Regulatory Analysis for the Final Rule: Emergency Preparedness for Small Modular Reactors and Other New Technologies

RIN No.: 3150-AJ68; NRC Docket ID: NRC-2015-0225

[ENTER DATE WHEN READY TO ISSUE]

U.S. Nuclear Regulatory Commission

ABSTRACT

Certain existing emergency preparedness (EP) regulations and guidance are focused on large light-water reactors (LWRs) and non-power reactors. In 2015, the Commission approved the U.S. Nuclear Regulatory Commission (NRC) staff's recommendation to initiate a rulemaking to revise EP regulations and guidance for small modular reactors (SMRs) and other new technologies (ONTs). The final rule and guidance could affect existing and future SMR and ONT applicants and licensees, such as non-light-water reactors (non-LWRs) and certain medical radioisotope facilities, and non-power reactors that will be licensed after the effective date of the final rule. These applicants and licensees will have the option to develop a performance-based EP program as opposed to using the existing deterministic EP requirements in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." This document presents a final regulatory analysis of the benefits and costs of the final rule requirements relative to the baseline case (i.e., the no-action alternative) and the associated regulatory guidance document, Regulatory Guide 1.242, "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities," to be issued with the final rule.

CONTENTS

List of Figures

List of Tables

ABBREVIATIONS AND ACRONYMS

ADAMS	Agencywide Documents Access and Management System
AEA	Atomic Energy Act of 1954, as amended
ANS	American Nuclear Society
ANSI	American National Standards Institute
BLS	Bureau of Labor Statistics (U.S. Department of Labor)
CANDU	Canada deuterium uranium (a Canadian pressurized heavy-water reactor)
CFR	*Code of Federal Regulations*
COL	combined license
CPI-U	consumer price index for all urban consumers
CRGR	Committee to Review Generic Requirements
DBA	design-basis accident
EP	emergency preparedness
EPA	U.S. Environmental Protection Agency
EPZ	emergency planning zone
FEMA	Federal Emergency Management Agency
FR	*Federal Register*
IPZ	Ingestion pathway emergency planning zone
km	kilometer or 1,000 meters
LAR	license amendment request
LWR	light-water reactor
MHTGR	modular high-temperature, gas-cooled reactor (an advanced nuclear reactor concept)
mSv	millisievert, 0.001 of a sievert (the international system of unit of dose equivalent or the biological effect of ionizing radiation)
MWt	megawatt thermal
non-LWR	non-light-water reactor (a nuclear power reactor using a coolant other than water)
NPUF	non-power production or utilization facility
NPV	net present value
NRC	U.S. Nuclear Regulatory Commission
NUREG	an NRC technical report designation
OL	operating license
OMB	U.S. Office of Management and Budget
ONT	other new technology
ORO	offsite response organization
PAG	protective action guide
PERT	program evaluation and review technique
PIUS	process inherent ultimate safety (a Swedish design concept for a light-water reactor)
PRA	probabilistic risk assessment
PRISM	power reactor innovative small module (a General Electric Hitachi Nuclear Energy International, LLC, reactor)
RG	regulatory guide
SECY	Secretary of the Commission
SMR	small modular reactor
SOC	standard occupational classification (code)
SRM	staff requirements memorandum

