ADVANCED REACTOR IMPLEMENTATION ACTION PLAN—PROGRESS SUMMARY AND FUTURE PLANS

Enclosure 1

1.0 Introduction

This enclosure summarizes activities underway and planned by the U.S. Nuclear Regulatory Commission (NRC) staff to make the safe use of advanced nuclear technology possible. This enclosure covers progress made during calendar year (CY) 2022, in the six strategic areas:[1]

(1) Acquire/develop sufficient knowledge, technical skills, and capacity to perform reviews.
(2) Acquire/develop sufficient computer codes and tools to perform reviews.
(3) Develop guidance for a flexible non-light-water reactor (non-LWR) review process within existing regulations.
(4) Facilitate industry codes and standards needed to support the non-LWR life cycle.
(5) Identify and resolve technology-inclusive policy issues that impact reviews.
(6) Develop and implement strategic communications with internal and external stakeholders.

Figure 1 shows the broad range of activities underway. Checkmarks indicate completed activities. All other activities have been initiated and are being implemented.

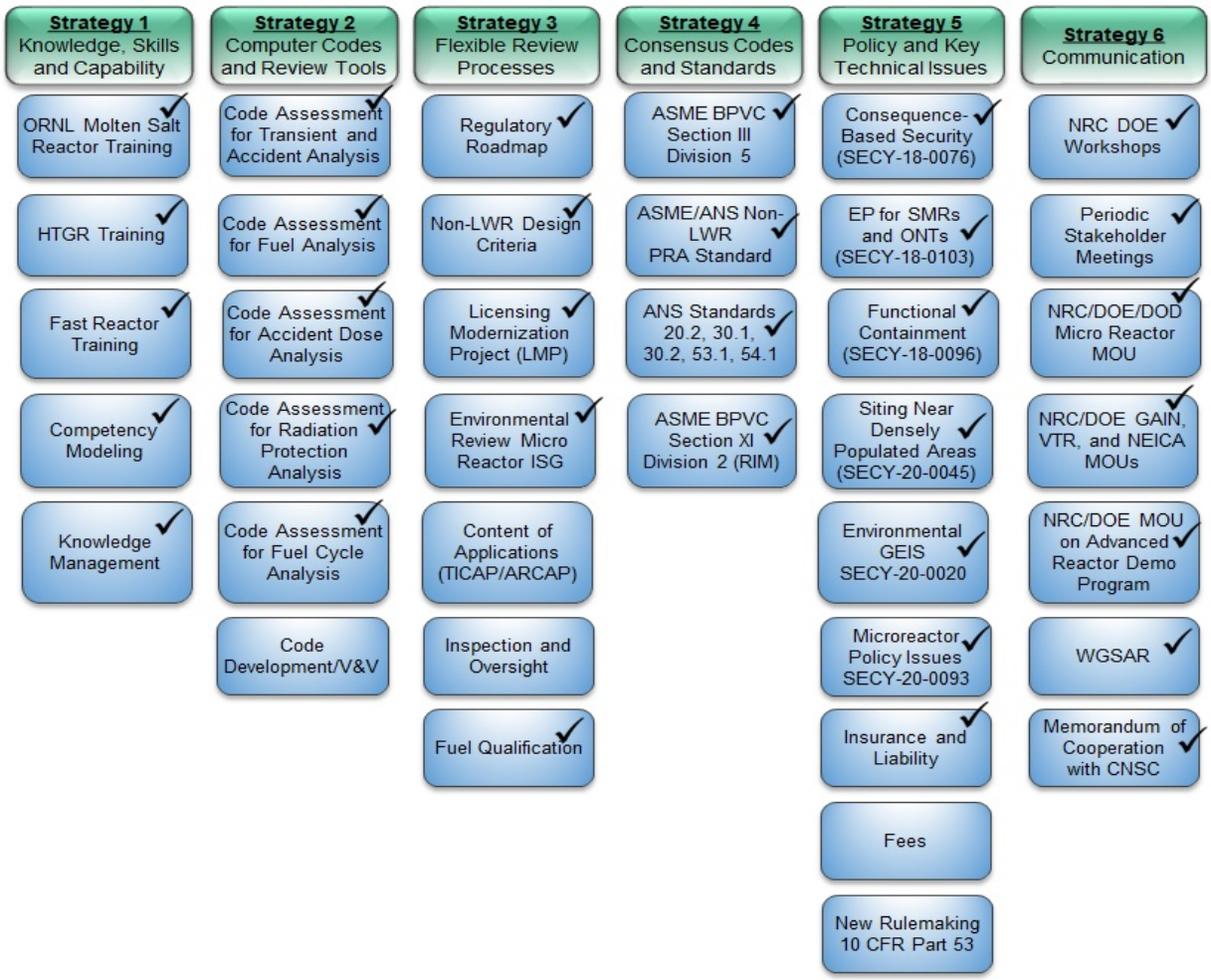

Figure 1: Implementation action plan activities

[1] Agencywide Documents Access and Management System Accession No. ML17165A069

In addition, the NRC staff continues to engage with developers through flexible and multi-staged non-LWR regulatory review processes for preapplication interactions. Based on indications from prospective applicants, the NRC staff expects preapplication engagement to increase in CY 2023. Current and anticipated licensing actions are discussed in enclosure 2.

Significant accomplishments in 2022 include the following:

- On January 3, 2022, the NRC staff submitted to the Commission SECY-22-0001, "Final Rule: Emergency Preparedness for Small Modular Reactors and Other New Technologies,"[2] for Commission consideration. This rule would amend the NRC's regulations to add alternative emergency preparedness requirements for facilities such as non-light-water reactors (non-LWRs) and nonpower production or utilization facilities.

- On March 1, 2022, the NRC staff issued for public comment supplemental information for DG-1380, "Acceptability of ASME Code, Section III, Division 5, 'High Temperature Reactors," (87 Federal Register (FR) 11490) which proposed to endorse American Society of Mechanical Engineers (ASME) Code Cases N-872 and N-898. Technical Letter Report (TLR)-RES/DE/REB-2022-01, "Review of Code Cases Permitting Use of Nickel-Based Alloy 617 in Conjunction with ASME Section III, Division 5," dated January 31, 2022,[3] presents the technical basis for the NRC's proposed endorsement of Code Cases N-872 and N-898.

- In March 2022, the NRC staff issued as final NUREG-2246, "Fuel Qualification for Advanced Reactors,"[4] which contains a fuel qualification assessment framework that can be used by non-LWR developers and NRC staff as licensing evaluation techniques and guidance for fuel designs that differ from previous NRC frameworks applicable to traditional light-water reactor fuel.

- On July 8, 2022, the NRC staff issued the final version of NUREG-2159, Revision 1, "Acceptable Standard Format and Content for the Fundamental Nuclear Material Control Plan Required for Special Nuclear Material of Moderate Strategic Significance."[5]

- On August 2, 2022, the NRC staff submitted SECY-22-0072, "Proposed Rule: Alternative Physical Security Requirements for Advanced Reactors (RIN 3150-AK19),"[6] for Commission consideration. This rule would establish voluntary alternative physical security requirements for advanced reactors.

- On September 28, 2022, the NRC staff hosted the 2022 NRC Standards Forum to facilitate the identification of needed consensus codes and standards and to explore collaboration to accelerate their development. This forum covered initiatives being undertaken by industry in support of codes and standards, efforts by the NRC staff to streamline the NRC staff's review and endorsement of codes and standards, perspectives from advanced reactor developers as to their needs and priorities for codes and standards, perspectives from nuclear as well as aerospace industry representatives

2 ML21200A055
3 ML22031A137
4 ML22063A131
5 ML22143A963
6 ML21334A003

on the rapid qualification of advanced manufacturing technologies, research developments related to advanced construction technologies, and discussions of recent and planned developments on a number of specific codes and standards.[7]

- On September 30, 2022, the NRC staff released a draft proposed rulemaking package to add Title 10 of the *Code of Federal Regulations* (10 CFR) Part 53, "Risk-Informed, Technology-Inclusive Regulatory Frameworks for Commercial Nuclear Plants" (Part 53)[8] to existing NRC regulations. The draft rulemaking package, including the draft proposed rule language, associated preamble, and the following five implementing guidance documents, was publicly released to support the final Advisory Committee on Reactor Safeguards (ACRS) meetings on the proposed rule in October and November 2022:

  (1) Draft Guide (DG)-1413, "Technology-Inclusive Identification of Licensing Events for Commercial Nuclear Plants"[9]

  (2) DG-1414, "Alternative Evaluation for Risk Insights Methodology"[10]

  (3) Division of Reactor Oversight (DRO) Interim staff guidance (ISG) DRO-ISG-2023-01, "Operator Licensing Programs"[11]

  (4) DRO-ISG-2023-02, "Guidance for Assessing Exemption Requests from the Nuclear Power Plant Licensed Operator Staffing Requirements Specified in 10 CFR 50.54(m)"[12]

  (5) DRO-ISG-2023-03, "Development of Scalable Human Factors Engineering Review Plans"[13]

  The NRC staff sent the Part 53 rulemaking package to the Commission on February 28, 2023.

- On October 3, 2022, the NRC staff prepared for discussion at public meetings the pre-decisional draft guide on Technology-Inclusive, Risk-Informed, and Performance-Based Methodology for Seismic Design of Commercial Nuclear Plants[14] and the pre-decisional draft guide on Seismically Isolated Nuclear Plants.[15]

- On October 11, 2022, the NRC staff issued TLR-RES/DE/REB/ 2022-008, "Status of Advanced Non-Light Water Reactor Research Activities: Materials, Chemistry, and Component Integrity,"[16] which documents activities being conducted to optimize review readiness. This includes identifying, developing, and acquiring sufficient computer codes and tools to address materials, chemistry, and component integrity issues.

---

7 ML22224A172
8 ML22272A034
9 ML22272A042
10 ML22272A045
11 ML22272A047
12 ML22272A049
13 ML22272A051
14 ML22276A149
15 ML22276A154
16 ML22258A194

- On October 17, 2022, the NRC staff issued an FR notice (87 FR 62894) to discuss significant public comments received on the RG 1.247 (For Trial Use), "Acceptability of Probabilistic Risk Assessment Results for Advanced Non-Light Water Reactor Risk-Informed Activities,"[17] which endorses the ASME/American Nuclear Society (ANS) standard ASME/ANS RA-S-1.4-2021, "Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants." On November 8, 2022, the staff held a public meeting with stakeholders to discuss the comments received and to explain why no changes were made to the trial use regulatory guide as a result of the comments.

- On October 24, 2022, the NRC staff issued RG 1.246, "Acceptability of ASME Code, Section XI, Division 2, 'Requirement for Reliability and Integrity Management (RIM) Programs for Nuclear Power Plants,' for Non-Light Water Reactors"[18] (87 FR 66227). RG 1.246 endorses the ASME Boiler and Pressure Vessel Code (BPVC), Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," Division 2, "Requirements for Reliability and Integrity Management (RIM) Programs for Nuclear Power Plants" (BPVC-XI-2).

- On December 5, 2022, the NRC staff issued NUREG/CR-7299, "Fuel Qualification for Molten Salt Reactors,"[19] in cooperation with Oak Ridge National Laboratory (ORNL), which supports development of an efficient, appropriate methodology or process for qualification of liquid salt fuel systems.

- On January 3, 2023, the NRC staff submitted to the Commission SECY-23-0001, "Options for Licensing and Regulating Fusion Energy Systems,"[20] providing options for Commission consideration on the appropriate treatment of fusion energy systems within NRC's regulatory structure.

- Throughout 2022, the NRC staff briefed the ACRS Full Committee and the Subcommittees on Future Plant Designs; Regulatory Rulemaking, Policies, and Practices; Fuels Materials and Structures; and Kairos Power Licensing during separate meetings. The topics covered included the Part 53 rulemaking, integration of source term activities in support of advanced reactor initiatives, acceptability of ASME BPVC-XI-2 (RG 1.246), Kairos Power construction permit application; Kairos Power fuel qualification methodology, and fusion energy systems.

