Regulatory Analysis

Non-Power Production or Utilization Facility License Renewal Final Rule

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U.S. Nuclear Regulatory Commission

Date

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Abbreviations

ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954, as amended
AGN	Aerojet-General Nucleonics
BLS	Bureau of Labor Statistics
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
FR	*Federal Register*
FSAR	final safety analysis report
GAO	United States Government Accountability Office
GE	General Electric
HEU	highly enriched uranium
hr	hour(s)
ICE	independent cost estimate
ISG	interim staff guidance
kW	kilowatt(s)
LOE	level of effort
n	number of years
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NPR	non-power reactor
NPUF	non-power production or utilization facility
NRC	U.S. Nuclear Regulatory Commission
NWMI	Northwest Medical Isotopes, LLC
r	discount rate
RA	regulatory analysis
RAI	request for additional information
rem	Roentgen equivalent man

RTR	research and test reactor
SHINE	SHINE Medical Technologies, Inc.
SRM	staff requirements memorandum
TAMU (A)	Texas A&M University/Aerojet General Nucleonics Reactor
TRIGA	Training Reactor and Isotopes Production, General Atomics
UC/Davis	University of California/Davis

Executive Summary

The U.S. Nuclear Regulatory Commission (NRC) is amending its regulations that govern the license renewal process for certain production or utilization facilities. In this final rule, the NRC collectively refers to these facilities as non-power production or utilization facilities (NPUFs). The final rule does the following:

- creates a definition for "non-power production or utilization facility" and revises the definitions for "non-power reactor," "research reactor," and "testing facility"
- eliminates license terms for facilities, other than testing facilities, licensed under Section 50.21(a) or (c) of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities" (Ref. 1)
- defines the license renewal process for NPUFs (including testing facilities) licensed under 10 CFR 50.22, "Class 103 licenses; for commercial and industrial facilities" and testing facilities licensed under 10 CFR 50.21(c)
- requires all NPUF licensees to submit an updated final safety analysis report (FSAR) and subsequent FSAR updates to the NRC at intervals not to exceed 5 years
- amends the current timely renewal provision under 10 CFR 2.109, "Effect of timely renewal application" of 10 CFR Part 2, "Agency Rules of Practice and Procedure" (Ref. 2) allowing an NPUF subject to license renewal to continue operating under an existing license past its expiration date if the licensee submits a license renewal application at least 2 years before the current license expiration date
- provides an accident dose criterion of 1 Roentgen equivalent man (rem) (0.01 sievert (Sv)) total effective dose equivalent for NPUFs other than testing facilities
- extends the applicability of 10 CFR 50.59, "Changes, tests and experiments," to NPUFs regardless of their decommissioning status
- clarifies the requirements for NPUF applicants to meet the existing provisions of 10 CFR 51.45, "Environmental report" of 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions" (Ref. 3)
- eliminates the requirement to submit financial qualification information with license renewal applications under 10 CFR 50.33(f)(2)

The analysis presented in this document examines the costs, averted costs, and benefits of the final rule and implementing guidance relative to the baseline case (i.e., the no-action alternative).

The NRC has made the following key findings:

- Final Rule Analysis. The final rule will result in a total net benefit of $17 million ($12 million using a 3-percent discount rate or $8.4 million using a 7-percent discount rate) over the 20-year analysis period. Of the $17 million in net benefits, licensees are expected to receive $5.5 million ($3.9 million using a 3-percent discount rate or $2.6 million using a 7-percent

discount rate), and the NRC is expected to receive $12 million ($8.6 million using a 3-percent discount rate or $5.9 million using a 7-percent discount rate).

Exhibit ES-1. Undiscounted Total Costs and Averted Costs of the Final Rule (2020$)

Category*	Low	Medium	High	Other NPUFs	Total**
Costs					
Licensees	($150,000)	($870,000)	($270,000)	($220,000)	($1,500,000)
NRC	($92,000)	($510,000)	($120,000)	($80,000)	($800,000)
Averted Costs					
Licensees	$850,000	$5,100,000	$1,000,000	$0	$7,000,000
NRC	$1,400,000	$8,900,000	$2,000,000	$0	$12,000,000
Net Benefits					
Licensees	$700,000	$4,200,000	$700,000	($220,000)	$5,500,000
NRC	$1,300,000	$8,400,000	$1,900,000	($80,000)	$12,000,000

*NPUFs are categorized as Low, Medium, High, or Other NPUFs based on various characteristics (e.g., power level of the NPUF, type of staff employed, and date of last license renewal). See Section 3.1.1, Affected Universe, for more information.
**Totals may not match due to rounding.

- Qualitative benefits. The final rule's qualitative benefits include enhanced regulatory efficiency for the NRC and licensees as well as public health and safety benefits.

  The final rule provides stability, predictability, and clarity by creating a license renewal framework for NPUFs in regulation, rather than relying solely on the guidance in NUREG-1537, Parts 1 and 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors" (Ref. 4). In addition, for NPUFs that will continue to undergo license renewal, the requirements for submitting updated FSARs and subsequent FSAR updates, and the amended timely renewal provision will create efficiencies during the license renewal process by reducing the number and scope of requests for additional information and shortening the review time for a license renewal application. As a result, the NRC and licensees will expend fewer resources during the license renewal process.

  The final rule will result in public health and safety benefits because the final rule improves the NRC's oversight of NPUFs. The FSAR submittals will increase licensees' focus on maintaining their facilities' licensing bases. In addition, with a 5-year interval between FSAR submittals, licensees will realize benefits in knowledge management as compared to the baseline.

- Per Sections 104a and c of the Atomic Energy Act of 1954, as amended (Ref. 5), the Commission is required to impose only the minimum amount of regulation on facilities used for medical therapy or research and development activities that is needed to promote common defense and security, and protect the health and safety of the public. Not all licensees will see burden reduction as a result of this final rule. Commercial NPUFs (including SHINE Medical Technologies, Inc. and Northwest Medical Isotopes, LLC), as well as the testing facility at the National Institute of Standards and Technology, will experience net costs. However, as discussed above, there are significant qualitative benefits, including regulatory efficiency and public health and safety benefits that will offset these costs.

- According to Executive Order 12866, Regulatory Planning and Overview (58 FR 190) (Ref. 6), an economically significant regulatory action is one that would have an annual effect on the economy of $100 million or more. This final rule does not reach this threshold.

- The Regulatory Flexibility Act (RFA) of 1980, as amended (5 U.S.C. 601 et seq.) (Ref. 7) requires that all Federal agencies review their regulations to ensure that they do not unduly inhibit the ability of small entities to compete. The NRC concludes that this final rule would not have a significant economic impact on a substantial number of small entities.

- Decision Rationale. Relative to the no-action baseline, the NRC concludes that the final rule's averted costs justify the incremental costs. Further, the final rule will address the inefficiencies and existing issues affecting the NPUF license renewal process. All estimated net benefits are dependent on economic assumptions holding true. For more discussion on the sensitivity of the analysis to changes to economic assumptions, see Section 3.6, Uncertainty Analysis.

1. Introduction

This document presents the regulatory analysis of the final rule to streamline the license renewal process for non-power production or utilization facilities (NPUFs). This section is divided into two parts: Section 1.1 provides background information on the final rule, and Section 1.2 identifies the problems that the U.S. Nuclear Regulatory Commission (NRC) seeks to address, as well as the objectives for the final rule.

1.1 Background

The NRC licenses NPUFs under the authority granted in Sections 103 and 104 of the Atomic Energy Act of 1954, as amended (AEA). Section 103 of the AEA applies to commercial or industrial facilities, Section 104a of the AEA applies to facilities used for medical therapy, and Section 104c of the AEA applies to facilities useful in the conduct of research and development activities. Furthermore, Sections 104a and c of the AEA require that the Commission impose only the minimum amount of regulation needed to promote the common defense and security; protect public health and safety; and permit, under Section 104a, the widest possible amount of effective medical therapy and, under Section 104c, widespread and diverse research and development.

The NRC regulates 36 NPUFs, of which 31 are research reactors or testing facilities currently licensed to operate. Two of the five remaining facilities have been issued construction permits (SHINE Medical Technologies, Inc. (SHINE) and Northwest Medical Isotopes, LLC (NWMI)), and the other three facilities are in the process of decommissioning. The NRC regulates one operating testing facility at the National Institute of Standards and Technology (NIST).

As part of its oversight of NPUFs, the NRC administers an initial licensing process, followed by a license renewal process for those NPUFs that seek to continue operating beyond their initial license term. In 2008, the NRC identified a need to identify and implement efficiencies in the NPUF license renewal process to streamline the process while ensuring that adequate protection of public health and safety is maintained. This need to improve the reliability and efficiency of the process was primarily driven by four issues:

(1) Beginning in late 2001, as a result of the NRC's response to the events of September 11, 2001, the NRC deferred work on a number of NPUF license renewal applications. In addition, the NRC's NPUF licensing activities focused on the higher-priority activity of implementing 10 CFR 50.64, "Limitations on the use of highly enriched uranium (HEU) in domestic non-power reactors," to convert non-power reactor licensees to the use of low-enriched uranium. Therefore, reviews of these license renewal applications extended for many years. In all cases, the timely renewal provision enabled these NPUFs to continue operating during the NRC's review period.

(2) Many NPUF licensees have limited staff resources available for licensing support. The number of NPUF staff can range from one part-time employee for some low-power facilities to as many as four or five full-time employees for higher-power facilities. The NPUF staff that perform the licensing function typically do so in addition to their normal organizational responsibilities, which often results in delays (particularly in responding to the NRC's requests for additional information) in the license renewal process.

(3) The NPUFs licensed under § 50.21(a) or (c) are primarily at college and university sites. Staff turnover and limited staffing resources at an NPUF often contribute to a lack of historical knowledge of the development of the licensee's FSAR and changes to the FSAR. During the most recent round of license renewals, the NRC found that some of the submitted FSARs did not adequately reflect the current licensing basis for the respective licensees. Because the only required FSAR submission comes at license renewal, which can be at 20-year or greater intervals, submitted FSARs often contain varying levels of completeness and accuracy. Consequently, the NRC has issued requests for additional information to obtain missing information, seek clarifications and corrections, and document the current licensing bases.

(4) For power reactors, license renewal reviews have a defined scope, primarily focused on aging management for passive, long-lived systems, structures, and components, as described in 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants" (Ref. 8). For NPUFs, the scope of issues to be addressed during license renewal is not similarly limited. Therefore, the scope of review for license renewal was initially treated the same as that for an original license. In response to Commission direction in the staff requirements memorandum (SRM) to SECY-91-061, "SECY-91-061—Separation of Non-Reactor and Non-Power Reactor Licensing Activities from Power Reactor Licensing Activities in 10 CFR Part 50," dated April 11, 1991 (Ref. 9), the NRC developed licensing guidance. In that guidance (NUREG-1537, Parts 1 and 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors," issued February 1996 (Ref. 4)), the NRC provides detailed descriptions of the scope, content, and format of FSARs and the NRC's process for reviewing initial license applications and license renewal applications. However, at the time of the first license renewals using NUREG-1537, some license renewal applications had varying levels of consistency with NUREG-1537, without proposing acceptable alternatives to the guidance. This resulted in the NRC issuing requests for additional information and some of the issues described above.

As a result of these issues, a backlog of NPUF license renewal applications developed and persisted. The Commission and other stakeholders voiced concerns not only about the backlog but also about the burdensome nature of the license renewal process itself. In April 2008, the Commission issued SRM-M080317B, "Briefing on the State of NRC Technical Programs," (Ref. 10), in which the Commission directed the staff to "examine the license renewal process for non-power reactors and identify and implement efficiencies to streamline this process while ensuring that adequate protection of public health and safety are maintained."

In October 2008, the staff provided the Commission with plans to improve the review of NPUF license renewal applications in SECY-08-0161, "Review of Research and Test Reactor License Renewal Applications" (Ref. 11). In SECY-08-0161, the NRC staff summarized a public meeting held with stakeholders to gather feedback on the current process, ways the process could be improved, and options for improving the review process. The Commission issued SRM-SECY-08-0161 in March 2009 (Ref. 12), in which it directed the staff to develop program initiatives to address the backlog of existing NPUF license renewal applications. In addition, the Commission directed the staff to submit a long-term plan for an enhanced NPUF license renewal process. The Commission directed that the plan include development of a basis for redefining the scope of the license renewal process as well as a recommendation on the need for rulemaking and guidance development.

The staff issued SECY-09-0095, "Long-Term Plan for Enhancing the Research and Test Reactor License Renewal Process and Status of the Development and Use of the Interim Staff Guidance" (Ref. 13), in June 2009 to provide the Commission with a long-term plan for enhancing the NPUF license renewal process. In the long-term plan, the staff proposed to develop a draft regulatory basis to support proceeding with rulemaking to streamline and enhance the NPUF license renewal process. The Commission issued SRM-M090811, "Staff Requirements Memorandum—Briefing on Research and Test Reactor (RTR) Challenges" (Ref. 14), in August 2009, which directed the staff to accelerate the rulemaking to establish a more efficient, effective and focused regulatory framework for NPUF license renewal.

The NRC completed the regulatory basis in August 2012 (Ref. 15). The regulatory basis analyzed the NPUF license renewal process's technical, legal, and policy issues; impacts on public health, safety, and security; impacts on licensees; impacts on the NRC; stakeholder feedback; and other considerations. The NRC concluded that a rulemaking was warranted.

On March 30, 2017, the NRC published a proposed rule, "Non-Power Production or Utilization Facility License Renewal" (Volume 82 of the *Federal Register* (FR), page 15643, March 30, 2017 (82 FR 15643)) (Ref. 16). The agency provided a public comment period of 75 days for review and comment on the proposed rule and associated guidance (including the proposed rule's regulatory analysis).

1.2 Statement of the Problem and NRC Objectives for the Rulemaking

The NRC has developed this final rule to address gaps and issues in current regulations. The Commission directed the staff to develop a streamlined license renewal process for NPUFs. The staff identified four areas of concern with respect to the current license renewal process: (1) the current reliance on initial licensing regulations for license renewal, (2) the need for periodic updates to the FSAR, (3) the constraints related to the current "timely renewal" provision in 10 CFR 2.109, "Effect of Timely Renewal Application," and (4) other issues in the existing rule language. To address these areas of concern, the final rule:

- Creates a definition for "non-power production or utilization facility" and revises the definitions for "non-power reactor," "research reactor," and "testing facility." The final rule addresses inconsistencies in definitions and terminology throughout 10 CFR Chapter I to improve clarity in determining the applicability of regulations associated with NPUFs. The NRC is adding a specific definition for "non-power production or utilization facility" to 10 CFR 50.2, "Definitions," to establish a term that is flexible in order to capture all non-power facilities licensed under 10 CFR 50.22, "Class 103 Licenses; for Commercial and Industrial Facilities," or 10 CFR 50.21(a) or (c). Examples of these facilities include medical radioisotope irradiation and processing facilities, research reactors, and testing facilities. Although these licensees currently are subject to existing regulations, a more inclusive definition clarifies that not all NPUFs are non-power reactors and will alleviate any ambiguity surrounding applicability to new licensees. This administrative change, discussed further in Section 3.3, will not impose any additional cost.

  In response to public comment, the NRC is revising the definitions of "testing facility" in 10 CFR 50.2 and "research reactor" in 10 CFR 170.3 (Ref. 17). The technical basis associated with the 10 MW(t) threshold, while generally based on safety significance, is

not documented. Similarly, the technical basis for the 1 MW(t) threshold under the current definition for "testing facility" is also not documented. These prescriptive power thresholds do not account for the safety features that are engineered into a facility design and the barriers that must be breached during an accident before a release of radioactive material to the environment can occur. Therefore, these thresholds do not accurately represent the risk associated with a particular facility. For these reasons, the use of a postulated accident dose (1 rem (0.01 Sv)) is a more risk-informed, performance-based approach than using the power level of a reactor for distinguishing between types of NPUFs, such as a research reactor and a testing facility. As a result of this public comment, the NRC revised the definitions of "testing facility" and "research reactor" to reflect this risk-informed approach.

Additionally, the NRC made conforming changes to the definitions of "testing facility," "research reactor," and "non-power reactor" wherever these definitions appear throughout 10 CFR Chapter I. Also, where appropriate, the NRC standardized the terminology in other parts of the regulations to modify the intended scope of regulations citing "research and test reactors" to be either "non-power reactors" or "non-power production or utilization facilities." The NRC also revised the definition of "non-power reactor" to clarify the nomenclature used to distinguish between non-power reactors used for research and development activities and non-power reactors used for commercial or industrial purposes.

- Eliminates license terms for facilities, other than testing facilities, licensed under 10 CFR 50.21(a) or (c). By issuing non-expiring licenses for facilities licensed under 10 CFR 50.21(a) or (c), other than testing facilities, the NRC will reduce the burden on qualifying NPUFs (i.e., research reactors currently licensed to operate) while continuing to protect public health and safety, promote the common defense and security, and protect the environment through regular, existing oversight activities and the addition of FSAR update submittals. The AEA does not establish specific license terms nor the need for license terms for facilities, other than testing facilities, licensed under 10 CFR 50.21(a) or (c). Historically, license renewal has afforded both the NRC and the public the opportunity to re-evaluate the licensing basis of the NPUF. The purpose of the license renewal review was to assess the likelihood of continued safe operation of the facility, such that radioactive materials can be used for beneficial civilian purposes in a safe and secure manner. For several reasons that are unique to NPUFs, this objective can be achieved through existing oversight activities and review of updated FSARs and subsequent FSAR updates submitted pursuant to the new requirements in 10 CFR 50.71(e) of the final rule (see Section II.4. of the final rule *Federal Register* document). This approach is consistent with the NRC's goal of efficient and effective licensing and will implement and reflect lessons learned from decades of processing license renewal applications. The final rule also will make conforming changes to requirements for facilities that are decommissioning by revising 10 CFR 50.82(b) and (c), where license expiration is used as a reference point (see Section 3.6.3 for a sensitivity analysis on the costs and benefits relating to decommissioning NPUFs). The NRC will issue orders following the publication of the final rule to remove license terms from each license. In addition, the orders will establish when the respective licensee's initial FSAR update will be due to the NRC. In total, there will be 27 orders issued by the NRC. The recipients of the orders include those facilities identified in Group 1 and Group 2 of Exhibit 3-2 plus the NIST testing facility.

- Defines the license renewal process for NPUFs (including testing facilities) licensed under 10 CFR 50.22 and testing facilities licensed under 10 CFR 50.21(c). Section 103 of the AEA establishes a license term of no more than 40 years for commercial facilities licensed under 10 CFR 50.22. Although the AEA does not establish a fixed license term for testing facilities, licensees for these facilities currently are subject to additional regulatory requirements (e.g., siting subject to 10 CFR Part 100, "Reactor Site Criteria" (Ref. 18), Advisory Committee on Reactor Safeguards review, and environmental impact statements) because of higher radiological risks associated with their design, operation, or use as compared to other class 104a or c licensees. Therefore, all commercial NPUF facilities (including testing facilities) licensed under § 50.22 and testing facilities licensed under § 50.21(c) will continue to have fixed license terms and undergo license renewal. By defining a license renewal process in the new 10 CFR 50.135, "Renewal of non-power production or utilization facility licenses issued under 10 CFR 50.22 and testing facility licenses," specific to NPUFs (including testing facilities) licensed under 10 CFR 50.22 and testing facilities licensed under 10 CFR 50.21(c), the NRC will consolidate existing requirements for current and potential future licensees in one section.

