Nuclear Reactor Licensing 101

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I. Introduction

The successful deployment of advanced nuclear energy requires ensuring safety, security, and environmental protection through responsible commercial operations and effective regulation. The U.S. Nuclear Regulatory Commission (NRC) is responsible for the licensing of nuclear reactors in the United States and conducts a comprehensive review of all stages of nuclear power operations, from initial site selection and nuclear materials handling to decommissioning. The NRC regulatory process ensures that all aspects of nuclear reactor design, construction, operation, and maintenance adhere to strict safety and environmental standards, providing "reasonable assurance of adequate protection" [1] for workers, the public, and the environment. This standard serves as the basis for all NRC reactor licensing and regulatory activities. While the NRC licensing process may seem complex, understanding it is vital for both public and private stakeholders.

This report aims to demystify the reactor licensing process by providing an overview of the existing regulatory framework governing nuclear reactors. Understanding the various states and requirements of the licensing application allows policymakers and thought leaders to identify opportunities for enhancing the process, ensuring that nuclear energy is safely and effectively deployed to achieve a sustainable future. This paper outlines the steps involved in the NRC licensing process for a new nuclear reactor application.

For detailed discussion on potential improvements to the NRC licensing process for new reactors, refer to the Nuclear Innovation Alliance (NIA) report, *The Urgency of NRC Reform*.[2]

II. Classification of Reactors for Licensing

Nuclear reactors that are used to create heat or electricity, or to produce neutrons for purposes other than the production of special nuclear material,[3] are formally licensed by the NRC as "utilization facilities."[4] The specific requirements, review processes, and available licensing pathways for a new nuclear reactor depend on the intended use by an applicant and the reactor technology. To differentiate among nuclear reactors, two main characteristics are typically considered:

- Power reactors versus non-power reactors
- Light water reactors versus non-light water reactors

[1] NRC Mission Statement

[2] NIA developed this brief to serve as a guide for policymakers, the NRC itself, and key stakeholders in considering and then taking action to ensure the NRC can "become an agile, modern, risk-informed, and performance-based regulator to successfully meet this moment."

[3] Atomic Energy Act Sec. 11aa.

[4] 10 CFR 50.2 Domestic Licensing of Production and Utilization Facilities | Definitions

Additionally, classifying a reactor as a prototype can impose specific requirements, initiate review processes, and determine available licensing pathways. This section describes how the classification of nuclear reactors - based on their purpose, application, technology, and design - impacts their licensing and regulation. It also outlines the NRC organizations responsible for the review and oversight of these reactor classes.

Power Reactors and Non-power Reactors

Nuclear reactors in the United States can generally be classified into two categories – power reactors and non-power reactors:

- Power reactors are operated to produce heat or electrical power for commercial[5] or industrial applications.
- Non-power reactors are operated by commercial, academic, or government organizations for research, training, testing, or development.[6] Although these reactors may also be used for medical applications, there are currently no operating nuclear reactors in the U.S. with radiotherapy applications.[7]

The licenses for power and non-power reactors are defined in Title 10, Part 50 of the Code of Federal Regulation (10 CFR Part 50) based on authorization from Congress in the Atomic Energy Act (AEA):

- Power reactors in the U.S. are licensed using a Class 103 license, named after the section of the AEA that authorizes the NRC to grant licenses for commercial reactors.[8]
- Non-power reactors are licensed under a Class 104 license, based on the section of the AEA that authorizes the NRC to grant licenses for reactors used for medical therapy and for research and development.[9]

The main difference between the two classes of licenses is rooted in Congress's directives in the AEA to facilitate the development and deployment of research and test reactors. For research and test reactors licensed under Section 104(c) of the AEA, Congress directs the Commission to:

> "…impose only such minimum amount of regulation of the licensee as the Commission finds will permit the Commission to fulfill its obligations under this Act to promote the common defense and security and to

[5] Commercial operation is defined by spending more than 50% of annual operating costs on the production and sale of energy or by spending more than 75% of annual operating on the production and sale of non-energy services, energy, or a combination of non-energy services and energy. Any reactor that exceeds either of these expenditure test must be classified as a commercial reactor. (Section 104 c. of the Atomic Energy Act of 1954 (42 9 U.S.C. 2134(c)))
[6] Backgrounder On Research and Test Reactors | NRC.gov
[7] Radiotherapy, used in this context, specifically pertains to external beam therapy and does not include isotope production.
[8] Section 103 of the Atomic Energy Act of 1954 (42 U.S.C. 2134(c))
[9] Section 104 of the Atomic Energy Act of 1954 (42 U.S.C. 2134(c))

protect the health and safety of the public and will permit the conduct of widespread and diverse research and development."[10]

This differentiation in the authorizing language of the AEA creates two parallel but distinct pathways for reactor licensing. While they adhere to the same regulatory standards for public health and safety, Class 104 reactors are subject to different regulatory requirements and guidance that are intended to enable licensing for medical therapy and research and development reactors.[11]

Light Water Reactors and Non-Light Water Reactors

Nuclear reactors in the United States are also typically classified into two categories based on their technology and design: light water reactors and non-light water reactors.

Light water reactors (LWRs) use highly purified water (H_2O) as a coolant to remove heat created by fission reactions in the nuclear fuel. This heat is then used to generate steam, which drives turbines to produce electricity. Currently, all operating power reactors in the U.S. are LWRs. As of 2024, there are 94 LWRs providing nearly 20% of U.S. electricity. Over the past half-century, the licensing and regulatory system for power reactors in the U.S. has evolved and been optimized for the predictable licensing of large LWRs, each producing hundreds of megawatts to gigawatts of electrical power.

Non-light water reactors (non-LWRs) use alternative coolants to remove heat generated by fission reactions. This heat can be used to produce steam for turbines, directly drive turbines, or provide heat for industrial applications. Examples of coolants proposed for non-LWRs include helium gas, liquid metallic sodium, molten salts (e.g., fluoride lithium beryllium salt or FLiBe), and solid heat pipes filled with alkali metals (e.g., sodium, potassium). Between 1950 and 1990, several commercial non-LWR power reactors were licensed and operated in the U.S. However, as of 2024, only small non-power reactors using non-LWR designs are in operation.[12] At least a dozen private companies have begun pre-application or application engagement with the NRC on non-LWR designs.[13]

These alternative coolants have different physical and thermodynamic properties than water, enabling new reactor designs with improved economic, operational, and safety characteristics. Advances in reactor design and analysis have also led to the

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[10] Section 104 of the Atomic Energy Act of 1954 (42 U.S.C. 2134(c)).

[11] For example, NRC guidance for the review of applications for power reactors is provided in NUREG-0800 while NRC guidance for the preparation and review of applications for non-power reactors is provided in NUREG-1537.

[12] Examples of non-LWR reactors in the United States include the Peach Bottom Atomic Power Station Unit 1 (helium cooled), Fort St. Vrain Nuclear Power Plant (helium cooled), Hallam Nuclear Power Facility (sodium cooled), Enrico Fermi Nuclear Generating Station Unit 1 (sodium cooled), and the Piqua Nuclear Generating Station (organic oil cooled).

[13] Pre-Application Activities | NRC.gov

development of new LWR reactor designs that offer enhanced features compared to existing LWR power reactors. While non-LWRs are often described as "advanced reactors," the term "advanced reactor" is used inconsistently in reactor licensing due to slightly different definitions provided by Congress and the NRC. These differing definitions result in different regulatory review processes for LWR and non-LWR designs.

The term "advanced nuclear reactor" is defined by Congress for regulatory purposes in the Nuclear Energy Innovation and Modernization Act (NEIMA) as any nuclear reactor (including both non-LWRs and LWRs) with improved economic, operational, and safety characteristics compared to reactors that were operating or under construction in 2019.[14] This definition clearly indicates that both LWR and non-LWR technologies can be considered advanced reactors if they meet the other criteria. However, the NRC generally limits the definition of advanced reactors to non-LWR technologies.[15] This distinction is largely based on the differing challenges associated with the licensing and regulation of LWR versus non-LWR technology.