- The NRC chairs the Small Modular Reactor Regulators' Forum. In 2022, the forum started work on topics in the areas of licensing, safety analysis, and manufacturing oversight of small modular reactors (SMRs). In addition, the International Atomic Energy Agency (IAEA) accepted the forum's offer of assistance in the Nuclear Harmonization and Standardization Initiative. The forum is leading a working group in the regulatory track of the NHSI and addressing the issue of leveraging other regulators' reviews.

- The NRC chairs the Organisation for Economic Co-operation and Development (OECD)/Nuclear Energy Agency's (NEA's) Working Group on the Safety of Advanced Reactors. In 2022, the working group completed a report on "Common Regulatory

17 ML21246A216
18 ML22061A244
19 ML22339A161
20 ML22273A178

Practices to Ensure Appropriate Qualification and Through-Life Performance of Materials in Advanced Reactors—Survey Analysis." At the end of CY 2022, the Working Group on the Safety of Advanced Reactors was sunset, and ongoing work is being transitioned to the newly formed Committee on Nuclear Regulatory Activities Working Group on New Technologies.

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

2.1 Overview

This strategic area supports the objective of enhancing non-LWR technical readiness. By investing in its people, the NRC can position itself to address the challenges of licensing new technologies. The near-term objectives in this area are to identify work requirements, identify critical skills and NRC staff capacity requirements, assess the NRC staff's current non-LWR technical readiness, and close gaps in technical readiness. Activities within Strategic Area No. 1 are informed by ongoing U.S. Department of Energy (DOE) and industry technology development. The NRC also monitors the plans of prospective applicants to assess future workload and prioritize its readiness in technology-specific areas.

In 2022, the NRC staff successfully increased their knowledge of non-LWRs, as described below. The NRC staff's main objective in Strategic Area No. 1 is to continue to expand its capabilities so that it is prepared to review the advanced reactor applications expected in the next few years.

2.2 Progress Summary

The NRC staff enhanced its advanced reactor technical readiness in accordance with section 103(a)(5) of the Nuclear Energy Innovation and Modernization Act (NEIMA). This section requires the training for NRC staff or hiring of experts to support the activities specified in section 103(a)(1) – (4) of NEIMA, as well as to support preparations for preapplication interactions and license application reviews for commercial advanced reactors.

The inclusion of advanced reactor licensing in the same division as non-power production and utilization facility licensing continues to allow the NRC staff to leverage synergies and experience in the licensing of novel technologies, by using experience gained from the initial licensing of medical radioisotope facilities, for example. Further, to conduct non-LWR application reviews and prepare for applications, the NRC reassigned subject matter experts from critical disciplines to the Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU) to increase capacity and formed a second licensing branch for advanced reactors in DANU. DANU also used subject matter experts from across the agency and external contractors to add additional capacity. During 2022, the NRC staff used strategic workforce planning to identify and fill vacancies in DANU to increase organizational capacity for the projected advanced reactor workload.

In 2022,[21] the NRC staff focused on two types of activities in support of Strategic Area No. 1: (1) training and (2) knowledge management.

[21] This enclosure covers accomplishments through December 31, 2022, and discusses work currently planned for the remainder of fiscal year 2023 with available budgeted resources.

2.2.1 Training

In 2022, the NRC staff undertook training on technical topics related to advanced reactor technologies.

In August 2022, the Office of Nuclear Regulatory Research (RES), in conjunction with Idaho National Laboratory (INL), held a training course on graphite behavior, graphite degradation mechanisms, graphite modeling in the Multiphysics Object Oriented Simulation Environment (MOOSE) computer code, and ASME qualification methodology for nuclear graphite applications.

In September 2022, the NRC staff, together with Sandia National Laboratories and ORNL, held public workshops on using the NRC's Standardized Computer Analyses Licensing Evaluation (SCALE) and MELCOR computer codes to predict source terms for a sodium-cooled fast reactor (SFR) design and a molten-salt-fueled reactor (MSR) design. The NRC staff also held internal workshops on developing representative non-LWR nuclear fuel cycles and potential accidents to demonstrate using SCALE and MELCOR for safety analysis of fuel cycle concepts.

The NRC staff also attended other training offered by the conferences, workshops, and meetings listed in section 7.2.4.

Recorded training is available in the NRC's Talent Management System on SFRs, micro-reactors, and high-temperature gas-cooled reactors (HTGRs), for NRC staff members new to advanced reactors who are involved in the licensing review of those designs. In December 2022, live training was provided on MSRs, targeted to NRC staff reviewing the Abilene Christian University Molten Salt Research Reactor application. Background reference material is also available, such as the report "NRC Regulatory History of Non-Light Water Reactors (1950–2019)," dated June 10, 2019,[22] which introduces relevant concepts and historical context to NRC staff unfamiliar with non-LWRs.

Next steps: The NRC staff will continue to assess training needs and develop courses and other training opportunities, such as seminars on specific technical topics relevant to non-LWR technology and licensing.

2.2.2 Knowledge Management

Extensive information is available on technical, policy, and regulatory issues associated with licensing non-LWR designs. Knowledge Management activities aim to consolidate existing materials to make them more easily accessible and searchable and to develop additional resources as needed to support NRC staff development.

[22] ML19282B504

This year, the NRC staff continued to reorganize and regularly update the NRC's public website on advanced reactors[23] to improve developers' and stakeholders' access to information and to increase both public and internal transparency. The website provides up-to-date information on public meetings, links to Advanced Reactor Content of Application Project (ARCAP) draft guidance and to recently issued documents, the Advanced Reactor Summary of Integrated Schedule and Regulatory Activities, information on ongoing licensing activities and preapplication activities with specific vendors, and reports prepared for the NRC by the national laboratories.

The NRC staff also developed and published several pages on advanced reactors and the non-LWR regulatory framework in the NRC's internal Nuclepedia Knowledge Management platform.[24] These include a main page that serves as a portal to more detailed information on advanced reactors; key NRC staff training resources; and pages for specific non-LWR technologies, including SFRs, liquid-metal-cooled fast reactors, MSRs, microreactors, and fusion energy systems.

The NRC staff is using DANU's internal SharePoint and Nuclepedia Knowledge Management platforms as the primary tools for knowledge management and to provide program status and information in key focus areas to interested NRC staff and management. In 2022, in addition to updating the public web pages and maintaining internal SharePoint and Nuclepedia platforms, the NRC staff conducted internal briefings on subjects such as advanced reactor program status, licensing activities, and specific non-LWR technologies. These briefings are typically widely attended by the NRC staff, and several were recorded for knowledge management purposes.

Next steps: In 2023, the NRC staff will continue to update the internal SharePoint and public websites and add non-LWR information to internal Nuclepedia to make the information more accessible within the agency.

3.0 Strategic Area No. 2: Analytical Tools

3.1 Overview

This strategic area supports the objective of enhancing non-LWR technical and regulatory readiness. The main goal in this strategic area is to develop the computer code capability needed for the NRC staff to independently analyze advanced reactor designs. The NRC uses computer codes and tools to perform confirmatory, sensitivity, and uncertainty analyses to investigate design margins, commensurate with the risk and safety significance of the phenomena applicable to each specific design.

The NRC's approach in Strategic Area No. 2 is to (1) identify the tools, information, and data that the NRC staff may need in reviewing non-LWR designs; (2) evaluate the existing computer codes, tools, and supporting information to identify gaps in both analytical capabilities and supporting information and data; and (3) identify opportunities to collaborate with both domestic and international organizations working on non-LWR technologies, in order to close the gaps while avoiding conflicts of interest. Through these activities, the NRC staff will also develop technical bases to resolve major materials-related issues, such as those related to chemistry, component integrity, and seismic safety.

---

[23] See https://www.nrc.gov/reactors/new-reactors/advanced.html.

[24] See https://nuclepedia.usalearning.gov/index.php?title=Advanced_Reactors.

The NRC staff continues interactions related to computer codes and analytical tools with the DOE, the Electric Power Research Institute, the national laboratories, reactor vendors, prospective licensees, and the international community. In addition, the NRC staff has built a cooperative relationship with the DOE, consistent with the NRC's statutory authority, to coordinate funding activities and reduce costs to the NRC and the U.S. Government.

3.2 Progress Summary

In 2022, the NRC staff continued to develop knowledge, technical skills, and capacity to strengthen the technical bases for regulatory decisions while increasing review agility. The NRC staff continued its efforts to identify the information, experimental data, and analytical tools needed to support non-LWR reviews and to address those gaps. In addition, the NRC staff continues to assess performance needs and issues related to seismic safety, materials, chemistry, and component integrity in non-LWR designs. Through strong engagement with domestic and international partners, the NRC staff has collected information on non-LWR operating experience and is heavily involved in activities related to consensus standards and codes. For example, in 2022, safety demonstration tests were conducted by the High Temperature Engineering Test Reactor of Japan Atomic Energy Agency to verify the inherent safety features of HTGRs quantitatively, as well as to contribute to advancing HTGR technologies. Also, in September 2022, INL developed the numerical model of the High Temperature Engineering Test Reactor loss of forced cooling experiment with the INL codes Griffin, BISON, and RELAP-7 based on the MOOSE framework. The NRC is reviewing the INL report and plans to perform analysis to demonstrate the flow pattern during the loss of forced coolant event. Section 7.2.5 contains additional details on non-LWR cooperation with international partners.

To improve its understanding of the unique codes, experimental data, features, phenomena, and knowledge gaps relevant to non-LWR technologies, the NRC staff has performed the following activities:

- In 2020, the NRC staff completed a series of reports documenting a comprehensive plan for developing computer code capabilities to support non-LWR reviews. This plan describes the overall code development approach, the codes themselves, knowledge gaps, and necessary development activities. These reports are available to the public and cover the following topics:
  - The introduction, "Approach for Code Development in Support of NRC's Regulatory Oversight of Non-Light Water Reactors," dated January 31, 2020, gives an overview of the NRC's approach to code development in support of advanced reactor reviews.[25]
  - Volume 1, Revision 1, "Computer Code Suite for Non-LWR Plant Systems Analysis," dated January 31, 2020, focuses on computer code readiness for plant systems analysis.[26]

[25] ML20030A174
[26] ML20030A176

- Volume 2, “Fuel Performance Analysis for Non-LWRs,” dated January 31, 2020, focuses on computer code readiness for fuel performance analysis.[27]

- Volume 3, “Computer Code Development Plans for Severe Accident Progression, Source Term, and Consequence Analysis,” dated January 31, 2020, focuses on computer code readiness for severe accident progression, source term, and accident consequence analysis.[28]

- Volume 4, “Licensing and Siting Dose Assessment Codes,” issued August 2020, focuses on computer code readiness for licensing and siting dose assessments.[29]

- Volume 5, “Radionuclide Characterization, Criticality, Shielding, and Transport in the Nuclear Fuel Cycle,” dated November 3, 2020, focuses on computer code readiness for criticality and shielding considerations for the front and back end of the fuel cycle.[30]

- To prepare to perform independent advanced reactor safety analyses using the capabilities covered in Volumes 1, 2, and 3 of this plan, the NRC staff continues to develop reference plant models from publicly available information. The purpose of this effort is to test the codes and models and to identify and correct errors ahead of future licensing support. These reference plant models are expected to save approximately 6 months of NRC staff time to develop codes and build plant-specific models if independent confirmatory analyses are needed to support the review of an application submittal.

- Under Volume 1, the NRC staff has developed initial reference plant models from publicly available information for designs such as heat-pipe microreactors, SFRs, HTGRs, and fluoride salt-cooled pebble bed reactors. Under an addendum to the Nuclear Energy Innovation Capabilities Act of 2017, highlighted in section 7 of this enclosure, the NRC has access to analytical models being developed under the DOE’s Virtual Test Bed Program to support the agency’s readiness for advanced reactors. The NRC staff can revise these reference plant models as applicant design information becomes available. The models help to build NRC staff and contractor expertise in the use of computer codes, analytical modeling, and the design and operation of the different types of advanced reactors.

