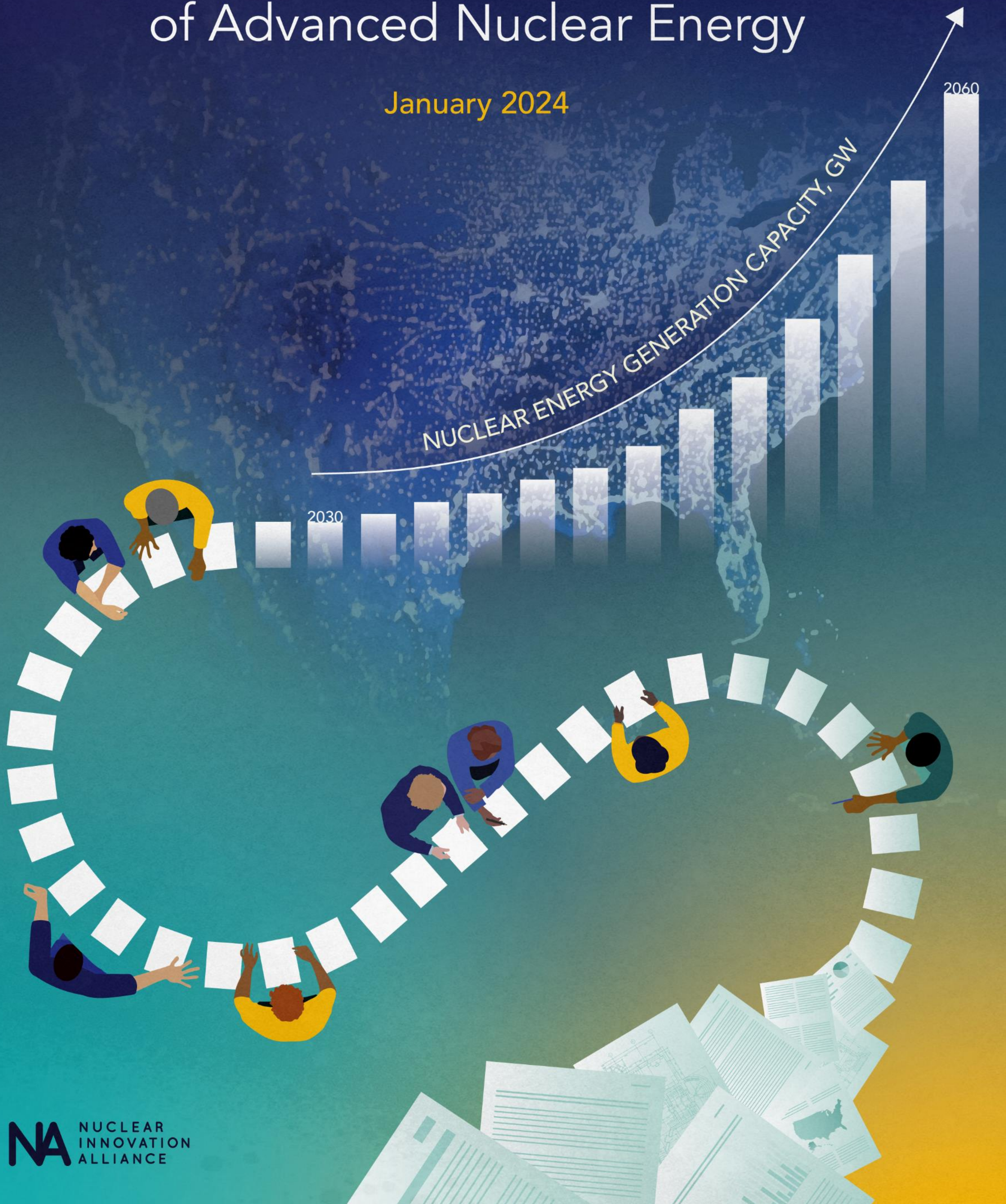
Enabling High Volume Licensing of Advanced Nuclear Energy

January 2024



NUCLEAR INNOVATION ALLIANCE

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January 2024

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Executive Summary

Achieving deployment of advanced nuclear energy at scale to make a meaningful contribution to clean energy production in the next few decades will require the Nuclear Regulatory Commission (NRC) to effectively and efficiently review and license large numbers of new nuclear power plants annually. The tens to hundreds of new nuclear reactors that would need to be licensed each year (based on clean energy targets and growing customer interest in small modular reactors [SMRs] and microreactors) are comparable to the total number of licenses that the NRC and its predecessor agency have issued in the seventy-year history of U.S. commercial nuclear energy. Enabling “high volume licensing” at the NRC is critical to the future deployment of advanced nuclear energy as a climate solution.

Improvements to the regulatory process are needed on three different timescales: near-term (mid-2020s through early 2030s), mid-term (early 2030s through mid-2030s), and long-term (mid-2030s and beyond). While prior reports by NIA have focused on improving NRC licensing in the near term[1] and the mid term[2], this report focuses on enabling effective licensing in the long term.

This report reviews the current licensing process for new nuclear power plants at the NRC and shows it is unlikely the agency could reasonably scale existing licensing processes to meet the potential high volume licensing demand. A combination of process bottlenecks, resource-intensive processes, and prescriptive regulatory process requirements limit the capacity of the agency to scale without significant changes to existing regulatory processes. This paper identifies three critical steps in the existing licensing process that most significantly constrain the NRC’s licensing capacity relevant to future high volume licensing:

1. Staff preparation and finalization of the safety evaluation report (SER), including reviews by the Advisory Committee on Reactor Safeguards (ACRS)
2. Staff preparation and finalization of the environmental impact statement (EIS)
3. Commission completion of the licensing process through a mandatory public hearing

The limitations associated with these process steps are largely based on the legacy processes and requirements associated with the licensing, construction, and operation of large conventional light water reactors. The review requirements and processes developed by the Atomic Energy Commission (AEC)[3] and used by the NRC are optimized for the licensing and regulation of bespoke, conventional, large light water reactors in a regulatory process that reflects the agency positions and actions in the 1950s, 1960s, and 1970s.

These three critical process steps (as currently implemented) will create unnecessary barriers to high volume licensing by the NRC. Increased agency transparency and public involvement throughout the licensing process, renewed industry focus on reactor standardization for new reactor deployment, and the

[1] NIA Report on Promoting Efficient NRC Advanced Reactor Licensing Reviews to Enable Rapid Decarbonization

[2] NIA Brief on Bridging the Gap on Part 53 Rule Development

[3] The Atomic Energy Commission was created on August 1, 1946 with the Atomic Energy Act signed into law by President Truman. Major amendments in the Atomic Energy Act of 1954 established the legal and regulatory framework for the commercial use of nuclear power. In 1974 Congress passed the Energy Reorganization Act, which abolished the AEC and replaced it with the NRC and the Energy Research and Development Administration (ERDA). On August 4, 1977, President Carter signed into law the Department of Energy Organization Act, creating the Department of Energy, which assumed the responsibilities of the ERDA and several other federal agencies.

expected safety and environmental improvements of a new generation of advanced reactor designs make these critical processes too burdensome and unnecessary in their current form. These processes must be reformed to enable high volume licensing by the NRC.

This report provides three specific proposals for the NRC Commission and staff to revise these process steps over the next five to ten years to increase the effectiveness and efficiency of advanced reactor regulation, and enable high volume licensing of advanced nuclear energy by the NRC in the mid-2030s. Many of these proposals can be completed by NRC staff and the Commission with effective Congressional oversight and without new legislation; some changes to the Atomic Energy Act (AEA) may be required to enable more significant process changes. New legislation, however, may be effective in expediting changes and providing NRC clear direction to prioritize updates to long-standing licensing processes and requirements.

Proposal 1: Increase the use of standardized applications for new reactors and leverage existing regulatory tools to minimize the scope of new or site-specific safety reviews performed by NRC staff and ACRS for new reactors with designs that have been previously licensed and operated.

This proposal includes minimizing the scope of reviews for aspects of standardized reactor designs that have received prior approval from ACRS and NRC staff. This proposal enables high volume licensing by reducing the process bottlenecks associated with ACRS review of new reactor applications, making safety reviews less resource-intensive by focusing NRC staff effort on site-specific or novel safety issues that have not previously been reviewed by NRC staff, and reducing prescriptiveness by eliminating time- and resource-intensive reviews that are duplicative for standardized reactor applications.

Proposal 2: Enable use of alternative environmental review processes that scale staff effort and public review based on the expected and demonstrated environmental impact of new reactor projects.

This proposal includes enabling the use of environmental assessments (EAs) and categorical exclusions (CATEXs) in addition to EISs as acceptable methods to meet the environmental review requirements of the National Environmental Policy Act (NEPA). This proposal enables high volume licensing by reducing the process bottlenecks associated with preparation of site-specific EISs when deploying a standardized reactor technology that has previously been evaluated to have small or no environmental impacts. This can reduce dependence on prescribed resource-intensive processes and will enable NRC staff to scale the environmental review process based on the expected and demonstrated environmental impacts of projects. Supplementary detailed reviews can still be conducted, if needed, to reduce dependence on prescriptive processes by scaling the requirements for public input and involvement based on the regulatory scope and impact of the decision.

Proposal 3: Enable the Commission to use less time- and resource-intensive oversight processes to complete the licensing review process based on the characteristics of each application and eliminate the requirement for the NRC mandatory hearing in Section 189a of Atomic Energy Act.

This proposal includes enhancing the ability of the Commission to use public meetings, staff briefings, or informal adjudication to complete the licensing review process following NRC staff reviews and eliminating the mandatory hearing for new reactors required by Section 189a of the Atomic Energy Act. This proposal enables high volume licensing by eliminating the process bottlenecks associated with preparing for and scheduling Commission participation in mandatory hearings for all applications, reducing resource-intensive processes by reducing the burden on NRC staff to prepare for mandatory hearings when the staff preparation has little impact on the outcomes of the hearing process, and reducing prescriptive processes by enabling the Commission to scale any final adjudication processes based on application-specific factors.

These three proposals help resolve key barriers in the long term for licensing of advanced nuclear energy at scale to make a meaningful contribution to clean energy production in the United States. Creating an effective and efficient performance-based regulatory framework that can scale to support deployment of advanced nuclear energy at scale will help ensure a regulatory environment that enables innovation and creates the conditions for success for advanced nuclear energy as a climate solution.

1. Introduction – The Need for High Volume Licensing

Avoiding climate change requires solutions to match the scope of the challenge. While deploying a small number of advanced reactors would provide much-needed dispatchable clean energy, meeting our goals requires us to think bigger and consider the role advanced nuclear energy could play *at scale* in helping to provide safe, reliable, affordable, and clean energy. Meeting midcentury climate goals and realizing the potential advanced nuclear energy can play in decarbonizing both the electric and non-electric sectors could require the deployment of at least 100 – 200 gigawatts (GW) of new nuclear energy in the United States within the next 25 years.[4,5] In December 2023, the United States and 24 other countries publicly signed a "Declaration to Triple Nuclear Energy" globally by 2050 to help meet greenhouse gas emission reduction targets,[6] requiring deployment of an unprecedented number of new nuclear reactors.

Deployment of advanced nuclear energy as a climate solution in the next 25 years can be characterized over three separate timeframes:

- Near-term (mid-2020s through late 2020s) – deployment of initial demonstration reactors and first-of-a-kind commercial advanced reactors.
- Mid-term (early 2030s through mid-2030s) – deployment of subsequent commercial advanced reactors, scaling deployment infrastructure for demonstrated designs, and demonstration of less mature advanced reactor technologies using a combination of existing regulatory frameworks and regulatory frameworks currently under development (specifically 10 CFR Part 53).
- Long-term (mid-2030s and beyond) – widespread deployment of standardized commercial advanced nuclear reactors at large scale for both electric and non-electric applications.

The transition between mid-term and long-term reflect the challenges of developing and scaling an industrial base to support deployment of hundreds of GW of new nuclear reactors by mid-century. New nuclear build-out scenarios presented in the DOE report "Pathways to Commercial Liftoff"[7] illustrate the importance of timely mid-term and long-term deployment trends (Figure 1). Achieving widespread deployment of advanced nuclear energy at scale (e.g., 10-15 GW per year) in the mid to late 2030s is critical to supporting a sustainable industrial base that can meet mid-century deployment goals.

[4] NIA Fission Vision: Doubling Nuclear Energy Production to Meet Clean Energy Needs
[5] DOE LPO Pathways to Commercial Liftoff - Advanced Nuclear
[6] Countries Launch Declaration to Triple Nuclear Energy Capacity by 2050
[7] Pathways to Commercial Liftoff - Advanced Nuclear

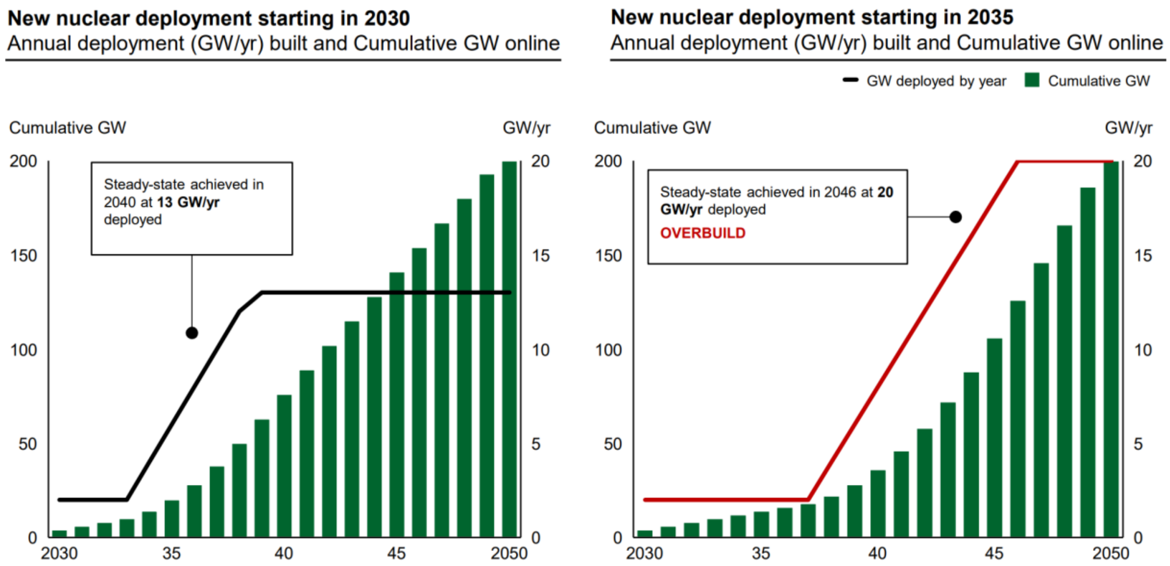

Figure 1. New nuclear deployment scenarios from DOE report "Pathways to Commercial Liftoff"[8]

The challenges facing deployment of advanced nuclear energy in each of these timeframes differ significantly. For example, near-term deployment will focus on the successful on-schedule completion of novel reactor projects leveraging federal support programs such as the Advanced Reactor Demonstration Program (ARDP). Mid-term deployment will focus on demonstrating learning-by-doing across multiple reactor projects and achieving sufficient scale to initiate robust supply chains. Long-term deployment will focus on wide-scale success and creating sustainable continuous growth to meet energy needs. The differing challenges facing deployment of advanced nuclear energy will include engineering, commercial, and regulatory challenges in each timeframe.

If this scale of deployment is satisfied with small modular reactors (SMRs) or microreactors,[9] effectively doubling nuclear energy production from 100 GW to 200 GW by 2050 in the United States would require deployment of a very large number of new nuclear reactors. This scale of deployment would create significant market opportunities for advanced reactor developers and enable the nuclear industry to reduce the cost of new nuclear energy by leveraging learning-by-doing over many newly deployed units.

