The methodology in NEI 18-04 also includes a different definition and means to identify safety-related SSCs from those used in the deterministic approaches for LWRs. NEI 18-04 includes a glossary to help alleviate some of the issues that will arise because of differences in terminology.

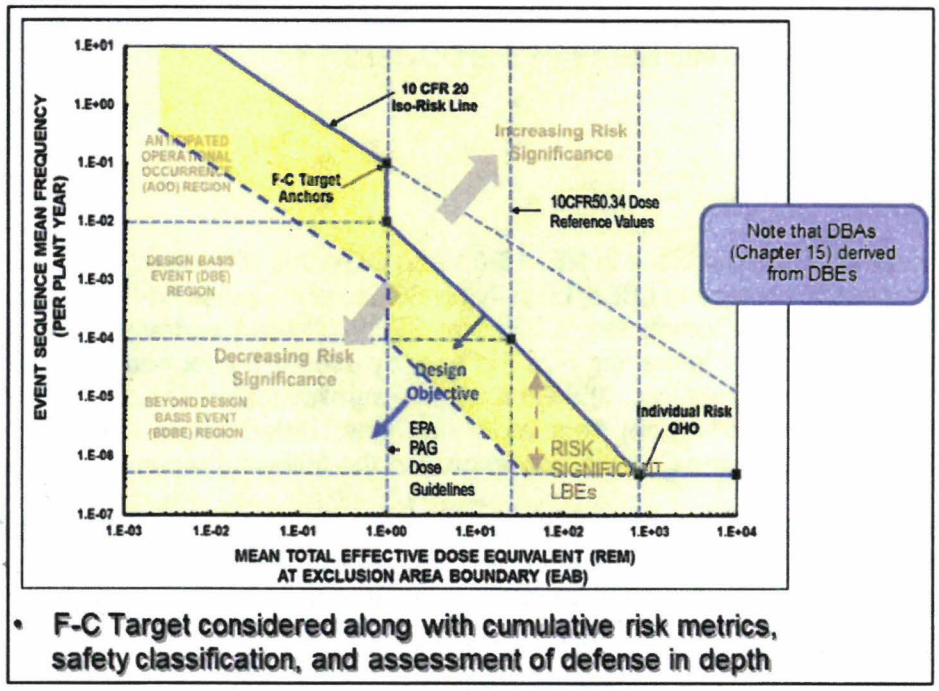

Figure 1. Frequency-consequence target (derived from NEI 18-04)

The analyses of event sequences are an input into the subsequent processes described in NEI 18-04 for the safety classification of SSCs and the assessment of DID. The assessments of LBEs within the methodology focus on safety functions such as removing heat from the fuel and the identification of SSCs needed to fulfill those functions. The plotting of event sequences, considering frequencies and consequences, with the F-C targets support defining needed SSC capabilities and reliabilities to support the design process and inform the content of applications. The uncertainties related to event sequences, plant behavior, assumed reliability of SSCs, and other aspects of the estimation of event frequencies and consequences are key considerations.

The approach described in NEI 18-04 and endorsed in DG-1353 is consistent with the Commission's approval of the recommendation in SECY-03-0047 to replace the single-failure criterion with a probabilistic (reliability) criterion. DG-1353 documents the staff's finding that assessing event sequences (including reliability and availability of SSCs and combinations of SSCs) over a wide range of frequencies, including BDBEs, and establishing risk and safety function reliability measures for both safety-related and selected nonsafety-related SSCs, obviates the need to use the single failure criterion applied to the deterministic evaluations for LWRs.

Safety Classification and Performance Criteria for Structures, Systems, and Components

The methodology described in NEI 18-04 involves assessing the risk significance of SSCs and determining if special treatments beyond normal industrial practices are needed to ensure SSC performance of safety functions in the prevention and mitigation of LBEs. The safety classification of SSCs and the determination of performance criteria are directly related to and performed in an iterative process along with the identification and evaluation of LBEs and the assessment of DID. Consistent with the Commission's approval of the recommendation in SECY-03-0047 to allow a probabilistic approach for the safety classification of SSCs, NEI 18-04

describes the evaluations of LBEs and DID and the classification of safety functions to be used in designing and categorizing specific SSCs for non-LWRs.

