PREPARING THE LICENSING PROCESS FOR RESEARCH AND TEST REACTORS WITHIN THE EXISTING REGULATORY FRAMEWORK

A Report for the
Senate Committee on Environment and Public Works and the
House Committee on Energy and Commerce

By the U.S. Nuclear Regulatory Commission

Enclosure

INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) developed this report as required by the Nuclear Energy Innovation and Modernization Act (NEIMA). Specifically, Section 103(d) of NEIMA requires that, "[n]ot later than 1 year after the date of enactment of [NEIMA], the Commission shall submit to the appropriate congressional committees a report for preparing the licensing process for research and test reactors within the existing regulatory framework…." Section 103(d) further directed NRC to "seek input from [DOE], the nuclear energy industry, a diverse set of technology developers, and other public stakeholders" in developing a report that "shall include proposed cost estimates, budgets, and timeframes for preparing the licensing process for research and test reactors." The NRC has addressed each of these requirements in this report.

NEIMA defines a "research and test reactor" as a reactor that (1) falls within the licensing and related regulatory authority of the Commission under Section 202 of the Energy Reorganization Act of 1974 (ERA) (42 U.S.C. § 5842), (2) is useful in the conduct of research and development activities as licensed under Section 104c of the Atomic Energy Act of 1954, as amended (AEA) (42 U.S.C. § 2134(c)), and (3) is not a commercial nuclear reactor. Accordingly, this report focuses on advanced nuclear reactors that meet this definition.[1] These include light-water small modular reactors; micro-reactors; non-LWRs, including high-temperature gas-cooled reactors, liquid metal fast reactors (e.g., sodium-cooled fast reactors), and molten salt reactors. This report also covers licensing of utilization facilities under Section 104c of the AEA (Class 104c licenses) with designs like those currently in operation, including facilities used for research and development of advanced reactor technologies. Consistent with NEIMA's direction, this report does not cover licensing of commercial nuclear reactors under Section 103 of the AEA, but does note that the NRC's readiness activities for commercial facility licensing could also support licensing of advanced research and test reactors. Finally, this report also addresses NRC licensing processes for utilization facilities under Section 104c of the AEA, including certain facilities owned by DOE.

Based on the evaluation of the existing regulatory framework and available licensing and technical guidance documents, the NRC concludes that it is prepared to license new research and test reactors under Section 104c of the AEA.

BACKGROUND

Under Section 104c of the AEA, the NRC licenses research and test reactors for specific research and development activities.[2] Under the regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," the

[1] The report does not address licensing fusion reactors because fusion reactors are not covered by the existing regulatory framework for research and test reactors.

[2] Section 31 of the AEA (42 U.S.C. § 2051)

NRC currently licenses these facilities as either research reactors[3] or testing facilities.[4,5] The NRC applies its current guidance[6] to the licensing of research reactors and testing facilities.

Federal agencies, States, institutions of higher education, and commercial entities currently operate 30 research reactors and 1 testing facility across the United States. These facilities conduct research and development in areas such as basic science, nuclear engineering and technology, medical radioisotopes and nuclear-based medical therapy, materials science, and industrial applications. These facilities also provide education and training opportunities for students and nuclear professionals. DOE also operates reactors for research and development, but consistent with the Energy Reorganization Act of 1974 (ERA), these facilities are not subject to licensing by the NRC. Additional research reactors and testing facilities may be developed to supplement the existing national capacity for research and development related to advanced reactor technology, including prototype plants operated as research and test reactors.[7]

The NRC also regulates nuclear power reactors that were originally licensed under Section 104b of the AEA (Class 104b licenses) as part of the Atomic Energy Commission's (the NRC's predecessor) Power Demonstration Reactor Program (and its successor programs) to encourage the commercialization of nuclear reactors for electricity production. At the time of their initial licensing, these reactors were intended to demonstrate practical value for industrial or commercial applications rather than to test reactor concepts or safety systems. Section 202 of the ERA, which applies to DOE facilities, uses the term "demonstration nuclear reactor" and refers to demonstration reactors "operated as part of the power generation facilities of an electric utility system" or "operated in any other manner for the purpose of demonstrating the suitability for commercial application of such a reactor." In the context of NEIMA, demonstration reactors, whether owned by DOE or other entities, may be part of the process for commercializing various advanced reactor technologies in the future. Although the NRC is not currently authorized to issue Class 104b licenses to new facilities, advanced reactor demonstrations could be licensed as commercial nuclear power reactors under Section 103 of the AEA or, in certain circumstances described later in this report, as research and development facilities under Section 104c of the AEA.