Table 1 shows the approximate number of new reactors required annually to produce 5 GW of additional capacity for three different representative sizes of advanced reactors currently under development. Licensing and deployment of 10-15 GW annually starting in 2035 may be required to meet the mid-century climate goals of 100-200 GW by 2050 in the United States.

Table 1. Example Deployment of New Reactors to Produce 5 GW of New Capacity

Company	Reactor	Power (MW)	Number of Reactors
TerraPower	*Natrium*	345	15
X-energy	*Xe-100*	80	63
Oklo	*Aurora*	15	334

[8] Pathways to Commercial Liftoff - Advanced Nuclear

[9] SMRs are generally defined as nuclear reactors that produce up to about 300 MW of electric power. Microreactors are generally defined as nuclear reactors that produce up to about 30 MW of electric power.

The deployment timelines in Figure 1 and the deployment scale in Table 1 highlight the challenges of meeting mid-century deployment goals. Annual deployment of advanced reactors in the United States could easily exceed 100 new reactors per year by the mid 2030s depending on the reactor size, with a total deployment exceeding 1000 new reactors by 2050. One significant barrier to the deployment of advanced nuclear energy at this scale, however, is the ability of the Nuclear Regulatory Commission (NRC) to review hundreds to thousands of new reactor applications.

Deploying 100 GW of new nuclear generation capacity in the United States with SMRs would require the NRC to license over twice as many plants in the next 25 years as they have in the past 70 years.[10] Recent experience with reactor licensing (including the Westinghouse *AP1000* and NuScale *US600 SMR*) suggests the costs and personnel requirements for this scale and timeline of reactor license approvals with current processes would be impractical due to the increase in personnel needed to support dozens or hundreds of simultaneous license application reviews.

This paper reviews current NRC licensing processes and proposes alternative licensing processes that could be more easily scaled to facilitate the licensing of tens or hundreds of new advanced nuclear reactors per year.

1.1 Licensing Challenges Across Different Deployment Timeframes

The challenges associated with new nuclear power plants will vary based on the deployment timeframe due to the level of technology maturity, the scale of the deployment, and the availability of different regulatory processes to support deployment.

In the near term (mid-2020s through late 2020s), applicants will build first-of-a-kind commercial advanced reactors using existing regulatory processes. Reactor deployment this decade requires companies to begin licensing in the next 2 – 3 years using the licensing processes currently in place, since there is not sufficient time to complete a formal rulemaking process for a new nuclear power plant licensing regime, and any new processes would initially entail significant uncertainty. Near-term reactors will require detailed reviews as NRC staff ensure the safety of new technologies and designs, many for the first time. Efficiently and effectively navigating the regulatory process is critical to the successful completion of the near-term projects, but they must be completed without new regulatory tools or pathways (i.e., through the existing 10 CFR Part 50 and 10 CFR Part 52).[11] The NRC may be expected to review 10 – 20 reactors during this period (1 – 5 per year) depending on commercial interest and investment.

In the mid term (early 2030s through mid-2030s), applicants will build subsequent commercial advanced reactors and continue licensing new first-of-a-kind commercial advanced reactor for the next wave of less mature advanced reactor technologies using a combination of existing regulatory frameworks and new regulatory frameworks currently under development. Applicants will have the opportunity to leverage lessons learned from the near-term licensing activities to license their designs more efficiently under

[10] The U.S. NRC and its predecessor agency the Atomic Energy Commission (AEC) have issued a total of 127 operating licenses and 14 combined licenses for commercial nuclear power plants in the United States over the past 70 years as compared with at least 300 licenses necessary to create 100 GW of new capacity using the 345 MW *Natrium* reactor.

[11] For previous NIA recommendations on near-term licensing, see the NIA Licensing Efficiency Workshop Summary Report

either the existing regulatory frameworks the new regulatory frameworks (such as 10 CFR Part 53) being designed for licensing advanced reactors.[12] Some reactors may require detailed safety reviews as they are licensed by the NRC for the first time while others may be subsequent deployments of a standardized technology with little, if any, novel technology. The NRC may be expected to review 50 – 100 reactors during this period (5 – 20 per year) depending on the successful commercialization of advanced reactors in the near term.

In the long term (mid-2030s and beyond), applicants deploy commercial advanced nuclear reactors at a large scale to enable the U.S. to meet its mid-century climate and clean energy goals. While specific number of new reactors deployed per year will vary significantly based on business, market, and policy conditions, the overall pace of deployment of new nuclear reactors required to meet 2050 goals would far exceed historical precedent for the licensing and construction of new nuclear reactors. Deploying 10 GW – 15 GW of new nuclear reactors per year could require the NRC to license hundreds of new reactors per year (depending on the reactor size). Scaling the existing licensing processes and tools from reviewing and approving 5 – 20 reactors per year to 50 – 100 reactors per year would be extremely challenging, as the NRC could be managing the simultaneous reviews of 100 – 400 reactors at any time, depending on the duration of the licensing process.[13] As currently implemented, NRC licensing processes could not effectively scale to manage this large number of applications and approvals per year. If NRC licensing capacity is not proactively addressed and NRC attempts to linearly scale existing licensing processes, the delay may hinder advanced reactor deployment and preclude meeting U.S. mid-century targets.

The potential challenge of licensing large numbers of new nuclear reactors in the mid-2030s and beyond can be solved by identifying factors constraining current licensing processes and developing process and pathway solutions that enable more effective and efficient licensing of large numbers of reactors. The NRC needs to focus on incremental improvements in the near term (mid-2020s through late 2020s) and significant innovative improvements in the mid term (early 2030s through mid-2030s). Near-term efforts will set the stage for transformative processes and legislative changes needed to enable high volume licensing in the mid and long term. This set of efforts over time will enable the commercial conditions necessary for wide-scale deployment.

1.2 Characterizing the Factors Affecting NRC Licensing Capacity

The NRC licensing process for a new advanced reactor can be easily conceptualized by non-expert stakeholders based on three main observable attributes:

- Review duration – how many months are there between an application submission and a formal licensing decision. This can also include any time required for engagement with the regulator before submission of an application (i.e., “pre-application” review).
- Review effort – what is the amount of effort required by the NRC staff and the applicant to complete the licensing. This can include costs to the applicant to prepare the licensing application,

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[12] For previous NIA recommendations on 10 CFR Part 53, see [NIA Brief on Bridging the Gap on Part 53 Rule Development]

[13] Assuming the licensing review process requires 24 - 48 months to complete results in a steady state NRC workload of approximately two to four times the number of applications approved annually.

costs for the regulator and applicant to engage before and during the licensing review to answer questions, and costs for the regulator to review the application.

- Review variability – how predictable are the duration and cost of the review, and what is the expected process variability when completing a license review.

These three attributes have a significant impact on the commercial case associated with licensing new nuclear power plants at scale because they affect deployment timelines and regulatory costs for new commercial projects.

The duration, cost, and variability of an application review can depend on many factors including:

- Application quality – does the application contain all information necessary for NRC staff to make a safety determination on the application and does the application organization and format facilitate efficient NRC staff reviews
- Application novelty – does the application contain any novel technical or policy issues NRC staff will need to resolve through technical discussions or Commission input before making a safety determination on the application
- Applicant engagement with regulator – does the applicant engage effectively with the regulator to answer questions, provide additional information, and resolve licensing challenges during the application review process
- Regulator engagement with the applicant – is the regulator prepared to engage effectively with the applicant, actively reviewing submitted material and providing clear questions and requests for additional information (RAIs) with sound regulatory bases, and are they focused on attributes necessary to make safety findings
- Regulator familiarity with application – is the regulator familiar with the technology, application, and technical and policy issues important to the application or will the regulator need additional time and resources to develop familiarity during the review
- Regulator staffing availability – does the regulator have the necessary staff with the appropriate skills available to support the project at the required time
- Scope and depth of application review – does the regulator need to review every portion of an application or can portions of the application be excluded from review based on prior analyses or its minimal importance to safety
- Schedule and duration of prescriptive regulatory review processes – are there required regulatory review processes (e.g., mandatory hearings or a full EIS) with duration or scope impacts on the licensing process independent of the project- specific regulatory characteristics
- Efficiency of application review – does the regulator prioritize timeliness and efficient use of agency and applicant's time and resources

A number of these factors are under the control of the applicant (e.g., application quality and novelty, applicant engagement with the regulator, and regulator familiarity with the application through pre-application engagement), while other are largely based on the design and implementation of licensing processes (e.g., regulator staff availability and efficiency, scope of application review, and licensing review processes required by law or regulation).

These factors illustrate that while there are many factors an applicant can control, there are a number of key factors based solely on the regulatory process and implementation. As a result, the licensing process duration, cost, and variability depend both on factors beyond the applicants' control as well as applicant performance. Further analysis of these factors is critical to assessing how to reduce the average duration, staff effort, and review variability for licensing reviews.

1.3 Characterizing the NRC Licensing Process

Three main factors that can impact licensing duration, cost, and variability outside of applicant control are regulatory staff availability, scope of application review, and mandatory prescriptive review processes. Characterizing the specific impact of these factors on licensing (and subsequent identification of strategies to reduce or control licensing review duration, cost, and changes) requires a more detailed description of the licensing process.

The specific steps in the NRC licensing process can vary based on the choices applicants make regarding pre-application engagement, use of regulatory tools that reduce application risk or support faster licensing of standardized designs (available under either the Part 50 or Part 52 regulatory framework), and pursuit of an operating licensing under the 10 CFR Part 50 licensing framework (i.e., separate construction permit and operating license) vs. the 10 CFR Part 52 licensing framework (i.e., a combined license [COL]).

The general process for licensing a new nuclear power plant (applicable to either 10 CFR Part 50 or 10 CFR Part 52) consists of safety reviews, financial reviews, and environmental reviews that must be successfully completed before the Commission can issue a construction permit, operating license, or combined license. Each step in the licensing process will have different constraints on duration, cost, and staff requirements. A more detailed description of the component activities completed as part of the licensing process provides insights on the specific licensing factors that will impact the licensing duration and cost. Figure 2 shows a more detailed process diagram for licensing a new nuclear power plant.

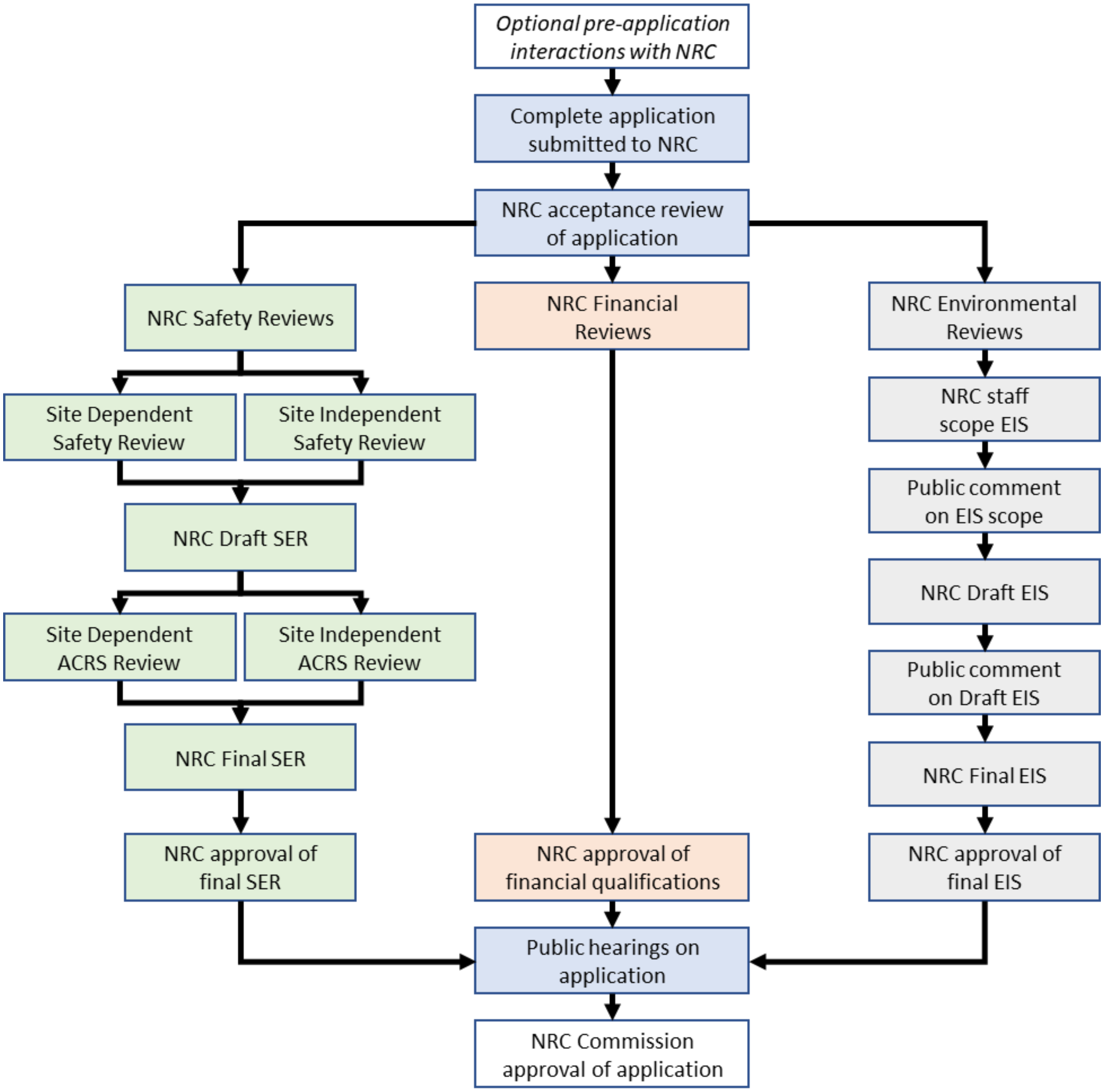

Figure 2. Expanded NRC licensing process for completing safety reviews and environmental reviews for new nuclear power plants[14]

[14] The separation of "Site Dependent" and "Site Independent" reviews in Figure 2 is intended to illustrate that there are portions of a safety review that could be performed independent of a specific site. For example, the safety reviews performed within the context of a Standard Design Certification approval are completed using an assumed site envelope. This characterization between "Site Dependent" and "Site Independent" is used in this report to highlight portions of a review that could be standardized across multiple applications to reduce staff effort and review duration. NRC's staff do not perform separate reviews for "Site Dependent" and "Site Independent" issues.

The process shown in Figure 2 provides several important insights into the licensing process:

1. The licensing process consists of multiple sets of activities completed in parallel and in series. While there are some interactions between the NRC teams completing the safety, financial, and environmental reviews, they can be generally treated as three independent review processes.
2. The safety, financial, and environmental reviews for a new reactor application can be characterized based on what aspects of the reviews will be site- or technology-specific and what aspects of the reviews can be generally applicable across applications. If reactor technology and designs are standardized, portions of the safety review will be identical for different applications of the reactor design but there will still be application- and site-specific issues for the safety, financial, and environmental reviews.
3. The environmental review process currently requires development of an environmental impact statement (EIS) that is both broad in scope and extremely detailed regardless of the expected environmental impacts of a specific project. This process is resource-intensive and time-intensive, and will be highly site- and technology-specific. Standardization of technology and designs will enable reductions in the duration and cost of some licensing activities, but the site-specific nature of environmental reviews under the existing framework will limit opportunities to reduce environmental review resource requirements or review duration.

These three insights can be used as the basis for creating a more efficient licensing and regulatory process for advanced reactors at the NRC that enables high volume licensing.