A major objective of the process described in NEI 18-04 is to establish a systematic approach to assessing and determining appropriate relationships between the needed capabilities and reliabilities for SSCs and the role of those SSCs in mitigating and preventing LBEs. The safety classification of SSCs is made in the context of how the SSCs perform specific safety functions for each LBE in which they play a role to prevent or mitigate the event. The reliability of the SSC serves to prevent the LBE by lowering its frequency of occurrence. If the SSC function is successfully completed within an event sequence, the SSC and its associated capabilities have helped to mitigate the consequences of the LBE. The physical characteristics that are needed for SSCs to mitigate an LBE will define acceptance criteria for those SSCs. Examples of such acceptance criteria include defining needed material properties for piping and vessels during operations and LBEs, ensuring needed coolant flows for heat removal, and providing needed retention of radionuclides. The safety classification process and the corresponding special treatments serve to control the frequencies and consequences of the LBEs in relation to the F-C target and ensure that the cumulative risk metrics are not exceeded. DG-1353 documents the staff's planned endorsement of the approach described in NEI 18-04 for classifying and establishing performance criteria for SSCs as part of an overall methodology for designing and licensing non-LWRs.

Evaluation of Defense-in-Depth Adequacy

NEI 18-04 describes a framework that includes probabilistic and deterministic assessment techniques to confirm adequate DID using a combination of plant capabilities and programmatic controls. Evaluations are based on several established approaches to DID to assess a reactor design and determine whether additional measures are appropriate to address uncertainties or an overreliance on specific SSCs.

NEI 18-04 calls for the reactor designer to use an integrated decisionmaking process, which supports the overall design effort (including the development of plant capability and programmatic DID features), assesses the DID adequacy for the design, and documents the DID baseline. An application for a license, certification, or approval will describe the process and outcome in terms of assessments and demonstration that the design incorporates a reasonable level of DID. Figure 2, "Framework for Establishing DID Adequacy," represents the relationships between the various parts of the methodology described in NEI 18-04 (LBEs, SSC safety classification, and DID), as well as how the plant capabilities and programmatic controls are assessed, using both deterministic and risk-informed techniques to ensure DID adequacy for a specific design.

