U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NON-LIGHT-WATER REACTOR IMPLEMENTATION ACTION PLAN—PROGRESS SUMMARY AND FUTURE PLANS

Enclosure

CONTENTS

1.0 Introduction

This enclosure summarizes activities underway and planned by the staff of the U.S. Nuclear Regulatory Commission (NRC) to make the safe use of advanced nuclear technology possible. The staff described background information and previous accomplishments in previous annual updates: SECY-18-0011, "Advanced Reactor Program Status," dated January 25, 2018,[1] and SECY-19-0009, "Advanced Reactor Program Status," dated January 17, 2019.[2]

The staff has organized its non-LWR readiness efforts into six strategic areas:

(1) staff development and knowledge management
(2) analytical tools
(3) regulatory framework
(4) consensus codes and standards
(5) resolution of policy issues
(6) communications

This enclosure provides the status of each of the readiness strategies, with an emphasis on accomplishments achieved during calendar year 2019. This enclosure also describes next steps and planned activities. The staff is developing and implementing transformational approaches to conducting advanced reactor licensing reviews, including the development of staff review strategy guidance, use of limited staffing core review teams, focus on safety-significant design and operational characteristics, preparation of streamlined review documentation, and use of regulatory audits and meetings to reduce the number of requests for additional information. By fostering a culture of change, the staff seeks to innovate how licensing reviews are conducted to facilitate more effective and efficient use of NRC resources and to make the safe use of advanced nuclear technologies possible.

The staff has made significant progress over the past year on its ongoing activities to support licensing non-LWRs, many of which support the activities required by Section 103 of the Nuclear Energy Innovation and Modernization Act (NEIMA), which was signed into law on January 14, 2019. As required by Sections 103(b) and 103(c) of NEIMA, the NRC prepared two reports to Congress regarding (1) expediting and establishing stages in the licensing process for commercial advanced nuclear reactors; and (2) increasing, where appropriate, the use of risk-informed and performance-based evaluation techniques and regulatory guidance in licensing commercial advanced nuclear reactors within the existing regulatory framework. These reports were sent to Congress on July 12, 2019. Under NEIMA, the NRC is also required by January 2021 to "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, including evaluation techniques and guidance" for topics including source terms, licensing basis event selection and evaluation, containment performance and emergency preparedness. Finally, consistent with Section 103 of NEIMA, staff has begun efforts to establish a "technology-inclusive regulatory framework" for optional use by applicants for new commercial advanced nuclear reactor licenses. The NRC plans to complete this rulemaking by December 31, 2027. The status of these ongoing activities are discussed under Strategic Areas Nos. 3 and 5 in this enclosure.

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[1] See SECY-18-0011, "Advanced Reactor Program Status," dated on January 25, 2018 (ADAMS No. ML17334B217)
[2] See SECY-19- 0009, "Advanced Reactor Program Status," dated on January 17, 2019 (ADAMS Accession No. ML18346A075)

NEIMA defines “advanced nuclear reactor” as a nuclear fission or fusion reactor, including a prototype plant, with significant improvements compared to commercial nuclear reactors under construction as of the date of enactment of the Act. Therefore, the NRC and the U.S. Department of Energy (DOE) Office of Science/Fusion Energy Sciences have initiated routine interactions to develop longer-term strategies for the possible deployment of fusion reactors. Many of the regulatory changes being considered for non-LWRs will inform strategies for licensing fusion reactors. The NRC staff also plan to support an upcoming DOE/NRC workshop on fusion technologies in March 2020.

2.0 Strategic Area No. 1: Staff Development and Knowledge Management

2.1 Overview

This strategy supports the objective of enhancing non-LWR technical readiness. By investing in our people, we are positioned to address the challenges of licensing new technologies. The near-term objectives for this strategy are to identify work requirements, identify critical skills and staff capacity requirements, assess the staff’s current non-LWR technical readiness, and close gaps in technical readiness. Activities within Strategic Area No. 1 are informed by ongoing DOE and industry technology development activities. The NRC also monitors the plans of prospective applicants to assess future workload in this changing environment to ensure that the staff prioritizes its readiness in technology-specific areas appropriately.

In 2019, the staff made progress in increasing staff knowledge of non-LWRs. The staff’s main objective in 2020 under this strategy will be to continue to expand the staff’s capability and capacity in order to support anticipated workload.

2.2 Progress Summary

The staff has enhanced its advanced reactor technical readiness in accordance with Section 103(a)(5) of NEIMA, which requires the NRC to provide for staff training or hiring of experts to support activities required under Section 103(a)(1)–(4) of the Act and support preparations for preapplication interactions and commercial advanced reactor license application reviews.

In March 2019, the Office of New Reactors (NRO) created the Division of Advanced Reactors (DAR) to focus on advanced reactor technical readiness, to support preapplication interactions, and to perform technical reviews of advanced reactor applications. In October 2019, when NRO merged with the Office of Nuclear Reactor Regulation, the new division became the Division of Advanced Reactors and Non-Power Production and Utilization Facilities. The staff created the new division with the intention of providing increased focus on advanced reactor readiness activities and increasing staff capacity to support advanced reactor licensing. The new division has three branches that focus on advanced reactors: the Advanced Reactor Policy Branch, the Advanced Reactor Licensing Branch, and the Advanced Reactor Technical Branch. By including advanced reactor licensing in the same division as non-power production and utilization facility licensing, the staff can leverage synergies and experience in the licensing of novel technologies. Subject matter experts from critical disciplines were reassigned to this new division to prepare for potential early mover advanced reactor applications. This has helped position the staff for success in conducting preapplication reviews and the continued development of the regulatory infrastructure for non-LWRs. The staff plans to continue to fill remaining vacancies in the new division in (fiscal year) FY 2020 to further increase the organizational capacity to support the projected advanced reactor workload.

The staff focused primarily on two activities in support of Strategic Area No. 1 in 2019[3]: (1) training and (2) knowledge management efforts.

2.2.1 Training

To supplement the course on molten salt reactors (MSRs) developed in 2017 by Oak Ridge National Laboratory (ORNL), the staff contracted with Argonne National Laboratory (ANL) to develop training curricula for sodium-cooled fast reactors (SFRs), including micro-reactors, and high-temperature gas-cooled reactors (HTGRs). The SFR and HTGR workshops were provided in April and July 2019 respectively. The knowledge gained from this training assisted the staff in understanding SFR, micro-reactor, and HTGR technologies, and helped to enable the staff to perform regulatory reviews of designs using these technologies and to develop guidance for performing future application reviews, as needed. The training materials for these courses have been made publicly available and the training was video recorded to facilitate training additional staff as needed in the future. The staff has also begun a series of seminars on advanced reactor technical and regulatory topics such as risk informed decision-making and accident source terms.

Next Steps: The staff will continue to assess training needs and develop additional training courses and other training opportunities, including additional seminars on specific technical and regulatory topics of importance for non-LWR technology.

2.2.2 Knowledge Management

Significant information is available on technical, policy, and regulatory issues associated with licensing non-LWR designs. The goal of this activity is to consolidate existing documents and training materials to make them more easily accessible and searchable and to develop additional knowledge management resources as needed to support staff development.

In 2018, the staff contracted with Brookhaven National Laboratory to prepare a report on the "NRC Regulatory History of Non-Light Water Reactors," which was finalized and made publicly available on October 18, 2019.[4] This report will assist the staff in understanding the history of non-LWR technologies and facilitate future reviews of these technologies. This report will introduce non-LWR concepts to NRC staff members who are not familiar with non-LWRs and will provide the associated historical context.