1.4 Characterizing Factors Limiting NRC Licensing Throughput

Developing a regulatory framework for effectively and efficiently reviewing the large number of new advanced reactor license applications that may be expected in the late 2030s requires a characterization of the factors that may limit the ability of the NRC to scale existing licensing processes to review and license large numbers of new reactors.

The number of licenses the NRC can issue on an annual basis can be described by the agency capacity (number of NRC staff reviewing applications and average work performed by each staff member), and the staff effort to review an application (average number of hours to review and approve a license application). Significantly increasing the number of licenses that the NRC can issue on an annual basis (enabling high volume licensing and deployment) in this conceptual model would thus require a combination of increasing NRC agency capacity or optimizing staff effort to complete an application review.

This simplistic throughput model, however, belies the fact that licensing activities are completed in both series and in parallel, and series process bottlenecks and unevenly scaled parallel review activities can limit the ability to scale the overall throughput of existing licensing processes.

Certain licensing processes shown in Figure 2 can be scaled by adding additional staff. For example, expanding the number of NRC staff teams available to perform safety reviews and develop the safety evaluation report (SER) for applications in parallel would increase the NRC licensing capacity. Other licensing processes cannot scale with additional staff. Reviews by the Advisory Committee on Reactor Safeguards (ACRS) cannot be scaled with additional NRC staff as ACRS reviews are currently completed independently by subcommittee and full committee reviews. As a result, the ACRS review could become a process bottleneck for NRC safety reviews (regardless of increases in NRC staff capacity), especially in subsequent applications of a technology already reviewed and approved by the ACRS and the NRC staff, unless corresponding changes were made to ACRS reviews to enable high volume licensing. This is one example of a potential series bottleneck in the existing licensing process.

Other licensing processes shown in Figure 2 could be scaled by reducing the duration or staff resources required to complete a review. For example, use of standardized reactor designs by applicants could enable portions of the safety review to be identical for different applications and reduce the scope of staff reviews to application- and site-specific safety questions. This could reduce both the duration and staff resources required to complete the safety reviews. The safety review, however, is just one of the major review activities that must be completed in parallel (along with the financial and environmental reviews) before NRC staff can finalize an application review the staff and Commission can complete statutorily required public hearings and adjudicatory procedures, and the Commission can consider the application for approval. As a result, if major reductions in duration and staff resources were achieved for the safety review but corresponding process improvements were not made to the environmental review, the overall NRC licensing throughput could be limited by the duration of the required environmental review processes. This is one example of a potential parallel bottleneck in the existing licensing process.

Identification, prioritization, and resolution of process bottlenecks, resource-intensive processes, and prescriptive regulatory processes is critical to enabling high volume licensing at the NRC. These limiting processes will inhibit the ability of the NRC to increase licensing throughput even if there are staff resource increases or process duration reductions for other important licensing review activities. Process improvements, operational improvements, and staff capacity increases are all critical to enabling the NRC to license large numbers of new reactors. An initial focus on process and operational improvements, however, is essential for regulatory reforms as it enables the NRC to create a more effective scalable process over time that can then be supported with additional staff as application volumes increase.

2. Proposals to Enable High Volume Licensing

Both the duration and capacity of the NRC to license new reactors under the current licensing process are currently dominated by three critical process steps:

1. Staff preparation and finalization of the safety evaluation report (SER), including reviews by the ACRS,
2. Staff preparation and finalization of the environmental impact statement (EIS)
3. Completion of the hearing process through a public hearing with the Commission

These three process steps have a combination of characteristics that inhibit high volume licensing:

- process bottlenecks: processes that cannot be easily scaled under the existing regulatory framework
- resource-intensive processes: processes that require significant staff effort and schedule to complete
- prescriptive processes: processes with regulatory or statutory requirements that mandate lengthy public comment periods or reviews without consideration of project-specific factors or regulatory intent

These three characteristics at each of the critical steps identified in the licensing process limit the ability of the NRC to scale the existing licensing process to review and approve tens or hundreds of new nuclear reactors per year.

New processes that still meet the regulatory intent of each of the three identified critical process steps of the licensing process while eliminating or reducing process bottlenecks, resource- intensive processes, or prescriptive processes can enable high volume licensing while still maintaining an effective regulatory process.

This paper proposes new regulatory strategies, processes, and requirements for each of the three critical process steps that can help resolve current challenges related to process bottlenecks, resource-intensive processes, and prescriptive processes.

> **Proposal 1: Increase the use of standardized applications for new reactors and leverage existing regulatory tools to minimize the scope of new or site-specific safety reviews performed by NRC staff and ACRS for new reactors using designs that have been previously licensed and operated.**
>
> **Proposal 2: Enable use of alternative environmental review processes that scale staff effort and public review based on the expected and demonstrated environmental impact of new reactor projects.**
>
> **Proposal 3: Enable the Commission to use less time- and resource-intensive oversight processes to complete the licensing review process based on the characteristics of each application and eliminate the requirement for the NRC mandatory hearing in Section 189a of Atomic Energy Act.**

Achieving high volume licensing by the NRC will require significant and sustained effort by applicants, NRC staff and management, the Commission, and other stakeholders. Modifying the licensing processes for safety reviews, environmental reviews, and adjudicatory processes (i.e., the mandatory hearing) can significantly increase the NRC's ability to review large numbers of new reactor applications effectively and efficiently without impacting the quality of the review, transparency of the review process, or opportunities for the public to provide meaningful input.

These changes to the licensing process must also be accompanied by applicant efforts to ensure high quality new reactor applications and interactions with NRC staff, industry alignment on standardized designs and analyses, and effective regulatory strategies to maximize the use of existing regulatory processes and pathways that enable the standardized review and approval of reactor designs or reactor sites. These changes by both NRC and applicants can create the conditions for success for high volume licensing and widescale deployment of advanced nuclear energy.

3. Standardizing Safety Bases and Reviews for New Reactors

The first proposal is to use standardized safety and technical applications for new reactors and leverage existing regulatory tools to minimize the scope of new or site-specific safety reviews performed for new reactors using designs that have previously been licensed and operated.

3.1 Existing Standardized Reactor Design Licensing Pathways

The safety review for a new reactor application is essential to NRC regulatory activities. The review process requires a technical evaluation of the nuclear reactor to ensure compliance with regulations and includes both site-independent and site-specific issues. The NRC's internal guidance for the review of applicant safety analysis reports (NUREG-0800[15]) provides insights on the topics the NRC expects to cover during the safety review of a new reactor application (titles of NUREG-0800 Chapters 2 through 19):

- Site Characteristics and Site Parameters
- Design of Structures, Components, Equipment, and Systems
- Reactor
- Reactor Coolant System and Connected Systems
- Engineered Safety Features
- Instrumentation and Controls
- Electric Power
- Auxiliary Systems
- Steam and Power Conversion System
- Radioactive Waste Management
- Radiation Protection
- Conduct of Operations
- Initial Test Program and Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)-Design Certification
- Transient and Accident Analysis
- Technical Specifications
- Quality Assurance
- Human Factors Engineering
- Severe Accidents

The only topic considered by NRC staff guidance during safety reviews that is inherently site-specific is "Site Characteristics and Site Parameters" (Chapter 2 of NUREG-0800). Other topics may have site-specific considerations (such as impact of site characteristics on the design of structures, components, equipment, and systems), but these topics could be developed and presented in a site-independent manner. The development and use of a site-independent safety analysis to support licensing could enable more effective staff evaluation of new reactor applications by leveraging a one-time detailed staff review of a site-independent safety analysis to support subsequent applications.

[15] NUREG-0800 "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants"

Use of standardized site-independent safety analysis to support new reactor licensing has been a goal of both industry and regulators for over 50 years[16]. Nuclear reactors are sufficiently complex engineering systems that use of a generic site-independent safety analysis for all nuclear technologies is infeasible but development of a generic site-independent safety analysis for a specific *standardized* reactor design is possible.

Standardized reactor designs have benefits for licensing, construction, and operation. Use of a standardized design reduces the engineering costs associated with project-specific design and engineering, enables learning-by-doing on repeated manufacturing and construction processes, and allows the regulator to leverage prior regulatory evaluations in subsequent licensing reviews. These potential benefits have been recognized by the nuclear industry for decades, but the industry has struggled to realize this potential in practice. The NRC, however, has created processes intended to support the more efficient licensing of standardized reactors. Specifically, 10 CFR Part 52 contains optional regulatory pathways that facilitate the review and approval of a reactor design for use in multiple subsequent license applications. The main regulatory pathways available are:

- Standard Design Certification (SDC) – 10 CFR Part 52, Subpart B
- Standard Design Approvals (SDA) – 10 CFR Part 52, Subpart E

These tools allow an applicant to submit a reactor design (for SDC) or a major portion of a reactor design (for SDA) to the NRC for review or approval. For each regulatory pathway, the NRC staff reviews safety information (final safety analysis report and environmental report for SDC and safety analysis report for major portions for SDA) associated with the standardized design application. These regulatory reviews by NRC staff and the ACRS become the basis for the NRC to issue an SDC or SDA for the specific standardized design submitted by the applicant.

The SDC and SDA are significant because they provide for a one-time, detailed regulatory review of a design (or major portion thereof[17]) that must be used by NRC staff to support subsequent licensing actions. This enables applicants to reference a SDC or SDA in their plant-specific application and the NRC will incorporate, by reference, the decisions and findings made during the SDC or SDA process. This has the potential to reduce the scope of the safety review for a new nuclear power plant license referencing the SDC or SDA and reduce the total staff effort required to complete the safety review process. A new nuclear power plant license application referencing an SDC or SDA should take significantly less time and resources to review, and should enable NRC staff to review a much smaller scope of site-specific issues and to ensure the generic site-specific conditions assumed in the SDC or SDA are appropriate for the specific site.

Standardized reactor applications have also been proposed as a method to reduce the applicant and staff effort required to license standardized designs.[18] A voluntary, industry-led design center working group[19] composed of applicants expecting to submit a standardized COL referencing a SDC would designate one COL application as the "reference combined license" (R-COL). This R-COL would specify what sections of

[16] Trosten and Moore, "Nuclear Power Plant Standardization: Promises and Pitfalls"

[17] Clarifying "Major Portions" of a Reactor Design in Support of a Standard Design Approval

[18] Regulatory Guide 1.206, Revision 1 "Applicants for Nuclear Power Plants"

[19] Design center working groups (DCWGs) are voluntary working groups composed of reactor developers, potential owners and operators, and other industry stakeholders that collaboratively participate on the development of standardized designs and applications for a specific reactor design. DCWGs were previously developed for advanced large light water reactor designs including the AP1000, EPR, US-APWR, ABWR, and ESBWR.

the application would be standardized for all subsequent applications and what sections would discuss site-specific application details. These "subsequent combined license" (S-COL) applications would reuse the standardized portions of the R-COL and justify the applicability of these standardized sections for the subsequent application. Citation of prior applicant and staff positions on the R-COL was intended to reduce the effort required by both applicants and staff to prepare and review the standardized portions of an application.[20] The R-COL and S-COL process, however, does not provide formal regulatory finality by rule (like the SDC or SDA) and NRC staff are still required to evaluate each S-COL in full and cannot formally incorporate the R-COL by reference.

3.2 Previous Challenges with Standardized Licensing Pathways

Industry has previously used SDCs to support licensing of advanced large light water reactors (most notably the AP1000 for Vogtle Units 3 and 4), but has faced challenges realizing the licensing process efficiency gains that were expected with standardizing a reactor design and incorporating large portions of the safety evaluation by reference. Lessons learned reviews by both the NRC[21] and industry provide some insights into why reactor standardization processes thus far have not significantly improved the licensing review process. Factors relevant to the safety review process attributable to both NRC and industry include:

- Application quality and availability of information to support NRC staff reviews
- Staff and applicant inexperience with the 10 CFR Part 52 licensing process and inadequate guidance
- Incomplete design for the standardized plant and subsequent SDC revisions and changes
- Parallel applicant preparation and NRC review activities across multiple separate applications that did not enable staff or applicant "learning-by-doing"
- Inefficient processes for resolving technical issues common across multiple applications

While initial licensing for standardized advanced large light water reactors should have seen improvements in the licensing process duration, there were many "first-of-a-kind" challenges. This includes a changing "standardized design" that had not yet been built and was undergoing multiple rounds of design changes, applications that did not reflect a complete understanding of either the plant design or the NRC expectations for applications, and a novel regulatory process that was challenging for both applicants and NRC staff to navigate. For example, the AP1000 reactors constructed at Vogtle had numerous site-specific modifications and changes requiring additional NRC staff review.[22] The designs and their safety bases were not actually standardized for this first generation of advanced large light water reactors and the benefits of design standardization were not fully realized.

Later reviews of the advanced large light water reactors did see improvement in the time required to complete the safety review. For example, the formal review schedule for the AP1000 reactors licensed for the Vogtle site (the first AP1000 to receive a COL) was issued in 2008 and the final safety evaluation report (SER) for the project was completed in under 38 months.[23] The formal review schedule for the AP1000 reactors proposed for the Turkey Point site (the most recent AP1000 to receive a COL) was issued in 2015

[20] Regulatory Guide 1.206, Revision 1 "Applicants for Nuclear Power Plants"
[21] NRC New Reactor Licensing Process Lessons Learned Report
[22] Issued Amendments List Vogtle Electric Generating Plant, Unit 4
[23] Vogtle, Units 3 & 4 Application Review Schedule

and the final SER for the project was completed in under 13 months.[24] A significant number of factors contribute to the reduction in the time required to complete the safety analysis (including engagement between the NRC and the Turkey Point applicant before the formal review schedule was issued in 2015), but a more formalized standardized design and improvements to applicant and industry application preparation and review practices were critical to reducing the time associated with safety reviews of a standardized AP1000 reactor design.

Applicant use of the R-COL and S-COL to streamline the review of advanced large light water reactors also encountered challenges. The R-COL for a standardized application and design was typically based on the COL application that was closest to completion in the review process. As projects encountered review issues or as applicants suspended or withdrew their COL applications for a variety of commercial reasons, however, the applicants and the NRC began to designate new R-COLs for designs. For example, Bellefonte Units 3 and 4 were intended as the R-COL for the AP1000 but encountered challenges related to site specific hydrology and geology data so the R-COL designation was transferred to Vogtle Units 3 and 4.[25] The R-COL designation for the ESBWR was transferred multiple times as different applicants suspended or withdrew their application reviews.[26] While the R-COL and S-COL process did appear to provide benefits to applicants in terms of review duration and resolution of technical issues, the simultaneous review of the R-COL and S-COL (and changing R-COL designations) may have limited the realization of licensing schedule and effort gains from the use of a standardized application.[27]

3.3 Standardized Reactor Design Licensing Pathways in 10 CFR Part 50

The standardized reactor design licensing pathways in 10 CFR Part 52 (SDC and SDA) are typically understood as the only pathways for leveraging reactor standardization to reduce the schedule and scope of reactor safety and technical reviews for new nuclear power plants. There is an additional pathway, however, available in 10 CFR Part 50 that enables applicants to incorporate prior safety analysis reports into subsequent applications.

10 CFR Part 50 Appendix N ("Standardization of Nuclear Power Plant Designs: Permits To Construct and Licenses To Operate Nuclear Power Reactors of Identical Design at Multiple Sites") allows applicants to construct and operate "nuclear power reactors of essentially the same design" at multiple sites.[28] These applications, completed using the 2-step construction permit and operating licensing pathway in 10 CFR Part 50, can reference a single safety analysis report and justify use of a single set of site parameters applicable to multiple sites.

The standardized reactor design licensing pathways in 10 CFR Part 50 Appendix N has not yet been used by an applicant to support licensing of a new nuclear power plant but is an additional available standardization tool, especially for applicants choosing to use 10 CFR Part 50 for new reactor licensing.