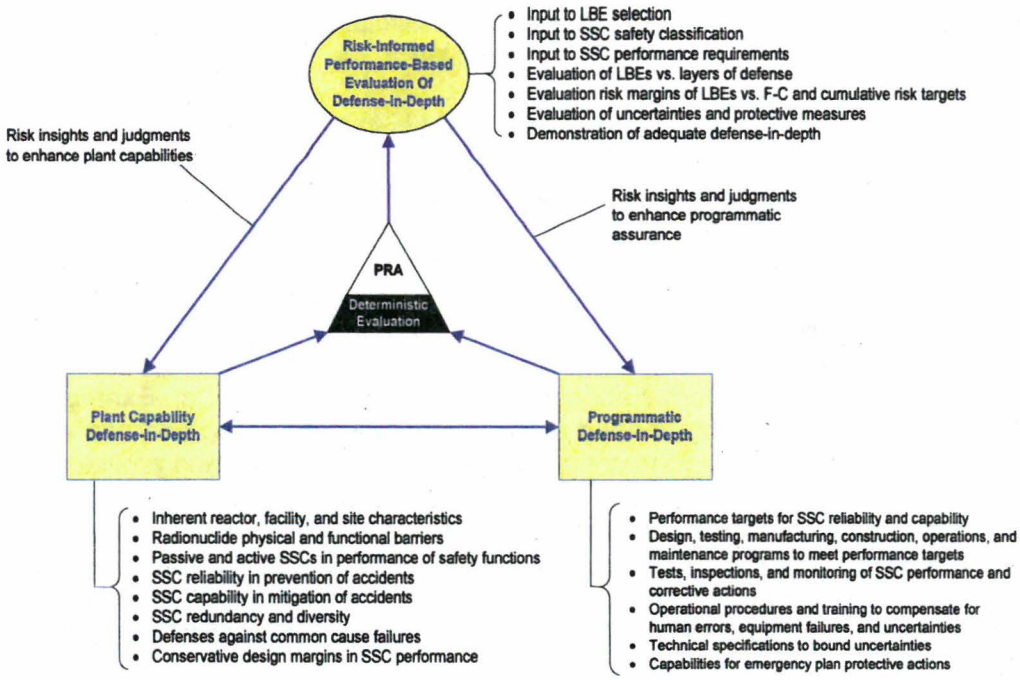

Figure 2. Framework for establishing DID adequacy (from NEI 18-04)

The NRC has long recognized the importance of DID and considers its implementation in guidance such as regulatory guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis" (ADAMS Accession No. ML17261A618). However, the Commission stated in its SRM dated March 9, 2016, for SECY-15-0168, "Recommendations on Issues Related to Implementation of a Risk Management Regulatory Framework" (ADAMS Accession No. ML16069A370), that "a formal agencywide definition and criteria for determining the adequacy of DID should not be developed." The staff is not proposing to define DID or impose the process described in NEI 18-04 onto any applicant not choosing to use the methodology as part of the design and licensing for a non-LWR. This approach is consistent with the Commission's approval of SECY-15-0168, while also providing a standard process for developers and the NRC staff to use in considering DID within the design and licensing of future non-LWR technologies. DG-1353 documents the staff's planned endorsement of the process described in NEI 18-04 for assessing defense in depth as part of an overall methodology for designing and licensing non-LWRs.

Informing the Content of Applications

Applicants can use the design-related activities described above to identify and provide the appropriate level of information needed to satisfy key parts of the regulatory requirements related to the content of applications for licenses, certifications, and approvals.

The analysis of AOOs, DBEs, BDBEs, and design-basis accidents plays an important role in defining safety functions, classifying SSCs, and assessing DID. The system designs and safety evaluations may demonstrate compliance with or justify exemptions from specific NRC regulations and identify where design-specific regulatory controls are warranted. The integrated process described in NEI 18-04 and its consideration of plant capabilities and programmatic controls are well-suited to inform the content of applications, including discussions of

appropriate performance-based controls for some SSCs. The level of detail in applications describing physical systems and programs and the associated resources needed for NRC staff review of applications may be reduced commensurate with the risks posed by a non-LWR design. The staff plans to use risk-informed, performance-based approaches not only to guide staff reviews as directed in the SRM dated May 11, 2011, for SECY-11-0024, "Use of Risk Insights To Enhance the Safety Focus of Small Modular Reactor Reviews" (ADAMS Accession No. ML111320551), but also to ensure the scope and level of detail provided in non-LWR applications is commensurate with the risks posed by the specific reactor design.

As stated in the policy statements on advanced reactors, the Commission expects that advanced reactors will provide enhanced margins of safety and/or use simplified, inherent, passive, or other innovative means to accomplish their safety and security functions. The Commission elaborated on this expectation in the SRM for SECY-10-0121, "Modifying the Risk-Informed Regulatory Guidance for New Reactors," dated September 14, 2010 (ADAMS Accession No. ML102430197). In that SRM, dated March 2, 2011 (ADAMS Accession No. ML110610166), the Commission stated that "... New reactors with these enhanced margins and safety features should have greater operational flexibility than current reactors. This flexibility will provide for more efficient use of NRC resources and allow a fuller focus on issues of true safety significance...." The methodology described in NEI 18-04 and DG-1353 supports assessing inherent characteristics, passive features, and other attributes of advanced reactors to help justify flexibility in areas such as emergency planning and functional containment performance criteria.[4] The methodology includes identifying potential benefits provided by design features and programmatic controls in terms of the margins between estimated doses and the reference values in NRC regulations and the margins between estimated health effects and the NRC's safety goals. SECY-18-0096 and SECY-18-0103 provide examples of how those margins are used within performance criteria established to assess potential operational flexibilities.