LWRs classified as advanced reactors under NEIMA are more likely to resemble existing NRC-licensed LWRs than non-LWRs, particularly in terms of design, operating experience, and the applicability of current regulations and guidance. NRC staff are therefore leveraging much of the existing regulatory guidance for LWRs as a starting point for reviews of LWRs that could be classified under NEIMA as advanced reactors. As a result, while both LWR and non-LWR designs can be defined as advanced reactors under NEIMA, the NRC's definition of advanced reactors generally applies only to non-LWR designs unless otherwise specified. The implications and implementation of this regulatory distinction are discussed further below.

Prototype, Demonstration, and First-of-a-Kind Reactors

The development and commercialization of any new nuclear reactor technology inherently requires the construction and operation of an initial commercial reactor. Several terms are commonly used to describe this initial reactor, including demonstration reactors, first-of-a-kind (FOAK) reactors, and prototype reactors. Although these terms are often used interchangeably, they can have different implications for licensing and regulation.

The terms "demonstration reactor" and "FOAK reactor" do not have any specific regulatory implications. Both demonstration reactors and FOAK reactors would be licensed under either a Class 103 or Class 104 license, depending on the applicant's proposed use of the reactor. If a reactor design or technology is new, preparing a complete safety analysis may be more challenging for the applicant due to limited operating or testing experience. However, the regulatory standards and requirements

[14] Text - S.512 - 115th Congress (2017-2018): An act to modernize the regulation of nuclear energy
[15] Advanced Reactors (non-LWR designs) | NRC.gov

for a reactor described as a "demonstration" or "FOAK" reactor are the same as those for a more mature or commercially standardized reactor technology.

The term "prototype reactor" has specific implications for the regulatory process. A prototype plant is defined as "a nuclear reactor that is used to test design features" that cannot be adequately demonstrated through analysis alone.[16] The NRC requires any Class 103 reactor that "differs significantly from light-water reactor designs licensed before 1997, or uses simplified, inherent, passive, or other innovative means to accomplish its safety functions" to provide additional demonstration of safety features based on "analysis, appropriate test programs, experience, or a combination thereof" across a wide range of design conditions.[17]

However, an applicant can choose to test and demonstrate novel safety features using a prototype reactor instead of relying solely on analysis, test programs, or operational experience. The prototype reactor "is similar to a first-of-a-kind or standard plant design in all features and size but may include additional safety features to protect the public and the plant staff from the possible consequences of accidents during the testing period."[18] A Class 103 license for a prototype may include "additional requirements on siting, safety features, or operational conditions" to ensure public and worker safety during testing. The prototype reactor pathway allows the deployment of a novel nuclear reactor under a Class 103 license.[19] Alternatively, the applicant could choose to use a Class 104 licensed research and test reactor to demonstrate the safety and design features of a novel design. However, a Class 104 reactor cannot be operated as a commercial power reactor.

Licensing Organization Based on Reactor Characteristics

The licensing and regulation of nuclear reactors at the NRC are overseen by the Office of Nuclear Reactor Regulation (NRR). NRR is "responsible for accomplishing key components of the NRC's nuclear reactor safety mission" and focuses on regulatory areas such as licensing, operational oversight, and rulemaking.[20] The NRC separates its licensing, oversight, and regulation activities for light-water power reactors from those for advanced, non-light-water power reactors and all non-power reactors.

The Division of New and Renewed Licenses (DNRL) is responsible for the licensing of all Class 103 LWRs. This includes both the relicensing of existing commercial LWRs and the initial licensing of new LWR designs (e.g., the Westinghouse *AP1000*, Westinghouse *AP300*, Holtec *SMR 300*, GEH *BWRX-300*, and NuScale *VOYGR)*.

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[16] 10 CFR 50.2 Domestic Licensing of Production and Utilization Facilities | Definitions
[17] 10 CFR 50.43(e) Domestic Licensing of Production and Utilization Facilities | Additional standards and provisions affecting class 103 licenses and certifications for commercial power.
[18] 10 CFR 50.2 Domestic Licensing of Production and Utilization Facilities | Definitions
[19] Ibid.
[20] Nuclear Reactor Regulation | NRC.gov

The Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU) is responsible for the licensing of any Class 103 non-light water advanced reactors and all Class 104 reactors. This division handles reactors not licensed by DNRL, which can include commercial non-LWRs, medical, research, and test reactors. Examples of reactors licensed by DANU include the TerraPower *Natrium*, X-energy *Xe-100*, Kairos Power *Hermes* and *Hermes 2*, and Abilene Christian University *Molten Salt Research Reactor (MSRR)*.

III. Current Licensing Pathways

Nuclear reactors in the United States can be licensed through two primary pathways: 10 CFR Part 50 and 10 CFR Part 52. Part 50 allows for a two-step process involving a construction permit followed by an operating license, while Part 52 offers a combined license (COL) approach that includes both construction and operation approvals in a single step. Each application submitted to the NRC is subject to comprehensive safety, environmental, financial, and legal reviews. Below is an overview of these critical areas, followed by a step-by-step explanation of the Part 50 and Part 52 processes.[21]

For information on predicted advanced reactor stakeholder engagements with the NRC, see [Expected Advanced Reactor Engagement with the U.S. Nuclear Regulatory Commission in FY25].

Overview of NRC Licensing Process

While the specifics of the NRC licensing process differ depending on the specific regulatory activity, nearly all major regulatory activities follow the same general steps for review and approval. Figure 1 illustrates this general licensing process. Each major step is described in detail in the following sections.

Pre-Application Process

The NRC pre-application process[22] is designed to optimize the licensing review process for reactor developers by encouraging early, robust engagement that allows for early identification and resolution of technical and policy issues. The pre-application process enables applicants to provide “information or to solicit feedback on testing programs, safety analysis approaches, or the overall feasibility of licensing a design,”[23] to help enhance regulatory predictability and expedite subsequent application reviews.

[21] The NRC was directed by NEIMA in 2019 to create an additional licensing pathway for advanced reactors, termed 10 CFR Part 53. The NRC staff has been developing the new rule since 2020 and a proposed draft rule for 10 CFR Part 53 is expected in October 2024. The 10 CFR Part 53 licensing pathway is not discussed further in this paper since it is not available for use. Additional information on the 10 CFR Part 53 rulemaking process can be found on the NRC Part 53 rulemaking webpage.

[22] Pre-Application Activities | NRC.gov

[23] A Regulatory Review Roadmap for Non-Light Water Reactors | NRC.gov

The value of pre-application activities – whether in reducing the overall duration of the licensing process or minimizing regulatory risks – depends on several factors. These include timely responses by applicants to NRC staff's requests for additional information (RAIs) during the pre-application period, a mature design that enables meaningful and focused engagement with NRC staff, and the absence of significant design modifications or application changes between the pre-application and application phases.