- Using capabilities developed under Volume 2, the NRC staff completed an evaluation of metallic and tristructural isotropic (TRISO) fuel models and identified potential improvements for the Fuel Analysis under Steady-state and Transients (FAST) fuel performance computer code. The NRC staff added material property correlations, spherical solvers, and TRISO mechanical failure modes to FAST. The NRC staff is collaborating with INL to assess FAST and BISON against experimental breeder reactor data.

- Under Volume 3, the NRC staff developed SCALE and MELCOR reference plant models from publicly available information for an MSR and an SFR. The NRC staff applied these

27 ML20030A177
28 ML20030A178
29 ML20028F255
30 ML20308A744

models to a range of accident scenarios to demonstrate code capability and to provide a first look at non-LWR accident progression. The NRC staff used the results of this work to hold public workshops to facilitate dialogue on the NRC's approach to non-LWR accident progression and source term. These two public workshops plus the three public workshops held in 2021 covered the five basic non-LWR designs outlined in Volume 3.

- Using capabilities developed under Volume 3, Sandia National Laboratories worked with the NRC staff to complete an assessment of the MELCOR Accident Consequence Code System (MACCS) capabilities to handle the effect of alternate chemical and physical forms on deposition and internal dosimetry. After review, the NRC staff concluded that the existing MACCS code can model the effect of many alternate chemical and physical forms on deposition and internal dosimetry. Sandia National Laboratories and NRC staff also developed and demonstrated a quantitative methodology for identifying isotopes for MACCS consequence analysis using a SCALE core inventory computer model developed for a reference heat-pipe reactor. Lastly, the NRC staff completed an initial evaluation of use of the MACCS code to analyze an accident scenario from a heat-pipe reactor reference design. As new advanced reactor designs and source terms become available, work is needed to assess the feasibility of the MACCS code and address issues as they arise.

- In the areas of licensing and siting dose assessment computer codes described in Volume 4, Pacific Northwest National Laboratory completed the prototype (beta version) of the Software Integration for Environmental Radiological Release Assessments (SIERRA) computer code for testing by the NRC staff (meteorologists). This initial version of the SIERRA computer code contains the consolidated atmospheric transport and dispersion module (i.e., ARCON, PAVAN, and XOQDOQ Fortran codes). In fiscal year 2023, the NRC staff and Pacific Northwest National Laboratory will be finalizing the atmospheric transport and dispersion module for the SIERRA computer code and incorporating the LWR coolant source term (i.e., pressurized-water reactor gaseous effluent (PWRGE), pressurized-water reactor liquid effluent (PWRLE), boiling-water reactor gaseous effluent (BWRGE), and boiling-water reactor liquid effluent (BWRLE)) from the Gaseous and Liquid Effluent (GALE) computer code, as well as developing generic reactor coolant source term inventories for the various non-LWR designs (i.e., helium-cooled prismatic reactor and helium-cooled Pebble Bed Reactors with TRISO fuel, lead-cooled fast reactor and heat-pipe fast reactor with uranium dioxide fuel, and MSR (thermal and fast) with liquid fuel).

- Under Volume 5, the NRC staff developed five representative nuclear fuel cycle designs for the heat-pipe reactor, SFR, MSR, HTGR, and fluoride salt-cooled reactor from publicly available information and identified potential accidents and hazards. The NRC staff will apply these designs to analyze a range of accident scenarios to demonstrate code capability. The NRC staff will use the results of this work to hold a public workshop for the HTGR in early 2023.

Next steps: The NRC staff continues to assess the information, experimental data, and analytical tools needed to support non-LWR reviews. The NRC plans to continue developing its own codes, while leveraging DOE codes to fill any gaps. The NRC staff will focus on technology-inclusive capabilities and on enhancing its understanding of, and regulatory readiness to review, the materials likely to be proposed for use in advanced reactors, which include high-temperature alloys, graphite, and molten salt.

The NRC staff will continue to develop proof-of-concept reference plant models for plant systems analysis; it expects to complete two more models in the next year beyond the 10 models completed previously. For fuel performance, the NRC staff will continue to address gaps identified in the assessment reports. For source term and accident progression, the NRC staff will continue to distribute the reference plant models to external stakeholders and use their feedback to improve modeling capability and performance. For consequence analysis, over the next year, the NRC staff plans to continue evaluating the feasibility of improving MACCS models for tritium releases and will also examine the significance of chemical and physical transformations during atmospheric transport. For licensing and siting dose assessment computer codes, the next step is to complete the quality assurance and functionality testing of the consolidated atmospheric dispersion engine and continue the development of the consolidated source term engine (reactor coolant source terms for both LWRs and non-LWRs). For the nuclear fuel cycle, the NRC staff will simulate potential accidents and hazards for demonstrating code capabilities related to the front and back end of the nuclear fuel cycle. The first readiness demonstration will be a public workshop for the HTGR in early 2023.

The NRC staff is also conducting a preliminary assessment of technical information needs and regulatory considerations for future MSR fuel cycles, including activities related to the fabrication and transportation of fuel-salt mixtures.

4.0 Strategic Area No. 3: Guidance Development within Current Regulatory Framework

4.1 Overview

This strategic area supports the objective of optimizing non-LWR regulatory readiness. One of the NRC's goals in Strategic Area No. 3 is to develop guidance for flexible non-LWR regulatory review processes, including conceptual design reviews and staged review processes, within the bounds of existing regulations. In 2022, the NRC staff continued activities to support the development of technology-inclusive, risk-informed, and performance-based licensing framework, in support of the NRC's goal of being a modern, risk-informed regulator.

4.2 Progress Summary

4.2.1 Non-Light-Water Reactor Licensing-Basis Development

In 2022, the NRC staff continued to work with stakeholders to create guidance for non-LWR developers on the content of applications that use the Licensing Modernization Project (LMP) methodology. The LMP methodology focuses 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 assessment of defense in depth. The LMP methodology is described in Nuclear Energy Institute (NEI) report NEI 18-04, Revision 1, "Risk-Informed Performance-Based Technology-Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development," issue August of 2019.[31] The NRC staff endorsed this guidance in RG 1.233, "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," issued June 2020.[32]

[31] ML19241A472
[32] ML20091L698

As a result of over 20 public meetings and four tabletop exercises beginning in 2019, the industry issued NEI 21-07, Revision 1, "Technology Inclusive Guidance for Non-Light Water Reactors: Safety Analysis Report Content for Applicants Using the NEI 18-04 Methodology,"[33] in February 2022. NEI 21-07, Revision 1, describes a means of developing portions of the safety analysis report content for advanced reactor applicants that use NEI 18-04, Revision 1. In 2022 the NRC staff developed DG-1404, "Guidance for a Technology-Inclusive Content of Application Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Advanced Reactors," that it intends to issue for public comment in 2023. This draft guide would endorse NEI 21-07, Revision 1, with appropriate clarifications and additions.

Under the technology-inclusive content of applications project (TICAP), the NRC staff plans to cover the scope and level of detail for the safety analysis report portion of an application based on the LMP methodology. The NRC staff recognizes that some portions of an application, such as occupational dose and routine plant radiological effluents, are outside the scope of TICAP and the LMP methodology. Therefore, the NRC staff is also working on the ARCAP, which expands on TICAP and includes guidance for portions of applications not covered by TICAP. In 2022 the NRC staff developed the following ARCAP ISG documents that it intends to issue for public comment in 2023:

- DANU-ISG-2022-01, "Advanced Reactor Content of Application Project, 'Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications—Roadmap'"
- DANU-ISG-2022-02, "Advanced Reactor Content of Application Chapter 2 'Site Information'"
- DANU-ISG-2022-03, "Advanced Reactor Content of Application Chapter 9 'Control of Routine Plant Radioactive Effluents, Plant Contamination and Solid Waste'"
- DANU-ISG-2022-04, "Advanced Reactor Content of Application Chapter 10 'Control of Occupational Dose'"
- DANU-ISG-2022-05, "Advanced Reactor Content of Application Chapter 11 'Organization and Human-System Considerations'"
- DANU-ISG-2022-06, "Advanced Reactor Content of Application Chapter 12 'Post-Construction Inspection, Testing, and Analysis Program'"
- DANU-ISG-2022-07, "Advanced Reactor Content of Application 'Risk-Informed ISI/IST Programs'"
- DANU-ISG-2022-08, "Advanced Reactor Content of Application 'Risk-Informed Technical Specifications'"
- DANU-ISG-2022-09, "Advanced Reactor Content of Application 'Risk-Informed, Performance-Based Fire Protection Program (for Operations)'"

[33] ML22060A190

In 2022, the NRC staff worked with industry members that are developing a proposed change control process for non-LWRs using the LMP process, which would be similar to the process in 10 CFR 50.59, “Changes, tests and experiments.” For the proposed process, identified as the technology-inclusive risk-informed change evaluation process, the NRC staff gave feedback on three draft documents, held three public meetings, and participated in two sets of tabletop exercises to test the process. Industry plans to submit a final guidance document for possible NRC endorsement in 2023.

In addition, during 2022, the NRC staff developed a vision document for the Advanced Reactor Construction Oversight Program, with support from both NRC staff and external experts in construction inspection and oversight for power reactors and research and test reactors. As part of this effort, the NRC staff examined lessons learned from recent NRC construction inspection and oversight experiences for new reactors (e.g., Vogtle Electric Generating Plant, Units 3 and 4), new non-power production and utilization facilities (e.g., the SHINE Technologies, LLC, medical isotope production facility), and operating experience with research and test reactors. The Advanced Reactor Construction Oversight Program vision document outlines the strategy for the Advanced Reactor Construction Oversight Program development effort and considers a broad range of advanced non-LWR designs and technologies, including microreactors, as well as light--water SMRs. The document also describes how the Advanced Reactor Construction Oversight Program will consider the full spectrum of construction, fabrication, and manufacturing environments, from completely factory-built reactors with minimal site preparation to larger reactors involving site preparation and onsite construction activities resembling current practice. In 2023, the NRC staff will further engage advanced reactor stakeholders in discussing the development of Advanced Reactor Construction Oversight Program guidance and will engage the Commission, as appropriate, when policy issues arise.

Next steps: The NRC staff plans to continue developing Advanced Reactor Construction Oversight Program guidance documents. The NRC staff will continue to develop ARCAP, TICAP, and technology-inclusive risk-informed change evaluation process guidance, extensively engaging with stakeholders to obtain further input. The NRC staff will engage the Commission, as appropriate, when policy issues arise.

4.2.2 Fuel Qualification Strategies

The considerable experience base for traditional LWR fuel may not apply to proposed advanced reactor technologies, which use different fuel designs and operating environments (e.g., neutron energy spectra, fuel temperatures, neighboring materials). Advanced reactor designers are considering several fuel types, including fuels based on TRISO particles, metallic uranium alloys, and liquid salt fuels. The NRC staff is consulting with the DOE and the national laboratories on the qualification of each of these fuel types. The NRC staff is also discussing fuel qualification with individual developers and other stakeholders.

The type of fuel affects many aspects of the overall design of a nuclear power plant, and fuel qualification has historically required long development times. Recognizing these challenges, in early 2020, the NRC staff began developing guidance on a performance-based fuel qualification assessment framework for advanced reactor technologies, including both power and nonpower reactors. This framework follows a top-down approach in which lower-level objectives support high-level regulatory requirements. The NRC staff solicited extensive external engagement and incorporated feedback from the NEA, the ACRS, and stakeholders, including the industry-led Accelerated Fuel Qualification Working Group. In March 2022, the NRC staff issued NUREG-2246, “Fuel Qualification for Advanced Reactors,” which the ACRS concluded provides

a logical approach to fuel qualification that includes identifying relevant experimental data and assessing associated safety margin. Public comments suggested that the NUREG guidance relies too heavily on existing LWR fuel designs that may not apply to all non-LWR designs. The NRC staff recognized that it does not have sufficient information to provide example criteria for specific advanced reactor fuel types. To close this gap, the NRC staff has initiated separate activities with ORNL on MSR fuel qualification, and the NRC staff has awarded contracts to INL and Pacific Northwest National Laboratory to exercise the framework outlined in NUREG-2246 through generic assessments of metal fuel and TRISO fuel.