Next Steps: The staff plans to leverage the NRC's Nucleopedia knowledge management platform to make non-LWR information more readily accessible to the staff.

3.0 Strategic Area No. 2: Analytical Tools

3.1 Overview

This strategy supports the non-LWR vision and strategy objective of enhancing non-LWR technical readiness and optimizing regulatory readiness. The NRC may use computer codes to

[3] This enclosure covers accomplishments through December 31, 2019 and discusses work currently planned for the remainder of FY 2020 with available budgeted resources.

[4] See "NRC Regulatory History of Non-Light Water Reactors (1950-2019)," dated June 10, 2019 (ADAMS Accession No. ML19282B504)

perform confirmatory, sensitivity, and uncertainty analyses to help investigate margins in the design commensurate with the risk and safety significance of the phenomena applicable to each specific design.

The approach taken for this strategy is to: (1) identify the tools, information, and data that may be needed to support the staff's review of non-LWR designs, (2) evaluate the existing computer codes and supporting information and identify gaps in both analytical capabilities and supporting information and data, and (3) interact with both domestic and international organizations working on non-LWR technologies to identify opportunities to collaborate and cooperate in closing the gaps, while avoiding potential conflicts of interest.

The staff has continuing interactions with DOE, the Electric Power Research Institute (EPRI), National Laboratories, reactor vendors, utilities, and the international community related to computer codes and analytical tools. The important objective for this strategy is to build a cooperative relationship with DOE with the goal of coordinating funding activities, as appropriate, and to reduce costs to the NRC and the U.S. Government.

One of the challenges for computer code development is the limited experimental data on non-LWR fuel types. For example, several fuel types are being considered for non-LWRs, including tristructural isotropic (TRISO) particle, metallic, and liquid salt fuels. The TRISO fuel is a uranium oxy-carbide used in both HTGRs and one type of a fluoride-salt-cooled high-temperature reactor, and the metallic fuel is a uranium-zirconium used in SFRs. Some MSRs have the nuclear fuel dissolved in the molten salt coolant, and some use solid fuel such as TRISO fuel and are cooled by molten salt. To better understand modeling and simulation requirements for these fuels, NRC and DOE fuel performance specialists exchange information on the NRC's Fuel Analysis under Steady-state and Transients (FAST) code and DOE's BISON code. This interaction reduces the need for the NRC to develop models previously developed by DOE.

3.2 Progress Summary

The staff continued assessment of the information, experimental data, and analytical tools needed to support non-LWR reviews. The staff also completed its assessment of existing computer codes and tools that have the potential to meet non-LWR review and other regulatory application needs. The assessment included overall life cycle costs and development schedules, and considered NRC developed codes, computer codes developed by DOE under the Nuclear Energy Advanced Modeling and Simulation (NEAMS) project, and international computer codes. The codes identified for non-LWR analysis are expected to be suitable for a broad range of hypothetical accidents regardless of the licensing approach taken by the applicant and can accommodate reviews of applications using the Licensing Modernization Project (LMP) or more traditional licensing approaches. As part of the staff's assessment of analytical tools, knowledge and capability gaps have been identified. Based on these gaps, the staff has identified necessary code development tasks.

The staff has identified technical gaps associated with various non-LWR technologies; enhanced its knowledge of non-LWR designs; assessed the capabilities of candidate computer codes; and conducted some code development activities. The staff developed a coherent plan for developing computer code capabilities to support non-LWR reviews. These documents describe the overall code development approach, the codes, knowledge gaps, and necessary development activities. These plans, along with the supporting technical rationale and decision

criteria, provide a roadmap and priorities for future computer code development and assessment activities.

Enhancing Staff Knowledge

The staff performed several activities as described below to better understand the unique codes, experimental data, features, phenomena and knowledge gaps related to non-LWR technologies.

- To increase staff knowledge on DOE computer code development efforts, DOE continued to assist the staff in "hands-on" training of some of the DOE NEAMS codes. NRC staff traveled to Idaho National Laboratory (INL) and ANL to work alongside DOE code developers and gain in-depth knowledge on DOE codes. Staff participated in these training visits and attended meetings with prospective applicants to gain a better understanding of the non-LWR reactor systems and analysis needs. Staff also attended design and information meetings conducted by DOE on the Versatile Test Reactor (VTR) under a DOE/NRC Memorandum of Understanding (MOU).[5]

- The staff participated in a workshop with DOE and National Lab representatives on experimental data needs for assessment of codes for non-LWR analysis and licensing. Access to data, data quality, and new experimental support was discussed in the first of several meetings that are expected to provide the NRC with qualified data for non-LWRs.

- The staff signed an agreement to join an International Atomic Energy Agency (IAEA) international standards program that will provide unique code assessment data for a fast reactor. The NRC expects to obtain experimental data for the Chinese Fast Reactor Experiment and use it to assess neutronics codes. The data are considered very important for fast reactor designs, including some micro-reactor designs cooled by heat pipes.

- The staff participated in two meetings for the Molten Salt Reactor Phenomena Identification and Ranking Table (PIRT) held at Chalk River, Canada. The MSR PIRT was conducted to rank the importance and knowledge of different phenomena for radionuclide release for two representative molten salt reactor types, liquid fuel salt and fixed-fuel coolant salt. The scenarios considered included the failure of barriers resulting in the contact of air and moisture with salt.

- The staff participated in an MSR Licensing Basis Event (LBE)/Initiating Event (IE) workshop at ORNL. Participants included representatives from U.S. and Canadian regulatory agencies, U.S. and Canadian national laboratories, prospective reactor vendors, industry, and academia. The objectives of the workshop were to identify MSR IEs as precursors to LBEs and determine how IEs feed into the risk-informed, performance-based reactor safety evaluation process described in 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."

- The staff participated in the 2019 MSR Workshop held at ORNL. Topics discussed at this workshop included salt chemistry and development, MSR modeling and simulations, MSR materials (e.g., graphite degradation, structural alloys, and corrosion) and MSR safety (including fuel qualification and licensing). The workshop concluded with an MSR

[5] See "Memorandum of Understanding between US NRC and US DOE on Versatile Test Reactor Engagement," dated September 19, 2019 (ADAMS Accession No.ML19266A003)

developer's forum where current MSR designers provided updates on their reactor developments and licensing.

- The staff engaged DOE's Office of Nuclear Energy in a cooperative effort to coordinate MSR research activities. This enabled information-sharing between NRC and DOE about MSR technologies and the identification of potential licensing challenges to support the efficient use of limited MSR research funds. Staff identified and prioritized high-priority MSR research topics that will be used to prioritize NRC-funded MSR research activities.
- The staff completed a gap analysis on the most important materials and component integrity issues that should be considered for licensing MSRs. The report, "Technical Gap Assessment for Materials and Component Integrity Issues for Molten Salt Reactors,"[6] considered materials issues for both fluoride and chloride applications, with both fast and thermal neutron spectra, and included the following priority knowledge gaps: code qualification of structural alloys, incomplete corrosion data, incomplete irradiation data, modeling and targeted experimentation to understand degradation fundamentals, limitations of older data sets, modified Hastelloy N variants, and incomplete data on moderator behavior. The staff publicly released the report in July 2019.
- The staff completed a report, "Advanced Non-Light-Water Reactors Materials and Operational Experience,"[7] that summarizes the available domestic and international operational experience (OpE) for both power and research non-LWRs about materials and structural performance. It is focused on SFRs and HTGRs.
- The staff began work to assess source-dependent graphite properties, including degradation in the presence of molten salts. This work will contribute to the review of high temperature graphitic components for MSRs and HTGRs.
- The staff initiated work to understand the compatibility of reactor components with chloride and fluoride salt environments. This work will contribute to the development of corrosion criteria and guidance to facilitate the review of environmental effects on materials degradation in MSRs. This effort will leverage ongoing work at ORNL funded by DOE.
- The staff began work to assess the influence, if any, of thermal embrittlement upon structural alloys undergoing high-temperature creep and creep-fatigue behavior under operating conditions for non-LWRs.