- Requires all NPUF licensees to submit updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years. By requiring periodic submittals of subsequent FSAR updates, the NRC anticipates that licensees will document changes in licensing bases as they occur, which will maintain the continuity of knowledge both for the licensee and the NRC and the understanding of changes and the effects of changes on the licensee. From a safety perspective, an updated FSAR is important for the NRC's inspection program and for effective licensee operator training and examination. The NRC decided on a 5-year periodicity for FSAR submittals for two reasons. First, 5 years is less frequent than what is required of power reactors, reflecting the "minimum regulation" standard applied to most NPUF licensees. Second, the design bases of these facilities evolve slowly over time. The NRC has received approximately five license amendment requests from all NPUF licensees combined each year and, on average, only five 10 CFR 50.59 evaluations per facility per year for changes that do not require prior NRC approval. Should the NRC identify any potential issues with the facility's continued safe operation, the Commission can undertake regulatory actions specified in 10 CFR 2.202 to modify, suspend, or revoke a license. In addition, the public will remain informed about facility operations through the publicly available FSAR updates and will continue to have opportunities to participate in the regulatory process through licensing actions and the 10 CFR 2.206 petition process. As a result, updated FSAR submittals will enhance the NRC's continuous oversight of facilities during their operation, while imposing a minimal amount of regulation needed to promote the common defense and security, protect public health and safety, and permit widespread and diverse research and development and the widest possible amount of effective medical therapy.

- Amends the current timely renewal provision under 10 CFR 2.109, allowing an NPUF subject to license renewal to continue operating under an existing license past its expiration date if the licensee submits a license renewal application at least 2 years before the current license expiration date. Under the final rule, if an NPUF subject to license renewal (i.e., NPUFs (including testing facilities) licensed under 10 CFR 50.22 and testing facilities licensed under 10 CFR 50.21(c)) files a sufficient application for

license renewal at least 2 years (rather than the current 30 days[1]) before the expiration of the existing license, then the existing license will not be deemed to have expired until the NRC has made a final determination on the application. The revision will ensure that the NRC has adequate time to review the sufficiency of NPUF license renewal applications while the licensee continues to operate under the terms of its current license. This provision will apply to NIST, SHINE, and NWMI.[2]

- Provides an accident dose criterion of 1 rem (0.01 Sv) total effective dose equivalent for NPUFs other than testing facilities. Before this final rule, the NRC compared the results from the accident analyses submitted in initial or renewed license applications with the standards for doses to members of the public in 10 CFR Part 20, "Standards for Protection against Radiation" (Ref. 19). Because of the low potential radiological risk posed by NPUFs to the environment and the public, these dose limits are unnecessarily restrictive for use as accident dose criteria in NPUF license reviews.[3] The NRC is amending its regulations in 10 CFR 50.34, "Contents of applications; Technical information," to add an accident dose criterion for NPUFs not subject to 10 CFR Part 100. For testing facilities, accident dose criteria are found in 10 CFR Part 100: 25 rem (0.25 Sv) to the whole body and 300 rem (3 Sv) to the thyroid. The addition of an accident dose criterion for NPUFs will not require any changes to current licensee practices and therefore will not result in any incremental costs.

- Extends the applicability of 10 CFR 50.59, "Changes, tests and experiments," to NPUFs regardless of their decommissioning status. The final rule revises 10 CFR 50.59(b); the regulation currently does not apply 10 CFR 50.59 to NPUFs whose licenses have been amended to cease operations and that no longer have fuel on site (e.g., have returned all of their fuel to the U.S. Department of Energy). For these licensees, the NRC has typically added license conditions identical to those of 10 CFR 50.59 to allow the licensee to make changes in its facility or procedures that would not otherwise require obtaining a license amendment pursuant to 10 CFR 50.90, "Application for amendment of license, construction permit, or early site permit." The license amendment process imposes an administrative burden on the licensees and the NRC, which will be alleviated with the regulatory change.

- Clarifies an applicant's requirements for meeting the existing provisions of 10 CFR 51.45, "Environmental report." This change clarifies an applicant's requirements for meeting the existing provisions of 10 CFR 51.45 and improves consistency throughout 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," with respect to environmental report submissions required of applicants. The final regulatory requirements help to ensure that the NRC effectively and efficiently meets its environmental review requirements consistent with the National Environmental Policy Act of 1969, as amended (Ref. 20) and the NRC's implementing regulations.

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[1] Under the final rule, the 30-day timely renewal period will still apply to the one remaining license renewal application for a research reactor that is expected to be submitted after the final rule is published. This change from the proposed rule does not affect the costs evaluated in this regulatory analysis.

[2] The NRC estimates the costs associated with the amendment to the timely renewal provision to amount to between $700 and $7,000 per licensee over the analysis period. This provision will also result in additional public health and safety benefits (see Section 3.4) that will offset this cost.

[3] The NRC Atomic Safety and Licensing Appeal Board suggested that the standards in 10 CFR Part 20 are unduly restrictive as accident dose criteria for research reactors (Ref. 21).

- Eliminates the requirement for NPUFs to submit financial qualification information with license renewal applications under 10 CFR 50.33(f)(2). On January 30, 2004, the NRC published the final rule, "Financial Information Requirements for Applications to Renew or Extend the Term of an Operating License for a Power Reactor" (69 FR 4439) (Ref. 22). This final rule eliminated financial qualification requirements for power reactor licensees at the time of license renewal, except in very limited circumstances. The same basis for the NRC's elimination of financial qualification requirements for power reactor licensees at the time of license renewal supports the NRC's elimination of NPUF financial qualification requirements at the time of license renewal. The NRC is not aware of any connection between an NPUF's financial qualifications at license renewal and safe operation of the facility. Moreover, because NPUFs have significantly smaller fission product inventory and potential for radiological consequences than do power reactors, the NPUF financial qualification reviews are of less value in ensuring safety than reviews previously required of power reactors. Nevertheless, the NRC can request financial information from licensees, as needed.

2. Identification and Preliminary Analysis of Alternative Approaches

In addition to the final rule (identified as Option 3), the NRC identified three alternatives for consideration:

- Option 1: Take No Action (not selected)
- Option 2: Undertake Rulemaking to Require Final Safety Analysis Report Updates and Revise the Timely Renewal Provision (not selected)
- Option 3: Undertake Rulemaking to Require Final Safety Analysis Report Updates, Revise the Timely Renewal Provision, and Eliminate License Terms for Class 104a or c Licensees Other Than Testing Facilities (selected—final rule)
- Option 4: No Rulemaking for License Renewal; Issue a New Regulatory Guide and Update NUREG-1537 to Incorporate a Streamlined License Renewal Process (not selected)

2.1 Option 1: Take No Action (Not Selected)

Under Option 1 (not selected), the NRC would not have changed existing license terms or licensees' responsibilities under the license renewal process (including drafting narrative and technical chapters of the application, reviewing RAIs, drafting RAI responses, conducting additional analyses, and revising the application) as described in current regulations and guidance. This alternative serves as the baseline against which the impacts of the other identified alternatives are measured.

This option would have posed no incremental burden on licensees or on the NRC. However, this option would not have been responsive to the Commission's direction in SRM-M080317B (Ref. 10). This option does not address issues identified with timely renewal or the lack of periodic FSAR updates. Stakeholders voiced opposition to the status quo during a public

meeting on December 19, 2011, because it would not have incorporated lessons learned from the recent NPUF license renewal application reviews. As a result, this option would not have achieved the NRC's objectives.

2.2 Option 2: Undertake Rulemaking to Require Submission of Final Safety Analysis Report Updates and Revise the Timely Renewal Provision (Not Selected)

Under Option 2 (not selected), the NRC would have revised its regulations to require all licensees to submit (1) license renewal applications 2 years in advance of license expiration (rather than the current 30 days) and (2) updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years.

The current timely renewal provision in 10 CFR 2.109(a) allows a licensee to continue operation as long as it has submitted its license renewal application more than 30 days before the expiration of its existing license. Historical precedent indicates that 30 days is not a sufficient period of time for the NRC to adequately assess the sufficiency of a license renewal application for review. As a result, the NRC accepted license renewal applications and addressed their deficiencies in the license renewal process through issuing to the licensee requests for additional information. This approach increased the duration of the license renewal process and resulted in multiple facilities operating many years into a "timely renewal" period without renewed licenses. Under this option, the NRC would have modified 10 CFR 2.109(a) to require licensees to submit their license renewal applications 2 years (rather than the current 30 days) before their license is set to expire. This would have granted the NRC time to thoroughly review an application and address any missing elements without having to prolong the full review of the license renewal application.

This option also would have required licensees to submit updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years. Under current regulations, licensees are not required to submit updated FSARs on a periodic basis. During the most recent round of license renewals, the NRC found that some of the submitted FSARs did not adequately reflect the current licensing basis for the respective licensees. As a result, licensees had to reconstitute their licensing basis through the license renewal process. The reconstitution of licensing basis added burden on both licensees and the NRC and prolonged the license renewal process. This option would have required that licensees submit updates to their FSARs to the NRC every 5 years. The submittal would have kept their licensing basis current and the NRC aware of any modifications.

The NRC expects that this option would have reduced the burden of the license renewal process on licensees and the NRC for the following two reasons:

(1) The current regulatory framework of 30 days is not sufficient for the NRC to complete a comprehensive acceptance review. Additional time would have streamlined the overall license renewal process by addressing the adequacy of an application before addressing the technical content of the application. This would have resulted in a decreased burden to the NRC and licensees and would have created efficiencies in the license renewal process.

(2) Requiring licensees to submit updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years would have led licensees to integrate changes to

their facility operations and design into their licensing basis as they occur, ensuring that their licensing basis remains up to date. Therefore, the burden on the NRC and licensees associated with reconstituting each licensee's licensing basis during license renewal would have been avoided, resulting in decreased burden for both parties.

Although this option would have provided some streamlining to the license renewal process by allowing additional time for acceptance reviews and requiring more frequent submittals of FSAR updates, all NPUF licensees would still have had to undertake a license renewal application process, which would have continued to impose burden on these licensees without corresponding benefits to public health and safety. Section 3.3 outlines the costs that this option would have imposed. Even though this option would have resulted in some efficiencies, this option was not cost-beneficial.

2.3 Option 3: Undertake Rulemaking to Require Final Safety Analysis Report Updates, Revise the Timely Renewal Provision, and Eliminate License Terms for Class 104a or c Licensees, Other than Testing Facilities (Selected—Final Rule)

Under Option 3 (the final rule), the NRC will eliminate license terms for facilities, other than testing facilities, licensed under 10 CFR 50.21(a) or (c). As a result, these licensees will not be subject to a license renewal process. However, to provide assurance that these NPUFs continue to operate safely, this option will implement additional provisions for licensees and the NRC. Further, under this option, the NRC will define a license renewal process for commercial or industrial NPUFs and testing facilities in the new 10 CFR 50.135, consolidating existing requirements for current and potential future licensees in one section.

This option will require licensees to submit updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years. This requirement will result in licensees reflecting operation or design changes in their FSARs, ensuring that their licensing basis is kept current.

For commercial or industrial NPUFs and testing facilities, this option will still require licensees that wish to continue operating to submit a license renewal application. However, this option also will include the license renewal streamlining features described under Option 2 (not selected) (i.e., modify the timely renewal provision in 10 CFR 2.109 and require licensees to submit updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years).

Option 3 will eliminate the burden associated with the license renewal process for all but one of the NPUFs currently licensed to operate (NIST). This large reduction in burden will be slightly offset by the minimal burden associated with submitting FSARs to the NRC on an ongoing basis.

In addition to NIST, there will be additional burden for the two NPUFs anticipated to be licensed within the next 5 years (SHINE and NWMI) (see Section 3.3 for a breakout of these differing costs). The final rule imposes an Option 2 framework on these facilities. For these NPUFs that expect additional burden, the qualitative benefits associated with regulatory efficiency and public health and safety offset these costs. See Section 3.4 for a discussion of these qualitative benefits.

The staff plans to update NUREG-1537 following the publication of this final rule to incorporate interim staff guidance that was produced outside of this final rule.

This option will establish an overall streamlined approach to license renewal that will result in a net burden reduction for both licensees and the NRC, while enhancing regulatory efficiency and public health and safety. Therefore, Option 3 will best address the NRC's regulatory objectives and is the selected option.

2.4 Option 4: Non-rulemaking Alternatives (Not Selected)

The NRC considered other non-rulemaking approaches such as issuing a new regulatory guide and updating NUREG-1537 to include a streamlined license renewal process. Under Option 4 (not selected), the NRC would have updated NUREG-1537 to include lessons learned from the license renewal process, including from application of the "Interim Staff Guidance on the Streamlined Review Process for License Renewal for Research Reactors," issued October 2009 (ISG) (Ref. 23). Although this option would have updated NUREG-1537 to incorporate lessons learned from past license renewals, these changes would have been made to guidance documents and would not have had the force of regulation. As a result, licensees would not have had to comply with the changes, and there may have been no ensuing benefit or averted costs.

Although this option could have resulted in increased efficiency for licensees and the NRC because of the incorporation of lessons learned, this option would not have fully addressed any of the issues that formed the basis of the Commission's direction and the staff's objectives. Specifically, this option would not have addressed lack of regulations specific to the license renewal process for NPUFs or issues associated with the current timely renewal provision. Further, licensees' application of the updated guidance would have been voluntary and would not have achieved the broad effects of a rulemaking.

3. Estimation and Evaluation of Costs, Averted Costs, and Benefits: Presentation of Results

This section details the NRC's approach to estimating the costs and benefits of the final rule and presents the results of the analysis:

- Section 3.1 details the methodology, assumptions, and baseline used to evaluate the costs, averted costs, and benefits associated with the options considered in the regulatory analysis.
- Section 3.2 summarizes the costs, averted costs, and benefits associated with the options.
- Section 3.3 presents the details of the costs and averted costs associated with the final rule.
- Section 3.4 discusses the benefits of the final rule.
- Section 3.5 discusses the disaggregated results.
- Section 3.6 discusses the uncertainty analysis.

3.1 Methodology and Assumptions

This section explains the process used to evaluate the costs, averted costs, and benefits associated with the rulemaking options, consistent with the guidance in draft final NUREG/BR-0058, Revision 5, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," April 2017 (Ref. 24).[4] The benefits include improved regulatory efficiency and public health and safety, averted costs include other desirable changes in affected attributes (e.g., monetary savings, reduced burden on licensees), while costs include any undesirable changes in affected attributes (e.g., monetary costs).

The NRC estimated the incremental costs and averted costs of the final rule compared to a "no-action" baseline. The no-action baseline includes the historical costs incurred by licensees and the NRC during the license renewal process. The NRC estimated all of the incremental costs and averted costs resulting from the final requirements that will be incurred beginning in 2020, which is the year the final rule is assumed to come into effect. All costs and averted costs presented in this analysis are in 2020 dollars.[5] All estimated net benefits are dependent on economic assumptions holding true. For more discussion on the sensitivity of the analysis to changes to economic assumptions, see Section 3.6. The regulatory baseline assumes full compliance with existing NRC requirements and guidance. However, in the absence of rulemaking, the NRC expects that many of the recent challenges with license renewals would continue to be experienced.

3.1.1 Affected Universe

The final rule will affect all NPUF licensees. However, the costs, averted costs, and benefits affecting individual licensees differ depending on various characteristics (e.g., power level of the NPUF, type of staff employed, and date of last license renewal).

The NRC estimated the costs and averted costs incurred by the 31 NPUFs currently licensed to operate, as well as two NPUFs anticipated to be licensed to operate within the next 5 years. The incremental costs of one of the other three regulated NPUFs that are in the process of decommissioning, have possession-only licenses, or are permanently shut down are considered separately in Section 3.6.4.[6] Appendix A details the cost and savings buildup.

For the purposes of estimating the costs, averted costs, and benefits of the final rule, the 33 analyzed NPUFs are broken into four categories based on the power of the facility or facility type: Low (<100 kW), Medium (≥100 and <2000 kW), High (≥2,000 kW), and Other NPUFs (consisting of commercial facilities and testing facilities). There are five facilities in the Low category, 21 facilities in the Medium category, four facilities in the High category, and three facilities in the Other NPUFs category. These divisions allow for the estimation of regulatory compliance costs and savings that differ based on the size, staffing, and power level of the

[4] The draft final NUREG/BR-0058 was under Commission review at the time this regulatory analysis was conducted; however, it was applied to this analysis to ensure updated guidance was followed regarding evaluation of qualitative factors, as well as other best practices in regulatory analysis.

[5] Where appropriate, values were scaled to 2020 dollars using Bureau of Labor Statistics (BLS) Consumer Price Index data (Ref. 27).

[6] The NRC expects that the licenses for the two General Atomics facilities will be terminated in 2019, before implementation of the rule. Additionally, the NRC expects the General Electric Co. (GE) General Electric Test Reactor to stay in SAFSTOR until 2041, and then be decommissioned. As a sensitivity, NRC examined the costs associated with a facility in SAFSTOR. See Section 3.6.4 for more information.

different facilities. Exhibit 3-1 lists the NPUFs included in the universe of affected entities under this analysis, by category.

Exhibit 3-1. Categorization of NPUFs by Type

Low <100 kW	Medium (<2,000 kW)	High (2,000+ kW)	Other NPUFs***
Idaho State University	Aerotest	Massachusetts Institute of Technology	SHINE**
Purdue University	Dow Chemical Company	Rhode Island Atomic Energy Commission	NWMI**
Rensselaer Polytechnic Institute	GE-Hitachi	University of California (UC)/Davis	NIST
Texas A&M University Aerojet-General Nucleonics (AGN) (TAMU (A))*	Kansas State University	University of Missouri/Columbia	
University of New Mexico	Missouri University of Science and Technology		
	Ohio State University		
	Reed College		
	UC/Irvine		
	University of Florida		
	University of Utah		
	University of Maryland		
	Armed Forces Radiobiology Research Institute		
	North Carolina State University		
	Oregon State University		
	Pennsylvania State University		
	Texas A&M University Training Reactor and Isotopes Production, General Atomics (TRIGA)		
	U.S. Geological Survey		
	University of Massachusetts/Lowell		
	University of Texas		
	University of Wisconsin		
	Washington State University		
5 Licensees	**21 Licensees**	**4 Licensees**	**3 Licensees**

Source: Appendix H to NUREG-1350, Volume 30, "NRC Information Digest, 2018–2019," issued August 2018 (http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/) (Ref. 25).
* TAMU (A) is currently shut down. The analysis assumes that TAMU (A) will undergo license renewal in 2021.
** SHINE and NWMI currently hold construction permits but have not yet applied for operating licenses. The analysis assumes that each facility will be licensed to operate in 2021. The actual dates could be earlier or later depending on the timing of the license applications, but this would not significantly affect the conclusions of the analysis.
*** SHINE, NWMI, and NIST have specific requirements discussed in Section 3.2.

As described in the final rule provided for Commission approval (Ref. 26), the 31 NPUFs currently licensed to operate are separated into different groups that will dictate when the licensee's initial updated FSAR will be due to the NRC. The NRC grouped facilities by when they have undergone license renewal using NUREG-1537. These groupings also vary the times when different costs and averted costs are incurred across the analysis period. The NRC will issue orders following the publication of the final rule to establish when the respective licensee's initial FSAR update will be due to the NRC. In addition, the orders will remove license terms from each license in Group 1 and Group 2. In total, there will be 27 orders issued by the NRC.

- Group 1 consists of licensees that completed the license renewal process most recently using NUREG-1537. The NRC will establish a due date for the updated FSAR that will be at least 1 year and no later than 3 years from the effective date of this final rule. The NRC will require these licensees to submit an updated FSAR first because, with a recent license renewal, the FSARs should require minimal updates.

- Group 2 generally consists of licensees for which the NRC reviewed the license renewal application before Group 1 using NUREG-1537, and includes the three facilities currently in decommissioning. The NRC will establish a due date for the updated FSAR that will be at least 2 years and no later than 5 years from the effective date of this final rule. The NRC will allow these licensees more time to submit an updated FSAR than Group 1 licensees because more time has passed since license renewal.

