United States Government Accountability Office
Report to Congressional Requesters

July 2023

NUCLEAR POWER

NRC Needs to Take Additional Actions to Prepare to License Advanced Reactors

GAO-23-105997

GAO Highlights

Highlights of GAO-23-105997, a report to congressional requesters

July 2023

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NRC Needs to Take Additional Actions to Prepare to License Advanced Reactors

Why GAO Did This Study

Our nation's demand for energy is expected to grow in the coming decades. To address this demand, Congress has supported the development of advanced nuclear reactors. NRC officials anticipate receiving a significant increase in the number of applications for advanced reactors in the next several years. However, because NRC's regulations and licensing processes have been used to evaluate existing nuclear reactor technologies, NRC is in the process of making changes to license advanced reactors.

GAO was asked to review NRC's preparedness to review applications for advanced nuclear reactors. This report examines (1) NRC's actions to modify its licensing process to include advanced reactors and (2) the extent to which modifications to NRC's licensing process have prepared the agency to review advanced reactors. GAO reviewed statutes, NRC regulations and guidance; analyzed NRC documentation on the modifications to its licensing process; interviewed NRC officials; and interviewed a nongeneralizable sample of 17 stakeholders.

What GAO Recommends

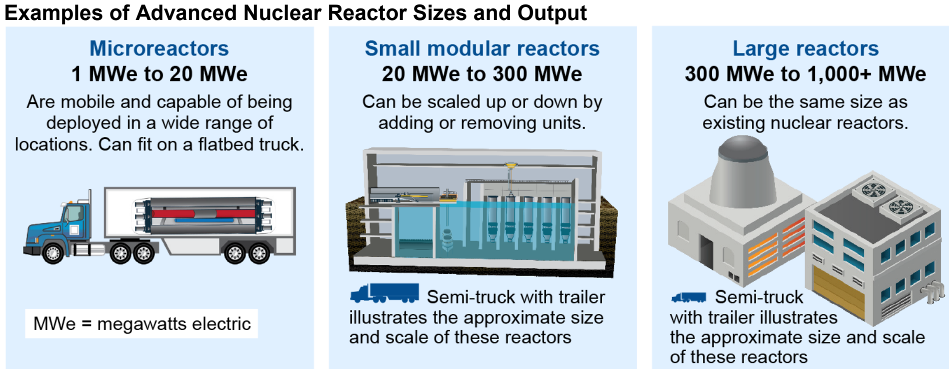
GAO is making four recommendations, including that NRC establish benchmarks and measures to assess the effectiveness of its recruitment, relocation, and retention strategies and incentives to help NRC retain and hire the staff to license advanced reactors. NRC generally agreed with our recommendations.

View GAO-23-105997. For more information, contact Frank Rusco at (202) 512-3841 or ruscof@gao.gov.

What GAO Found

The Nuclear Regulatory Commission (NRC) has taken several actions to modify its licensing process to include advanced nuclear reactors—nuclear fission reactors that may offer significant improvements over the most recent generation of nuclear fission reactors and may involve first-of-a-kind designs. For example, NRC reorganized its offices responsible for licensing advanced reactors and established dedicated review teams to provide continuity of staff throughout the review of an advanced reactor license application. NRC also issued a regulatory roadmap to help advanced reactor developers navigate the agency's licensing process. Furthermore, NRC has engaged with the nuclear industry to develop a technology-inclusive, risk-informed, and performance-based approach for assessing advanced reactor applications. NRC has also cooperated with the Department of Energy to share technical expertise and has incorporated feedback from several federal agencies and other stakeholders regarding modifications to its licensing process.

Examples of Advanced Nuclear Reactor Sizes and Output



Sources: GAO analysis of Department of Energy (DOE) and NuScale Power, LLC, information; DOE (left and right panel illustrations); NuScale Power, LLC (center panel illustration); GAO (truck silhouette) | GAO-23-105997

Some of the modifications NRC made to its licensing process have better prepared the agency to review advanced reactors. However, the modifications do not fully address ongoing challenges related to hiring and retaining the staff necessary to license advanced reactors. NRC analyzes its workforce annually and has implemented several measures to address its estimated workforce shortfalls, such as offering recruitment, relocation, and retention incentives for hard-to-fill positions. NRC recognizes its staffing limitations, recruitment challenges, and the expected influx of advanced reactor applications. However, NRC has not evaluated its efforts to address staffing gaps. NRC does not know the extent to which its recruitment strategies and incentives have had a positive effect on hiring and retention because the agency does not have benchmarks to assess their effectiveness. Without measures and benchmarks to assess its recruitment, relocation, and retention incentives and recruitment strategies, NRC is unable to determine the effectiveness of its efforts to ensure that it has sufficient numbers of knowledgeable staff needed to conduct licensing reviews in the coming years.

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Abbreviations

ACRS	Advisory Committee on Reactor Safeguards
AEA	Atomic Energy Act of 1954
ARC-20	Advanced reactor concepts-20
ARDP	Advanced Reactor Demonstration Program
C.F.R.	Code of Federal Regulations
CNSC	Canadian Nuclear Safety Commission
DOE	Department of Energy
FDA	Food and Drug Administration
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
LWR	Light-water reactor
MOU	Memorandum of Understanding
MWe	megawatts of electricity
MWth	megawatts thermal
NRC	Nuclear Regulatory Commission
NRIC	National Reactor Innovation Center
SMR	small modular reactor

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July 27, 2023

The Honorable Shelley Moore Capito
Ranking Member
Committee on Environment and Public Works
United States Senate

The Honorable Cathy McMorris Rodgers
Chair
Committee on Energy and Commerce
House of Representatives

In 2022, nuclear power generated about 18 percent of our nation's electricity and nearly 50 percent of the nation's carbon-free electricity. Energy demand in the United States is expected to continue to grow over the coming decades, and the Department of Energy (DOE) considers nuclear power to be one means of meeting the increased demand without producing air pollution. However, 13 nuclear reactor plants have been closed in the past decade, and more are expected to be shut down in 2030 and beyond. In response, Congress has supported the development of advanced nuclear reactors—nuclear fission reactors that may offer significant improvements over the most recent generation of nuclear fission reactors.[1] Designs for advanced nuclear reactors include small mobile reactors (microreactors) that can be moved to different locations, as well as larger reactors capable of producing power at levels comparable to existing reactors. Proponents of advanced nuclear reactors expect them to be less expensive, safer, and more fuel efficient than existing light-water reactors (LWR).

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[1]The nuclear reactors currently operational in the United States are referred to as light-water reactors, meaning reactors that use light water (ordinary water) to cool and moderate the reactor, as opposed to heavy water, which contains deuterium, an isotope of hydrogen. In 2018, Congress passed the Nuclear Energy Innovation Capabilities Act of 2017, which updates the mission and objectives of DOE's civilian nuclear energy programs, particularly supporting the deployment of advanced reactors and developing a reactor-based fast neutron source for the testing of advanced reactor fuels and materials. Pub. L. No. 115-248, 132 Stat. 3154. In 2019, Congress passed the Nuclear Energy Innovation and Modernization Act. Pub. L. No. 115-439, 132 Stat. 5565. The purpose of the act is to provide a program to develop the expertise and regulatory processes necessary to promote innovation and facilitate the commercialization of advanced nuclear reactors.

The U.S. Nuclear Regulatory Commission (NRC) is an independent federal agency responsible for regulating commercial nuclear power. NRC's Office of Nuclear Reactor Regulation conducts a broad range of regulatory activities, including licensing and oversight for new commercial nuclear power reactors and advanced reactor technologies. NRC is currently developing a regulatory framework in title 10 of the Code of Federal Regulations (C.F.R.)—known as Part 53—to license advanced reactors. NRC is expected to complete the framework in July 2025. In the meantime, NRC will use its existing regulations, known as Part 50 and 52, to license advanced reactors. Generally, NRC has used these regulations to evaluate and license LWR technologies.[2]

As of May 2023, NRC was reviewing applications for three advanced reactors and is engaged in preapplication discussions with multiple companies that are developing advanced reactor designs.[3] Additionally, DOE intends to provide more than $3 billion through its Advanced Reactor Demonstration Program (ARDP) for two non-light-water demonstration projects and $1.4 billion through its Advanced Small Modular Reactor (SMR) Research, Development, and Demonstration program for one light-water SMR demonstration project, through which developers will soon seek NRC approval of their reactor designs. Furthermore, DOE has reported that there are more than 60 companies and research institutions working on advanced nuclear projects. Their aim is to help meet our nation's future energy needs and reach the goal of producing 100 percent carbon-free electricity by 2035 and net-zero carbon emissions by 2050. It is in this context that NRC officials anticipate receiving a significant increase in the number of applications for advanced reactors in the next several years.

We have previously issued reports on the development of advanced reactor technologies. In 2015, we reported that the DOE officials and reactor designers we interviewed told us that advanced reactors, and other new reactor concepts designed to provide benefits over existing LWRs, could facilitate the deployment of nuclear reactors in new markets,

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[2]NRC licenses nuclear power plants under Title 10 of the Code of Federal Regulations (C.F.R.) under Part 50, or a combined process under 10 C.F.R. Part 52. Because our report focuses on NRC's existing regulations for licensing advanced reactors, NRC's draft proposed regulations, known as Part 53, are not within the scope of our review.

[3]To date, NRC has approved one small modular reactor design that was based on LWR technology and denied one application for an advanced reactor that was based on non-LWR technology.

such as rural and remote areas of the country.[4] However, our report also noted that DOE officials, experts, and reactor designers told us that the cost and time needed to certify or license a reactor design, and then construct a reactor, posed obstacles, among other challenges to developing and deploying new reactors. In 2020, we reported that microreactors might offer advantages over large LWRs, including faster, cheaper, and more efficient electricity production.[5] However, we also reported that microreactors using advanced reactor technologies posed regulatory challenges and that longer design certification times could delay their deployment.

You asked us to examine NRC's preparedness to review applications for advanced nuclear reactor designs. This report examines (1) actions NRC has taken to modify its existing licensing process to include advanced reactors and (2) the extent to which the modifications to NRC's licensing process have prepared the agency to review advanced reactors.

To address these objectives, we reviewed NRC regulations, policies, and guidance, including NRC documentation outlining modifications the agency made to its licensing process to include advanced reactors.[6] We interviewed NRC officials about the agency's existing process for licensing all nuclear reactors and how the agency modified that process for licensing advanced reactors. We interviewed a nongeneralizable sample of 17 selected stakeholders to obtain their views on the strengths and challenges of NRC's process for licensing advanced reactors.[7] Stakeholders included advanced reactor developers, former NRC staff, academics and research organizations, and members of groups with expertise in advanced nuclear reactors and NRC's licensing process.[8] To

[4]GAO, *Technology Assessment: Nuclear Reactors: Status and Challenges in Development and Deployment of New Commercial Concepts*, GAO-15-652 (Washington, D.C.: July 28, 2015).

[5]GAO, *Science & Tech Spotlight: Nuclear Microreactors*, GAO-20-380SP (Washington, D.C.: Feb. 26, 2020).