Computer Code Development and Assessment

To prepare computer codes for future non-LWR reviews, the staff initiated several code development and assessment activities as described below. In addition to code development activities, work was initiated on several "reference plant" models that will enable the staff to rapidly begin independent evaluations of applicant designs. The reference plant models are based on publicly available information and are similar to expected applicant designs. These models will be used to perform sensitivity and exploratory studies and help educate the staff on the new designs. The staff plans to continue to perform code development work focused on technology-inclusive capabilities for NRC codes. In parallel, the staff is developing plans and reports, as described below, to guide a broader spectrum of activities, including technology-specific code development.

[6] See "Technical Gap Assessment for Materials and Component Integrity Issues for Molten Salt Reactors, dated March 31, 2019 (ADAMS Accession No. ML19077A137)

[7] See "Advanced Non-Light-Water Reactors Materials and Operational Experience," dated March 31, 2019 (ADAMS ML18353B121)

- The staff is updating its FAST fuel performance code to add finite-volume modeling capability, which enables the code to model any fuel geometry, including spherical and plate type fuel, under steady-state and transient conditions. A gap analysis of FAST for metallic fuels was initiated to support adding missing correlations to the code and expand validation and assessment of the code against available data. Additionally, the staff updated FAST with properties for metallic fuels and assessed it against Experimental Breeder Reactor-II (EBR-II) data.[8]
- The NRC, DOE and INL completed definition and creation of a new multi-physics code suite, called the Comprehensive Reactor Analysis Bundle (CRAB). The suite is designed to integrate the NRC's reactor safety analytical tools with codes developed under the DOE NEAMS program. The CRAB suite proposes to address design-basis events (DBEs), in which little or no fuel damage is expected using the NRC's TRAC/RELAP Advanced Computational Engine (TRACE) thermal hydraulics code and a limited number of NEAMS codes. Specific code development tasks related to this include the following.
    - To better assess the integrated capabilities of the CRAB suite, staff developed a new feature in TRACE to communicate boundary conditions to and from the NEAMS suite of codes via a DOE framework of coupled solvers called the Multiphysics Object-Oriented Simulation Environment (MOOSE). The new capabilities in CRAB are being tested to predict several code validation scenarios in which data are transferred between TRACE and the DOE fuel performance code, BISON.
    - The staff updated MAMMOTH/Rattlesnake (NEAMS code) to improve the meshing scripts to be applicable to heat pipe cooled micro-reactors of both the prismatic and monolithic designs, including treatment for rotating control drums.
    - The staff began PRONGHORN (NEAMS code) development and validation, including development of a reactor cavity cooling system model (RCCS) for radiation/convection from the vessel wall to the heat exchanger panel. Example problems demonstrate how to apply a thermal resistance for gaps between graphite blocks at both radial and axial faces.
    - Staff began making the following improvements to the heat transfer modeling capabilities of the ANL System Analysis Module (SAM) code: (1) implementing coupling of porous medium fluid energy equation to the solid energy equation, (2) implementing coupling capability for a one-dimensional flow channel embedded in a three-dimensional solid to model both circular channels in a block and plate fuel geometries, (3) adding coupling for a two-dimensional heat structure to the fluid in a three-dimensional porous medium, and (4) implementing a package of effective thermal conductivity models for conduction in pebble beds.
    - To leverage and assess models developed under the DOE NEAMS code development program, work was initiated to couple the NRC's FAST computer code to MOOSE. This enables FAST to couple to any MOOSE-based or MOOSE-wrapped computer code (including NEAMS computer codes). Additionally, the NRC and ORNL have begun coupling FAST and SCALE to calculate the radial power distribution inside of a representative non-LWR metallic fuel element.

[8] See K.J. Geelhood, I.E. Porter, "Modeling and Assessment of EBR-II Fuel with the US NRC's FAST Fuel Performance Code," Proceedings of TopFuel 2018, Czech Republic, September 30–October 4, 2018

- Significant progress was made in coupling TRACE and the BISON fuel performance code. This activity will enable the staff to perform benchmark and validation activities to support NRC's FAST fuel performance code development activities.
- The staff completed a preliminary model of a micro-reactor using CRAB and has started to perform simulations of hypothetical accidents. The model is representative of the type of micro-reactor designs the staff expects to review, although it is based on publicly available information. The model will be used to perform sensitivity and exploratory studies enabling the staff to better understand behavior of a micro-reactor during various event scenarios. These models are expected to assist the staff in evaluating the safety margins inherent to micro-reactor designs and provide an early identification of technical issues.

- The staff began an effort to perform MELCOR full-plant demonstration calculations for three non-LWR designs. The project includes feedback obtained from public workshops which will provide insights for developing source term guidance for vendors.
- The staff evaluated different atmospheric transport and dispersion models for potentially integrating them into the MELCOR Accident Consequences Code System (MACCS) to address near-field phenomena like building wake effects that are of increased importance for nuclear power plants like non-LWRs that may have smaller emergency planning zones and site boundaries relative to large LWRs. MACCS is used for probabilistic consequence calculations of dose, health, economic, and societal consequences.

Documenting Code Development Plans

The staff prepared a three-volume draft report[9] with an introductory volume that describe computer code needs, current capabilities, and gaps relevant to non-LWR confirmatory and future (beyond initial licensing) safety analysis. The reports identify candidate computer codes, the decision criteria and technical rationale applied to the selection process, and specific development activities needed to address known gaps. These draft reports, briefly described below, were reviewed internally, and stakeholder feedback was sought to ensure they reflect the best available information and an appropriate range of perspectives. On May 1, 2019, the staff briefed the Advisory Committee on Reactor Safeguards (ACRS) Future Plant Design Subcommittee on its plans for development of DBE and Beyond DBE (BDBE) codes for non-LWR analysis. This was followed by a meeting on September 17, 2019, to the same subcommittee, on NRC's fuel performance analysis codes. On October 3, 2019, the staff briefed the ACRS full committee on the role of computer codes in regulatory activities and needs for advanced reactor reviews and codes the staff intends to develop. On November 4, 2019, the ACRS transmitted a letter[10] containing its conclusions, recommendations and constructive feedback on the staff's code development strategies which will be considered in revisions to the reports.

- The staff completed a draft of "Code Assessment Plans for NRC's Regulatory Oversight of Non-Light Water Reactors." This report provides an overview of the staff's approach for code development to support the licensing of non-LWRs; describes the factors considered for code selection and prioritization of code development activities; and approach to obtain stakeholder feedback to inform NRC code development decisions.