---

[3] As defined in 10 CFR 170.3, "research reactor" means a nuclear reactor that is licensed by the Commission under the authority of Section 104c of the AEA and under the provisions of 10 CFR 50.21(c) for operation at a thermal power level of 10 megawatts or less and that is not a testing facility.

[4] As defined in 10 CFR 50.2, "testing facility" means a nuclear reactor that is of a type described in 10 CFR 50.21(c) and for which an application has been filed for a license authorizing operation at one of the following:
(1) a thermal power level in excess of 10 megawatts; or
(2) a thermal power level in excess of 1 megawatt, if the reactor is to contain one of the following:
(i) a circulating loop through the core in which the applicant proposes to conduct fuel experiments; or
(ii) a liquid fuel loading; or
(iii) an experimental facility in the core in excess of 16 square inches in cross-section.

[5] The Commission is currently considering a draft final rule titled "Non-Power Production or Utilization Facility License Renewal." This draft final rule would revise the definitions of "research reactor" and "testing facility" to reflect a risk-informed, performance-based approach that relies on postulated accident dose rather than the power level of the reactor to distinguish between research reactors and testing facilities. This change, if approved by the Commission, would not affect the conclusions of this report.

[6] NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors," February 1996

[7] As defined in 10 CFR 50.2, "prototype plant" means a nuclear reactor that "is used to test design features, such as the testing required under [10 CFR] 50.43(e). The prototype plant is similar to a first-of-a-kind or standard plant design in all features and size, but may include additional safety features to protect the public and the plant staff from the possible consequences of accidents during the testing period."

In December 2016, the NRC issued its "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness" in response to increasing interest in advanced reactor designs. DOE issued a similar document in January 2017.[8] The NRC considered DOE's stated goals when setting priorities for its own advanced reactor readiness activities.

PREPARING THE LICENSING PROCESS FOR RESEARCH AND TEST REACTORS WITHIN THE EXISTING REGULATORY FRAMEWORK

Section 104c of the AEA directs the Commission "to impose only such minimum amount of regulation of the licensee as the Commission finds will permit the Commission to fulfill its obligations under [the AEA] to promote the common defense and security and to protect the health and safety of the public and will permit the conduct of widespread and diverse research and development." The NRC implements this direction through the existing regulatory framework, which specifies the process and requirements for the initial licensing of research reactors and testing facilities under Section 104c of the AEA. The 10 CFR Part 50 licensing process follows a two-stage approach consisting of a construction permit and an operating license. This process applies to facilities of the types currently licensed for operation that use a variety of heterogenous solid fuel forms, aqueous-fueled reactors, advanced reactor prototype plants and demonstration reactors, and DOE demonstration reactors.

Many aspects of the licensing process are the same for research reactors and testing facilities. However, because they may have potentially greater risks of off-site radiological consequences compared to research reactors, testing facilities are subject to several additional requirements that make the licensing process for a testing facility similar to the licensing process for a commercial nuclear power reactor licensed under 10 CFR Part 50.[9] These additional procedural requirements include a mandatory hearing on each construction permit application as well as an independent review and report to the Commission by the Advisory Committee on Reactor Safeguards on each construction permit and operating license application. Also, the regulations in 10 CFR Part 100, "Reactor Site Criteria" apply to testing facilities and commercial nuclear power reactors, but not to research reactors. Figure 1 illustrates the two-stage licensing process for research reactors and testing facilities and identifies the additional requirements for testing facilities.

[8] DOE/NE-0147, "Vision and Strategy for the Development and Deployment of Advanced Reactors,

[9] Commercial nuclear power reactors may also be licensed under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," but these regulations do not apply to licensing research and test reactors.