With ORNL support, the NRC staff is developing fuel qualification criteria for liquid-fueled MSRs. As part of this effort, ORNL prepared ORNL/LTR-2018/1045, "Molten Salt Reactor Fuel Qualification Considerations and Challenges," issued November 2018,[34] and ORNL/TM-2020/1576, "MSR Fuel Salt Qualification Methodology," issued July 2020.[35] The NRC has contracted with ORNL to develop a draft NUREG/CR[36] for the fuel qualification of liquid-fueled MSRs. The NRC staff discussed the draft NUREG/CR with the ACRS Full Committee on November 3, 2021, and with advanced reactor stakeholders in a public meeting on November 10, 2021. The ACRS concluded that the NUREG/CR provides a reasonable and practical approach to developing a licensing basis for fuel qualification for MSRs.[37] The NRC staff issued the final NUREG/CR-7299 on MSR fuel qualification on December 5, 2022.[38]

Advanced reactor developers have already begun to submit design-specific topical reports to the NRC for review and approval of their fuel qualification plans, and more are expected. During 2022, the NRC staff continued generically applicable fuel qualification activities, while also engaging with advanced reactor developers on specific fuel qualification issues. For example, the NRC staff is currently reviewing topical reports from Kairos Power and X-energy on design-specific fuel qualification, and it has provided feedback on the Westinghouse eVinci™ white paper entitled "TRISO Fuel Qualification and Testing"[39] dated November 10, 2022. To support staged licensing approaches, the NRC staff encourages early engagement and feedback from developers on technical issues.

In response to Commission direction in Staff Requirements Memorandum (SRM)-SECY-19-0095, "Staff Requirements—SECY-19-0095—Discontinuation of Rulemaking—Enhanced Security of Special Nuclear Material," dated August 4, 2021,[40] the NRC staff is developing a notation paper presenting a full range of options for the scope of the rule on enhanced security of special nuclear material, together with the potential regulatory, resource, and timing impact of each option.

Next steps: The fuel qualification assessment framework in NUREG-2246 is being exercised for a generic assessment of metal fuel through a contract with INL and for TRISO fuel through a contract with Pacific Northwest National Laboratory. The NRC staff plans to issue the options paper for the scope of the rule on enhanced security of special nuclear material in October 2023.

---

34 ML18347A303
35 ML20197A257
36 ML21245A493
37 ML21313A361
38 ML22339A161
39 ML22287A164
40 ML21217A065

4.2.3 Additional Guidance Development Activities

In addition to the specific activities discussed in section 4.2.1, the NRC staff identified three broad regulatory framework development activities in support of Strategic Area No. 3:

(1) Establish criteria, as necessary, to reach safety, security, and environmental findings for non-LWR technologies

(2) Identify and resolve gaps in the current regulatory framework for non-LWRs and the relevant fuel cycles

(3) Update guidance to support Part 53 rulemaking efforts

The following specific activities support these three broad activities:

- On July 8, 2022, the NRC staff issued the final version of NUREG-2159, Revision 1, "Acceptable Standard Format and Content for the Fundamental Nuclear Material Control Plan Required for Special Nuclear Material of Moderate Strategic Significance."

- On September 21, 2020, in SRM-SECY-20-0020, "Staff Requirements—SECY-20-0020—Results of Exploratory Process for Developing a Generic Environmental Impact Statement for the Construction and Operation of Advanced Nuclear Reactors,"[41] the Commission directed the NRC staff to initiate rulemaking to codify the Advanced Nuclear Reactor Generic Environmental Impact Statement. The NRC staff drafted the Generic Environmental Impact Statement and the associated proposed rule package in 2021 and submitted them on November 29, 2021, for Commission review and approval. If the Commission approves the rule package and the draft Generic Environmental Impact Statement, the NRC staff will release the draft Generic Environmental Impact Statement and proposed rule for public comment.

- The NRC staff anticipated the need to conduct human factors engineering reviews of applications for facilities (e.g., non-LWRs and micro-reactors) that differ substantially from the large LWRs for which the NRC-developed NUREG-0711, Revision 3, "Human Factors Engineering Program Review Model," issued November 2012.[42] For such facilities, a scalable or graded process is needed to (1) assess the potential contribution of human performance to the risk that the facility presents to public health and safety and (2) assess, commensurate with that risk, whether the facility design or design process is adequate to identify and address this contribution. The NRC staff contracted with Brookhaven National Laboratory to develop a human factors engineering process and guidance for non-design-specific technical reviews of small advanced reactors. The resulting five-step process considers the NRC's new vision for advanced reactor reviews, including the requirements in NEIMA. In the new approach, existing NRC review processes and criteria do not structure the review process. Instead, they serve as resources that the reviewer can use when appropriate. A Brookhaven technical letter report[43] documents the approach. The NRC staff used this report as the basis to develop

41 ML20265A112
42 ML12324A013
43 ML21287A088

draft DRO-ISG-2023-03. This draft ISG describes a scalable approach to human factors that will be used for human factors engineering reviews for advanced reactors. On September 30, 2022, the NRC staff released the draft proposed Part 53 rulemaking package[44] that included this draft ISG, to support the Advisory Committee on Reactor Safeguards (ACRS) Subcommittee meeting that was held October 18-19, 2022. The NRC staff intends to finalize this guidance with the Part 53 final rule.

- The NRC staff contracted with INL to support the development of guidance on operator licensing examinations for advanced reactors. This guidance, draft DRO-ISG-2023-01, (1) outlines an acceptable process for applicants to develop both initial and continuing examination methods that can be tailored to different types of commercial nuclear plants and (2) defines review criteria by which the NRC staff can establish that an applicant's operator licensing examination program will conform to the proposed Part 53 regulations. INL reviewed existing guidance, state-of-the-art research on educational testing, and benchmarked licensing and credentialing practices in other safety-critical industries. This draft ISG was issued on September 30, 2022, as part of the draft proposed Part 53 rulemaking package described in the previous paragraph. The NRC staff intends to finalize this guidance with the Part 53 final rule.

- The NRC staff also determined that guidance would be needed to facilitate the review of facility staffing plans submitted under the flexible staffing provisions of the preliminary Part 53 rule. In response to this, the NRC staff developed draft DRO-ISG-2023-02. This draft ISG uses an approach that is performance based and incorporates well-established human factors engineering methods. This draft ISG was also issued on September 30, 2022, as part of the draft proposed Part 53 rulemaking packaged described in the previous two paragraphs. The NRC staff intends to finalize this guidance with the Part 53 final rule.

- Regarding the third broad activity discussed above in this section, the current ARCAP/TICAP guidance applies only to applications for non-LWRs under Parts 50 and 52. The NRC staff has contracted with INL to expand ARCAP/TICAP applicability beyond non-LWRs and to develop equivalent guidance documents applicable under Part 53, Framework A and Framework B that will start in early 2023.

Next steps: In 2023, the NRC staff will continue to develop guidance for content of applications including human factors engineering and operator staffing and licensing.

5.0 Strategic Area No. 4: Consensus Codes and Standards

5.1 Overview

This strategic area supports the objective of enhancing non-LWR technical and regulatory readiness. The NRC staff is applying its established process for incorporating codes and standards into its regulatory framework. NRC Management Directive 6.5, "NRC Participation in the Development and Use of Consensus Standards," dated October 28, 2016,[45] describes this process. The process has three steps: (1) identifying and prioritizing needs for new and revised technical standards, (2) participating in the development of codes and standards, and

[44] ML22272A034
[45] ML16193A497

(3) endorsing codes and standards. The NRC is working with standards development organizations, non-LWR designers, the DOE, and other stakeholders to identify and facilitate new codes needed for non-LWR development.

5.2 Progress Summary

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

The ASME BPVC provides NRC-accepted rules for the design, construction, testing, certification, and quality assurance of nuclear reactors with systems operating below 425 degrees Celsius (°C) (800 degrees Fahrenheit (°F)). However, non-LWR designs may incorporate novel materials or systems operating above 425°C (800°F). At these elevated temperatures, the structural capacity of systems and components will change as a function of time, temperature, and previously applied stress. BPVC Section III, Division 5 (BPVC-III-5) provides rules for the design, construction, testing, certification, and quality assurance of high-temperature reactors. It also covers the use of metallic, graphite, and composite materials.

Industry technology working groups for the major advanced reactor types (i.e., HTGRs, MSRs, and fast reactors) and ASME have requested that the NRC endorse the 2017 Edition of BPVC-III-5 to improve the efficiency and effectiveness of the agency's review process, to provide 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 working groups and subgroups associated with the development of BPVC-III-5. NRC staff members representing the agency on the ASME Qualification of Active Mechanical Equipment Committee and BPVC-III-5 committees are also supporting the development of rules for active components operating above 425°C (800°F).

Working with its contractors, the NRC staff continued to update codes and software tools to strengthen technical bases for non-LWR regulatory decisions. The following specific activities support this objective:

- Argonne National Laboratory completed the report TLR-RES/DE/REB-2021-17, "Assessing the ASME Section III, Division 5, Class A Primary Load Design Rules Against Creep Notch Effects,"[46] dated November 30, 2021, which assesses how well the current BPVC rules for high-temperature reactors deal with the effects of complex, multiaxial stresses on creep fatigue. The report follows work completed in 2020 on environmental creep fatigue. In 2021, the NRC distributed a software tool, completed in 2020, that executes the design rules of BPVC-III-5. This was distributed to stakeholders through the agency's public website. The NRC staff is currently enhancing the software and expects to distribute it by the end of 2023 or 2024.

- Under contract with the NRC, INL is providing technical support related to the use of graphite in advanced non-LWRs. INL has conducted seminars with the NRC staff on graphite degradation, aging, and failure mechanisms relevant to advanced non-LWRs. The NRC staff is also engaged with INL to develop tools for modeling graphite behavior in advanced non-LWRs, as well as training the NRC staff in the use of these tools.

[46] ML21319A160

In 2022, the NRC staff reviewed Code Cases N-872 and N-898, which permit the use of Alloy 617 with BPVC-III-5 for low-temperature service and elevated-temperature service, respectively. Alloy 617 will supplement the five materials currently allowed by BPVC-III-5 for use in high-temperature Class A components. Because Alloy 617 has better high-temperature strength than the currently allowed materials, it can be used to higher maximum temperatures, which may be important for some non-LWR designs. Code Cases N-872 and N-898, approved by ASME in 2020, represent the first new materials to be allowed for use with BPVC-III-5 since its initial publication in 2011.

The NRC staff contracted with commercial entities to provide expert recommendations on endorsement of Code Cases N-872 and N-898. The NRC issued an FR notice (87 FR 11490) describing the additions to DG-1380 related to the endorsement of the Alloy 617 Code Cases for a 30-day public comment period. The comment period ended on March 31, 2022. The NRC staff documented the technical basis for its review of Code Cases N-872 and N-898 in TLR/RES/DE/REB-2022-01.

Next steps: The NRC staff plans to issue the final NUREG-2245 and RG 1.87, Revision 2 (including the endorsement of Code Cases N-872 and N-898), in 2023. The NRC staff has updated stakeholders, and will continue to do so, in the quarterly ASME BPVC meetings, the NRC's Standards Forum, the advanced reactor stakeholder meetings, and other public venues.

5.2.2 American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI, Division 2, for Reliability and Integrity Management Programs

BPVC Section XI, Division 2 (BPVC-XI-2) provides a methodology for developing a requirement for a Reliability and Integrity Management program, similar to a traditional preservice and in-service inspection program under the ASME BPVC, Section XI, Division 1, "Rules for Inspection and Testing of Components of Light-Water-Cooled Plants" (BPVC-XI-1), for all types of nuclear power plants. The Reliability and Integrity Management program lets plant owners implement alternative strategies from BPVC-XI-1 to maintain the reliability of plant structures, systems, and components. It contains provisions beyond those of a traditional program, such as significant use of probabilistic risk assessment (PRA) to develop reliability targets for structures, systems, and components. BPVC-XI-1 is incorporated by reference in 10 CFR 50.55a, "Codes and standards," but the NRC's regulations and guidance currently do not reference BPVC-XI-2. ASME has requested that the NRC endorse the 2019 Edition of BPVC-XI-2 in 10 CFR 50.55a.

