Promoting Efficient NRC Advanced Reactor Licensing Reviews to Enable Rapid Decarbonization

December 2021

NUCLEAR INNOVATION ALLIANCE

Promoting Efficient NRC Advanced Reactor Licensing Reviews to Enable Rapid Decarbonization

Lead Author:
Alex Gilbert

NIA Contributors:
Dr. Patrick White
Judi Greenwald

Acknowledgements:
This report was informed by research and input from Amy Roma, Sachin Desai, and the Nuclear Energy Institute. NIA would also like to thank multiple external reviewers from NGOs, industry, and other experts.

Disclaimer:

The views expressed herein are those of the authors and the Nuclear Innovation Alliance.

December 2021

This report is available online at:
https://nuclearinnovationalliance.org/licensingdurationsforclimatemitigation

Executive Summary

Nuclear power is needed to fight climate change and meet clean energy goals. Nuclear power, especially next generation advanced reactors, are vital to the United States and global community meeting clean energy goals and limiting the detrimental effects of climate change. The world now widely recognizes that climate change is widespread, rapid, and intensifying, and that immediate and significant action is required to slow down and reverse its impacts. The general global goal is to achieve net zero carbon emissions over the next several decades.[1] For the U.S, that goal also includes cutting greenhouse gas (GHG) emissions by half by 2030, making the electricity grid carbon neutral by 2035, and reaching net zero emissions economy-wide by no later than 2050.[2]

U.S. advanced reactor developers are rising to meet the decarbonization challenge—both here and abroad. In the United States, many advanced reactor developers plan on initial deployment within the next decade. Decarbonizing at scale, in time to meet global and national climate objectives, requires that reactors are licensed and built rapidly to achieve technological learning and reduce costs. Several companies are in NRC licensing now and more are expected to enter soon.[3] To facilitate these new reactors, NRC is embarking on regulatory modernization as directed by Nuclear Energy Innovation and Modernization Act (NEIMA). For the near term, this means adapting existing licensing processes to these new reactors. For the longer term, NRC is creating a new technology-inclusive regulatory framework called "Part 53" (the NRC's current reactor licensing frameworks are set forth in 10 CFR Parts 50 and 52).

The lengthy duration of NRC licensing reviews could threaten meaningful advanced reactor deployment. Historically, the NRC often took five years or more took to conduct a license review and make a safety determination for a large light water reactor (LWR). This length of time reflected both the engineering complexity of such large LWRs as well as the business needs of applicants. However, advanced reactors, which are expected to be simpler, smaller, and safer, will need licensing reviews of 1-3 years to facilitate business models that reduce cost and meet the public's need for clean energy. Unnecessarily long licensing reviews can raise significant barriers to investment, reduce customer interest in advanced reactors, and threaten their successful long-term deployment. Assuming an applicant submits a high-quality application, the NRC estimates that it will take about 3-4 years to obtain a Combined License for a new reactor design under the NRC's licensing process set forth in 10 CFR Part 52, and about twice as long—about 6-7 years—to complete both phases of the two-step Construction Permit and Operating License applications under 10 CFR Part 50. These estimates also assume that there are no

---

[1] United Nations, *The Race to Zero Emissions, and Why the World Depends on It* (Dec. 2, 2020), https://news.un.org/en/story/2020/12/1078612.

[2] White House, *Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies* (Apr. 22, 2021), https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/.

[3] See NRC Website on Advanced Reactor Licensing and Small Modular Reactor (Light Water Reactor) licensing, setting forth ongoing preapplication and licensing activities, available at https://www.nrc.gov/reactors/new-reactors/advanced/ongoing-licensing-activities.html and https://www.nrc.gov/reactors/new-reactors/smr.html, respectively..

significant NRC staff-applicant impasses within an application that can themselves result in long delays.

Simply put, the current NRC licensing regime for advanced reactors takes too long. This can significantly harm the deployment of advanced reactors in time to address climate change.

The NRC can reduce licensing durations without reductions in safety. NRC and industry can both take actions to shorten licensing review timelines while ensuring adequate protection of the public health and safety. NIA makes four high-level recommendations for how NRC and industry can establish licensing review durations consistent with the national interest in commercializing advanced reactors in time to greatly reduce carbon emissions:

1. **Rethink Preapplication Engagement.** Due to limited design and operational experience with advanced reactor designs, license reviews may need to deal with multiple policy issues. Preapplication engagement can facilitate timely reviews, but future application reviews must be improved based on recent experiences. Improving applicant use of preapplication activities can help achieve finality on critical topics and enable the NRC to reduce durations while optimizing plans for staff resources. With targeted asks and strategic engagement, industry can leverage preapplication to reduce the risk of licensing delays or an unacceptably lengthy licensing process. Industry-developed, NRC-endorsed preapplication guidance would be helpful.
2. **Restructuring the NRC's safety evaluation process.** Advanced reactors offer significant safety improvements that can be handled with more responsive safety evaluation processes. NRC should pursue process changes to reduce license review times to 18-24 months, including consideration of conducting only one ACRS review, modernizing information exchange processes, and defining a high-quality application. Industry can contribute to timely safety reviews by right-sizing applications, and sharing best practices.
3. **Early management and Commission involvement on key policy issues.** The NRC and applicants should use existing regulatory tools to identify and resolve key licensing issues early in each proceeding, reducing uncertainty, inefficiencies, and delays. Examples of existing regulatory tools include certified questions to the Commission, use of hearing orders to set licensing schedules, and encouraging licensing boards in contested hearings to certify novel questions of law or policy to the Commission early on in a proceeding.
4. **Establish effective communication during application review.** Facilitating timely reviews requires that NRC and industry understand expectations and progress on specific elements of a review. Improving communications to identify bottlenecks can ensure progress on reviews. Modernizing the Request for Additional Information (RAI) process, including trying alternative approaches, can facilitate timely approval of licensing while improving NRC's ability to reach a finding of adequate protection.

Contents

I. Introduction: Improving Advanced Reactor Deployment to Help the Planet

Advanced reactors are needed now. There is an urgent need to reduce GHG emissions to stem the tide of climate change. Globally, reaching international targets to combat and reverse the effects of climate change requires significant and rapid decarbonization by mid-century at the latest. After years of delay, the U.S. is again making ambitious commitments to reduce GHG emissions. In 2021 the Biden Administration pledged to reduce U.S. greenhouse gas emissions 50% below 2005 levels by 2030.[4] Congress is also taking significant strides to make this happen, passing legislation providing billions of dollars to address climate change.[5] States are also taking action to reduce their local GHG emissions, including establishing Clean Energy Standards, encouraging vehicle electrification, and increasing participation in regional GHG emission cap and trade programs.[6] Decarbonization is not going to be an easy task. The electricity sector is the second largest source of U.S. GHG emissions, accounting for about 25% of both the U.S. and global total, with fossil fuel providing about 60% of electricity in the United States and about 80% of electricity globally.[7][8]

Decarbonization requires bringing large amounts of clean energy online as fast as possible, including next-generation small modular and non-LWR (collectively "advanced reactors"). Nuclear energy is an essential component of meeting national and international climate goals. In the U.S., nuclear energy currently provides nearly 20% of total electricity generation, while producing half of our clean energy—as much carbon-free energy as wind, solar, hydro, and other renewables combined. Rapid deployment of advanced reactors can bring gigawatts of 24/7 clean energy to market, reducing climate-related emissions without sacrificing reliability and while improving the standard of living for developing countries (approximately 860 million people now have no access to electricity and progress in increased electronification efforts have been stalled further due to the pandemic).[9]

Advanced nuclear energy is not just essential for decarbonizing the power grid. It can also help decarbonize the industrial sector, which contributes just over 20% of GHG emissions in the U.S.[10] The thermal output of advanced reactors can be useful in process and district heating, hydrogen

---

[4] White House, Paris Climate Agreement (Jan. 20, 2021), https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/20/paris-climate-agreement/.

[5] E.g., On November 15, 2021, the President signed into law the Infrastructure Investment and Jobs Act, a $1 trillion act providing billions of dollars to strengthen the county's resilience to extreme weather and climate change while reducing GHG emissions, expanding access to clean drinking water, and building up a clean power grid.

[6] Center for Climate and Energy Solutions, Market-Based State Policy (updated Jan. 2021), https://www.c2es.org/content/market-based-state-policy/.

[7] EPA, Sources of Greenhouse Gas Emissions (2019), https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions#:~:text=In%202019%2C%20the%20electricity%20sector,percent%20of%20the%20U.S.%20total.

[8] EIA, *What is U.S. electricity generation by energy source?* (Feb 2021), https://www.eia.gov/tools/faqs/faq.php?id=427&t=3; Forbes, *Fossil Fuels Still Supply 84 Percent Of World Energy — And Other Eye Openers From BP's Annual Review* (June 20, 2020), https://www.forbes.com/sites/rrapier/2020/06/20/bp-review-new-highs-in-global-energy-consumption-and-carbon-emissions-in-2019/?sh=460b579c66a1.

[9] Bill Gates, How to Avoid a Climate Disaster (2021); IEA, *Access to electricity* (2019), https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity.

[10] Sources of Greenhouse Gas Emissions (2019), *supra* note 4.

production, desalination, green steel manufacturing, and energy resilience. Beyond these applications, advanced reactors can serve to decarbonize hard-to-reach areas, such as islands through floating nuclear reactors, or remote areas through microreactors. Advanced reactors can provide improved safety performance and also address waste concerns. Even though the climate benefits of advanced reactors alone justify their rapid deployment, advanced reactors also promise very significant benefits to national security and U.S. job creation.[11]

Licensing can be made more efficient. The U.S. Nuclear Regulatory Commission (NRC) licenses nuclear reactors with a framework that instills high levels of safety and environmental protection. However, in recent years that framework has proven to take very long amounts of time, inconsistent with the public's interest in timely deployment of nuclear energy for climate mitigation and other public goals. It is possible for the NRC to conduct thorough safety and environmental reviews in a timely and efficient licensing process with shorter review durations.