[6]For the purposes of this report, we are defining licensing process to include preapplication engagement and licensing activities under 10 C.F.R. Part 50 and Part 52.

[7]In addition to conducting interviews, in some cases, we also obtained written follow-up responses from stakeholders.

[8]While we refer to this group collectively as stakeholders, it is comprised of both individuals and groups. By groups, we refer to industry groups, for-profit and not-for-profit organizations, and public interest groups.

identify the strengths and challenges cited most often in the interviews, we conducted a content analysis of stakeholders' answers, as well as their written responses to our questions in semistructured interviews. We also included responses from current NRC officials.[9] Further details on our objectives, scope, and methodology can be found in appendix I.

We conducted this performance audit from May 2022 to July 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Advanced Reactor Technologies

NRC officials we interviewed told us that NRC considers advanced nuclear reactors to include all non-LWRs and light-water SMRs—reactors that can be scaled up or down by adding or removing units.[10] Existing nuclear power plants in the United States use LWRs that are large in size and have been expensive to build.[11] According to NRC officials we interviewed, advanced nuclear reactor designs are first-of-a-kind, meaning that they are reactor designs that have never been licensed in the United States.[12] Advanced reactors range in size from

[9]When summarizing stakeholders' views on the common categories we identified, we use the quantifiers "some," "many," and "most." Specifically, the term "some" indicates that two to six stakeholders expressed the idea; the term "many" indicates that seven to 11 stakeholders expressed the idea; and the term "most" indicates that 12 to 17 stakeholders expressed the idea. The views of current NRC officials and the 17 stakeholders we interviewed are not generalizable to NRC officials and stakeholders we did not interview.

[10]More broadly, NRC considers advanced reactors to include any reactor with significant improvements over reactors constructed before January 2019, consistent with the definition of "advanced nuclear reactor" in the Nuclear Energy Innovation and Modernization Act. Pub. L. No. 115-439, § 3(1), 132 Stat. 5565, 5566 (codified at 42 U.S.C. § 2011 note).

[11]GAO-22-105394. Designing large reactors can take over 10 years, including more than 3 years for NRC design certification, and cost $1 billion to $2 billion (in 2015). GAO-20-380SP.

[12]Nuclear Regulatory Commission, *Preliminary Draft, Nuclear Power Reactor Testing Needs and Prototype Plants for Advanced Reactor Designs*, ML17025A353 (June 14, 2017).

microreactors—some of which could fit on a flatbed truck—and SMRs, to larger reactors the size of existing large LWRs.[13]

Advanced reactors vary by coolant and fuel type. Some advanced reactors, such as SMRs, use light water as a coolant, whereas non-LWRs use material such as liquid metal, gas, and molten salt as coolants instead of water. In addition, in contrast to large LWRs that use low-enriched uranium fuel, most advanced reactor designs use high-assay low-enriched uranium fuel.[14] According to academic and government research we reviewed, non-LWRs use core materials that have a higher heat capacity and are stable at higher temperatures compared with the core materials used in LWRs.

Advanced reactors are also characterized by whether they use a moderator to slow the speed of fission neutrons to generate energy. Some advanced reactors are thermal reactors that use a water-based or graphite moderator to slow fission neutrons. Other advanced reactors are fast reactors that do not moderate fission neutrons so as to keep the neutrons moving quickly. See table 1 for a comparison of the characteristics of large LWRs and advanced reactors.

[13]The electricity generated by nuclear reactors is measured in megawatts of electricity (MWe). Microreactors generate between 1 MWe and 20 MWe. Small modular reactors generate up to 300 MWe. Similar to large LWRs, large advanced reactor designs can generate between 300 MWe and about 1,000 MWe.

[14]Existing large LWRs in the United States generally use low-enriched uranium fuel, enriched up to around 3 percent to 5 percent of the uranium-235 isotope. High-assay low-enriched uranium is uranium fuel that is enriched to higher levels, up to 20 percent uranium-235. Most of the advanced reactors being developed in the United States will use high-assay low-enriched uranium to enable them to use more compact designs, longer operating cycles, and achieve higher efficiencies than existing reactors. However, high-assay low-enriched uranium is not currently available at commercial scale from domestic suppliers.

Table 1: Characteristics of Large Light-Water and Advanced Reactor Technologies

Type	Thermal vs. fast reactor	Core materials		
		Coolant[a]	Fuel	Moderator[b]
Large light-water reactors	Thermal	Light-water	Uranium dioxide	Light-water
Gas-cooled fast reactors	Fast	Helium gas	Fuel type varies	None
Heat-pipe-cooled reactors	Either	Heat-pipe	Fuel type varies	Varies
High-temperature gas reactors	Thermal	Helium gas	TRISO[c]	Graphite
Lead-cooled fast reactors	Fast	Molten lead or lead-bismuth eutectic	Oxide or uranium-metal[d]	None
Molten salt reactors	Either	Molten salt	Uranium fluoride salt, chloride salt, or TRISO[c,d]	Varies
Sodium-cooled fast reactors	Fast	Liquid sodium	Oxide or uranium-metal[d]	None

Source: GAO analysis of information from the Department of Energy, Congressional Research Service, Massachusetts Institute of Technology Energy Institute, and the National Academy of Science. | GAO-23-105997

[a]A coolant transfers heat from the reactor core to the electrical generator or other systems that require heat. In doing so, the coolant helps ensure that the reactor does not overheat.

[b]A moderator is the material, such as ordinary water, heavy water, or graphite, that is used in a reactor to slow down fission neutrons.

[c]TRISO fuel is short for tristructural isotropic fuel, which is composed of poppy-seed-sized uranium dioxide, oxycarbide, or carbide fuel particles that have been encased in silicon carbide and other highly heat-resistant coatings.

[d]These advanced non-light-water reactor designs use high-assay low-enriched uranium.

According to the academic and government research we reviewed, the core materials of some advanced reactors consist of a variety of nontraditional coolants, fuels, and moderators that may enhance their safety compared with existing large LWRs.[15] For example, according to a 2017 report by the Columbia University Center on Global Energy Policy, the design of some high-temperature gas reactors can help the reactor naturally shut down when the temperature gets too high.[16] Advanced reactor designs that incorporate passive cooling systems require less

[15]See, for example, Massachusetts Institute of Technology, *The Future of Nuclear Energy in a Carbon-Constrained World: An Interdisciplinary MIT Study* (2018).

[16]Andrew C. Kadak, Columbia Center on Global Energy Policy and School of International and Public Affairs, “A Comparison of Advanced Nuclear Technologies” (New York, NY: March 2017).

human intervention and reduce the risk and possibility of human error or indecision. A 2023 report by the Congressional Research Service stated that some advanced reactors use coolants, such as liquid metals, that remain at atmospheric pressure under high reactor temperatures, thereby putting less stress on primary reactor components compared with water-cooled reactors.[17] Furthermore, some advanced reactors use simplified safety systems that allow for a more automated and streamlined response to accidents. Finally, because SMRs and microreactors are smaller, they may require storing less radioactive material (in terms of total volume) at the reactor site and, therefore, pose lower risks to the environment in the event of an accidental release.[18]

However, there has been limited testing or demonstrations of advanced reactor technologies. Further, a 2018 study raised concerns about the reactivity of materials with certain chemical properties in advanced reactors and how the materials might react if exposed to air, water, and concrete.[19] In addition, the 2023 report by the Congressional Research Service stated that some advanced reactor coolants and moderators have chemical properties that pose safety concerns related to reactivity, toxicity, and the corrosiveness of the primary coolant in the case of sodium, lead, and molten salts.

NRC's Regulatory Framework and Licensing Process for Nuclear Reactors

Under NRC's existing regulatory framework, advanced reactor developers can consider two main licensing pathways in order to construct and operate a nuclear reactor. Regulations in 10 C.F.R. Part 50 detail a two-step licensing process in which an applicant applies for a construction permit and operating license separately. The contents of a construction permit application include, among other things, preliminary safety analyses, an environmental review, and financial statements for a proposed reactor.[20]

[17] Congressional Research Service, *Advanced Nuclear Reactors: Technology Overview and Current Issues*, R45706 (February 2023).

[18] Natural hazards (such as hurricanes, floods, and earthquakes), human errors, and mechanical failures can cause an accidental release of radioactive material. Nuclear Information and Resource Service, *Natural Disasters and Safety Risks at Nuclear Power Stations* (Washington, D.C.: November 2004).

[19] See Massachusetts Institute of Technology, *The Future of Nuclear Energy in a Carbon-Constrained World: An Interdisciplinary MIT Study* (2018).

[20] 10 C.F.R. § 50.34 (2022).

NRC staff conducts a safety and environmental review of construction permit applications. After completing a site safety review, NRC staff issues a Safety Evaluation Report on the proposed facility's anticipated effects on public health and safety. The application is also referred to the Advisory Committee on Reactor Safeguards (ACRS), an independent body of experts, who review the application and the NRC staff Safety Evaluation Report and issues a report.[21] ACRS officials we interviewed said that ACRS and NRC staff coordinate on scheduling safety reviews but noted that ACRS's review can be ongoing while NRC staff completes their safety evaluation. NRC staff also conducts environmental reviews to evaluate the potential environmental impacts of a proposed reactor. NRC also provides an opportunity for public comment on its draft environmental impact statement. Once an applicant obtains a construction permit, they can begin building a reactor.

Further, an applicant is to submit an operating license application before the scheduled completion of a reactor's construction. The operating license application must include a final report on the reactor's site, design, safety, and operations, among other required information. NRC staff prepare a final Safety Evaluation Report for the operating license, and the ACRS conducts an independent safety review. NRC staff will supplement and update its prior environmental review, if needed, to cover new and significant information from its previous review and provide another opportunity for public comment.

NRC must hold a public hearing during its review of construction permit applications. Additionally, NRC provides an opportunity for individuals or entities affected by an NRC licensing action to request a hearing during the construction permit and operating license application review processes. NRC also holds public meetings to provide the public with information about the operating license application, including the planned location and type of reactor, the safety and environmental aspects of the

[21]In 1957, Congress established the Advisory Committee on Reactor Safeguards (ACRS) in an amendment to the Atomic Energy Act of 1954 (AEA). Pub. L. No. 85-256, 71 Stat. 576, 579 (1957). The ACRS is an entity independent of the NRC staff that reports directly to NRC, which appoints members to the ACRS. The ACRS reviews and reports on safety studies, hazards, reactor facility licenses, and license renewal applications, among other matters. The ACRS also has other roles and duties as defined in the AEA as amended, and NRC regulations. 42 U.S.C. §§ 2039, 2232; 10 C.F.R. §§ 1.13, 52.23, 52.53, 52.87, 54.25 (2022). The ACRS's role is further clarified in its Charter, Bylaws, Memorandum of Understanding with the NRC Executive Director for Operations, and NRC Staff Requirements Memoranda.

proposed reactor, the regulatory process, and the terms for public participation in the licensing process.