The NRC recognizes that non-LWR designers would benefit from a standardized set of requirements for design, construction, and in-service inspection. The NRC staff has reviewed BPVC-XI-2 for non-LWR applications and has endorsed it, with conditions, in RG 1.246, which the agency published on October 24, 2022.

Next steps: The NRC will continue to participate in ASME BPVC-XI-2 committees and standards development working groups, as appropriate, to support further developments related to Reliability and Integrity Management programs.

5.2.3 American Nuclear Society Standards

The NRC participates in several ANS standards development working groups and consensus committees. The table below shows the status of each.

Standard/Committee	Status
Research and Advanced Reactor Consensus Committee (RARCC)	The last meeting took place in November 2022; the next meeting is anticipated in November 2023.
Risk-Informed, Performance-Based Principles and Policy Committee	The last meeting took place in November 2022; the next meeting is anticipated in November 2023.
ANS 53.1, “Nuclear Safety Design Process for Modular Helium-Cooled Reactor Plants”	Issued in 2011, reaffirmed in 2016 and again in 2021. The ANS plans to update this standard. The RARCC formed a working group and began revising the standard in September 2022. Significant modifications are needed to align the standard with RG 1.233.
ANS 20.1, “Nuclear Safety Criteria and Design Process for Fluoride Salt-Cooled High-Temperature Reactor Nuclear Power Plants”	Project Initiation Notification System (PINS) form submitted to ANSI on February 26, 2014. The development of this standard is on hold because of limited applicability to industry.
ANS 20.2, “Nuclear Safety Design Criteria and Functional Performance Requirements for Liquid-Fuel Molten-Salt Reactor Nuclear Power Plants”	PINS form submitted to ANSI on July 7, 2016. The standard was submitted for committee balloting and parallel public review in August 2022. The standard is currently with the working group for comment resolution.
ANS 30.1, “Integrating Risk and Performance Objectives into New Reactor Nuclear Safety Designs” (proposed)	Proposed; PINS form submitted to ANSI on July 31, 2016. The ANS is in the process of converting this standard from a requirements standard to a guidance standard.
ANS 30.2, “Categorization and Classification of Structures, Systems, and Components for New Nuclear Power Plants” (proposed)	Proposed; PINS form submitted to ANSI on July 7, 2016. The draft standard is under development and anticipated by summer 2023.

Next steps: The NRC will continue to participate in ANS committees and standards development working groups, as appropriate, to support development of standards for non-LWR technologies.

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

In 2013, the ASME/ANS Joint Committee on Nuclear Risk Management issued ASME/ANS RA-S-1.4-2013 for trial use. The technical requirements for this standard were developed using source material from the existing ASME/ANS Level 1 full-power LWR PRA standard—namely, ASME/ANS RA-Sa-2009, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," as revised in ASME/ANS RA-Sb-2013 (Addendum B)—as well as from draft LWR standards for low-power and shutdown PRA, Level 2 PRA, and Level 3 PRA.

To support a variety of reactor concepts, including HTGRs, SFRs, and MSRs, the Joint Committee on Nuclear Risk Management has updated ASME/ANS RA-S-1.4-2013 to make it more technology inclusive, 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). To cover the wide range of applications defined by non-LWR stakeholders, this standard has a very broad scope, comparable to that of a full-scope Level 3 PRA for an LWR with a full range of plant operating states, radiological sources, and hazards. Because the standard supports modular reactor concepts, it addresses the evaluation of integrated risk for multi-reactors or multiunit plants, including concurrent accidents on two or more reactor units or modules.

Several national and international organizations are using the standard as they develop non-LWR PRAs. These organizations provided valuable feedback to the Joint Committee on Nuclear Risk Management writing group for incorporation into the final draft of the standard. In September 2020, the Joint Committee on Nuclear Risk Management voted to approve the final draft. The updated ASME/ANS RA-S-1.4 was published in February 2021 as a consensus standard. The NEI developed guidance for peer reviews for the non-LWR PRAs and submitted NEI 20-09, "Performance of PRA Peer Reviews Using the ASME/ANS Advanced Non-LWR PRA Standard," to the NRC in May 2021.

The NRC staff reviewed ASME/ANS RA-S-1.4 and NEI 20-09 for endorsement. The NRC staff made the pre-decisional version of RG 1.247 (For Trial Use) publicly available in August 2021 for the briefing of the ACRS Future Plant Designs Subcommittee and the Full Committee in September 2021 and October 2021, respectively. The NRC staff received comments from stakeholders, including the Joint Committee on Nuclear Risk Management, the NEI, and industry representatives, and has considered them in its development of the RG (For Trial Use). The NRC issued the RG (For Trial Use) for public comment in March 2022. The NRC staff considered comments received from the public and discussed significant comments in the FR notice (87 FR 62894; October 17, 2022).

Next steps: Applicants may use this guidance on a trial basis. Before finalizing the RG, the NRC staff will incorporate lessons learned from these piloted applications of the guidance, as well as any revisions to ASME/ANS RA-S-1.4.

5.2.5 American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) 43-19, "Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities,"

The NRC staff is continuing to work with the Southwest Research Institute, to develop a technology-inclusive, risk-informed and performance-based pathway for advanced non-LWRs to

address seismic safety within the LMP framework. One part of the contract aims to (1) evaluate the feasibility and adequacy of potential technical criteria through demonstration studies, (2) perform communication and outreach activities to help reach consensus with pertinent stakeholders on a viable and practical technology-inclusive, risk-informed and performance-based approach for advanced non-LWR seismic safety, (3) develop associated implementation guidance, and (4) identify potential regulatory improvements for future rulemaking activities. The other part of the contract aims to identify and evaluate technical criteria for regulatory guidance on the design and review of seismic isolation technologies included in commercial nuclear power plant licensing applications.

On October 3, 2022, the NRC staff issued two pre-decisional draft regulatory guides, "Technology-Inclusive, Risk-Informed, and Performance-Based Methodology for Seismic Design of Commercial Nuclear Plants,"[47] and "Seismically Isolated Nuclear Power Plants."[48]

Next steps: In 2023, the NRC staff plans to issue the draft regulatory guides on "Technology-Inclusive, Risk-Informed, and Performance-Based Methodology for Seismic Design of Commercial Nuclear Plants" and "Seismically Isolated Nuclear Power Plants" for public comment. The NRC staff plans to issue the final regulatory guides in 2024.

5.2.6 The Standards Forum

The NRC Standards Forum aims to do the following:

- Identify standards needed within the nuclear industry that standards development organizations are not currently addressing and explore collaborations to accelerate their development.
- Identify process improvements for effective and timely standards development.
- Exchange information on standards for nuclear facilities across disciplines and stakeholders.
- Facilitate engagement and networking within the standards development community.

On September 28, 2022, the NRC staff held the 2022 NRC Standards Forum, chaired by the NRC's Standards Executive. Approximately 240 attendees joined the event, including participants from the NRC; standards development organizations such as the ANS, ASME, American Concrete Institute, American Society of Civil Engineers, and Institute of Electrical and Electronics Engineers; the NEI; Electric Power Research Institute; the DOE; DOE national laboratories; and academia. The NRC website offers a full summary and related documents.[49]

This year's event included six sessions. These sessions covered industry initiatives in support of codes and standards, efforts by the NRC staff to streamline the NRC's review and endorsement of codes and standards, perspectives from advanced reactor developers regarding their needs and priorities for codes and standards, perspectives from nuclear and aerospace industry representatives on the rapid qualification of advanced manufacturing technologies, research developments related to advanced construction technologies, and discussions of recent and

---

47 ML22276A149
48 ML22276A154
49 See https://www.nrc.gov/about-nrc/regulatory/standards-dev/standards-forum/2022.html

planned developments of a number of specific codes and standards. The discussions were valuable to understanding areas for further collaboration across standards development organizations and how the NRC and stakeholder groups can be more effective in developing, updating, and meeting the needs of codes and standards.

Next steps: The NRC staff expects to hold the next NRC Standards Forum in fall 2023.

6.0 Strategic Area No. 5: Resolution of Policy Issues

6.1 Overview

This strategic area 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 enhance technical and regulatory readiness and communications. Some policy issues are for the NRC staff to address, while others may require engagement with the Commission.

The NRC public website lists the policy issues the NRC staff is considering in relation to the licensing of SMRs and non-LWRs. The NRC staff revises this list routinely to reflect the latest updates on each policy issue. The NRC staff has discussed these issues with stakeholders in several of its recurring public meetings. These discussions will continue, so that the NRC receives ongoing stakeholder input on identifying, prioritizing, and resolving policy issues.

6.2 Progress Summary

6.2.1 10 CFR Part 53 Rulemaking

On January 14, 2019, the President signed NEIMA into law. NEIMA directs the NRC to develop the regulatory infrastructure to support the development and commercialization of advanced nuclear reactors. Section 103(a)(4) of NEIMA directs the NRC to "complete a rulemaking to establish a technology-inclusive, regulatory framework for optional use by commercial advanced nuclear reactor applicants for new reactor license applications" by December 31, 2027. The NRC staff presented its proposed plan for the rulemaking for Commission approval of the proposed scope in SECY-20-0032. The NRC staff proposed a rulemaking that would build on previous agency efforts in this area, including the work done under the LMP, described in NEI 18-04, Revision 1, and endorsed by the NRC in RG 1.233. The rulemaking would create Part 53, in keeping with the NRC vision and strategy report and the statutory provisions in section 103(a)(4) of NEIMA.

On October 2, 2020, the Commission issued SRM-SECY-20-0032,[50] in which it approved the staff's overall approach but directed the NRC staff to complete the rulemaking by 2024 instead of 2027, while still producing a high-quality, thoroughly vetted regulation. The Commission also directed the NRC staff to consider the appropriate treatment of fusion technologies in the NRC's regulatory structure by developing options for licensing and regulating fusion energy systems for Commission consideration. In a memorandum dated November 2, 2020,[51] the NRC staff

[50] ML20276A293

[51] See "Response to Staff Requirements—SECY-20-0032—Rulemaking Plan on 'Risk-Informed, Technology-Inclusive Regulatory Framework for Advanced Reactors (RIN-3150-AK31; NRC-2019-0062)'" (ML20288A251).

provided the Commission with the requested schedule, including milestones and resource requirements, as well as the list of key uncertainties affecting publication.

In accordance with Commission direction in SRM-SECY-20-0032, the NRC staff developed the proposed rule by intermittently releasing new preliminary language, engaging stakeholders, and revising the language. To date, the NRC staff has engaged stakeholders and the ACRS in over 30 public meetings to develop the draft proposed rule. The NRC has received over 260 public comment submittals on the preliminary proposed rule language. The NRC staff has considered the feedback received and made several changes in response to external stakeholder feedback.

Most significantly, stakeholders requested that the NRC make a more traditional, deterministic licensing framework available for advanced reactors. Based on this stakeholder feedback, the NRC staff requested a 9-month extension to the current schedule for the Part 53 rulemaking in October 2021. The NRC staff asked for the extension to address several issues it had identified as key challenges in its November 2020 memorandum to the Commission.[52] On November 23, 2021, the Commission approved the staff's extension request to (1) provide additional time for the NRC staff to continue efforts to reach alignment with external stakeholders on the scope of the rulemaking and further develop rule language, (2) allow additional time for external stakeholders to participate constructively in the rulemaking process, and (3) ensure better coordination with other NRC advanced reactor activities. Under the approved extension, the NRC staff submitted the Part 53 proposed rule package to the Commission in February 2023 and provide the final rule package, including key guidance, to the Commission by December 2024. The NRC staff is expecting to issue the final rule by July 2025, ahead of the NEIMA requirement of December 2027.