The duration of the NRC's review should match the risks the technology introduces, and the agency should be disciplined in how it conducts its reviews to ensure they are timely and efficient. That is not always the case now. As described in Appendix 1, more recently NRC has taken many years, and sometimes close to a decade, to license a new nuclear reactor. This has not been because of the risks associated with the facilities, but because of inefficiencies on the part of both the NRC and applicants during the licensing reviews. It is nonetheless far too long a review timeline. Even in the best cases, the NRC's target schedule for new reactor reviews, including 36-42 months for just the staff safety review, is too long and particularly not necessary for the smaller-scale projects being proposed today.

The NRC can shorten the review schedules, while still ensuring it conducts a through safety and environmental review much as it has proposed for commercial non-power reactors in the medical isotope space (e.g., an 18-24 review schedule), especially as the smaller sizes of proposed advanced reactor facilities mean they introduce far less significant risks for the NRC to evaluate.

Shortening the duration of the NRC licensing process is not just about accelerating timelines. It is about ensuring a process is in place that serves the public interest. It is in the public interest to ensure the NRC focuses its review on genuine safety issues; avoids immaterial issues that do not have a significant impact on safety; identifies and resolves key policy issues up front; and, when appropriate, acknowledges the unique safety features of advanced reactors that make them different from traditional LWRs. It is also in the public interest to ensure the NRC offers effective, consistent and efficient reviews and has time to carefully review and stay focused on matters that are most consequential to safety.

[11] Michael Wallace, Amy Roma, & Sachin Desai, Back from the Brink: A Threatened Nuclear Energy Industry Compromises National Security (July 17, 2018), https://www.csis.org/analysis/back-brink-threatened-nuclear-energy-industry-compromises-national-security; Amy Roma, Written Testimony Before the Senate Committee on Environment and Public Works
Hearing on Discussion draft bill, S._, the American Nuclear Infrastructure Act of 2020 (Aug. 5, 2020), https://www.epw.senate.gov/public/?a=Files.Serve&File_id=85FF756D-6D5D-4453-9D00-FB8FF6A3161F.

Timely and efficient licensing is needed to ensure reactors can come online to support climate change goals. Given the harmful impacts of climate change, a timely and efficient licensing process is also in the public's interest because it enables new reactors to come online in order to decarbonize our electric grid and other cardon-heavy industries in the timeframes needed to combat global warming. This further aligns with the original goals spelled out in the Atomic Energy Act, which provides that the NRC's safety reviews are intended to enable the beneficial use of nuclear power if it is safe, not unnecessarily hinder its deployment.

Moreover, from a business perspective, timely reviews make projects more attractive to customers and investors—especially in the large market for carbon-free power—and reduce the extra costs and resources associated with a longer, more drawn-out project. Advanced reactor designs are likely to follow a generational model. No one designs a reactor intending to build just one plant. The first-generation deployment of an advanced reactor will often be a commercial demonstration or pilot project, such as those planned by X-energy in Washington[12] and TerraPower in Wyoming[13], through the Advanced Reactor Demonstration Program (ARDP). When those reactors are licensed and constructed—de-risking their designs and accumulating construction and operating experience—those vendors will be able to turn to additional customers in the market and license a larger group of reactors, and then a still even larger group after that.

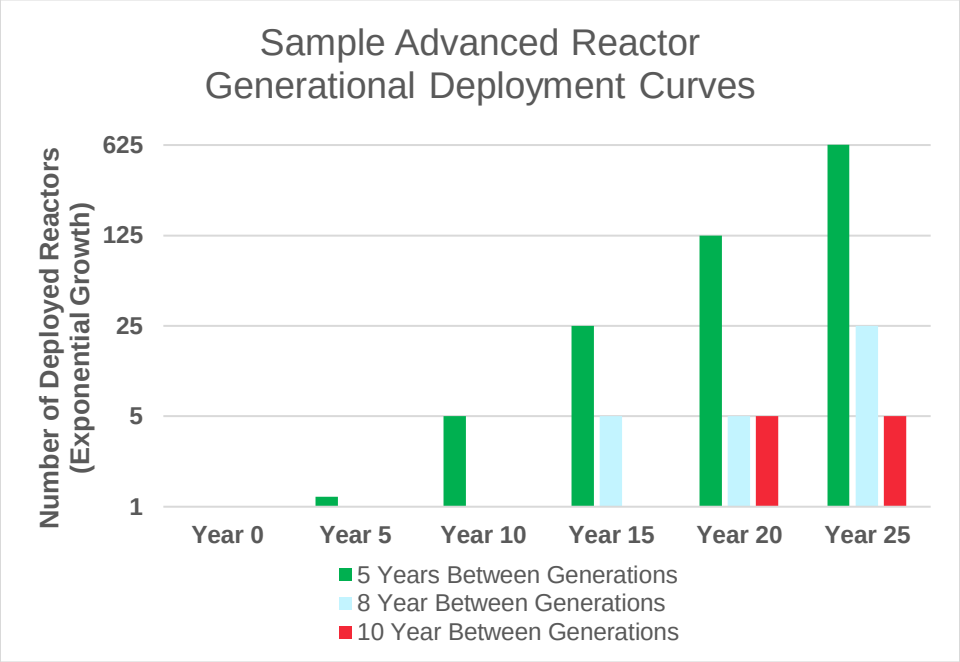
Within each of these generations the longest pole in the tent, after design engineering, is arguably the licensing process (while construction may be significant, it cannot even start until a large portion of the licensing process is complete). Given the expected exponential growth curve anticipated for advanced reactor deployment, shortening licensing durations is critical to successful advanced reactor deployment prospects and thus to fighting climate change. For example, presuming licensing and constructing advanced reactors takes 5 years, from 2025 to 2050 five generations of advanced reactors can be deployed—and following exponential growth predictions that could mean hundreds or more advanced reactors operating—which would bring with it a very material reduction in global GHG emissions.

However, if advanced reactors took just a few years longer to license per generation, raising the total generational timeline to eight years, potentially only three generations of advanced reactors could be deployed. The loss of exponential growth opportunities would mean that a much smaller number of advanced reactors would be deployed—dozens instead of hundreds —leading to hundreds of millions or billions of tons of GHGs that could have otherwise been avoided. And this still presumes that licensing durations are consistent even if long. To distill the message here, shortening licensing timelines is imperative. We simply cannot afford to fail.

[12] *Id.*

[13] DOE, U.S. Department of Energy Announces $160 Million in First Awards under Advanced Reactor Demonstration Program (Oct. 13, 2020), https://www.energy.gov/ne/articles/us-department-energy-announces-160-million-first-awards-under-advanced-reactor.

Figure 1. Deployment Curves Dependent on Generation Timeframes



NRC, Congress, industry, and the public have spent years revisiting and revising the substantive licensing requirements that will apply to advanced reactors. It is now equally urgent to give a fresh look to the *process* by which the NRC licenses new reactors.

Building on Congressional direction to improve licensing timelines. Congress recognized the problems of overly lengthy licensing reviews and, as part of the Nuclear Energy Innovation and Modernization Act (NEIMA), required the NRC to develop a performance-based, risk-informed, technology-inclusive licensing pathway for commercial reactors. NEIMA furthers requires the NRC to concurrently develop a licensing process for advanced nuclear reactors that is "predictable, efficient, and timely." While Congress did not mandate explicit timeframes for safety reviews, it has clearly expressed its desire that the NRC's regulatory responsibilities be carried out in a timely manner to realize the public benefits of nuclear power. Licensing durations must be both reasonable and predictable to provide the public good that is nuclear regulation, and to enable industry to support global decarbonization.

Currently in early stages of rulemaking, the new licensing pathway, called "Part 53," after its likely place in the NRC's Code of Federal Regulations, could open more options for timely licensing of advanced reactors. However, as discussed further below, improving licensing durations is largely the result of improved execution as opposed to improved rules. Many of the reforms suggested below can be addressed though execution and guidance. These reforms can thus apply across the regulatory spectrum, impacting reactors licensed under the current 10 CFR Parts 50, 52, or a future 10 CFR Part 53. While Part 53 will be valuable for deploying reactors, most reactor developers are looking at licensing their first-of-a-kind projects now under Parts 50 and 52. Timely reviews

of these first applications under existing licensing frameworks is critical to ensuring advanced reactors can contribute to decarbonization in the early 2030s.

In sum, the ability of NRC and industry to improve review efficiency has a direct effect on the ability of new advanced reactors to benefit society and meet the nation's environmental, economic and national security goals.

II. The Current Licensing Framework

Recommendations on changes to reduce licensing durations are best understood in the context of the current NRC reactor licensing framework. Under current NRC regulations, there are two regulatory pathways for licensing a new commercial reactor: a two-step process set forth in 10 CFR Part 50 ("Part 50") and one-step process set forth in 10 CFR Part 52 ("Part 52"). Both pathways address the same requirement in the underlying enabling statute, the Atomic Energy Act of 1954, as amended, that the reactor design provide "adequate protection" to the public but get there through different means.

Part 50

Under the two-step process outlined in Part 50, an applicant before the NRC would first seek a "Construction Permit," (CP) which authorizes construction of the facility. During the Construction Permit Review, the applicant can also ask for a Limited Work Authorization ("LWA") to start construction early on certain activities before a Construction Permit is issued (e.g., driving of piles, subsurface preparation, placement of backfill, concrete, or permanent retaining walls within an excavation for items relied on for safety).[14] In a Construction Permit application, the application consists of a preliminary Safety Analysis Report (SAR) and an environmental report (ER). The NRC also has the authority to defer some unresolved design issues to the operating license review.[15] Thereafter, during or after construction the applicant can submit an application for an "Operating License" (OL) to actually load fuel and run the reactor. [16] At this point, the applicant needs to provide a final design to the NRC for review.