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[24] Turkey Point, Units 6 & 7 Application Review Schedule
[25] "Renaissance Watch", Nuclear News, August 2009
[26] "Renaissance Watch", Nuclear News, June 2013
[27] Nuclear Power 2010 Program Lessons Learned Report on the Combined Construction and Operating License/Design Certification Demonstration Projects
[28] 10 CFR 50 Appendix N—Standardization Of Nuclear Power Plant Designs: Permits To Construct And Licenses To Operate Nuclear Power Reactors Of Identical Design At Multiple Sites

This yet-unused pathway would reduce the scope and time associated with site-independent safety and technical reviews and could enable a single safety analysis report to satisfy regulatory requirements for multiple standardized plants without the need to complete the SDC or SDA regulatory processes.

3.4 Proposal for Improving Standardized Safety and Technical Reviews

Use of a standardized safety and technical review can minimize the scope of new or site-specific safety reviews performed for new reactors with designs that have previously been licensed and operated. This, however, requires both applicants and the NRC to effectively utilize best practices and existing processes to minimize repeated safety and technical reviews across multiple applications.

3.4.1 Recommendations for Applicants and Industry

High volume licensing will only be possible if the industry can effectively standardize both advanced reactor designs and the safety and technical analyses submitted to NRC staff in new nuclear power plant applications.

Effectively utilizing any of the existing pathways for reactor standardization to reduce the duration of the review as well as reduce the applicant and NRC staff effort associated with safety evaluations requires a highly standardized design that does not change between iterations. Design iterations between an initial SDC or SDA approval and a subsequent application referencing the SDC or SDA, or design iterations between applications, will require additional NRC staff review. While these additional reviews can be minimized by NRC staff and management during the review, even small design changes may require additional reviews by NRC staff to ensure findings from their initial safety and technical analyses are still applicable.

Ensuring reactor standardization requires industry to both focus on standardizing proven and constructed designs, and limiting project or site-specific changes that could result in additional safety reviews.

Standardization of a final design is critical to efficient reviews of subsequent applications. While the AP1000 was an evolutionary LWR design, its design was not finalized when the SDC was completed, and the AP1000 design changes continued throughout the licensing and construction process based on lessons learned and insights from field construction. These changes required additional revisions to NRC staff safety reviews, resulting in an extended review schedule and additional NRC staff time (paid for by additional licensing review fees charged to applicants). Multiple revisions during construction on a supposedly “standardized design” limited the benefits of using a standardized design to reduce the time and effort required to complete the technical and safety evaluations. Industry and applicants should not “lock in” a standardized design through processes such as the SDC or SDA until the full design is completed and there is sufficient construction and operating experience to confirm additional critical design changes will not be needed for subsequent deployment. This strategy of design and licensing discipline will prevent licensing rework, resulting in a more effective and efficient licensing process.

The reactor standardization processes available in 10 CFR Part 50 Appendix N could be an effective strategy to allow for the earlier licensing of nearly compete standardized designs without requiring the finality of an SDC or SDA. This could enable the phased deployment of small numbers of nuclear power reactors of essentially the same design at multiple sites using 10 CFR Part 50 (allowing for changes during construction across all sites) as the advanced reactor developer optimizes the design over several iteration cycles. This would allow gradual learning-by-doing as applicants complete and optimize designs based on construction and operation lessons learned, ultimately culminating in a standardized plant design that could receive a SDC or SDA for wide-scale deployment licensed using 10 CFR Part 52. This enables near-term benefits associated with reactor standardization without requiring the high level of design finality associated with a fully mature design and enables a transition over time to a fully standardized reactor design that can maximally benefit from reductions in licensing duration and effort.

Industry must also commit to minimizing or avoiding project or site-specific changes that could result in additional safety reviews. These site-specific changes are often driven by either customer needs or site-specific geographic features (e.g., hydrologic, geologic, seismologic conditions) that affect the plant operations or design conditions. While these "bespoke" plants may more directly satisfy customer needs, they will require additional NRC staff reviews to justify differences between a standardized design and the site-specific design, introducing additional opportunities for licensing delays or demands on staff resources. Use of a broad set of generic site parameters for a standardized design can allow the reactor to be easily licensed at many sites without the need for additional safety analysis or site-specific design modifications.[29] Designing a standardized reactor for a broad set of generic site parameters can, however, result in a more costly design due to the incorporation of an additional design margin to accommodate a wide range of sites.[30] Use of innovative design approaches such as a seismic isolation technology[31] should be reviewed to determine whether they can lower the costs for a standardized design applicable to a wide range of sites.

Industry can also examine opportunities to leverage the NRC approval of a standardized design of a "major portion" of a nuclear power plant more effectively using the SDA pathway in 10 CFR Part 52. Prior NIA reports have highlighted the potential to use SDAs to facilitate the separate licensing of major portions of traditional nuclear power plants (e.g., nuclear steam supply system [NSSS] and balance of plant [BoP] systems).[32] Licensing of major portions could also apply to advanced reactors supplying heat for industrial processes, provide thermal energy storage to support flexible BoP operations, or produce low-carbon fuels such as hydrogen or ammonia.

Licensing of these standardized "major portions" of an advanced reactor under an SDA as commercially available systems would enable the NRC staff to complete a single safety review for these systems rather

[29] Generic site parameters are an envelope of bounding specific site conditions (e.g., hydrologic, geologic, seismologic conditions) that can be analyzed in advance as part of a standardized design process. If site-specific conditions are fully bounded by the analyzed conditions, it would not be necessary to perform additional site-specific analysis for each reactor application. Use of broader generic site parameters may increase the design loads and require additional initial design margin, increasing the capital cost of the plant. This increased capital cost could be compared against the efficiencies gained in the siting and licensing process for new sites.

[30] MIT Report "The Future of Nuclear Energy in a Carbon-Constrained World"

[31] Seismic isolation systems reduce the localized seismic loads from earthquakes on nuclear power plant systems, structures, and components. These reduced seismic loads could eliminate the need for site-specific seismic evaluations on plant systems and enable the use of standardized seismic design conditions and design features for multiple nuclear power plant sites.

[32] Clarifying "Major Portions" of a Reactor Design in Support of a Standard Design Approval

than reviewing them on each application. If the boundary conditions[33] for these SDAs properly account for system interactions, multiple SDAs could be referenced together in an application to create a new composite standardized design based on existing safety evaluations that together meet a specific customer's needs. For example, an applicant could reference separate SDAs for a nuclear heat source and an integrated process heat desalination facility – thus enabling customer-specific configurations while minimizing additional licensing reviews for a technology. This process could facilitate high volume licensing for a wider range of standardized designs to meet customer needs but requires careful consideration of the SDA boundary conditions and safety analysis to enable NRC staff review and approval without additional safety and technical reviews.

Use of the R-COL and S-COL methodology can help facilitate high volume licensing, but effective use of these tools requires industry alignment on the submission and complete review of a high-quality R-COL that effectively delineates standardized and site-specific portions of a COL application. Industry experience with the R-COL in the 2000s for advanced large light water reactors highlighted how the use of an R-COL can reduce the review duration and effort for an S-COL but simultaneous review of the R-COL and S-COL limits these benefits. Industry focus on identifying and completing a R-COL review before submitting S-COL applications can help ensure that S-COL fully incorporates lessons learned and best practices gained from the R-COL review. Increasing the review process predictability for the applicant and NRC staff helps enable high volume licensing, especially for large numbers of simultaneous application reviews.

Finally, applicants and industry must promote and utilize best practices for application preparation and interactions with NRC staff and management to benefit from the process improvements associated with standardized reactor design and safety reviews. Effective use of pre-application engagement by applicants supports the development and submission of applications NRC staff can effectively and efficiently review to prepare their SER. Engaging NRC staff from the start of the reactor design development process will help the NRC staff have a better understanding of the reactor, making the review process smooth and efficient.

Submission of complete, high-quality applications is critical to reducing or eliminating NRC staff requests for supplementary or additional information that are both resource and schedule intensive. Pre-engagement activities also help the applicant learn about NRC staff's expectations regarding the necessary information that the application must contain for an efficient review. Use of high-quality standardized applications (created by industry) for standardized reactor designs and submitted to the NRC for review could help reduce burden on applicants (limiting development of site- specific application materials) and provide predictability for NRC staff reviewers (enabling review of a smaller number of well characterized applications). Finally, proactive and continuous communication with NRC staff and management is important to ensuring alignment on key technical and policy issues and reaching a timely resolution on licensing questions. Without use of these and other best practices for licensing, it will be extremely challenging to achieve the resource and schedule improvements in safety and technical evaluations needed to enable high volume licensing.

[33] Boundary conditions refer to the assumed physical and operational conditions for each major portion of the SDA. This may include ranges of operating conditions (e.g., mass flow rates and temperatures), physical configurations (e.g., connections to other systems), and system behavior (e.g., transient system operating behavior).

3.4.2 Recommendations for NRC Staff and Management

Efficient safety and technical analyses by NRC staff of standardized reactor designs requires effective project management, regulatory discipline, and minimizing opportunities for process bottlenecks.

High volume licensing requires applicant submittal of complete, high-quality safety analyses that enable NRC staff reviews as well as NRC staff who can effectively review applications and minimize or eliminate duplicative safety and technical reviews. Applicants must also leverage standardized designs and regulatory processes (including SDCs, SDAs, and common safety evaluations permitted by 10 CFR Part 50 Appendix N) and regulatory guidance to enable NRC staff to maximize use of previous site-independent safety evaluations and focus NRC staff on reviewing a much smaller portion of site-specific safety characteristics as compared with previous new nuclear reactor reviews. These standardized regulatory processes will only yield schedule and effort improvements if NRC staff are able to leverage prior safety evaluations to complete subsequent licensing reviews.

An effective regulatory process requires both effective NRC project management and regulatory discipline to ensure NRC staff do not perform extraneous reviews. While NRC staff should always maintain a "questioning attitude"[34] as part of a strong nuclear safety culture, they must avoid reanalyzing or reopening prior licensing decisions unless there are changes or significant new information that could challenge them. Discussions with prior applicants have suggested that changes in NRC reviewers or management can contribute to a reopening or reanalysis of technical topics that had been informally (or even formally) previously reviewed and closed by NRC staff. NRC staff must be willing to "trust but verify" prior regulatory assessments based on an understanding and trust of the regulatory process controls in place to ensure the accuracy and completeness of all NRC decisions.

Effective project management and clear direction from NRC mid-level and senior management is needed to help provide an expectation that regulatory decisions with regulatory finality (e.g., SDA and SDC) should not be reevaluated unless a standard such as "significant new information that substantially affects the earlier determination or other good cause"[35] is provided to support additional regulatory reviews. This process may require NRC project managers and NRC management to work closely with NRC staff that are focused on specific technical topics, and be willing to push back or overrule regulatory reviews that do not have an adequate regulatory basis. There must be a strong regulatory basis for any required details provided in applications. The NRC staff and management should not simply base requirements on the regulatory precedent set by previous applicants – especially in cases where the regulatory precedent has limited to no applicability to the current application.

A clear understanding across the NRC on application content, regulatory requirements, and review processes is critical to developing alignment on the technical bases needed for the effective use of standardized design approvals, certifications, and applications for new reactor licensing activities.

[34] The NRC (NUREG-2165 "Safety Culture Common Language") defines a "questioning attitude" as "avoid[ing] complacency and continuously challeng[ing] existing conditions and activities in order to identify discrepancies that might result in error or inappropriate action."
[35] 10 CFR 52.145 Finality Of Standard Design Approvals; Information Requests

Additionally, while the ACRS plays an important role in the licensing process[36], it should not be allowed to become a process bottleneck in cases where the ACRS has already reviewed safety-relevant portions of a standardized reactor design and additional review by the ACRS is unlikely to yield additional safety insights. The ACRS risks becoming a process bottleneck for high volume licensing due, in part, to the statutory organization of the committee. The ACRS has a limited number of expert members (no more than 15), ACRS members work on a part-time basis (typically limited to half time), ACRS members only meet 10 times per year as a full committee, and all ACRS reports are written on a consensus basis by members.[37] The ACRS is currently tasked with reviewing and reporting on all safety studies associated with new reactor applications in addition to other statutory tasks related to review of proposed safety standards and other technical issues important to nuclear safety. ACRS currently manages the review of new reactor applications in parallel with its other statutory tasks, but a growing workload poses scheduling challenges. If the number of new reactor license applications were to increase from 1 – 2 applications per year to tens or hundreds of applications per year, the ACRS could not complete the required reviews using existing processes as currently implemented.

ACRS must maintain an important role in the licensing process, but the reactor standardization required for high volume licensing provides an opportunity to refocus the efforts of ACRS on issues most important to safety. The ACRS should continue to take an active role in reviewing the Safety Evaluation Reports (SER) and supporting application materials associated with first-of-a-kind nuclear reactors, initial review of standardized reactor designs, and other applications with novel or safety-significant issues so it can provide independent advice to the Commission through public letter reports.[38] The ACRS, however, should not be tasked to review of applications referencing standardized reactor designs that have already received detailed review by NRC staff, the ACRS, and the Commission on any new issues important to safety.

For new reactor applications where no new safety-significant issues exist, NRC staff and the ARCS should evaluate whether additional reviews are warranted. For example, the NRC staff could provide recommendations to the Commission (upon completing its draft safety review) on whether detailed ARCS reviews would contribute to a safety finding. If an ACRS review is recommended by NRC staff, the ACRS should consider an expedited review that incorporates by reference prior ACRS findings on issues and provides a concise explanation of why additional reviews by ACRS are not warranted. When multiple applications reference the same standardized design, a single letter report could be used by ACRS to consolidate multiple applications into a single expedited review. This would maximize the use of ACRS resources while still maintaining their statutory role to provide independent advice to the Commission. As discussed in NIA's report on ACRS,[39] alternative proposals for reforming the role of ACRS through legislative or Commission direction should consider how the expedited review of previously evaluated standardized designs can be incorporate into future ACRS processes and procedures.

3.4.3 Conclusions on Improving Standardized Safety and Technical Reviews

Safety and technical reviews of new reactor applications are a critical process step that could limit the ability of the NRC to license large numbers of new nuclear power plants. The recommendations in this

[36] NIA Report on Improving the Effectiveness and Efficiency of the Advisory Committee on Reactor Safeguards
[37] 2022 FACA Charter Renewal for the Advisory Committee on Reactor Safeguards
[38] NIA Report on Improving the Effectiveness and Efficiency of the Advisory Committee on Reactor Safeguards
[39] NIA Report on Improving the Effectiveness and Efficiency of the Advisory Committee on Reactor Safeguards

section for applicants and NRC focus on leveraging standardized reactor designs to reduce the duration and effort required to complete safety and technical reviews. High-quality standardized applications can enable NRC staff to focus on a small number of site-specific licensing issues and limit their review for subsequent applications when prior regulatory reviews have fully evaluated the safety and technical basis for the standardized design. Ensuring effective review by NRC staff though regulatory discipline and effective project management can help maximize the impact of standardized applications on licensing durations. Reconsidering the focus of ACRS when reviewing subsequent standardized reactor applications can reduce the likelihood of ACRS becoming a process bottleneck while still ensuring they can fulfill their intended role. These recommendations for both applicants and NRC will help resolve current challenges related to process bottlenecks and resource-intensive processes as part of the safety and technical reviews of new nuclear power plants.

4. Use of Scalable Environmental Review Processes for Advanced Reactors

The second proposal is the use of new environmental review processes that scale NRC staff effort based on the expected and demonstrated environmental impact of a new reactor project to reduce process bottlenecks, resource-intensive processes, and prescriptive regulatory processes.