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) is amending its regulations to introduce a new alternative emergency preparedness (EP) regulatory framework for small modular reactors (SMRs) and other new technologies (ONTs). The new EP requirements will appear in a new section of the regulations, Title 10 of the *Code of Federal Regulations* (10 CFR) 50.160, "Emergency preparedness for small modular reactors, non-light-water reactors, and non-power production or utilization facilities." For the purposes of this final rule, the term "small modular reactor" refers to a nuclear power reactor, which may be of modular design as defined in 10 CFR 52.1, "Definitions," and is licensed by the Commission under the authority of Section 103 or 104 of the Atomic Energy Act of 1954, as amended, and under the provisions of 10 CFR 50.21, "Class 104 licenses; for medical therapy and research and development facilities," or 10 CFR 50.22, "Class 103 licenses; for commercial and industrial facilities," to produce heat energy up to 1,000 megawatts thermal per module. In this final rule, the NRC is using the term "other new technologies" to refer to new technologies, such as non-light-water reactors to be licensed under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," or 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," and medical radioisotope facilities that would be licensed under 10 CFR Part 50. This final rule defines "non-power production or utilization facility" (NPUF) to clarify the applicability of the performance-based EP framework. As used in this final rule, the term "non-power production or utilization facility" includes production or utilization facilities licensed under 10 CFR 50.21(a), 10 CFR 50.21(c), or 10 CFR 50.22, as applicable, that are not nuclear power reactors or production facilities as defined under paragraphs (1) and (2) of the definition of "production facility" in 10 CFR 50.2, "Definitions." Proposed medical radioisotope facilities licensed under 10 CFR Part 50 are also included within this definition of NPUF.

This regulatory analysis discusses two alternatives—Alternative 1, the no-action or regulatory baseline, and Alternative 2, pursuance of the final rule. For Alternative 2, the regulatory analysis assesses the costs and benefits of the final rule requirements and development of Regulatory Guide 1.242, "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities" (NRC, 2022). The regulatory analysis makes the following key findings:

- Final Rule Analysis. The final rule is projected to result in a cost-justified change based on a net (i.e., accounting for both costs and benefits) averted cost to the industry that ranges from $5.62 million using a 7-percent discount rate to $10.7 million using a 3-percent discount rate. Relative to the regulatory baseline, the NRC realizes a net averted cost of $2.36 million using a 7-percent discount rate and $4.24 million using a 3-percent discount rate. Table ES-1 shows the total costs and benefits to the industry and the NRC of proceeding with the final rule. The final rule alternative results in net averted costs to the industry and the NRC ranging from $7.98 million using a 7-percent discount rate to $14.9 million using a 3-percent discount rate.

Table ES-1 Total Costs and Benefits for Alternative 2

Attribute	Costs		
	Undiscounted	7% NPV	3% NPV
Total Industry Costs:	($130,000)	($110,000)	($120,000)
Total NRC Costs:	($80,000)	($70,000)	($80,000)
Total Costs:	($210,000)	($180,000)	($200,000)
Attribute	**Benefits**		
	Undiscounted	7% NPV	3% NPV
Total Industry Benefits:	$23,080,000	$5,730,000	$10,820,000
Total NRC Benefits:	$8,834,000	$2,430,000	$4,315,000
Total Benefits:	$31,914,000	$8,160,000	$15,135,000
Attribute	**Net Benefits (Costs)**		
	Undiscounted	7% NPV	3% NPV
Industry	$22,950,000	$5,620,000	$10,700,000
NRC	$8,754,000	$2,360,000	$4,235,000
Total	$31,704,000	$7,980,000	$14,935,000

Note: NPV = net present value, expressed in 2021 dollars. There may be small differences between tables in this analysis as a result of rounding.

The costs in Table ES-1 result from the additional probabilistic risk assessment work to apply for the reduced plume exposure pathway emergency planning zone size.

According to Executive Order 12866, "Regulatory Planning and Review," dated September 30, 1993 (Executive Order, 1993), 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.

- Nonquantified Benefits. Alternative 2 will establish regulatory language in the NRC's regulations for EP for SMRs and ONTs. By regulating emergency planning through rulemaking instead of through the exemption process, the NRC will provide the industry with greater regulatory predictability and efficiency. In addition to regulatory efficiency, licensing SMRs and ONTs through rulemaking instead of through the exemption request process provides for the opportunity for a broad set of external stakeholders to provide input on the specific emergency planning requirements that the NRC will use, which will increase public confidence in the NRC's ability to adapt to new technology and new regulatory needs and will maintain the NRC's role as an effective industry regulator.