- Group 3 consists of the remaining NPUF licensees that have not undergone license renewal using NUREG-1537. The licenses for these facilities are all due to expire in less than 5 years from the effective date of this final rule. If these licensees choose to renew their facility operating licenses, they will be subject to the requirements in § 50.71(e) after issuance of the renewed license.

This regulatory analysis adds a fourth group (Group 4), which consists of NIST and potential future operating licensees, which will be subject to recurring license renewal. Exhibit 3-2 details the different groupings.

All NPUF licensees will be required to submit updated FSARs and then submit subsequent FSAR updates to the NRC at intervals not to exceed 5 years. For Group 4 licensees, additional updated FSARs will be required to be submitted following subsequent license renewals, which are outside the period covered by the regulatory analysis.

The NRC assumes that each operating NPUF licensee will continue operating. For the purposes of the analysis, the NRC assumes no currently operating NPUFs will enter decommissioning during the 20-year period of analysis. See Section 3.6.4 for a sensitivity analysis on this assumption.

Exhibit 3-2. List of NPUFs by Implementation Groups

Group 1 Implementation by Order (due 1–3 years after effective date of rule)	Group 2 Implementation by Order (due 2–5 years after effective date of rule)	Group 3 Implementation by License Renewal	Group 4** Fixed License Terms
UC/Irvine	Idaho State University	Aerotest	SHINE**
U.S. Geological Survey	Kansas State University	UC/Davis	NWMI**
Purdue University	Ohio State University	GE-Hitachi	
Armed Forces Radiobiology Research Institute	Oregon State University	TAMU (A)*	NIST***
University of Maryland	Missouri University of Science and Technology		
Rhode Island Atomic Energy Commission	Pennsylvania State University		
University of Missouri/Columbia	Massachusetts Institute of Technology		
University of Florida	University of New Mexico		
University of Massachusetts/Lowell	University of Wisconsin		
North Carolina State University	Rensselaer Polytechnic Institute		
University of Texas	Washington State University		
	University of Utah		
	Reed College		
	Dow Chemical Company		
	Texas A&M University (TRIGA)		
11 Licensees	**15 Licensees**	**4 Licensees**	**3 Licensees**

* TAMU (A) is currently shut down. The analysis assumes that TAMU (A) will undergo license renewal in 2021. This assumption maximizes the cost to the licensee by assuming the greatest number of subsequent FSAR updates.
** SHINE and NWMI currently hold construction permits for their facilities but have not yet applied for operating licenses. The analysis assumes that each facility will be licensed to operate in 2021. The actual dates could be earlier or later depending on the timing of operating license applications, but this would not significantly affect the conclusions of the analysis. SHINE, NWMI, and NIST have specific requirements discussed in Section 3.2.
*** NIST will receive an order requiring an updated FSAR concurrent with that of Group 2 but will continue to undergo license renewal.

3.1.2 Cost Estimation

In order to estimate the costs associated with the final rule, the NRC used a work breakdown approach to deconstruct the final rule requirements according to the necessary activities for each requirement. For each needed activity, the NRC further subdivided the work across labor categories (e.g., Professor, Operator, Technician, Student, and Administrator). The NRC estimated the required level of effort (LOE) for each labor category and for each required activity in order to develop bottom-up cost estimates.

The NRC gathered data from several sources and consulted licensees to develop LOE and unit cost estimates. Mean hourly wage rates for various labor categories were derived from the Bureau of Labor Statistics (BLS) 2017 Occupational Employment and Wages data (Ref. 27) (see footnote 1 in Section 3.1). In accordance with NUREG/CR-4627, Revision 2, "Generic Cost Estimates," issued February 1992 (Ref. 28), direct wage rates are loaded using a multiplier of two to account for licensee and contractor labor and overhead (i.e., fringe, benefits, general administration, and profit). Exhibit 3-3 presents the mean wage rates, loaded wage factor, and loaded wage rates used throughout this analysis.

Exhibit 3-3. Wage Rate Estimates by Labor Category (2020$)

Labor Category	Mean Wage Rate**	Loaded Wage Factor*	Loaded Wage Rate
	A	B	C = A x B
Reactor Director, Engineering Professor	$56.65	2	$113.31
NPUF Operator, Assistant Director	$48.67		$97.34
Nuclear Technician	$41.27		$82.53
Graduate Teaching Assistant	$19.46		$38.91
Administrator Education, Postsecondary	$55.54		$111.08
Nuclear Engineer	$56.18		$112.36
Technical Writer	$38.40		$76.80
General Engineer	$50.65		$101.31
Project Manager	$63.68		$127.36
NRC Staff			$131.76***

* The loaded wage factor was based on NUREG/CR-4627 (Ref. 28).
** The mean wage rate for Engineering Professors (25-1032), Nuclear Power Reactor Operators (51-8011) (henceforth NPUF Operator), Nuclear Technicians (19-4051), Graduate Teaching Assistants (25-1191), Administrators (11-9033), Nuclear Engineers (17-2161), Technical Writers (27-3042), General Engineers (17-2000), and Project Managers (11-1021) were obtained from May 2017 BLS data (Ref. 27). The Nuclear Power Reactor Operator job category was used as a proxy for NPUF Operator based on direct licensee input.
*** The NRC staff loaded labor rates are estimated to be $131.76 per hour and are calculated based on actual labor and benefit costs from the prior fiscal year (2018) by office and grade, and then scaled to 2020 dollars.

Cost Estimation Methods

This analysis relied on several methods of cost estimation. The NRC used its professional knowledge and judgment to estimate many of the costs and averted costs. Additionally, it used a buildup method, solicitation of licensee input, and extrapolation techniques to estimate costs and averted costs.

The NRC consulted experts within and outside of the agency to develop most of the LOE estimates used in the analysis. For example, the NRC contributed to the estimation of LOE required for FSAR review activities. For both averted costs and the costs of the final rule, the NRC consulted licensees when estimating the LOE required for the existing license renewal application process.

The staff estimated some activities using the analogy method of cost estimation, which combines incremental costs of an activity from the bottom up to estimate a total cost. For this step, the NRC reviewed previous license applications and extracted the length of each section, in page numbers, then used these data to develop preliminary LOEs that could then be compared to licensee feedback.

The NRC used extrapolation to estimate some cost activities, relying on actual past or current costs to estimate the future cost of similar activities. For example, to calculate the estimated costs of the existing license renewal process and the final rule, the NRC extrapolated the labor categories of the staff responsible for the work based on licensee data. Where possible, the NRC relied directly on licensee input. In addition, the NRC used actual timekeeping data and contractor costs from the review of several NPUF license renewal applications and extrapolated these data to estimate the NRC cost savings per NPUF and the total averted costs. For license renewal activities for which the NRC had no data, the NRC determined the labor categories of the responsible staff and the distribution of work among the labor categories based on similar steps in the process for which data are available.

To incorporate uncertainty into the model, the NRC employed Monte Carlo simulation, which is an approach to uncertainty analysis in which values for input variables are expressed as distributions defined by the analyst. The analysis was then run 5,000 times, and values were chosen at random from the distributions of the input variables. The result was a distribution of values for the output variable of interest. With Monte Carlo simulation, it is also possible to determine the input variables that have the greatest effect on the value of the output variable. Section 3.6 gives a detailed description of the Monte Carlo simulation methods and presents the results.

3.1.3 Time Period of Analysis

To define the time period of analysis covered by this regulatory analysis (i.e., the period over which costs and averted costs will be incurred), the NRC decided on a 20-year time horizon based on the current, standard 20-year license renewal term for NPUFs. By defining the period of analysis as an increment of 20 years, the costs and averted costs of the final rule can be easily extended to include another full round of license renewals. The 20-year analysis period for this regulatory analysis runs from 2020 (the anticipated effective date of the final rule) through 2039.

3.1.4 Present Value Calculations

The NRC calculated the present value of the costs and averted costs (in 2020 dollars) that NPUFs will incur over the analysis period. The rule is assumed to be finalized and become effective in 2020. One-time implementation costs for both the NRC and licensees will be incurred in 2020. Beginning in 2021, a once-per-5-year cost per licensee (to draft and submit the updated FSAR and subsequent FSAR updates) will be incurred by the licensee, as well as a cost incurred by the NRC to review the submittal.[7] The initial updated FSAR will be a complete

[7] The NRC decided on a 5-year periodicity for FSAR submittals for two reasons. First, 5 years is less frequent than what is required of power reactors, reflecting the “minimum regulation” standard applied to most NPUF licensees. Second, this period of time provides an appropriate level of oversight because the design bases of these facilities evolve slowly over time, with approximately five license amendment requests from all NPUF licensees combined each year and, on average, only five 10 CFR 50.59 evaluations per facility per year for changes that do not require prior NRC approval.

submittal of the FSAR, while subsequent FSAR updates will require fewer changes and will be completed at a lower cost.[8] As discussed previously, currently operating licensees were separated into distinct groupings according to their current license status (shown in Exhibit 3-2). These groups will have a staggered FSAR update submittal schedule to prevent a backlog of FSAR update submittals from occurring. These staggered updates highlight the importance of discounting on the resulting net benefit estimates, as costs and averted costs in the near future are worth more than those that occur further in the future when a discount rate is applied due to the time-value of money (a dollar is worth more today than tomorrow). In accordance with guidance provided by the Office of Management and Budget in Circular A-4, "Regulatory Analysis" (Ref. 29), the NRC presents results at both 3-percent and 7-percent discount rates.

3.2 Summary of Costs, Averted Costs, and Benefits of the Regulatory Options

This section presents the costs, averted costs and benefits of the final rule with respect to three options: (1) take no action, (2) undertake a rulemaking to revise the timely renewal provision and require FSAR updates, and (3) undertake a rulemaking to revise the timely renewal provision, require FSAR updates, and eliminate license terms for Class 104a or c licensees other than testing facilities. The NRC considered a fourth option (i.e., Option 4) that would have used non-rulemaking approaches, such as the issuance of a new regulatory guide and updating NUREG-1537, to address the objectives of the rulemaking (see Section 2.4). Option 4 was rejected and not included in the analysis of costs, averted costs, and benefits because this option would not have fully addressed the Commission's direction and the NRC's objectives for the rulemaking.

The NRC monetizes the impacts of the regulatory options where data allow. Those impacts that cannot be monetized are instead described qualitatively. This section summarizes the total costs and averted costs associated with each option. Sections 3.3 and 3.4 describe the costs, averted costs, and benefits of the final requirements in greater detail. Note that all costs and averted costs presented in this analysis are rounded to two significant figures. The NRC used Monte Carlo simulation methods to account for uncertainty in the estimated costs and averted costs of the final rule. Section 3.6 discusses the uncertainty analysis in detail, and Appendix A gives a more detailed presentation of the cost data.

Exhibit 3-4 shows a summary of the final rule's estimated costs, averted costs, and benefits (qualitative) incurred by licensees and the NRC, according to the facility categories identified in Exhibit 3-1. Further detail on these estimates is provided in Section 3.3 and 3.4.

[8] The NRC anticipates that licensees will document changes in their licensing bases as they occur. This requirement will result in licensees reflecting operation or design changes in their FSARs frequently over time, ensuring that their licensing basis is kept current. These continual updates will require less effort than it takes should the licensee wait to incorporate and submit the updates after 20 years have passed.

Exhibit 3-4: Total Costs, Averted Costs, and Benefits of the Final Rule (2020$)

Category	Low	Medium	High	Other NPUFs	Total
Costs					
Licensees	($150,000)	($870,000)	($270,000)	($220,000)	($1,500,000)
NRC	($92,000)	($510,000)	($120,000)	($80,000)	($800,000)
Averted Costs					
Licensees	$850,000	$5,100,000	$1,000,000	$0	$7,000,000
NRC	$1,400,000	$8,900,000	$2,000,000	$0	$12,000,000
Benefits (Qualitative)					
Licensees	• The initial updated FSAR and subsequent FSAR updates will maintain the continuity of knowledge both for the licensee and the NRC and the understanding of changes and the effects of changes on the licensee. • From a safety perspective, an updated FSAR is important for the NRC's inspection program and for effective licensee operator training and examination. • Establishing a regulatory framework for NPUF license renewal enhances regulatory efficiency by providing stability, predictability, and clarity for licensees. • The amended timely renewal provision will create efficiencies during the license renewal process by reducing the number and scope of requests for additional information and shortening the period of time a license renewal application is pending. As a result, the NRC and licensees will expend less resources during the license renewal process.				
NRC					

Option 1: Take No Action (not selected)

Under Option 1 (not selected), the NRC assumes that the rule would not have been implemented; however, existing programs and regulatory efforts would still have been in effect. No incremental costs or averted costs would have been associated with this option over the 20-year analysis period, as shown in Exhibit 3-5.

Exhibit 3-5: Summary of Incremental Costs and Averted Costs for Option 1: No-Action Baseline [Not Selected]

Incremental Costs	Incremental Averted Costs
Licensees: ($0) using a 3% discount rate ($0) using a 7% discount rate	None
NRC: ($0) using a 3% discount rate ($0) using a 7% discount rate	None

Option 2: Undertake Rulemaking to Require Final Safety Analysis Report Updates and Revise the Timely Renewal Provision (not selected)

Under Option 2 (not selected), the NRC assumes that the current license renewal process would have remained in place. In addition, the NRC would have required the submittal of updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years. This additional requirement would have imposed incremental costs (implementation and

operation) to both licensees and NRC equal to the costs incurred under the final rule (Option 3) without any of the final rule's averted costs.[9]

Exhibit 3-6 presents the incremental costs and averted costs of Option 2. The incremental costs of Option 2 are the same as Option 3. The total costs of Option 2 are estimated at ($1.9 million) at a 3-percent discount rate or ($1.6 million) at a 7-percent discount rate over the 20-year analysis period.

Exhibit 3-6: Summary of Incremental Costs and Averted Costs for Option 2 [Not Selected]

Incremental Costs	Incremental Averted Costs
Licensees: ($1,300,000) using a 3% discount rate ($1,100,000) using a 7% discount rate	None
NRC: ($640,000) using a 3% discount rate ($500,000) using a 7% discount rate	None

Qualitative benefits of Option 2 include enhanced regulatory efficiency as well as public health and safety benefits. In terms of regulatory efficiency, Option 2 would require updated FSARs, subsequent FSAR submittals, and an amended timely renewal provision, which would create efficiencies during the license renewal process by reducing the number and scope of requests for additional information and shortening the period of time a license renewal application is pending. As a result, the NRC and licensees would expend fewer resources during the license renewal process.

Public health and safety benefits from Option 2 include improved NRC oversight of NPUFs. The FSAR submittals require licensees to maintain a facility's licensing basis, which provides the NRC with reasonable assurance that a facility will continue to operate without undue risk to public health and safety. In addition, with a 5-year interval between FSAR submittals, licensees will realize benefits in knowledge management as compared to the baseline.

Option 3: Undertake Rulemaking to Require Final Safety Analysis Report Updates, Revise the Timely Renewal Provision, and Eliminate License Terms for Class 104a or c Licensees Other Than Testing Facilities (selected—final rule)

Under Option 3 (the final rule), the NRC will adopt non-expiring licenses for qualifying facilities. The NRC estimates the costs and averted costs of Option 3 relative to a no-action baseline (i.e., Option 1). Option 3 will result in incremental costs of ($1.9 million) using a 3-percent discount rate or ($1.6 million) using a 7-percent discount rate or over the 20-year analysis period. Exhibit 3-7 presents the breakdown of total costs (e.g., preparing updated FSARs and subsequent FSAR updates).

[9] The revised timely renewal provision and the requirement of licensees to submit updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years would result in efficiencies and burden reductions during the license renewal process. The NRC did not monetize these impacts because of a lack of data and reliable assumptions.

Exhibit 3-7. Summary of Total Costs for Option 3 [Selected-Final Rule] (2020$)

Year		Licensee Cost	NRC Cost	Total Costs
		A	B	C = A + B
1	2020	($190,000)	($71,000)	($260,000)
2	2021	($83,000)	($36,000)	($120,000)
3	2022	($220,000)	($86,000)	($300,000)
4	2023	($200,000)	($79,000)	($280,000)
5	2024	($97,000)	($43,000)	($140,000)
6	2025	($58,000)	($20,000)	($78,000)
7	2026	($120,000)	($47,000)	($170,000)
8	2027	($55,000)	($43,000)	($98,000)
9	2028	($72,000)	($49,000)	($120,000)
10	2029	($24,000)	($21,000)	($46,000)
11	2030	($14,000)	($10,000)	($25,000)
12	2031	($46,000)	($33,000)	($78,000)
13	2032	($55,000)	($43,000)	($98,000)
14	2033	($57,000)	($44,000)	($100,000)
15	2034	($24,000)	($21,000)	($46,000)
16	2035	($14,000)	($10,000)	($25,000)
17	2036	($46,000)	($33,000)	($78,000)
18	2037	($55,000)	($43,000)	($98,000)
19	2038	($57,000)	($44,000)	($100,000)
20	2039	($24,000)	($21,000)	($46,000)
Undiscounted 20-year total		($1,500,000)	($800,000)	($2,300,000)
20-year total with 3% discounting		($1,300,000)	($640,000)	($1,900,000)
20-year total with 7% discounting		($1,100,000)	($500,000)	($1,600,000)
20-year average		($75,000)	($40,000)	($120,000)
Annualized with 3% discounting		($85,000)	($43,000)	($130,000)
Annualized with 7% discounting		($99,000)	($48,000)	($150,000)

The following formula was used to calculate discounted annualized costs and benefits (where r is the discount rate and n is the number of years (i.e., 20 years)): $Annualized\ Cost = Present\ Value\ Cost \cdot \frac{r \cdot (1+r)^n}{(1+r)^n - 1}$.

Note that the annualized cost estimates at 3 percent and 7 percent are higher than the undiscounted yearly average cost estimate because the annualized cost formula described above accounts for both the number of periods (20 years) and the discount rate, which together in this formula serve as a growth rate.
Totals may not match due to rounding.

Implementation of Option 3 will realize a number of benefits and averted costs to both the NRC and NPUFs, as the license renewal process will be replaced with non-expiring licenses for qualifying facilities. The NRC estimates the benefits of Option 3 (i.e., costs averted from license renewals that will not occur) by estimating the cost of the current license renewal process. By moving to non-expiring licenses, Option 3 will result in incremental averted costs of $14 million using a 3-percent discount rate or $10 million using a 7-percent discount rate over the 20-year analysis period. Exhibit 3-8 presents the breakdown of total averted costs.

Exhibit 3-8. Summary of Total Averted Costs for Option 3 [Selected-Final Rule] (2020$)

Year		Licensee Averted Costs	NRC Averted Costs	Total Averted Costs
		A	B	C = A + B
1	2020	$0	$0	$0
2	2021	$210,000	$350,000	$560,000
3	2022	$0	$0	$0
4	2023	$0	$0	$0
5	2024	$0	$0	$0
6	2025	$0	$0	$0
7	2026	$480,000	$820,000	$1,300,000
8	2027	$0	$0	$0
9	2028	$1,600,000	$2,900,000	$4,500,000
10	2029	$1,400,000	$2,600,000	$4,000,000
11	2030	$270,000	$470,000	$740,000
12	2031	$1,400,000	$2,400,000	$3,800,000
13	2032	$270,000	$470,000	$740,000
14	2033	$0	$0	$0
15	2034	$540,000	$940,000	$1,500,000
16	2035	$270,000	$470,000	$740,000
17	2036	$270,000	$470,000	$740,000
18	2037	$270,000	$470,000	$740,000
19	2038	$0	$0	$0
20	2039	$0	$0	$0
Undiscounted 20-year total		$7,000,000	$12,000,000	$19,000,000
20-year total with 3% discounting		$5,200,000	$9,200,000	$14,000,000
20-year total with 7% discounting		$3,600,000	$6,400,000	$10,000,000
20-year average		$350,000	$620,000	$970,000
Annualized with 3% discounting		$350,000	$620,000	$970,000
Annualized with 7% discounting		$340,000	$600,000	$940,000

The following formula was used to calculate discounted annualized costs and averted costs (where r is the discount rate and n is the number of years (i.e., 20 years)): $Annualized\ Cost = Present\ Value\ Cost \cdot \frac{r \cdot (1+r)^n}{(1+r)^n - 1}$.
Totals may not match due to rounding.