It is important to note this paper focuses only on the environmental reviews completed by the NRC that are required by the National Environmental Policy Act (NEPA). It does not include other federal environmental legislation and reviews (e.g., National Pollutant Discharge Elimination System, Resource Conservation and Recovery Act) or local and state environmental reviews and permits (e.g., state implementation of the National Emission Standards for Hazardous Air Pollutants and state and local water quality use permits). These requirements are outside the scope of the NRC licensing process and were not evaluated to determine their impact on high volume licensing at the NRC. The ability of these other environmental review processes to scale to enable deployment of large numbers of new nuclear reactors is important to creating the conditions for success for advanced nuclear energy as a climate solution but would require evaluation of a much larger number of federal, state, and local agencies and processes. The cumulative effect of these additional environmental review and permitting processes should be evaluated as part of follow-up work on high volume licensing.

4.1 Federal Environmental Review Requirements under NEPA

Environmental reviews for nuclear power plants are required under the National Environmental Policy Act (NEPA). NEPA requires that all "major federal actions" be assessed to determine the impact of the action on the human environment. Different levels of review may be performed to satisfy NEPA requirements depending on the expected environmental impacts of the proposed activity. It is important to note that NEPA is a process-based law and that there are no quantitative regulatory requirements associated with it; instead, the different levels under NEPA relate to the scope and detail of the analysis of the proposed action that must be completed to provide adequate assessment of the potential environmental impacts.

In each case, it is up to the lead agency responsible for the federal action to conduct the environmental review process and prepare the report documenting the process, results, and conclusions.[40] In some cases, an agency can have the applicant or an authorized contractor prepare the environmental review under the supervision of the agency. This can help reduce the resources required by the agency to complete the NEPA review process, but the agency must independently evaluate and take responsibility for the content of the prepared review documents.[41]

The first level of NEPA assessment is a categorial exclusion (CATEX).[42] Specific major federal actions may be "categorically excluded" from more detailed NEPA reviews if an agency demonstrates that the individual and cumulative effects of the activity on the environment will not be significant.[43] These activities are not subject to additional environmental review, but substantial justification and rulemaking is required before an activity can be defined as "categorically excluded" from future reviews.

The second level of NEPA assessment is an environmental assessment (EA).[44] An EA provides a brief description of the purpose and need for the proposed action, a description of reasonable alternative actions, and an assessment of the environmental impacts of the proposed action and possible alternatives.[45] These reports are generally limited in scope and are based on prior agency experience with the activity. Based on the results of the EA, an agency can either issue a "Finding of No Significant Impact" (FONSI) or require a more detailed assessment of possible environmental impacts.

An agency will issue a FONSI if they find the proposed action will not have any significant impact on the human environment. The FONSI will document the basis for the finding and provide a justification for concluding the NEPA review process.[46] If the agency finds the proposed action will have significant impacts on the human environment or if the impacts on the human environment cannot be conclusively determined, then the agency will prepare a more detailed environmental assessment – an environmental impact statement.

The environmental impact statement (EIS) is the third and most detailed level of NEPA assessment. An EIS provides a detailed description of the purpose and need for the proposed action, a description of reasonable alternative actions, and a detailed and rigorous assessment of the environmental impacts of a proposed action and the reasonable alternatives. It will also evaluate, when necessary, additional options to mitigate or reduce the environmental impacts of the proposed action.

An EIS is much wider in scope and deeper in depth than an EA. It requires significantly more time and resources to prepare and complete, mandates greater consultation with other agencies, governments, and stakeholders, and must explore the reasonably foreseeable environmental consequences associated with the proposed action. It is important to note there are no statutory requirements on how the results of an EIS affect the decision to proceed or halt a proposed federal action – it is instead up to the agency to decide how to evaluate the implications of the EIS.

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[40] A Citizen's Guide to NEPA
[41] 40 CFR 1506.5 - Agency responsibility for environmental documents
[42] 10 CFR 51.22 - Criterion for categorical exclusion
[43] National Environmental Policy Act At The NRC
[44] 10 CFR 51.21 - Criteria for and identification of licensing and regulatory actions requiring EAs
[45] National Environmental Policy Act Review Process at EPA
[46] National Environmental Policy Act At The NRC

Historically, the duration and effort associated with an EA and EIS (along with the length of the published recommendations) were the purview of the implementing agency, subject to litigation as to whether it was adequately meeting the intent of NEPA. The Fiscal Responsibility Act of 2023, however, made several important reforms to NEPA and added new requirements for the implementation of NEPA reviews. Specific reforms relevant to nuclear reactor licensing by the NRC included[47]:

- EAs have to be completed within 1 year and have a 75-page limit for the main report (excluding appendices and supporting documents)
- EISs have to be completed within 2 years and generally have a 150-page limit for the main report and up to 300 pages for EISs of "extraordinary complexity" (excluding appendices and supporting documents)
- If an agency fails to complete the EA or EIS review within the required timeframe, an applicant may petition a court to compel the agency to complete the review process
- All agencies may now authorize an applicant or its contractor to prepare an EA or EIS under the supervision of the agency. The agency is still required to independently evaluate the EA or EIS and validate its finding before publication.

These are major changes to the NEPA process. The goal of NEPA reform across the federal government is to reduce the duration and effort associated with environmental reviews while still meeting the law's original intent of public assessment of impacts of major federal actions on the human environment.

4.2 Current Environmental Review Requirements for Nuclear Power Plants

The NRC is the lead agency for implementation of NEPA for nuclear power plants. By regulation, all permits and licenses to construct and operate a nuclear power reactor require a complete EIS to satisfy the statutory requirements in NEPA.[48] Other NRC actions (such as nuclear materials licenses) may meet the NEPA requirements based on an EA or a CATEX, but any nuclear power reactor or testing facility licensed under 10 CFR Part 50 or 10 CFR Part 52 requires an EIS for construction and operation. These requirements apply regardless of the size of the reactor, the reactor technology, or the proposed use case for the facility. These prescriptive regulatory requirements reflect the historical implementation of NEPA by both the NRC and the Atomic Energy Commission (AEC), the predecessor of the NRC.

The initial implementation of NEPA by the AEC was the subject of a landmark U.S. Supreme Court case that set legal precedent for how any federal agencies would be required to implement the NEPA process. The AEC interpreted the NEPA requirements in December 1970 following the NEPA's passage in December 1969, and promulgated limited rules that largely leveraged the existing AEC environmental review processes. The AEC believed additional environmental reviews were not warranted and would limit the agency's ability to focus on nuclear safety issues, both stretching staff resources and increasing the duration of the licensing process.[49] The AEC's implementation of NEPA was challenged in 1971 and the federal DC Circuit Court of Appeals found in *Calvert Cliffs' Coordinated Committee v. Atomic Energy Commission* that the AEC had failed to properly implement NEPA and that the AEC's environmental review

[47] Debt Ceiling Legislation Includes First NEPA Reform in Over 50 Years
[48] 10 CFR 51.22(a) "Criterion For Categorical Exclusion"
[49] J. Samuel Walker and Thomas R. Wellock, "A Short History of Nuclear Regulation, 1946–2009"

process made “a mockery of the Act”.[50] The Court said that the AEC implementation overly relied on existing environmental certifications and review processes by states and other organizations, and that the AEC was required to implement a new, comprehensive process that carried out environmental review “to the fullest extent possible” to meet the NEPA statutory requirements.[51]

The AEC revised the NEPA implementation requirements to comply with the ruling and promulgated the new environmental review requirements in 10 CFR Part 50 Appendix D in September 1971.[52] These new regulations required “a detailed statement” for any application to construct or operate a nuclear power reactor. The environmental review regulations were revised in 1973, moving the requirements for preparation and review of an environmental impact statement into a newly created 10 CFR Part 51.[53] The provisions requiring an EIS for all nuclear power reactors in 10 CFR Part 51 were retained by the NRC in January 1975 following establishment of the NRC by the Energy Reorganization Act of 1974.[54]

It is important to note that federal agencies did not have regulatory direction to utilize environmental assessments and categorical exemptions until the federal office responsible for NEPA implementation (Council on Environmental Quality [CEQ]) promulgated regulations on NEPA implementation procedures in 1978.[55] When the NRC revised 10 CFR Part 51 in 1980 to voluntarily align with the new CEQ guidance, the NRC incorporated the use of EA and CATEX in certain circumstances into NRC regulation.[56] The NRC noted in both the Federal Register notice in the final rule[57] and in a public meeting discussing implementation of the CEQ guidance that the requirement to complete an EIS for nuclear power reactors was largely based on previous experience with NEPA reviews for large, light water reactors in the wake of the 1971 Calvert Cliffs decision.[58] These plants could have significant environmental effects and were subject to significant public scrutiny, so requiring an EIS was considered appropriate for licensing. This requirement for the use of EISs for nuclear reactor environmental reviews was fully promulgated in 1980 and remains unchanged to this day.

The requirement to develop an EIS for new nuclear power plants can require significant time and staff effort. For example, the EIS for the combined license for the AP1000 reactors at Vogtle 3 and 4 took nearly 3 years to complete and required a supplemental environmental impact statement of 568 pages[59] – in addition to the 2 years of review required to complete the 644-page EIS for the Vogtle 3 and 4 early site permit.[60]

One potential way to shorten the EIS development process for new reactors is through the use of a generic environmental impact statement (GEIS). A GEIS for new reactor licensing is developed by NRC staff using a public guidance development process that results in an NRC regulatory guide (NUREG) documenting the expected environmental impacts for a generic new reactor licensing activity. A GEIS requires significant

[50] 449 F.2d 1109 (D.C. Cir. 1971), cert. denied, 404 U.S. 942 (1972)
[51] DOE Summary of Major Cases Interpreting NEPA
[52] 36 FR 18060
[53] 38 FR 30203
[54] 45 FR 13737
[55] 43 FR 25217
[56] 45 FR 13737
[57] 49 FR 9333
[58] NRC Public Meeting Briefing On SECY-79-473 - CEQ-NEPA Regulations
[59] Final Supplemental Environmental Impact Statement for COL Vogtle Units 3 and 4
[60] Final Environmental Impact Statement for ESP Vogtle Units 3 and 4

upfront investment of staff time and resources but can shorten the duration of subsequent licensing activities by enabling staff to avoid repeated review of identical activities. Instead, staff leverage the GEIS for the specific activity and then prepare a supplemental EIS providing information on site-specific characteristics or characteristics that differ from those considered in the GEIS. A GEIS has been used since 1976 by the NRC for several major licensing actions,[61] most notably to support license renewal actions at existing operating nuclear power plants.[62]

The NRC staff began the development process for an advanced nuclear reactor generic environmental impact statement (AR GEIS) in 2019 based, in part, on Congressional passage of the Nuclear Energy Innovation Capabilities Act of 2017 and the Nuclear Energy Innovation and Modernization Act of 2019.[63] NRC is developing the AR GEIS as a technology-neutral GEIS that could be applied to multiple advanced reactor technologies that could be characterized using a "plant parameter envelop" (PPE) and constructed at a site that could be characterized using a "site parameter envelop" (SPE). An AR GEIS would enable staff to avoid duplicative reviews of new applications encompassed by the AR GEIS PPE and SPE.[64] The draft AR GEIS was submitted to the NRC Commission to review and approve for publication and comment in November 2021, but the Commission has not yet voted to publish the proposed rule. The NRC rulemaking website states the draft AR GEIS is expected to be published for public comment in November 2023 with a final AR GEIS issued in February 2025, but the Commission voting schedule is not clear at this time.[65]

The specific benefits of the AR GEIS on advanced reactor licensing on costs associated with NRC environmental reviews has been estimated by NRC staff. The draft regulatory analysis prepared by the NRC staff to support the AR GEIS quantifies the predicted impact of the AR GEIS on applicant and staff activities. The NRC staff calculated that use of an AR GEIS would reduce applicant preparation activities by 6,548 hours of effort per new reactor application (estimated $1,070,598 in saved costs) and would reduce NRC staff review activities by 6,416 hours of effort per new reactor application (estimated $1,924,800 in applicant billed fees at $300 per staff hour).[66] These effort and cost savings can be compared with the NRC's most recent fee and effort estimates for new reactor licensing activities in Table 2.

Table 2. Average Cost and Effort Requirements for NRC COL Reviews[67]

COL Review	Average Staff Hours	Average Billed Staff Cost (Note 1)	Additional Average Contractor Costs	Total Average Cost
Low Level of Effort	44,269	$13,280,700	$2,760,000	$16,040,700
Average	89,261	$26,778,300	$5,020,000	$31,798,300
High Level of Effort	178,160	$53,448,000	$8,880,000	$62,328,000

Note 1: "Average Billed Staff Cost" based on $300/hour NRC staff rate in 2023.

[61] SECY-20-0020: Results of Exploratory Process for Developing a Generic Environmental Impact Statement for the Construction and Operation of Advanced Nuclear Reactors

[62] NUREG-1437, Vol 1, Rev 1 "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" Main Report, Final Report

[63] SECY-21-0098: Enclosure 2 - Draft Advanced Nuclear Reactor Generic Environmental Impact Statement

[64] SECY-21-0098: Proposed Rule: Advanced Nuclear Reactor Generic Environmental Impact Statement (RIN 3150-AK55;NRC-2020-0101)

[65] Advanced Nuclear Reactor Generic Environmental Impact Statement (GEIS)

[66] SECY-21-0098: Enclosure 3 - Draft Regulatory Analysis

[67] New Reactors Business Line Fee Estimates

The total reduction in cost and effort is on the order of 5% - 10% when compared with the total NRC estimates for a COL review. It could be assumed that the applicant's preparation of the COL would require a similar (if not greater) amount of effort and costs as the staff's review, so the applicant's cost savings associated with use of an AR GEIS would be of a similar order of magnitude.

While there are new limitations on the duration and length of the EIS review process based on the NEPA reforms passed as part of the Fiscal Responsibility Act of 2023 (i.e., maximum 2 years of review and a 150 – 300 page main report for an EIS)[68], the experience at Vogtle 3 and 4 demonstrate the potential resource burden associated with environmental reviews and preparation of environmental impact statements for new nuclear power plants.

While an AR GEIS will help reduce the effort and time associated with a licensing review in the near term and mid term, each EIS will still require thousands of hours and millions of dollars to prepare and review and could still encounter schedule bottlenecks associated with a lengthy, prescriptive regulatory review process. Thus, while an AR GEIS will enable significant process efficiencies for the near and mid term, more fundamental change to the EIS process itself is needed in the long term to support tens to hundreds of EISs for new reactors each year under current regulatory requirements.

4.3 Limitations of Current EIS Requirements for Nuclear Power Plants

The implementation of NEPA for nuclear power plants is based not on the actual expected environmental impacts of nuclear power plants but on the presumption that all nuclear power plants have a significant impact on the human environment. Even if this presumption were actually accurate for conventional large light water reactors, it may not be in all cases for advanced reactors in the future. Environmental impacts of a project will be based on factors including:

- the power level of the reactor (i.e., thermal power in MW),
- the operational characteristics of the reactor (e.g., electricity production, process heat, etc.)
- the physical location and land use of the reactor (i.e., site footprint)
- the interactions between the reactor and the environment (e.g., water usage, liquid and gaseous effluents during operation, waste heat releases)
- the construction process and operational impacts on the community (e.g., duration and scope of construction and operations in terms of jobs and land usage)
- the safety characteristics (e.g., potential environmental impacts of normal, off-normal, design basis accidents, and beyond design basis accidents)

For conventional large light water reactors, it is reasonable to assume the impacts will be consistent across projects due to the similarity in the above characteristics across different designs and the environmental impacts of certain resource areas of conventional large light water reactors have been small or moderate. On the other hand, advanced reactors will likely significantly differ from conventional large light water reactors in one or more of the above factors – most often a change that will reduce the expected environmental impacts of the nuclear power plant. For example, it is clear by observation that a 3000 MW thermal large light water reactor will have a different environmental impact than a 2 MW high temperature gas microreactor based simply on the amount of waste heat that will be released to the environment.