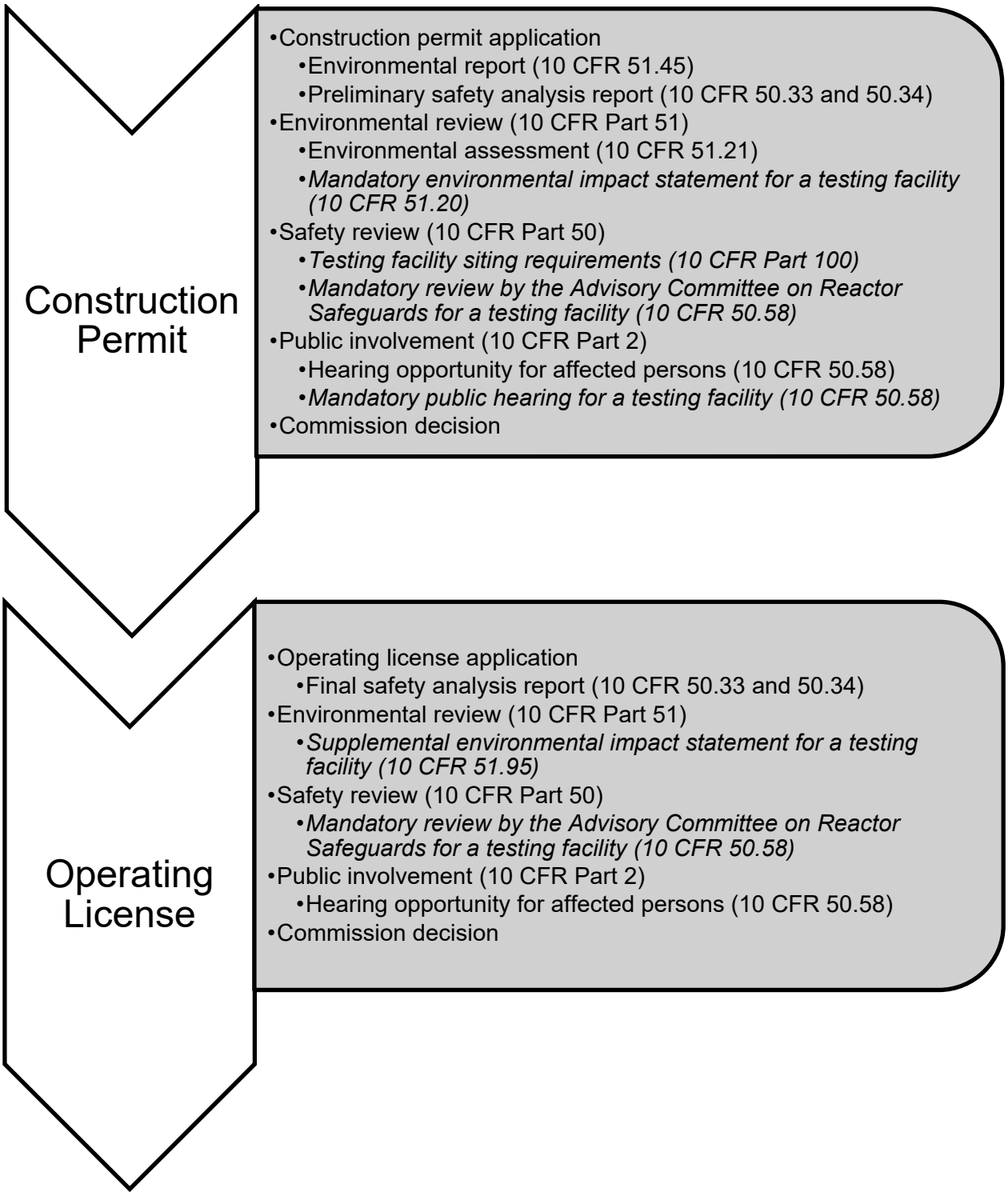

Figure 1 Depiction of the two-stage licensing process for research and test reactors, highlighting the additional requirements for testing facilities (in *italics*)

Given the wide variety of potential research and test reactor designs and operational characteristics, the NRC will apply the licensing process to a given facility using guidance appropriate for a specific application. For this reason, potential applicants are encouraged to engage with the NRC staff early in the development of proposed new research and test reactor projects to reach a common understanding of the applicable regulatory requirements and guidance. The NRC staff may also issue additional guidance to address specific issues. Recent NRC experience in issuing construction permits under 10 CFR Part 50 for medical radioisotope facilities demonstrated the efficacy of this case-by-case approach in certain circumstances.[10] However, as a general matter, the NRC expects to apply guidance for licensing various types of research and test reactors as shown in Table 1.