- Sensitivity Analysis. This regulatory analysis contains a sensitivity analysis to evaluate the effect if potential SMR and ONT applicants delay their submittal of a license application after the final rule goes into effect or decide not to go forward with their applications. Additionally, the regulatory analysis considers the effect if the remaining applications are delayed a few years. Based on the sensitivity analysis, the regulatory analysis demonstrates that, if 6 applicants submit applications and these submittals are delayed 10 years, the final rule remains cost beneficial, with averted costs ranging from $2.20 million at a 7-percent discount rate to $5.82 million at a 3-percent discount rate.

- Uncertainty Analysis. The regulatory analysis contains an uncertainty analysis that shows that the estimated mean benefit for this final rule is $7.98 million with a greater than 99-percent confidence that the final rule is net beneficial using a 7-percent discount rate. A reasonable inference from the uncertainty analysis is that proceeding with the final rule represents an efficient use of resources and will result in significant averted costs to the NRC and the industry.

- Decision Rationale. Relative to the no-action baseline, the NRC concludes that the final rule is justified from a quantitative standpoint because its provisions will result in net averted costs (i.e., net benefits) to the industry and is effectively cost-neutral to the NRC. In addition, the NRC concludes that the final rule is also justified when considering nonquantified costs and benefits because the significance of the nonquantified benefits outweighs those of the nonquantified costs.

1. Introduction

This document presents the regulatory analysis for the final rule to revise the emergency preparedness (EP) requirements for small modular reactors (SMRs) and other new technologies (ONTs) and develop the new regulatory guidance document, Regulatory Guide (RG) 1.242, "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities."

2. Statement of the Problem and Objective

Certain existing regulations and guidance are focused on large light-water reactors (LWRs) and non-power reactors. Through this final rulemaking, the U.S. Nuclear Regulatory Commission (NRC) is amending its regulations to create an alternative EP framework for SMRs and ONTs. The scope of this final rule includes medical radioisotope facilities licensed as utilization or production facilities under Title 10 of the Code of Federal Regulations (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." However, the NRC does not expect any such facilities to submit license applications using this final rule.

In December 2016, the NRC developed and published "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness" (NRC, 2016c), with a goal to further develop the NRC's SMR and ONT regulatory, technical, and policy infrastructure. This EP rulemaking represents an important facet of the NRC's plan to review licensing applications for SMRs and ONTs efficiently and effectively.

2.1 Background

Concurrent with large LWR deployment and design evolution, the United States and other countries have developed and promoted several different reactor designs that are either light-water SMRs with passive safety features or reactors that do not use light water as a coolant. This latter category is commonly referred to as non-light-water reactor (non-LWR) technology. Advanced designs using non-LWR technology include liquid-metal-cooled reactors, gas-cooled reactors, and molten-salt-cooled reactors. These advanced designs range from a few to hundreds of megawatts in power size and apply modular construction concepts. In addition, proposed medical radioisotope facilities licensed under 10 CFR Part 50 include production or utilization facilities that are nonreactor technologies. This analysis groups the designs discussed in this paragraph as SMRs and ONTs. These new designs typically have lower probabilities of severe accidents because of their smaller source terms or innovative safety features, which will result in lower impacts to public health and safety from any radiological emergency, as compared to large LWRs.

Historically, as the industry proposed new reactor designs, the NRC considered the need to modify EP requirements that were developed to support the large LWRs in operation today. The final regulatory basis for this rule covers this history in detail (NRC, 2017a), and Appendix A to this document summarizes the history.