Under 10 C.F.R. Part 52, an applicant may obtain a combined construction permit and operating license in a single process. Applications for a combined license must include the same complete information regarding site, design, and operation as required for an operating license application under 10 C.F.R. Part 50. However, unlike the application process under Part 50, NRC staff conducts a safety evaluation and an environmental review once in the combined license application process. NRC staff must verify that the applicant has completed and met the Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC) before operations can begin.[22] These criteria provide reasonable assurance that the reactor design approved in the combined license application will be constructed and operated according to its license and legal requirements.[23] The ACRS conducts a single independent review of a combined license application and the associated NRC staff safety evaluation, as opposed to the two separate reviews conducted under Part 50. Both Part 50 and Part 52 require NRC to hold a public hearing during the application review process. However, instead of having two separate opportunities for public hearings (one for the construction permit and one for the operating license), as required under Part 50, the combined license process only requires one opportunity for a hearing prior to issuance of the combined license under Part 52. Under the regulations of Part 52, developers can also seek optional certification, approvals, and early site permits before submitting a combined license

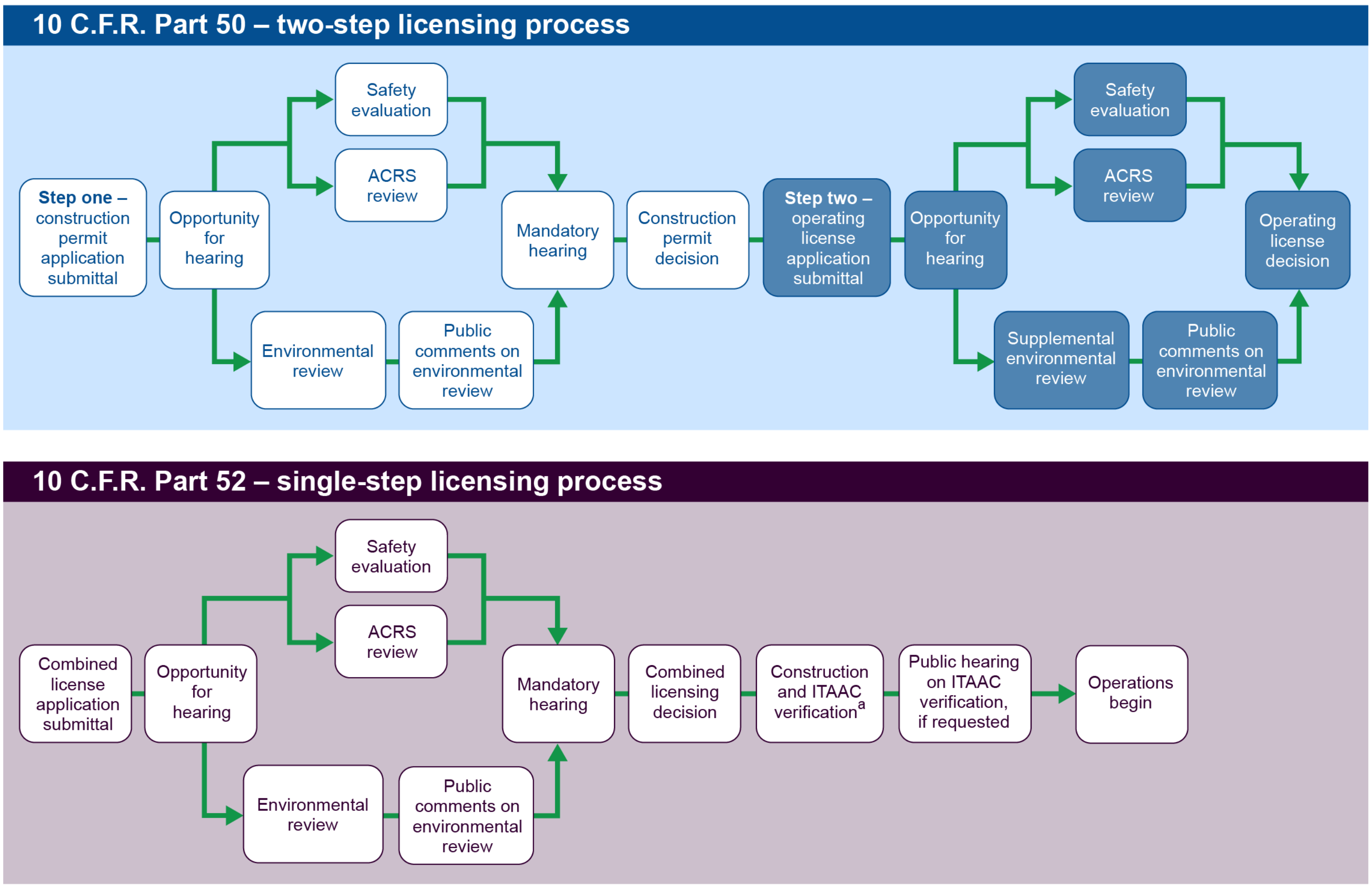
[22]Nuclear Regulatory Commission, *Regulatory Guide 1.215 Guidance for ITAAC Closure Under 10 C.F.R. Part 52,* ML112580018 (May 2012).

[23]10 C.F.R. § 52.80(a) (2022).

application.[24] See figure 1 comparing NRC's licensing processes under Part 50 and Part 52.

[24]For example, developers may seek a Design Certification, Standard Design Approval, or Early Site Permit under Part 52. A Design Certification certifies a generic and complete reactor design for up to 15 years, independent of a specific site. Standard Design Approval approves a major portion of a generic reactor design for up to 15 years. According to NRC, they do not define "major portions" because of the relationships between various plant systems and the contributions of safety and nonsafety systems to plant risk. Instead, developers need to provide the rationale for which portions of the design will be included. An Early Site Permit is for 10 to 20 years and resolves site safety, environmental protection, and emergency preparedness issues independent of a specific nuclear plant design. A Design Certification is a final regulatory decision and is not subject to modification unless NRC meets one of the regulatory criteria to modify, rescind, or impose different requirements in a new rulemaking based on substantial new evidence. Conversely, a Standard Design Approval is based on NRC's conclusive findings and does not prevent the approval from being reconsidered if NRC identifies significant new information that substantially affects the earlier determination or other good cause.

Figure 1: Comparison of the Nuclear Regulatory Commission's (NRC) Licensing Processes under 10 C.F.R. Part 50 and Part 52



10 C.F.R. Title 10 of the Code of Federal Regulations
ACRS Advisory Committee on Reactor Safeguards
ITAAC Inspections, Tests, Analyses, and Acceptance Criteria

Source: GAO analysis of NRC information. | GAO-23-105997

[a]According to NRC, if the standards identified in a combined license are met and verified, a combined license enables a licensee to construct and operate a plant once its construction is complete. These standards are called Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC).

Preapplication Engagement with NRC

Advanced reactor applicants are encouraged to engage in preapplication activities with NRC before submitting an application for a formal licensing review. According to NRC guidance, preapplication engagement is not a formal process nor is it required. Preapplication engagement can include informal communications with NRC staff, submitting documents to solicit

NRC's feedback, and other interactions between advanced reactor developers and NRC that occur before developers submit a license application.[25]

NRC guidance states that preapplication engagement may benefit both NRC staff and advanced reactor developers by helping to identify relevant regulatory requirements and licensing issues early in the licensing process. Furthermore, NRC's draft preapplication guidance states that preapplication engagement can help to identify technical and policy issues and enhance NRC staff's familiarity with novel reactor design features. NRC guidance also states that engaging in a set of specific preapplication activities prior to submitting an application may shorten the application review time by at least 6 months, depending on the complexity of the reactor design.

As of May 2023, NRC staff was engaged in preapplication activities with 11 advanced reactor developers with non-LWR designs and five developers with light-water SMR designs. In addition, NRC staff was formally reviewing two applications for non-LWRs and one application for an SMR. See appendix II for more information about the developers who have submitted applications to NRC for review and the developers engaged in preapplication activities with NRC.

DOE's Role in Advanced Reactor Research and Development, and Coordination with NRC

DOE supports the development of advanced nuclear technologies through research, development, and demonstration programs directed by DOE's Office of Nuclear Energy and DOE's Office of Clean Energy Demonstrations. Both DOE offices work to manage awards under the ARDP, as well as the demonstration award for the NuScale SMR technology. The ARDP supports early demonstrations of advanced

[25]During preapplication engagement, advanced reactor developers can submit documents, such as white papers, technical reports, and topical reports for NRC to review. White papers outline an applicant's position on specific technical or regulatory issues. Technical reports provide supporting information regarding technical safety issues in license applications. Topical reports address technical topics related to nuclear safety that will apply to multiple applications or licenses.

reactors through arrangements with developers in which costs are shared.[26]

In 2020, advanced reactor developers had the opportunity to apply for the Advanced Reactor Demonstration Funding Opportunity Announcement to support reactor development and demonstrations in three different categories:

1. **Advanced reactor demonstrations** provide support for near-term projects designed to produce fully functional, advanced reactors capable of being licensed by NRC as soon as this decade. The award term was up to 7 years.
2. **Risk reduction for future demonstrations** supports up to five developers to help improve the commercial readiness of their advanced reactor designs within 10-14 years of the award. The award term was up to 7 years.
3. **Advanced reactor concepts-20 (ARC-20)** supports innovative designs that have a lower technology readiness level but have the potential to achieve commercial readiness in the mid-2030s or later. The goal of the ARC-20 program is to assist the progression of advanced reactor designs in their earliest phases. The award term was up to 5 years.

Advanced reactor developers have access to DOE's National Reactor Innovation Center (NRIC) to test and evaluate their technologies. Specifically, the NRIC can facilitate access to DOE's national laboratories, which developers can use to test advanced reactor technologies and develop data needed to support their licensing activities. DOE finalized the Carbon Free Power Project award in October 2020 and in December 2020 announced that it was supporting 10 advanced reactor projects through the Advanced Reactor Demonstration Funding Opportunity Announcement. As of May 2023, eight of these projects were participating in licensing activities with NRC.

[26]We reported in September 2022 that DOE made these awards subject to cost-share arrangements under which DOE would provide up to 50 percent of project costs, and the award recipient would pay the rest. DOE funding for the TerraPower Natrium™ demonstration was $1.979 billion, DOE funding for the X-energy Xe-100 demonstration was $1.232 billion, and DOE funding for the NuScale VOYGR demonstration was $1.355 billion. GAO, *Nuclear Energy Projects: DOE Should Institutionalize Oversight Plans for Demonstrations of New Reactor Types*, GAO-22-105394 (Washington, D.C.: Sept. 8, 2022).

The Nuclear Energy Innovation Capabilities Act of 2017 formalized cooperation between DOE and NRC on advanced reactor technologies. For example, the act directed DOE and NRC to enter into a Memorandum of Understanding (MOU).[27] In 2019, DOE and NRC established an MOU that included an agreement to share technical expertise and facilitate the deployment of advanced nuclear technologies. According to the MOU, NRC technical staff will have access to observe and learn about technologies developed by DOE, including through the NRIC. DOE officials we interviewed emphasized the importance of coordinating with NRC, because ARDP demonstration awards require developers to license, construct, and operate their reactors within 7 years of receiving an award.[28] Under an addendum to the 2019 MOU, NRC provided DOE with feedback on the draft ARDP funding opportunity announcement to clarify NRC's regulatory requirements and on DOE's requests for information to help ensure that such requests are consistent with information required for the NRC licensing process. DOE officials told us that they have attended preapplication meetings with reactor demonstration recipients and regularly interact with relevant NRC staff as part of DOE's oversight responsibilities.