Subsequently, the NRC staff developed the alternative framework requested by stakeholders to complement the risk-informed and performance-based approach initially developed in Part 53 (referred to as Framework A in the proposed rule). The alternative deterministic option, referred to as Framework B, more closely aligns with licensing methodologies used in international standards to allow flexibility for future applicants. Within Framework B, the NRC staff has also developed an approach that allows for an alternative to the use of PRA in developing the licensing basis. The proposed requirements that would allow certain applicants to use this approach, known as alternative evaluation for risk insights (AERI), are designed to limit use of the proposed approach to commercial nuclear plants whose designs are relatively straightforward and do not involve overly complex systems and interactions and, accordingly, would not warrant development of a PRA to provide quantitative risk insights.

The NRC staff has made many other changes in response to external stakeholder feedback, as discussed in last year's paper to the Commission on the advanced reactor program status.[53] In addition, the NRC staff carefully considered feedback received from the ACRS in numerous meetings and in several interim letters that the Committee has written to the Commission concerning Part 53.[54] After considering both internal and external feedback, the NRC staff released a draft proposed Part 53 rulemaking package on September 30, 2022,[55] to support the final ACRS meetings on the proposed rule in October and November 2022. Following the

---

52 ML20288A251
53 ML21337A377
54 ML20295A647, ML21140A354, ML22040A361, and ML22196A292
55 ML22272A034

completion of those meetings, the ACRS issued its final letter on the proposed rule on November 22, 2022.[56] In its letter, the ACRS concluded that the draft rulemaking package and associated guidance (see list of accomplishments in Section 1.0, "Introduction") are adequate to solicit public comments. In addition, the ACRS made recommendations for the AERI approach, the definition of a "self-reliant mitigation facility," the need for human oversight of every operating reactor, and the rule's discussion of defense in depth. On February 10, 2023, the NRC staff issued a response to the final ACRS letter.[57]

Within the draft proposed rulemaking for Part 53, the NRC staff has created a transformative security framework for advanced reactors that ensures at least the same degree of protection as is required of current-generation LWR security programs. To determine the appropriate level of security for advanced reactors, commensurate with the risks of activities involving special nuclear materials (including higher enriched fuels), the NRC staff built on the existing regulatory framework and implementation experience with security programs for power reactors, nonpower reactors, and fuel manufacturing facilities. The proposed framework allows for advanced reactor designs to incorporate security upfront or security by design. It applies a graded approach to a comprehensive range of security areas, including physical security, fitness for duty, access authorization, and cybersecurity, commensurate with the corresponding risk to public health and safety. The NRC staff has developed the proposed security framework to provide clarity, stability, and protection in a dynamic environment by keeping abreast of new technologies, trends, and emerging threat vectors. It has leveraged work from the rulemaking on emergency preparedness for SMRs and other new technologies (ONTs) to develop a consequence-based approach to security. The NRC staff has developed companion security guidance to be issued with the proposed rule, which provides flexibility for the licensing of advanced reactors with enhanced safety and security features. The benchmark in the graded approach of the current risk-informed and performance-based security framework is that the potential radiological consequences of activities involving nuclear material do not pose unreasonable risk to public health and safety.

Consistent with the Commission-approved rulemaking schedule, the NRC staff provided the Part 53 draft proposed rule for Commission consideration in February 2023.

Next steps: The NRC staff will continue to develop additional guidance documents (e.g., risk-informed performance-based approaches methodology for seismic design (see Section 5.2.5) and material compatibility (see Section 5.2.1)).

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

In SECY-20-0045, "Population Related Siting Considerations for Advanced Reactors," dated May 8, 2020,[58] the NRC staff presented the Commission with several options for addressing questions on population-related siting. The NRC staff recommended revising NRC guidance to provide an alternative population density criterion that is directly related to the potential radiological consequences estimated for a range of possible design-specific events.

In SRM-SECY-20-0045, "Population Related Siting Considerations for Advanced Reactors,"[59] dated July 13, 2022, the Commission approved the staff's recommended option to revise the

56 ML22319A104
57 ML22341A047
58 ML19262H055
59 ML22194A885

guidance in Regulatory Guide 4.7, “General Site Suitability Criteria for Nuclear Power Stations,” related to Title 10 of the Code of Federal Regulations Part 100, “Reactor Site Criteria,” Section 100.21(h). In addition, the SRM also directed the NRC staff to provide guidance on assessing defense in depth adequacy and establishing hypothetical major accidents for applicants using a traditional dose assessment approach.

Next steps: The NRC staff has started developing guidance in the form of a white paper. In 2023, the NRC staff plans to engage with stakeholders on the white paper, consider stakeholder feedback, and incorporate updated guidance into a new appendix to Regulatory Guide 4.7.

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

Consistent with the Commission’s direction in SRM-SECY-15-0077, “Options for Emergency Preparedness for Small Modular Reactors and Other New Technologies,”[60] dated August 4, 2015, the NRC staff developed a proposed rule providing alternative emergency preparedness requirements for SMRs and other new technologies, following a consequence-oriented, risk-informed and performance-based approach. This rulemaking would reduce potential requests for exemptions from the current emergency preparedness requirements and would promote regulatory stability, predictability, and clarity in the licensing process for future facilities. Along with the proposed rule, the NRC staff developed draft guidance in DG-1350, “Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light Water Reactors, and Non-Power Production or Utilization Facilities,”[61] issued May 2020. This DG includes methods and procedures for demonstrating compliance with performance-based emergency preparedness requirements and a methodology to inform the size of the plume exposure pathway emergency planning zone.

The NRC staff published the regulatory basis for the rulemaking on November 15, 2017, and presented the proposed rule for Commission consideration in SECY-18-0103, “Proposed Rule: Emergency Preparedness for Small Modular Reactors and Other New Technologies (RIN 3150-AJ68; NRC-2015-0225),”[62] dated October 12, 2018. On December 17, 2019, in SRM-SECY-18-0103,[63] the Commission approved publication of the proposed rule. On May 12, 2020, the NRC published the proposed rule with a 75-day public comment period (85 FR 28436). On June 24, 2020, the NRC staff hosted a public meeting to answer questions about the proposed rule and guidance document, then extended the public comment period to September 25, 2020.

The NRC staff received over 2,000 public comments, which it reviewed and considered in the formulation of a proposed final draft rule and associated guidance. The final rule was provided to the Commission for consideration in SECY-22-0001, "Rulemaking: Final Rule Emergency Preparedness for Small Modular Reactors and Other New Technologies (RIN 3150-AJ68; NRC-2015-0225)"[64] on January 3, 2022.

Next steps: If approved by the Commission, the NRC staff will publish the final rule.

---

60 ML15216A492
61 ML18082A044
62 ML18134A086
63 ML19351C729
64 ML21200A055

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

In SECY-16-0012, "Accident Source Terms and Siting for Small Modular Reactors and Non-Light Water Reactors,"[65] dated February 7, 2016, the NRC staff stated that the evaluation of mechanistic methods would be important for application reviews and that it did not note concerns or policy issues related to the implementation of mechanistic accident modeling of source terms. Specifically, the NRC staff affirmed that although it has not yet developed source term tools and technical expertise for non-LWRs to the same level as for LWRs, it finds that a mechanistic approach could also be applied to non-LWRs, given adequate tools and methods of analysis.

In a letter dated October 19, 2018,[66] the ACRS stated that the NRC 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," as well as guidance "on how source terms should be developed." In a response dated November 9, 2018,[67] the NRC staff stated that it would continue to evaluate the need to enhance its guidance on mechanistic source term (MST) development. Subsequently, NEIMA specified that the NRC should develop and implement guidance on MST use by January 2021.

The NRC contracted with INL to produce a report summarizing existing technology-inclusive and risk-informed and performance-based approaches to developing source terms for dose-related assessments at advanced nuclear facilities. INL issued the final report, INL/EXT-20-58717, "Technology-Inclusive Determination of Mechanistic Source Terms for Offsite Dose-Related Assessments for Advanced Nuclear Reactor Facilities,"[68] in June 2020. The report outlines graded technical approaches to the development of design-specific MSTs, including previous approaches such as that of the Next Generation Nuclear Plant Project; it also describes how MSTs are used in the methodology of NEI 18-04 and RG 1.233. The report does not provide MST methodologies or assumptions for the various advanced reactor technologies under development.

The NRC staff has continued interactions with potential non-LWR applicants on related MST methodologies that account for the retention of radionuclides by barriers and the transport of radionuclides for all barriers and pathways to the environment. As previously stated, the NRC supports the use of MSTs, as evidenced by documents such as "Next Generation Nuclear Plant Licensing Strategy: A Report to Congress,"[69] issued August 2008, and more recently, the final safety evaluation report for the NuScale design certification.[70]

To support the use of MSTs, the NRC staff is conducting an endorsement review for the ASME/ANS non-LWR PRA standard, ASME/ANS RA-S-1.4. This standard provides a way to determine source terms; it references the calculation guidance in RG 1.183, "Alternative

---

65 ML15309A319

66 See "Draft Proposed Rule, "Emergency Preparedness for Small Modular Reactors and Other New Technologies," (ML18291B248)

67 ML18305B312

68 ML20192A250

69 ML082290017

70 ML20023A318

Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," issued July 2000.[71]
In February 2022, the NRC staff went live with a public webpage[72] on advanced reactor source term to provide a one-stop shop on existing information including a discussion of accident source terms and a linked list of documents relevant to development of non-LWR accident source terms for licensing. This web page provides information about nuclear power reactor source term for stakeholders considering preapplication engagements with the NRC or developing applications for new nuclear power reactors under Parts 50 and 52.

In February 2022, the NRC staff briefed the ACRS Future Plant Designs Subcommittee on integration of source term activities in support of advanced reactor initiatives. The NRC staff is also interacting with stakeholders and engaging the national laboratories to support the use of MSTs by advanced reactor developers. In 2022, with support from ORNL and Sandia National Laboratories, the NRC staff conducted workshops to demonstrate the application of its MELCOR and SCALE computer codes to two reference plants: an MSR and an SFR. The NRC uses MELCOR and SCALE to simulate reactor accidents, including the release of radionuclides from fuel and radionuclide retention or attenuation by plant systems and structures, to obtain insight into reactor safety and assess accident mitigation strategies.

Next steps: The NRC staff plans to continue holding public meetings in 2023 to discuss its approach to assessing source terms for non-LWR technologies with stakeholders.

6.2.5 Alternative Physical Security Requirements for Advanced Reactors (Small Modular Reactors and Non-Light-Water Reactors)

On August 1, 2018, the NRC staff issued SECY-18-0076, "Options and Recommendation for Physical Security for Advanced Reactors."[73] In its SRM dated November 19, 2018,[74] the Commission directed the NRC staff to initiate a limited-scope revision to regulations and guidance on physical security for advanced reactors; it also approved, subject to edits, a related rulemaking plan. The NRC staff prepared a regulatory basis, which was released for public comment on July 16, 2019 (84 FR 33861). Since then, the NRC staff has held 12 public meetings and released three versions of the preliminary proposed rule language throughout the development of the proposed rule. The preliminary proposed rule language gives alternatives to certain existing security requirements in 10 CFR 73.55, "Requirements for physical protection of licensed activities in nuclear power reactors against radiological sabotage," that, in their current format, may not be appropriate for all advanced reactors. It also states eligibility criteria that advanced reactor licensees must meet before using one or more of these alternative security requirements. The NRC staff held a public meeting, in January 2022, to discuss preliminary rule language and key elements of the draft proposed rule and associated guidance.

In 2022, the NRC staff continued developing the NRC's draft implementation guidance to support this limited-scope security rule. This included developing new regulatory draft guidance in draft DG-5072, "Guidance for Alternative Physical Security Requirements for Small Modular Reactors and Non-Light-Water Reactors,"[75] dated July 15, 2022, which focuses on the eligibility criteria in the preliminary proposed rule language and on implementing the proposed alternative

[71] ML003716792
[72] https://www.nrc.gov/reactors/new-reactors/advanced/nuclear-power-reactor-source-term.html
[73] ML18170A051
[74] ML18324A469
[75] ML20041E037

physical security requirements. In parallel, the NRC staff drafted DG-5071 (nonpublic), Revision 2 of RG 5.81, "Target Set Identification and Development for Nuclear Power Reactors,"[76] to address target set identification for advanced reactors. DG-5071 is being withheld from public disclosure but is available to affected stakeholders who qualify for access and have a demonstrated need to know.