[9] See "Draft Non-LWR Code Plans: Intro, Vol. 1, 2 and 3," dated April 3, 2019 (ADAMS Accession No. ML19353C811)

[10] See "Review of Advanced Reactor Computer Code Evaluations," dated November 4, 2019 (ADAMS Accession No. ML19302F015)

- The staff completed a draft of "NRC Non-Light Water Reactor (Non-LWR) Vision and Strategy, Volume 1 – Computer Code Suite for Non-LWR Design Basis Event Analysis." This report discusses the analysis codes to be used for ten types of non-LWR designs including gas-cooled, liquid metal-cooled, molten salt cooled, molten fuel salt systems as well as "micro-reactors" cooled with heat pipes. The report discusses code validation needs and provides a status of code capability for each design type. The codes identified as part of the NRC's CRAB suite are intended to perform system analysis and confirm the adequacy of emergency core cooling and shutdown performance of a design. Codes developed by the NRC and through DOE's NEAMS program are included in CRAB.
- The staff completed a draft of "NRC Non-Light Water Reactor (Non-LWR) Vision and Strategy, Volume 2 – Fuel Performance Analysis for Non-LWRs." This report summarizes proposed code development efforts to extend NRC's modeling and simulation capabilities for fuel thermal-mechanical performance to non-LWR technologies. It describes proposed non-LWR fuel designs, as well as the modeling gaps and development plans for NRC's FAST fuel performance code. The report focuses mainly on metallic and TRISO fuels but includes brief discussion of other fuel types as well. Finally, the report describes areas where the NRC might use the DOE-sponsored BISON fuel performance code or collaborate with the BISON code developers at INL.
- The staff completed a draft of "NRC Non-Light Water Reactor (Non-LWR) Vision and Strategy, Volume 3 – Computer Code Development Plans for Severe Accident Progression, Source Term, and Consequence Analysis." This report summarizes proposed code development efforts to extend NRC's modeling and simulation capabilities for accident progression, source term, and consequence analysis for non-LWR technologies. It describes the different types of non-LWRs as well as the modeling gaps and development plans for NRC's computer codes including MELCOR for accident progression and source term analysis, MACCS for consequence analysis, and SCALE for radionuclide inventories, kinetics parameters, and decay heats.

Next Steps: The staff plans to finalize the set of reports described above based on ACRS and stakeholder comments. These reports will provide a coherent basis and technical rationale for the selection of computer codes, and related development activities, in support of safety reviews of non-LWR designs and will be used to prioritize resources for future code development activities. Additionally, the staff plans to develop similar code development reports that identify candidate computer codes, technical rationale applied to the selection process, specific development activities and known gaps for licensing and siting dose assessment analyses and fuel cycle analysis topics. Finally, the staff plans to collaborate with DOE to conduct training on using the BISON fuel performance code.

4.0 Strategic Area No. 3: Regulatory Framework

4.1 Overview

This strategy supports the objective of optimizing non-LWR regulatory readiness. One of the objectives of Strategic Area No. 3 is to develop guidance for flexible non-LWR regulatory review processes within the bounds of existing regulations, including the use of conceptual design reviews and staged-review processes. In 2019, the staff placed the priority on activities to support the development of technology-inclusive, risk-informed, and performance-based licensing approaches, in support of the NRC's goal to be a modern-risk informed regulator.

4.2 Progress Summary

4.2.1 Non-Light-Water Reactor Design Criteria

Developing design criteria for non-LWRs is an important first step in providing stakeholders with insights on how the NRC staff views the unique characteristics of non-LWR technology. Starting in 2013, the NRC, in coordination with DOE, began work on the initiative to develop guidance for principal design criteria (PDC) for non-LWRs. After significant stakeholder interaction, the staff published Regulatory Guide (RG) 1.232, "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors," on April 3, 2018.[11] RG 1.232 provides guidance to reactor designers, applicants, and licensees of non-LWR designs on developing PDC for any non-LWR design subject to 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." The non-LWR design criteria included in Appendices A–C to RG 1.232 are intended to provide stakeholders with insight into the staff's views on how the GDC could be interpreted to address non-LWR design features. These are not considered to be final or binding requirements for a non-LWR applicant. Because the General Design Criteria (GDC) are considered guidance for non-LWRs, non-LWR applicants would not need to request an exemption from the GDC in 10 CFR Part 50 when proposing PDC for a specific design. They may use RG 1.232 to develop all or part of the PDC and are free to choose among the advanced reactor, SFR, or HTGR design criteria provided in RG 1.232 to develop their PDC.

Next Steps: In the next update to RG 1.232, the staff plans to address the Commission's decision on functional containment.[12]

4.2.2 Non-Light-Water Reactor Licensing-Basis Development

The NRC is continuing to interact with industry initiatives such as the Licensing Modernization Project (LMP), a cost-shared initiative being led by Southern Company, coordinated by Nuclear Energy Institute (NEI), and supported by DOE. The industry LMP team generated the guidance document, NEI Working Draft 18-04, Revision 1, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development," dated August 2019.[13] The NRC issued DG-1353, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors," proposing to endorse NEI 18-04. These guidance documents focus on key areas of the design and licensing of advanced reactors, such as the selection of licensing-basis events; classification of structures, systems, and components; and assessing defense in depth. The staff is gaining experience with the application of the LMP methodology through tabletop exercises and preapplication submittals by various non-LWR designers.

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[11] See RG 1.232, "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors," dated April 3, 2018 (ADAMS Accession No. ML17325A611)

[12] See SRM SECY-18-0096 "Functional Containment Performance Criteria for Non-Light Water Reactors," dated December 4, 2018 (ADAMS Accession No. ML18338A502)

[13] See "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development," dated August 2019 (ADAMS Accession No. ML19241A472)

The current efforts resulting in the preparation of NEI 18-04 and DG-1353 continue activities that have been carried out over many years. Although recent activities are consistent with past Commission decisions, the development of NEI 18-04 and DG-1353 provides an opportunity to demonstrate the integration of past decisions and to request Commission agreement with the resultant methodology supporting the design and licensing of non-LWRs. The staff submitted SECY-19-0117[14] requesting the Commission to find that the use of the methodology is a reasonable approach for establishing key parts of the licensing basis for non-LWRs. The staff will address any direction from the Commission when finalizing the guidance in DG-1353. In addition, the staff has begun working with the industry and DOE on developing guidance to non-LWR developers on the content of applications that use the LMP methodology. This project is called the Technology-Inclusive Content of Applications Project (TICAP) and aims to provide guidance on the scope and level of detail for applications.

Next Steps: The staff is continuing to interact with stakeholders, including joint industry-DOE projects like the TICAP. The methodology described in NEI 18-04 and planned to be endorsed through finalizing the regulatory guidance in DG-1353 is 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 NEIMA. The staff will provide the Commission with a rulemaking plan for the NEIMA-required rulemaking in 2020.

4.2.3 Additional Guidance Development Activities

In addition to the specific activities discussed in Sections 4.2.1–4.2.2 of this enclosure, the staff identified two broad regulatory framework development activities in support of Strategic Area No. 3:

(1) Establish criteria, as necessary, to reach a safety, security, or environmental finding for non-LWR technologies.
(2) Identify and resolve gaps in the current regulatory framework associated with non-LWR reactors and the relevant fuel cycle.

The following specific activities support these two-broad regulatory framework development activities:

- The staff visited the X-Energy, LLC, fuel fabrication pilot facility at ORNL on February 11, 2019. Several pre-application meetings occurred with X-Energy, LLC including a) a discussion of nuclear criticality safety on December 12, 2018, and b) a discussion of Integrated Safety Analysis methods on September 11, 2019. These meetings helped to identify any regulatory or guidance gaps for this specific advanced reactor fuel cycle licensing action.