Table 1 Guidance for Licensing Various Types of Research and Test Reactors

Type of Facility	Existing Guidance for Licensing
Water-cooled research and test reactors using previously certified heterogeneous solid fuel forms and of designs similar to those currently in operation	NUREG-1537
Aqueous-fueled research and test reactors	NUREG-1537
Research and test reactors of novel designs and not operated as advanced reactor prototype plants or demonstration reactors	NUREG-1537 (supplemented by technology-specific guidance, as needed)
Research and test reactors operated as advanced reactor prototype plants	NUREG-1537 (supplemented by technology-specific guidance, as needed) Commercial advanced reactor guidance, as needed
Research and test reactors operated as demonstration advanced reactors	Commercial advanced reactor guidance

The NRC staff expects that the guidance presented in NUREG-1537 would likely be adequate for most aspects of licensing for novel designs of new research and test reactors that are not operated as advanced reactor prototype plants or demonstration reactors. The NRC expects that proposed facilities in this category would seek to perform research and development activities similar to those conducted at existing facilities. However, as explained later in this report, technology-specific guidance, such as that currently under development for molten salt reactors, may be needed for specific reactor designs or operational characteristics not covered by NUREG-1537.

For research and test reactors seeking to operate as prototype plants, the NRC expects that NUREG-1537, as supplemented by technology-specific guidance, would provide an adequate basis for many aspects of the licensing process. The commercial advanced reactor guidance could be used to address facility design and operational characteristics outside the scope of NUREG-1537, such as power conversion systems and novel safety features. The NRC does not have regulations specific to “demonstration reactors,” nor does it use this term in its current licensing processes. Accordingly, such a facility could be licensed under NRC regulations as a Class 104c research reactor or testing facility or as a Class 103 commercial facility, depending

[10] The NRC issued construction permits under 10 CFR Part 50 for medical radioisotope facilities to SHINE Medical Technologies, Inc., and Northwest Medical Isotopes, LLC, in 2016 and 2018, respectively, using guidance published in 2012 for preparing and reviewing applications for aqueous homogeneous reactors and production facilities used for making medical radioisotopes.

on the purpose and attributes of the proposed facility. Because the fundamental purpose of a demonstration reactor is to demonstrate the practical value for industrial or commercial applications, the NRC expects that the guidance developed for licensing commercial advanced reactors under Section 103 of the AEA would in most cases be better suited to the licensing of demonstration advanced reactors under Section 104c than the guidance in NUREG-1537.

UNIQUE ASPECTS OF RESEARCH AND TEST REACTOR LICENSING AND ANY ASSOCIATED LEGAL, REGULATORY, AND POLICY ISSUES (NEIMA Sec. 103(d)(4)(A))

Research and test reactor licensing has several unique aspects that primarily concern the information to be included in the construction permit and operating license applications. This information is necessary to show that a proposed facility will meet the licensing criteria in Section 104c of the AEA and, if it is a proposed DOE facility, that it falls within the NRC's regulatory jurisdiction. An applicant must clearly show that a proposed facility meets the following three criteria:

(1) The facility will be a nuclear reactor useful in the conduct of research and development activities of the types specified in Section 31 of the AEA.

(2) The facility will not be a commercial nuclear reactor in that it will not recover more than 75 percent of the annual costs to the licensee of owning and operating the facility through sales of nonenergy services, energy, or both, other than research and development or education and training, of which not more than 50 percent may be through sales of energy.

(3) If it will be a DOE facility, the facility will be a demonstration reactor as described in subsections (1) or (2) of Section 202 of the ERA.

With regard to Criterion 1, the applicant must describe the research and development activities related to the fields specified in Section 31 of the AEA[11] that it intends to conduct. The applicant must also describe the facility design features and operational characteristics and provide any other information necessary to show that the facility will be capable of such activities and that the applicant is qualified to carry them out. Finally, the applicant must describe the safety characteristics of intended experimental devices or modes of facility operation as well as all technical specifications necessary for the safety of the research and development activities under 10 CFR 50.36, "Technical Specifications."

[11] Section 31 of the AEA specifies the following six fields:
(1) nuclear processes;
(2) the theory and production of atomic energy, including processes, materials, and devices related to such production;
(3) utilization of special nuclear material and radioactive material for medical, biological, agricultural, health, or military purposes;
(4) utilization of special nuclear material, atomic energy, and radioactive material and processes entailed in the utilization or production of atomic energy or such material for all other purposes, including industrial or commercial uses, the generation of usable energy, and the demonstration of advances in the commercial or industrial application of atomic energy;
(5) the protection of health and the promotion of safety during research and production activities; and
(6) the preservation and enhancement of a viable environment by developing more efficient methods to meet the Nation's energy needs.