The public has a right to seek a hearing on the application over potential safety or environmental issues at the time of submission of both the Construction Permit application and the Operating License application. In addition, the NRC Commission itself holds a "Mandatory Hearing" near the conclusion of the Construction Permit permitting process, per the Atomic Energy Act, which

[14] NRC, Interim Staff Guidance on the Definition of Construction and on Limited Work Authorizations, Authorization to conduct limited work authorization activities, 10 CFR § 52.91 (2007).

[15] For example, when issuing the construction permit for the SHINE medical isotope production facility under Part 50, the NRC staff stated in its Safety Evaluation Report that "the design and analyses of the SHINE facility are in preliminary stages . . . [w]hile the staff's review concluded that the applicant may proceed with construction, additional information is required to confirm the adequacy of the design." See NUREG-2189 at 6-31 (emphasis added). To address the issue of gaps in the application, the NRC staff suggested issuing a number of license conditions requiring SHINE to submit additional information before construction could be completed. In the end, the NRC Commission conditioned the construction permit on SHINE providing the following information before the completion of construction, including: the technical basis for the design of the criticality accident alarm system; the basis for determining that criticality events are "not credible" for RPF processes even though fissile materials may be present; summaries of the criticality safety analysis for the affected processes, which shall address the reactivity contributions from all fissile isotopes (or apply a safety margin); and design information on the RPF supercells, tank vaults containing the liquid waste storage tanks, evaporation hot cells, and other facilities. *See* SHINE Facility Construction Permit, cond. 3(D)(1) (listing information still to be provided) (Feb. 29, 2016).

[16] From a review of the Part 50 regulations, it appears possible to file an Operating License application during the Construction Permit phase, to try to accelerate the overall licensing timeline. However, the NRC staff has indicated that it views there to be potential challenges with the approach. NRC, *Draft White Paper: Safety Review of Power Reactor Construction Permit Applications* (Jan. 2021), https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML21043A339.

evaluates the sufficiency of the NRC staff's review. As the Part 52 process did not become available until 1989, the Part 50 two-step process was the process by which all currently operating reactors in the country were licensed.

Currently, the NRC generically estimates it takes about 3 years to process each of the two applications (for the Construction Permit and Operating License), from the point of acceptance of the application to issuance of the NRC staff's Safety Evaluation Report ("SER"), which marks the formal end of the review.[17] However, administrative activities both before acceptance of the application and after issuance of the SER can add six months to a year to the overall timeline for each filing, making the total review schedule six or more years.

Part 52

In 1989, the NRC staff amended its regulations to promulgate a new licensing regime intended to standardize the licensing process.[18] Although called a "one-step" licensing process, the pathway features multiple optional components. The core component is what is called a "Combined License", or a "COL" which authorizes both construction and operation of the nuclear reactor. An applicant thus applies for a COL and, upon receipt, receives authorization to construct and operate their facility. Like with the Construction Permit, a Combined License applicant can also seek a LWA prior to completion of licensing, to start safety-related construction.

The Part 52 regulations also added new, optional pre-licensing actions that could be used by applicants to expedite the COL review process by addressing certain safety and site-specific environmental characteristics up front. First, the applicant can seek a "Design Certification" for their reactor design prior to obtaining a COL.[19] The Design Certification process allows the NRC staff to review and evaluate the essentially complete design before any license application for a specific project at a specific site is filed. The NRC certifies in a rulemaking that the design, or key aspects thereof, meets NRC requirements, reducing the number of issues to be reviewed in a later COL application review. An applicant could in addition or alternatively obtain an "Early Site Permit" before filing for a COL, which allows the NRC to evaluate a specific site for environmental issues compared to a bounding set of parameters representing different reactor options that could be sited there.

In theory, the Part 52 process can be accomplished faster than a Part 50 licensing process. The NRC has generically estimated that a COL application for an advanced reactor can be reviewed by the NRC staff in three years (plus six months to one year for front and back-end activities), and potentially faster if pre-licensing activities occurred. However, there is a major drawback that has caused the Part 52 licensing process to become less popular for some advanced reactor vendors: the COL requires a *final design* for the reactor to be submitted to the NRC. For first-of-

[17] NRC, Generic Milestone Schedules of Requested Activities of the Commission, https://www.nrc.gov/about-nrc/generic-schedules.html.
[18] *Final Rule, Part 52 Rulemaking*, 54 Fed. Reg. 15,372 (April 18, 1989).
[19] An analog is a Standard Design Approval. Standard Design Approvals are discussed in a Nuclear Innovation Alliance Report, *Clarifying "Major Portions" of a Reactor Design in Support of a Standard Design Approval* (Apr. 2017), https://www.nuclearinnovationalliance.org/sites/default/files/2019-10/Clarifying%20%E2%80%9CMajor%20Portions%E2%80%9D%20of%20a%20Reactor%20Design%20in%20Support%20of%20a%20Standard%20Design%20Approval.pdf.

a-kind facilities, the flexibility of first obtaining a Construction Permit based on a preliminary design information has proven compelling, despite the extended overall time of review and potential risk in the back end of the schedule. This is, in part, because the Commission has made it very difficult to make changes to the design during construction.

Part 53

NEIMA instructed the NRC to develop a new technology-inclusive regulatory framework to improve the licensing of advanced reactors by December 31, 2027.[20] Following a letter from some of the initial sponsors of the bill requesting an earlier rule completion date, the Commission directed NRC staff to accelerate the rulemaking process, setting a new goal to complete the rulemaking by the end of 2024.[21] The rulemaking is still in the early stages of development, but it is expected to allow applicants to either undertake a two-part licensing process, with a Construction Permit and Operation License option, or engage in a one-part Combined License process. The Part 53 rulemaking is also likely to further address the possibility of a manufacturing license for reactors or reactor modules to be made at factories and shipped in a substantial complete form—possibly even fully fueled—to the power plant site.

It is hoped that the Part 53 rulemaking could be more efficient for advanced reactor licensees as the regulatory requirements would be amenable to a variety of advanced reactor designs instead of LWR-centric like under Parts 50 and 52. However, the rulemaking will not be finalized by the time many leading advanced reactor vendors, such as TerraPower, X-energy, Westinghouse, and others, are set to file their NRC license applications with the NRC. Indeed, Oklo and Kairos have already filed Part 50 and 52 applications and NuScale is set to receive a Part 52 design certification enabling future Part 52 license applications. Thus, applicants will have to rely on the existing licensing pathways in Part 50 and Part 52 for at least their first-of-a-kind reactors.

[20] Nuclear Energy Innovation and Modernization Act, S. 512, Public Law No: 115-439, 115th Congress (2019).
[21] Letter from Matthew Sunseri, Chairman of NRC Advisory Committee on Reactor Safeguards to Kristine Svinicki, former NRC Chairman (Oct. 21. 2020), https://www.nrc.gov/docs/ML2029/ML20295A647.pdf.

The generic milestones for the current options are summarized below:

Options	Timeline (Acceptance to SER)[22]	Key Difference
Part 50 – Construction Permit & Operating License	6 Years (3 years for each step)	Can construct with preliminary design only but may carry more risk of licensing delays or additional regulatory requirements when seeking an operating license.
Part 52 – Combined License	3 Years	Need final design up front, though timeline may be longer if using a reference design (DCA or SDA) pathway
Part 53	*To be determined*	*To be determined*

[22] From acceptance of the application to the SER. Need to add six months to one year to estimate total licensing time.

III. Recommendation 1: Rethink Preapplication Engagement

A key opportunity for expediting the NRC licensing process exists before a license application is even submitted—preapplication engagement. The NRC welcomes preapplication engagement and indeed anticipates such engagement, especially for novel technologies or approaches.[23]

The NRC's July 1986 "Statement of Policy for Regulation of Advanced Nuclear Power Plants" encourages reactor designers to discuss licensing issues with the Commission before submitting a full license application. In 1988, the NRC provided additional "preapplication" guidance for advanced reactor design reviews in NUREG-1226, "Development and Utilization of the NRC Policy Statement on the Regulation of Advanced Nuclear Power Plants." The NRC explains that preapplication interactions with reactor designers are expected to identify and address topics such as: unique design features or systems, structures, or components; new methods demonstrating the acceptability of safety features; potential Commission-level policy decisions; and potential research to resolve identified issues.[24] The NRC references the use of preapplication engagement in its Advanced Reactor Policy Statement,[25] where it encourages early interactions with advanced reactor developers and prospective applicants, stating:

> To provide for more timely and effective regulation of advanced reactors, the Commission encourages the earliest possible interaction of applicants, vendors, other government agencies, and the NRC to provide for early identification of regulatory requirements for advanced reactors and to provide all interested parties, including the public, with a timely, independent assessment of the safety and security characteristics of advanced reactor designs. Such licensing interaction and guidance early in the design process will contribute towards minimizing complexity and adding stability and predictability in the licensing and regulation of advanced reactors.

Recognizing the preapplication process could be improved, in January 2021 the NRC staff issued a draft white paper, Preapplication Engagement to Optimize Application Review (Draft Preapplication Engagement White Paper).[26]

Reactor designers are aware years in advance of putting pen to paper on their design that eventually they will need to file a license application with the NRC. Indeed, many have recently worked or are working with the Commission now on licensing reform efforts, such as the Licensing Modernization Project.[27] The opportunity for preapplication engagement to benefit the licensing process also appears obvious at first glance. A constant struggle between applicants and the NRC pertains to expectations of the scope and technical content of applications, and

---

[23] NRC, Draft Pre-application Engagement to Optimize Application Reviews (May 2021), https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML21145A106 (Draft Preapplication Engagement White Paper).