NRC Issued Guidance and Has Taken Other Actions to Modify Its Licensing Process to Include Advanced Reactors

NRC issued guidance that modified its licensing process to include advanced reactors and has taken additional actions to modify its licensing process, including restructuring certain offices and cooperating with DOE and others.

[27]Nuclear Energy Innovation Capabilities Act of 2017, Pub. L. No. 115-248, § 2(h), 132 Stat. 3154, 3157 (2018) (codified at 42 U.S.C. § 16278(e)). Department of Energy and Nuclear Regulatory Commission, "Memorandum of Understanding Between U.S. Department of Energy and U.S. Nuclear Regulatory Commission on Nuclear Energy Innovation" (Oct. 7, 2019).

[28]Developers may request an extension.

NRC Issued Guidance and Continues to Modify Its Licensing Process to Include Advanced Reactors

Since 2016, NRC has issued guidance on licensing advanced reactors under its existing regulatory framework and has engaged with industry stakeholders to develop a licensing process that is more technology inclusive, risk informed, and performance based.[29] Specifically, in 2016, NRC issued a vision and strategy document that outlined objectives for enhancing technical and regulatory readiness, as well as improving communication internally and with advanced reactor developers and other stakeholders.

In 2017, NRC issued near-, mid-, and long-term action plans that outlined strategies for achieving the objectives established in NRC's 2016 vision and strategy document, including strategies for (1) developing guidance for NRC's regulatory framework on non-LWRs; (2) resolving policy issues affecting advanced reactor regulatory reviews, siting, permitting, and licensing; (3) enhancing NRC's capacity to review advanced reactors; and (4) improving communication with internal and external stakeholders.[30] In 2022, NRC issued a progress report that stated that the agency had implemented a majority of the actions it established to support the strategies for achieving the objectives outlined in NRC's 2016 vision and strategy document.[31]

NRC has also issued guidance to advanced reactor developers on how to navigate the licensing process. Specifically, in 2017, NRC issued a regulatory review roadmap for non-LWRs to help advanced reactor developers understand the options available for NRC reviews of preapplication information and license applications. In 2021, NRC issued

[29]According to NRC's December 2016 *NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness*, technology inclusive is independent of the technology being reviewed. NRC's glossary of terms defines risk-informed regulation as an approach that incorporates an assessment of safety significance or relative risk. This approach is designed to ensure that the burden imposed by an individual regulation or process is appropriate to its importance in protecting the health and safety of the public and the environment. NRC defines performance-based regulation as an approach that focuses on desired, measurable outcomes, rather than prescriptive processes, techniques, or procedures.

[30]NRC's implementation action plan defines near-term as between 0 and 5 years, mid-term as between 5 and 10 years, and long-term as greater than 10 years. The time frames are based on NRC's strategic goal of reviewing and regulating non-LWRs by no later than 2025.

[31]Nuclear Regulatory Commission, *Non-light-water Reactor Implementation Action Plan—Progress Summary and Future Plans* (January 2022). NRC's report states that the agency had completed 21 of the 38 activities that NRC established to support its strategies for achieving the objectives outlined in the agency's 2016 vision and strategy document.

draft guidance on preapplication engagement that outlined activities for prospective advanced reactor applicants that NRC stated would make preapplication more predictable and efficient.[32] Further, in 2022, NRC staff issued a draft final rule on new emergency preparedness requirements for SMRs and other new technologies, including non-LWRs, and submitted it to the Commission for approval. If approved by the Commission, the rule would be technology inclusive and provide existing and future light-water SMRs and non-LWRs the option of developing an alternative performance-based emergency preparedness program.[33]

NRC has also engaged with the nuclear industry to modify its licensing process to include advanced reactors. For example, NRC worked with industry stakeholders on the Licensing Modernization Project, which sought to develop a technology-inclusive, risk-informed, and performance-based approach for assessing advanced reactor applications.[34] According to NRC officials we interviewed, the project sought to move away from the prescriptive requirements in Part 50 and Part 52 and to define a methodology focused on addressing risks posed by non-LWR technologies. As part of the project, in 2020, NRC issued a regulatory guide that non-LWR applicants can use when applying for permits, licenses, certifications, and approvals under Part 50 and Part 52. The regulatory guide endorsed the methodology described in a report published by the Nuclear Energy Institute, which is the policy organization of the nuclear technologies industry, as one acceptable method for non-

[32]In May 2023, NRC issued the draft preapplication white paper as draft guidance for public comment, entitled: Appendix A to DANU-ISG-2022-01, *Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications—Roadmap*, Draft Interim Staff Guidance, ML22048B546. NRC officials we interviewed told us that NRC continues to encourage preapplication engagement.

[33]Nuclear Regulatory Commission, SECY-22-0001, “Rulemaking Issue (Affirmation), Final Rule: Emergency Preparedness for Small Modular Reactors and Other New Technologies (RIN 3150-AJ68; NRC-2015-0225)” (Jan. 3, 2022). If approved, the rule would provide new alternative requirements for SMRs and other new technologies that provide for reasonable assurance that adequate protective measures would be taken in the event of a radiological emergency consistent with the existing emergency preparedness requirements.

[34]The initiative was a cost-sharing agreement between nuclear utilities and DOE.

LWR designers to use when engaged in licensing activities and preparing their applications.[35]

Furthermore, NRC is working on the Advanced Reactor Content of Application Project. The project encompasses a prior industry-led effort to provide guidance on the content of applications and is based on the outcome of the Licensing Modernization Project. NRC officials we interviewed said that the Advanced Reactor Content of Application Project will provide advanced reactor applicants with guidance about the information they should include in their applications.

NRC Made Organizational Changes and Cooperated with DOE in Modifying Its Licensing Process

In modifying its licensing process, NRC made organizational changes, such as reorganizing its offices that license advanced reactors and creating dedicated license review teams. Specifically, in 2019, NRC merged its Office of Reactor Regulation and Office of New Reactors to create a new Office of Nuclear Reactor Regulation. NRC officials told us that merging the offices was intended to facilitate more efficient reviews of advanced reactors by leveraging staff knowledge of both NRC's regulatory framework and advanced reactor technologies. NRC officials we interviewed also told us that before the creation of the Office of Nuclear Reactor Regulation, NRC's reviews of applications for research and test reactors were managed separately from reviews of applications for new reactors, such as advanced reactors.

In modifying its licensing process, NRC also instituted a core team concept, which, according to one stakeholder we interviewed, is a team composed of specialists from various disciplines within NRC. The stakeholder told us that the intent of the core team concept was for each specialist within the team to think about licensing in a novel way and to provide continuity of staff throughout the review of an advanced reactor license application. According to NRC officials we interviewed, the agency assigns a core team of NRC staff to each application, akin to how NRC employs "tiger teams" in other contexts. A 2018 NRC Policy Issue document defines tiger teams as small groups of NRC staff empowered

[35]See Nuclear Energy Institute, 18-04, "Modernization of Technical Requirements for Licensing of Advanced Non-Light Water Reactors: Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development," Report Revision 1 (August 2019) endorsed by NRC Regulatory Guide 1.233.

to identify solutions to licensing challenges without being constrained by current processes or past practices.[36]

In addition, NRC cooperated with DOE to share technical expertise and incorporated feedback from several federal agencies and other organizations in modifying its licensing process. NRC also cooperates with DOE to share technical expertise through its 2019 MOU, as well as informal communications.[37] NRC officials told us that, through the 2019 MOU, NRC leverages DOE national laboratory staff to review draft NRC guidance on advanced reactors, review environmental issues, and develop software and simulations.[38] According to DOE officials, both agencies look for opportunities that would give NRC insight into technologies that DOE is researching and developing and how NRC may regulate those technologies from a licensing standpoint.

NRC also solicited and incorporated feedback from other federal agencies and external stakeholders regarding proposals to modify its licensing process. For example, a 2018 NRC Policy Paper identified ways in which NRC could transform its regulatory framework to better prepare the agency to regulate new technologies.[39] According to NRC documentation, the agency solicited feedback and ideas from several federal agencies, including DOE, the Federal Aviation Administration, and the Food and Drug Administration (FDA).[40] NRC also sought feedback from external stakeholders from industry, state organizations, and international regulators. According to NRC documentation, NRC staff incorporated feedback from internal and external stakeholders about

[36]According to a 2018 NRC Policy Issue Paper, NRC staff recommended expanding the use of several organizational tools, one of which included tiger teams, to effectively implement a risk-informed licensing framework. See Nuclear Regulatory Commission, Policy Issue SECY-18-0060, “Achieving Modern Risk-Informed Regulation” (May 2018).

[37]Department of Energy and Nuclear Regulatory Commission, “Memorandum of Understanding Between U.S. Department of Energy and U.S. Nuclear Regulatory Commission on Nuclear Energy Innovation.”

[38]NRC officials told us that because NRC is an independent regulatory body, DOE staff do not conduct license reviews of advanced reactors.

[39]Nuclear Regulatory Commission, Policy Issue SECY-18-0060.

[40]According to an enclosure for SECY-18-0060, NRC solicited and gathered ideas through internal and external outreach efforts. NRC contacted the Department of Defense, Department of Energy, Department of Transportation, Federal Aviation Administration, Food and Drug Administration, Federal Energy Regulatory Commission, General Services Administration, National Aeronautics and Space Administration, and Naval Reactors. The enclosure does not describe how NRC selected the agencies.

recommending expanding NRC's use of risk-informed decision-making, such as scaling the scope and level of reviews based on risk, and increasing NRC's ability to accept uncertainty.

According to NRC officials we interviewed, NRC incorporated the feedback it received for more risk-informed decision-making into other guidance. According to NRC officials we interviewed, NRC staff worked with FDA officials to understand how FDA conducts day-to-day activities to assess new technologies. NRC officials told us that their discussions with FDA helped them to understand the need to focus on the highest risks and safety issues for advanced reactors, as opposed to considering every issue in equal measure. NRC has translated this understanding into guidance, such as guidance for the Technology-Inclusive Content of Application Project and Advanced Reactor Content of Application Project, which prioritize risk and safety issues in the licensing process.

NRC is also incorporating ideas from other federal agencies into its draft regulation, Part 53, according to NRC officials we interviewed. Specifically, NRC officials solicited feedback from officials in other federal agencies to learn about ways in which the agencies were assessing new technologies. NRC received feedback that indicated that NRC should pursue a risk-informed regulation for Part 53 and move away from the prescriptive, existing regulation of Part 50 and 52.