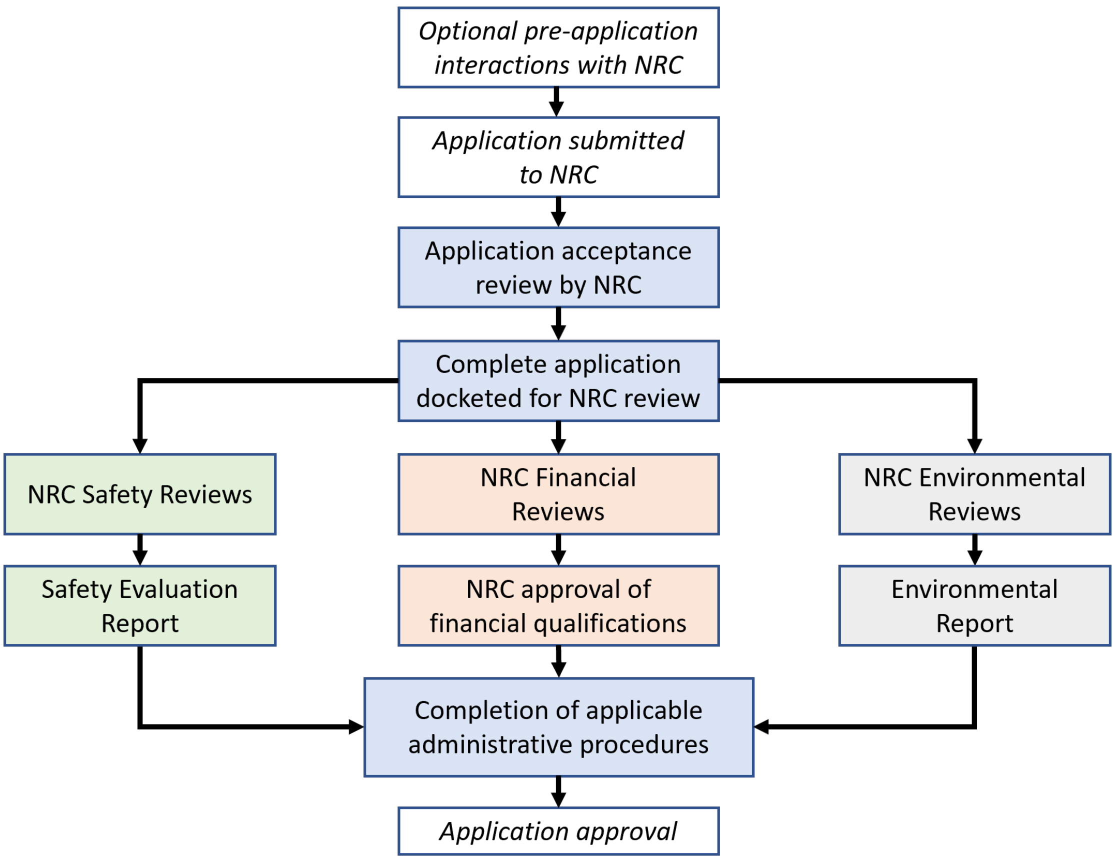

Figure 1. Typical NRC Licensing Review Process

Pre-application engagement involves several types of activities, including submission of topical reports and the use of white papers, audits, and meetings. Topical reports cover critical issues, such as principal design criteria, licensing basis event selection, fuel qualification plans, source term methodologies, quality assurance programs, safeguards information, and safety and accident analysis methodologies. These reports result in formal, definitive safety findings by the NRC that can be later referenced in the application process. Meanwhile, technical papers, white papers, application audits, and informational meetings offer opportunities for feedback on the application process and help maintain awareness and two-way communication between the applicant and the NRC staff regarding progress on topics like probabilistic risk assessment, regulatory gap analysis, policy issues, and environmental analysis and reviews.

The final key activity in the NRC pre-application process is the pre-application readiness assessment,[24] which is most beneficial when conducted approximately six months prior to the intended application submission date. During this assessment, the applicant provides NRC staff with the most current drafts of their safety analysis report, environmental report, referenced technical documentation, and information about their staff and contractors. This allows NRC staff to offer focused feedback on significant issues or gaps in the application that should be addressed before submitting the final version for review and docketing. While the pre-application readiness assessment is not mandatory, it can offer valuable insights, particularly for new designs or first-time applicants. It also reduces the likelihood of an application being denied or delayed during the docketing process due to information gaps.

In summary, early, comprehensive, and frequent engagement during the pre-application process can help ensure an efficient NRC review and more timely licensing.

Acceptance Review and Docketing

The acceptance review marks the initial phase of the NRC's evaluation of a nuclear reactor license application. During this stage, the NRC staff conducts a preliminary review to verify that the application includes all necessary information to begin a detailed evaluation. This step verifies that the application meets minimum regulatory standards and provides sufficient detail for further review. If the application is deemed incomplete, the NRC may issue a request for supplementary information (RSI) [25] to the applicant or deny the application, providing justification for its decision.[26] Once the application is deemed complete, it is officially docketed and entered into the NRC's public system, marking the formal start of licensing review. A notice of hearing is issued promptly upon docketing, informing the public about the commencement of the licensing proceedings and inviting public input or contestation to the application and review process.

Safety Review

The NRC conducts a detailed safety review for each reactor application to assess whether the proposed reactor design and operation align with its mission to "provide reasonable assurance of adequate protection of public health and safety."[27] After reviewing the applicant's preliminary and final Safety Analysis Reports (SARs), the NRC prepares preliminary and final Safety Evaluation Reports (SERs) to ensure the applicant meets rigorous safety standards. This review includes an evaluation of site

[24] Preapplication Readiness Assessment | ML20104B698 | NRC.gov

[25] 10 CFR 2.102 Agency Rules of Practice and Procedure | Administrative review of application.

[26] 10 CFR 2.108 Agency Rules of Practice and Procedure | Denial of application for failure to supply information.

[27] NRC Mission Statement

characteristics, accident mitigation strategies, and radioactive waste management plans, among other factors.

If NRC staff require additional information to make a fully informed, technically accurate, and legally defensible regulatory decision, they may issue RAIs[28] during their review of the applicant's SAR and preparation of the SER. RAIs allow staff to request information not included in the initial application, not available in previous docketed correspondence, or that cannot reasonably be inferred from the provided materials. RAIs may result in revisions to the application to address NRC staff questions and ensure a complete licensing basis. However, one challenge with the RAI process is that it can lead to lengthy back-and-forth interactions, particularly if there is a misunderstanding about the intent of the RAIs.[29]

Applicants and NRC staff may alternatively decide to conduct a regulatory audit to provide additional information and context for application review in lieu of, or in addition to, an RAI.[30] During a regulatory audit, the applicant and NRC staff together define a scope for reviewing materials outside of the docketed application. This enables the NRC staff to "gain understanding, verify information, and identify information" that is needed to support the application review.[31] Following documentation and completion of the audit, the applicant may voluntarily submit additional information to the docket to support NRC staff reviews, coordinate with NRC staff on an RAI to add information to the docket, or issue a revision to the text of the application to provide needed context or information. The audit process, when used appropriately, can reduce licensing time and costs, while making the RAI process more efficient for NRC staff reviewing new reactor applications.[32]

While the safety review is primarily the responsibility of the NRC staff, their findings are independently evaluated by the Advisory Committee on Reactor Safeguards (ACRS).[33] The ACRS is an independent, Commission-appointed, expert panel that reviews both applicant and NRC staff's work and provides public reports directly to the Commission.[34]

Environmental Review

Under the National Environmental Policy Act (NEPA), federal agencies are required to evaluate and document the impacts of proposed major federal actions on the human environment.[35] Under NEPA, issuance of an NRC license to construct and operate a

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28 LIC-115, Revision 1 Processing Requests for Additional Information | NRC.gov
29 NRC Staff Lessons Learned Report for the Review of NuScale SMR Design Certification Application
30 LIC-111, Revision 1 Regulatory Audits | NRC.gov
31 NRC Staff Lessons Learned Report for the Review of NuScale SMR Design Certification Application
32 Promoting Efficient NRC Advanced Reactor Licensing Reviews to Enable Rapid Decarbonization | NIA
33 ACRS History | NRC.gov
34 Advisory Committee on Reactor Safeguards | NRC.gov
35 National Environmental Policy Act at the NRC | NRC.gov

nuclear reactor is considered a major federal action.[36] NEPA allows federal agencies to prepare one of three different levels of review (in increasing level of detail) to complete the required evaluation[37]:

- Categorical exclusion (CATEXs): Classifies a federal action as falling under previous evaluations by an agency, which determined it would not have an individual or cumulative significant effect on the human environment.
- Environmental assessment (EA): A project-specific assessment of the potential environmental effects of a project on the human environment.
- Environmental impact statement (EIS): A more detailed, project-specific evaluation and documentation of environmental effects.

The NRC implements NEPA through regulations in 10 CFR Part 51, which outlines the administrative procedures for various NRC licensing activities.[38] Under these regulations, the NRC is typically required to prepare an EIS for all nuclear reactor applications.

Recently, the NRC has begun exploring alternative NEPA review processes for certain new nuclear reactor applications. In 2023, the NRC staff decided to prepare an EA for the Kairos *Hermes 2* construction permit application instead of an EIS, based on the staff experience with the *Hermes* construction permit EIS.[39] The EA, completed in September 2024, resulted in a "Finding No Significant Impact" (FONSI), satisfying the NEPA statutory requirements.[40] Using an EA instead of an EIS significantly reduced both the cost and duration of the NEPA review for *Hermes 2* compared to the *Hermes* project. Since an EIS had already been conducted for the original *Hermes* project, the NRC determined that a full EIS was not necessary for *Hermes 2*, allowing for a more efficient and cost-effective NEPA review, marking a significant regulatory adaptation. However, this approach has not yet been applied to commercial power reactor licenses and still requires a regulatory exemption from the NRC. Without such an exemption, all new reactor license applications will continue to require preparation of an EIS to meet NEPA requirements.[41]

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[36] 10 CFR 51.20 Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions | Criteria for and identification of licensing and regulatory actions requiring environmental impact statements.
[37] A Citizen's Guide to NEPA | doe.gov
[38] 10 CFR Part 51 Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions
[39] SECY-23-0080: Environmental Review Approach for the Kairos Power, LLC Hermes 2 Construction Permit Application | NRC.gov
[40] Federal Register: Kairos Power, LLC; Hermes 2; Environmental Assessment, Finding of No Significant Impact, and Exemptions
[41] 10 CFR 51.20 Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions | Criteria for and identification of licensing and regulatory actions requiring environmental impact statements.