[68] Fiscal Responsibility Act of 2023

Assuming all advanced reactors will have similar impacts on the human environment to large light water reactors creates a prescriptive process requirement that does not accurately reflect the expected environmental impact of different reactors. This process creates an unnecessary regulatory burden and does not efficiently meet the underlying intent of NEPA of assessing the environmental impacts of agency activities.

While using the AR GEIS would help accelerate the preparation of an EIS for an advanced reactor, the wide variety of technologies encompassed by the AR GEIS could result in excessive conservatism in many cases. For example, the draft AR GEIS assumes permanent land use of up to 100 acres could be acceptable without producing any significant environmental effects.[69] This assumed land use can be compared with the actual land use cited in the final EIS for two recently reviewed advanced reactor projects: the Kairos *Hermes* reactor (completed by the NRC) and the BWXT *Project Pele* microreactor (completed by the Department of Defense). The 100 acres of assumed land use in the AR GEIS compares with 30 acres of land use for the Kairos Power *Hermes* reactor[70] and 1.6 acres for the BWXT *Project Pele* microreactor.[71] The actual environmental impact from some future advanced reactor projects may be much smaller than previously considered by the draft AR GEIS and may not require an EIS at all to satisfy the NEPA process requirements.

4.4 Options for Alternative Processes for NEPA Compliance for Nuclear Power Plants

There is precedent at both the NRC and the Department of Energy (DOE) to use tools other than an EIS to evaluate the environmental impacts of nuclear reactors and demonstrate compliance with NEPA. There is also recent precedent at both the NRC and the Department of Defense (DOD) on the results and conclusions from the NEPA evaluation of proposed advanced reactors using EISs.

The NRC currently allows the use of EAs to meet NEPA requirements for certain non-power reactors facilities. Specifically, NRC staff guidance in NUREG-1537 for the licensing of research reactors concludes that "no significant environmental impact will be associated with the licensing of research reactors" with power level of 2 MW thermal or less and that an EIS is not required when granting a construction permit or operating license for these reactors.[72] As a result, the NRC allows these facilities to use an EA to meet the NEPA requirements and to prepare an EIS only if the EA is unable to reach a FONSI.

The DOE also currently allows the use of EAs to meet NEPA requirements for certain nuclear research reactors and has successfully completed EAs for two advanced research reactor projects in the past two years. While DOE normally requires an EIS for nuclear reactor projects,[73] DOE used EAs to meet NEPA requirements for two small research reactors sited at the Idaho National Lab (INL). The two research reactors, the Microreactor Applications Research, Validation and Evaluation (MARVEL) project[74] and the

[69] SECY-21-0098: Draft Advanced Nuclear Reactor Generic Environmental Impact Statement
[70] NUREG-2263, "Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor" Final Report
[71] Construction and Demonstration of a Prototype Mobile Microreactor Environmental Impact Statement – Volume 1 (Final EIS and Appendices)
[72] NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors"
[73] 10 CFR 1021 Subpart D Appendix D
[74] DOE/EA-2146: Microreactor Applications Research, Validation and Evaluation (MARVEL) Project

Molten Chloride Reactor Experiment (MCRE) project[75], are 100 kW thermal and 200 kW thermal, respectively. Both projects were evaluated using EAs that provided a brief description of the purpose and need for the proposed action, a description of reasonable alternative actions, and an assessment of the environmental impacts of the proposed action and possible alternatives. Both EAs found that the environmental impacts of the research reactors would not be significant and that it was appropriate to issue a FONSI for both reactor projects.[76, 77]

Both MARVEL and MCRE fall below the NRC's evaluation threshold of 2 MW thermal for research reactors. While this is an important metric for consideration of microreactors and highlights that a FONSI may be appropriate for these reactors, it is unclear whether the conclusions of an EA or EIS would be the same if performed for larger advanced reactor reactors. There is recent precedent, however, from both NRC and DOD to use an EIS to evaluate the environmental impacts of larger advanced reactors. The NRC completed the EIS for Kairos Power's 30 MW thermal *Hermes* test reactor in 2023 and the DOD competed the EIS for the DOD Strategic Capabilities Office (SCO) 5 – 15 MW thermal *Project Pele* test reactor in 2022.

Kairos Power submitted a construction permit (CP) application to the NRC on September 29th, 2021 for the *Hermes* reactor, a 30 MW thermal test reactor sited at an existing industrial park in Oak Ridge, Tennessee.[78] As part of the CP application review process, the NRC staff prepared an EIS for the *Hermes* reactor. The draft EIS for the project was issued on September 29th, 2022, and the final EIS was issued on August 17th, 2023.[79] The EIS evaluated the construction, operation, and decommissioning of the test reactor at the site and the environmental impacts associated with each phase of operation. The NRC staff review found that the impact of *Hermes* reactor across all NEPA resource areas and for all phases of operation would be "small" and the NRC staff recommended that "unless safety issues mandate otherwise, that the NRC issue the CP to Kairos".[80] The NRC staff's evaluation of Kairos *Hermes* reactor in the EIS provides a valuable data point that the environmental impacts of a similar advanced reactor at an existing industrial site may have small environmental impacts across all resource areas.

For the Project Pele microreactor demonstration project, the DOD staff prepared an EIS as part of the implementation process. The Project Pele microreactor is a 5 – 15 MW thermal transportable microreactor with a primary development contract currently awarded to BWXT. The EIS evaluated the reactor assembly, operation, and decommissioning of the test reactor at an existing site at the Idaho National Lab. The DOD staff review found that the impact of the Project Pele microreactor project across all stages of manufacturing, assembly, operation, and decommissioning would be negligible to small for all NEPA resource areas.[81] The DOD staff's evaluation of the Project Pele microreactor in the EIS provides a valuable data point that the environmental impacts of a similar microreactor at an existing research or industrial facility may have negligible to small environmental impacts across all resource areas.

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[75] DOE/EA-2209: Molten Chloride Reactor Experiment (MCRE) Project

[76] FONSI for MARVEL Project Environmental Assessment

[77] FONSI for MCRE Project Environmental Assessment

[78] NUREG-2263, "Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor" Final Report

[79] Hermes Reactor Application, Kairos Power

[80] NUREG-2263, "Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor" Final Report

[81] Project PELE Mobile Nuclear Reactor – DoD Research & Engineering, OUSD(R&E)

In both the Hermes and Project Pele cases, the EIS for the advanced reactors found the environmental impacts would be negligible to small for all evaluation categories. While it is appropriate that a first-of-a-kind project may need to complete an EIS to help assess the environmental impacts, the incredibly small quantitative impacts of these projects suggest that for subsequent projects using a similar design at a similar site an EA may be more appropriate than an EIS and that the EA would likely lead to a FONSI. This conclusion could be extended across different projects with similar characteristics and sites, including reactors with higher power outputs.

The recent experience with NEPA reviews of four advanced reactors (Marvel, MCRE, Hermes, Project Pele) across three federal agencies suggests that use of alternative NEPA review processes may be appropriate for the licensing of commercial advanced reactors by the NRC.

In July 2023, Kairos Power submitted a CP application for *Hermes 2*, a two-reactor facility sited at the same location as the *Hermes* reactor. The physical design of the *Hermes* and *Hermes 2* reactors are identical with facility differences limited to the buildings, balance of plant, auxiliary support systems, and instrumentation and control systems. After reviewing the Kairos Power CP application, the NRC staff has decided to prepare an EA for the *Hermes 2* CP application instead of an EIS. This change was based on the staff's experience with Hermes EIS and NRC staff findings that the Hermes CP application would have small to negligible environmental impacts across all resource areas. The NRC staff noted that an EA approach could provide "significant schedule and resource advantages" and that they could revert to an EIS if the EA reveals any significant environmental impacts.[82] This decision by NRC staff on the *Hermes 2* CP environmental review demonstrates that there may be an opportunity to utilize EAs and that NRC staff recognize such reviews are appropriate for certain advanced reactor reviews and would have significant process advantages.

4.5 Proposal for Scalable Environmental Review Processes for Advanced Reactors

The current NRC requirement for an EIS for all power reactors is an outdated, resource-intensive, and prescriptive regulatory process that does not reflect potential environmental impacts of certain advanced reactors and cannot leverage well characterized environmental impact assessments for a standardized reactor design that is repeatedly deployed and operated. Enabling the use of EAs and CATEX in addition to EIS as acceptable methods to meet the environmental review requirements of NEPA for advanced nuclear power reactors would enable high volume licensing.

The main challenge with developing regulatory processes for environmental reviews under NEPA is that the process is inherently a qualitative process and not a quantitative process. There are no quantitative numerical regulatory requirements to satisfy, no consistent definition of "significant impact" when evaluating environmental impacts, and the process is largely based on qualitative agency interpretation of requirements and legal precedent of what is sufficient to satisfy the statutory intent of NEPA. This imprecise but flexible process is designed to reflect the challenges associated with assessment of environmental impacts, many of which cannot be precisely measured or quantified without introducing inherent bias or limitation. This flexibility to scale the evaluation of environmental impact based on a

[82] SECY-23-0080: Environmental Review Approach for the Kairos Power, LLC Hermes 2 Construction Permit Application

particular activity should be more effectively leveraged in the NRC's environmental reviews of advanced reactors.

The NRC staff are familiar with the challenges of regulation based on a qualitative standard. The NRC's regulatory standard of "reasonable assurance of adequate protection" is the underlying basis of all licensing activities but has required development of qualitative processes and quantification of surrogate regulatory metrics (sometimes only in regulatory guidance) to provide a more predictable regulatory process. This process of developing qualitative processes and quantification of regulatory metrics can be extended to the NRC's environmental reviews to determine the environmental reviews that are appropriate for a new reactor license on a more performance-based and less prescriptive framework. The NRC staff's use of a 2 MW thermal power level limit in guidance that permits use of EAs with research and test reactors is an example of an important (but prescriptive) regulatory precedent that could extend a more flexible process (as appropriate) to commercial power reactors.

Figure 3 illustrates a simplistic approach to a more flexible and performance-based approach to implementing environmental reviews by the NRC. All new reactor projects would complete a decision-making process with the NRC staff where they determine their preferred approach to completing the environmental review process. An applicant and NRC staff would collaboratively develop a proposed pathway for completing the environmental review process under NEPA based on factors related to the specific reactor project and applicant preferences on handling regulatory uncertainty.

For example, an applicant could choose to pursue an EA or EIS for a reactor project where the environmental impacts are expected to be small for all cases but there is uncertainty on certain review aspects. If the applicant requests that staff pursue an EA based on the characteristics of the reactor, the NRC staff may determine that a FONSI is substantiated and could conclude the environmental review process without additional work. If, however, the NRC staff find that some environmental impacts may be significant or that additional study is needed to appropriately quantify the environmental impacts, the NRC staff would then also need to develop an EIS (or supplemental EIS if the application can leverage a GEIS) – adding additional duration and staff costs to the licensing process. The applicant could alternatively request that staff pursue an EIS from the beginning and reduce the schedule delays and resource costs associated with completion of both an EA and EIS. This would provide the applicant with the opportunity to provide input on the environmental review process and select the regulatory pathway that best reflects the appropriate level of regulatory risk for their specific project.

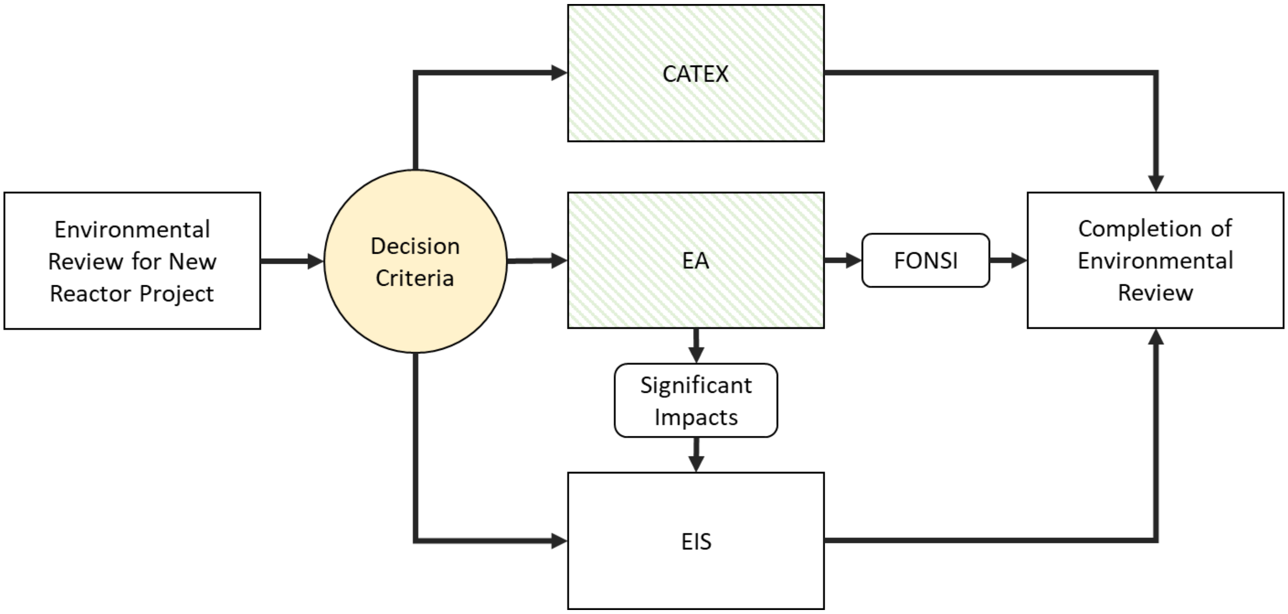

Figure 3. Simplified Model of an NRC Performance-Based Environmental Review Process

A more flexible environmental review process illustrated in Figure 4 requires the development of performance-based decision criteria that could be used to support NRC staff decisions on environmental reviews. Figure 4 illustrates a simplistic decision model that could guide decisions by applicants and NRC staff on the appropriate environmental review process for a new reactor application.

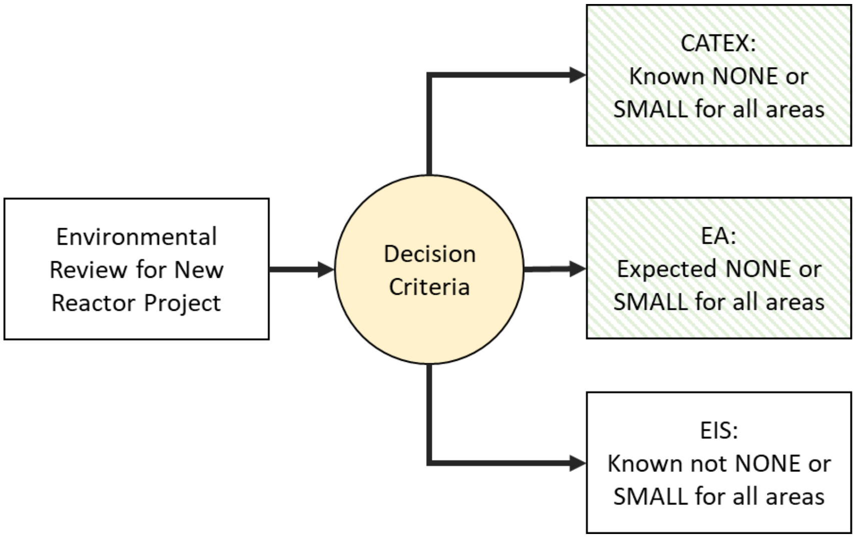

Figure 4. Simplified Decision Criteria for an NRC Performance-Based Environmental Review Process

The decision criteria suggested here are based on applicant and NRC staff expectations for the results of the environmental review process that account for the reactor characteristics and prior environmental reviews of similar or identical designs. The NRC defines three levels of significance for potential environmental impacts evaluated in NEPA reviews:[83]

- SMALL: environmental effects are not detectable or are so minor they will neither destabilize nor noticeably alter any important attribute of the resource[84]
- MODERATE: environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource
- LARGE: environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource

The decision criteria suggested here use these definitions (in addition to the category "NONE" for cases where the environmental impacts are not applicable) to provide guidance on the selection of appropriate environmental review processes. The environmental effects would be qualitatively or quantitatively evaluated across multiple resource areas based on the required scope of environmental reviews under NEPA. Relevant resource areas for NRC environmental reviews of new nuclear reactors include:[85]

- land use
- air quality
- aquatic ecology
- terrestrial ecology
- surface and groundwater
- waste (radiological and non-radiological)
- human health (radiological and non-radiological)
- socioeconomics
- environmental justice
- cultural resources
- fuel cycle, decommissioning, and transportation

The environmental impacts of a proposed activity on each of these resource areas would need to be considered for the incremental impacts of construction and operation activities. An initial qualitative or quantitative scoping assessment of a new nuclear reactor project across these resource areas would provide insights on which environmental review processes would be most appropriate for a specific new reactor application. The specific factors that could affect selection of a CATEX, EA, or EIS as part of the decision criteria for a new advanced reactor application are discussed below.