For Criterion 2, in addition to the financial information required by 10 CFR Part 50, the applicant must provide estimates of the projected sources and amounts of revenues as percentages of the annual cost to the licensee of owning and operating the facility. These estimates must demonstrate that the facility will meet the cost recovery criteria in Section 104c of the AEA, as amended by Section 106 of NEIMA, and not be a commercial facility. Also, under the existing regulations in 10 CFR 50.22, "Class 103 Licenses; for Commercial and Industrial Facilities," the applicant must show that not more than 50 percent of the annual cost to the licensee of owning and operating the facility will be devoted to the commercial activities listed in 10 CFR 50.22.[12]

With regard to Criterion 3, DOE must be able to describe the facility design features and operational characteristics that will allow for the facility to operate (1) as part of the power generation facilities of an electric utility system, or (2) in any other manner for the purpose of demonstrating the suitability for commercial application of such a reactor. DOE facilities that do not meet this criterion, such as prototype plants operated solely to test new or innovative design or safety features, would not be within the NRC's existing regulatory jurisdiction.

GUIDELINES FOR ADVANCED REACTOR DEMONSTRATIONS AND PROTOTYPES (NEIMA Sec. 103(d)(4)(B))

The NRC is fully capable of reviewing and reaching a safety, security, or environmental finding if a commercial advanced reactor application were to be submitted today. This includes applications for reactors with designs that use alternative coolants or alternative fuels, operate at or near atmospheric pressure, and use passive safety strategies. The review process and guidance for commercial advanced reactors, including advanced reactor demonstrations and prototype plants licensed as commercial facilities, are already largely established and will be in place by January 2021, consistent with NEIMA's requirements. This review process and guidance are generally applicable to the licensing of research and test reactors under Section 104c of the AEA. The relevant documents include the following:

- "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness." The NRC staff has developed a vision and strategy to ensure that the NRC is ready to review potential applications for non-LWR technologies effectively and efficiently. To achieve the goals and objectives of the NRC's vision and strategy, the NRC staff has developed implementation action plans that identify the specific activities that the NRC staff plans to conduct in the near-term (within 5 years), mid-term (5–10 years), and long-term (beyond 10 years) time frames.

- SECY-19-0009, "Advanced Reactor Program Status," dated January 17, 2019. This paper provides the status of the NRC staff's activities related to advanced reactors, including the progress of and path forward on each of the implementation action plan strategies. It also provides an overview of the various external factors influencing the NRC staff's activities to prepare for possible licensing and deployment of advanced reactors.

- "A Regulatory Review Roadmap for Non-Light Water Reactors," issued in December 2017. The NRC's review and licensing processes are flexible and allow interactions related to a wide variety of design development and deployment strategies.

[12] While the cost recovery criteria in Section 104c of the AEA are binding on the NRC's authority to issue licenses under Section 104c, an applicant may request an exemption from the regulations in 10 CFR 50.22 under 10 CFR 50.12, "Specific Exemptions."

Based on interactions with stakeholders, the NRC determined that guidance would be beneficial to assist non-LWR developers in planning regulatory interactions. To address this need, the NRC developed guidance for its flexible regulatory review processes within the bounds of existing regulations, including the use of conceptual design reviews and staged-review processes. The roadmap is also intended to help designers prepare technology- or design-specific regulatory engagement plans (also referred to as licensing project plans).

- Nuclear Energy Institute (NEI) 18-04, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development," Draft Report Revision N, dated September 28, 2018. The licensing modernization project is a cost-shared initiative being led by Southern Company, coordinated by NEI, and supported by DOE; the objective of this project is to develop technology-inclusive, risk-informed, and performance-based regulatory guidance for licensing non-LWRs for the NRC's consideration and possible endorsement.

- NRC Draft Regulatory Guide DG-1353, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors," April 2019. This proposed new regulatory guide endorses, with clarifications, the principles and methodology in NEI 18-04 as one acceptable method for determining the appropriate scope and level of detail for parts of applications for licenses, certifications, and approvals for non-LWRs.

- NRC Regulatory Guide 1.232, "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors." This covers a key portion of the licensing framework essential to advanced reactor technologies. It provides guidance on how the general design criteria in 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," which were developed primarily for LWRs, may be adapted for use in advanced reactor designs. The issuance of this new NRC regulatory guidance is expected to provide the following benefits: (1) reduced regulatory uncertainty for advanced reactor developers, (2) improved guidance for NRC staff reviewing advanced reactor license applications, and (3) improved timeliness and efficiency of licensing activities for applicants and NRC staff.