In addition to these efforts, the NRC is developing the New Nuclear Reactor Generic Environmental Impact Statement (NR GEIS),[42] proposed in 2024. The proposed NR GEIS is designed to make the NEPA review process more efficient for new advanced nuclear reactors, including small modular reactors, non-light-water reactors, and microreactors. By using a "technology-neutral, performance-based approach,"[43] the NR GEIS will reduce the need for site-specific EISs for each project, allowing for a more efficient and standardized NEPA review process. This initiative is one part of the NRC's broader modernization efforts to support the timely deployment of new reactor technologies.

NRC staff may continue to evaluate the use of EA instead of EIS for future new reactor applications, especially for small reactors or microreactors.[44] In the future, it may be possible to utilize a CATEX for new reactor environmental reviews under NEPA, which would further streamline the environmental review process for projects with minimal environmental impacts. These changes would facilitate faster, less burdensome regulatory approvals, particularly for microreactors, but would require additional regulatory study and rulemaking.

Financial Review

The NRC assesses the financial qualifications of the applicant to ensure that they can fund the construction, operation, and eventual decommissioning of the facility. Applicants must demonstrate that they have the necessary financial resources to cover these costs.[45, 46] This review includes the evaluation of financial statements, funding sources, and long-term financial projections.

Administrative Review and Procedures

Following the completion of the safety, environmental, and financial reviews, several administrative steps must be completed by the NRC before issuing a license. These steps include "mandatory hearings" on new reactor applications, opportunities for public intervention through "contested hearings," and a final Commission vote on the new reactor application.

Mandatory Hearings

The NRC is required by the AEA to conduct a "mandatory hearing" for each reactor application and uranium enrichment facility license, as mandated under AEA Section 189a.(1)(A). These hearings occur after the NRC staff has completed its review of the safety, environmental, and financial aspects of a new reactor application. Mandatory

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[42] New Nuclear Reactor Generic Environmental Impact Statement (NR GEIS) | NRC.gov
[43] Ibid.
[44] U.S. Nuclear Regulatory Commission Draft White Paper on Micro-Reactor Licensing Approach | NRC.gov
[45] 10 CFR 50.33 Domestic Licensing of Production and Utilization Facilities | Contents of applications; general information.
[46] 10 CFR 50.75 Domestic Licensing of Production and Utilization Facilities | Reporting and recordkeeping for decommissioning planning.

hearings are required for all Construction Permit and Combined License applications submitted to the NRC.

Unlike public meetings, only the NRC staff, the applicant, and the Commission actively participate in mandatory hearings.[47] These hearings are open to public observation, but direct public participation is not allowed, although written comments may be submitted. During the mandatory hearing, the NRC staff and the applicant present extensive written and oral evidence, and the Commission conducts the proceedings. NRC's implementation of mandatory hearings has faced criticism for being outdated and resource-intensive, which can prolong the licensing process and increase costs without significantly enhancing transparency or public safety.[48, 49, 50]

In July 2024, the Commission voted to reform this process by eliminating oral arguments and moving to a simplified review of written records.[51] The new format involves submitting the final safety evaluation or environmental assessment by the NRC staff, followed by a period during which States, local government bodies, and federally recognized Indian Tribes can file written statements for Commission consideration and additional questions. Following opportunities for the Commission questions on the written statements and submission of written responses, the Commission will submit written votes. [52] This change is expected to reduce the duration of the mandatory hearing process from approximately four months to eight weeks.[53]

Contested Hearings

The nuclear reactor licensing process allows for public participation through contested hearings, where the public can challenge the review of new reactor applications. The Atomic Safety and Licensing Board Panel (ASLB),[54] composed of judges with technical or legal expertise, oversees these licensing and regulatory hearings as directed by the Commission.[55] The typical configuration for the ASLB in any given case includes a legal judge who serves as the chair, and two technical

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[47] Improving the Efficiency of NRC Power Reactor Licensing: The 1957 Mandatory Hearing Reconsidered, Center on Global Energy Policy

[48] 10 CFR 50.33 Domestic Licensing of Production and Utilization Facilities | Contents of applications; general information.

[49] Enabling High Volume Licensing of Advanced Nuclear Energy | NIA (nuclearinnovationalliance.org)

[50] Recommendations to Improve the Nuclear Regulatory Commission Reactor Licensing and Approval Process | INL.gov

[51] SRM-SECY-24-0032: Revisiting the Mandatory Hearing Process at the U.S. Nuclear Regulatory Commission | NRC.gov

[52] SECY-24-0032: Revisiting the Mandatory Hearing Process at the U.S. Nuclear Regulatory Commission | NRC.gov

[53] Ibid.

[54] Atomic Safety and Licensing Board Panel | NRC.gov

[55] The ASLB may include Administrative Law Judges (ALJs); however, ALJs have not typically participated in ASLB proceedings since the 1980s.

judges. Contested hearings may be convened for both safety and environmental reviews after NRC staff have completed their reviews and reported on their findings.

During the contested hearing process, participants[56] such as interested members of the public, non-governmental organizations, state and local governments, and other federal agencies can raise specific contentions about the safety, security, or environmental aspects of the proposed project. To participate, individuals or organizations must submit a petition to intervene - to present evidence or challenge aspects of the application - or to request a hearing. The latter option does not necessarily involve direct intervention, but still allows for participation by presenting comments or concerns. The petition must outline their concerns, specify the contentions they wish to raise, and demonstrate how their interests may be affected by the proposed nuclear licensing activity. The ASLB initially evaluates these contentions to determine whether they warrant further examination during the hearing process. Decisions made by the ASLB can be appealed to the Commission, which then reviews the case in its adjudicatory capacity.

Hearing Processes

Public hearings vary in format. While historically termed 'formal hearings,' most licensing hearings follow the NRC's internal informal hearing procedures,[57] which involve presentations by expert witnesses and inquiries from the involved parties. Traditional cross-examination is rare, and hearings may consist primarily of written submissions and limited oral statements. The NRC's Office of the General Counsel (OGC)[58] provides legal representation and guidance to NRC staff, ensuring legal compliance, and creates documents and findings. Some OGC staff, separate from those participating in hearings, may advise the Commission on appeals, a function generally performed by the Office of Commission Appellate Adjudication.

Commission Vote and Approval

Once the NRC staff has completed its technical, safety, and environmental reviews, as well as all applicable hearings, the Commission votes on whether to grant the license. The Commission considers all input, including the final safety evaluation report (SER), the environmental review documentation, and public comments or hearings. The final decision to approve or deny the application is based on whether the proposed reactor can operate safely and in compliance with NRC regulations. If the Commission approves the license, it may include conditions or additional requirements to ensure ongoing safety and regulatory compliance during construction and operation.

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[56] Public Involvement in NRC Hearings | NRC.gov

[57] 10 CFR 2 Subpart L Agency Rules of Practice and Procedure | Simplified Hearing Procedures for NRC Adjudications

[58] The Office of the General Counsel | NRC.gov

10 CFR Part 50

Part 50 is the original, stepwise licensing process for nuclear reactors, consisting of two key stages: the Construction Permit (CP), which authorizes the construction of a nuclear power plant at a specific site, and the Operating License (OL), which authorizes the plant's operation. Both Class 103 and 104 reactors can be licensed under Part 50. This process was the first licensing process developed for commercial nuclear reactors and was used to license 92 of the 94 commercial power reactors currently operating in the U.S.

Since the NRC follows a similar process for multiple regulatory actions, descriptions for specific steps are omitted when they are repeated across the licensing pathways below.