- The staff contracted with ORNL to develop a model material control and accounting (MC&A) program for pebble bed reactors and a methodology for assessing MC&A performance at pebble bed reactors. This will help the staff to establish MC&A review guidance for this type

[14] See SECY-19-0117 "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," dated December 2, 2019 (ADAMS Accession No. ML18311A264)

of non-LWR. ORNL provided a draft report in September 2019 and it is being reviewed by the NRC staff.

- The staff contracted with DOE national laboratories to provide information that will support the future development of licensing review guides for metal fuel fabrication operations and fuel salt processing operations for advanced reactors. This will help the staff establish safety review guidance for non-LWR fuel cycles that use these fuel materials. The national laboratories made presentations on their work to the NRC staff. Both the reports and the slides from the presentations have been posted on the advanced reactor public web page.

- The Center for Nuclear Waste Regulatory Analysis assisted the NRC staff with identifying and assessing the significance of potential challenges associated with the safe transportation, storage, and disposal of advanced reactor fuel with a focus on TRISO and metal fuel. This effort included a review of information on degradation mechanisms for these two fuel types that would have to be considered in the design of systems for the transportation, storage or disposal of these fuels. This will help the staff identify if any revisions or enhancements are needed in the transportation, storage, and disposal review guidance for non-LWR fuel cycles.

- The staff arranged for ORNL to provide an information/training session that reviewed advanced reactor technology that industry was developing, the fuel for such advanced systems, and the expected fuel cycle issues. The session addressed MSRs, HTGRs and SFRs. It also discussed the use of high assay low enriched uranium (HALEU).

- The NRC staff prepared the "Non-Light Water Reactor Review Strategy – Staff White Paper,"[15] in anticipation of the receipt of near-term applications for non-LWR power facilities. This draft document supports the near-term reviews of applications for non-LWR designs that are submitted prior to the development of the technology-inclusive, risk-informed, and performance-based regulatory framework, as required by NEIMA. The white paper provides NRC staff with an approach to reviewing the licensing basis information of a non-LWR application independent of the specific design or methodology used.

- DOE/ANL submitted the "Draft Quality Assurance Program Plan for SFR Metallic Fuel Data Qualification - ANL/NE-16/17." Generic NRC approval of the quality assurance of this data would benefit several of the designers of non-LWR fast reactors seeking to use this legacy data as part of the safety case for their fuels. The report is currently under NRC review and the staff expects to issue a safety evaluation by the end of March 2020.

- Another area of focus is development of guidance for environmental reviews for micro-reactors that appropriately scales the depth and scope of content of the environmental documentation prepared by the staff. The staff is developing this guidance based on an acknowledgement of the expected design features and smaller size of advanced micro-reactors (e.g., reduced radionuclide inventories and enhanced safety features) when compared to large light-water reactors and a recognition that the potentially lessened environmental impacts of micro-reactors could reduce documentation needed for impacted areas. The staff is also exploring development of a generic environmental impact statement (GEIS) for the construction and operation of advanced nuclear reactors. The staff held one public meeting in November 2019 and a workshop in January 2020 to explore the interaction

[15] See "Non-Light Water Reactor Review Strategy – Staff White Paper," dated September 30, 2019 (ADAMS Accession No. ML19275E869)

of various advanced nuclear reactor designs with the environment. NRC intends to gather information that will inform its decision on whether to proceed with the development of a GEIS. The intent of a GEIS is to improve the efficiency of the environmental review process.

Next Steps: The NRC staff will continue to engage with interested stakeholders on regulatory issues associated with non-LWR and fuel cycle licensing and the production or use of HALEU and, if appropriate, proceed with guidance development activities.

5.0 Strategic Area No. 4: Consensus Codes and Standards

5.1 Overview

This strategy supports the objective of enhancing non-LWR technical readiness and optimizing regulatory readiness. The staff intends to enhance the NRC's technical readiness for possible non-LWR designs by applying its established process for incorporating codes and standards into its regulatory framework. NRC Management Directive (MD) 6.5, "NRC Participation in the Development and Use of Consensus Standards," dated October 28, 2016, describes this process, which consists of three primary steps: (1) identifying and prioritizing the need for new and revised technical standards, (2) participating in codes and standards development, and (3) endorsing codes and standards. The NRC works with standards development organizations (SDOs), non-LWR designers, DOE, and other stakeholders to identify and facilitate new codes needed for non-LWR development.

5.2 Progress Summary

5.2.1 The American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, Division 5, for High-Temperature Reactors

The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code provides NRC-accepted rules for the design, construction, testing, certification, and quality assurance of nuclear reactors with systems operating below 426 degrees Celsius (800 Fahrenheit). However, non-LWR designs may incorporate novel materials or systems operating above 426 degrees Celsius. At these elevated temperatures, the structural capacity of systems and components will change as a function of time, temperature, and previously applied stress.

ASME B&PV Code, Section III, Division 5, provides rules for the design, construction, testing, certification, and quality assurance of high-temperature reactors. The scope of the rules in ASME B&PV Code, Section III, Division 5, covers the use of metallic, graphite, and composite materials. The industry technology working groups for the major advanced reactor types (i.e., HTGRs, MSRs, and fast reactors) and ASME have requested NRC endorsement of the 2017 Edition of the ASME B&PV Code in order to improve the efficiency and effectiveness of the agency's review process, to provide the non-LWR designers a stable set of rules for reactor development, and to facilitate the certification of non-LWR component vendors.

The NRC staff is actively participating in subgroups and working groups associated with the development of ASME B&PV Code, Section III, Division 5. Two joint ASME/NRC task groups, related to metallics and nonmetallics, have produced ASME reports identifying gaps and optimizations in ASME B&PV Code, Section III, Division 5, that need to be resolved. The ASME reports conclude that while further optimizations should be pursued by the ASME B&PV

Committees, there are no significant gaps in Section III, Division 5, that would prevent the NRC from endorsing the standard.

The ASME Qualification of Active Mechanical Equipment (QME) Committee has approached the NRC and the Section III, Division 5, Committees seeking input for the development of rules for active components operating at temperatures above 426 Celsius. NRC staff representing the agency on the QME Committee and Section III, Division 5, Committees are supporting QME-1 development. The NRC staff provided an outline of guidance, prior to the November 2019 QME meeting, for demonstrating the qualification of materials in active mechanical components to facilitate QME activity to develop the necessary standards for advanced non-light water reactors.

Next Steps: The NRC has received draft products from DOE national laboratories and contracted commercial entities which provide expert recommendations on endorsement of the code and any recommended limitations thereof. The NRC is reviewing these documents for quality and clarity. The NRC plans on developing three documents for the endorsement effort: (1) a regulatory guide which states the outcome of the NRC review and provides any conditions that should be applied to the use of Section III, Division 5, (2) a NUREG documenting the staff's technical evaluation, and (3) a revised regulatory guide removing endorsement of code cases (X and Y). The NRC will ensure that all documents important to the staff's evaluation will be available to the public. The staff's technical review will begin in January 2020 with the goal of developing a draft RG by April 2021. The staff will continue to update stakeholders at the ASME B&PV Code Week meetings, the Advanced Reactor Stakeholder meetings, and other public venues. The staff will begin engaging with the ACRS during the development of the draft NUREG.