[24] *See* NRC Backgrounder on New Nuclear Plant Designs (last updated Dec. 29, 2020), available at https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/new-nuc-plant-des-bg.html#pre.

[25] Policy Statement on the Regulation of Advanced Reactors (73 FR 60612; October 14, 2008).

[26] Draft Preapplication Engagement White Paper, *supra* note 29.

[27] NRC, Advanced Reactors Details, Licensing Modernization Project, https://www.nrc.gov/reactors/new-reactors/advanced/details.html.

interpretations of key regulations. These are the types of issues where discussion before formal submittal of an application seems very appropriate.

Based on an evaluation of various perspectives in this area, it appears there are two key issues that may inhibit full utilization of preapplication engagement:

- **Lack of discrete benefit:** NRC preapplication review can incur extensive costs—i.e., many millions of dollars—both in applicant time and applicant fees paid to the NRC for staff time, but does not necessarily return a clear, actionable benefit to the applicant. Particularly, it is not apparent that engagement will materially reduce licensing review times, especially considering that preapplication is a type of review. Historically, the NRC staff did not commit to any improvements in licensing timelines or process as a result of preapplication engagement.

  Even with extensive engagement, the benefits of preapplication can remain unclear. For example, NuScale engaged in over ten years[28] of preapplication engagement with the NRC at the cost of hundreds of millions of dollars in private cost.[29] Although this was partially due to design changes and other issues not related to review, this investment did not lead to reduced licensing timeframes: the NRC staff took the full 41 months it had generically indicated that it would take to review a design certificate application, at the cost of half a billion dollars in design costs and licensing fees.[30] This is despite the fact that NuScale worked with NRC on a regulatory gap analysis four years before filing its Design Certification application.[31] Despite such effort, after its application was submitted, NuScale received over a 1,500 Requests for Additional Information (RAIs) from the NRC.[32]

  Ideally the preapplication process should reduce RAIs, reduce the length of licensing reviews, and produce other concrete benefits to the applicant and NRC staff. Topical reports can create finality on specific issues but the benefits of other actions are not always clear to most applicants. Without clear benefits, preapplication may be seen as solely adding costs and lengthening review times, as opposed to creating more efficient reviews. Given such feedback and an overarching drive by investors to get license applications in as soon as possible, applicants may be incentivized to direct their limited resources elsewhere, absent a demonstrable benefit to preapplication engagement.

---

[28] Slide Presentation for Meeting on NuScale Power Reactor Design (July 24, 2008), https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML082130430.

[29] NuScale Power, *Licensing*, https://www.nuscalepower.com/technology/licensing.

[30] NuScale, Lessons-Learned from the Design Certification Review of the NuScale Power, LLC Small Modular Reactor (Feb. 19, 2021), https://www.nrc.gov/docs/ML2105/ML21050A431.pdf (NuScale DCA Lessons Learned Report).

[31] NuScale, *Regulatory Gap Analysis Presentation* (May 9, 2021), https://www.nrc.gov/docs/ML1212/ML12125A112.pdf

[32] NRC, eRAI Public Report for Website (Dec. 12, 2019), https://www.nrc.gov/reactors/new-reactors/new-licensing-files/nuscale-dc-safety-rai.pdf. There appear to be nearly *two thousand* RAI questions posed per the NRC report.

Further, the preapplication engagement process does not necessarily produce a holistic NRC determination as to the general apparent license-ability of the reactor, which could be of significant benefit to investors and potential customers. A simple letter from NRC to an applicant acknowledging the benefits of preapplication efforts and summarizing the level of engagement, along with any milestones accomplished, may help in that regard. This change is fully within the regulatory and legal authority of the NRC and could be undertaken by prompt policy action on the part of the Commissioners.

- **Outcomes shaped by personnel, not safety**. Many companies have found preapplication not to be durable as informal agreements or understandings formed during preapplication are often tied to specific reviewers and are lost when a formal application are assigned to different reviewers. Staff turnover is also a challenge with general education efforts about the novelty of advanced reactor designs. For certain preapplication interactions, applicants with experienced licensing professionals working with effective NRC project managers can create the conditions for successful exchange of information. However, the robustness of preapplication interactions should not overly depend on the effectiveness of NRC management. Moving to a core team of reviewers may help, but only if such changes in NRC administration include discrete goals of targeting reviews towards resolution of safety-relevant information.

- **Lack of robust discussion:** Another common challenge is that preapplication engagement does not always appear to engender robust conversation that could give the license applicant a better understanding of the NRC staff's initial position on key issues. Except in the context of topical reports (where the NRC provides a formal safety evaluation), many conversations with the NRC staff during the preapplication period still largely entail the applicant talking about their facility or approach, with limited NRC staff feedback. Without sufficient feedback—even informal and preliminary comments—applicants sometimes do not feel that preapplication moves the ball forward on key issues, and it may be faster to actually file an application to get that feedback. If applicants recognize staff feedback as informal comments, as opposed to regulatory commitments, NRC staff can identify key areas of concern and identify pathways forward before a formal application.

  Pre-filing activities with other regulators demonstrate how to engender effective communication before a formal application. For example, for the permitting of liquified natural gas (LNG) terminals, the Federal Energy Regulatory Commission has a process that applicants engage in to address environmental issues related to filing.[33] As part of this preapplication process, applicants iteratively submit their draft environmental review documents (called "Resource Reports" in FERC parlance) to FERC and the FERC staff

[33] FERC, FERC Processes (updated Mar. 15, 2021), https://www.ferc.gov/industries-data/resources/ferc-processes. Examples of some of the comments FERC provides in pre-filing process can be found in the following links: https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20190710-3036&optimized=false; https://elibrary.ferc.gov/eLibrary/filelist?accession_number=20191122-3050&optimized=false. FERC staff can also provide more direct feedback informally during the pre-filing.

provide very specific and discrete markup comments.[34] This exchange often leads to immediate, actionable feedback that expedites subsequent formal licensing.

In the recently issued NRC Draft Preapplication Engagement White Paper,[35] it appears the NRC is trying to improve the utility of preapplication engagement. For example, the draft white paper sets out much clearer expectations for preapplication engagement and explains that if certain preapplication engagement activities are undertaken, the NRC staff can commit to a reduction in the license review period.

This is a critical step forward to reform the current process, although the Draft Preapplication Engagement White Paper still seeks significant information with an unclear promise of benefits. The draft white paper asks that license applicants submit a host of topical reports and white papers (over ten sets of documents)—many of which require *two years* for the NRC staff to review—to get the NRC staff to commit to a *six months savings* in formal application review time as well as expedited acceptance review.[36] Further, the white paper does not necessarily apply to vendors, owners groups, industry representatives, or other pre-applicants. It represents a one-size-fits-all approach to preapplication that may not match the licensing strategies, design complexities, or technology novelty for different advanced reactors. While the process envisioned in the white paper may save time on the back end, it requires a long lead time on the front end and, given the staff charges per hour, seems like it could be a considerably more expensive option than just submitting an application. Moving part of the scope of licensing review from a formal application to preapplication can also lead to greater regulatory risks for applicants. And it still does not guarantee that NRC will not revisit resolved issues during licensing review. Finding ways to establish durable plans and understandings during preapplication is critical to successfully conducting efficient licensing reviews.

These challenges are resolvable, however, and speak to the need for more constructive engagement between the NRC staff and advanced reactor community. There needs to be more and better guidance developed by NRC staff and industry to make preapplication valuable to NRC, industry, and, ultimately, the public. Therefore, NIA makes the following recommendation:

Recommendation 1: Improve the effectiveness of preapplication engagement to offer more discrete benefits and concrete discussion

- **Recommendation for the NRC:** The NRC should continue to improve the effectiveness of its preapplication engagement process by identifying instances of ineffective preapplication, reviewing root causes with industry partners, and addressing NRC-relevant improvements in those areas. In exchange for a commitment by applicants to undergo preapplication engagement, the NRC staff should offer a reduction in the range of nine to twelve months (instead of six months) from the generic licensing schedule. The NRC

[34] Environmental reports for Natural Gas Act applications, 18 CFR § 380.12 (2009).
[35] Draft Preapplication Engagement to Optimize Application Reviews, *supra* note 30.
[36] NRC, *Generic Milestone Schedules of Requested Activities of the Commission* (updated June 8, 2020), https://www.nrc.gov/about-nrc/generic-schedules.html.

should evaluate what is required to enable the additional reduction in time, and present options for consideration in a new draft of the Preapplication Engagement White Paper. Unlike the first draft white paper, this time reduction should not be tied to a specific checklist of documents that is "one-size-fits-all." Rather, it should be predicated on resolving the issues most likely to emerge as a challenge during a formal application. Preapplication needs flexibility to deal with diverse reactor designs and regulatory uncertainty. The revised draft should also explore how the NRC can effectively communicate with applicants and provide candid, specific, and actionable feedback as part of preapplication engagement to strategically reduce site-specific licensing timelines to the mutual benefit of NRC and the applicant.

In addition, for those applicants who have completed the preapplication process, the NRC staff should provide a brief summary of the work completed, issues resolved, milestones hit, and a statement as to the estimated timeline and high-level path forward to license a site-specific application if a high-quality application is provided consistent with expectations from preapplication engagement.[37] This alone can improve applicants' abilities to market their reactors without binding the NRC to any safety or environmental determinations. NRC can manage staff turnover issues by documenting any informal agreements (acknowledging that they do not entail finality) or other information gained from company interactions to ensure they carry over into formal applications.

Ultimately, NRC should recognize the importance of seamlessly integrating preapplication activities into application processes so that NRC can most effectively establish adequate protection of public health.