Stage 1: Construction Permit Application

To obtain a CP, the applicant must first submit a complete construction permit application (CPA). A complete application[59] consists of:

1. Preliminary Safety Analysis Report (PSAR)

   The applicant must submit a PSAR that provides detailed descriptions of the proposed reactor design, safety features, and site characteristics. This report includes an analysis of potential accident scenarios, emergency response plans, and the measures in place to protect public health and safety. The NRC staff reviews this report to determine whether the proposed design meets regulatory requirements and whether the reactor can be constructed safely at the proposed site.

2. Preliminary Environmental Report

   The applicant must also submit an environmental report that assesses the potential environmental impacts of the proposed reactor construction and operation. This report evaluates factors such as land use, water resources, air quality, and ecological impacts. Additionally, the applicant must describe the primary objectives of the project, explain its necessity, and provide an analysis of power needs and energy alternatives.

3. Preliminary Financial Information

   The applicant must demonstrate that they possess, or have reasonable assurance of obtaining, the funds necessary to cover the estimated costs of constructing the facility and related fuel cycle costs. The application must include estimates of the

[59] 10 CFR 50.30, 50.33, 50.34 Domestic Licensing of Production and Utilization Facilities | Filing of application; oath or affirmation Contents of applications; general information. Contents of applications; technical information.

total construction costs and related fuel cycle costs and identify the source(s) of funds to cover these costs.[60]

In addition to demonstrating financial capability, the applicant must provide[61] the name and address of the applicant, a description of their business or occupation, and relevant citizenship details. For corporations or associations, the state of incorporation, business location, and the names and citizenship of directors and officers must be included, as well as any foreign ownership. If acting as a representative, the principal's information must be provided. The application must also specify the license class, intended facility use, duration, and any other licenses issued or applied for.

4. Other Supporting Documents

   The applicant will submit other supporting documents as required by the NRC. These could include supporting calculations, site assessments, or specific documents addressing unique aspects of the project. The NRC uses these additional documents to address any specific regulatory requirements or project details that are not covered by the primary reports.

Within 30 days of receiving a complete application, the NRC will complete the acceptance review process for the CPA. This process involves the NRC staff reviewing the technical completeness of the CPA and issuing a public notification of its receipt.[62] If the application is complete and accepted for review, the NRC staff will begin their technical, financial, and environmental reviews of the application. The review process will result in:

5. Preliminary Safety Evaluation Report (PSER)

   After thoroughly reviewing the PSAR, the NRC prepares a preliminary Safety Evaluation Report (SER). This document summarizes the NRC's findings regarding the reactor's safety features, the adequacy of the proposed design, and the suitability of the site. The SER assesses the applicant's compliance with regulatory requirements and evaluates whether the reactor can be constructed and operated safely.

6. Draft Environmental Impact Statement (or Assessment)

   Concurrently, the NRC completes its review of the environmental report and issues a draft Environmental Impact Statement (EIS) or Environmental Assessment (EA), the latter being less extensive. The EIS or EA assesses the environmental impacts of the proposed reactor and outlines any necessary mitigation measures. It

[60] 10 CFR 50.33 Domestic Licensing of Production and Utilization Facilities | Contents of applications; general information.

[61] Ibid.

[62] 10 CFR 2.101 Agency Rules of Practice and Procedure Subpart A | Procedure for Issuance, Amendment, Transfer, or Renewal of a License, and Standard Design Approval | Filing of application.

ensures that all environmental aspects of the project have been thoroughly evaluated and that the potential impacts remain within acceptable limits.

7. Assurance of Financial Capability

   The NRC reviews the applicant's financial information to confirm that the applicant has the necessary financial resources to fund the construction and operation of the reactor. This step involves verifying the applicant's financial statements, funding sources, and long-term financial projections. The NRC ensures that the project is financially viable and that sufficient financial safeguards are in place to support the successful completion and operation of the reactor.

In the process of completing these documents, the NRC will:

8. Convene public meetings on safety and environmental reviews.

   As part of the licensing process, the NRC holds public meetings to discuss both the safety and environmental reviews. These meetings provide an opportunity for stakeholders — including local communities, environmental groups, and state and local governments — to offer input. Feedback from these meetings is considered in the NRC staff's reviews on all aspects of the project. Public meetings for the environmental reviews are explicitly required under NEPA. Public participation ensures that diverse perspectives are considered, helping to identify any environmental concerns that may not have been addressed in the initial report.

9. Complete safety reviews.

   The NRC staff conducts a comprehensive review of the PSAR and produces the SER. The ACRS then independently reviews the scope of the PSAR and the staff's SER, evaluating the proposed reactor's design and construction for safety and compliance with regulatory requirements. ACRS meetings are open to the public, and the committee may allow for public comments. However, this is not equivalent to the mandatory hearing process, as described in the administrative review section.

After the NRC completes the above steps, it will:

10. Complete administrative review of the CP.

    After the public intervention period, resolution of contested hearings, and completion of staff reviews, the NRC Commission conducts the mandatory hearing. If the NRC determines that the reactor can be constructed safely, all regulatory requirements have been met, and that the applicant has the financial and technical qualifications to complete the project, the Commission will approve issuance of the Construction Permit.

    The CP authorizes the applicant to begin construction of the reactor but does not permit its operation. It includes specific conditions and requirements that must be adhered to during construction to ensure safety and regulatory compliance.

The CP is valid for a period specified in the permit, not exceeding 40 years from the date of issuance.[63] If construction has not begun within this period, the permit may expire unless the applicant applies for and is granted an extension.

Stage 2: Operating License (OL) Application

Once the construction of the nuclear reactor is substantially complete, the applicant submits the Operating License Application (OLA), which contains the following:

1. Final Safety Analysis Report (FSAR)

   The FSAR provides detailed information on the as-built facility, including a description of its structures, systems, and components, as well as safety analyses.[64] It builds upon the Preliminary Safety Analysis Report (PSAR) submitted during the Construction Permit (CP) phase and includes:

   - Facility Description and Design Bases: Detailed information describing the as-built facility's structures, systems, and components, with an emphasis on performance requirements and technical justifications. This includes the reactor core, reactor coolant system, instrumentation and control systems, electrical systems, containment system, other engineered safety features, auxiliary and emergency systems, power conversion systems, and radioactive waste handling systems.
   - Final Safety Analyses: Detailed assessments of the reactor's safety systems and components, reflecting any design changes or modifications made during construction. This includes analyses of potential accident scenarios, system redundancies, and safety systems designed to prevent and mitigate incidents.
   - Operational Procedures: A description of the applicant's plans for the conduct of normal operations, including maintenance, surveillance, and periodic testing of structures, systems, and components, as well as preoperational testing and initial operations.
   - Organizational Structure: A description of the applicant's organizational structure, allocation of responsibilities and authorities, and personnel qualification requirements to ensure the safe operation of the facility.
   - Emergency Preparedness Plans: Detailed strategies outlining the response to various emergency situations, including evacuation plans, communication protocols, and coordination with local and federal emergency services.
   - Radiation Protection and Effluent Controls: Detailed plans for monitoring and controlling radiation exposure to workers and the public. This includes shielding designs, monitoring systems, and methods to control radioactive

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[63] 10 CFR 50.51(a) Domestic Licensing of Production and Utilization Facilities | Continuation of license.

[64] 10 CFR 50.34(b) Domestic Licensing of Production and Utilization Facilities | Contents of applications; technical information.

effluents and maintain radiation exposures within the limits set forth in 10 CFR Part 20.
- Security Plans: Robust measures to protect the facility against threats such as sabotage, theft of nuclear materials, and cyber-attacks, ensuring the physical and informational security of the reactor.