5.2.2 American Nuclear Society Standards

The NRC provides representation on several American Nuclear Society (ANS) standards working groups and consensus committees, including ANS 53.1, "Nuclear Safety Design Process for Modular Helium-Cooled Reactor Plants," ANS 54.1, "Nuclear Safety Criteria and Design Process for Liquid-Sodium-Cooled Nuclear Power Plants," ANS 20.2, "Nuclear Safety Design Criteria and Functional Performance Requirements for Liquid Fuel Molten-Salt Reactor Nuclear Power Plants," ANS 30.1, "Integrating Risk and Performance Objectives into New Reactor Nuclear Safety Designs," and ANS 30.2, "Categorization and Classification of Structures, Systems, and Components for New Nuclear Power Plants." Staff participation on these working groups and committees contributes to improving staff knowledge of the non-LWR technologies and helps influence guidance that can allow for more effective and efficient licensing reviews.

Next Steps: The NRC will continue its membership and participation on ANS committees and standards development working groups to support standards for non-LWR technologies, where appropriate.

5.2.3 Development of the American Society of Mechanical Engineers/American Nuclear Society Non-Light-Water Reactor Probabilistic Risk Assessment Standard

The ASME/ANS Joint Committee on Nuclear Risk Management (JCNRM) issued ASME/ANS RA-S-1.4-2013, "Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants," for trial use in 2013. Source material from the existing ASME/ANS Level 1, full power, LWR PRA standard, ASME/ANS RA-Sa-2009, as revised in 2013 in

ASME/ANS RA-Sb-2013 (Addendum B), as well as draft LWR PRA standards for low-power and shutdown PRA, Level 2 PRA, and Level 3 PRA, have been used, where appropriate, in developing the technical requirements for this standard. To support a diverse mixture of reactor concepts, including HTGRs, SFRs, and MSRs, an updated version of the ASME/ANS non-LWR PRA standard is being developed on a reactor-technology-inclusive basis using established technology-inclusive risk metrics common to existing LWR Level 3 PRAs. Such risk metrics include frequency of radiological consequences (e.g., dose, health effects, and property damage impacts). To support a wide range of applications defined by the non-LWR stakeholders, the scope of this standard is very broad and comparable to a full-scope Level 3 PRA for an LWR with a full range of plant operating states and hazards. Because some of the non-LWR designs supported by this standard include modular reactor concepts, this standard will address the evaluation of integrated risk of multi-reactor or multi-unit plants, including accidents on two or more reactor units or modules concurrently.

Several national and international organizations currently use the standard as they develop non-LWR PRAs and are providing valuable feedback to the JCNRM writing group for incorporation into the final draft of the standard. This writing group, which includes a member of the NRC staff, met on September 24, 2019, enhanced the current version of the non-LWR PRA standard, and revised the plan for balloting this standard in Spring 2020, with the aim to have it ready for final publication by December 2020.

Next Steps: The writing group met during the week of December 16, 2019, to conduct a cross-cutting review of the non-LWR PRA standard and initiate the readiness review. The NRC staff will review the issued version of the non-LWR PRA standard for possible endorsement when it is published.

6.0 Strategic Area No. 5: Resolution of Policy Issues

6.1 Overview

This strategy supports the identification and resolution of policy issues within the purview of the NRC that contribute directly to regulatory predictability, effectiveness, and efficiency. Early identification and resolution of policy issues help to achieve the objective of enhanced technical and regulatory readiness and communications. Some policy issues are for the NRC staff to address, while other policy issues represent matters that may require engagement with the Commission.

The list of policy issues the staff is considering with regard to the licensing of SMRs and non-LWRs is available on the NRC public Web site and is routinely revised to reflect the latest updates on each policy issue. The policy issues have been discussed in several of the recurrent public stakeholder meetings. These discussions will continue in order for the NRC to obtain stakeholder input on the identification and resolution of policy issues and to help prioritize these issues.

6.2 Progress Summary

6.2.1 Siting for Small Modular Reactors and Non-Light-Water Reactors

In November 2017, the NRC issued the draft white paper, “Siting Considerations Related to Population for Small Modular and Non-Light Water Reactors.” The purpose of the paper was to facilitate stakeholder engagement in a potential policy issue involving siting considerations for

SMRs and non-LWRs related to population distribution and density. SECY-16-0012, "Accident Source Terms and Siting for Small Modular Reactors and Non-Light Water Reactors," dated February 7, 2016,[16] had previously identified this issue. During a public meeting on May 3, 2018, NEI provided feedback on behalf of its nuclear industry members, stating its position that the NRC should update Regulatory Guide (RG) 4.7, Revision 3, "General Site Suitability Criteria for Nuclear Power Stations," issued March 2014,[17] to scale the population density guidance based on the smaller source term and lower probability of release anticipated for SMRs and advanced reactors. In June 2019, Oak Ridge National Laboratory completed a technical report, ORNL/TM-2019/1197, "Advanced Reactor Siting Policy Considerations,"[18] identifying potential alternative siting criteria for SMRs and non-LWRs recognizing the possible reduced offsite releases for advanced reactor designs. The report provided insights to inform the staff's plans to develop additional regulatory guidance for SMR and non-LWR siting. On June 13, 2019, the staff released a second draft white paper, "Population-Related Siting Considerations for Advanced Reactors,"[19] to facilitate stakeholder discussions at a public meeting that was held on June 27, 2019. The staff addressed stakeholder feedback and issued a draft SECY paper on July 19, 2019,[20] to support meetings with the ACRS Subcommittee on August 23, 2019, and with the ACRS Full Committee on September 4, 2019. The ACRS issued a letter to the NRC Chairman on October 7, 2019,[21] agreeing with the proposed option in the draft SECY and recommending that RG 4.7 be revised with illustrative examples.

Next Steps: The staff plans to send a paper to the commission in FY 2020 with potential options and a recommendation regarding changes to NRC's siting considerations.

6.2.2 Emergency Preparedness Requirements for Small Modular Reactors and Other New Technologies

Consistent with the Commission's direction in 2015, the NRC staff developed a proposed rule that would provide for alternative emergency preparedness requirements for SMRs and other new technologies. The proposed alternative emergency preparedness requirements would adopt a consequence-oriented, risk-informed, and performance-based approach. In part, this rulemaking would reduce potential requests for exemptions from the current emergency preparedness requirements and promote regulatory stability, predictability, and clarity in the licensing process for these future facilities. The NRC published the regulatory basis on November 15, 2017. The NRC staff provided the proposed rule to the Commission for its consideration in SECY-18-0103[22] on October 12, 2018.

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[16] See SECY-16-0012, "Accident Source Terms and Siting for Small Modular Reactors and Non-Light Water Reactors," dated February 7, 2016 (ADAMS Accession No. ML 15309A319)

[17] See RG 4.7, Revision 3, "General Site Suitability Criteria for Nuclear Power Stations," issued March 2014 (ADAMS Accession No. ML12188A053)

[18] See ORNL/TM-2019/1197, "Advanced Reactor Siting Policy Considerations," dated June 2019 (ADAMS Accession No. ML19192A102)

[19] See "Population-Related Siting Considerations for Advanced Reactors," dated June 13, 2019 (ADAMS Accession No. ML19163A168)

[20] See Draft SECY Paper - Population-Related Siting Considerations for Advanced Reactors, dated July 29, 2019 (ADAMS Accession No. ML19203A219)

[21] See "Review of Draft SECY Paper, "Population-Related Siting Considerations for Advanced Reactors," dated October 7, 2019 (ADAMS Accession No. ML19277H031

[22] See SECY-18-0103 "Proposed Rule-Emergency Preparedness for Small Modular Reactors and Other New Technologies," dated October 31, 2018 (ADAMS Accession No. ML 18134A086)

Next Steps: On December 17, 2019, in SRM-SECY-18-0103,[23] the Commission approved publication of the proposed rule. The staff will publish the proposed rule in the Federal Register in 2020 for public comment. The staff will review the public comments and make appropriate changes in the formulation of a proposed final rule to be provided to the commission.