This final rule will ease the burden on licensees by creating non-expiring licenses that will result in considerable time and cost savings as compared to Options 1 and 2. Under this option, cost savings will not accrue to Group 4 licensees as they will still be subject to the current license renewal requirements. For further discussion, see Section 3.3. Exhibit 3-9 summarizes the incremental costs and averted costs of the final rule under Option 3. Option 3 will result in net benefits of $12 million using a 3-percent discount rate or $8.4 million using a 7-percent discount rate over the 20-year analysis period.

Exhibit 3-9. Summary of Incremental Costs & Averted Costs for Option 3 [Selected-Final Rule] (2020$)

Year		Total Averted Costs	Total Costs	Net Benefits
		A	B	C = A – B
1	2020	$0	($260,000)	($260,000)
2	2021	$560,000	($120,000)	$440,000
3	2022	$0	($300,000)	($300,000)
4	2023	$0	($280,000)	($280,000)
5	2024	$0	($140,000)	($140,000)
6	2025	$0	($78,000)	($78,000)
7	2026	$1,300,000	($170,000)	$1,100,000
8	2027	$0	($98,000)	($98,000)
9	2028	$4,500,000	($120,000)	$4,400,000
10	2029	$4,000,000	($46,000)	$3,900,000
11	2030	$740,000	($25,000)	$720,000
12	2031	$3,800,000	($78,000)	$3,700,000
13	2032	$740,000	($98,000)	$640,000
14	2033	$0	($100,000)	($100,000)
15	2034	$1,500,000	($46,000)	$1,400,000
16	2035	$740,000	($25,000)	$720,000
17	2036	$740,000	($78,000)	$660,000
18	2037	$740,000	($98,000)	$640,000
19	2038	$0	($100,000)	($100,000)
20	2039	$0	($46,000)	($46,000)
Undiscounted 20-year total		$19,000,000	($2,300,000)	$17,000,000
20-year total with 3% discounting		$14,000,000	($1,900,000)	$12,000,000
20-year total with 7% discounting		$10,000,000	($1,600,000)	$8,400,000
20-year Average		$970,000	($120,000)	$850,000
Annualized with 3% discounting		$970,000	($130,000)	$840,000
Annualized with 7% discounting		$940,000	($150,000)	$800,000

The following formula was used to calculate discounted annualized costs and benefits (where r is the discount rate and n is the number of years (i.e., 20 years)): $Annualized\ Cost = Present\ Value\ Cost \cdot \frac{r \cdot (1+r)^n}{(1+r)^n - 1}$.

Note that the annualized cost estimates at 3 percent and 7 percent are higher than the undiscounted yearly average cost estimate because the annualized cost formula described above accounts for both the number of periods (20 years) and the discount rate, which together in this formula serve as a growth rate.
Totals may not match due to rounding.

The facilities in Group 3 (Aerotest, GE-Hitachi, TAMU (A), and UC/Davis) will be required to renew their facility operating licenses using the ISG and NUREG-1537 as part of receiving a non-expiring license. Aerotest and UC/Davis are expected to undergo license renewal in 2020, TAMU (A) in 2021, and GE-Hitachi, in 2023. Group 3 specific costs and averted costs are presented in Sections 3.3 and Section 3.4.

The facilities in Group 4 (SHINE, NWMI, and NIST) are subject to the license renewal process and will not receive a non-expiring license. These requirements result in the full costs of the final rule, without any of the averted costs (as the current NPUF license renewal application

process will continue). The total 20-year undiscounted cost of the final rule to Group 4 NPUFs is estimated at ($220,000), with an incremental operation cost estimated at ($11,000) per subsequent FSAR update. At the time the staff drafted this report, SHINE, NWMI, and NIST are anticipated to be the only NPUFs that will not be eligible for a non-expiring license term.

3.3 Costs of the Final Rule

This section details the estimated costs and averted costs of the final rule. Under the final rule, the following change to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," will result in costs:

- 10 CFR 50.71(e) will require each NPUF licensee to submit an updated FSAR and subsequent FSAR updates to the NRC at intervals not to exceed 5 years. Although the initial updated FSAR will be a complete submittal of the FSAR, licensees will incur a lower cost for subsequent FSAR updates because the NRC anticipates there will be fewer changes for which to account.

The following final rule change will result in cost savings (see Section 3.4 for a detailed discussion of cost savings):

- 10 CFR 50.51(a) and (c) will eliminate fixed license terms for NPUFs licensed under 10 CFR 50.21(a) or (c), other than Class 103 licensees and testing facilities. This rule change will result in cost savings because the affected NPUFs will no longer be required to go through the license renewal application process.

In addition, the final rule also will include the following changes, which the staff did not quantify in this regulatory analysis:

- Changes to 10 CFR 2.109 will require certain NPUF licensees to file an application for license renewal at least 2 years (rather than the current 30 days) before the expiration of the existing license. This final rule provision will not impose any significant incremental costs (see Section 3.5 for more information) on the NPUFs that will continue to be subject to license renewal, as this activity occurs in the baseline, albeit at a different time (30 days before expiration of the existing license). In addition, the NRC expects this final rule change to provide cost savings as a result of efficiency gains during the license renewal process. Although this requirement will result in gains in efficiency during the license renewal process, the NRC did not attempt to quantify or monetize this improvement.

- Changes to 10 CFR 50.2 will define a non-power production or utilization facility as a production or utilization facility, licensed under 10 CFR 50.21(a), 10 CFR 50.21(c), or 10 CFR 50.22, as applicable, that is not a nuclear power reactor or a production facility as defined under paragraphs (1) and (2) of the definition of "production facility" in 10 CFR 50.2. This provision is an administrative change to create a single definition for these types of facilities. The final rule also revises the definitions of "non-power reactor," "testing facility," and "research reactor." These changes will not result in any quantifiable costs or cost savings during the 20-year period of analysis.

  The final rule also makes conforming changes to terminology used throughout 10 CFR Chapter I. Where appropriate, the NRC added, corrected, or standardized the

terminology and definitions. Additionally, the final rule standardizes the terminology in other parts of the regulations, where appropriate, to modify the intended scope of regulations citing "research and test reactors" to be either "non-power reactors" or "non-power production or utilization facilities." Also, where appropriate, the uses in other parts of the regulations for "testing facility," "research reactor," and "non-power reactor" are changed to only reference one definition in the part where that definition is used most, unless the specific meaning is needed and different for a given part. These changes improve clarity by providing definitions for all NPUF-related terms where used in the regulations while removing the possibility for unintended consequences of possible errors as a result of variations in definitions. The changes are not anticipated to impose quantifiable incremental costs or cost savings on licensees. In a few instances, the NRC replaced the term "non-power reactor" with "non-power production or utilization facility" to include potential future NPUF licensees, such as SHINE and NWMI. However, in the absence of the final rule, the NRC anticipates that these requirements, if applicable, would be imposed on medical radioisotope facilities through license conditions. Therefore, these changes will not result in any quantifiable incremental costs or cost savings during the 20-year period of analysis.

- Changes to 10 CFR 50.33(f)(2) will eliminate the requirement that NPUF applicants need to submit financial information in their license renewal applications that is equivalent to financial information included at the time of initial licensing. Although this requirement will result in cost savings during the license renewal process, the NRC did not attempt to quantify or monetize these savings given the small fraction of the review this represents and the narrow applicability of the new license renewal provision.

- Changes to 10 CFR 50.34 will establish an accident dose criterion for NPUFs other than testing facilities. Existing licensees will not need to change any existing practices. Therefore, this provision will not impose incremental costs on licensees.

- Changes to 10 CFR 50.59(b) will extend the applicability of 10 CFR 50.59 to NPUFs that have permanently ceased operations and returned fuel to the U.S. Department of Energy. This will allow licensees, in some cases, to make changes without the additional burden of requesting prior NRC approval. For the purposes of this analysis, the NRC does not anticipate operating NPUF licensees will permanently cease operations and return their fuel during the 20-year period of analysis. Therefore, this administrative change will not result in any quantifiable incremental cost savings during the 20-year period of analysis. See Section 3.6.3 for sensitivities around decommissioning.

- Changes to 10 CFR 50.82, "Termination of license," will make conforming changes to existing requirements to align terminology and existing requirements with the final rule's terminology and non-expiring license terms. The costs associated with these administrative changes are accounted for in the model through guidance and training costs for NRC and implementation costs for licensees (see Section 3.3.3 and 3.3.4).

- The new 10 CFR 50.135 will define a license renewal process specific to NPUFs (including testing facilities) with licenses issued under 10 CFR 50.22 and testing facilities licensed under 10 CFR 50.21(c), consolidating existing requirements for current and potential future licensees in one section. The final rule will not change the license

renewal process from current requirements. Therefore, the analysis does not include incremental costs for these requirements.

- Changes to 10 CFR 51.45 will cite a new 10 CFR 51.56, "Environmental report—non-power production or utilization facility," in the list of sections that clarify the requirements for an applicant or petitioner to submit an environmental report. This will be an administrative change that will not impose incremental costs on licensees or the NRC.

- The new 10 CFR 51.56 will clarify the existing requirements for each applicant for an NPUF license or license renewal to submit an environmental report. The NRC currently requires licensees to submit equivalent environmental information in the baseline. This section will establish the regulatory framework, which currently does not exist. This new paragraph is not an expansion of the current regulations, and therefore, the final provision will not result in any incremental costs.

The estimated costs and averted costs (i.e., cost savings) of the final rule are higher relative to the proposed rule for the following reasons:

- The NRC issued construction permits to SHINE on February 29, 2016 (Ref. 30), and NWMI on May 9, 2018 (Ref. 31). The scope of the proposed rule's regulatory analysis did not include these construction permit holders. The final rule's regulatory analysis accounts for the rule's impact on these two construction permit holders.

- Since 2017, the NRC has concluded additional license renewal application reviews. The final rule's regulatory analysis accounts for the additional data on the costs associated with the license renewal process. Any costs associated with license renewal applications prior to the publication of the rulemaking are assumed to be sunk costs, and not included in the analysis.

- The NRC adjusted assumptions related to the timing and LOE associated with the submittal of updated FSARs and subsequent FSAR updates to reflect the NRC's approach to applying the requirements in 10 CFR 50.71(e) to NPUF licensees.

In addition, the NRC updated elements of the analysis that have changed as a result of the passage of time between the proposed rule and the final rule (e.g., wage rates, period of analysis).

3.3.1 Independent Cost Estimate

In December 2014, the United States Government Accountability Office (GAO) published GAO-15-98, "Nuclear Regulatory Commission—NRC Needs to Improve Its Cost Estimates by Incorporating More Best Practices" (Ref. 32). The GAO report examined the extent to which the NRC's cost estimating procedures support development of reliable cost estimates and follow specific best practices that are identified in GAO-09-3SP, "GAO Cost Estimating and Managing Capital Program Costs" (Ref. 33). As a result of this audit, the GAO recommended that the NRC align its cost estimating procedures with relevant cost estimating best practices stated in GAO-09-3SP in an effort to ensure that the NRC's future cost estimates are prepared in accordance with relevant cost estimating best practices. Additionally, the GAO recommended that the NRC demonstrate credibility in its cost estimates by cross-checking their results with

independent cost estimates (ICEs) that are developed by others and conducting sensitivity analysis to identify variables most affecting cost estimates (i.e., cost drivers).
In response to the GAO concerns and recommendations, an ICE was performed for this regulatory action. The cost estimating procedures used to develop NRC cost estimates (e.g., draft final NUREG/BR-0058 (Ref. 24) and NUREG/BR-0184 (Ref. 34)) were the same as those used in the ICE, but the methods and techniques used in the ICE were independent of those used in the regulatory analysis. The key differences are the following:

- The regulatory analysis and the independent cost estimate use different labor mixes.
- The regulatory analysis and the independent cost estimate use different quantities of labor.

Exhibit 3-10 shows the difference between the ICE and the regulatory analysis for Net Benefits, Total Costs, and Total Averted Costs. Based on the slight difference between the ICE and regulatory analysis, no changes were made to the estimates in the regulatory analysis.

Exhibit 3-10. Independent Cost Estimate Comparison

	A	B	C = B - A	D = C / A
	Independent Cost Estimate	**Final Rule Regulatory Analysis**	**Difference***	
	Net Costs & Averted Costs	**Net Costs & Averted Costs**	**Magnitude***	**Percent**
Undiscounted 20-year total	17,000,000	$17,000,000	$100,000	1%
20-year total with 3% discounting	12,000,000	$12,000,000	$300,000	3%
20-year total with 7% discounting	8,000,000	$8,400,000	$400,000	5%
	Total Costs	**Total Costs**	**Magnitude***	**Percent**
Undiscounted 20-year total	($2,200,000)	($2,300,000)	($100,000)	5%
20-year total with 3% discounting	($1,800,000)	($1,900,000)	($100,000)	6%
20-year total with 7% discounting	($1,400,000)	($1,500,000)	($100,000)	7%
	Total Averted Costs	**Total Averted Costs**	**Magnitude***	**Percent**
Undiscounted 20-year total	$19,000,000	$19,000,000	$200,000	1%
20-year total with 3% discounting	$14,000,000	$14,000,000	$500,000	4%
20-year total with 7% discounting	$9,000,000	$10,000,000	$700,000	8%

***Differences in ICE (Column A) or final rule regulatory analysis (Column B) may not be exact because of rounding.

3.3.2 Affected Entity Implementation

The final rule will impose implementation costs on the 33 NPUFs that are currently licensed to operate or anticipated to be licensed to operate within the next 5 years.[10] These incremental implementation costs include: reviewing the finalized rule, reviewing the NRC-issued guidance documents, reviewing and updating facility procedures, and allowing the licensee's safety

[10] One decommissioning facility is separately assessed in Section 3.6.4.

review board to review the rule and guidance. One-time licensee implementation costs are assumed to accrue in 2020 (the expected effective date of the rule).

Exhibit 3-11 breaks down the licensee implementation costs by the categories of NPUFs (Low, Medium, High, and Other NPUFs, as shown in Exhibit 3-1). The NRC estimates the implementation costs to range from ($5,600) for each NPUF in the Low, Medium, and High categories to ($6,200) for each NPUF in the Other NPUFs category.

Exhibit 3-11. Breakdown of Affected Entity Implementation Costs per NPUF (2020$)

One-Time Implementation Costs	Low	Medium	High	Other NPUFs
Reviewing Finalized Rule	($1,300)	($1,300)	($1,300)	($1,400)
Reviewing NRC-Issued Guidance Documents	($1,200)	($1,200)	($1,200)	($1,400)
Reviewing and Updating Procedures	($2,300)	($2,300)	($2,300)	($2,600)
Allowing Review by Safety Review Board	($790)	($790)	($790)	($820)
Total One-Time Licensee Implementation Costs*	**($5,600)**	**($5,600)**	**($5,600)**	**($6,200)**

* Totals may not match due to rounding. Totals represent per-NPUF costs.

Exhibit 3-12 details total licensee implementation costs, which amount to ($28,000) for the Low category, ($120,000) for the Medium category, ($22,000) for the High category, and ($19,000) for Other NPUFs. These per-category costs amount to a total one-time licensee implementation cost of ($190,000) over the 20-year analysis period.

Exhibit 3-12. Total Present Value Affected Entity Implementation Costs (2020$)

Component	Identifier	Low	Medium	High	Other NPUFs
One-Time Licensee Implementation Costs	**A**	($5,600)	($5,600)	($5,600)	($6,200)
Number of Licensees	**B**	5	21	4	3
Cost per Category*	**C = A x B**	($28,000)	($120,000)	($22,000)	($19,000)
Present Value Total Licensee Implementation Cost**	**D = ∑ (C)**	**($190,000)**			

* The Cost per Category is equal to the One-time Licensee Implementation Costs multiplied by the Number of Licensees per category (see Exhibit 3-1).
** The Present Value Total Implementation Cost is equal to the summation of the Cost per Category. Because all of the implementation costs are incurred during the first year of the rule, discounting at 3 and 7 percent results in the same present value. Totals may not match due to rounding.

3.3.3 Affected Entity Operation

The final rule will impose operation costs on the 33 NPUFs that are currently licensed to operate or anticipated to be licensed to operate within the next 5 years. These incremental operation costs include routine and recurring activities under the final rule, such as preparing and submitting an updated FSAR and preparing and submitting subsequent FSAR updates.

Exhibit 3-13 breaks down the licensee initial updated FSAR costs and ongoing operation costs by category. These costs include preparing the initial updated FSAR and preparing subsequent FSAR updates. The NRC estimates the initial operation cost per NPUF for the initial FSAR update to be ($6,900) in the Low category, ($10,000) in the Medium category, ($18,000) in the High category, and ($22,000) in the Other NPUFs category. The NRC estimates the ongoing operation costs for each subsequent FSAR update to be ($3,500) per Low category NPUF, ($5,200) per Medium category NPUF, ($9,300) per High category NPUF, and ($11,000) per licensee in the Other NPUFs category. Additionally, the NRC conducted a sensitivity analysis to

estimate operation costs associated with decommissioning NPUFs. See Section 3.6.4 for more information.

Exhibit 3-13. Breakdown of Affected Entity Operation Costs (2020$)*

Licensee Operation Costs	Low	Medium	High	Other NPUFs
Preparing Updated FSAR**	($14,000)	($21,000)	($37,000)	($42,000)
Preparing Subsequent FSAR Updates***	($3,500)	($5,200)	($9,300)	($11,000)

* Values presented are the mean value from the uncertainty analysis. Section 3.6 and Appendix A provide more information.
** The NRC does not anticipate RAIs associated with updated FSARs. Any questions or additional information queries are captured in the LOE or will be addressed by activities outside the scope of the rule. Costs are per NPUF per FSAR update.
*** The NRC does not anticipate RAIs associated with subsequent FSAR updates. Any questions or additional information queries are captured in the LOE or will be addressed by activities outside the scope of the rule. Costs are per NPUF per FSAR update.

Exhibit 3-14 presents the total licensee operation costs for Group 1 and Group 2. Over the course of the 20-year analysis period, four FSAR updates will occur (one every 5 years) consisting of one initial update and three subsequent updates for licensees in Group 1 and Group 2. Therefore, the Undiscounted Total Operating Cost (row F) is equal to the Operation Cost per Category per Initial FSAR Update (row E) plus three times the Operation Cost per Category per FSAR Update (row D) (for three updates in 20 years). These costs per category amount to an undiscounted total licensee operation cost of ($980,000) (($820,000) using a 3-percent discount rate or ($660,000) using a 7-percent discount rate) over the 20-year analysis period.