2. Environmental Report

The completed environmental report provides an updated and thorough assessment of the environmental impacts associated with the operation of the reactor.[65] Building upon the environmental report submitted during the CP phase, the environmental report includes:

- Description of the Proposed Action: A detailed description of the reactor's operation and the purpose of the proposed action.
- As-Built Environmental Impact Analysis: An analysis of the environmental impacts of the proposed action, including any adverse environmental effects that cannot be avoided should the proposal be implemented. This includes effects on air and water quality, ecosystems, and wildlife, with impacts discussed in proportion to their significance.
- Alternatives to the Proposed Action: A discussion of reasonable alternatives to the proposed action, including the environmental impacts of these alternatives, which could be implemented to mitigate or avoid adverse environmental impacts.
- Irreversible and Irretrievable Commitments of Resources: A description of any irreversible and irretrievable commitments of resources that would be involved in the proposed action, such as land use, water, or materials, should the reactor be operated.
- Short-term vs. Long-term Environmental Relationships: An analysis of the relationship between short-term uses of the environment, such as those during operational phases, and the maintenance or enhancement of long-term productivity.
- Status of Compliance with Environmental Regulations: A discussion of the status of compliance with applicable environmental quality standards and requirements, including federal permits, licenses, and other entitlements that must be obtained in connection with the proposed action. This includes compliance with water pollution limitations, land-use regulations, and any other environmental protection requirements set by federal, state, or local agencies.
- Cumulative Impact Analysis: An analysis of cumulative impacts that considers the combined environmental effects of the proposed reactor

[65] 10 CFR 51.45 Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions | Environmental report.

operation in conjunction with other facilities and preconstruction activities at the site.

- Mitigation Measures: A discussion of measures that would be taken to reduce or avoid adverse environmental effects. This includes plans for mitigation strategies to minimize or remediate potential impacts from reactor operation.

3. Completed Financial Information

   Building upon the preliminary financial information submitted with the construction permit application, the applicant must provide updated and detailed financial information to demonstrate reasonable assurance of obtaining the funds necessary to cover the costs of operating the reactor safely and responsibly.[66] This includes submitting detailed projections of the total annual operating costs for each of the first five years of operation, as well as identifying the sources of funds to cover these expenses.[67]

4. Active Construction Permit

   An active CP is essential for proceeding to the OL stage. The applicant must demonstrate:

   - Compliance with CP Conditions: All conditions and requirements specified in the original Construction Permit have been satisfactorily met, including adherence to approved designs, construction standards, and safety protocols.
   - Completion of Construction Milestones: The reactor construction has progressed to a stage where all essential structures, systems, and components are in place and functional in accordance with the approved specifications.
   - Documentation of Construction Activities: Comprehensive records and reports detailing the construction process, quality assurance measures, and any deviations or modifications from the original plans, along with justifications and approvals for such changes.

5. Technical Specifications

   The applicant must provide technical specifications, which define the operational limits and safety requirements necessary to ensure the safe operation of the reactor.[68] These specifications are derived from the safety analysis report and

[66] 10 CFR 50.33(f)(2) Domestic Licensing of Production and Utilization Facilities | Contents of applications; general information.

[67] For applicants seeking to renew or extend the operating license of a power reactor, this financial information is not required. However, applicants for nonpower reactor license renewals must include the same financial information required for an initial license.

[68] 10 CFR 50.36 Domestic Licensing of Production and Utilization Facilities | Technical specifications.

include key parameters that must be maintained to prevent accidents and ensure system reliability. These include:

- Safety Limits: Boundaries on important process variables that protect the integrity of critical safety barriers, such as the reactor coolant system, to prevent the uncontrolled release of radioactivity.
- Limiting Safety System Settings: Automatic protective device settings that ensure safety limits are not exceeded, initiating corrective actions when necessary.
- Limiting Conditions for Operation (LCOs): The minimum performance or functional capability required for systems and components essential to reactor safety. If these conditions are not met, the reactor must be shut down or other remedial actions must be taken.
- Surveillance Requirements: Procedures for testing, calibration, and inspections that ensure systems and components remain within safety limits and the LCOs are met.
- Design Features: Physical characteristics and construction materials of the reactor that impact safety and must remain unchanged unless explicitly approved by the NRC.
- Administrative Controls: Provisions for organizational management, procedures, and recordkeeping necessary to ensure the reactor operates safely, including reporting and audit requirements.

Within 30 days of receiving a complete application, the NRC will complete the acceptance review process for the OLA. This process involves the NRC staff reviewing the technical completeness of the OLA and issuing a public notification of its receipt.[69] If the application is complete and accepted for review, the NRC staff will begin their final technical, financial, and environmental reviews of the application. The review process will result in:

6. Safety Evaluation Report (SER)

   The SER is a detailed document prepared by the NRC that summarizes the review findings of the applicant's FSAR. Key components[70] of the SER include:

   - Technical Evaluation: A detailed assessment of the reactor's safety features, including design descriptions, safety system functionality, and responses to potential accident scenarios.
   - Compliance with Regulations: Verification that the reactor design and operational plans adhere to the regulations regarding safety margins, system redundancy, and passive safety features.

[69] 10 CFR 2.104 Agency Rules of Practice and Procedure Subpart A | Notice of a Hearing.
[70] Final Safety Evaluation Report Related to Certification of the AP600 Standard Design | ML19336A027 | NRC.gov

- Safety System Performance: Independent analyses of safety-critical systems like cooling, containment, and instrumentation, ensuring they meet NRC standards.
- Risk and Accident Analysis: Evaluation of potential accidents, including loss-of-coolant scenarios, shutdown safety, and radiation protection measures.
- Conclusions and Recommendations: A summary of the NRC's conclusions regarding the safety of the proposed reactor operations and any recommendations or conditions that should be applied to the Operating License.

7. Supplemental Environmental Impact Statement (or Assessment)

   The SEIS is a comprehensive document prepared by the NRC after the completion of the draft SEIS and public comment period. It incorporates the findings of the environmental review and public input.[71] The SEIS includes:

   - Responses to Public Comments: The NRC provides detailed responses to substantive comments on the draft EIS. This may involve modifications to the proposed action or alternatives, factual corrections, or explanations regarding why certain comments do not require further action.
   - Consideration of Alternatives: The SEIS discusses any modifications to alternatives, the development of new alternatives, or further evaluation of previously considered alternatives, based on public comments and new information.
   - Final Analysis: The document includes a final analysis of the environmental impacts, including an evaluation of the potential effects on air and water quality, ecosystems, and public health. This analysis is informed by the draft EIS and any updates made in response to comments.
   - Opposing Views: Any responsible, opposing views that were not adequately discussed in the draft EIS are presented and addressed.
   - Final Recommendations: The SEIS concludes with the NRC's final recommendation on the proposed action, including any conditions or mitigation measures that should be implemented to minimize adverse environmental impacts. The recommendations are informed by NEPA requirements and other relevant environmental laws and policies.

Alternatively, the supplemental EA would be less comprehensive and typically focuses on determining whether the proposed action would significantly affect the environment, thereby requiring the preparation of an SEIS. The supplemental EA is shorter, involves less detailed analyses, and does not require extensive public involvement or the detailed response to comments found in the SEIS.

In the process of completing these documents, the NRC will:

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[71] 10 CFR 51.91 Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions | Final environmental impact statement—contents.

8. Convene public meetings on the safety and environmental reviews.

   As part of the licensing process, the NRC holds public meetings to discuss both the safety and environmental reviews. These meetings provide an opportunity for stakeholders – including local communities, environmental groups, and state and local governments – to offer input. Feedback from these meetings is considered in the NRC staff's reviews on all aspects of the project. Public meetings for environmental reviews are explicitly required under NEPA. Public participation ensures that diverse perspectives are considered, helping to identify any environmental concerns that may not have been addressed in the initial report.

9. Complete safety reviews.

   The NRC staff conducts a comprehensive review of the PSAR and produces the SER. The ACRS then independently reviews the scope of the PSAR and the staff's SER for safety and compliance with regulatory requirements. ACRS meetings are open to the public, and the committee may allow for public comments. However, this is not equivalent to the mandatory hearing process, as described in the administrative review section.

After the NRC completes the above steps, it will:

10. Complete administrative review of the OLA.

    Following the public intervention period, resolution of contested hearings, and completion of staff reviews, the Commission will vote to issue the license. If the NRC determines that the reactor can be operated safely, that all regulatory requirements have been met, and that the applicant has the financial and technical qualifications to safely commission and operate the plant, the Commission will approve issuance of the OL. The OL includes specific conditions and requirements (technical specifications) that must be met during operation to ensure safety and compliance with regulations. The issuance of the OL is a significant milestone in the Part 50 process, marking the transition from construction to fuel loading, commissioning, and operation.

Like the CP, an OL is issued for a fixed period of time, not to exceed 40 years from the date of issuance.[55] The license duration can be based on the term requested by the applicant or the estimated lifetime of the facility, if the NRC determines that the facility's life is shorter than the requested term.