- **Recommendation for Applicants:** Applicants should clearly communicate their goals, strategy, and realistic timelines associated with preapplication engagement in their Regulatory Engagement Plan (REP) with NRC staff to help facilitate more effective interactions. Applicants should have a strategic dialogue with the NRC staff as to how the preapplication process can be tailored to address both the applicant's and NRC's specific interests. Critically, having clear high-level goals and asks of the NRC for preapplication engagement can help ensure that activities are focused and productive. Discussing key preapplication engagement goals with the NRC early on as part of their REP will help ensure alignment and prioritization of activities that applicants feel are of highest importance. Applicants need to focus not just on checking the boxes, but on approaching the licensing process with an overall strategy that informs how preapplication engagement supports overall licensing goals (which will be different for each applicant). Collaborative development of project-specific preapplication engagement schedules can provide clarity and accountability for both NRC and applicants. However, this type of high-value, strategic engagement has to occur *early in the process* in order to be effective, and cannot be brought

[37] What constitutes a high-quality application is discussed further in the context of Recommendation 2.

up mere months before filing of an application. Applicants must also recognize that NRC feedback as part of preapplication engagement is preliminary and subject to further development after the full application is submitted.

Finally, industry should consider generating guidance for what effective and successful preapplication entails, with a goal to receive NRC endorsement. Such guidance can provide direction to NRC staff on what conclusions they are able to make regarding specific preapplication content, as well as formalize NRC's use of preapplication to guide internal resource allocations for formal applications.

IV. Recommendation 2: Restructure the NRC's safety evaluation process

What is the difference between a 10 MW thermal (MWt) reactor producing medical isotopes, and 10MWt reactor producing power? *Several more years spent in the NRC licensing process.*

Unbeknownst to many, the NRC has already taken huge strides to reduce licensing timelines for certain nuclear reactors and utilization facilities. Specifically, the NRC staff states that non-power reactors used in medical isotope production can be licensed by the NRC in approximately 18-24 months.[38] These types of facilities can only use the Part 50 process, but could still be fully licensed (both Construction Permit and Operating License) in 3-4 years (18-24 months safety review per application, with expedited administrative processes on the back end), whereas the starting point for a similarly sized power reactor under the same licensing process is 6-7 years (36 months per application, plus additional acceptance review and administrative time).

Indeed, one of the most recent applicants to be issued a construction permit under Part 50 by the NRC received its construction permit close to 24 months after acceptance, despite raising a variety of novel policy and technical issues for the NRC to resolve during the licensing process. The SHINE facility in Wisconsin plans to produce molybdenum-99 at a commercial scale, using a low enriched uranium (LEU) accelerator-based production system.[39] The license application for the SHINE Facility was accepted in full in December of 2013, and the Commission decision issuing the construction permit was issued February 2016—approximately 26 months later.[40] The NRC staff later estimated that the operating license for the SHINE Facility could be granted 24 months after acceptance of the application (October 2019 to October 2021).[41]

While the SHINE facility comprises a series of accelerator-driven systems, this does not change the licensing analysis—the NRC applied the same schedule to reactor-based medical isotope production companies and has indicated as much in preapplications meetings with medical isotope production companies using 10 MW non-power reactors.[42] The NRC appears to have prioritized the expedited licensing of medical isotope facilities to combat a potential shortage in medical isotopes. The same priority should now apply to licensing advanced reactors given the need to combat climate change and mitigate its human and environmental consequences. Given the NRC's transition to performance-based regulation, there is no significant reason the expedited licensing timeframes seen for licensing medical isotope production facilities under Part 50 cannot therefore be replicated for at least some advanced reactors; or at the least, many of the licensing efficiencies leveraged for power reactors.

---

[38] NRC, Construction Permit Applications for Medical Radioisotope Irradiation and Processing Facilities (last updated June 5, 2020), https://www.nrc.gov/reactors/medical-radioisotopes/construction-applications.html.

[39] World Nuclear Association, *Radioisotopes in Medicine* (last updated Apr. 2021), https://www.world-nuclear.org/information-library/non-power-nuclear-applications/radioisotopes-research/radioisotopes-in-medicine.aspx.

[40] NRC, Application Review Schedule for SHINE Medical Technologies Inc. (updated Oct. 19, 2020), https://www.nrc.gov/info-finder/nonpower/shine-schedule.html.

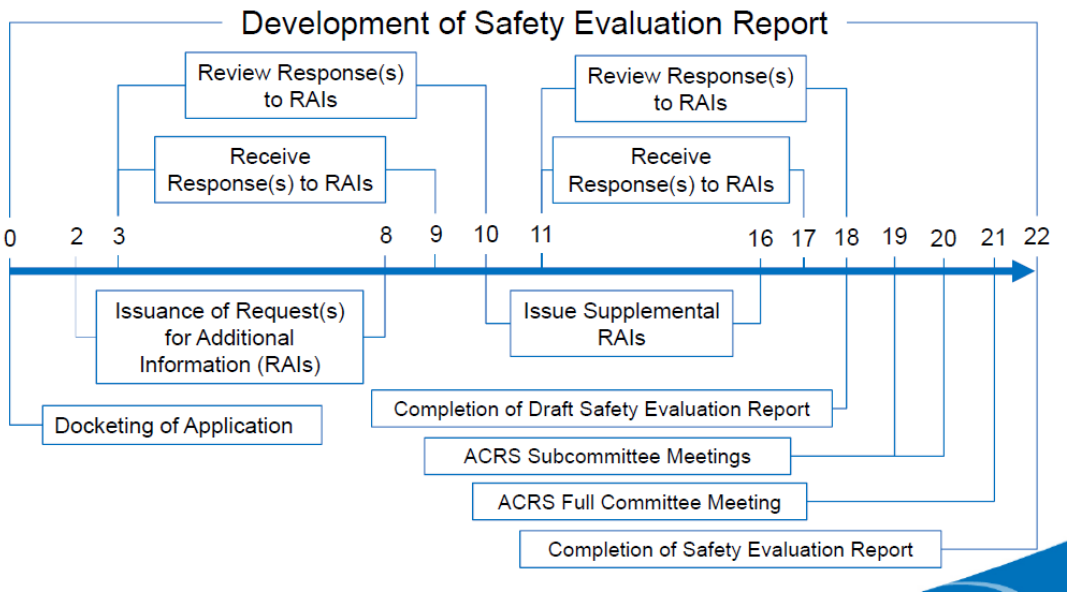
[41] Letter from Steven T. Lynch, Project Manager Non-Power Production and Utilization Facility Licensing Branch Division of Advanced Reactors and Non-Power Production and Utilization Facilities Office of Nuclear Reactor Regulation to Gregory Piefer, Ph.D. Chief Executive Officer SHINE Medical Technologies, LLC (Apr. 30, 2020), https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML20114E315.

[42] Construction Permit Applications for Medical Radioisotope Irradiation and Processing Facilities, *supra* note 38.

The NRC staff should consider (or reconsider if appropriate) whether the licensing schedule it has set forth for medical isotope production facilities can apply to advanced reactors, and what needs to change to make that happen. Upcoming applications for the first advanced reactors provide an opportunity. NRC staff has indicated that it would accept application format and content closer to current non-power reactor guidance than LWR guidance.

The first step to this end should be to evaluate the process used to license medical isotope facilities. The NRC sets out a 22-month safety evaluation schedule[43] for non-power utilization facilities used for medical isotope production, as follows:

Figure 2: Safety Evaluation Timeline for Medical Isotope Production Facilities



The process set forth for non-power facilities takes advantage of two key efficiencies:

> ***Preparation of safety evaluations and meeting with the Advisory Committee on Reactor Safeguards (ACRS)*:** One thing that stands out is that the actual production and review of the Safety Evaluation Report proceeds quickly, along with a focused single engagement with ACRS. This is in stark contrast to the licensing process for power reactors. For power reactors, the process for a Design Certification and Combined License review includes, in part:
>
> (i) preparing a Preliminary Safety Evaluation Report with Open Items;
> (ii) presenting this document to the ACRS and resolving their comments;
> (iii) preparing an Advanced Safety Evaluation Report with No Open Items;

[43] Note that this schedule is narrowly for the Safety Evaluation Report, and does not include acceptance review and potential contested hearings after the Report.

(iv) presenting that document to the ACRS and resolving any additional comments; and then proceeding to a final SER.

The very iterative process for power reactors may have had merit when licensing large LWRs in the past, but such a process is inefficient for licensing advanced reactors. For example, the NuScale design contains only one-third of the safety systems as the current generation of operating plants. Similarly, the Oklo Aurora advanced non-LWR only contains about 100 unique components compared to the thousands found in a traditional large LWR. Iterative development of the SER and targeted engagement with ACRS should be the norm for licensing these simplified designs.

There are multiple ways to reform the ACRS review process in actual implementation. A single ACRS review may be applicable in most cases. There could also be a primary ACRS review earlier focused on key policy issues going to the Commission, and a shorter review in a later phase to follow up on the key issues raised from first review. This aligns with suggestions in 2019 ACRS itself proposed to the review process, particularly to prioritize its review on high-importance issues and reduce review on less critical topics.[44] While the Atomic Energy Act requires an independent review by the ACRS, the Commission has the authority to determine what that process should encompass. The multilayered and complex review process currently utilized by ACRS is well beyond what is needed to provide an independent assessment and certainly beyond was conducted during reactor reviews decades ago. The Commission should systematically evaluate the ACRS review process and how this can be appropriately aligned with the expectations that Congress set out for the Commission under NEIMA.