The review process and guidance would be discussed in any pre-application interactions between the NRC staff and potential applicants, including any specific applicability to contemplated designs.

Because these reactors generally represent the last stage in the commercialization process for a given design, demonstration reactors may be presumed to be nearly identical to a commercial facilities. For this reason, the existing guidelines for reviewing licensing applications for commercial advanced reactors, in most cases, could be applied to research and test reactors considered to be demonstration reactors under Section 202 of the ERA and licensed under Section 104c of the AEA.

The NRC's "A Regulatory Review Roadmap for Non-Light Water Reactors" covers the purpose of commercial prototype plants and their role in the development of advanced reactor designs and commercialization. The purpose of a prototype plant is to test innovative design or safety

features and to validate integral system computer models. A DOE prototype plant that is not also a demonstration reactor would be outside the NRC's existing regulatory jurisdiction.

To support the reviews of specific technologies, with assistance from Oak Ridge National Laboratory (ORNL), the NRC is developing new guidelines for reviewing applications for molten salt reactors by adapting the guidance in NUREG-1537. These guidelines will be available by January 2021. Using lessons learned from developing this technology-specific guidance, the NRC expects to be able to develop similarly adapted guidance for other anticipated advanced reactor technologies as vendors' plans for future submittals become more clear.

The NRC is also exploring ways with ORNL to update NUREG-1537 to include guidance on power conversion systems, such as those for generating electricity or process steam, which could be included in the design of a prototype plant or demonstration reactor licensed under Section 104c of the AEA.

The NRC is also updating NUREG-1537 to cover the information that must be included in an application for a Class 104c license in order for the NRC to determine that a given facility meets the cost recovery criteria in Section 104c of the AEA, as amended by Section 106 of NEIMA.

COORDINATION AND STAKEHOLDER INPUT (NEIMA Sec. 103(d)(2))

The NRC staff sought and received input from DOE and other stakeholders in developing this report. Specifically, the NRC held public meetings on March 28 and October 10, 2019, during which the preparation of this report was discussed and planned with participants, including DOE, the nuclear energy industry, a diverse set of technology developers, DOE, and other public stakeholders. The NRC licensing of DOE facilities was also discussed separately with DOE. The NRC also held a public meeting on September 26, 2019, primarily with existing research and test reactor licensees, to explain and collect feedback on the changes made to Section 104c of the AEA by Section 106 of NEIMA. The NRC will continue to interact with DOE and other stakeholders to gather information to inform the NRC's research and test reactor readiness activities. The NRC staff provided DOE with a draft of this report.

COST AND SCHEDULE ESTIMATES FOR PREPARING THE LICENSING PROCESS FOR RESEARCH AND TEST REACTORS (NEIMA Sec. 103(d)(3))

The primary costs related to preparing the licensing process for research and test reactors will involve updating NUREG-1537's guidance. To date, the cost of these activities has been funded using the non-fee-recoverable appropriations that the NRC has received for advanced reactor regulatory infrastructure activities. The agency's fiscal year (FY) 2020 appropriation funds the continuation of these efforts.

EXTENT TO WHICH COMMISSION ACTION OR MODIFICATION OF POLICY IS NEEDED TO IMPLEMENT THIS REPORT (NEIMA Sec. 103(d)(4)(C))

The NRC has not identified any Commission action or modification of policy needed to prepare or implement the process for licensing research and test reactors under Section 104c of the AEA.

The NRC staff is considering several policy issues about other matters related to the licensing of small modular reactors and non-LWRs that may also be relevant to research and test reactors. The NRC staff raised these policy issues in public meetings. These discussions will continue in

order for the NRC to obtain stakeholder input to identify possible policy issues, potential options to resolve them, and views on their priority. The NRC continues to provide the status of these potential policy issues to the Commission and in quarterly and semiannual reports to Congress. The public can access additional information regarding the status of the NRC's non-LWR readiness activities through the NRC's public Web site (https://www.nrc.gov/reactors/new-reactors/advanced.html).

CONCLUSION

The NRC is prepared to review and license research and test reactors under Section 104c of the AEA, including prototype plants and demonstration advanced nuclear reactors. In addition, the NRC continues to engage with advanced reactor stakeholders, the nuclear energy industry, technology developers, DOE, and other public stakeholders to further strengthen its readiness to regulate advanced reactors, including demonstrations of innovative nuclear technologies, consistent with the agency's public health and safety mission.