NRC is also working to modify its licensing process through a 2019 Memorandum of Cooperation with the Canadian Nuclear Safety Commission (CNSC). The stated purpose of the memorandum is to expand cooperation between NRC and CNSC on activities associated with advanced reactor technologies, which may include collaborating to develop (1) preapplication activities for advanced reactors, (2) approaches for technical reviews of advanced reactors, and (3) regulatory approaches to address unique technical considerations for ensuring the safety of advanced reactors. One NRC official told us that the agency developed its memorandum with CNSC in response to feedback from external stakeholders who suggested that NRC should consider leveraging licensing reviews conducted by other regulators. According to one stakeholder we interviewed, the memorandum of cooperation between NRC and CNSC will be useful because advanced reactor developers and operators may head toward international deployment after initial demonstrations.

NRC's Modifications Have Enhanced Its Licensing Process but Do Not Fully Address Ongoing Challenges to Reviewing Advanced Reactors

Some of the modifications made by NRC have enhanced its licensing process. However, the modifications do not fully address ongoing challenges related to clarity of guidance, sufficient staffing, and developer engagement with the ACRS that affect NRC's ability to review advanced reactors.

Some Modifications to NRC's Licensing Process Have Enhanced Its Ability to Review Advanced Reactors

Some of the modifications that NRC made to its licensing process have enhanced the agency's ability to review advanced reactors. More specifically, NRC officials and stakeholders we interviewed told us that by establishing mechanisms for early interactions between NRC and reactor developers through preapplication engagement and instituting dedicated core review teams, NRC has improved its ability to manage the review of preapplication and application materials for advanced reactors.[41]

Early interaction through preapplication engagement. The 2019 Nuclear Energy Innovation and Modernization Act required NRC to develop a staged approach for reviewing advanced reactors to make the licensing process more predictable, efficient, and timely.[42] To address part of this requirement, NRC drafted a set of preapplication activities to facilitate communication and the exchange of information between NRC and advanced reactor developers.[43]

NRC officials and stakeholders we interviewed cited several strengths of NRC's preapplication engagement activities. For example, some stakeholders stated that preapplication allowed for early and efficient

[41]As described above, we interviewed NRC officials and a nongeneralizable sample of 17 selected stakeholders to obtain their views on the strengths and challenges of NRC's process for licensing advanced reactors. Stakeholders included advanced reactor developers, former NRC staff, academics and research organizations, and other interested groups with expertise in advanced nuclear reactors and the NRC licensing process. For more information on our scope and methodology, see app. I.

[42]*See* Pub. L. No. 115-439, § 103(a), 132 Stat. 5565, 5571 (2019) (codified at 42 U.S.C. § 2133 note).

[43]Nuclear Regulatory Commission, *Draft Pre-application Engagement to Optimize Advanced Reactors Application Reviews*, ML21145A106 (May 2021).

communication with NRC.[44] One stakeholder told us that during preapplication, advanced reactor developers may submit a proposal to NRC requesting exemptions from certain regulatory requirements that the developer believes are not applicable to their reactor designs. Such proposals can facilitate a more efficient license application review because they help NRC and reactor developers establish an approach for reviewing proposed exemption requests or the applicability of orders or certain regulations.

Core teams. Some stakeholders stated that core teams helped strengthen the licensing review process for advanced reactors. For example, one stakeholder stated that a core team builds trust between NRC and the developer. Another stakeholder said that the core team concept ensures continuity of staff throughout the preapplication and application review process. NRC officials told us that a strength of the concept was that the core team will become familiar with the design. However, some stakeholders identified potential challenges with NRC's use of core teams. For example, one of these stakeholders told us that NRC's core team approach to reviewing various advanced reactor designs may not work once the agency received multiple applications because there were not enough review teams available. NRC officials told us that the agency is addressing future potential peaks in advanced reactor licensing work by using other NRC staff to augment core team staffing and using contractors.

Ongoing Challenges Continue to Affect NRC's Ability to Review Advanced Reactors

NRC's modifications to its licensing process do not fully address ongoing challenges related to clarity of guidance, sufficient staffing, and the ACRS's role in the licensing review process.

Clarity of guidance. According to our analysis, existing NRC guidance does not clearly advise staff on how to establish and manage licensing review schedules for incomplete applications. According to NRC guidance, an application is incomplete if it omits information required by

[44]When summarizing stakeholders' views on the common themes we identified, we use the quantifier "some" to indicate that two to six stakeholders expressed the idea, use the term "many" to indicate that seven to 11 stakeholders expressed the idea, and use the term "most" to indicate that 12 to 17 stakeholders expressed the idea. For more information, see app. I.

the regulations governing the contents of applications.[45] NRC guidance outlines criteria for NRC to use when determining whether an application is complete and whether to accept it for review. The guidance states that in rare circumstances, NRC staff can deviate from established procedures and accept an incomplete application. According to NRC regulations, once NRC accepts an application, NRC staff must establish a review schedule from the time it dockets the application until agency staff complete their review.[46] However, current NRC regulations and guidance do not advise staff on how to establish and manage licensing review schedules for incomplete applications that NRC staff accepts for docketing.

In June 2020, NRC invoked a "rare circumstance" provision to accept and docket an incomplete license application for a microreactor.[47] NRC guidance at the time that the agency reviewed the application outlined criteria for NRC to use when determining whether an application is complete and whether to accept it for review. In its letter notifying the developer that NRC had accepted its application for review, NRC considered that the application was for a first-of-a-kind submission involving a novel reactor design for which NRC has yet to establish

[45]Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Office Instruction LIC-117, *Acceptance Review Process for New Nuclear Facility Licensing Applications* (January 2021).

[46]10 C.F.R. § 2.102(a) (2022).

[47]Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Office Instruction LIC-109, Revision 2, Acceptance Review Procedures (Jan. 16, 2017). According to NRC's Office Instruction LIC-109, Revision 2, in certain rare circumstances, there may be situations where evaluating an application against the criteria provided in NRC's review guidance suggests one action, but a different action may be more appropriate. The guidance specifies that such circumstances include reviewing applications for novel or "first of a kind" designs or reactors that are in the interest of public health, safety, and security. At the time of NRC's review of the license application, the agency followed Revision 2 guidance. One month later, in July 2020, NRC issued Revision 3, which excluded combined license applications. However, in 2021, NRC's Office of Nuclear Reactor Regulation issued Office Instruction LIC-117, which applies to combined license applications and allows NRC staff to invoke the rare circumstance provision and accept an incomplete application. To docket an application, NRC will establish a docket number for the application and issue a notice in the *Federal Register* of NRC's acceptance and docketing of the application.

consistent standards for acceptance.[48] NRC also stated that agency staff were unable to establish a reliable review schedule because the staff identified significant information gaps within the application. In its response to NRC, the developer indicated that, without a review schedule, the company was uncertain about the time frame and manner in which NRC would review the application. NRC denied the application without prejudice in January 2022, meaning that the developer could resubmit its application supplemented by additional information that NRC requested. According to the developer, the denial had a chilling effect on private investment in advanced fission, and at least one other company reevaluated its project risk evaluations based on the application's denial.

Written procedures for incomplete applications are particularly important because advanced reactors may have novel, first-of-a-kind advanced reactor designs that are not complete. According to NRC officials, advanced reactors with first-of-a-kind designs may not have been tested. Once the designs are tested, developers may find that their designs do not perform as expected and must make changes to their applications, which would prompt NRC to redo work for its review.

Additionally, NRC's Principles of Good Regulation state that regulations should be reliable and not unjustifiably in a state of transition; and regulatory actions should be consistent with written regulations and should be promptly, fairly, and decisively administered to lend stability to the nuclear operational and planning processes.[49] Without written procedures that outline how NRC will establish and manage review schedules for incomplete applications, NRC's reviews of advanced reactors may lack clarity, and developers may face an unpredictable review process when submitting applications for first-of-a-kind designs.

[48]According to NRC, agency staff also considered the following circumstances as part of their decision to accept the combined license application: (1) the national interest in promoting innovation and supporting the commercialization of safe and secure advanced nuclear reactors, as called for in the Nuclear Energy Innovation and Modernization Act; and (2) the belief that accepting the application would improve the efficiency, timeliness, and cost-effectiveness of NRC's review and could help minimize any delays caused by the need for the developer to make amendments or provide supplemental information for its application. Nuclear Regulatory Commission, *Oklo Power LLC – Acceptance of the Application for A Combined License Application for The Aurora at Idaho National Laboratory,* ML20149K616 (June 2020).

[49]Nuclear Regulatory Commission, *Principles of Good Regulation,* ML14135A076 (May 2014).

Developers are also unclear about NRC’s expectations regarding preapplication engagement. In May 2021, NRC issued draft preapplication guidance for advanced reactor developers, which NRC released in May 2023 for public comment.[50] The draft guidance notes that it is subject to change and that its contents do not represent the agency’s official position. NRC officials told us that NRC staff are open to alternative approaches to the regulations and that no guidance, including draft guidance, is treated as a requirement. However, one stakeholder we interviewed told us that NRC staff expect compliance with draft products the same as with established guidance. Furthermore, NRC encourages advanced reactor developers to participate in preapplication activities but does not require participation. For instance, NRC’s preapplication guidance states that if developers complete the outlined preapplication activities, then NRC staff could establish a review schedule at least 6 months shorter than for developers that do not engage in preapplication, depending on the complexity of the design.

NRC’s descriptions of the benefits of preapplication and the consequences of limited engagement suggest that although preapplication is voluntary, participation is an unwritten rule. For example, NRC stated in its letter denying one applicant’s combined-license application, that its decision was based, in part, on the fact that the developer’s participation in preapplication discussions with NRC was limited and ineffective and because the developer did not incorporate NRC feedback from its preapplication discussions into its application.

While it is up to each advanced reactor developer to determine the extent to which it should engage with NRC during preapplication, NRC’s Principles of Good Regulation state that agency positions should be readily understood and easily applied. Until NRC finalizes guidance that clarifies the extent to which developers should engage in preapplication, developers cannot be certain about NRC’s expectations and will be unable to make a fully informed decision about whether to participate in preapplication activities. In addition, if developers do not fully engage in preapplication, they may submit applications that are insufficient or incomplete and that result in inefficient and lengthier reviews.

Sufficient staffing. While NRC has taken steps to address staffing challenges, some of the modifications to its licensing process do not

[50]Nuclear Regulatory Commission, *Draft Pre-application Engagement to Optimize Advanced Reactors Application Reviews.*

address staffing challenges that may affect its ability to manage the anticipated increase in advanced reactor application submissions. NRC officials and most stakeholders we interviewed stated that NRC faces ongoing challenges related to retaining and hiring the staff necessary to review advanced reactors. According to our analysis of NRC data, NRC's budget and staff for its Nuclear Reactor Safety program—which manages the licensing of advanced reactors—have decreased on average from fiscal years 2016 through 2021.[51] Moreover, within the Nuclear Reactor Safety program, the budget for licensing new reactors decreased by an annual average of 15 percent, while the number of full-time equivalents decreased by an annual average of 16 percent.[52]

NRC officials and some stakeholders we interviewed said that reductions in NRC's budget for staffing has limited NRC's ability to compete with advanced reactor developers to hire technical experts.[53] More specifically, some stakeholders stated that NRC faces staffing challenges because developers have more resources to hire employees and can offer incentives that NRC cannot. For example, two stakeholders we interviewed said that advanced reactor developers can offer staff higher salaries. NRC officials we interviewed told us that NRC had difficulty recruiting staff in locations that were remote or high cost. In addition, NRC officials said that there is a limited pool of potential employees with the requisite knowledge and skills from which to recruit.