Focused RAI Process: In licensing the SHINE Facility, the NRC staff emphasized its focus on the "most safety-significant technical aspects," as well as "[f]ocused requests for additional information."[45] Advanced reactor developers have provided feedback to the NRC about the scope of RAIs and their ability to drag on a licensing proceeding despite many not being central to the main safety case for a reactor. In contrast, the licensing timeline for medical isotope production facilities described above presumes only two RAI cycles. The NRC retains the responsibility to gather the information it believes necessary to provide for adequate protection of the public health and safety. However, an expectation going forward of two RAI cycles focused only on information required for safety determinations can help align NRC staff and applicants on the review process. With sufficient work, it is possible to reduce an application to only one RAI cycle and, with sufficient preapplication engagement and licensing experience, even conduct a no-RAI process.

[44] Commission Meeting with the Advisory Committee on Reactor Safeguards (Dec. 6, 2019). The slides are available at: https://www.nrc.gov/reading-rm/doc-collections/commission/slides/2019/20191206/staff-20191206.pdf (see slides 5 to 8).

[45] NRC, Technical Meeting on State of the Art Reactor Based Radioisotope and Radiopharmaceutical Production, Insights on Adapting Licensing Frameworks to New Radioisotope Production Technologies (Mar. 2021), https://www.nrc.gov/docs/ML2109/ML21096A291.pdf.

Along with an evaluation of the medical isotope production facility licensing process, the NRC staff may benefit from review of recommendations contained in NRC's memorandum "Key Principles for Nuclear Material Safety & Safeguards Reviews" ("NMSS Memorandum").[46] This memorandum builds off the NRC Staff Paper "Achieving Modern Risk-Informed Regulation," although is targeted to the RAI process for materials licensing. While directed at NMSS licensing actions, the NMSS Memorandum contains observations and recommendations that are also relevant to reactor licensing actions, particularly insofar as they address the question of "how much information is enough" to make a reasonable assurance finding.

For example, to assist the staff in "becoming more risk-informed in [its] decision-making," the NMSS Director recommended that staff reviews be adjusted in the following ways:

- Focus staff resources and expertise on the *most safety-significant portions* of a licensing decision;

- Focus staff effort on reaching "adequate protection" or other regulatory conclusions based on *reasonable assurance with respect to system performance*, rather than an individual component; and

- Enable the staff to *acknowledge that a new technology may be safer than an existing technology*, although operating experience with that new technology may be lacking and the new technology may not meet the specific regulatory review standards developed for the existing technology.

These recommendations are particularly well-suited to advanced reactors, which through holistic design choices provide reasonable assurance, and implement new technologies that are inherently safe rather than trying to make an existing technology as safe as possible. They also align with licensing of medical isotope production facilities. Implementing them would bring significant public benefits by increasing overall safety, improving overall regulatory efficiency and effectiveness, and enabling the rapid adoption of nuclear energy to meet the public's climate mitigation needs.

The enclosure to the NMSS Memorandum also contains additional discussion on structuring RAIs and drafting SERs—including the following: (i) focus on radiological risk; (ii) zero risk is not required;[47] (iii); account for advances in technology; (iii) consider the objective and purpose of each regulatory requirement[48]; (iv) tailor use of guidance to specific applications; (v) focus on

[46] "Key Principles for Nuclear Material Safety & Safeguards Reviews" (Jan. 15, 2019) (ML19015A290) (NMSS Memorandum).
[47] Id., noting that "some level of risk is expected when it comes to activities involving the use of a radioactive source, and absolute protection is not required.".
[48] January 15, 2019, Memorandum, Enclosure at 3.

each item's relative safety significance;[49] (vi) incorporate applicant program implementation into the review; and (vii) focus SERs on information essential to safety findings and conclusions.

NIA recognizes that the suggestions above may not in themselves be sufficient to reduce licensing timelines by over 33% across the board (from three+ years to two or less), nor is it possible to perfectly compare advanced reactors to non-power facilities that produce medical isotopes. But a major effort itself will likely yield significant insights and benefits, as well as model guidance and out-of-the box ideas. For example, it may be the case that aspects of the construction permit review may be able to be expedited, so that a Construction Permit can be issued within a 24-month period, with open issues passed off to the Operating License review.[50] The NRC took this approach in the licensing of the SHINE facility, leaving multiple open issues to resolution as part of the Operating License review, allowing the Construction Permit review to proceed to conclusion in a timely fashion.[51] Similarly, certain issues were left open for the NuScale DCA.

NIA makes the following recommendations:

Recommendation 3: Restructuring the NRC's safety evaluation process

- **Recommendation for the NRC:** The NRC should explore dramatically reducing current power reactor licensing timelines to approach an 18-24 month safety review schedule for Construction Permit and Operating License applications under Part 50 (with a similar timeline for Combined License application reviews under Part 52). Staff's review should focus on adequate protection of health and safety established in the regulations, not guidance documentation based on previous technology. Moving to only one ACRS review and reforming the process can reduce timelines, reflecting smaller sizes of advanced reactors while still meeting AEA requirements. A mandatory hearing and license should follow promptly (e.g., within 2 months) following completion of the safety review.[52]

  To assist in this effort, a sample comparison of the current process for a Combined License application review to a potentially expedited process is provided in Appendix 2 (as discussed above, there are a few ways to address the ACRS review component). This effort can also be synergistic with the current Part 53 rulemaking, so lessons learned from reducing durations can be leveraged into Part 53. This should not likely require significant regulatory reform, as this schedule has already been used for other Part 50 facilities; instead, lessons learned should be implemented in guidance.

[49] *See also* SECY-18-0060 at 8 ("[T]he depth of information needed to reach a licensing decision that provides reasonable assurance of adequate protection would be commensurate with the safety or security significance of the commercial power reactor matter under review."); 2011 Ostendorff Remarks at 4 ("The main factor that I find critical to decision making related to 'adequate protection' is the consideration of risk. In short, this requires an assessment of the probabilities and consequences of a particular risk, as well as a hard look at whether concerns raised in a proposal are based on realistic assumptions, or real world safety, security, or legal issues.").

[50] Contingent on findings under 10 CFR 50.35(a)

[51] SHINE Med., SHINE Construction Permit Application Accepted by NRC (Dec. 4, 2013), https://shinemed.com/shine-construction-permit-application-accepted-by-nrc/.

[52] Congress should consider removing the statutory requirement for a mandatory hearing for uncontested proceedings

Beyond this, NRC should also work to more clearly define what a high-quality application entails (in a technology-inclusive way) in order to guide applicants as they seek to right-size applications. In doing so, NRC should recognize concerns that providing extraneous information in the past has led to lengthening durations of licensing review as NRC reviews the additional information as opposed to focusing narrowly on the safety significant portions.

- **Recommendation for Applicants:** Accelerated NRC review will only be feasible where there are high-quality applications that provide sufficient information to NRC for its review and that minimize the number of required RAIs. What constitutes a high-quality application is not just in the eye of the beholder, but has objective aspects. First, drafting a high-quality application entails not just stating a position, but putting yourself in the shoes of the reviewer and providing reasonable underlying support to help walk the reviewer through why that position is the correct one. A key part of this is understanding that the NRC staff reviewer will simply have less expertise on the design the applicant has worked on for years or a decade, and so should not be expected to come to the same safety conclusion immediately. Second, it includes reviewing past precedent to identify gaps between the planned filing and what has been submitted in the past. A key aspect of this is reviewing questions the NRC asked on similar issues in the past, and addressing those questions proactively in the current filing. Useful precedent may have been lacking in the past, but now recent precedent is available (e.g., NuScale, Oklo), and the NRC's review of applications filed during the nuclear Renaissance can also be referenced to provide background on generic issues (such as the scope of the NRC environmental review). Applicants should also clearly communicate expected licensing challenges to NRC staff to facilitate more efficient allocation of NRC resources and development of accurate schedules.

  Figuring out what constitutes high-quality applications necessarily requires some trial-and-error to "right-size" the application. Sharing lessons learned across industry through working groups can help industry find the balance and optimize application content and size. Only with high quality applications can the NRC be reasonably expected to adhere to its accelerated timeline and pass through ACRS review only one time. Preapplication engagement under the revised framework discussed above can also help set applicants on a glide path for a high-quality application by allowing the NRC staff and applicant to align on the content of the application and identify key issues for early Commission involvement.

V. Recommendation 3: Promote early management and Commission engagement on key policy issues

Ongoing and upcoming advanced reactor applications raise a number of complex policy issues, such as use of obtaining exemptions to inapplicable portions of the current LWR-specific framework, security and staffing requirements, and more. Policy issues may not always be "big picture" in nature either, but still raise key issues that require Commission action before an application can move forward. For example, the NRC staff and NuScale reached an impasse on whether an actuator valve needed to be single fault tolerant—hardly in itself a broad-scope issue—but the internal disagreement spanned years, multiple filings, and eventually required the Commission to step in to resolve it through evaluation of how risk-informed and performance-based licensing principles applied to analysis of the device.[53]

Given the variety of anticipated designs coming through the door, the ability to address all these issues through generic processes is nearly impossible. However, in most cases these issues are known by the time of the license application (in part due to productive preapplication engagement) or come to light early in the licensing process. This speaks to a need for earlier escalation to middle and senior management for resolution of key policy issues presented by an application—or up to the Commission if necessary (but hopefully avoidable in most situations if the escalation to middle and senior management is working well). It would be even more effective to utilize these tools during the preapplication phase. For example, the NRC staff set forth key licensing issues to the Commission for a proposed Babcock & Wilcox medical isotope production facility during preapplication engagement.[54]

The mechanisms to utilize these tools are already in place and sometimes early engagement happens and works well. For example, as occurred in the Louisiana Energy Services (LES) uranium enrichment facility licensing proceeding where the Commission issued a hearing order setting the licensing schedule and requested that novel legal and policy issues be sent to the Commission early for resolution.[55] In that proceeding, the Commission's guidance in the hearing

---

[53] Staff Requirements Memorandum (July 2, 2019), https://www.nrc.gov/docs/ML1918/ML19183A408.pdf, on SECY-19-0036, Application of the Single Failure Criterion to NuScale Power LLC's Inadvertent Actuation Block Valves (Apr. 11, 2019), https://www.nrc.gov/docs/ML1906/ML19060A081.pdf; NuScale Power, LLC Request for Commission Clarification on the Application of the Single Failure Criterion to "Active-Passive" Components, Letter LO-1218-63707 (Dec. 14, 2018), https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML18351A145.