For the purposes of this regulatory analysis, the term "small modular reactor" refers to a nuclear power reactor (or module) that has a licensed thermal power rating of less than or equal to 1,000 megawatts (approximately 300 megawatts electric) per module and that is licensed by the Commission under the authority of Section 103 or 104 of the Atomic Energy Act of 1954, as amended (AEA), and under the provisions of 10 CFR 50.21, "Class 104 licenses; for medical

therapy and research and development facilities," or 10 CFR 50.22, "Class 103 licenses; for commercial and industrial facilities." The final rulemaking defines the term "small modular reactor" to clarify the applicability of EP requirements for these facilities. The definition of SMR will be based, in part, on the definition of SMR in 10 CFR 171.5, "Definitions." For the purposes of this regulatory analysis, the term "non-light-water reactor" means a nuclear power reactor using a coolant other than light water.

Current Emergency Preparedness Regulations for Large Light Water Reactors

The NRC's existing EP regulations vary depending on the type of licensee. Applicants for a construction permit, early site permit, operating license (OL), or combined license (COL) are required to provide emergency planning information as described under 10 CFR 50.33, "Contents of applications; general information"; 10 CFR 50.34, "Contents of applications; technical information"; 10 CFR 52.17, "Contents of applications; technical information"; or 10 CFR 52.79, "Contents of applications; technical information in final safety analysis report." Emergency plans must include the specific items set forth in Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities," to 10 CFR Part 50. Additionally, the regulations in 10 CFR 50.47, "Emergency plans," provide EP requirements for nuclear power reactors. Other relevant regulations include 10 CFR 50.54(q), (s), and (t). Based on its authority under the AEA, the Commission determined that these requirements are necessary for operating production and utilization facilities to protect public health and safety. This section summarizes the existing regulatory frameworks applicable to large LWRs.

The EP regulatory framework requires each large LWR licensee to establish and maintain emergency plans and EP. The regulations include standards for onsite and offsite emergency response plans. These regulations and the planning basis for EP are based on the methodology presented in NRC technical report (NUREG) NUREG-0396 (U.S. Environmental Protection Agency (EPA) 520/1-78-016), "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," issued December 1978 (NRC and EPA, 1978).

Through an NRC-approved EP program, a large LWR licensee has the capability to identify emergency conditions, assess radiological impact, communicate protective action recommendations, and mitigate the event. Offsite response organizations (OROs) maintained by State and local government authorities are responsible for developing their EP programs as they apply to an offsite response. These programs give OROs the capability to alert and notify the public, implement protective actions as warranted, and assess radiological conditions beyond the facility to protect public health and safety.

This regulatory structure requires licensees to develop and maintain site-specific emergency plans in compliance with the planning standards in 10 CFR 50.47(b). In addition, it requires licensees to conduct drills and exercises to demonstrate response capabilities and to provide for critiques and corrective actions to address capability and performance weaknesses. Section IV, "Content of Emergency Plans," of Appendix E to 10 CFR Part 50 describes the information that a licensee's emergency plan must contain. In 10 CFR 50.54(q), the NRC requires each licensee to follow and maintain the effectiveness of its emergency plan.

In 1978, a task force of NRC and EPA representatives established the technical basis for EP for large LWRs and published the results in NUREG-0396. The task force's report concluded that the objective of emergency response plans should be to reduce human radiation exposure from a spectrum of accidents that could produce offsite doses exceeding the EPA protective action

guides (PAGs)[1] (EPA, 2017). The scope of the EP planning effort includes three elements: (1) the distance to which planning for the initiation of predetermined, prompt protective measures is necessary, (2) the time-dependent characteristics of potential releases and exposures, and (3) the types of radioactive materials potentially released to the environment.

For the first element, there are two types of emergency planning zones (EPZs). In the plume exposure pathway EPZ, the principal exposure sources are from whole body external exposure to gamma radiation from the plume and from deposited material and inhalation exposure from the passing radioactive plume. For the plume exposure pathway EPZ, emergency plans are prepared to identify prompt protective actions directed at avoiding or reducing dose to the members of the public. In the ingestion pathway EPZ (IPZ), the principal exposure would be from ingestion of contaminated food or water. For the IPZ, emergency plans are prepared to prevent radioactive material from potentially entering the food chain.