4.5.1 CATEX for New Reactor Environmental Reviews

Selecting a CATEX for a new nuclear reactor project would require the Commission to find that "the category of actions does not individually or cumulatively have a significant effect on the human

[83] 10 CFR 51 Appendix B

[84] A "resource" in NRC NEPA reviews is any physical, environmental, or social attribute that may be affected by a proposed action. Examples of resources include land, water, visual aesthetic, noise and sound pollution, ecology, socioeconomic status, and human health. 10 CFR Part 51 Appendix B

[85] Standard Review Plan for Environmental Reviews of Nuclear Power Plants (NUREG-1555)

environment" using performance-based criteria for a nuclear reactor projects.[86] NRC staff would need to perform significant regulatory evaluations, solicit public comment and input, and complete a formal rulemaking process to develop and promulgate performance-based criteria for use of a CATEX.

The NRC already uses CATEXs for a wide range of licensing activities that have been previously evaluated to demonstrate they do not individually or cumulatively have a significant environmental impact. For example, certain nuclear byproduct materials licenses regulated under 10 CFR Part 30 are eligible for a CATEX based on a regulatory analysis of the historical environmental impacts associated with licensee activities. The NRC regulatory analysis for byproduct material licenses focused on the radiological effluents and public and worker radiation exposures associated with 10 CFR Part 30 licensee activities. The NRC regulatory analysis found that the past radiological effluents and radiation doses associated with 10 CFR Part 30 activities were less than 5% - 10% of the radiological effluents and radiation doses limits in 10 CFR Part 20. The Commission found that the Part 30 licensed activities "comprise a category of actions which do not individually or cumulatively have a significant effect on the human environment" and could be designated for a CATEX.[87] The NRC staff and Commission also reserved the option to require an EA or EIS in cases where a proposed nuclear byproduct materials license regulated under 10 CFR Part 30 could exceed previous regulatory analysis on environmental impacts of operation and should be subject to additional environmental reviews.[88] This example demonstrates a process that could be used to create an CATEX for new reactor projects.

Development of performance-based criteria for advanced reactor eligibility for a CATEX would enable the applicable advanced reactor projects to rapidly complete the NEPA-mandated environmental review process. While the criteria for the CATEX might be quite stringent (e.g., reactor thermal power levels below 1 MW, small site footprint, no credible release scenarios) to meet the Commission standard of actions that "do not individually or cumulatively have a significant effect on the human environment", the development of a performance-based CATEX for advanced reactors would create a clear regulatory pathway for applicants. Industry and applicants could choose to design reactors that meet the CATEX requirement to eliminate the schedule and resource requirements associated with NRC staff preparation of an EA or EIS. This enables a market-driven approach to innovation while still maintaining the statutory intent of NEPA. The NRC staff and management could still retain the option to require an EA or EIS in cases where there is sufficient cause to believe a CATEX is not appropriate for an application (e.g., novel reactor designs, new uses, unique siting characteristics), but this process should be judiciously used (e.g., based on Commission policy statements or NRC staff guidance) to maximize the regulatory predictability of the CATEX process for advanced reactors.

Development of the specific criteria would be challenging and would require NRC staff to perform significant regulatory evaluations, solicit public comment and input, and complete a formal rulemaking process in the near term, but could have significant benefits for high volume licensing in the long run.

[86] 10 CFR 51.22(a)
[87] 49 FR 9379
[88] 10 CFR 30.33(a)(5)

4.5.2 EA and EIS for New Reactor Environmental Reviews

Selecting an EA for a new nuclear reactor project would require the NRC staff to expect the environmental impacts of the new reactor not to be significant in all cases based on previous NRC regulatory precedent and guidance for research reactors.[89] NRC staff already permit the use of EAs for non-power research reactors with a power level of less than 2 MW thermal and this permission could be broadened based on a combination of performance-based qualitative and quantitative criteria. An EIS should be used if the applicant and NRC staff do not believe an EA of the project will lead to an FONSI, if there are novel environmental issues associated with a project that warrant additional environmental review (e.g., novel reactor designs, new uses, unique siting characteristics), or if an applicant requests an EIS to help provide additional independent review of the environmental impacts of a project or eliminate the project schedule risk of an EA requiring a subsequent EIS based on a findings of moderate or significant impacts during the EA review.

For new reactor projects not eligible for a CATEX, applicants and NRC staff should begin by collaboratively assessing the expected environmental impacts of a new reactor project based on project-specific factors and past environmental reviews. Sources of information could include:

- applicant assessment of expected environmental impacts for a project provided in their application environmental report
- insights from generic environmental impact statements (GEIS) or generic environmental assessments (GEA) developed for advanced reactors
- NEPA reviews and findings from prior reactor environmental reviews of similar designs
- environmental reviews performed as part of the review of a standardized plant design

Applicants and NRC staff could use a combination of qualitative and quantitative criteria (e.g., new NRC staff guidance on evaluating the NEPA significance of expected radiological effluents or exposures) to determine whether the application would likely result in a FONSI if an EA were conducted or the impacts are expected to be significant and require completion of an EIS for the project. For example, the FONSI for the MARVEL and MCRE projects by DOE provide some indication that an EA conducted by NRC for a similar project could reasonably conclude in a FONSI. The NRC findings of only small environmental impacts for the Hermes project and the DOD findings of only small environmental impacts for Project Pele suggest that future reviews of similar designs and applications using an EA could reasonably conclude in a FONSI and that an EA may be appropriate for their NEPA review.

Discussions between applicants and NRC staff on initially performing an EA instead of an EIS could be completed as part of public meetings and would provide transparency with respect to the regulatory basis for the chosen NEPA review process. Applicant input to the process is important to consider because they should be allowed to consider the regulatory costs and risks associated with the two NEPA review pathways (EA or EIS) in the context of their commercial licensing strategy. In either case, an appropriate NEPA review will be completed, but the applicant has an incentive to develop reactor applications that provide technical justification for simplified NRC environmental reviews. It is important that NRC staff and management could still request or require an EIS if there are novel issues associated with a project that

[89] NUREG 1537 "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors"

warrant additional environmental review (e.g., novel reactor designs, new uses, or unique siting characteristics). While an applicant could request an EA that would ultimately result in a required EIS for these reviews, use of an EA when one or more significant environmental impacts are likely could be an unnecessary burden on NRC staff resources due to iterative work required for NRC staff preparation of both an EA and EIS. These concerns should be included in the collaborative discussions between the NRC staff and applicants.

Applicant preparation of the draft EA or EIS should also be considered by the NRC staff. NEPA regulation allow applicants to prepare a draft EA or EIS under the supervision of the agency.[90] The Fiscal Responsibility Act of 2023 further clarified that the lead agency for an EA or EIS shall create procedures for applicants to prepare the draft documents and that the lead agency must independently evaluate the draft documents and is responsible for its contents.[91] The NRC should implement these procedures and enable applicants to prepare draft documents. This process could reduce the effort and cost of NRC completion of the NEPA process by providing the NRC a starting point for the EA or EIS based on the information submitted by the applicant – focusing NRC staff effort on their independent review.

The development of the qualitative and quantitative criteria and an EA/EIS evaluation process would require significant NRC staff and Commission resources but could have significant benefits for high volume licensing by reducing the duration and resource requirements of completing environmental reviews, especially for standardized advanced reactor designs that may have smaller and better characterized expected environmental impacts than large light water reactors.

4.5.3 Conclusions on Scalable Environmental Review Processes for Advanced Reactors

Environmental reviews of new reactor applications are a critical process step that could limit NRC's ability to license large numbers of new nuclear power plants due the prescriptiveness of the EIS process currently required. While the NEPA reforms enacted as part of the Fiscal Responsibility Act of 2023 will reduce the duration and resource requirements of environmental reviews, the current NEPA process is still a significant process bottleneck, requires substantial resources, and is overly prescriptive. The proposals in this section for reforming the NEPA review process create a more scalable environmental review process by developing performance-based environmental review processes. Enabling NRC staff to utilize CATEXs and EAs would reduce the duration and resources required for the NEPA review process and could better reflect the actual environmental impacts associated with construction, deployment, and operation of advanced reactors. This suggested environmental review process would require the development of new qualitative and regulatory criteria for use of CATEX and EA, but the upfront costs associated with NRC staff development and promulgation of requirements and guidance would significantly reduce use of staff resources for environmental reviews. This proposal helps applicants and NRC resolve current challenges related to environmental review process bottlenecks, resource-intensive processes, and prescriptive regulatory processes to enable high volume licensing by the NRC.

[90] 40 CFR 1506.5 – Agency responsibility for environmental documents
[91] Fiscal Responsibility Act of 2023

5. Modifying Mandatory Hearing Requirements for Advanced Reactors

The third proposal is modifying requirements for the NRC mandatory hearing process following completion of technical, financial, and environmental reviews to enable the Commission to use less time- and resource-intensive oversight processes for the reviews.

5.1 History of Public Hearings for New Nuclear Reactor Licenses

The NRC hearing process for new reactor licenses is based primarily on early public and political missteps by the AEC in the earliest days of commercial reactor licensing.[92] In January 1956, the AEC started the CP review process for Fermi 1, a novel fast metal breeder reactor sited outside of Detroit, Michigan. The reactor's novel design presented several important technical challenges and questions for the AEC. Technical experts on the ACRS concluded in an internal report that "there is insufficient information available at this time to give assurance that the [Fermi 1] reactor can be operated at this site without public hazard".[93] The AEC refused to release the ACRS report upon request by both Congress and the state of Michigan, and public statements by AEC Chair Lewis Strauss about AEC plans to grant the CP despite the letter angered Congressional oversight committee members. The AEC staff ultimately required the applicant to perform additional tests before issuing a "conditional" construction permit for the project in August 1956.[94]

Congressional and public frustration over the opacity of the AEC licensing process and concern over conflicts of interest between the AEC's promotional and regulatory mandates ultimately led to changes in the AEC licensing process for new reactors. A package of AEC legislative reforms enacted in 1957 included requirements for the AEC to conduct a mandatory public hearing before issuing a license for a nuclear power plant and established the ACRS as a statutory organization required to produce public reports on all reactor license applications.[95] This mandatory hearing was in addition to a hearing that could be contested – a process by which an additional hearing can be requested by concerned individuals or groups who demonstrate standing as affected parties to the licensing action and provide a legally admissible contention regarding the licensing process in a timely fashion.[96] These reactive legislative changes were intended to provide much needed transparency and accountability for the early AEC, especially in cases where there were disagreements among stakeholders on the technical or legal basis for a license.

Additional AEC legislative reforms enacted in 1962 provided additional clarification on the hearing process and enabled the AEC to delegate authority to conduct licensing hearings. The first major change was that the Commission was only required to hold a mandatory public hearing for all construction permit applications and not for operating license applications. The Commission was still required to hold a hearing for any construction permit or operating license application if "any person whose interest may be affected" by the license could demonstrate standing and provide and a timely admissible contention regarding the

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[92] Improving the Efficiency of NRC Power Reactor Licensing

[93] George T. Mazuzan and J. Samuel Walker, "Controlling the Atom: The Beginnings of Nuclear Regulation 1946-1962" (1984), NUREG-1610

[94] J. Samuel Walker and Thomas R. Wellock, "A Short History of Nuclear Regulation, 1946–2009"

[95] Public Law 85-256

[96] Public Law 83-703

licensing process.[97] If a hearing on an admissible issue was not requested in a timely fashion by a party with standing, the AEC was not required to conduct an additional hearing. This clarification created two separate hearing types (mandatory and contested) with varying requirements based on the application type (construction permit or operating license).

The second major change was that the AEC could establish Atomic Safety and Licensing Boards (ASLBs) to conduct hearings on behalf of the Commission. Each ASLB was composed of three experts – two with technical qualifications and one with administrative law qualifications – and the Commission could delegate regulatory or administrative functions to these Boards.[98] This change helped provide the Commission additional staff flexibility in response to the additional workload associated with the new mandatory hearings for construction permit applications.

Finally, NRC reforms enacted in 1992 clarified the hearing requirement process for combined license (COL) applications, requiring mandatory hearings before issuing a combined license and enabling a contested hearing on issues limited to the operational conditions and requirements of the COL before start of facility operations for any facility licensed using a COL.[99] These statutory NRC hearing requirements are applicable today for all new nuclear power plants.

5.2 Characterizing Existing Hearing Requirement Types for New Reactors

The current hearing process for new nuclear reactors following completion of staff reviews is diagramed in Figure 5. Discussion of the regulatory implications of this process first requires precise definition of each hearing type ("contested hearing", "mandatory hearing", "contested hearing for final COL conditions") shown in Figure 5.

5.2.1 Contested Hearing

A "contested hearing" is a hearing that "any person whose interest may be affected" by the licensing process can request on any NRC action to grant, suspend, revoke, amend, or transfer any license or construction permit if they have standing, provide an admissible contention, and meet the procedural hearing requirements in 10 CFR Part 2. These are also defined as "contested proceedings" by the NRC in 10 CFR Part 2.[100]

These hearings are administered by the Commission or ASLB and may include members of the public or groups filing contentions; applicants or licensees; NRC staff; and other parties. These hearings may be open to other members of the public to observe but members of the public not party to the hearing may not actively participate in it.

The scope of a "contested hearing" is limited to specific admissible contentions that are cited by a person or group with standing in their petition or request for a hearing. These hearings do not review the general facts or process of the licensing activity and are specific to the topics that can be considered. The results

[97] Public Law 87–615
[98] Public Law 87–615
[99] Public Law 102–486, Title XXVIII
[100] 10 CFR Part 2

from hearings are provided publicly in writing after the hearing based on the hearing procedures in 10 CFR Part 2 and NRC guidance. The results of the hearing may be appealed to the Commission.[101] These contestable hearings may be requested before the Commission issues a CP, OL, or COL. If a hearing is not requested or granted to a person or group, no additional action is taken by the Commission on this specific hearing type.

5.2.2 Mandatory Hearing

A "mandatory hearing" is a hearing that the Commission is required to perform for CP and COL applications to comply with statutory requirements. These hearings are also defined as "uncontested proceedings" by the NRC in 10 CFR Part 2.[102] This terminology can be confusing to lay audiences because it could be interpreted that "uncontested" means no contentions have been filed on this hearing. This terminology actually refers to the fact that this hearing is conducted separately from the "contested hearing" process and is conducted irrespective of contest by the public.