Exhibit 3-14. Total Present Value Group 1 and Group 2 Entity Operation Costs (2020$)

Component	Identifier	Low	Medium	High
One-Time FSAR Update Costs	**A**	($14,000)	($21,000)	($37,000)
Operation Cost per FSAR Update	**B**	($3,500)	($5,200)	($9,300)
Number of Licensees*	**C**	4	19	3
Operation Cost per Category per FSAR Update**	**D = B x C**	($14,000)	($99,000)	($28,000)
Operation Cost per Category per Initial FSAR Update***	**E = A x C**	($55,000)	($390,000)	($110,000)
Undiscounted Total Licensee Operating Cost******	**F = ∑ (D) x 3 + ∑ (E)**	**($980,000)**		
Total Licensee Operation Cost at 3% discounting		**($820,000)**		
Total Licensee Operation Cost at 7% discounting		**($660,000)**		

* The number of licensees differs from Exhibit 3-1 as this table does not include NPUFs in Groups 3 and 4.
** The Operation Cost per Category per FSAR Update (Row D) is equal to the Operation Cost per FSAR update (Row B) multiplied by the Number of Licensees per category (Row C).
*** The Operation Cost per Category per Initial FSAR Update (Row E) is equal to the One-Time FSAR Update Cost (Row A) multiplied by the Number of Licensees per category (Row C).
**** The Undiscounted Total Operating Cost (Row F) is equal to the Operation Cost per Category per FSAR Update (Row D) multiplied by three (the number of subsequent FSAR updates required per NPUF over the 20-year time period of the analysis) plus the Operation Cost per Category per Initial FSAR Update (Row E). Totals may not match due to rounding.

Exhibit 3-15 presents the total licensee operation costs for NPUFs in Groups 3 and 4. Over the course of the 20-year analysis period, the total number of subsequent FSAR updates submitted by these licensees will vary depending on the timing of the initial licensing or license renewal.

The total operation cost for these licensees is ($340,000) undiscounted (($270,000) using a 3-percent discount rate or ($200,000) using a 7-percent discount rate) over the 20-year analysis period.

Exhibit 3-15. Total Present Value Group 3 and Group 4 Entity Operation Costs (2020$)

	Group 3				Group 4		
Component	**Aerotest**	**GE-Hitachi**	**TAMU (A)**	**UC/Davis**	**NIST**	**SHINE**	**NWMI**
Initial Updated FSAR Costs	($21,000)	($21,000)	($14,000)	($37,000)	($42,000)	($42,000)	($42,000)
Undiscounted Total Licensee Operation Cost	**($340,000)**						
Total Licensee Operation Cost at 3% Discounting	**($270,000)**						
Total Licensee Operation Cost at 7% Discounting	**($200,000)**						

3.3.4 NRC Implementation Costs

The final rule will impose implementation costs on the NRC. These incremental implementation costs include procedural and administrative activities such as updating guidance on the license renewal process, issuing orders to remove license terms and trigger updated FSAR submittals, training NRC staff, and updating the project qualification program.[11] These one-time costs are assumed to be incurred in 2020.

Exhibit 3-16 presents the NRC's total implementation costs, which amount to a one-time cost of ($71,000) over the 20-year analysis period. The NRC's implementation costs are not dependent on licensee categories or groups.

Exhibit 3-16. Breakdown of NRC Implementation Costs (2020$)

One-Time NRC Implementation Costs	All Categories/Groups
Updating Guidance on Revised License Renewal Process	($26,000)
Issue Orders*	($21,000)
Training NRC Staff**	($22,000)
Updating Project Manager Qualification Program	($1,600)
Total NRC Implementation Cost* **	**($71,000)**

*Orders will remove license terms (with the exception of NIST) and trigger updated FSAR submittals.
**The NRC assumes this training will take place in Rockville, Maryland at NRC HQ and 25 NRC staff and inspectors will participate.
***Totals may not match due to rounding.

[11] NRC anticipates issuing 27 orders. Group 1 licensees, Group 2 licensees, and NIST will each receive an order.

3.3.5 NRC Operation Costs

The final rule will also impose operation costs on the NRC. These incremental operation costs include recurring activities under the final rule such as the review of the updated FSARs and review of subsequent FSAR updates.

Exhibit 3-17 details the NRC's initial and ongoing operation costs. The NRC initial costs per licensee amount to ($6,800) in the Low category, ($9,000) in the Medium category, ($11,000) in the High category, and ($11,000) in the Other NPUFs category. These costs are incurred from reviewing the initial updated FSAR.

NRC's ongoing operation costs per licensee amount to ($3,400) in the Low category, ($4,500) in the Medium category, ($5,600) in the High category, and ($5,600) in the Other NPUFs category. These costs are incurred from reviewing the subsequent FSAR updates.

Exhibit 3-17. Breakdown of NRC Operation Costs (2020$)

NRC Operation Costs	Low	Medium	High	Other NPUFs
Reviewing Updated FSAR*	($6,800)	($9,000)	($11,000)	($11,000)
Reviewing Subsequent FSAR Updates*	($3,400)	($4,500)	($5,600)	($5,600)

* Total NRC operation costs are costs per updated FSAR per NPUF.

Exhibit 3-18 presents the total NRC operation costs for NPUFs in Group 1 and Group 2 over the analysis period. Over the course of the 20-year analysis period, four FSAR updates will take place (one initial update and three subsequent updates), resulting in four reviews. The first review will incur the largest cost. The total cost for Group 1 and Group 2 NPUF operation costs is ($580,000) undiscounted (($570,000) using a 3-percent discount rate or ($430,000) using a 7-percent discount rate) over the 20-year analysis period.

Exhibit 3-18. Total Present Value of NRC Operation Costs Associated with Group 1 and Group 2 NPUFs (2020$)

Component	Identifier	Low	Medium	High
Initial Operation Cost per FSAR Update	**A**	($6,800)	($9,000)	($11,000)
Ongoing Operation Cost per FSAR Update	**B**	($3,400)	($4,500)	($5,600)
Number of Licensees*	**C**	4	19	3
Operation Cost per Category per Ongoing FSAR Update**	**D = B x C**	($14,000)	($86,000)	($17,000)
Operation Cost per Category per Initial FSAR Update***	**E = A x C**	($27,000)	($170,000)	($34,000)
Undiscounted Total NRC Operation Cost******	**F = ∑ (D) x 3 + ∑ (E)**	**($580,000)**		
Total NRC Operation Cost at 3% discounting		**($570,000)**		
Total NRC Operation Cost at 7% discounting		**($430,000)**		

* The number of licensees differs from Exhibit 3-1 as NPUFs included in Groups 3 and 4 are not included in this table.
** The Operation Cost per Category per Ongoing FSAR Update (Row D) is equal to the Ongoing Operation Cost per FSAR update (Row B) multiplied by the Number of Licensees per category (Row C).
*** The Operation Cost per Category per Initial FSAR (Row E) is equal to the Initial Operation Cost per FSAR (Row A) multiplied by the Number of Licensees per category (Row C).

**** The Undiscounted Total Operating Cost (Row F) is equal to the Operation Cost per Category per Ongoing FSAR Update (Row D) multiplied by three (the number of subsequent FSAR updates required per NPUF over the 20-year time period of the analysis) plus the Operation Cost per Category per Initial FSAR (Row E).
***** Totals may not match due to rounding.

Exhibit 3-19 presents the total NRC operation costs for NPUFs in Group 3 and Group 4 over the analysis period. Over the course of the 20-year analysis period, the number of subsequent FSAR updates will depend on the date of each NPUF's license renewal. Aerotest, GE-Hitachi, NWMI, SHINE, TAMU (A), and UC/Davis are expected to complete two subsequent FSAR updates. NIST is expected to complete three subsequent FSAR updates. These per-category costs amount to total Group 3 and Group 4 NPUF operation costs of ($150,000) undiscounted (($110,000) using a 3-percent discount rate or ($80,000) using a 7-percent discount rate) over the 20-year analysis period.

Exhibit 3-19. Total Present Value of NRC Operation Costs Associated with Group 3 and Group 4 NPUFs

Component	Group 3				Group 4		
	Aerotest	**GE-Hitachi**	**TAMU (A)**	**UC/Davis**	**SHINE**	**NWMI**	**NIST**
Initial Updated FSAR Costs	($9,000)	($11,000)	($6,800)	($11,000)	($11,000)	($11,000)	($11,000)
Operation Cost per Subsequent FSAR Update	($4,500)	($4,500)	($3,400)	($5,600)	($5,600)	($5,600)	($5,600)
Number of Subsequent FSAR Updates	2	2	2	2	2	2	3
Undiscounted Total NRC Operating Cost	**($150,000)**						
Total NRC Operation Cost at 3% Discounting	**($110,000)**						
Total NRC Operation Cost at 7% Discounting	**($80,000)**						

Totals may not match due to rounding.

3.3.6. Averted Costs Associated with Affected Entities and NRC Operation

This section details the estimated averted costs (i.e., cost savings) of the final rule for both licensees and the NRC. The monetized benefits of the final rule are averted operation costs. The averted operation costs for licensees are presented in Exhibit 3-20. These averted costs stem from the savings in time and money created by discontinuing the existing license renewal process for qualifying NPUFs (i.e., research reactors currently licensed to operate). The licensee averted operation cost represents the cost savings per NPUF by switching to non-expiring licenses. Group 3 and Group 4 licensees do not incur averted costs because their averted license renewals will occur beyond the time horizon of this analysis (Aerotest, GE-Hitachi, TAMU (A), and UC/Davis) or they will continue to go through the existing license renewal process (NIST, SHINE, and NWMI). If the analysis time period were extended,

Group 3 NPUFs (Aerotest, GE-Hitachi, TAMU (A), and UC/Davis) would realize cost savings from the final rule similar to the savings realized by other licensees.

The NRC estimates that the final rule will result in total cost savings in the form of averted operation costs to affected entities of $7.0 million undiscounted ($5.2 million using a 3-percent discount rate or $3.6 million using a 7-percent discount rate) over the 20-year analysis period.

Exhibit 3-20. Total Present Value Averted Operation Costs for Group 1 and Group 2 Affected Entities (2020$)

Component	Identifier	Low	Medium	High
NPUF Averted Operation Cost	**A**	$210,000	$270,000	$340,000
Number of Licensees*	**B**	4	19	3
Averted Operation Cost per Category	**C = A x B**	$850,000	$5,100,000	$1,000,000
Undiscounted Total Present Value Averted Operation Cost**	**D = ∑ (C)**	$7,000,000		
Total Present Value NPUF Averted Operation Cost at 3% discounting		$5,200,000		
Total Present Value NPUF Averted Operation Cost at 7% discounting		$3,600,000		

* The number of licensees differs from Exhibit 3-1 as NPUFs in Groups 3 (Aerotest and GE-Hitachi (Medium Category); TAMU (A) (Low Category); UC/Davis (High Category)); and 4 (SHINE, NWMI, and NIST (All Other NPUFs Category)) are assumed to not realize any averted costs.
**Totals may not match due to rounding.

The averted operation costs realized by the NRC are presented in Exhibit 3-21. These averted operation costs result from fewer license renewal application reviews. To estimate these averted costs, the NRC used historical cost data for representative license renewal application review efforts (i.e., Purdue University, Dow Chemical Company, and Rhode Island Atomic Energy Commission).

The NRC estimates that the final rule will result in total averted costs to the agency of $12 million undiscounted ($9.2 million using a 3-percent discount rate or $6.4 million using a 7-percent discount rate) over the 20-year analysis period.

Exhibit 3-21. Present Value Averted Operation Costs for NRC (2020$)

Component	Identifier	Low	Medium	High
NRC Averted Operation Costs Per NPUF	**A**	$350,000	$470,000	$670,000
Number of Licensees*	**B**	4	19	3
NRC Averted Operation Costs Per Category	**C = A x B**	$1,400,000	$8,900,000	$2,000,000
Undiscounted Total Present Value Averted Operation Cost**	**D = ∑ (C)**	**$12,000,000**		
Total Present Value NRC Averted Operation Cost at 3% discounting		**$9,200,000**		
Total Present Value NRC Averted Operation Cost at 7% discounting		**$6,400,000**		

* The number of licensees differs from Exhibit 3-1 as NPUFs in Groups 3 (Aerotest and GE-Hitachi (Medium Category); TAMU (A) (Low Category); UC/Davis (High Category)); and 4 (SHINE, NWMI, and NIST (All Other NPUFs Category)) are assumed to not realize any averted costs.
**Totals may not match due to rounding.

3.4 Benefits of the Final Rule

Relative to the no-action baseline, the options under consideration have the following incremental benefits:

- Option 1 (not selected): No-action alternative. This option would not have resulted in any incremental benefits.

- Option 2 (not selected): Undertake rulemaking to require FSAR updates and revise the timely renewal provision. This option would have resulted in improvements in the following benefits: Public Health and Safety (Accident), Occupational Health (Accident), Offsite Property, Onsite Property, Environmental Considerations, and Regulatory Efficiency.

- Option 3 (the final rule): Undertake rulemaking to require FSAR updates, revise the timely renewal provision, and eliminate license terms for medical therapy or research and development facilities, other than testing facilities, licensed under § 50.21(a) or (c) (among other changes described in Section 3.3). This option, which is the final rule, will result in improvements to Public Health and Safety, and substantial improvements associated with Regulatory Efficiency (as discussed below).

3.4.1 Benefits Associated with Public Health (Accident), Occupational Health (Accident), Offsite Property, Onsite Property, and Environmental Considerations

Because NPUFs operate at a low power level and are recognized as having no major impact on the environment or public health and safety, the rule's associated safety risks and public health, occupational health, and environmental benefits are very small.

Under Option 3 (the final rule), all eligible NPUF licensees must undergo license renewal using the guidance in NUREG-1537 to qualify for non-expiring license terms to ensure that each licensee's licensing basis has been appropriately maintained.[12] This final rule will add new requirements such as the submittal of updated FSARs and subsequent FSAR updates to the NRC at intervals not to exceed 5 years, which will help ensure that a licensee does not lose its licensing basis over time.[13] Recurring FSAR updates by licensees and reviews by the NRC will increase licensees' focus on maintaining their facilities' licensing bases. In addition, the public will remain informed about facility operations through the publicly available FSAR submittals and will continue to have opportunities to participate in the regulatory process through licensing actions and the 10 CFR 2.206 petition process. By eliminating license terms and requiring periodic FSAR update submittals, coupled with existing oversight processes, the NRC will reduce the burden on the affected licensees and the NRC, which is consistent with the AEA and supports the NRC's goal of efficient and effective licensing. In addition, recurring FSAR updates

[12] By the time the rule is effective, all but four NPUFs will have undergone license renewal using the guidance in NUREG-1537. These four NPUFs will be subject to license renewal before being granted a non-expiring license.

[13] As discussed previously, the NRC decided on a 5-year periodicity for FSAR submittals for two reasons. First, 5 years is less frequent than what is required of power reactors, reflecting the "minimum regulation" standard applied to most NPUF licensees. Second, the design bases of these facilities evolve slowly over time, with approximately five license amendment requests from all NPUF licensees combined each year and, on average, only five 10 CFR 50.59 evaluations per facility per year for changes that do not require prior NRC approval.

will maintain continuity of knowledge both for the licensee and the NRC and the understanding of changes and effects of changes on the facility.

3.4.2 Benefits Associated with Regulatory Efficiency

Under Option 3 (the final rule), the NRC anticipates that the requirements will result in regulatory efficiency through improved stability, predictability, and clarity of the license renewal process.

The final rule explicitly defines the regulatory requirements governing the license renewal process and updates the timely renewal requirements in 10 CFR 2.109 to provide additional time for the NRC to perform an acceptance review and, in many cases, conduct the license renewal review. Challenges with the current license renewal process contributed to long review durations and additional costs to the NRC and licensees to address deficiencies in licensees' documentation.

Under Option 3, the final rule creates a consolidated regulatory framework for NPUF license renewal in 10 CFR 50.135. This framework provides stability, predictability, and clarity for the license renewal process. In addition, for NPUFs that will continue to undergo license renewal, the requirements for updated FSARs, subsequent FSAR submittals, and the amended timely renewal provision will create efficiencies during the license renewal process by reducing the number and scope of requests for additional information and the NRC's review time. As a result, the NRC and licensees will expend fewer resources during the license renewal process.

3.5 Disaggregation

To conform to the guidance in draft final NUREG/BR-0058, Section 4.3.2, "Criteria for the Treatment of Individual Requirements" (Ref. 24), the NRC performed a screening review to determine whether the final rule is unnecessary to achieve the objectives of the rulemaking. Exhibit 3-22 shows how each component of the rule corresponds to the final rule's objectives. Exhibit 3-23 presents costs, averted costs, and benefits by the objectives of the rule.

Exhibit 3-22. Final Rule Components and Objectives

Components	**Objective 1:** Address Reliance on Initial Licensing Regulations for License Renewal	**Objective 2:** Address Lack of Periodic Updates to FSAR	**Objective 3:** Address Constraints Related to Current "Timely Renewal" provision in 10 CFR 2.109	**Objective 4:** Address Other Rule Language Issues
New and revised definitions				X
Eliminates license terms for NPUFs, other than testing facilities, licensed under 10 CFR 50.21(a) or (c)	X			
Defines license renewal process	X			
Requires NPUFs to submit updated FSARs and subsequent FSAR updates		X		
Amendment of timely renewal provision under 10 CFR 2.109			X	
Accident dose criterion				X
Extends applicability of 10 CFR 50.59				X
Clarifies requirements of 10 CFR 51.45				X
Elimination of requirement under 10 CFR 50.33(f)(2)				X

Exhibit 3-23. Undiscounted Costs, Averted Costs, and Benefits by Objective (2020$)

Objectives	**Costs**	**Averted Costs**	**Net**	**Qualitative Benefits**
Objective 1	$0	$19.3 million	$19.3 million	Regulatory efficiency benefits
Objective 2	($2.3 million)	$0	($2.3 million)	Public health and safety benefits
Objective 3	($2,100) – ($21,000)	$0	($2,100) – ($21,000)	Public health and safety benefits
Objective 4	*	$0	*	Regulatory efficiency, public health and safety benefits

*Objective 4, Other Rule Language Issues, is expected to impose a portion of the one-time implementation costs associated with the final rule (e.g., administrative review of the final rule requirements). These incremental costs are assumed to be offset by the ongoing regulatory efficiency and public health and safety benefits.

With regard to Objective 2, which shows a sizable cost without quantified averted costs, the final rule will help the NRC and licensees avoid the burden associated with reconstituting licensing basis information that can be lost over time if FSARs are not routinely updated. Recurring FSAR updates by licensees and reviews by the NRC will increase licensees' focus on maintaining their facilities' licensing bases and provide reasonable assurance that a facility will continue to operate without undue risk to public health and safety and without compromising common defense and security.

Therefore, the NRC concludes that the final rule is necessary to achieve the objectives of the rulemaking, and each aspect when considered separately adds to the net cost beneficial nature of the final rule.

3.6 Uncertainty Analysis

To determine the robustness of the costs and net benefits of the final rule, the NRC examined how licensee and the NRC costs change as a result of uncertainties associated with the NRC's analytical assumptions and input data. As mentioned in Section 3.1, the NRC used Monte Carlo simulation to examine the impact of uncertainty on the estimated net benefits of the final rule. These Monte Carlo simulations were performed using the @Risk software package by Palisade Corporation.[14]

Monte Carlo simulations involve introducing uncertainty into the analysis by replacing the point estimates of the variables used to estimate costs and averted costs with probability distributions. By defining input variables as probability distributions rather than point estimates, the effect of uncertainty on the results of the analysis (i.e., the net benefits) can be effectively modeled.

The Monte Carlo simulations were performed by repeatedly running the analysis (5,000 times). For each iteration of the analysis, the staff chose a value randomly from the probability distributions that define the input variables. The value of the output variable (the net benefits) was recorded for each iteration, and all of the resulting values for the output variable were used to define a distribution for the results.

3.6.1 Uncertainty Model Inputs

To account for uncertainty, the NRC assigned probability distributions to the inputs of LOE, workload percentage, and existing NRC costs for Low, Medium, High, and Other NPUF category facilities:

- The LOEs for both the licensees and the NRC for the current license renewal process and the final rule are uncertain; therefore, the NRC assigned distributions to these variables.