[54] *See, e.g.,* SECY-09-0101, Licensing of a Babcock and Wilcox Medical Isotope Production Facility (July. 9, 2009).

[55] Notice of Receipt of Application for License Notice of Availability of Applicant's Environmental Report; Notice of Consideration of Issuance of License; and Notice of Hearing and Commission Order; Louisiana Energy Services, LP.; Claiborne Enrichment Center, 56 Fed. Reg. 23,310 (May 21, 1991); In the Matter of Louisiana Energy Services, L.P. (National Enrichment Facility); Notice of Receipt of Application for License; Notice of Availability of Applicant's Environmental Report; Notice of Consideration of Issuance of License; and Notice of Hearing and Commission Order, 69 Fed. 5873 (Feb. 6, 2004); USEC, Inc. (American Centrifuge Plant); Notice of Receipt of Application for License; Notice of Availability of Applicant's Environmental Report; Notice of Consideration of Issuance of License; and Notice of Hearing and Commission Order, 69 Fed. 61,411 (Oct. 18 2004); GE-Hitachi Global Laser Enrichment LLC; (GLE Commercial Facility); Notice of Receipt of Application for License; Notice of Consideration of Issuance of License; Notice of Hearing and Commission Order; In the Matter of Areva Enrichment Services, LLC (Eagle Rock Enrichment Facility), 74 Fed. Reg. 38052 (July 30, 2009); Notice of Receipt of

order was crucial, as it served to focus both the NRC staff's review of the application and the licensing board's disposition of contentions.

Another crucial factor was the Commission's clearly stated expectation—again in the hearing order—for "prompt and efficient resolution of contested issues" and elimination of "unnecessary delays in the NRC's review and hearing process." In the hearing order, the Commission set forth a 30-month schedule, with detailed milestones for completing the proceeding, including specific time frames for discovery, summary disposition, evidentiary hearings, and key licensing board decisions. In addition, consistent with the Commission's directive, the Atomic Safety Licensing Board (ASLB) promptly certified novel legal or policy issues to the Commission for early consideration. In short, the direction and oversight provided by the Commission in the hearing order, as supported by the ASLB to filter and clarify issues, proved integral to the efficient conduct of the NRC's licensing and adjudicatory reviews.

To ensure timely reviews, it is critical for the mid- and senior- level management, and Commissioners where appropriate, to be actively engaged in the process and able to support quick staff resolution of key issues. The LES licensing proceeding moved forward smoothly and on time because of such engagement, including through a complex contested hearing that touched upon multiple novel policy issues (e.g., decommissioning requirements for a facility without clear waste disposal paths, and waste classification and disposal for significant quantities of depleted uranium).

But many times, the tools in place are not used well. One striking example is the resolution of the NRC staff's foreign ownership, control, or domination (FOCD) concern in the South Texas Project expansion project to add units 3 and 4 (STP 3&4) combined operating license and the resolution of the more generic financial qualifications for merchant plants matter in the same and other proceedings.[56] Both these issues were outcome determinative, in that the license could not be issued until they were resolved and whether they could be resolved was very uncertain. Yet these matters were resolved at the very tail end of a long licensing process—about *8.5 years*[57]—and the FOCD issue nearly derailed the entire application after over a billion dollars had already been spent on the project.

It appears that the mechanisms for a timely resolution of key licensing matters have not worked well to date in the advanced reactor space. Several novel policy issues have been raised without early resolution —especially where the applicant and NRC staff reviewers disagree. Indeed, in its Lessons Learned Report regarding its Design Certification Application, NuScale's first suggestion was for there to be a process for resolving key policy issues where the applicant and NRC staff may disagree, which a hearing order could serve:

Application for License; Notice of Consideration of Issuance of License; Notice of Hearing and Commission Order, 75 Fed. Reg. 1819 (Jan. 13, 2010).

[56] "Request for Additional Information Related to Part 1 General and Financial Information of the Combined License Application for the South Texas Project, Units 3 & 4" (April 18, 2012) (ML121010491).

[57] See NRC STP 3&4 licensing webpage, available at https://www.nrc.gov/reactors/new-reactors/col/south-texas-project.html#application.

> Establish an appeal process. Presently an applicant has no clear or established means to challenge Staff's preliminary conclusions on the adequacy of the design with respect to regulatory requirements. In order to promote regulatory clarity, certainty, and efficiency, a process and arbiter should be established to consider and decide significant disagreements in a timely manner.

The lack of an appeal process on NRC staff determinations also almost derailed the STP 3&4 licensing proceeding over the FOCD issue. In that case, the NRC staff actually rejected the application near completion of its review on novel grounds that a minority stake in the project by Toshiba, along with financial support to help the project get through licensing, led to impermissible foreign control of the planned nuclear power plant in violation of the Atomic Energy Act. The NRC staff's rejection of the application would have shut the door on a multi-year licensing effort for a project with significant public benefits, without any realistic avenue for review, were a hearing proceeding not already ongoing before an NRC Atomic Safety and Licensing Board.[58] In that hearing, the Atomic Safety and Licensing Board disagreed with the NRC staff and found that Toshiba did not impermissibly control the project, and the Commission thereafter agreed.[59] While successfully resolved, this process itself took many years—with the contention proposed in June 2011, the Licensing Board decision in April 2014, and the Commission decision in 2015—about 4 years after the issues was raised. A more streamlined process could have shaved years off Commission resolution of this critical issue—but instead the applicant and the public had over four years of uncertainty as to whether the project could be licensed, and again, after over a billion dollars had been spent on the project.[60]

The Commission is broadly empowered with the ability to guide conduct of licensing proceedings,[61] and there are few other priorities as important for the Commission to be involved in. Therefore, the opportunity exists for the advanced reactor community, the NRC staff, and the Commission to develop a more efficient, effective and consistent process for obtaining prompt Commission guidance on key licensing issues early on with applications for first-of-a-kind advanced reactor facilities. The goal of using tools like those used in the LES proceeding, for the proposed Babcock & Wilcox medical isotope production facility, or during the FOCD in the STP 3&4 proceeding, would be to obtain greater clarity on key issues in order to lead to a more efficient proceeding, and reduce the risk of delays on lingering issues where the regulator and regulatory staff are at odds over reasonable interpretations.

---

[58] Note that in this proceeding, an intervenor group also raised an FOCD concern after the NRC staff. That enabled the issue to be dispositioned before the Licensing Board. Had this issue not already been pending in an already existing contested proceeding, it was unclear whether the applicant could have raised it on their own. Moreover, the issue was not resolved quickly, but rather over the course of a few years.

[59] *Nuclear Innovation N. Am. LLC* (S. Texas Project, Units 3 & 4), LBP-14-3, 79 NRC 267 (Apr. 10, 2014), *aff'd* CLI-15-7, 81 NRC 481, 499 (2015).

[60] For more on this topic, please see M. Segarnick and S. Desai, Preparing for Advanced Reactors: Exploring Regulatory and Licensing Reform, American Bar Association (Nov. 14, 2018), *available at* https://www.americanbar.org/groups/environment_energy_resources/publications/nl/20181114-preparing-for-advanced-reactors/. The NuScale Lessons Learned Report also discusses various options for implementing an appeals process.

[61] Energy Reorganization Act, Pub. L. 93-438, 88 Stat. 1233 (1974).

Recommendation 3: Promote early management and Commission engagement on key policy issues

- **Recommendation for the NRC:** The NRC should use its existing processes and develop additional ones as needed for early escalation of key policy issues to middle and senior management, and to the Commission as needed. The process should include early Commission involvement, if necessary, and especially if there is an unresolved disagreement between the NRC staff and applicants, on key policy issues, with the list of issues jointly developed by the applicant and staff. As one example, a generic schedule could be established in which the NRC staff submits a list of joint issues for Commission guidance shortly after application acceptance. Active involvement by Commissioners to support management and staff conducting timely reviews is essential to establish review duration accountability for early reactor projects. The Commission should also consider issuing hearing orders with specific licensing schedules, as occurred in the LES proceeding hearing order.

- **Recommendation to Applicants:** Applicants should work with the NRC staff to support these efforts, particularly through early engagement to let them know what the key issues are expected in the review of the application and as new issues emerge. The NRC staff has explicitly indicated that it is interested in early Commission engagement—if the applicants bring up these issues as part of preapplication engagement.[62] Many applicants go into licensing already aware of at least some critical issues, and these should be shared early in order to obtain quick resolution. In order to facilitate a fast timeline for Commission engagement on key issues, the applicant should endeavor to complete the preapplication process and incorporate addressing key policy issues as part of an overall strategy to preapplication engagement. That process should include open discussion and possibly submission of a specific White Paper on key policy issues that are likely to require Commission input. This process could also extend to the NRC review of other generic regulatory documents (e.g., technical reports and topical reports) developed by industry organizations or standards groups that have policy implications for applicants.

[62] NRC Staff Response to Nuclear Energy Institute's Input on Analysis of Applicability of the U.S. Nuclear Regulatory Commission's Regulations for Non-Light Water Reactors (July 29, 2021) ("Nonetheless, these options are available for use in connection with a specific application, especially in cases where an applicant has a mature design and desires early Commission engagement. Pre-application engagement should help to determine if these options would be useful in a particular context.").