Stakeholder Interactions

The NRC staff held numerous public meetings on the topics addressed in NEI 18-04 during its interactions on the NGNP. More recently, the industry participated in cost-share projects with DOE to prepare white papers and the consolidated guidance in NEI 18-04. Drafts of NEI 18-04, DG-1353, and related papers were made publicly available to support public meetings and interactions with the Future Plant Designs Subcommittee of the Advisory Committee on Reactor Safeguards (ACRS). The meetings with the ACRS included presentations by industry representatives on how the methodology would be applied to specific non-LWR designs.

The ACRS issued a letter dated March 19, 2019 (ADAMS Accession No. ML19078A240), providing its conclusions and recommendations. Observing that this paper proposes the next evolution of a licensing approach that has been developed over the past 30 years, the ACRS recommended that the Commission adopt the proposed approach. The ACRS also found that the guidance provided in DG-1353 is adequate to support the implementation of the approach described herein, with the exception that guidance for developing mechanistic source terms should be expanded, and it recommended that the guidance be finalized and published for comment.

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[4] See related papers such as SECY-18-0103, "Proposed Rule: Emergency Preparedness for Small Modular Reactors and other New Technologies (RIN 3150-AJ68; NRC-2015-0225)," dated October 12, 2018 (ADAMS Accession No. ML18134A076) and SECY-18-0096, "Functional Containment Performance Criteria," dated September 28, 2018 (ADAMS Accession No. ML18115A157).

Relationship to other Non-LWR Priorities

The staff is currently interacting with non-LWR stakeholders (e.g., DOE, designers) on a variety of policy and regulatory issues. Together, these and other activities are intended to provide an integrated approach to resolving issues and developing a logical regulatory framework for non-LWRs. The methodology described in NEI 18-04 and planned to be approved through finalizing the regulatory guidance in DG-1353 is also expected to be an important part of (1) the NRC's development and implementation of strategies for increased use of risk-informed, performance-based licensing evaluation techniques and guidance, and (2) the NRC's rulemaking to establish a technology-inclusive regulatory framework for advanced nuclear reactors as required by the Nuclear Energy Innovation and Modernization Act.

Next Steps

The staff is continuing to interact with stakeholders to identify and resolve policy and licensing issues associated with developing and possibly deploying non-LWRs. The staff will work with stakeholders, including potential joint industry-DOE projects similar to LMP, to provide additional guidance to non-LWR developers in areas such as the content (scope and level of detail) of applications and assessing potential radiological releases using design-specific mechanistic source term models. The methodology described in this paper also supports the potential development of a broader regulatory framework for advanced reactors, including rulemakings as described in the Nuclear Energy Innovation and Modernization Act.

RECOMMENDATION:

The staff recommends that the Commission find that it is reasonable for the staff to use the technology-inclusive, risk-informed, and performance-based methodology described in this paper to inform the licensing basis and content of applications for licenses, certifications, and approvals for non-LWRs.

Margaret M. Doane

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Executive Director for Operations

Enclosure:
Technology-Inclusive, Risk-Informed,
Performance-Based Methodology

SECY PAPER "TECHNOLOGY-INCLUSIVE, RISK-INFORMED, AND PERFORMANCE-BASED METHODOLOGY TO INFORM THE CONTENT OF APPLICATIONS FOR LICENSES, CERTIFICATIONS, AND APPROVALS FOR NON-LIGHT-WATER REACTORS" DATED DECEMBER 2, 2019

ADAMS Accession No: ML18311A264 (Pkg) ***Via e-mail** SECY-012

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