NRC's steps to address the agency's staffing challenges include analyzing its workforce annually to identify staffing gaps in the office responsible for licensing advanced reactors. For example, in its fiscal year 2022 staffing capacity assessment, NRC stated that the agency

[51]We analyzed NRC's congressional budget justifications for fiscal years 2018 through 2023. These budget justifications contain budget and staffing data for fiscal years 2016 through 2021. From fiscal years 2016 through 2021, NRC's Nuclear Reactor Safety program budget decreased by an annual average of 3 percent, and staffing levels decreased by an annual average of 5 percent.

[52]The budget for training related to new reactors from fiscal years 2016 through 2021 decreased by an annual average of 10 percent, and staffing levels for training related to new reactors decreased an annual average of 7 percent. As defined by NRC, full-time equivalent is a basic measure of the levels of employment used in the budget. It is the total number of hours worked (or to be worked) divided by the number of compensable hours applicable to each fiscal year. Nuclear Regulatory Commission, Congressional Budget Justification Fiscal Year 2023, NUREG-1100, vol. 38 (Washington, D.C.: April 2022).

[53]Nearly all advanced reactor developers we interviewed told us that they hired former NRC staff to help them navigate the licensing process.

anticipated a significant increase in workload for licensing activities related to advanced reactors. Additionally, NRC's staffing analysis concluded that based on current staffing levels, expected staff attrition, and future workforce demands, the NRC division responsible for licensing advanced reactors had a shortage of 57 staff persons as of fiscal year 2023. NRC has implemented several measures to address workforce shortfalls, such as establishing core review teams and moving staff within the agency to where they were most needed. According to NRC officials, the agency has developed a strategic workforce plan and budget processes to help ensure that NRC will have sufficient staff with the appropriate skills needed to address workload demands from the anticipated increase in advanced reactor application submissions. According to NRC officials, the agency is engaged in an aggressive human capital campaign to recruit and retain the necessary staff, including offering relocation and retention incentives and the option for full-time remote telework for hard-to-fill positions. NRC officials told us that the agency is also exploring leveraging NRC staff throughout the agency, as well as using contractors to address future potential peaks in advanced reactor licensing work.

The Atomic Energy Act of 1954, as amended, authorizes NRC to set compensation for its employees.[54] NRC has also issued policy on using recruitment, retention, and relocation incentives. According to an NRC Management Directive on recruitment, relocation, and retention incentives, NRC can offer incentives for hiring staff, including providing a recruitment incentive of up to 50 percent of the employee's annual rate of basic pay.[55] However, NRC officials told us that incentives may not be effective, given certain limits on total compensation allowed in the federal government.

While NRC recognizes its staffing limitations, recruitment challenges, and the expected influx of advanced reactor applications, NRC has not evaluated its efforts to address staffing gaps. As a result, NRC does not know the extent to which its recruitment strategies and incentives have a positive effect on hiring and retention. NRC officials told us that they do not have benchmarks to determine the effectiveness of the recruitment, relocation, and retention incentives, which would also inform what they need to change. NRC also has not developed measures to assess

[54]42 U.S.C. § 2201(d) (2022).

[55]Nuclear Regulatory Commission Management Directive MD 10.51, *Recruitment, Relocation, and Retention Incentives*, DT-18-14 (July 27, 2018).

progress in addressing gaps, and NRC officials told us that they were unable to measure the effectiveness of the agency's hiring incentives or recruitment strategies to expand their candidate pool because the agency does not have data on what hiring and recruitment outcomes would have been without the strategies or incentives. According to NRC's strategic workforce planning document, the agency must develop a strategy to address gaps, surpluses, and a plan to execute the strategies, and measures for assessing progress.[56]

Given that NRC expects to receive an influx of applications for advanced reactors in the near future, and the fact that some preapplicants have funding tied to aggressive timelines under DOE's ARDP, NRC may find it challenging to ensure that it has sufficient numbers of the staff necessary to review advanced reactors. Without measures and benchmarks to assess its recruitment, relocation, and retention incentives and recruitment strategies, NRC will be unable to determine the effectiveness of its efforts to ensure that it has the sufficient numbers of knowledgeable staff needed to conduct licensing reviews in the coming years. For more information on NRC's licensing activities and DOE's award time frames, see appendix III.

Developer engagement with NRC's Advisory Committee on Reactor Safeguards (ACRS). NRC has not made clear to advanced reactor developers the role that the ACRS plays in NRC's licensing process or the expectations regarding developers' engagement with the ACRS during the licensing process.

NRC's draft preapplication guidance for advanced reactor developers notes the importance of early engagement with the ACRS during the licensing process. NRC has stated that applicants, NRC staff, and the ACRS should meet early to discuss how to identify the number of ACRS interactions and meetings that may be necessary during the review and identify the most risk-significant aspects of the design. However, NRC's draft guidance does not outline how to initiate and coordinate early contact with the ACRS nor does it provide sufficient detail on when the ACRS is to engage with applicants or the scope of the ACRS's review. For example, NRC's draft preapplication guidance for advanced reactor developers does not discuss the ACRS's role in the review process nor

[56]Nuclear Regulatory Commission, *Enhanced Strategic Workforce Planning*: *Office Director and Regional Administrator Guidance* (October 2020).

does it provide information about the timing and processes for conducting these interactions. In addition, the regulatory review roadmap that NRC issued to developers of non-LWR's designs does not provide detailed information about the course of interactions between developers and the ACRS.[57] NRC officials told us that contact with the ACRS is conducted through an NRC project manager, but this interaction is not documented in the roadmap or the preapplication guidance. ACRS officials told us that scheduling a due date for the ACRS final safety report occurs early in the application review and depends on many factors, including the complexity of the reactor design, completeness of the application, and applicant availability for ACRS meetings.

NRC's Executive Director for Operations and the ACRS's Executive Director have a March 2021 MOU that aims to establish a process for effective planning and engagement regarding the safety of proposed or existing NRC-licensed facilities and the adequacy of proposed safety standards. Specifically, the MOU states that NRC and the ACRS should have early discussions to identify matters requiring ACRS consideration and should have informal meetings regarding technical matters. However, the memorandum does not define technical matters or specify when NRC and ACRS meetings should occur. Furthermore, while the MOU outlines the scope of the regulatory and technical activities that the ACRS should review, the MOU does not constitute guidance for advanced reactor developers on how to interact with the ACRS during the licensing process. Moreover, the 2021 MOU is not publicly available and, therefore, not accessible to developers.

According to many stakeholders we interviewed, the role of the ACRS during the licensing process remains unclear. For example, one stakeholder told us that it is not clear when and how often it is necessary to meet with the ACRS during preapplication engagement. The same stakeholder also told us that the timing of the ACRS's participation in NRC's licensing process is not sufficiently transparent. One stakeholder we interviewed told us that it is difficult to meet with the ACRS because the committee's schedule is difficult to predict, while another stakeholder told us that it can take months to meet with the ACRS. In addition,

[57]Nuclear Regulatory Commission, *A Regulatory Review Roadmap for Non-light Water Reactors*, ML17312B567 (December 2017). The roadmap states that NRC developed it with the intent to help define processes and interactions for various stages of the design and licensing processes and to standardize terminology and expectations.

another stakeholder told us that clarifying the role of the ACRS during the licensing process would lead to more timely and efficient reviews.

NRC officials stated that they plan to communicate the process for interacting with the ACRS in meetings with prospective applicants and referred us to three additional documents that they stated outlined the role of the ACRS during the licensing process. However, one of the documents is not public, and the other documents, although public, are specific to (1) NRC project managers and not developers and (2) the process for reviewing topical reports and does not cover the broader licensing process.

An ACRS official also told us that ACRS staff coordinate with NRC staff to establish time frames for their safety reviews but that those time frames depend on the applicant submitting a high-quality and complete application that results in few requests for additional information. NRC officials told us that they include the ACRS's time frames when developing application review schedules. According to ACRS officials, the ACRS's role is outlined in the Atomic Energy Act of 1954, its charter and bylaws, Staff Requirements Memoranda from the Commission, and NRC and Federal Advisory Committee Act regulations. However, these laws, regulations, NRC guidance, and other agency documents for advanced reactor developers do not specify how and when to engage with the ACRS during the licensing process.

ACRS officials told us that it is not possible to precisely state the timing and scope of the ACRS's reviews. The officials also said that the ACRS's important role should not be limited and that the ACRS is strongest and most valuable when it can review cross-cutting issues and broadly examine reactor safety issues, particularly in first-of-a-kind applications and technologies. However, additional clarity in NRC guidance could help reactor developers better understand when and how they should interact with the ACRS during the licensing process. Without clarifying how and when advanced reactor developers should engage with the ACRS during the licensing process, applicants may experience uncertainties that could create delays and increased costs during the review of their applications, which could, in turn, hinder developers' ability to deploy advanced reactors.

Conclusions

With energy demand in the United States expected to increase, and many existing nuclear plants shut down in recent years, advanced nuclear reactors have the potential to help meet the nation's energy demand as a clean energy source. In anticipation of an influx in license applications for advanced reactors, NRC modified its licensing process and took other actions to prepare the agency for reviewing advanced reactors. While some of NRC's modifications have improved its licensing process, they do not fully address ongoing challenges that affect the agency's ability to review advanced reactors.

Despite the likelihood that NRC will receive incomplete applications for advanced reactors in the future, NRC has not developed guidance regarding how to establish and manage licensing review schedules for incomplete applications. Without such guidance, NRC's reviews of advanced reactor applications may not be clear and predictable.

In 2021, NRC issued draft guidance for advanced reactor developers regarding engagement in preapplication activities. However, the draft guidance does not make clear the extent to which developers are expected to participate in preapplication activities. Moreover, the fact that the guidance remains in draft status creates uncertainties that may affect developers' decisions about participating in preapplication engagement. Until NRC finalizes guidance that clarifies the extent to which developers should engage in preapplication, NRC's expectations may be unclear, and some developers may choose not to participate in preapplication activities.

NRC officials and most stakeholders we interviewed indicated that NRC faces challenges in hiring and retaining the staff necessary to review advanced reactors. More specifically, some stakeholders said that reductions in NRC's budget for staffing has limited the agency's ability to compete with industry for hiring. NRC has used recruitment, relocation, and retention incentives to hire talent in a targeted manner. However, despite the expected influx in advanced reactor applications and NRC's recognition of its staffing limitations and recruitment and retention challenges, NRC has not benchmarked and evaluated whether these incentives or other recruitment strategies are effective. Until NRC does so, the agency cannot ensure that it has sufficient numbers of skilled staff necessary to license advanced reactors. In addition, without pursuing such options, NRC will likely experience staffing challenges that can lead to lengthy review schedules and inefficiencies in NRC's advanced reactor reviews.

Finally, while NRC has documented the importance of early engagement with the ACRS, NRC guidance does not provide sufficient information to advanced reactor developers about the ACRS's role in the licensing process or how and when developers should engage with the ACRS.