- The NRC also assigned probability distributions to the workload percentages, or the amount of work performed by each labor category.

- The NRC relied upon NRC timekeeping data and NRC contractor cost data to estimate the cost of the existing license renewal process to the NRC. The NRC assigned probability distributions informed by these data to the NRC costs.

The probability distributions chosen to represent the different variables in the analysis were bounded by the range of LOE and labor category workloads derived from licensee input and the NRC's professional judgment. These distributions have mean values equal to the average LOE or workload per NPUF category (Low, Medium, High, and Other NPUFs). These mean values appear in the exhibits in Section 3.2, Section 3.3, and Appendix A.

[14] Information about this software is available at http://www.palisade.com (Ref. 35).

When defining the probability distributions for use in the Monte Carlo simulation, the staff needed other summary statistics besides the mean value to characterize the distributions. These other summary statistics include the standard deviation of a distribution with a normal shape, or the minimum and maximum of a triangular distribution. For the LOE distributions, the NRC used input from licensees to set the minimum and maximum values of the triangular distributions.

As an example of the variables and distributions used in the Monte Carlo simulations, Exhibit 3-24 displays the inputs for the analysis runs for Medium category facilities (see Exhibit 3-1). The NRC constructed these distributions differently for Low, Medium, High, and Other NPUF category facilities. Appendix A contains a complete list of the variables included in the uncertainty analysis.

Exhibit 3-24. Example Variables and Distributions Used in the Monte Carlo Analysis (Medium Category)

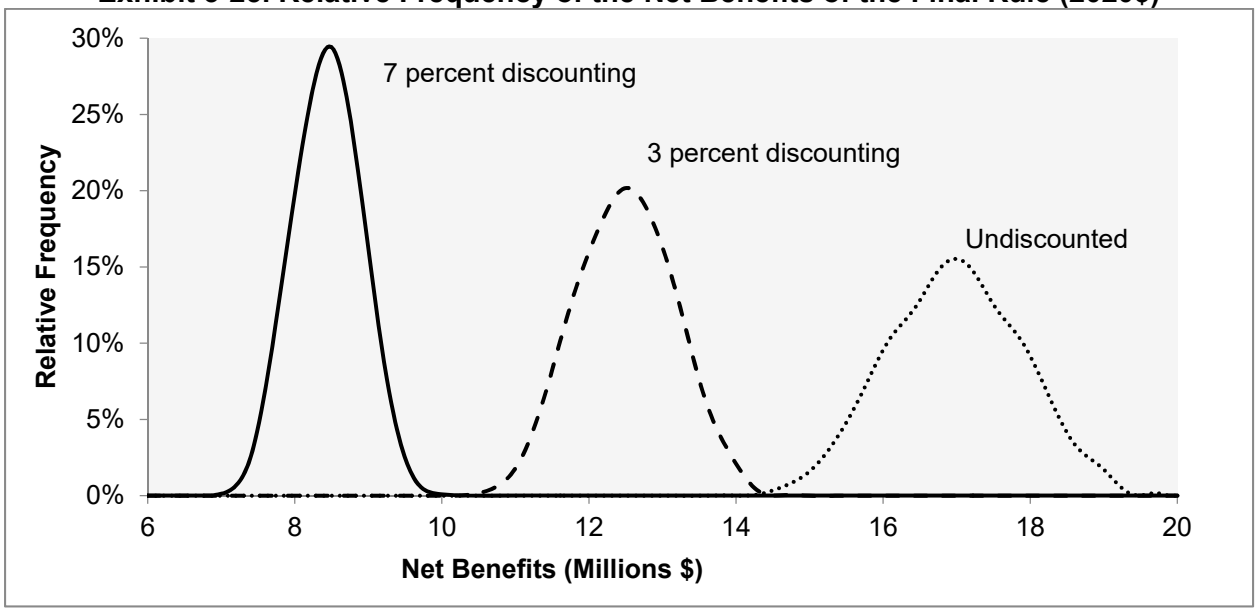
Variable	Description	Distribution	Mean	Minimum	Maximum
Responding to All RAIs	NPUF Pre-Rule LOE*	Triangular	1,491 hours	120 hours	2682 hours
Preparing Updated FSAR	NPUF Post-Rule LOE	Triangular	127.5 hours	110 hours	145 hours
Preparing Updated FSAR	NPUF Post-Rule Graduate Student Workload	Triangular	30%	10%	50%

*Costs described as “Pre-Rule LOE” are costs assumed not to be incurred by licensees after the effective date of the rule (i.e., averted costs or cost savings).

3.6.2 Uncertainty Model Results

Exhibit 3-25 summarizes the distribution of the undiscounted net benefits (dotted line) and the results discounted at 3 percent (dashed line) and 7 percent (solid line). The exhibits below present the results and include all categories of facilities (Low, Medium, High, and Other NPUFs). As can be seen below, regardless of discount rate, the final rule has a positive net benefit (i.e., 100 percent of the distributions are above zero).

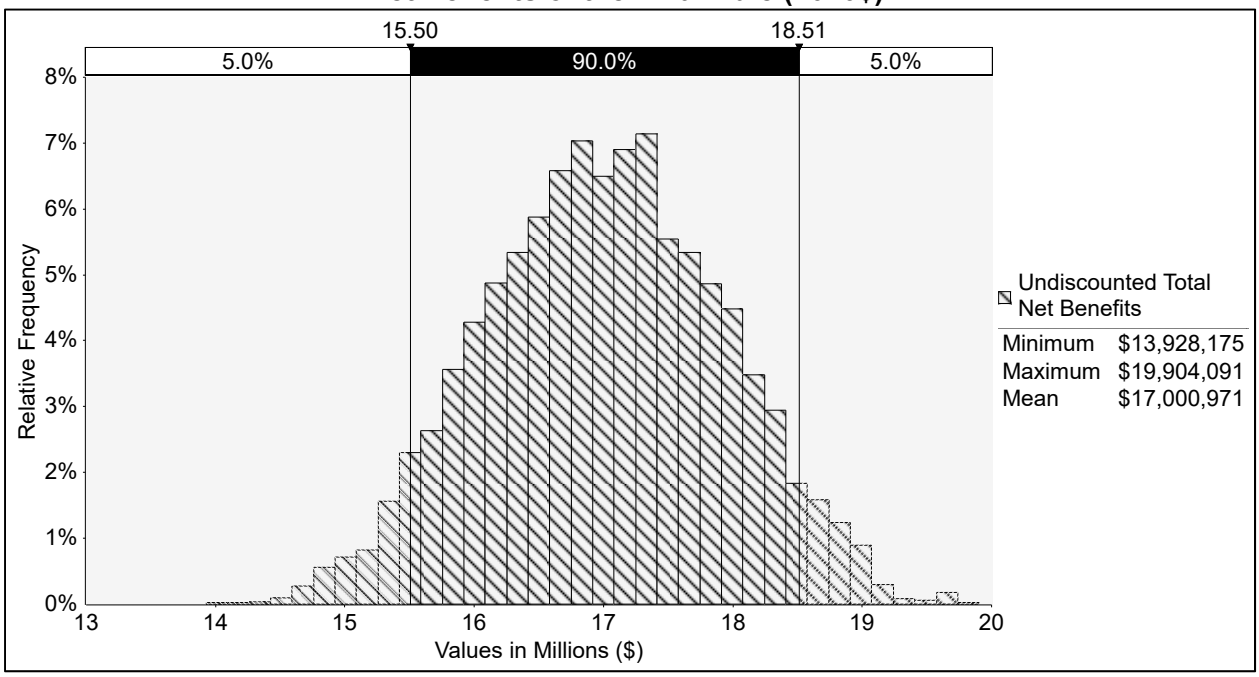
Exhibit 3-25. Relative Frequency of the Net Benefits of the Final Rule (2020$)



NOTE: As the discount rate increases in the above exhibit, the distributions become narrower. This narrowing is a result of the decreasing range of present value net benefits as discount rates increase. Larger discount rates result in smaller cost and benefit values in later years in the analysis period, resulting in a smaller range and a narrower distribution.

Exhibit 3-26 displays the results of the uncertainty analysis for the net benefits (averted costs minus costs) of the final rule. By allowing uncertain assumptions and inputs to range across a distribution, the results are no longer static and instead spread across a range with varying degrees of certainty. In this particular simulation, the analysis indicates that 90 percent of the times the model was run (out of 5,000 times), the final rule resulted in an averted cost of $15.5 million to $18.5 million. In some iterations, the model did result in a net benefit as low as $13.9 million and as high as $19.9 million, with an average of $17.0 million.

Exhibit 3-26. Relative Frequency of the Undiscounted Net Benefits of the Final Rule (2020$)



Similarly, Exhibit 3-27 and Exhibit 3-28 show the net benefits with 3- and 7-percent discounting. When using 3-percent discounting, 90 percent of the times the model was run, the final rule resulted in an averted cost of $11.4 million to $13.6 million. In some iterations, the model did result in a net benefit as low as $10.2 million and as high as $14.6 million, with an average of $12.5 million.

When using 7-percent discounting, 90 percent of the times the model was run, the final rule resulted in an averted cost of $7.7 million to $9.2 million. In some iterations, the model did result in a net benefit as low as $6.9 million and as high as $9.9 million, with an average of $8.4 million.

Exhibit 3-27. Relative Frequency of the Net Benefits of the Final Rule at 3 Percent Discounting (2020$)

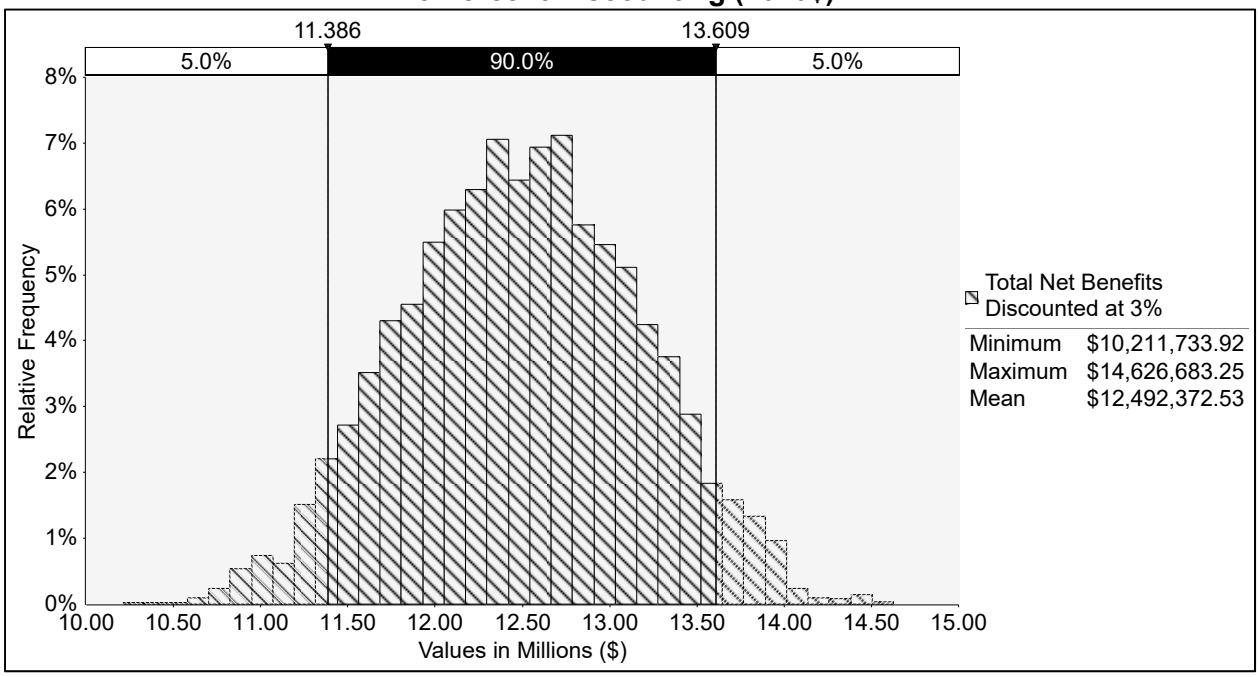
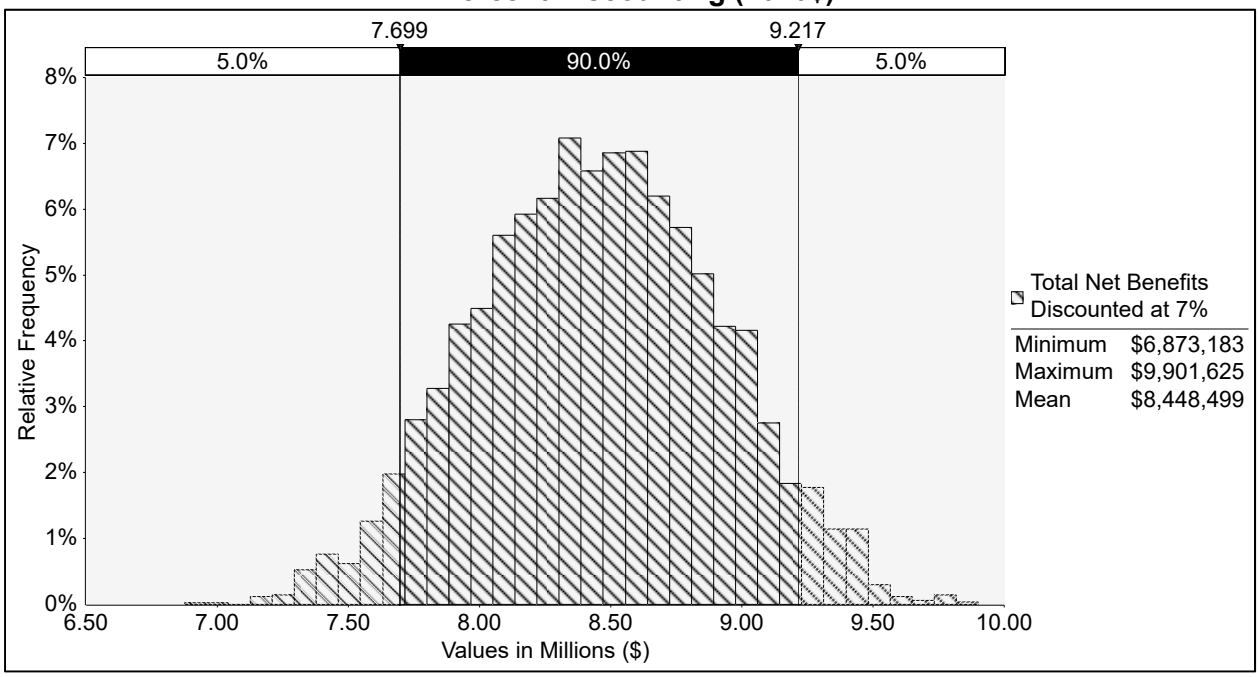


Exhibit 3-28. Relative Frequency of the Net Benefits of the Final Rule at 7 Percent Discounting (2020$)



Examining the range of the resulting distributions of net benefits, it is possible to more confidently discuss the potential costs and averted costs of the final rule. As mentioned above, the exhibits display a 90-percent confidence interval, meaning that the net benefits will fall between the ranges mentioned above for 90 percent of the iterations run as part of the Monte

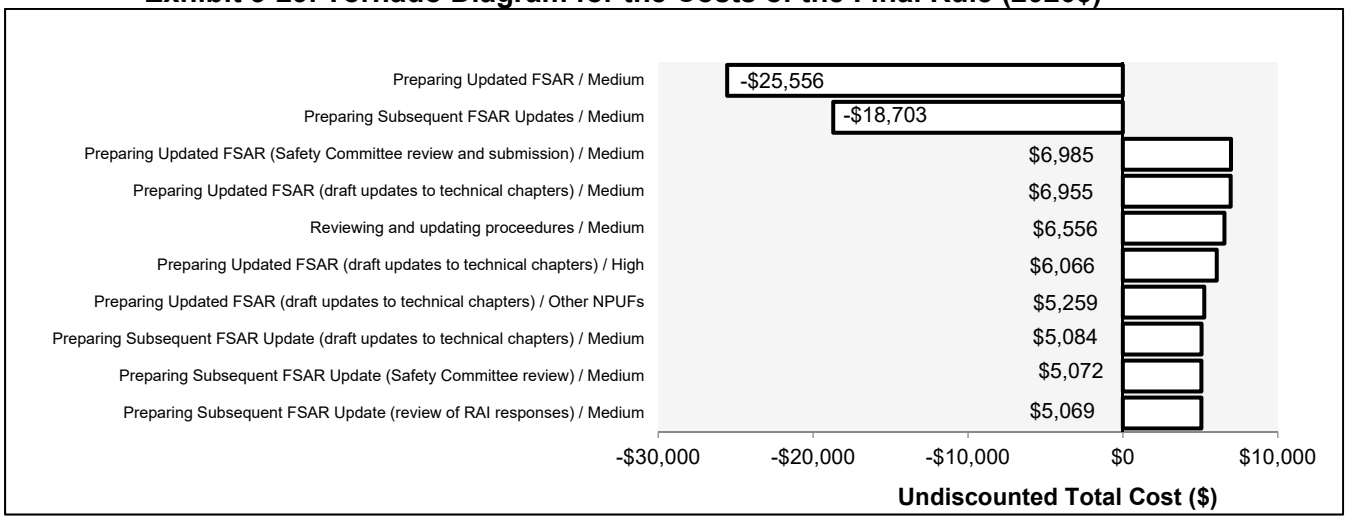
Carlo simulations. In all cases, regardless of the discount rate used, the averted costs of the final rule will outweigh the costs that will be incurred by licensees and the NRC for implementation of the final rule. This result is demonstrated by the fact that the resulting distributions of net benefits, whether undiscounted or at 3- or 7-percent discount rates, are always above zero.

3.6.3 Sensitivity Analysis

In addition to estimating the probability distributions for the net benefits of the final rule, the NRC used Monte Carlo simulation to conduct a sensitivity analysis to determine the variables with the greatest impact on the resulting net benefits. Variables shown to have a large effect on the resulting net benefits may deserve more attention and scrutiny than variables shown to have a small or minimal effect.

To estimate the effect of each variable on the net benefits, the staff performed a regression with the net benefits as the dependent variable and the inputs as the independent variables. The result of this regression, called a "tornado diagram," presents in vertical order the variables with the greatest influence on net benefits. The tornado diagram also displays the resulting regression coefficient for each of the input variables. Exhibit 3-29 presents a tornado diagram for the total costs of the final rule. Similarly, Exhibit 3-30 presents the tornado diagram for the net benefits of the final rule.