Specifically, the task force calculated: (1) the release fraction from plants that exceeded EPA PAG doses beyond 10 miles (16 kilometers (km)) for design-basis accidents (DBAs), (2) the probability of exceeding various dose thresholds as a function of distance from the reactor, and (3) the benefit of various protective action strategies. Based on these analyses, the task force recommended that plants develop emergency plans for an area within a radius of about 10 miles (16 km) from the reactor for the plume exposure pathway EPZ. Using a similar rationale and considering the projected dispersal and deposition of the radioactive material and the conversion of atmospheric iodine to chemical forms that do not readily enter the ingestion pathway, the task force selected an area within a radius of about 50 miles (80 km) from the reactor for the IPZ.

Current EP regulations allow for a case-by-case consideration of alternative-sized EPZs for reactors with certain specifications. The regulation at 10 CFR 50.47(c)(2) states the following:

> Generally, the plume exposure pathway EPZ for nuclear power plants shall consist of an area about 10 miles (16 km) in radius and the ingestion pathway EPZ shall consist of an area about 50 miles (80 km) in radius. The exact size and configuration of the EPZs surrounding a particular nuclear power reactor shall be determined in relation to local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes, and jurisdictional boundaries. The size of the EPZs also may be determined on a case-by-case basis for gas-cooled nuclear reactors and for reactors with an authorized power level less than 250 MW thermal. The plans for the ingestion pathway shall focus on such actions as are appropriate to protect the food ingestion pathway.

Some licensees (e.g., Fort St. Vrain Nuclear Power Plant, Big Rock Point Nuclear Power Station, and La Crosse Boiling Water Reactor) have used this flexibility to size their EPZs.

1 The PAGs are reference values for radiation doses that warrant preselected protective measures for public protection if the projected dose received by an individual in the absence of protective actions exceeds the radiation dose reference value.

Emergency Preparedness Regulations for Non-power Production or Utilization Facilities

While RTRs and other NPUFs must meet the emergency planning requirements of §§ 50.34(a)(10) and (b)(6)(v) and 50.54(q) and Appendix E to 10 CFR Part 50, the requirements of § 50.47 do not apply to these facilities. Additionally, in 10 CFR Part 50, Appendix E, Section I.3, the NRC differentiates between emergency planning requirements for nuclear power reactors and other facilities, as follows:

> The potential radiological hazards to the public associated with the operation of research and test reactors and fuel facilities licensed under 10 CFR parts 50 and 70 ["Domestic Licensing of Special Nuclear Material"] involve considerations different than those associated with nuclear power reactors. Consequently, the size of Emergency Planning Zones (EPZs) for facilities other than power reactors and the degree to which compliance with the requirements of this section and sections II, III, IV, and V of this appendix as necessary will be determined on a case-by-case basis.

Furthermore, 10 CFR Part 50, Appendix E, Footnote 2, allows the use of RG 2.6, "Emergency Planning for Research and Test Reactors and Other Non-Power Production and Utilization Facilities," Revision 2, issued September 2017 (NRC, 2017b), for the development and evaluation of emergency response plans at NPUFs.

Consistent with the radiological risks associated with operating power levels between 5 watts thermal and 20 megawatts thermal (MWt) for currently licensed research and test reactors, RG 2.6 endorses the use of the source term and power-level-based emergency planning guidance in American National Standards Institute (ANSI)/American Nuclear Society (ANS)-15.16-2015, "Emergency Planning for Research Reactors" (ANSI, 2015).

The guidance in ANSI/ANS-15.16-2015 and NUREG-0849, "Standard Review Plan for the Review and Evaluation of Emergency Plans for Research and Test Reactors," issued October 1983 (NRC, 1983a), addresses EPZs for research and test reactors ranging from the operations boundary[2] to 0.5 miles (0.8 km) for facilities operating up to 50 MWt. The EPZs for facilities operating above 50 MWt are to be considered on a case-by-case basis.