On August 2, 2022, the NRC staff submitted SECY-22-0072, "Proposed Rule: Alternative Physical Security Requirements for Advanced Reactors,"[77] and associated guidance for Commission consideration. This proposed rule would amend the NRC's regulations under 10 CFR 73.55 to add alternative physical security requirements to certain existing physical security requirements without changing the overall existing framework. The proposed rule would include criterion to demonstrate eligibility to implement any proposed physical security alternatives. The associated guidance consists of DG-5072 (formerly DG-1365) and DG-5071.

Next steps: If the Commission approves the proposed rule, the NRC staff will incorporate any Commission changes and prepare the package for publication. The NRC staff will issue the proposed rule and the draft guidance documents, DG-5071 (nonpublic) and DG-5072, for a 75-day public comment period (DG-5071 would have a limited and controlled release for public comments). The NRC staff expects to provide the final rule package to the Commission by October 2023 and issue the final rule, with key guidance, by May 2024. This schedule is ahead of the NEIMA requirement of December 2027.

6.2.6 Micro-reactors

Micro-reactors, which are generally small (on the order of 1 megawatt thermal to tens of megawatts thermal operating power), are envisioned to perform nontraditional roles for nuclear power, such as providing power for defense sites and remote areas. It is expected that microreactors will rely less on complex safety systems and more on inherent safety features and that the potential consequences of any postulated accidents will be less severe. The NRC staff has identified several potential policy and licensing issues to address for microreactors, including the following:

- security requirements
- emergency preparedness
- staffing requirements
- remote operation
- aircraft impact
- oversight
- annual fee structure
- manufacturing licenses
- transportable reactors
- siting
- environmental reviews

On October 6, 2020, the NRC staff provided SECY-20-0093, "Policy and Licensing Considerations Related to Micro-Reactors,"[78] to the Commission. This paper (1) informs the

[76] ML22021B529
[77] ML21334A003
[78] ML20254A363

Commission of licensing topics related to nuclear microreactors that may necessitate departures from current regulations, related guidance, and precedent, (2) identifies potential policy issues related to licensing microreactors, and (3) describes the staff's approach to facilitating licensing submittals for near-term and future deployment and operation of microreactors.
On October 20, 2020, the NRC staff issued COL ISG-029, "Environmental Considerations Associated with Micro-reactors,"[79] providing guidance for the NRC staff in determining the scope and scale of environmental reviews considering the unique characteristics of micro-reactors.

On November 24, 2021, the NRC issued a draft white paper outlining optional strategies for streamlining the licensing of anticipated microreactors.[80] These strategies leverage flexibilities in existing regulations and identify options for changes to regulatory requirements that could provide additional flexibilities, to the extent permitted under Commission policy and existing laws (e.g., the Atomic Energy Act of 1954, as amended). The strategies aim to maximize standardization and finality using design certification, standard design approval, and topical report approvals.

Next steps: In 2023, the NRC staff is planning to engage stakeholders on potential policy issues related to microreactors that may be fueled or tested in the factory and then transported to an approved site. The NRC staff will engage the Commission, as appropriate, on any policy issues that necessitate Commission direction. The NRC staff is also addressing annual fees for microreactors in the annual fee rule.

6.2.7 Fusion Energy Systems

NEIMA definition of "advanced nuclear reactor" includes nuclear fusion reactors. In 2020, the Commission directed the NRC staff to develop options on licensing and regulating fusion energy systems appropriately within the NRC's regulatory structure.

To support development of these options, the NRC staff conducted several public meetings in 2021 and on March 23, 2022, and June 7, 2022, to engage stakeholders on fusion energy systems and seek feedback on developing a regulatory framework. The meeting agendas, presentations, and summaries for these interactions can be found on the NRC's fusion public website.[81] The NRC staff engaged the ACRS on proposed options for licensing and regulating fusion energy systems and presented these in a NRC staff white paper[82] and at meetings on September 23 and October 5, 2022. The NRC staff received a letter from the ACRS on October 21, 2022,[83] providing their conclusions and recommendations. The NRC staff responded to this letter on November 7, 2022.[84] On November 8, 2022, the NRC staff participated in a Commission Meeting on Regulatory Approaches for Fusion Energy Devices. At this meeting, the NRC staff updated the Commission on the development of regulatory approaches for fusion energy systems.

---

79 ML20252A076
80 ML21328A189
81 See https://www.nrc.gov/reactors/new-reactors/advanced/policy-development/fusion-energy.html
82 ML22252A192
83 ML22290A177
84 ML22306A260

On January 3, 2023, the NRC staff submitted SECY-23-0001, "Options for Licensing and Regulating Fusion Energy Systems,"[85] providing three options for Commission consideration. These three options included:

(1) categorization of fusion energy systems as utilization facilities with the NRC staff developing a new framework to address the associated specific hazards

(2) a byproduct material approach augmenting the framework in 10 CFR Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material," for byproduct material licenses

(3) a hybrid framework with decision criteria, based on the potential risks and hazards of a specific fusion energy system, to determine whether a byproduct material or a utilization facility approach is appropriate for that system

The NRC staff recommended that the Commission approve the hybrid approach. Implementation of this option would entail a two-phase approach, with the first phase involving a limited-scope rulemaking to establish a regulatory framework for fusion energy systems that builds upon the NRC's byproduct material framework and includes decision criteria to determine when a fusion energy system should be licensed using a utilization facility approach. The second phase would involve rulemaking to establish requirements for fusion energy systems that are categorized as utilization facilities. This second phase would be deferred until developers provide detailed information describing the anticipated design and deployment of new fusion energy systems with greater risk profiles or common defense and security concerns than currently contemplated fusion facilities. The hybrid approach would ensure a systematic and risk-informed approach to the licensing and regulation of fusion energy systems and their associated hazards.

The NRC staff's development of a framework for fusion regulation is on a separate schedule from its Part 53 rulemaking efforts. Therefore, should the NRC staff initiate a rulemaking to address fusion facilities, the schedule could extend beyond the Commission approved deadline for the Part 53 rulemaking; however, the NRC staff anticipate that the fusion rulemaking, for the recommended option, would be completed before the NEIMA deadline of 2027.

Next steps: The NRC staff will continue to interact with key domestic and international stakeholders, such as the Fusion Industry Association, DOE, Agreement States, ACRS, ASME, and IAEA, among others. The NRC staff will implement Commission direction received in response to SECY-23-0001 and anticipate that any rulemaking, for the recommended option, to support such direction would be completed by the NEIMA deadline of 2027.

[85] ML22273A178

7.0 Strategic Area No. 6: Communication

7.1 Overview

This strategic area supports the objective of optimizing communications. The communications plan seeks to do the following:

- Provide timely, clear, and consistent communication of NRC requirements, guidance, processes, and other regulatory topics, and offer 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 communicate with stakeholders and seek their feedback on all non-LWR readiness activities. The NRC also meets with prospective applicants upon request, and it shares information with various international groups, including the NEA, the IAEA, the Generation IV International Forum, and the NRC's international regulatory counterparts. The sections below describe key accomplishments of these efforts and ongoing activities.

7.2.1 Stakeholder Engagement

The NRC conducts public meetings with stakeholders every 6–8 weeks. In early 2020, to maximize participation in the regulatory process, the NRC staff made it possible for stakeholders to participate either in person or virtually. The NRC staff conducted seven such meetings in 2022, as well as topic-specific meetings on Part 53; the technology-inclusive and risk-informed regulatory framework; and ARCAP, TICAP, and technology-inclusive risk-informed change evaluation process guidance development.

The NRC staff also briefed the ACRS Future Plant Subcommittee and Full Committee on various topics, including Part 53; fuel qualification for advanced reactors; risk-informed and performance-based human-system considerations for advanced reactors; potential endorsement of BPVC-III-5; RG 1.247 (For Trial Use) supporting ASME/ANS RAS1.42021; and MSR fuel qualification.

Next steps: The NRC staff will continue to hold stakeholder meetings approximately every 6–8 weeks, as well as engaging with the ACRS in 2023. It will also hold public meetings on topical issues related to Part 53 and other ongoing rulemakings, as well as on ARCAP, TICAP, and technology-inclusive risk-informed change evaluation process guidance. It will continue to conduct public interactions with stakeholders on developing a regulatory framework for fusion energy systems.

7.2.2 Coordination with the U.S. Department of Energy

In 2020, the NRC and the DOE put in place, "Addendum to DOE/NRC Memorandum of Understanding on Nuclear Energy Innovation,"[86] covering each agency's role and responsibilities in the DOE's Advanced Reactor Demonstration Program. The NRC interacts frequently with the DOE, consistent with the NRC's statutory authority, on activities related to regulatory development and to modernizing the NRC's regulatory framework to facilitate the licensing of advanced reactors. The NRC staff has been preparing to receive applications for advanced reactor designs, including two proposals to build advanced reactors arising out of the DOE's Advanced Reactor Demonstration Program, through which the DOE selected two new advanced reactor designs and awarded funding to support fully functional advanced nuclear reactors within 7 years of the award. In October 2020, the DOE selected two teams, one led by TerraPower and the other by X-energy, to receive initial funding for Advanced Reactor Demonstration Program demonstration projects, which will lead to applications within the next several years. Additional information related to licensing actions is discussed in Enclosure 2.

In addition, the NRC staff is conducting preapplication interactions with advanced reactor vendors and, within the bounds of its statutory authority, working with the DOE on its Risk Reduction for Future Demonstration Projects program and Advanced Reactor Concepts-20 program. In December 2020, the DOE selected five teams to receive initial funding under the Risk Reduction for Future Demonstration Projects program and three U.S.-based teams to receive funding under the Advanced Reactor Concepts-20 program. These awards have generated preapplication engagement for multiple advanced reactor designs.

Additionally, the DOE has direction and funding to work with the NRC and to pursue regulatory development activities through the national laboratories. The NRC staff has been coordinating with the DOE and the national laboratories on the qualification of each of the fuel types under consideration by advanced reactor designers. In monthly calls, the NRC and the DOE discuss areas of mutual interest. They also hold periodic management meetings to share information about advanced reactor readiness activities.

The Memoranda of Understanding (MOU) between the NRC and the DOE on Nuclear Energy Innovation[87] allows the sharing of technical expertise and knowledge as required by the Nuclear Energy Innovation Capabilities Act. The primary purpose of this MOU is to coordinate DOE and NRC technical readiness and to facilitate the sharing of expertise on advanced reactor technologies and nuclear energy innovation. This includes activities involving the National Reactor Innovation Center, which is a DOE program established under the Nuclear Energy Innovation Capabilities Act to enable the testing and demonstration of reactor concepts to be proposed and funded, wholly or in part, by the private sector. In 2021, the NRC and the DOE put in place three addenda to this MOU, covering DOE and NRC roles and responsibilities for (1) research, development, and demonstration projects undertaken by the National Reactor Innovation Center, (2) activities related to the characterization of radiological source terms and the development of the MELCOR code, and (3) advanced technologies for long-term operations and plant modernization. In 2022, the NRC and the DOE put in place an additional addendum, "Enabling Technologies for Advanced Fuels and Fuel Cycle Applications."[88]

---

86 ML20098E846
87 ML19263C976
88 ML22132A082

The NRC and the Fusion Energy Sciences program of the DOE Office of Science interact regularly to develop longer term strategies for the possible deployment of fusion energy systems.

Next steps: The NRC staff will continue to interact frequently with the DOE to gather information relevant to the NRC's non-LWR activities. The NRC staff will also continue to support the Gateway for Accelerated Innovation in Nuclear initiative and attend Gateway for Accelerated Innovation in Nuclear workshops, as specified in the Gateway for Accelerated Innovation in Nuclear MOU. The NRC staff will continue to work with the DOE on the regulatory development activities in the Nuclear Energy Innovation Capabilities Act MOU, consistent with the NRC's statutory authority. The NRC staff is outlining a new addendum to the Nuclear Energy Innovation Capabilities Act MOU specific to modeling and simulation activities.