The Part 50 licensing process allows an applicant to begin construction with preliminary design information, rather than waiting for a finalized design. This two-step process provides flexibility by only requiring a preliminary safety review before construction begins and allowing design modifications during the construction phase so that the Operating License (OL) reflects the as-built plant. However, this sequential approach can introduce delays and uncertainties, as regulatory requirements may change during the construction phase, and legal challenges to the OL could lead to significant delays.

10 CFR Part 52

To address the potential challenges associated with the traditional Part 50 process, the NRC introduced Part 52 as an alternative, one-step licensing approach that integrates both construction and operation approvals into a single Combined License (COL). This approach was designed for completed and standardized plant designs, and was intended to reduce regulatory uncertainty, minimize the risk of mid-construction changes, and shorten the overall timeline for bringing new reactors online. Part 52 allows applicants to resolve key safety and environmental issues upfront, enabling a more predictable and efficient path for deployment of multiple reactors of a standardized design. The Part 52 pathway can only be used for Class 103 reactors.

The contents of a COL application are nearly identical to the required contents for an OLA. See descriptions in the 10 CFR Part 50 section above for details on the content of each report, analysis, or review mentioned below in the COL application process.

COL Application

Before starting construction of a nuclear reactor, an applicant is required to submit the following documents to obtain a COL:

1. Safety Analysis Report
2. Environmental Report
3. Financial Information
4. Technical Specifications

Meanwhile, NRC staff will review the application and provide:

5. Safety Evaluation Report
6. Environmental Impact Statement or Assessment
7. Assurance of Financial Capability

In the process of completing these documents, the NRC will:

8. Convene public meetings on the safety and environmental review.
9. Complete safety reviews with the ACRS.

After the NRC completes the above steps, it will:

10. Complete administrative review of the COL.

Again, the COL is issued for a fixed period of time, based on the term requested by the applicant or estimated lifetime of the facility, not to exceed 40 years from the date of issuance.[55]

Additional Regulatory Tools under Part 52

Part 52 offers additional tools[72] that are particularly useful for applicants seeking a more predictable and efficient path to reactor deployment. These tools allow applicants to address key regulatory requirements in phases, which can reduce the financial and schedule risks associated with reactor development. Below are detailed descriptions of these tools:

Early Site Permit (ESP)

The ESP allows applicants to obtain NRC approval of a site for a nuclear power plant before applying for a construction permit or combined license. The ESP process evaluates site safety, environmental protection, and emergency planning independent of a specific reactor design. This process allows applicants to resolve potential site-related issues early, securing a site for up to 20 years (with the possibility of a 20-year renewal) without committing to a specific reactor project. ESP holders can reference their permit in future applications, significantly streamlining the construction permit or combined license process by eliminating the need to reassess the site. The ESP process also includes public hearings.

Standard Design Certification (SDC)

The SDC or Design Certification (DC) process allows reactor developers to obtain NRC approval of a reactor design independent of a specific site or plant project. Once certified through a rulemaking process, the design is codified in the NRC's regulations and can be referenced by any applicant for a construction permit or combined license, thus avoiding the need for a site-specific review of the design. Certified designs are valid for 15 years and can be renewed. This regulatory tool not only enhances safety by promoting standardized designs but also reduces uncertainties and costs for future applicants by eliminating repetitive reviews for the same design. By referencing a certified design, an applicant for a COL can focus the review process on site-specific issues.

Standard Design Approval (SDA)

Similar to the SDC, the SDA or Design Approval (DA) provides NRC approval of a reactor design, but without the formal rulemaking process. The SDA is an NRC approval that allows the design to be referenced in construction permit, operating license, or combined license applications. While the design approval process does not confer the same regulatory certainty as a design certification, it still offers the advantage of reducing the time required for future licensing activities by pre-reviewing and approving portions of a design. An SDA does not expire and can be renewed, providing flexibility to reactor vendors and applicants. However, unlike design certifications, SDAs are not written into regulations, and applicants must

[72] A Regulatory Review Roadmap for Non-Light Water Reactors | ML17312B567 | NRC.gov

demonstrate in their applications that the design complies with all current regulatory requirements.

Manufacturing License

This tool allows applicants to receive NRC approval to manufacture and assemble major components of a reactor at a separate location before receiving a construction permit or combined license for the specific site where the reactor will be installed. A Manufacturing License is valid for up to 10 years and can be renewed. By securing a Manufacturing License, applicants can accelerate the deployment of new reactors by starting the production of key components ahead of the site-specific licensing process. This tool is especially useful for reactors that use modular components or designs intended to be replicated across multiple sites, as it allows for standardized manufacturing and quality control processes to be applied uniformly.

Limited Work Authorization (LWA)

An LWA allows applicants to begin certain construction-related activities before a full construction permit or combined license is issued. These activities include non-safety-related site preparation, such as excavation, clearing, grading, and installation of temporary construction infrastructure. An LWA is particularly beneficial in reducing construction delays by allowing applicants to prepare a site in advance of the full NRC approval for reactor construction. However, the applicant must provide sufficient environmental and safety information to support these activities, and the scope of work permitted under an LWA is carefully controlled to ensure it does not preempt the full licensing process. The LWA can expedite the overall project timeline by allowing early work while the final regulatory approvals are still being processed.

IV. Licensing Costs

In the United States, the substantial costs associated with obtaining a nuclear reactor license follow a structured framework. These costs include application review fees mandated by the NRC. Once the reactor is operating, it is subject to annual NRC operating fees.

Application Review Fees

Applicants are required to pay specific fees for the NRC's review of Construction Permit, Operating License, and Combined License applications. These fees cover the NRC’s costs related to pre-application activities, safety and environmental reviews, construction inspections, and other necessary evaluations to ensure compliance with regulatory requirements. Fees are charged on an hourly basis at $317 for Fiscal Year (FY) 2024[73] per professional staff hour. The total cost is contingent on the time required for the NRC to complete its review, which is influenced by the complexity, scope and duration of the review.

[73] § 170.20 Average Cost Per Professional Staff-hour. | NRC.gov

The NRC provides estimated NRC staff effort and costs for different types of applications based on historical data. [74] The estimate of NRC staff resources for different reviews is summarized in (Figure X) and the estimate of total costs billed to applicants (including both NRC Staff resources billing at $317 per hour and NRC contractors) is summarized in (Figure Y). For example, the NRC estimated that the average review of COL applications required 89,261 hours of NRC staff time and an additional $5.02 million in NRC contractor costs resulting in a total average COL review cost billed to applicants of $31.8 million. The NRC estimated that the average review of ESP applications required 29,104 hours of NRC staff time and additional $2.76 million in NRC contractor costs resulting in a total average ESP review cost billed to applicants of $11.5 million. Finally, the NRC estimated that the average review of design certifications applications required 179,395 hours of NRC staff time resulting in a total average DC review cost billed to applicants of $53.8 million.

These cost estimates are provided to help applicants plan and budget for the licensing process, though actual costs can vary, again, based on the quality of the application and the complexity of the review.