6.2.3 Appropriate Source Term and Dose Calculations for Small Modular Reactors and Non-Light-Water Reactors

In SECY-16-0012, the staff stated that the evaluation of the mechanistic methods would be important for application reviews and did not note concerns or policy issues about the implementation of mechanistic accident modeling of source terms. Specifically, the staff recognized that although it has not yet developed source term tools and technical expertise for non-LWRs to the same level as that for SMRs, the staff believes a mechanistic approach could also be applied to non-LWR designs, subject to the availability of adequate tools and analysis approaches.

The ACRS stated in a letter dated October 19, 2018, that the staff "should provide [mechanistic source term] guidance to evaluate the adequacy of the frequency of events considered and the duration over which such events must be analyzed" and "on how source terms should be developed." By response dated November 9, 2018, the staff informed the ACRS that it will continue to evaluate the need to further enhance our guidance on mechanistic source term development. Subsequently, NEIMA specifically identified for the NRC to develop and implement guidance on the "use of mechanistic source terms" by January 2021.

Next Steps: The staff contracted with INL to develop a report by mid-2020 that describes an advanced reactor technology-inclusive approach to developing mechanistic source terms for a range of licensing basis events. The staff will consider insights obtained from stakeholder discussions and determine whether clarifications or other actions would be beneficial to address source term guidance for SMRs and non-LWRs.

6.2.4 Security and Safeguards Requirements for Small Modular Reactors and Non-Light-Water Reactors

The staff prepared SECY-18-0076, "Options and Recommendation for Physical Security for Advanced Reactors," dated August 1, 2018, and in its SRM dated November 19, 2018, the Commission directed the staff to initiate a limited-scope revision to regulations and guidance related to physical security for advanced reactors and approved, subject to edits, a related rulemaking plan. The staff prepared a regulatory basis, which was published for public comment in the Federal Register on July 16, 2019.[24]

Next Steps: The staff will continue its interactions with stakeholders while preparing the proposed rule and related guidance.

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[23] See SRM-SECY-18-0103 "Proposed Rule-Emergency Preparedness for Small Modular Reactors and Other New Technologies," dated December 17, 2019 (ADAMS Accession No. ML19351C729)

[24] See 84 FR 33861 "Physical Security for Advanced Reactors"

6.2.5 Insurance and Liability for Small Modular Reactors and Non-Light-Water Reactors

The NRC staff has engaged stakeholders on the issue of insurance and liability during several public meetings. On October 14, 2008, the Commission issued its Policy Statement on the Regulation of Advanced Reactors[25] which states:

> Consistent with its legislative mandate, the Commission's policy with respect to regulating nuclear power reactors is to ensure adequate protection of the environment and public health and safety and the common defense and security. Regarding advanced reactors, the Commission expects, as a minimum, at least the same degree of protection of the environment and public health and safety and the common defense and security that is required for current generation light-water reactors (LWRs). [In this context, current generation LWRs are those nuclear power plants licensed before 1997] Furthermore, 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.

Given the expectations that advanced reactors provide at least the same degree of protection as existing reactors, the question goes to whether: (1) the risk profiles for advanced reactor facilities are comparable to existing facilities, for which the current insurance and liability requirements were established; or (2) the attributes of advanced reactor designs reduce the risk profiles in comparison to existing facilities such that changes to insurance and liability requirements might be warranted. Regarding the first question, the staff is documenting its assessments of the potential risks likely to be associated with advanced reactor facilities, including multi-module issues, for consideration in confirming the adequacy of existing requirements. Regarding the second question, the feedback from stakeholders, including designers and industry organizations, is that no immediate actions are called for to address the possibility that reduced risks posed by advanced reactors might warrant changes to the current insurance and liability requirements.

Next Steps: In accordance with the latest version of the Price-Anderson Act, the NRC will prepare a report to Congress, and an associated SECY paper, recommending the need for continuation or modification of the provisions of the Price-Anderson Act by December 31, 2021. This report and SECY paper will address any changes that the staff recommends for non-LWRs and SMRs.

6.2.6 Containment Functional Performance for Non-Light-Water Reactors

The staff provided SECY-18-0096, "Functional Containment Performance Criteria for Non-Light-Water Reactors," to the Commission on September 28, 2018. In SECY-18-0096, the staff recommended Commission approval of a proposed methodology for establishing functional containment performance criteria for non-LWRs in a manner that is technology inclusive, risk-informed, and performance based. In SRM-SECY-18-0096, dated December 4, 2018, the Commission approved the staff's proposed methodology for establishing functional containment performance criteria for non-LWRs. The Commission also requested that the staff continue to keep it informed as the staff develops the licensing framework for non-LWRs and notify the Commission if future policy issues arise as this work progresses.

[25] See 73 FR 60612 (ADAMS Accession No. ML082750370)

Next Steps: The staff is incorporating the methodology for functional containment performance criteria in ongoing activities, such as the preparation of DG-1353; future revisions of RG 1.232, "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors," issued April 2018; and, interactions with specific designers.

6.2.7 Micro-Reactors

NRC staff has met with individual designers, the DOE, and Department of Defense (DOD) regarding "micro-reactors." Micro-reactors, which are generally small (on the order of one to tens of MW-thermal), are envisioned to perform non-traditional roles for nuclear power, such as providing power for defense sites and remote areas. Micro-reactors are anticipated to have reduced reliance on complex safety systems, use more inherent safety features, and have lower potential consequences as a result of any postulated accidents. The NRC staff has identified a number of potential policy and licensing issues that may need to be addressed for micro-reactors, including security requirements, emergency preparedness, staffing requirements, remote operation, aircraft impact, oversight, annual fee structure, manufacturing licenses, transportable reactors, siting, and environmental reviews. The staff discussed these issues with the ACRS Future Plant Subcommittee on August 29, 2019, and with stakeholders during a public meeting on October 17, 2019. NEI issued a report on micro-reactor regulatory issues on November 13, 2019.[26] NEI presented its report during a public meeting on December 12, 2019. The NEI report and stakeholder interactions will inform the staff's evaluation of these potential policy issues.

Next Steps: The staff is evaluating the issues raised in the NEI report to assess whether any require a Commission policy decision. The staff will prepare a Commission paper on any identified policy issues.

7.0 Strategic Area No. 6: Communication

7.1 Overview

This strategy supports the non-LWR vision and strategy objective of optimizing communications. The plan for addressing communications consists of the following contributing activities:

- Provide timely, clear, and consistent communication of the NRC requirements, guidance, processes, and other regulatory topics and provide multiple paths for external feedback to the NRC.

- Develop consistent NRC messaging suitable for a range of audiences.

- Promote the exchange of non-LWR technical and regulatory experience with the NRC's international counterparts and industry organizations.