7.2.3 Coordination with the U.S. Department of Defense

The Strategic Capabilities Office in the U.S. Department of Defense is leading the mobile microreactor demonstration project, in collaboration with the DOE, the U.S. Army Corps of Engineers, and industry partners. In May 2019, the NRC, the DOE, and the Strategic Capabilities Office signed an MOU to coordinate technical readiness and share technical expertise and knowledge on microreactor technologies to support the Department of Defense's research and development of microreactors. By participating in this project, the NRC aims to enhance its understanding of advanced reactor technologies and gain insights to inform its licensing approaches, consistent with its role as an independent safety and security regulator. Coordination is key to the rapid development of workable prototype designs that can support evaluation, safety analysis, and ultimately construction and testing. The MOU states that the DOE and its national laboratories will provide technical, environmental, siting, and safety-basis documentation support for the project. The NRC staff has contributed explanations of the NRC's requirements and guidance when needed. In June 2022, Strategic Capabilities Office selected BWX Technologies (BWXT) to build the first advanced nuclear microreactor under Project Pele.

In November 2022, the NRC signed a memorandum of cooperation with the U.S. Department of the Army for support of mobile nuclear reactors. To ensure that the Army is prepared to meet potential future regulatory needs, new regulations are required to ensure the safe, secure, environmentally compliant, and operationally reliable use of mobile nuclear reactors. The NRC may provide technical support while the Army Reactor Office begins laying the new regulatory framework.

Next steps: The NRC staff will continue to cooperate with the Department of Defense and the DOE, within the bounds of its statutory authority, to resolve the technical and policy issues associated with the successful demonstration of a mobile reactor.

7.2.4 Meetings and Conferences

To facilitate outreach and communications, the NRC holds periodic stakeholder meetings to discuss topics of interest related to non-LWRs. In 2022, the NRC staff actively participated in many workshops, conferences, and meetings, most of which took place virtually because of the Coronavirus Disease 2019 (COVID-19) public health emergency. These included the following events:

- 2022 Probabilistic Flood Hazard Assessment Research Workshop
- 2022 seminars on graphite degradation, aging, and failure mechanisms relevant to advanced non-LWRs
- 2022 Microreactor Applications Research, Validation, and Evaluation (MARVEL) Project technology review webinar
- 2022 workshops on using the NRC's SCALE and MELCOR codes to predict source terms for an SFR design and a MSR design
- 2022 Molten Salt Reactor Workshop hosted by ORNL
- 2022 ANS Annual Meeting
- 2022 IAEA Consultancy Meeting on Fusion Regulatory Approach
- Quarterly ASME meetings
- NRC 2022 Codes and Standards Forum
- Meetings of the OECD/NEA Working Group on the Safety of Advanced Reactors

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

7.2.5 International Coordination

As part of the NRC's goal of continuing to be a modern risk-informed regulator and building strong partnerships, as well as optimizing resource use and leveraging experience, the NRC staff engages and cooperates extensively with international organizations, including the OECD/NEA, the IAEA, the Generation IV International Forum, and the NRC's international regulatory counterparts.

The NRC chairs the NEA's Working Group on the Safety of Advanced Reactors, in which international regulators exchange information on technical topics related to the safety and regulation of non-LWRs. As part of this working group, the NRC staff is leading a task group to study common regulatory practices to ensure appropriate qualification and through-life performance of materials in advanced reactors. In 2022, the Working Group on the Safety of Advanced Reactors completed the report "Common Regulatory Practices to Ensure Appropriate Qualification and Through-Life Performance of Materials in Advanced Reactors—Survey Analysis." At the end of 2022, the Working Group on the Safety of Advanced Reactors was

sunset, and ongoing work is transitioning to the newly formed Committee on Nuclear Regulatory Activities Working Group on New Technologies.

The NRC staff is also participating in several experimental programs under the NEA Committee on the Safety of Nuclear Installations. The NRC chairs the Loss of Forced Coolant Joint Project. This project gives the NRC access to HTGR data from the Japanese High Temperature Engineering Test Reactor and natural circulation data from integral test facilities. This data could improve the agency's confirmatory analysis capability. On January 24–28, 2022, the Japan Atomic Energy Agency performed the 30 percent power test without active cooling and the biological shielding test and provided reports for the test plan, measurement instrumentation, and High Temperature Engineering Test Reactor data and the test results to the project. This was a safety demonstration test to verify the inherent safety features of HTGRs quantitatively, as well as to advance HTGR technologies. Coolant flow reduction tests have been carried out by tripping one or two of three gas circulators to simulate partial loss of forced cooling by the High Temperature Engineering Test Reactor. Based on the results of these tests, the High Temperature Engineering Test Reactor carried out a loss of forced cooling test in January 2022 to verify the inherent safety of HTGRs under the condition of loss of forced cooling. The Loss of Forced Coolant 2023 meeting of the Project Review Board is scheduled for February 28, 2023, to discuss the status of the full power test.

The NRC staff has access to research and testing activities through bilateral agreements with international regulators. Since 2018, the NRC has built strong international partnerships on materials research, which have led to significant information exchange and increased the agency's knowledge, data, and international experience. Notable examples of these partnerships include the technical exchanges with the United Kingdom on the use of graphitic components; with Japan on high-temperature materials and surveillance programs; and with the Czech Republic on molten salt purity, best practices, and materials compatibility.

The NRC participates in and chairs the IAEA SMR Regulators' Forum, in which regulators identify and address key regulatory challenges to SMR oversight. Established in 2015, the Forum has completed projects on emergency planning zones; the principles of graded approaches and defense in depth; and manufacturing, commissioning, and operations. In 2021, the Forum issued several reports on licensing, safety analysis, and manufacturing oversight of SMRs, including "Framework for Mutual Recognition of Regulators' Assessment," "Capabilities of the Supply Chain When Supporting Licensees," and "Implications of SMR Deployment on Configuration Management."[89] The Forum has continued expanding its international platform for the understanding of SMR designs, licensing applications, and safety standards. Phase 3 of the project covers new topics such as the framework for international collaboration and joint assessments; the integration of security, safeguards, and safety-by-design principles; and regulatory considerations in prelicensing engagement for long-lead requests and items.

In 2022, the NRC staff continued to actively participate in an IAEA effort to review the applicability of IAEA safety standards to different power reactors including light-water SMRs and non-LWRs. Supported by a team of 150 international experts, from 30 member states and 40 organizations including regulatory bodies and technical safety organizations, the IAEA completed a review in October 2021. The IAEA coordinated this effort with the various safety standards committees and the SMR Regulators' Forum. The NRC participated in a series of three consultancy meetings in 2021 on (1) developing a framework to enable sharing of

[89] These reports are publicly available at https://www.iaea.org/topics/small-modular-reactors/smr-regulators-forum.

information among regulators, (2) developing a process and criteria for international prelicensing regulatory review, and (3) establishing an approach for how one regulator can use another regulator's reviews. A series of IAEA reports will be published on the outcomes of this work during the summer of CY23 that will provide guidance and best practices for embarking countries on how to effectively coordinate with and/or leverage their licensing activities in a harmonized manner associated with new SMR and advanced reactor technologies.

The NRC staff is supporting the IAEA's Nuclear Harmonization and Standardization Initiative, which was initiated by the IAEA Director General in early 2022 in response to growing international interest in deploying SMRs and advanced reactors. Under the NHSI, governments, regulators, designers, technology holders, operators, and other international organizations will come together in a collaborative effort, consistent with their national roles and responsibilities, to harmonize and standardize regulatory and industrial approaches in support of the global deployment of safe and secure SMRs. The NRC staff is participating in three working groups under the regulatory track of the NHSI that focus on developing an international framework for sharing regulatory information, leveraging other regulators' reviews, and conducting prelicensing reviews of generic SMR designs that may be built in multiple countries.

In 2022, the Forum started work on topics selected for phase 3 in the areas of licensing, safety analysis, and manufacturing oversight of SMRs. In addition, the IAEA accepted the Forum's offer of assistance with the NHSI. The Forum is leading working group 3 in the regulatory track of the NHSI and addressing the issue of leveraging other regulators' reviews.

In August 2019, the NRC signed a memorandum of cooperation with the Canadian Nuclear Safety Commission (CNSC) to expand interaction on advanced reactor and SMR activities, including the development of shared technical review approaches, preapplication activities, research, training, and the development of regulatory approaches addressing unique and novel technical considerations relevant to safety. The NRC and the CNSC agreed to implement the memorandum of cooperation under the existing NRC-CNSC Steering Committee. Committee members from both agencies have discussed these topics and the potential for future cooperation.

At its October 2019 meeting in Ottawa, Canada, the Steering Committee approved terms of reference for a new Subcommittee on Advanced Reactor Technologies and SMRs. This subcommittee currently meets every 4–6 weeks. It has approved work plans for the following collaborative projects:

- development of common guidance for the contents of new-build license applications for advanced reactor projects
- sharing of regulatory insights from the technical review of the NuScale SMR design certification review
- review of X-energy's request for informal feedback on its reactor pressure vessel construction code assessment for the Xe-100 design
- review of Terrestrial Energy's white paper on postulated initiating events
- review of the licensing topical report on the BWRX-300 containment evaluation method

- establishment of a common regulatory position on TRISO fuel qualification
- identification of key similarities and differences in the safety classification process for structures, systems, and components
- review of a white paper on advanced construction techniques for the BWRX-300
- review of the BWRX-300 safety strategy
- review of a white paper on prequalified fuel verification and validation for the BWRX-300

The projects will produce joint reports that contain feedback and positions from both the NRC and the CNSC, which may leverage them in their respective regulatory reviews and decision-making.

In June 2021, the NRC and the CNSC signed their first joint report, on prelicensing review activities for advanced reactors. The report documents the two agencies' collaborative review of X-energy's request for informal feedback on its reactor pressure vessel construction code assessment for the Xe-100 design.[90] The report was publicly released on June 15, 2021, and was posted on the NRC's public website and advertised through social media in coordination with the Office of Public Affairs, the Office of International Programs, and the CNSC.

On August 12, 2021, the CNSC and the NRC issued their second joint report, on technology-inclusive, risk-informed reviews for advanced reactors.[91] This report gives a broad overview of the NRC and CNSC regulatory frameworks and compares the LMP, as endorsed in RG 1.233, with the CNSC approach.

In April 2022, the CNSC and NRC issued a joint report on GE-Hitachi's containment evaluation method for the BWRX-300.[92] In May 2022, the CNSC and NRC issued a joint report on Terrestrial Energy's methodology for developing a postulated initiating events list for the integral MSR.[93] The NRC and CNSC also issued two interim joint reports on TRISO fuel qualification.[94]

In September 2021, the NRC and the CNSC mutually agreed to invite the United Kingdom's Office for Nuclear Regulation to observe the collaborative activities for TRISO fuel, and the Office for Nuclear Regulation accepted. The NRC will leverage the existing bilateral MOU with the Office for Nuclear Regulation to enable this outreach and initiative with the United Kingdom. Throughout 2022, staff from Office for Nuclear Regulation participated in working level meetings with NRC and CNSC staff. The involvement of Office for Nuclear Regulation in this project creates a foundation for future expanded cooperation.

In September 2022, the NRC and CNSC signed a charter documenting collaboration on a new project under the memorandum of cooperation covering both countries' interest in the BWRX-300 SMR design. The Tennessee Valley Authority and Ontario Power Generation are working together on the industry side to share experience and enhance design standardization. The CNSC and NRC collaboration is intended to reduce duplication of licensing review efforts,

90 ML21166A304
91 ML21225A101
92 ML22091A201
93 ML22139A124
94 ML22030A000 and ML22101A297

jointly use third-party verification, identify areas for collaborative verification, share expertise, and leverage analysis performed by each organization.

Next steps: The NRC will continue to foster international cooperation by exchanging information with international counterparts and participating in NEA and IAEA working groups. The NRC and the CNSC will continue frequent bilateral interactions under their memorandum of cooperation.