VI. Recommendation 4: Build effective communication into the safety review

The recommendations discussed above can greatly improve the duration and consistency of the licensing review. However, these initiatives can only go so far if there is no mechanism in place to establish increased understanding between the regulator and license applicant. It appears there is currently a significant disconnect between the NRC's high-level licensing goals (such as to be a risk-informed regulator) and day-to-day implementation by staff and review teams. Some argue this is due to a lack of oversight as to the scope and depth of NRC staff reviews and the failure of senior managers to appropriately guide the staff. While it is vital that differing opinions are heard, NRC managers must guide the review process to bring technical issues to a close and not simply allow differences to drag out with hope that they will resolve on their own. Others argue, however, that this disconnect is due to a lack of clarity by applicants as to how they reached certain conclusions in their applications. Both are likely true for different applications; the general theme, however, appears to be a lack of complete and effective communication on the day-to-day licensing review process.

Congress recognized this issue at a high level in the passage of NEIMA. Section 102(c)(1) of NEIMA required the NRC to establish milestones and performance metrics for review of advanced reactor applications (one result being the NRC's Generic Milestones for reactor licensing actions).[63] Sections 102(c)(2) and (3) placed an ongoing requirement for the NRC Executive Director of Operations to inform the Commission any time that generic milestone is exceeded, and for the Commission to inform Congress if the delay exceeds 180 days.[64]

While Congress in NEIMA recognized the need for greater transparency as to NRC processes and licensing timelines, its high-level requirement may not be sufficient to move the ball. The issuance of the SER is too late a point in time to "right the ship" for a review that has run into delays, nor does it provide a true accounting of any of the reasons for the delay—whether it be an untimely review, an incomplete application, or disagreement on key topics between staff and an applicant. Indeed, in practice the real choke points for application reviews occur in the day-to-day review work between the NRC reviewers and applicant licensing team.

Instead, NRC and applicants need to build effective communication into every aspect of a license application, to enable issues to be identified earlier in the process and to provide a clearer accounting of the causes of any delays. More than just evaluating the issuance of the SER against generic milestones, the NRC could benefit by evaluating individual licensing actions within a broader proceeding, such as the efficiency of RAI reviews, the issuance of draft SERs, and review by ACRS. The RAI process should be considerably reformed as it often requires multiple levels of review and approval by NRC and industry, often taking a long time to reach resolution. An alternative agile yet transparent RAI process could enable near real-time feedback from the NRC and quick resolution by applicants. Reducing RAI cycles to only one or two for an application, or even trying out non-RAI processes could lead to much more efficient reviews and better founded safety determinations.

[63] Generic Milestone Schedules of Requested Activities of the Commission, *supra* note 26.
[64] Along with this, Congress stressed the importance of accurate invoicing in Section 102(d) of NEIMA.

Better oversight and project management by both NRC and industry is needed to minimize bottlenecks that are bureaucratic and not substantive. The performance of individual project managers can vary greatly and the durations of licensing outcomes can thus vary for companies depending on company licensing managers and NRC staff assignments. Dedicated internal processes to support and train NRC and company staff in best practices in timely managing reviews, fielding and filtering questions, and keeping reviews focused on the adequate protection determination can improve regulator and applicant performance. While this may seem a significant effort on the part of the NRC staff, it optimizes staff resources to focus on the most safety-significant items and handle a growing array of advanced reactor designs and applications. Moreover, establishing an infrastructure of constant two-way communication will in itself help ensure that other reforms discussed in this report are better implemented and lead to increased self-improvement. A critical part of this process, however, is that communication be a two-way street. If the applicant has not fully taken advantage of its preapplication engagement opportunities or submitted a high-quality application, it should be prepared to accept its responsibility for any delays in the review. Indeed, it may be prudent that as part of any enhanced transparency efforts both the NRC staff and applicant jointly account for any apparent delays, and offer joint solutions, so the Commission has a better idea of next steps to take.

Recommendation 4: Building effective communication throughout the NRC review

- **Recommendation for the NRC:** The NRC should continue its efforts to build effective communication into its reviews by creating a process for evaluating and recording the efficiency of individual aspects of an NRC advanced reactor review, including (i) responses to RAIs, (ii) development of draft SERs, and (iii) review with ACRS. These reviews should be set against qualitative or quantitative performance metrics envisioning a 24-month review cycle before issuance of the SER. Sharing this tracking and metrics with applicants can enable both NRC and applicants to ensure continued progress in review. These processes should be developed for upcoming Part 50 and 52 applications and then subsequently incorporated into the Part 53 licensing process. NRC should work with industry on creative approaches to modernizing RAI processes to minimize RAI cycles, try out alternative approaches, and ensure RAIs can deliver the most needed information for safety determinations. Effective project management and training is also critical to ensure that applicants have a level playing field for timely reviews.

- **Recommendation for Applicants:** Applicants should have an open and realistic engagement with the NRC staff as to its expectations for the licensing review, including the feasibility of meeting milestones if there are still gaps in the application. Also, applicants should endeavor to work with the NRC staff on interim licensing efficiency reviews. As much as the NRC staff is being asked to perform more granular oversight of its review process, applicants should also do the same to ensure that their engagement with the NRC is well communicated. A key part of this is ensuring that the applicant's management closely monitors the day-to-day licensing activities. Increased management involvement may ensure that the applicant is being responsive to NRC requests, and that the overall licensing proceeding adheres to the strategic plan laid out in preapplication

engagement. Additionally, companies should focus on developing training and best practices for its own licensing management, and share lessons learned across the industry.

VII. Conclusion: Efficient Licensing Reviews for a Safe Climate

The duration of licensing reviews should be right-sized so that they meet the public need for timely deployment of advanced nuclear energy for climate mitigation while ensuring continued protection of public health and safety. Even with recent regulatory developments, including NRC's generic milestones required by NEIMA, the current expected duration of licensing reviews is too long to support rapid deployment of nuclear energy, especially considering business models planned by advanced reactor developers and their customers. Such long reviews are a legacy of the 5-year or longer reviews need for complex, large light-water reactors, not the time it takes for the NRC to reach a finding of adequate protection of health and safety for newer, less complicated advanced reactors.

Reducing the durations of licensing reviews so that we can deploy advanced reactors quickly to meet the climate imperative requires that both NRC and industry work together to ensure timely and efficient reviews in the public interest. Regulatory modernization is inherently an iterative process. The recommendations in this report can guide NRC and industry as they work through the novel technology issues associated with advanced reactors. Over time, the durations of licensing reviews could be shortened from 3 or more years to 24 months or less, all while creating more efficient and transparent licensing processes.

Appendix 1: Summary of Actual Milestone Durations for Past Part 52 Proceedings[65]

Early Site Permits (ESP)			
Applicant	**Duration for Environmental Review (ER)**	**Duration for Safety Review**	**Duration for ESP**
PSEG	63 months	61	69
North Anna	37	22	48
Grand Gulf	28	22	39
Clinton	32	27	40
Vogtle	22	28	35
Clinch River	27	29	35
Design Certifications			
Design	**Duration for Safety Review**	**Duration for Design Certification Review**	
ABWR	63*	97*	
ESBWR final rev.	63	106 (total from initial submittal to DCR for Rev 10	
- ESBWR DCD Rev 10	41	42	
APR-1400	42	54	
NuScale	42	42	
Combined Licenses			
Applicant	**Duration for ER**	**Duration for Safety Review**	**Duration for COL**
Fermi	50	72	77
Turkey Point 6,7	87	86	103**
Summer	32	36	43
Vogtle	34	38	44
South Texas	38	94	98
North Anna	25	107	112
Levy	42	91	96
Lee	70	102	105

* The durations for the ABWR shown in Table 2 reflect a start date of March 31, 1989, a publication date for the FSER of July 13, 1994, and a final approval of the rule of May 12, 1997. These dates are those provided by the NRC in Ref. 7.

** The COL duration for Turkey Point 6,7 is longer (103 months or 8.6 years) than the duration shown in Ref. 1 (7.8 years). The durations shown in Table 2 for Turkey point reflect a start date of September 4, 2009, and a final Commission decision on April 4, 2018. The discrepancy between the Ref. 1 duration and the duration in Table 2 could not be resolved for this report.

[65] Note that the causes for these specific timeframes may be caused by many factors including company decisions, project timelines, regulatory changes, and other factors beyond the control of applicants or staff. They are presented here to illustrate the historic timelines required for light water reactor reviews, which must be significantly improved upon if advanced reactors are to provide public health and climate mitigation benefits rapidly

Appendix 2: COL Key Milestones and Durations and Proposed Changes

Key Milestones in Review	Historical Durations*	Proposed Duration	Proposed Phases and Milestones
- **Phase 1 -- Requests for Additional Information Issued**	7-21 months	10-14 months	Proposed Phase 1 – Issue ~two phases of RAIs (presuming complete application with preapplication engagement); obtain Commission feedback on key policy issues
- **Phase 2 – SER with Open Items**	6-11 months		
- **Phase 3 – ACRS meeting on SER with Open Items**	1-11 months (if held)	N/A	N/A
- **Phase 4 – Advanced SER with No Open Items**	13-17 months	4-6 months	Proposed Phase 2 – Issue Advanced SER with No Open Items
- **Phase 5 – ACRS Review of SER with No Open Items**	2-3 months	2 months	Proposed Phase 3 – ACRS meeting and resolve comments
- **Phase 6 – Final SER Issued****	2-10 months	2 months	Proposed Phase 4 – Final SER Issued
TOTAL	**31-73 months**	**18-24 months**	

* Approximate periods

** A targeted mandatory hearing should be held within two months thereafter (which can be shorter in scope given early Commission engagement), with a license to be issued shortly after the hearing.