Absent guidance that clarifies how and when advanced reactor developers should engage with the ACRS during the licensing process, developers may experience delays and increased costs during the review of their applications. This could, in turn, hinder developers' ability to deploy advanced reactors.

Recommendations for Executive Action

We are making four recommendations to the Chairman of NRC:

The Chairman of NRC should direct staff to develop procedures for establishing and managing a review schedule for an incomplete application, including applications for first-of-a-kind designs. (Recommendation 1)

The Chairman of NRC should direct staff to finalize draft preapplication guidance to clarify the extent to which advanced reactor developers should participate in preapplication activities. (Recommendation 2)

The Chairman of NRC should direct staff to establish benchmarks and measures to assess its recruitment, relocation, and retention incentives and strategies to determine their effectiveness to help NRC retain and hire the staff necessary to license advanced reactors. (Recommendation 3)

The Chairman of NRC should direct staff to clarify in information provided to advanced reactor developers how and when they should engage with the ACRS during the licensing process. (Recommendation 4)

Agency Comments

We provided a draft of this report for review and comment to DOE and NRC. In its comments, reproduced in appendix IV, NRC stated that it was in general agreement with the report. NRC and DOE also provided technical comments, which we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the appropriate congressional committees, the Chairman of the Nuclear Regulatory Commission, the Secretary of Energy, and other interested parties. In addition, the report is available at no charge on the GAO website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact me at 202-512-3841 or ruscof@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix V.

Frank Rusco
Director, Natural Resources and Environment

Appendix I: Objectives, Scope, and Methodology

This report examines (1) actions the Nuclear Regulatory Commission (NRC) has taken to modify its existing licensing process to include advanced reactors and (2) the extent to which the modifications to NRC's licensing process have prepared the agency to review advanced reactors.

To describe actions that NRC has taken to modify its existing licensing process to include advanced reactors, we reviewed statutes, NRC regulations, policies, and guidance. Some of these include the Atomic Energy Act of 1954, the Nuclear Energy Innovation and Modernization Act, 10 C.F.R. Part 50 and Part 52, policy briefs, and guidance for advanced reactor developers outlining modifications that NRC made to its licensing process to include advanced reactors.[1] We also reviewed NRC's projects conducted with industry to develop guidance for completing advanced reactor applications. We reviewed NRC documents outlining the agency's organizational changes, including NRC office mergers and the modified structure of NRC licensing review teams for advanced reactors. We also reviewed NRC documents on its outreach efforts to external stakeholders, including other federal agencies, from whom NRC sought feedback on the modifications to its licensing process. We interviewed NRC officials about the agency's existing process for licensing all nuclear reactors and how the agency modified that process for licensing advanced reactors. Additionally, we interviewed officials at the Department of Energy (DOE) on cooperation efforts between NRC and DOE on advanced reactor research and sharing technical expertise between the two agencies.

To examine the extent to which the modifications to NRC's licensing process have prepared the agency to review advanced reactors, we reviewed NRC's guidance on advanced reactors and workforce planning documentation. We assessed this documentation for clarity and completeness against NRC's Principles of Good Regulation and NRC's strategic workforce planning guidance. We reviewed NRC's Congressional Budget Justifications for fiscal years 2018 through 2023 to obtain information about the agency's funding and staff levels for fiscal years 2016 through 2021. We interviewed NRC staff and officials from the Advisory Committee on Reactor Safeguards (ACRS). We interviewed a nongeneralizable sample of 17 selected stakeholders to obtain their views on the strengths and challenges of NRC's process for licensing advanced

[1]For the purposes of this report, we are defining licensing process to include preapplication engagement and licensing activities under 10 C.F.R. Part 50 and Part 52.

reactors.[2] Stakeholders included advanced reactor developers; former NRC staff who were last appointed to relevant positions and who had recent first-hand knowledge of NRC's licensing process; academics and research organizations; and members of interested parties, associations, and groups with expertise in advanced nuclear reactors and NRC's licensing process.[3] To identify advanced reactor developers, we reviewed publicly available NRC lists of entities engaged in preapplication and licensing activities as of September 2022. To identify former NRC staff, we compiled a list of former NRC staff by reviewing publicly available web pages on NRC staff who were last appointed to specific positions and who had recent first-hand knowledge of NRC's licensing process. We also conducted internet searches of former staff's biographies describing their current positions and past work related to advanced reactors. We identified academics and research organizations, as well as interested parties, associations, and groups, by conducting a review of relevant literature. Throughout the course of our engagement's design, we continued to ask officials we interviewed for additional recommendations of whom we should interview and added them to our list of potential interviewees.

From the list of stakeholders we identified, we selected 17 stakeholders to interview based on specific criteria for each stakeholder group.[4] We selected advanced reactor developers who had a range of experience with NRC's license review and preapplication activities. We selected former NRC staff who were last appointed to the identified positions. We selected academics and research organizations based on their relevant published research. We selected interested parties, associations, and groups that, based on the relevancy of their mission and published work, offered a range of organization types and perspectives.

To identify the strengths and challenges cited most often in the interviews, we conducted a content analysis of stakeholders' answers, as

[2]In addition to conducting interviews, in some cases, we also obtained written follow-up responses from stakeholders.

[3]While we refer to this group collectively as stakeholders, it is comprised of both individuals and groups. By interested parties, associations, and groups, we refer to industry groups, not-for-profit organizations, and public interest groups.

[4]We selected 17 stakeholders, which were comprised of six advanced reactor developers; three former NRC staff; three academics and research organizations; and five interested parties, associations, and groups. We initially selected 22 stakeholders but were unable to contact one advanced reactor developer, one former NRC staff, and three academics and research organizations.

well as their written responses to our questions in semistructured interviews. We also included responses from current NRC officials. We generally asked the same questions during each interview but also discussed individual stakeholders' perspectives, as appropriate. In our interviews, we asked NRC and stakeholders about any strengths or challenges with NRC's preapplication process, any challenges with NRC's application process, the clarity of NRC's licensing process, and how prepared or unprepared NRC was to handle the upcoming influx of advanced reactor applications. Two analysts developed categories of strengths and challenges identified by NRC officials and stakeholders, and each analyst independently determined whether each stakeholder had identified strengths and challenges that fit into these categories. The two analysts discussed and resolved any differences in their categorization. When summarizing stakeholders' views on the common categories we identified, we use the quantifiers "some," "many," and "most." Specifically, the term "some" indicates that two to six stakeholders expressed the idea; the term "many" indicates that seven to 11 stakeholders expressed the idea; and the term "most" indicates that 12 to 17 stakeholders expressed the idea. The views of current NRC officials and the 17 stakeholders we interviewed are not generalizable to NRC officials and stakeholders we did not interview.

We conducted this performance audit from May 2022 to July 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Additional Information on Advanced Reactor Applicants and Preapplicants, as of May 2023

Table 2 provides more information about the developers who have submitted applications to the Nuclear Regulatory Commission (NRC) for review and the developers engaged in preapplication activities with NRC.

Table 2: Advanced Reactor Applicants and Preapplicants, as of May 2023

Developer	Reactor	Type	Materials	Thermal vs. fast reactor	Energy capacity (MWe[a] or MWth[b])	Regulatory path[c]
Advanced reactor applicants						
Abilene Christian University	Molten Salt Research Reactor (MSRR)	Low-power molten salt research reactor	Molten salt coolant; graphite moderator; uranium fluoride salt fuel	Thermal	1 MWth[b]	Part 50
Kairos Power, LLC	Hermes Test Reactor	Low-power fluoride salt-cooled, high-temperature reactor (KP-FHR)	Molten fluoride salt coolant; graphite moderator; TRISO fuel[d]	Thermal	35 MWth[b]	Part 50
NuScale Power, LLC	US460	Light-water small modular reactor (SMR)	Light-water coolant and moderator; uranium dioxide fuel	Thermal	77 MWe	Part 52
Advanced reactor preapplicants[e]						
ARC Clean Technology	ARC-100	Sodium-cooled fast SMR	Liquid sodium coolant; no moderator; uranium-metal fuel	Fast	100 MWe	Not publicly available
GE-Hitachi Nuclear Energy	BWRX-300	Light-water SMR	Light-water coolant and moderator; uranium dioxide fuel	Thermal	300 MWe	Part 50
General Atomics	Energy Multiplier Module (EM^2)	Gas-cooled fast SMR	Helium gas coolant; no moderator; uranium carbide fuel	Fast	265 MWe	Part 52
General Atomics Electromagnetic Systems	Fast modular reactor	Gas-cooled fast reactor	Helium gas coolant; no moderator; uranium dioxide fuel	Fast	50 MWe	Part 50

Developer	Reactor	Type	Materials	Thermal vs. fast reactor	Energy capacity (MWe[a] or MWth[b])	Regulatory path[c]
Holtec International	SMR-160	Light-water SMR	Light-water coolant and moderator; uranium dioxide fuel	Thermal	160 MWe	Part 50
Kairos Power, LLC	KP-FHR[f]	Fluoride salt-cooled, high-temperature reactor	Molten fluoride salt coolant; graphite moderator; TRISO fuel	Thermal	140 MWe	Part 50
Oklo Inc.	Aurora Powerhouse	Fast microreactor	Liquid-metal coolant; no moderator; uranium-metal fuel	Fast	15 MWe	Part 52
TerraPower, LLC & GE-Hitachi	Natrium™	Sodium-cooled fast reactor	Liquid sodium coolant; no moderator; uranium-metal fuel	Fast	345 MWe	Part 50
TerraPower, LLC	Molten Chloride Fast Reactor (MCFR)	Molten salt reactor	Molten chloride salt coolant; no moderator; chloride salt fuel	Fast	Up to 1,200 MWe	Not publicly available
Terrestrial Energy USA Inc.	Integral Molten Salt Reactor (IMSR®)	Molten salt SMR	Molten fluoride salt coolant; graphite moderator; uranium fluoride salt fuel	Thermal	195 MWe	Part 52
University of Illinois at Urbana-Champaign and Ultra Safe Nuclear Corporation	Micro Modular Reactor (MMR®)	High-temperature gas-cooled test microreactor	Helium gas coolant; graphite moderator; TRISO fuel	Thermal	5 MWe	Part 50
Westinghouse Electric Company	eVinci™	High-temperature heat-pipe microreactor	Heat pipes containing liquid sodium; graphite moderator; TRISO fuel	Thermal	15 MWth	Part 52
X-Energy, LLC	Xe-100™	High-temperature gas-cooled SMR	Helium gas coolant; graphite moderator; TRISO fuel	Thermal	80 MWe	Part 50

Source: GAO analysis of information from the Nuclear Regulatory Commission (NRC), Department of Energy, and advanced reactor developers. | GAO-23-105997

[a]Megawatts electric (MWe) is the electric output of a nuclear reactor.

[b]Megawatts thermal (MWth) is the overall thermal power of a nuclear reactor.

[c]The regulatory path for preapplicants may be subject to change.

[d]TRISO fuel is short for tristructural isotropic fuel, which is composed of poppy-seed-sized uranium dioxide, oxycarbide, or carbide fuel particles that have been encased in silicon carbide and other highly heat-resistant coatings.