7.2 Progress Summary

The NRC continues to proactively communicate with stakeholders and seek stakeholder feedback on all non-LWR readiness activities. The NRC also meets with potential applicants upon request and shares information with various international groups, including the

[26] See NEI white paper "Micro-Reactor Regulatory Issues," dated November 13, 2019 (ADAMS Accession No. ML19319C449)

Organization for Economic Co-operation and Development's Nuclear Energy Agency, the International Atomic Energy Agency, the Generation IV International Forum, and the NRC's international regulatory counterparts. The sections below describe several key communications accomplishments and ongoing activities.

7.2.1 Stakeholder Engagement

The NRC conducts public meetings with stakeholders every 6-8 weeks. To maximize participation, stakeholders can participate in person or by phone and Webinar. The NRC has conducted eight such meetings in 2019, including topic specific meetings on physical security and micro-reactors. The NRC has also conducted four briefings of ACRS Future Plant Subcommittee and three briefings of the ACRS Full Committee.

Next Steps: The staff will continue to plan stakeholder meetings to take place approximately every 6 weeks in 2020.

7.2.2 Coordination with the U.S. Department of Energy

The NRC and DOE conduct monthly calls to discuss mutual areas of interest. The NRC and DOE also conduct periodic quarterly management meetings to share information about advanced reactor readiness activities. For example, the NRC provided technical and regulatory information to support DOE's preparation of its report to Congress on micro-reactors as required by the Nuclear Defense Authorization Act. The NRC and DOE also discussed areas of future cooperation, including DOE piloting RG 1.232 and DG-1353 during the DOE authorization process for the proposed versatile test reactor (VTR). The NRC and DOE also discussed opportunities for the NRC to observe or participate in the authorization process to gain knowledge about non-LWR technology and to build staff capability for future NRC licensing activities for non-LWR designs. The NRC and DOE have established an MOU to outline these interactions. Under the MOU, NRC staff participated in DOE training on the VTR authorization process on December 4, 2019. The NRC staff also participated in several workshops co-sponsored by the DOE's Gateway for Accelerated Innovation in Nuclear (GAIN) initiative. The specific workshops are listed in Section 7.2.3 of this enclosure.

The NRC and DOE also have developed an MOU to share technical expertise and knowledge as required by the Nuclear Energy Innovation Capability Act of 2017 (NEICA). The primary purpose of the MOU is to coordinate DOE and NRC technical readiness and sharing of technical expertise and knowledge on advanced nuclear reactor technologies and nuclear energy innovation, including through the National Reactor Innovation Center. The National Reactor Innovation Center is a DOE program under NEICA designed to enable the testing and demonstration of reactor concepts to be proposed and funded, in whole or in part, by the private sector.

The NRC and the DOE Office of Science/Fusion Energy Sciences have initiated routine interactions to develop longer-term strategies for the possible deployment of fusion reactors.

Next Steps: The NRC will continue to interact with DOE to gather information to inform the NRC's non-LWR readiness activities. The NRC will also continue to support the GAIN initiative, as specified in the GAIN MOU, and attend GAIN workshops. The staff will continue to conduct periodic coordination calls and management meetings with DOE. Lastly the NRC will continue to work with DOE to implement the activities identified in the VTR and NEICA MOUs.

7.2.3 Meetings and Conferences

The NRC has actively participated in numerous workshops, conferences, and meetings to facilitate stakeholder outreach and communications related to non-LWRs. For example, the NRC has participated in the following non-LWR events:

- EPRI Advanced Reactor Technical Advisory Group meetings
- ANS annual meetings
- NRC Regulatory Information Conference
- U.S. Nuclear Infrastructure Council's Advanced Reactor Technical Summits
- ORNL's Molten Salt Reactor Workshops
- IAEA and Nuclear Energy Agency (NEA) workshops related to advanced reactors
- GAIN-EPRI-NEI-US NIC Micro-Reactor Workshop
- GAIN Fast Reactor Working Group (FRWG)/DOE Fast Reactor Workshop
- GAIN-EPRI-NEI Advanced Fuels Workshop
- NEI advanced reactor working group meeting

Next Steps: The NRC will continue to participate in non-LWR meetings, conferences, and workshops as resources permit.

7.2.4 International Coordination

As part of the NRC goal's to be a modern-risk informed regulator and building strong partnerships, the NRC shares information and engages with various international groups, including the Organization for Economic Co-operation and Development's NEA, IAEA, the Generation IV International Forum, and the NRC's international regulatory counterparts.

The NRC chairs NEA's working group for international regulators of non-LWRs, known as the Working Group on the Safety of Advanced Reactors (WGSAR). The purpose of the group is to bring interested regulators together to discuss common interests, practices, and problems and to address both regulatory interests and research needs. Currently, Canada, China, France, Germany, Italy, Japan, Korea, Russia, the United Kingdom, and the United States are members of WGSAR. Representatives from the European Union and IAEA also attend WGSAR meetings. Initially, WGSAR focused on SFR reactor safety and regulatory issues, such as severe accident prevention and mitigation and fuel qualification. However, WGSAR has expanded its scope to other types of non-LWR designs. WGSAR also interfaces with the Generation 4 International Forum (GIF). GIF representatives attend WGSAR meetings and WGSAR comments on GIF documents, such as SFR safety design guidelines. In 2019, WGSAR and GIF began cooperation on the development of risk-informed and performance-based licensing approaches for non-LWRs.

The NRC also participates in and chairs the IAEA SMR Regulators' Forum, which is hosted by the IAEA and comprises representatives from Canada, China, Finland, France, Korea, Russia, Saudi Arabia, United Kingdom and the United States. In this forum, interested regulators identify and address key regulatory challenges that may emerge in future SMR regulatory discussions. This forum focuses on issues that are applicable to both light-water-cooled and non-LWR reactors, such as licensing, safety analysis and oversight of manufacturing.

In August 2019, the NRC entered into a Memorandum of Cooperation with the Canadian Nuclear Safety Commission (CNSC) to further expand cooperation on activities associated with

advanced reactor and SMR technologies. This may include cooperation in the development of shared advanced reactor and SMR technical review approaches, collaboration on pre-application activities, and collaboration on research, training, and in the development of regulatory approaches to address unique and novel technical considerations for ensuring the safety of advanced reactors and SMRs. The NRC and the CNSC agreed that implementation of the MOC would be carried out under the existing NRC-CNSC Steering Committee. Under the Steering Committee, staff from both agencies have already engaged in discussions on this topic and the potential for future cooperation.

At the 2019 Steering Committee meeting in Ottawa, Canada on October 29, 2019, the Steering Committee approved terms of reference for a new Subcommittee on Advanced Reactor Technologies and Small Modular Reactors (ART-SMR Subcommittee). The ART-SMR Subcommittee held its first meeting on October 30-31, 2019. Three proposed work plans were discussed:

- Sharing regulatory insights from the technical review of the NuScale small modular reactor design certification review,
- Developing common guidance for the contents of new build license applications for advanced reactor projects, and
- Cooperating in pre-application review activities pertinent to advanced reactors using Terrestrial Energy's integral molten salt reactor as a case study.

Working groups are being formed for these proposed projects.

Next Steps: The NRC will continue to exchange information with international counterparts and participate in NEA and IAEA working groups to foster international cooperation. The NRC will also continue frequent bilateral interactions with regulatory bodies, such as the CNSC, to implement activities under the NRC/CNSC Memorandum of Cooperation. The next meeting of the ART-SMR Subcommittee is being planned for March 2020 at NRC.