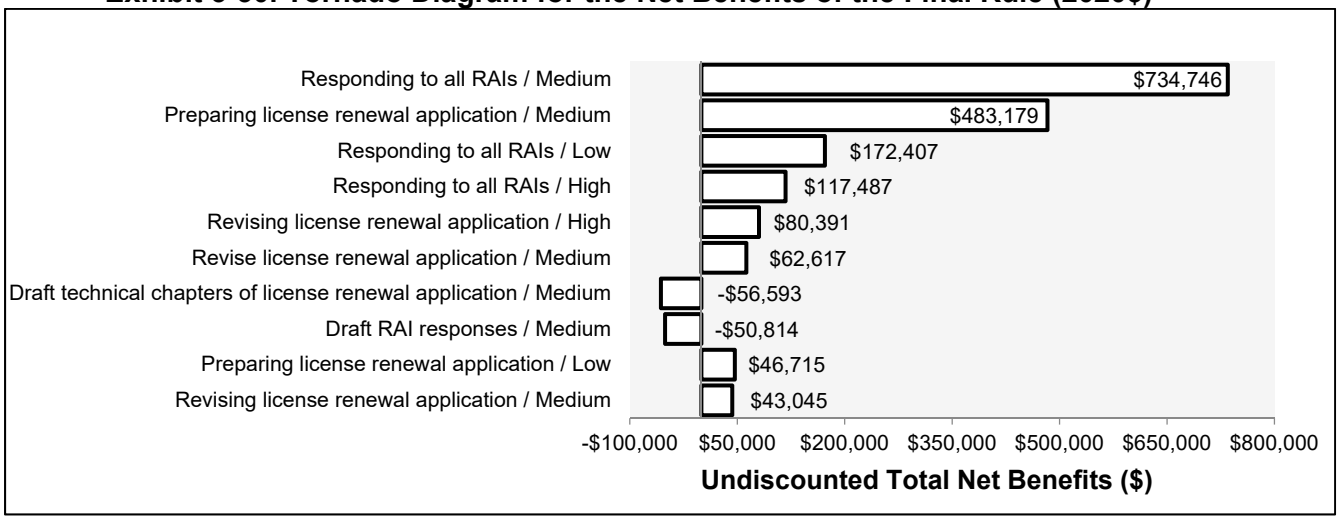
Exhibit 3-29. Tornado Diagram for the Costs of the Final Rule (2020$)*



* Some of the process steps, such as Preparing Updated FSARs, have multiple substeps. Exhibits A-1 and A-2 in Appendix A to this analysis detail these substeps.

The Y-axis in Exhibit 3-29 shows the process step followed by the category of facility. Therefore, Row 1 shows that the largest driving cost is "Preparing the Update FSAR" for medium category facilities.

Exhibit 3-30. Tornado Diagram for the Net Benefits of the Final Rule (2020$)



The Y-axis in Exhibit 3-30 shows the process step followed by the category of facility. Therefore, Row 1 shows that the largest net benefit is the Responding to RAIs averted costs for Medium category facilities.

Examining the tornado diagrams provides insight into which of the current and new licensing steps have the largest impacts on the results of this analysis. From Exhibit 3-29, the parameters having the greatest influence on the total costs of the final rule are the costs for preparing the updated FSARs and preparing the license renewal application for medium facilities. The influence of a variable on the output is not only a function of the value of the variable but also of the spread of its distribution.

The values shown in Exhibit 3-30 are net benefits and, therefore, are savings brought about by the final rule. The parameters having the greatest influence on the net benefits of the final rule are the averted costs, or savings, for responding to RAIs of medium category facilities under the current licensing process.

3.6.4 Decommissioning NPUFs Assumption Sensitivity

The NRC estimated the costs and averted costs incurred by the 31 NPUFs currently licensed to operate as well as two NPUFs anticipated to be licensed to operate within the next 5 years. Incremental costs and benefits to the other three regulated NPUFs that are in the process of decommissioning, have possession-only licenses, or are permanently shut down are not considered in the regulatory analysis. These other three regulated NPUFs include two General Atomics facilities whose licenses should be terminated in 2019 (so no costs would be incurred associated with the rule), and the General Electric Co. General Electric Test Reactor that will stay in SAFSTOR until 2041.

Based on the condition of the General Electric Test Reactor, the NRC estimates that the costs associated incurred by this decommissioning NPUF will be approximately $1,000, undiscounted, over the 20-year period of analysis. This cost estimate covers the time required to draft a letter once every 5 years indicating that there have been no changes to the facility's FSAR.

As an additional sensitivity, the NRC examined the costs associated with the potential outcome where an additional NPUF enters decommissioning during the period of analysis. Per the provisions in the final rule, an NPUF undergoing decommissioning would continue to submit subsequent FSAR updates to the NRC at intervals not to exceed 5 years. The NRC anticipates that subsequent FSAR submittals by the decommissioning NPUF would generally describe systems or components that have been removed from the facility or update the description of the site.

Based on this information, the NRC estimates that there is little difference between subsequent FSAR updates for operating reactors and decommissioning NPUFs in terms of NRC and licensee LOE. Additionally, an initial updated FSAR is not required, so a decommissioning facility would only provide the subsequent FSAR updates at the 5-year intervals. For the purposes of the sensitivity analysis, the NRC uses a conservative assumption that the decommissioning process for NPUFs will last 20 years. This assumption allows the sensitivity analysis to capture the maximum potential costs to NPUF licensees of complying with the final rule during decommissioning and ensures consistency with other assumptions in the regulatory analysis. The length of the decommissioning process for NPUFs may be less than 20 years, depending on licensee-specific criteria. In those cases, the regulatory analysis overestimates the costs of complying with the final rule during the period of decommissioning. Cost estimates by licensee and NRC are presented in Exhibit 3-31. Licensee undiscounted costs associated with decommissioning would amount to: ($26,000) for a Low category NPUF, ($37,000 for a Medium category NPUF, ($57,000) for a High category NPUF, and ($62,000) for an Other category NPUF.

Exhibit 3-31. Decommissioning Costs (2020$)

Costs	Low	Medium	High	Other NPUFs
Licensee	($13,000)	($20,000)	($35,000)	($41,000)
NRC	($13,000)	($17,000)	($21,000)	($21,000)
Total	($26,000)	($37,000)	($57,000)	($62,000)

Totals may not match due to rounding.

3.6.5 SHINE and NWMI Licensing Sensitivity

SHINE and NWMI currently hold construction permits for their facilities but have not yet applied for operating licenses. The regulatory analysis assumes that each facility will be licensed to operate in 2021. The actual dates could be earlier or later depending on various factors, such as when SHINE and NWMI submit operating license applications.

If SHINE and NWMI were to receive operating licenses prior to 2021, their FSAR update costs would be incurred earlier, and an additional round of subsequent FSAR updates may fall within the analysis period. Similarly, if they receive their operating license after 2021, their FSAR update costs would be incurred later, and fewer rounds of subsequent FSAR updates may occur during the analysis period. The NRC estimates an additional round of subsequent FSAR updates for the Other NPUF category to cost licensees $10,000 and NRC $5,000 per NPUF.

4. Regulatory Flexibility Analysis

The Regulatory Flexibility Act (RFA), as amended at 5 U.S.C. 601 et seq. (Ref. 7), requires that agencies consider the impact of their rulemakings on small entities and, consistent with applicable statutes, consider alternatives to minimize these impacts on the businesses, organizations, and government jurisdictions to which they apply.

In accordance with Small Business Administration's (SBA) regulation 13 CFR 121.903(c) (Ref. 36), the NRC has developed its own size standards for performing a Regulatory Flexibility Analysis pursuant to the RFA, and has verified with the SBA Office of Advocacy that its size standards are appropriate for NRC analyses. The NRC size standards at 10 CFR 2.810 are used to determine whether a licensee qualifies as a small entity in the NRC's regulatory programs. Section 2.810 defines the following types of small entities:

> **small business:** a for-profit concern and is a— (1) Concern that provides a service or a concern not engaged in manufacturing with average gross receipts of $7.0 million or less over its last 3 completed fiscal years; or (2) Manufacturing concern with an average number of 500 or fewer employees based upon employment during each pay period for the preceding 12 calendar months.
>
> **small organization:** a not-for-profit organization which is independently owned and operated and has annual gross receipts of $7.0 million or less.
>
> **small governmental jurisdiction:** a small governmental jurisdiction is a government of a city, county, town, township, village, school district, or special district with a population of less than 50,000.
>
> **small educational institution:** one that is— (1) Supported by a qualifying small governmental jurisdiction; or (2) Not state or publicly supported and has 500 or fewer employees.

Number of Small Entities Affected

The NRC has determined that one of the 31 NPUFs currently licensed to operate may be considered a small entity impacted by this final rule. Aerotest Radiography and Research Reactor (license R-98) was granted small entity status under the regulations at 10 CFR 171.16(c). These regulations state that certain NRC licensees may pay reduced annual fees if they qualify as small entities—although it does not include licensees authorized to conduct activities under 10 CFR Part 50 such as Aerotest. Although this small entity regulation does not apply to 10 CFR Part 50 licensees, the NRC granted Aerotest's request for a one-time fee exemption. In subsequent years, the NRC requested Aerotest to submit a new request for a fee exemption for each fiscal year for which it desires an exemption (Ref. 37). Therefore, Aerotest's status as a small entity will need to be reviewed year-to-year.

Aerotest is a unique licensee. Beginning in October 2010, Aerotest ceased day-to-day operations (reactor operation continued for surveillances) as the result of NRC investigations regarding foreign ownership and control concerns. In July 2013, the NRC issued Order EA-13-097 (Ref. 38), requiring the license to maintain the facility in shutdown condition. In July 2017, the reactor license was transferred to Nuclear Labyrinth, LLC, resolving the NRC's foreign ownership and control concerns. Nuclear Labyrinth is owned and operated by its chief executive officer, and currently has a single employee. In August 2017, the NRC withdrew

Order EA-13-097, and Aerotest was allowed to operate. However, the facility remains shut down as of the date this analysis was performed.

Because only one NPUF may be considered a small entity out of the current fleet of 31 operating NPUFs, the NRC has determined the final rule does not affect a substantial number of small entities.

Economic Impact on Small Entities

For the purposes of this regulatory analysis, the NRC assumes that Aerotest will recommence operations in 2020 and will be granted a renewed, non-expiring license. The total 20-year undiscounted cost of the final rule to Aerotest is estimated to be $57,000. Should there be additional delays in Aerotest's operating status, then the estimated incremental cost could be less than $57,000.

The NRC is unable to assess the economic impact of these incremental costs on Aerotest because the reactor has not been operational since 2010. As a result, current or recent revenue and gross receipts data are not available.

Because the final rule does not affect a substantial number of small entities, this analysis concludes that the final rule will not result in significant economic impacts on a substantial number of small entities.

5. Decision Rationale for Selection of Final Action

5.1 Safety Goal Evaluation

Safety goal evaluations are applicable only to regulatory initiatives that are evaluated as cost-justified substantial safety enhancements under 10 CFR 50.109(a)(3). The NRC has determined that the backfit provision in 10 CFR 50.109, "Backfitting," does not apply to NPUFs.[15] Because 10 CFR 50.109 does not apply to NPUFs, a safety goal evaluation is not needed.

5.2 Committee To Review Generic Requirements

Review by the Committee to Review Generic Requirements is not needed because the final requirements do not constitute backfitting.

[15] For those NPUFs licensed under the authority of Section 104 of the AEA, however, the Commission is directed to impose the minimum amount of regulation on the licensee consistent with its obligations under the AEA to promote the common defense and security, protect public health and safety, and permit the conduct of widespread and diverse research and development and the widest amount of effective medical therapy possible. The final rule would meet this standard by removing license renewal requirements for many entities licensed under Section 104 of the AEA, defining the license renewal process for testing facilities licensed under Section 104 of the AEA, and eliminating the requirement for NPUF licensees to submit financial qualification information at the time of license renewal.

6. References

1. *U.S. Code of Federal Regulations* (CFR), "Domestic Licensing of Production and Utilization Facilities," Part 50, Chapter I, Title 10, "Energy."

2. CFR, "Agency Rules of Practice and Procedure," Part 2, Chapter I, Title 10, "Energy."

3. CFR, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," Part 51, Chapter I, Title 10, "Energy."

4. Nuclear Regulatory Commission (NRC), NUREG-1537, Parts 1 and 2, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors," Washington, DC, February 1996.

5. Atomic Energy Action (AEA) of 1954, as amended in NUREG-0980, August 30, 1954.

6. Executive Order (EO) 12866, Regulatory Planning and Overview, September 30, 1993.

7. The Regulatory Flexibility Act (RFA) of 1980, as amended (5 U.S.C 601 et seq.), September 19, 1980.

8. CFR, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants," Part 54, Chapter I, Title 10, "Energy."

9. NRC, SRM-SECY-91-061, "SEC-91-061—Separation of Non-Reactor and Non-Power Reactor Licensing Activities from Power Reactor Licensing Activities in 10 CFR Part 50," Washington, DC, April 11, 1991. (ADAMS Accession No. ML010050021)

10. NRC, SRM-M080317B, "Staff Requirements—Briefing on the State of NRC Technical Programs," Washington, DC, April 3, 2008. (ADAMS Accession No. ML080940439)

11. NRC, SECY-08-0161, "Review of Research and Test Reactor License Renewal Applications," Washington, DC, October 24, 2008. (ADAMS Accession No. ML082550140)

12. NRC, SRM-SECY-08-0161, "Staff Requirements—SECY-08-0161—Review of Research and Test Reactor License Renewal Applications," Washington, DC, March 26, 2009. (ADAMS Accession No. ML090850159)

13. NRC, SECY-09-0095, "Long-Term Plan for Enhancing the Research and Test Reactor License Renewal Process and Status of the Development and Use of the Interim Staff Guidance," Washington, DC, June 24, 2009. (ADAMS Accession No. ML092150717)

14. NRC, SRM-M090811, "Staff Requirements Memorandum—Briefing on Research and Test Reactor (RTR) Challenges," Washington, DC, August 26, 2009. (ADAMS Accession No. ML092380046)

15. NRC, "Non-Power Reactor (NPR) License Renewal Rulemaking—Regulatory Basis Document," Washington, DC, August 27, 2012. (ADAMS Accession No. ML12240A677)

16. NRC, "Non-Power Production or Utilization Facility License Renewal," Washington, DC, March 30, 2017 (82 FR 15643). (ADAMS Accession No. ML17068A077)

17. CFR, "Fees for Facilities, Materials, Import and Export Licenses, and other Regulatory Services under the Atomic Energy Act of 1954, as Amended," Part 170, Chapter I, Title 10, "Energy."

18. CFR, "Reactor Site Criteria," Part 100, Chapter I, Title 10, "Energy."

19. CFR, "Standards for Protection against Radiation," Part 20, Chapter I, Title 10, "Energy."

20. National Environmental Policy Act (NEPA) of 1969, January 1, 1970.

21. Trustees of Columbia University in the City of New York, ALAB-50, 4 AEC 849, 854-855 (May 18, 1972).

22. NRC, "Financial Information Requirements for Applications to Renew or Extend the Term of an Operating License for a Power Reactor," Washington, DC, January 30, 2004 (69 FR 4439).

23. NRC, "Interim Staff Guidance on the Streamlined Review Process for License Renewal for Research Reactors," Washington, DC, October 2009. (ADAMS Accession No. ML092240244)

24. NRC, NUREG/BR-0058, draft Rev. 5, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," Washington, DC, April 2017. (ADAMS Accession No.ML17100A480)

25. NRC, NUREG-1350, "NRC Information Digest, 2018–2019" Volume 30, Washington, DC, August 2018. (ADAMS Accession No. ML18226A114)

26. NRC, "Non-Power Production or Utilization Facility License Renewal," Washington, DC, DATE. (ADAMS Accession No. ML18031A002)

27. Department of Labor (DOL), Bureau of Labor Statistics (BLS) Consumer Price Index data, https://www.bls.gov/cpi/.

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29. Office of Management and Budget (OMB), Circular A-4, "Regulatory Analysis," Washington, DC, September 17, 2003.

30. NRC, "SHINE Medical Technologies, Inc. – Construction Permit for Medical Isotope Facility," Washington, DC, February 2016. (ADAMS Accession No. ML16041A471)

31. NRC, "Northwest Medical Isotopes, LLC, Construction Permit for a Production Facility," Washington, DC, May 2018. (ADAMS Accession No. ML18037A468)

32. U.S. Government Accountability Office (GAO), "Nuclear Regulatory Commission—NRC Needs to Improve Its Cost Estimates by Incorporating More Best Practices," Report to Congressional Requesters, GAO-15-98, December 12, 2014. Available at http://www.gao.gov/assets/670/667501.pdf.

33. GAO, "GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs," GAO-09-3SP, March 2009. Available at http://www.gao.gov/assets/80/77175.pdf.

34. NRC, NUREG/BR-0184, Regulatory Analysis Technical Evaluation Handbook," Washington, DC, October 22, 2010. (ADAMS Accession No. ML050190193)

35. Palisade Corporation, @Risk software, http://www.palisade.com.

36. CFR, "Size Eligibility Provisions and Standards," Part 121, Subpart A, Chapter I, Title 13, "Business Credit and Assistance."

37. NRC, Letter to David M. Slaughter, Aerotest Fee Waiver Response To Request Dated July 16, 2018; Response Letter, Washington, D.C., November 07, 2018. (ADAMS Accession No. ML18268A345)

38. EA-13-097, Order Prohibiting Operating of Aerotest Radiology and Research Reactor, July 14, 2013. (ADAMS Accession No. ML13158A164)

Appendix A: Detailed Cost and Cost Savings Buildup

This appendix presents the inputs used in the estimation process. The list below explains the assumptions used in the estimation process. The exhibits detail the implementation and operation costs and averted costs of the final rule. It is important to note that the hours and workload percentages in the exhibits below are the expected values of the assigned distributions. For this reason, the estimates in the exhibits are rounded to the nearest digit. This makes the input estimates appear highly precise (e.g., the U.S. Nuclear Regulatory Commission (NRC) estimates that process step 1 took 33 hours for a Low category licensee). Instead, the values should be read as the mean value of the distributions applied to the process steps.

Assumptions:

(1) Of the 33 affected non-power production or utilization facilities (NPUFs), 30 will receive non-expiring licenses. Three NPUFs will continue to undergo license renewal but will incur costs for submitting to the NRC updated final safety analysis reports (FSARs) and subsequent FSAR updates at intervals not to exceed 5 years (see Assumption 12).

(2) Currently operating NPUFs are assumed to continue operating during the analysis period (i.e., none decide to transition to decommissioning).

(3) The affected facilities fall into different categories (Low, Medium, High, and Other NPUFs) based on power level or facility type (see Exhibit 3-1 in the main report).

(4) The timing of costs and cost savings is phased in based on implementation groupings. That is, 5 facilities fall into Group 1, 21 facilities fall into Group 2, 4 facilities fall into Group 3, and 3 facilities fall into Group 4 (see Exhibit 3-2 in the main report).

(5) Group 1 facilities are assumed to begin incurring operation costs in 2021, Group 2 in 2022, Group 3 in 2025, and Group 4 in 2023.

(6) Each licensee will incur a one-time implementation cost (which varies based on category) to perform certain activities as a result of the final rule.

(7) The NRC will incur a one-time implementation cost to revise guidance and train staff.

(8) Each licensee will incur both initial and ongoing operation costs derived from the final rule requirement to submit to the NRC updated FSARs and subsequent FSAR updates at intervals not to exceed 5 years. The cost of the FSAR updates varies by category. The initial updated FSAR requires a full update, while subsequent FSAR updates will require fewer changes and will be completed at a lower cost.

(9) Licensees will incur operation costs (FSAR updates) every 5 years (NPUFs are assumed to minimize costs and only provide updates every 5 years, rather than more frequently). The timing of FSAR submittals depends on the group to which the licensee belongs (see Assumption 3).

(10) The NRC will incur operation costs to review licensee-submitted updated FSARs and subsequent FSAR updates in the year of submission. The NRC operation costs begin in 2021 and mirror licensee operation costs (every 5 years and staggered by group).

(11) Estimates of level of effort are based on the NRC's professional judgment and licensee input.

(12) The SHINE Medical Technologies, Inc. (SHINE), Northwest Medical Isotopes (NWMI), and National Institute of Standards and Technology (NIST) facilities will continue to go through the existing license renewal process, and their licensees will be required to submit updated FSARs and subsequent FSAR updates. This assumption results in no averted costs for these facilities.

(13) Texas A&M University Aerojet-General Nucleonics (TAMU (A)) is currently not operational. The regulatory analysis assumes that TAMU (A) will undergo license renewal in 2021, then submit an updated FSAR 5 years after license renewal and subsequent FSAR updates thereafter.