The postulated radioactive releases from accidents associated with currently operating non-power reactors do not result in offsite radiological doses to the general public that exceed the EPA PAGs of 1 rem (10-millisieverts (mSv)) whole body or 5-rem (50-mSv) thyroid. Therefore, emergency plans for these facilities do not include the general emergency class of accidents requiring Federal assistance.

2.2 Statement of the Problem

This section describes the regulatory issues stemming from the fact that potential hazards from SMRs and ONTs could differ substantially from those posed by large LWRs. Differences may include the size of the EPZs, source terms, offsite dose consequences, siting requirements, operator staffing levels, co-location of facilities not licensed by the NRC, and multimodule designs.

2 As defined in ANSI/ANS-15.16-2015, "operations boundary" refers to the area within the site boundary such as the reactor building (or the nearest physical personnel barrier in cases where the reactor building is not a principal physical personnel barrier) where the reactor chief administrator has direct authority over all activities.

The potential for smaller reactor core sizes, lower power densities, lower probability of severe accidents, slower accident progression, and smaller accident offsite consequences per module that characterize some SMR and ONT designs have led the U.S. Department of Energy, SMR designers, and potential operators to propose changes to the size of the EPZs, the extent of onsite and offsite emergency planning, and the number of response staff needed. The NRC expects that future reactors with these characteristics can operate safely with smaller EPZs, perhaps even with EPZs at the site boundary in some cases. Other topics raised by the industry include the potential to revise public alert and notification requirements and the appropriateness of the protective action requirements in 10 CFR 50.47(b)(10). The performance-based framework of the final rule will address these issues and others related to the current prescriptive EP requirements.

In carrying out its responsibility under the AEA, the Commission establishes regulatory standards for onsite and offsite radiological emergency planning. If an applicant's or licensee's emergency plan meets the NRC's regulations, then the NRC has reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. In the case of existing EP regulations for NPUFs, fuel cycle facilities, and independent spent fuel storage installations, regulatory requirements for offsite radiological emergency plans do not exist. Accordingly, NRC guidance for such facilities states that Federal Emergency Management Agency (FEMA) findings and determinations are not needed to support NRC licensing decisions. Similarly, for SMRs and ONTs within the scope of this rulemaking, if the NRC determines that assurance of offsite radiological emergency preparedness is not required for specific facilities where the EPZs do not extend beyond the site boundary, FEMA findings and determinations on reasonable assurance under 10 CFR 50.54(s)(3) will likely not be needed. In such cases, even in the absence of NRC requirements for offsite radiological emergency planning, the responsible OROs would take actions to protect public health and safety by using the community's general emergency response capabilities that are not unique to radiological emergency response.

The NRC evaluates the radiological consequences of hypothetical DBAs for determining appropriate siting and the level of safety of the plant design. The NRC uses accident source terms in dose analyses to assess site suitability and the effectiveness of the containment or confinement and plant mitigation features, and to show compliance with regulations for determining the amount of dose to workers and members of the public. The technical basis for EP for large LWRs established in NUREG-0396 considers a wide spectrum of potential accidents for the facility, including severe accidents. NUREG-0396 states that, although the development of specific plans for the most severe and most improbable events is not appropriate, the characteristics of these events should be considered "in judging whether emergency plans based primarily on smaller accidents can be expanded to cope with larger events." This approach provides reasonable assurance that capabilities exist to minimize the impacts of even the most severe events. Consistent with this guidance from NUREG-0396, the NRC does not limit its consideration to DBAs. Furthermore, the NRC must consider the source terms associated with multimodule (e.g., multi reactor) designs of some SMRs and ONTs where those modules share structures, systems, and components to the extent that more than one module could potentially release fission products to the environment. Facility designers and applicants will need to establish appropriate credible source terms for SMRs and ONTs for this spectrum of accidents.