These hearings are administered by the Commission and the applicants and NRC staff are the only parties in the hearing. In some cases, interested states, local governments, federal agencies, and federally recognized Indian Tribes may have limited participation based on Commission discretion. These hearings are open to members of the public to observe but the public cannot actively participate in these hearings.

The scope of a "mandatory hearing" is extremely broad and covers all aspects of the NRC staff review. The NRC staff prepare a Commission Paper (SECY) that summarizes the staff review and the basis for the staff findings on the CP or COL. The paper also discusses any novel technical, environmental, financial, or policy issues that arose during the review.[103] The Commission reviews the paper in advance of the hearing and may provide written questions to supplement the hearing process. The hearing consists of presentations from the applicants and NRC staff and the Commission then asks questions at their discretion and provides follow-up questions. The Commission issues its decision following the hearing.

5.2.3 Contested Hearing for Final COL Conditions

A "contested hearing for final COL conditions" is a hearing similar to the "contested hearing" but is more limited in scope and only applicable before the initial loading of fuel in a plant licensed using a COL. The hearing is open to " any person whose interest may be affected by operation of the plant" to challenge "whether the facility as constructed complies, or on completion will comply, with the acceptance criteria of the license". The petitioner for hearing "shall show, prima facie, that one or more of the acceptance criteria in the combined license have not been (or will not be met) and the specific operational consequences of nonconformance that would be contrary to providing reasonable assurance of adequate protection of the public health and safety".[104] The Commission must then move expeditiously in accordance with hearing procedures in 10 CFR Part 2 and NRC guidance to render a decision on the hearing. This hearing is often informally referred to as the "ITAAC Hearing" because the hearing scope is

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[101] March 3, 2020 - Contested and Uncontested Hearing Processes for a Combined License (COL) Application
[102] 10 CFR Part 2
[103] March 3, 2020 - Contested and Uncontested Hearing Processes for a Combined License (COL) Application
[104] 42 USC 2239

limited to whether the applicant has satisfactorily completed the prescribed ITAAC as conditions for permitting operation in their COL.

These more limited scope of admissible contentions for the "contested hearing for final COL conditions" preserve the regulatory finality of the COL but still create a pathway for members of the public or groups to intervene if there is adequate cause to halt initial fuel loading in a plant licensed using a COL.

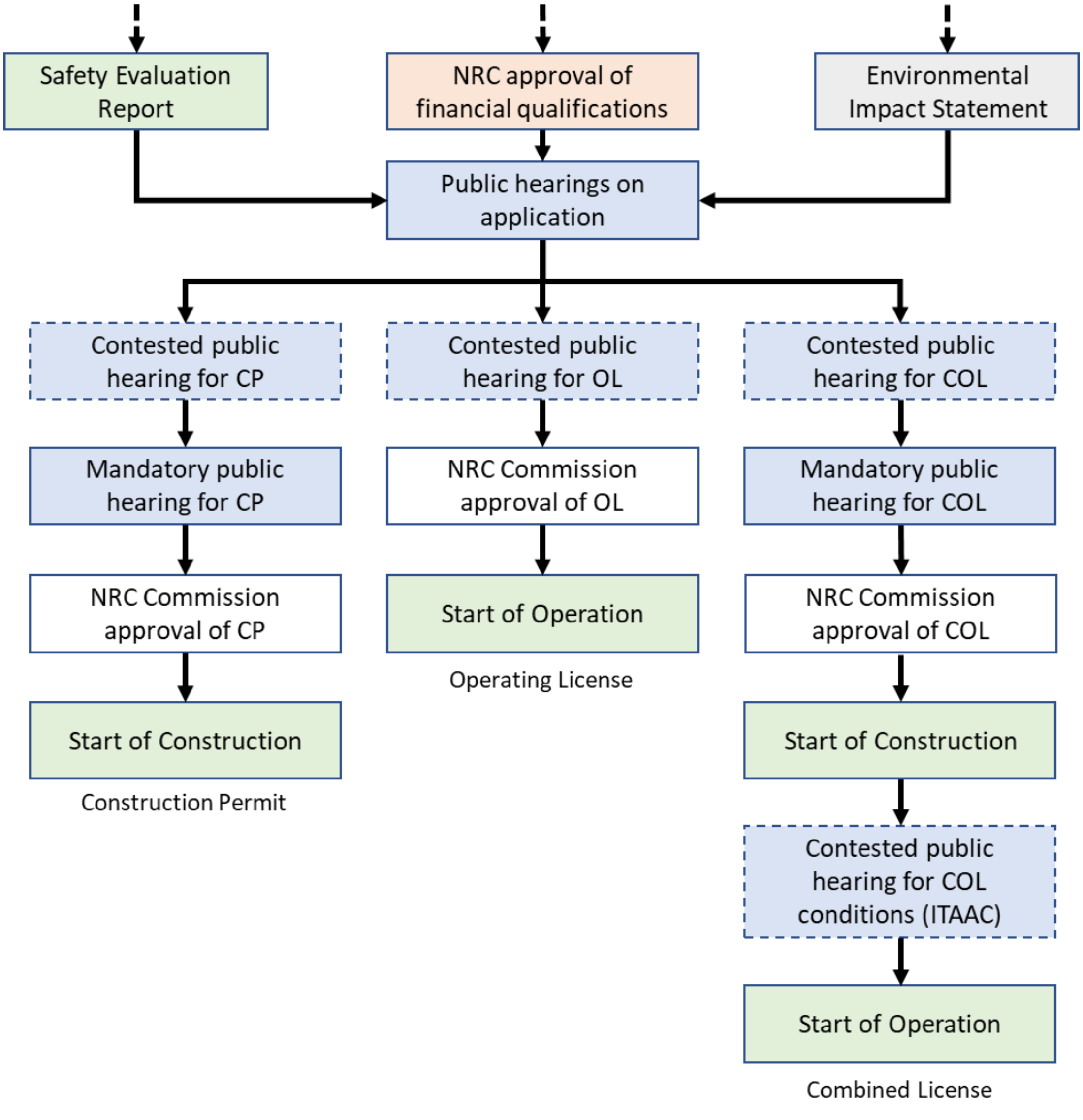

Figure 5. Hearing process for new reactor CP, OL, and COL applications

5.3 Challenges with Existing Mandatory Hearing Requirements for New Reactors

The current NRC mandatory hearing process was created during the early days of commercial nuclear reactor regulation by the Atomic Energy Commission (AEC). A number of factors limited public trust and accountability in the AEC licensing process including:

- Limited regulatory experience and technical expertise, especially in reviewing and licensing commercial nuclear power reactors
- Rapid licensing of bespoke reactors designs with different sizes, designs, and technologies
- Dual organizational mandate to promote and regulate commercial nuclear energy
- No independent statutory oversight (i.e., no statutorily independent ACRS) with publicly available reports or recommendations
- Limited number of public meetings on technical topics during the licensing process
- High barrier to participation in licensing process due to challenges of accessing physical application materials and documents
- No environmental review process that mandated public engagement (i.e., no NEPA)
- Limited organizational appreciation of importance of public trust and communication
- Absence of federal laws that mandate transparency such as Freedom of Information Act (1967), Federal Advisory Committee Act (1972), Sunshine Act (1976) and National Environment Policy Act (1970).

These factors and more contributed to an atmosphere of political and public distrust around the licensing process. Implementing a mandatory hearing on each construction permit application where AEC staff had to explain the licensing process and defend their decision making helped create significantly more transparency around the AEC licensing process. Establishing ACRS as a statutory organization with public reporting requirements created additional independent oversight and accountability for AEC staff completing the licensing review process. These changes (mandatory hearings and ACRS) provided greater political and public accountability for early AEC licensing activities.

As the NRC has evolved, however, many of the initial factors that supported additional independent oversight requirements and mandatory hearing requirements have been resolved through decades of incremental regulatory improvements. For the factors discussed above:

- NRC is a mature nuclear regulator with thousands of reactor-years of operating experience and a highly qualified technical staff and management team supported by independent contractors
- Economic deployment of advanced nuclear energy at scale will require substantial reactor standardization and may limit long-term deployment of bespoke facilities
- NRC, unlike the AEC, is an independent nuclear regulator focused on worker and public health and safety, and the environment
- ACRS is a mature statutory committee with significant technical expertise and resources
- Current NRC licensing processes provide dozens to hundreds of public meeting opportunities for members of the public and groups to engage with applicants and NRC staff, at the reactor site, NRC headquarters and virtually
- Use of online and in-person resources increases public availability of application materials
- NEPA review processes require public engagement and input on environmental impacts

- NRC focus on public engagement and applicant recognition of the importance of social license and public acceptance for new nuclear power projects have increased

These updated factors support a regulatory framework where public involvement and transparency is included at all stages of the licensing process.

Considering the developments in the transparency and maturity in the NRC's licensing and public engagement activities, mandatory hearing no longer adds any value to the NRC licensing process. Moreover, the process appears to be even more obsolete in subsequent deployments of the same reactor design on the same site. The elimination of mandatory hearing does not prevent the Commission from conducting a hearing of this format as and when it deems fit. For example, the Commission could conduct public hearings for first-of-a-kind reactor or licenses where there are novel design, technical, regulatory, siting, environmental, or policy issues. In future cases, however, where the staff could review a standardized reactor technology at an existing site, the NRC mandatory public hearing would provide neither important regulatory insights nor additional transparency into the licensing process. The limited benefits of such future NRC mandatory hearings can be compared with the expected effort, costs, and schedule duration associated with the process.

Estimates provided by NRC staff suggest that the mandatory hearing process may require more than 6,000 hours of staff time for preparation, review, and delivery of the mandatory hearing and all associated documents.[105] Using an hourly NRC staff rate of $300/hour, this hearing process could result in applicant charged fees of over $1.8 million for each mandatory hearing. This NRC effort and cost would be in addition to the effort and costs by applicants to prepare for the mandatory hearing. In addition, review of NRC licensing processes and timelines for prior COL reviews suggests that the NRC mandatory hearing process adds approximately 4-6 months to the scheduled duration of each application review.[106]

Beyond the additional costs and duration of the mandatory hearing, there are bigger concerns for high volume licensing. Like the current challenges associated with the ACRS review of all new reactor applications, the mandatory hearing by the Commission risks becoming a process bottleneck for high volume licensing. The Commission has a wide variety of responsibilities beyond new reactor licensing. If the number of new reactor license applications were to increase from 1 – 2 applications per year to tens or hundreds of applications per year, the Commission would not likely be able to complete all required mandatory hearings (as currently implemented) without significantly affecting their other work.

NRC's mandatory public hearing process can act as an important public review for some licensing applications if conducted at the discretion of the Commission for specific applications, but a general review of NRC staff activities at the end of the licensing process does not provide significant benefit to all future license application reviews. The benefits are further reduced when considering high volume licensing scenarios where the NRC is reviewing hundreds of new nuclear reactor applications per year with many standardized and previously reviewed elements. The mandatory public hearing process may become a resource-intensive process-bottleneck if changes are not made to the licensing process.

[105] Improving the Efficiency of NRC Power Reactor Licensing

[106] Recommendations to Improve the Nuclear Regulatory Commission Reactor Licensing and Approval Process

5.4 Proposal for Alternative Hearing or Review Requirements for Advanced Reactors

The current NRC requirements for a mandatory public hearing for all CP and COL applications is an outdated, resource-intensive, process bottleneck that does not reflect changes to the operation and culture of nuclear regulation over the past 70 years. Modifying the requirements for the hearing process to enable the Commission to use less resource-intensive processes and public forums (including public meetings, staff briefings, and other informal hearings) to conclude the licensing process would reduce the staff and applicant effort, cost, and schedule burden associated with mandatory public hearings.

The use of the different hearing or review processes would be at the discretion of the Commission (with input from NRC staff, NRC management, the applicant, ACRS, and possibly other stakeholders) and would enable the Commission to select the hearing or process that best reflected the detail and formality of information that the Commission requires to support an informed decision on the license application. A combination of new legislative language, rulemaking in 10 CFR Part 2, NRC staff guidance, and Commission procedure could have a significant benefit on future licensing activities by scaling the NRC review process based on the individual application.

In addition to the final hearings performed at the Commission discretion, the public would still be able to use the "contested hearing" to provide an effective process for members of the public or groups with standing and specific contentions to challenge the licensing basis or related findings.

Use of alterative final hearing processes enables high volume licensing by reducing the process bottlenecks associated with scheduling Commission participation in mandatory hearings (especially for cases where the staff is reapproving a previously reviewed and approved standardized reactor technology), reducing resource-intensive processes by reducing the burden on NRC staff to prepare for formal hearings when the staff preparation has little impact on the outcomes of the hearing process, and reducing prescriptive processes by enabling the Commission to scale the final hearing process based on project-specific factors.

6 Conclusions

Achieving deployment of advanced nuclear energy at scale to make a meaningful contribution to clean energy production in the next few decades will require the NRC to effectively and efficiently review and license large numbers of new nuclear power plants per year. The annual licensing of dozens to hundreds of new nuclear reactors (based on clean energy targets and growing customer interest in SMRs and microreactors) would be comparable to the total number of licenses that the NRC and its predecessor agency have issued in the history of U.S. commercial nuclear energy. The challenge of enabling high volume licensing at the NRC is critical to future deployment of advanced nuclear energy as a climate solution.

This paper reviews the current licensing process for new nuclear power plants at the NRC and shows it is unlikely the agency could reasonably scale existing licensing processes to meet the potential high volume licensing demand. A combination of process bottlenecks, resource-intensive processes, and prescriptive regulatory process requirements limits the capacity of the agency to scale without significant changes to existing regulatory processes.

This paper identifies three critical process steps that most significantly contribute to the NRC licensing capacity limitations:

1. Staff preparation and finalization of the safety evaluation report (SER), including reviews by the ACRS,
2. Staff preparation and finalization of the environmental impact statement (EIS)
3. Commission completion of the licensing process through a mandatory public hearing

The limitations associated with these process steps are largely based on the legacy processes and requirements associated with the licensing, construction, and operation of large conventional light water reactors. Similar to reactor technical safety requirements, the review processes developed by the AEC and used by the NRC are optimized for the licensing and regulation of bespoke large, conventional, light water reactors in a regulatory process that reflects the agency positions in the 1950s through 1970s. Updated agency practices promoting more transparent regulatory decision making, renewed industry commitment to reactor design standardization, and the inherent safety and environmental advantages of advanced reactor designs will make the three critical process steps above unnecessary barriers to high volume licensing by the NRC.

The proposals for standardized reactor safety reviews, scaled performance-based environmental reviews, and more efficient adjudicatory processes in this paper are intended to shorten advanced reactor licensing timelines, reduce bottlenecks for NRC review of advanced reactor applications, and enable high volume licensing by the NRC. Achieving the benefits of the proposals requires a combination of applicant and industry action (e.g., committing to standardized designs that enabling rapid reviews and reducing or eliminating site-specific changes), discipline by NRC staff and management (e.g., controlling review length and focusing reviews on novel or site-specific safety significant issues), and rulemaking and policy changes by the Commission to enable simpler environmental review processes (e.g., CATEX and EA) and simplified final regulatory reviews (e.g., alternatives to mandatory hearings).

Additional work is needed to develop a robust regulatory basis, decision criteria, and regulatory process to support scaled environmental reviews for advanced reactors and identify specific criteria for a performance-based regulatory framework, but these activities could have significant benefits for future environmental reviews, especially for standardized SMR and microreactor designs. Initiating these changes in the next five years are essential to creating an effective and efficient performance-based regulatory framework in the long term that can enable the deployment of advanced nuclear energy at scale.