Exhibit A-1. Description of Existing NPUF License Renewal Process Sub-Steps

Existing Process Steps	Substep	Description of Substep
Preparing License Renewal Application	**1**	Collect information for narrative components of license renewal application
	2	Draft narrative chapters of license renewal application
	3	Collect information for technical components of license renewal application
	4	Draft technical chapters of license renewal application
	5	Review by management
Responding to All Requests for Additional Information (RAIs)	**1**	Review RAIs
	2	Collect information
	3	Draft RAI responses
	4	Review by management
Revising License Renewal Application	**1**	Review, collect information, and conduct additional analyses
	2	Revise license renewal application
	3	Review by management

Exhibit A-2. Description of Post-Rule FSAR Process Sub-steps

Post-Rule Process Steps	Substep	Description of Substep
Licensees		
Preparing Updated FSAR	**1**	Collect and review recent annual reports
	2	Collect and review other information on updates to facility (e.g., license amendments, analyses under Title 10 of the *Code of Federal Regulations* (10 CFR) 50.59, "Changes, tests and experiments")
	3	Draft updates to narrative chapters
	4	Draft updates to technical chapters
	5	Review by management and submittal
Preparing Subsequent FSAR Update	**1**	Collect and review recent annual reports
	2	Collect and review other information on updates to facility (e.g., license amendments, 10 CFR 50.59 analyses)
	3	Draft updates to narrative chapters
	4	Draft updates to technical chapters
	5	Review by management and submittal
NRC		
Reviewing Updated FSAR	**1**	Conduct initial review
	2	Review narrative sections
	3	Review technical sections
	4	Review by management
Reviewing Subsequent FSAR Update	**1**	Conduct initial review
	2	Review narrative sections
	3	Review technical sections
	4	Review by management

Exhibit A-3a. Licensee Averted Costs of the Final Rule

Existing Process Steps	Sub step	Cost Inputs								Cost per Category		
		Labor Category or Input	Hours per Category			Rate	Workload			Low	Medium	High
			Low	Medium	High		Low	Medium	High			
Licensee Averted Costs												
Preparing License Renewal Application	**1**	Reactor Dir. / Professor / Project Manager	33	63	65	$56.65	10%	10%	10%	$368	$708	$737
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	60%	60%	65%	$1,898	$3,650	$4,113
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$1,073
		Graduate Student				$19.46	30%	30%	5%	$379	$730	$126
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	2	Reactor Dir. / Professor / Project Manager	228	438	455	$56.65	10%	10%	10%	$2,578	$4,957	$5,156
		NPUF Operator / Asst. Dir./ Nuclear Engineer				$48.67	60%	60%	65%	$13,287	$25,551	$28,788
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$7,511
		Graduate Student				$19.46	30%	30%	5%	$2,656	$5,108	$885
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	3	Reactor Director / Professor / Project Manager	33	63	65	$56.65	10%	10%	10%	$368	$708	$737

Existing Process Steps	Sub step	Cost Inputs								Cost per Category		
		Labor Category or Input	Hours per Category			Rate	Workload			Low	Medium	High
			Low	Medium	High		Low	Medium	High			
Licensee Averted Costs												
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	60%	60%	65%	$1,898	$3,650	$4,113
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$1,073
		Graduate Student				$19.46	30%	30%	5%	$379	$730	$126
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	4	Reactor Director / Professor / Project Manager	325	625	650	$56.65	10%	10%	10%	$3,683	$7,082	$7,365
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	60%	60%	65%	$18,981	$36,502	$41,126
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$10,729
		Graduate Student				$19.46	30%	30%	5%	$3,794	$7,297	$1,265
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	5	Reactor Director / Professor / Project Manager	33	63	65	$56.65	25%	25%	25%	$921	$1,770	$1,841
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	0%	0%	0%	$0	$0	$0

Existing Process Steps	Sub step	Cost Inputs								Cost per Category		
		Labor Category or Input	Hours per Category			Rate	Workload			Low	Medium	High
			Low	Medium	High		Low	Medium	High			
Licensee Averted Costs												
		Nuclear Technician / General Engineer				$41.27	0%	0%	0%	$0	$0	$0
		Graduate Student				$19.46	0%	0%	0%	$0	$0	$0
		Institution Admin. / Technical Admin. (Writer)				$55.54	75%	75%	75%	$2,708	$5,207	$5,415
Responding to All RAIs	**1**	Reactor Director / Professor/Project Manager	141	138	149	$56.65	10%	10%	10%	$1,595	$1,566	$1,688
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	60%	60%	65%	$8,220	$8,074	$9,427
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$2,460
		Graduate Student				$19.46	30%	30%	5%	$1,643	$1,614	$290
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	2	Reactor Director / Professor / Project Manager	422	415	447	$56.65	10%	10%	10%	$4,784	$4,699	$5,065
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	60%	60%	65%	$24,661	$24,223	$28,282
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$7,379
		Graduate Student				$19.46	30%	30%	5%	$4,930	$4,842	$870

Existing Process Steps	Sub step	Cost Inputs								Cost per Category		
		Labor Category or Input	Hours per Category			Rate	Workload			Low	Medium	High
			Low	Medium	High		Low	Medium	High			
Licensee Averted Costs												
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	3	Reactor Director / Professor / Project Manager	563	553	596	$56.65	10%	10%	10%	$6,379	$6,266	$6,753
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	60%	60%	65%	$32,881	$32,297	$37,709
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$9,838
		Graduate Student				$19.46	30%	30%	5%	$6,573	$6,456	$1,160
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	4	Reactor Director / Professor / Project Manager	282	277	298	$56.65	25%	25%	25%	$7,974	$7,832	$8,442
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	0%	0%	0%	$0	$0	$0
		Nuclear Technician / General Engineer				$41.27	0%	0%	0%	$0	$0	$0
		Graduate Student				$19.46	0%	0%	0%	$0	$0	$0
		Institution Admin. / Technical Admin. (Writer)				$55.54	75%	75%	75%	$23,452	$23,035	$24,827

Existing Process Steps	Sub step	Cost Inputs								Cost per Category		
		Labor Category or Input	Hours per Category			Rate	Workload			Low	Medium	High
			Low	Medium	High		Low	Medium	High			
Licensee Averted Costs												
Revising License Renewal Application	**1**	Reactor Director / Professor / Project Manager	100	100	100	$56.65	10%	10%	10%	$1,133	$1,133	$1,133
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	60%	60%	65%	$5,840	$5,840	$6,327
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$1,651
		Graduate Student				$19.46	30%	30%	5%	$1,167	$1,167	$195
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	2	Reactor Director / Professor / Project Manager	255	383	593	$56.65	10%	10%	10%	$2,889	$4,334	$6,714
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	60%	60%	65%	$14,893	$22,339	$37,488
		Nuclear Technician / General Engineer				$41.27	0%	0%	20%	$0	$0	$9,780
		Graduate Student				$19.46	30%	30%	5%	$2,977	$4,465	$1,153
		Institution Admin. / Technical Admin. (Writer)				$55.54	0%	0%	0%	$0	$0	$0
	3	Reactor Director / Professor / Project Manager	50	50	50	$56.65	25%	25%	25%	$1,416	$1,416	$1,416

Existing Process Steps	Sub step	Cost Inputs								Cost per Category		
		Labor Category or Input	Hours per Category			Rate	Workload			Low	Medium	High
			Low	Medium	High		Low	Medium	High			
Licensee Averted Costs												
		NPUF Operator / Asst. Dir. / Nuclear Engineer				$48.67	0%	0%	0%	$0	$0	$0
		Nuclear Technician / General Engineer				$41.27	0%	0%	0%	$0	$0	$0
		Graduate Student				$19.46	0%	0%	0%	$0	$0	$0
		Institution Admin. / Technical Admin. (Writer)				$55.54	75%	75%	75%	$4,166	$4,166	$4,166
Total NPUF Operation Cost (Per Licensee)										$211,472	$269,417	$336,387
Number of NPUFs*										4	19	3
Total Licensee Cost per Category										$845,888	$5,118,929	$1,009,162
Total Licensee Averted Cost										**$6,973,979**		

* The number of licensees differs from that in Exhibit 3-1 in the main report as NPUFs in Group 3 (Aerotest and General Electric (GE)-Hitachi (Medium category); TAMU (A) (Low category); UC/Davis (High category) and Group 4 (SHINE, NWMI, and NIST (All Other NPUFs category) are assumed to not realize any averted costs.

Exhibit A-3b. Averted Costs of the Final Rule

Existing License Renewal Costs	Cost Inputs		
	Cost per Category		
	Low	Medium	High
NRC Averted Costs			
Minimum Cost per NPUF	$147,434	$105,958	$486,807
Maximum Cost per NPUF	$457,270	$1,104,844	$932,244
Average Cost per NPUF	$346,701	$471,027	$666,126
Number of NPUFs*	4	19	3
Total Cost per Category	**$1,386,802**	**$8,949,508**	**$1,998,378**
Total NRC Averted Cost	**$12,334,688**		

* The number of licensees differs from that in Exhibit 3-1 in the main report as NPUFs in Group 3 (Aerotest and GE-Hitachi (Medium category); TAMU (A) (Low category); UC/Davis (High category) and Group 4 (SHINE, NWMI, and NIST (All Other NPUFs category) are assumed to not realize any averted costs.

Exhibit A-4a. Licensee Implementation Costs of the Final Rule

Post-Rule Process Steps	Cost Inputs						Cost per Category	
	Labor Category or Input	Hours per Category		Rate		Workload	Low / Medium / High	Other NPUFs
		Low / Medium / High	Other NPUFs	Low / Medium / High	Other NPUFs			
Licensee Implementation (One-Time) Costs								
Reviewing Finalized Rule	Reactor Director / Professor / Project Manager	12	12	$56.65	$63.68	0%	($680)	($764)
	NPUF Operator / Asst. Dir. / Nuclear Engineer			$48.67	$56.18	0%	($584)	($674)
	Nuclear Technician / General Engineer			$41.27	$50.65	0%	($0)	($0)

Post-Rule Process Steps	Cost Inputs						Cost per Category	
	Labor Category or Input	Hours per Category		Rate		Workload	Low / Medium / High	Other NPUFs
		Low / Medium / High	Other NPUFs	Low / Medium / High	Other NPUFs			
Licensee Implementation (One-Time) Costs								
	Graduate Student			$19.46	$19.46	0%	($0)	($0)
	Institution Admin. / Technical Admin. (Writer)			$55.54	$38.40	0%	($0)	($0)
Reviewing NRC-Issued Guidance Documents	Reactor Director / Professor / Project Manager	12	12	$56.65	$63.68	0%	($408)	($458)
	NPUF Operator / Asst. Dir. / Nuclear Engineer			$48.67	$56.18	0%	($818)	($944)
	Nuclear Technician / General Engineer			$41.27	$50.65	0%	($0)	($0)
	Graduate Student			$19.46	$19.46	0%	($0)	($0)
	Institution Admin. / Technical Admin. (Writer)			$55.54	$38.40	0%	($0)	($0)
Reviewing and Updating Procedures	Reactor Director / Professor / Project Manager	24	24	$56.65	$63.68	0%	($544)	($611)
	NPUF Operator / Asst. Dir. / Nuclear Engineer			$48.67	$56.18	0%	($701)	($809)
	Nuclear Technician / General Engineer			$41.27	$50.65	0%	($792)	($973)
	Graduate Student			$19.46	$19.46	0%	($0)	($0)
	Institution Admin. / Technical Admin. (Writer)			$55.54	$38.40	0%	($267)	($184)

Post-Rule Process Steps	Cost Inputs						Cost per Category	
	Labor Category or Input	Hours per Category		Rate		Workload	Low / Medium / High	Other NPUFs
		Low / Medium / High	Other NPUFs	Low / Medium / High	Other NPUFs			
Licensee Implementation (One-Time) Costs								
Safety Review Board	Reactor Director / Professor / Project Manager	7	8	$56.65	$63.68	0%	($397)	($509)
	NPUF Operator / Asst. Dir. / Nuclear Engineer			$48.67	$56.18	0%	($0)	($0)
	Nuclear Technician / General Engineer			$41.27	$50.65	0%	($0)	($0)
	Graduate Student			$19.46	$19.46	0%	($0)	($0)
	Institution Admin. / Technical Admin. (Writer)			$55.54	$38.40	0%	($389)	($307)
Total Licensee One-Time Cost (per NPUF)							($5,578)	($6,234)
Number of NPUFs							**30**	**3**
Total Licensee One-Time Cost							**($167,354)**	**($18,703)**
							($186,057)	

Exhibit A-4b. Licensee Level of Effort and Workload Proportions of the Final Rule

Post-Rule Process Steps	Cost Inputs									
	Labor Category or Input	Hours per Category				Rate		Workload		
		Low	Medium	High	Other NPUFs	Low / Medium / High	Other NPUFs	Low / Medium	High	Other NPUFs
Licensee Operation (Ongoing) Costs										
Preparing Updated FSAR	Reactor Director / Professor / Project Manager	170	255	395	395	$56.65	$63.68	10%	10%	20%
	NPUF Operator / Asst. Dir. / Nuclear Engineer					$48.67	$56.18	60%	65%	30%
	Nuclear Technician / General Engineer					$41.27	$50.65	0%	20%	40%
	Graduate Student					$19.46	$19.46	30%	5%	0%
	Institution Admin. / Technical Admin. (Writer)					$55.54	$38.40	0%	0%	10%
Preparing Subsequent FSAR Updates	Reactor Director / Professor / Project Manager	43	64	100	100	$56.65	$63.68	10%	10%	20%
	NPUF Operator / Asst. Dir. / Nuclear Engineer					$48.67	$56.18	60%	65%	30%
	Nuclear Technician / General Engineer					$41.27	$50.65	0%	20%	40%
	Graduate Student					$19.46	$19.46	30%	5%	0%
	Institution Admin. /					$55.54	$38.40	0%	0%	10%

Post-Rule Process Steps	Cost Inputs									
	Labor Category or Input	Hours per Category				Rate		Workload		
		Low	Medium	High	Other NPUFs	Low / Medium / High	Other NPUFs	Low / Medium	High	Other NPUFs
Licensee Operation (Ongoing) Costs										
	Technical Admin. (Writer)									

Exhibit A-4c. Licensee Operation Costs of the Final Rule

Post-Rule Process Steps	Cost per Category			
	Low	Medium	High	Other NPUFs
Licensee Operation (Ongoing) Costs				
Preparing Updated	($1,926)	($2,889)	($4,476)	($10,061)
	($9,929)	($14,893)	($24,992)	($13,315)
	($0)	($0)	($6,520)	($16,007)
FSAR Initial Update	($1,985)	($2,977)	($769)	($0)
	($0)	($0)	($0)	($3,034)
Preparing Subsequent FSAR Updates	($484)	($728)	($1,127)	($2,534)
	($2,497)	($3,752)	($6,295)	($3,354)
	($0)	($0)	($1,642)	($4,032)
	($499)	($750)	($194)	($0)

Post-Rule Process Steps	Cost per Category			
	Low	Medium	High	Other NPUFs
Licensee Operation (Ongoing) Costs				
	($0)	($0)	($0)	($764)
Total Licensee Initial Operation Cost (per NPUF)	($13,839)	($20,759)	($36,756)	($42,416)
Total Licensee Operation Cost Ongoing Updates (per NPUF)	($3,480)	($5,231)	($9,259)	($10,685)
Number of NPUFs	5	21	4	3
Total Licensee Operation Cost per Initial FSAR Update	($69,197)	($435,943)	($147,025)	($127,248)
Total Licensee Operation Cost per Ongoing FSAR Update (every 4 years)	($17,401)	($109,841)	($37,035)	($32,054)
Total Licensee Operation Cost in Analysis Period (20 years)	**($1,323,836)**			

Exhibit A-4d. NRC Implementation Costs of the Final Rule

Post-Rule Process Steps	Cost Inputs				Cost per Category
	Labor Category or Input	Hours per Category: All Categories	Rate	Workload	All Categories
NRC Implementation (One-Time) Costs					
Updating Guidance on Revised License Renewal Process	NRC Staff	200	$132/hr	100%	($26,351)
Issue Orders**	NRC Staff	160	$132/hr	100%	($21,081)

Post-Rule Process Steps	Cost Inputs				Cost per Category
	Labor Category or Input	Hours per Category: All Categories	Rate	Workload	All Categories
NRC Implementation (One-Time) Costs					
Training NRC Staff	NRC Staff	170	$132/hr	100%	($22,398)
Updating Project Manager Qualification Program	NRC Staff	12	$132/hr	100%	($1,581)
Total NRC Implementation Cost					**($71,411)**

* The NRC staff loaded labor rates are estimated to be $129 per hour (2019$) and are calculated based on actual labor and benefit costs from the prior fiscal year (2018) by office and grade. This rate has been scaled to 2020$ in this table.
**Issuance of order to remove license terms (with the exception of NIST) and add FSAR update requirements

Exhibit A-4e. NRC Operation Costs of the Final Rule

Post-Rule Process Steps	Cost Inputs						Cost per Category		
	Labor Category or Input	Hours per Category: Low	Hours per Category: Medium	Hours per Category: High and Other NPUFs	Rate	Workload	Low	Medium	High and Other NPUFs
NRC Operation (per FSAR Update) Costs									
Reviewing Updated FSAR—Initial Update	NRC Staff	6	8	10	$132/hr	100%	($791)	($1,054)	($1,318)
	NRC Staff	18	24	170	$132/hr	100%	($2,372)	($3,162)	($3,953)
	NRC Staff	24	32	12	$132/hr	100%	($3,162)	($4,216)	($5,270)
	NRC Staff	3.5	4.5	0	$132/hr	100%	($461)	($593)	($725)
Reviewing Updated FSAR—Subsequent Updates	NRC Staff	3	4	5	$132/hr	100%	($395)	($527)	($659)
	NRC Staff	9	12	15	$132/hr	100%	($1,186)	($1,581)	($1,976)
	NRC Staff	12	16	20	$132/hr	100%	($1,581)	($2,108)	($2,635)
	NRC Staff	2	2	2.75	$132/hr	100%	($231)	($296)	($362)
NRC Operation Cost (per Initial FSAR Update)							($6,785)	($9,025)	($11,265)

Post-Rule Process Steps	Cost Inputs						Cost per Category		
	Labor Category or Input	Hours per Category			Rate	Workload	Low	Medium	High and Other NPUFs
		Low	Medium	High and Other NPUFs					
NRC Operation (per FSAR Update) Costs									
NRC Operation Cost (per Subsequent FSAR Update)							($3,393)	($4,513)	($5,633)
Number of NPUFs							5	21	7
Total NRC Operation Cost per Initial FSAR Update							($33,927)	($189,530)	($78,856)
Total NRC Operation Cost per Subsequent FSAR Update							($16,964)	($94,765)	($39,428)
Total NRC Operation Cost in Analysis Period (20 years)							**($726,466)**		

Exhibit A-5. Uncertainty Analysis Distributions

Variable	Distribution
Licensee Averted Cost	
Preparing License Renewal Application Workload	Triangular
Preparing License Renewal Application Level of Effort	Triangular
Responding to all RAIs Workload	Triangular
Responding to all RAIs Level of Effort	Triangular
Revising License Renewal Application Workload	Triangular
Revising License Renewal Application Level of Effort	Triangular
Licensee One-Time Implementation Activities	
Reviewing Finalized Rule	Triangular
Reviewing NRC Issued Guidance Documents	Triangular
Reviewing and Updating Procedures	Triangular
Safety Review Board	Triangular
Licensee Ongoing Operational Activities	
Preparing Updated FSAR Level of Effort	Triangular
Preparing Subsequent FSAR Updates Level of Effort	Triangular
Preparing Updated FSAR Workload	Triangular
Preparing Subsequent FSAR Updates Workload	Triangular