The existing regulations and planning basis for EP for large LWRs are based on an anticipated prompt response to a wide spectrum of events. Similarly, for SMRs and ONTs, the NRC will consider an appropriate spectrum of accidents and consequences to provide a basis for judging

the adequacy of features such as functional containment design and offsite emergency planning. The NRC intends to consider accident scenarios during power ascension, full-power operation, power decrease, shutdown, and low-power operations. All sources of potential accidental radiological releases from the facility will be considered. For potential licensing of ONTs, the NRC staff is working with stakeholders to modernize the framework for the selection of licensing-basis events for safety analysis using a risk-informed approach. As these activities progress, the agency will maintain alignment between this rulemaking and the implementation of other aspects of the ONT regulatory framework, as intended in the NRC Vision and Strategy document (NRC, 2016c).

2.3 Objective

The purpose of this regulatory action is to enhance the effectiveness and efficiency of the regulatory framework for existing and future applicants and licensees of SMRs and ONTs, and the NRC, by enacting a performance-based EP framework that enables existing and future SMRs and ONTs to have flexible options for EPZ size, and other facets of EP, while continuing to provide adequate protection of public health and safety. In particular, the NRC's objective for this rulemaking is to create alternative EP requirements that (1) continue to provide reasonable assurance that adequate protective measures can and will be implemented by an SMR or ONT licensee, (2) promote regulatory stability, predictability, and clarity, (3) reduce the need for requests for exemptions from EP requirements, (4) recognize advances in design and technological advancements embedded in design features, (5) credit safety enhancements in evolutionary and passive systems, and (6) credit the potential benefits of smaller sized reactors and non-LWRs associated with postulated accidents, including slower transient response times and relatively small and slow release of fission products.

3. Identification and Preliminary Analysis of Alternative Approaches

This section analyzes the alternatives that the NRC considered with regard to the objective of enhancing the regulatory framework for applicants and licensees of SMRs and ONTs and the NRC. The NRC identified two alternatives:

(1) Alternative 1 will use the existing regulatory framework supplemented by existing guidance on how to apply for exemptions from the EP regulations.

(2) Alternative 2 will provide new regulations through rulemaking, along with new guidance to define the level of EP appropriate for an SMR or ONT facility.

3.1 Alternative 1—No Action

The no-action alternative is a non-rulemaking alternative. This alternative will retain the current EP provisions in 10 CFR Part 50. Certain existing EP requirements could impose regulatory costs on SMR and ONT applicants and licensees that are not necessary to protect public health and safety. Although potential SMR and ONT applicants and licensees would request EP exemptions, this alternative will require a site-specific analysis by the applicant or licensee and a review by the NRC for each exemption request. Alternative 1 will not relieve the costs imposed on applicants, licensees, and the NRC resulting from the case-by-case exemption request process to address EPZ size and emergency plans. Therefore, these exemption requests are included in Alternative 2 as averted costs.

3.2 Alternative 2—Rulemaking to Establish a Performance-Based Framework

This alternative will provide EP regulations and guidance developed specifically for SMR and ONT facilities. In particular, this alternative develops the regulatory guidance document RG 1.242, "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities," and establishes a regulatory framework for determining the size of the plume exposure pathway EPZ and ingestion response planning requirements for SMRs and ONTs. Under this alternative, the NRC establishes EP planning standards and requirements commensurate with EPZ size determinations. The new framework is: performance-based; expected to result in fewer license amendments and exemption requests; and a streamlined application process for existing and future SMRs and ONT applicants.

In an issue paper submitted to the Commission, SECY-11-0152, "Development of an Emergency Planning and Preparedness Framework for Small Modular Reactors," dated October 28, 2011 (NRC, 2011), the staff presented example calculations for establishing different plume exposure pathway EPZ boundaries based on the 1 rem (10 mSv) EPA PAG reference value. The staff used an example assessment of dose-at-distance for the plume exposure pathway EPZ boundary to obtain EPZ sizes based on the projected source term, which is a function of the specific reactor design being considered. The final rule includes a scalable method for determining EPZ size for these facilities, instead of the fixed 10-mile (16-km) plume exposure pathway EPZ and 50-mile (80-km) IPZ currently established for power reactors, to address a range of potential source terms and designs for SMRs and ONTs.