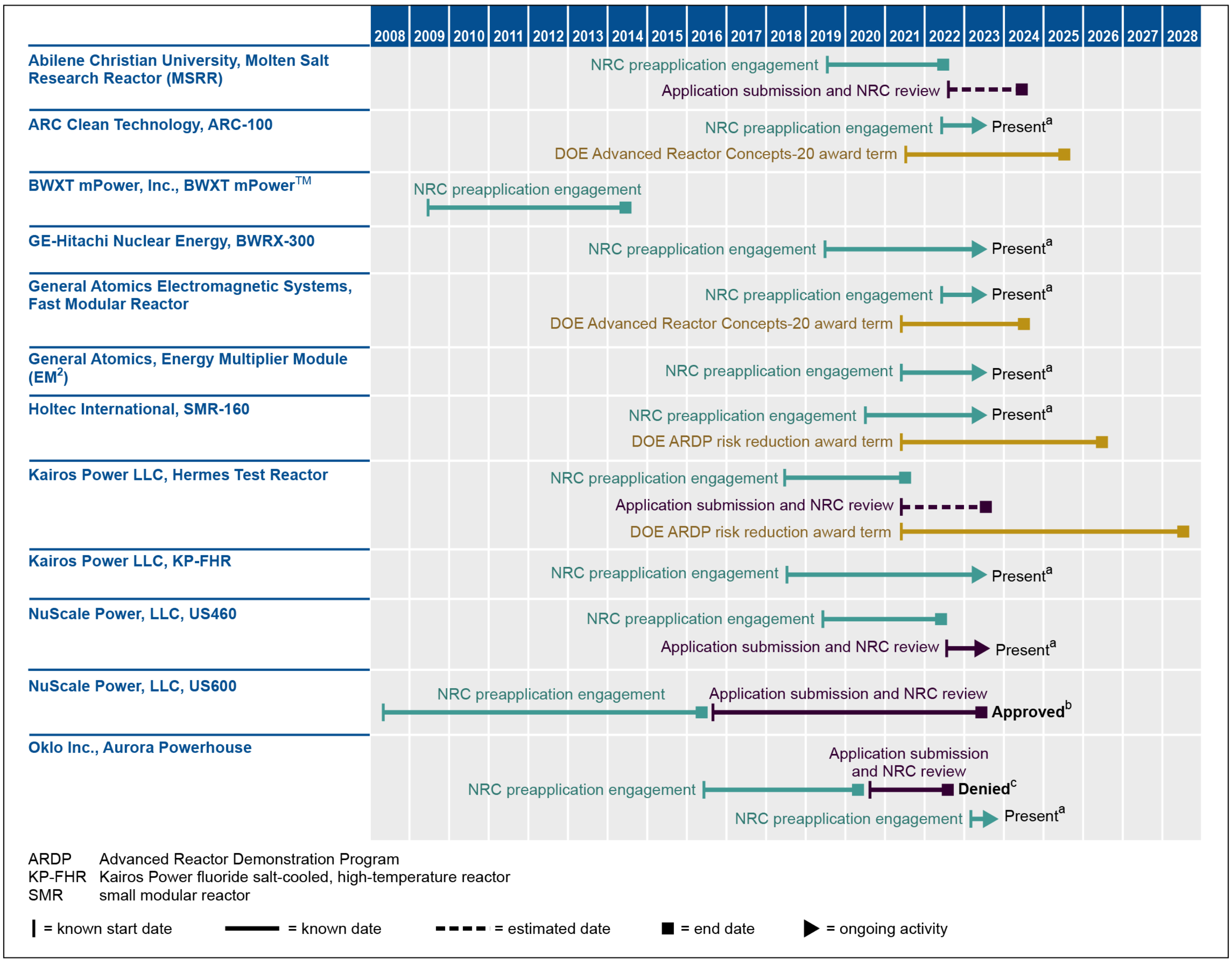
[e]According to NRC, Westinghouse Electric Company and the Tennessee Valley Authority were advanced reactor preapplicants as of May 2023. Westinghouse Electric Company and Tennessee Valley Authority were engaged in preapplication activities for SMR designs. Detailed information regarding their reactor designs and licensing activities were not publicly available.

[f]According to NRC, as of May 2023, Kairos's Power was engaged in preapplication for the KP-FHR. The KP-FHR is the commercial version of the Hermes Test Reactor.

Appendix III: Additional Information on Advanced Reactor Licensing Activities and Award Time Frames, as of May 2023

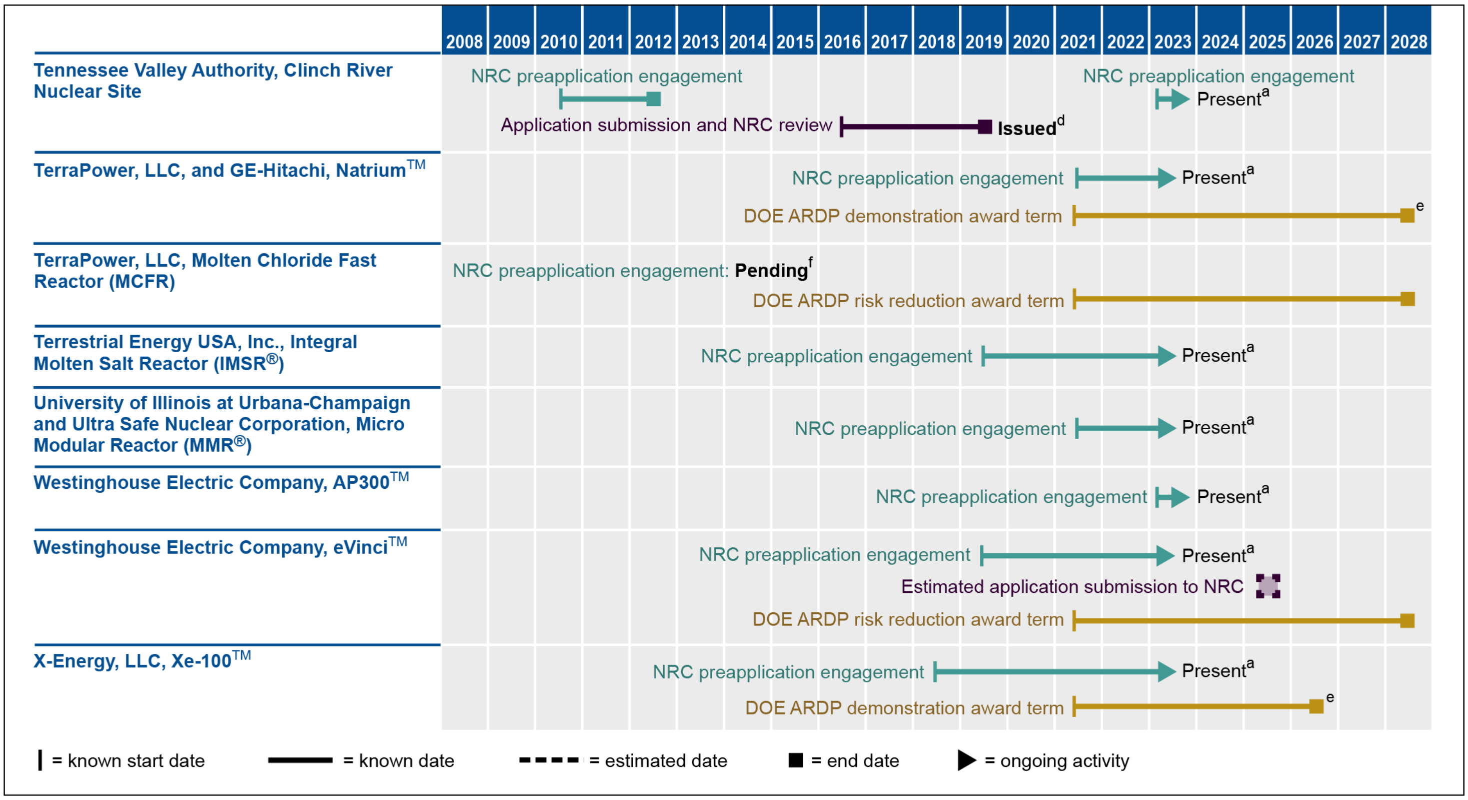
Figure 2 provides more information about the Nuclear Regulatory Commission's licensing activities for advanced reactor designs and the Department of Energy's advanced reactor award time frames.

Figure 2: Nuclear Regulatory Commission (NRC) Advanced Reactor Licensing Activities and Department of Energy's (DOE) Advanced Reactor Award Time Frames



Source: GAO analysis of NRC, DOE, and advanced reactor developer information. | GAO-23-105997

Part 1 of 2



Source: GAO analysis of NRC, DOE, and advanced reactor developer information. | GAO-23-105997

Part 2 of 2

[a]All dates listed as "Present" are as of May 2023.

[b]NuScale Power, LLC, submitted an application for design certification to NRC on December 31, 2016. NRC voted to certify the design in July 2022, and NRC published the final rule in the Federal Register on January 19, 2023.

[c]Oklo Power LLC submitted a combined license application to NRC on March 11, 2020, and NRC denied it without prejudice in January 2022.

[d]Tennessee Valley Authority submitted an early site permit application to NRC on May 12, 2016. NRC issued the early site permit in 2019.

[e]The schedules for TerraPower, LLC, and GE-Hitachi, Natrium™ and X-energy, LLC, Xe-100™ reflect the original applications. DOE is revising the project schedule.

[f]All dates listed as "Pending" are as of May 2023. According to NRC, preapplication interactions for the Molten Chloride Fast Reactor are being planned.

Appendix IV: Comments from the Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

July 14, 2023

Mr. Frank Rusco, Director
Natural Resources and Environment
U.S. Government Accountability Office
Washington, DC 20548

Dear Mr. Rusco:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letter dated June 16, 2023, requesting comments on the U.S. Government Accountability Office (GAO) draft report GAO-23-105997, "Nuclear Power: NRC Needs to Take Additional Actions to Prepare to License Advanced Reactors." As requested, the NRC has reviewed the draft report. The NRC is in general agreement with the draft audit report. The enclosure to this letter contains our technical comments seeking to improve the accuracy and clarity of the report and preliminary responses to the recommendations contained in the draft report.

If you have any questions regarding this response, please contact John Jolicoeur. Mr. Jolicoeur can be reached by telephone at 301-415-1642 or by via e-mail to John.Jolicoeur@nrc.gov.

Sincerely,

Daniel H. Dorman
Digitally signed by Daniel H. Dorman
Date: 2023.07.14 11:17:45 -04'00'

Daniel H. Dorman
Executive Director
for Operations

Enclosure:
As stated

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact:

Frank Rusco, (202) 512-3841 or ruscof@gao.gov

Staff Acknowledgments:

In addition to the contact named above, Christine Kehr (Assistant Director), Marie Bancroft (Analyst In Charge), Kevin Bray, Linda Tsang, Karen (Maggie) Bryson, John Delicath, Cindy Gilbert, David Marroni, Claire McLellan, Matty Njie, and Dan Royer made key contributions to this report.

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