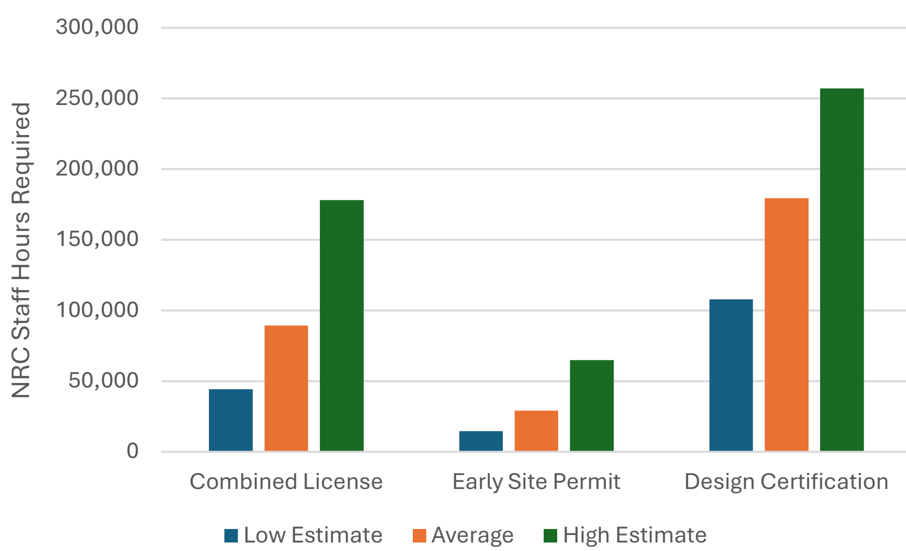

Figure X. Estimate of NRC Staff Hours Required for Licensing Reviews[75]

[74] New Reactors Business Line Fee Estimates (January 2023)
[75] New Reactors Business Line Fee Estimates (January 2023)

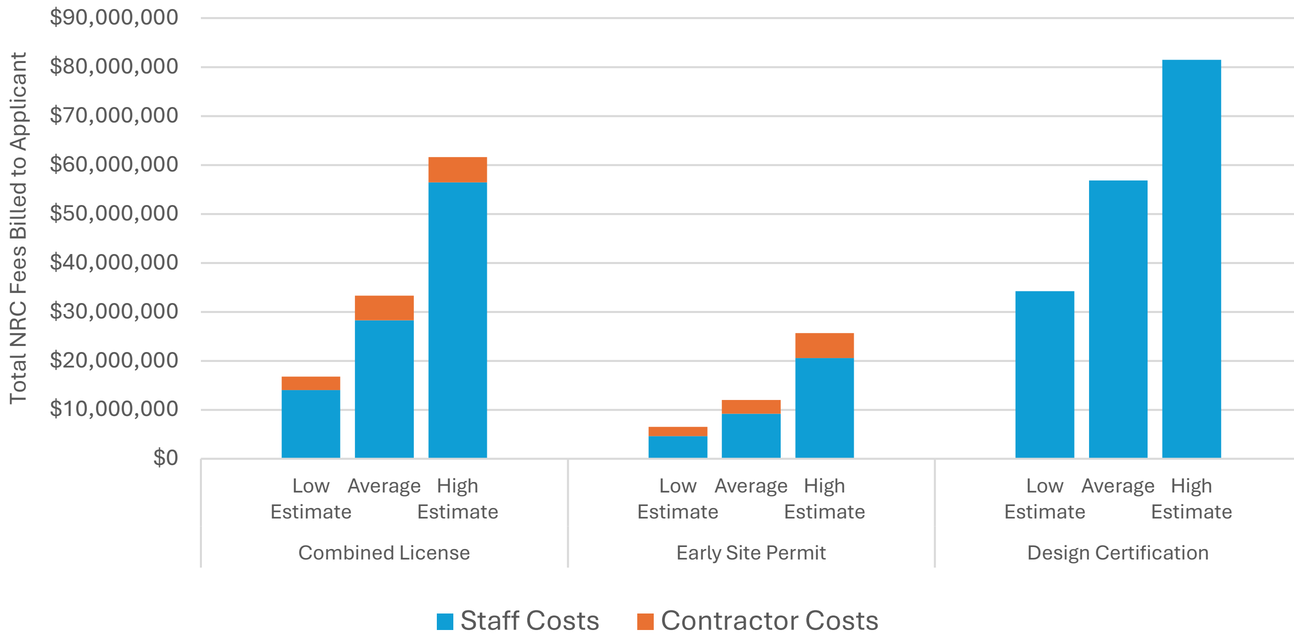

Figure Y. Estimate of Total Costs Billed to Applicants for Licensing Reviews[76]

Policy and Legislation Affecting Fees

The ADVANCE (Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy) Act,[77] signed into law on July 9th, 2024, aims to accelerate the deployment of advanced nuclear energy in the United States and promote U.S. exports of advanced nuclear technologies abroad. The Act includes a range of provisions focused on licensing reform for advanced nuclear reactors and fostering international cooperation to support their commercialization—both essential for meeting the nation's clean energy goals. Specifically, it directs the NRC to streamline the licensing process, with a particular emphasis on improving the efficiency of reviews for reactors sited at brownfield locations. It also establishes expedited procedures for combined licenses, especially for designs that have already been certified or are similar to previously licensed reactors. Additionally, the Act revises the NRC fee structure by reducing fees for advanced reactor application reviews by approximately 50%, effective October 1, 2025. It also removes costs related to pre-application activities and early site permit reviews for demonstration reactors located at Department of Energy (DOE) or Department of Defense (DoD) sites from the NRC's fee base.

To further incentivize innovation, the Act offers financial prizes to developers who reach specific licensing milestones, such as obtaining an operating license or utilizing recycled nuclear fuel, thus offsetting the costs incurred during the licensing process. Moreover, the Act authorizes the NRC to enhance its workforce by hiring additional,

[76] New Reactors Business Line Fee Estimates (January 2023)
[77] ADVANCE Act of 2024

highly qualified staff and providing robust training to ensure the agency is well-equipped to manage the demands of innovative technologies and accelerated licensing schedules. These measures are designed to improve the licensing process, making it more predictable and cost-effective, thereby fostering the development and deployment of advanced nuclear technologies.

In addition to the ADVANCE Act, DOE's Advanced Nuclear Energy Cost-Share Grant Program provides financial assistance to advanced reactor developers by covering a portion of the NRC licensing fees for innovative and advanced reactor designs, reducing the financial burden on applicants. In some instances, such as for research and test reactors used primarily for educational training and academic purposes, section 171.11(b) of the NRC regulations allows for exemptions from both annual NRC fees and application fees. Additionally, the NRC is considering fee reform and relief programs to better align licensing fees with the actual costs incurred, including potential waivers or reductions for university reactors and non-commercial facilities to encourage research and development. Moreover, discussions about university reactor fee waivers focus on providing financial relief to educational institutions, promoting nuclear research and training by reducing the costs associated with reactor licensing.

Annual Operating Fees

Once a nuclear reactor is operational, the licensee is required to pay an annual fee to the NRC. These fees cover the cost of NRC's regulatory oversight, including inspections, licensing activities,[78] and other regulatory functions necessary to oversee the safe operation of the facility. The fees are adjusted annually based on the number and type of reactors in operation, as well as the NRC's overall budget requirements.

Table 1. Summary of FY24 Annual Fees for Operating Reactors[79]

Reactor Type	FY24 Annual Fee
Commercial Power Reactors	$5,336,000 per reactor
Non-Power Production/Utilization Facilities	$97,000 per facility

Additional Cost Considerations

In addition to the direct fees associated with obtaining a nuclear reactor license, several other cost considerations can impact the overall financial burden of the licensing process. Pre-application preparation costs include gathering necessary data, conducting technical analyses, and compiling comprehensive documentation to meet the NRC's requirements. Many applicants also incur significant expenses from hiring

[78] The NRC defines licensing activities as the processes and actions involved in granting licenses for nuclear facilities, including nuclear reactors, fuel cycle facilities, and the use of nuclear materials in various applications. These activities include review and evaluation of applications, public participation and hearings, regulatory decisions, oversight and enforcement, and regulatory development.

[79] NRC FY24 Fee Rule

external consultants and legal experts to assist in preparing the application, conducting necessary analyses, and navigating the regulatory process.

Furthermore, the commercial reactor licensing process currently takes several years, during which time applicants must manage ongoing project expenses, including financing costs. Delays or RAIs from the NRC can further prolong the process, leading to additional financial obligations.

Lastly, license renewal is another important consideration. Commercial power reactors are typically licensed to operate for up to 40 years, with the possibility of renewing the license for an additional 20 years, potentially multiple times. The decision to seek renewal is usually based on the plant's economic viability and its ability to meet NRC requirements, which involves further costs related to regulatory compliance and potential upgrades.

V. Conclusion

The nuclear reactor licensing process is a critical component of ensuring the safety and security of nuclear energy. As the industry evolves, the regulatory framework must adapt to accommodate new technologies and support the deployment of advanced reactors. A clear understanding of the licensing process and a proactive approach to addressing its challenges will enable stakeholders to collaborate effectively and ensure a sustainable and innovative future for nuclear energy.

Continual improvements to the licensing process and adaptation to emerging technological developments will allow the NRC to better facilitate the rapid deployment of advanced nuclear technologies, ensuring that nuclear energy remains a cornerstone of the nation's energy strategy.