Under this alternative, the SMR or ONT applicant will submit specific information about the source term, isotopic mix, release pathways, accident types, and consequence assessment as part of the application process under 10 CFR Part 50 or 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The NRC will require applicants proposing site-specific EPZs to demonstrate in their application that the projected dose from a spectrum of accidents (DBAs, less severe accidents, and less probable but more severe accidents) would not exceed the EPA PAG dose threshold of 1 rem total effective dose equivalent over 96 hours outside the proposed EPZ considering accident likelihood and source term, timing of the accident sequency, and meteorology. In addition, applicants will need to show that the plume exposure pathway EPZ is the area in which predetermined, prompt protective measures are necessary. After receiving site- and design-specific information from an SMR or ONT applicant, the NRC will assess the accident scenarios being considered and could follow up with requests for additional information as it currently does.

As part of Alternative 2, the NRC is reviewing the emergency plans for NPUFs intending to produce medical radioisotopes, such as molybdenum-99, using the guidance in ANSI/ANS-15.16-2015, NUREG-0849, and the interim staff guidance augmenting NUREG-1537 (NRC, 2012a; NRC, 2012b). Use of the interim staff guidance augmenting NUREG-1537 accounts for the unique emergency planning considerations associated with the production facilities that would chemically process low-enriched uranium targets to separate molybdenum-99 from other fission products. Additionally, based on discussions with potential advanced reactor applicants, the NRC anticipates that some applicants for molten salt reactors may submit applications for production facilities to conduct onsite fuel cleanup activities. The potential future activities of possible licensees were not considered quantitatively in this analysis.

4. Estimation and Evaluation of Costs and Benefits

This section presents the process for evaluating the costs and benefits that are expected to result from each alternative relative to the regulatory baseline (Alternative 1). All costs and benefits are monetized, when possible. The total costs and benefits are then summed to determine whether the difference between the costs and benefits results in a positive benefit. In some cases, costs and benefits are not monetized because meaningful quantification is not possible. Instead, Section 5 of this regulatory analysis addresses these costs and benefits qualitatively, in accordance with Appendix A, "Qualitative Factors Assessment Tools," to NUREG/BR-0058, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission, Draft Report for Comment," Revision 5, issued January 2020 (NRC, 2020).

4.1 Identification of Affected Attributes

This section identifies the components of the public and private sectors, commonly referred to as attributes, that are expected to be affected by the alternatives identified in Section 3. The alternatives will apply to SMR and ONT licensees and applicants. The NRC believes that nuclear power plant licensees would be the primary beneficiaries. The NRC developed an inventory of the affected attributes using the list in NUREG/BR-0058, draft Revision 5, Chapter 5, "Details of a Cost-Benefit Analysis."

The rule will affect four attributes:

(1) Industry Operation. This attribute accounts for the projected net economic effect caused by routine and recurring activities required by the alternative on all affected entities. These activities include the reduction of exemption requests from applicants and licensees and the reduction of license amendment requests (LARs) from the licensees.

(2) NRC Implementation. This attribute accounts for the projected net economic effect on the NRC to place the alternative into operation. The NRC's implementation of the alternative will include the agency's cost to develop and issue the rule and any RGs that support the rule. These are sunk costs for the final rule and not included in the analysis.

(3) NRC Operation. This attribute accounts for the projected net economic effect on the NRC caused by routine and recurring activities required by the alternative after implementation of the final rule. These activities include the reduction in NRC reviews of exemption requests and LARs.

(4) Regulatory Efficiency. This attribute accounts for regulatory and compliance improvements resulting from the implementation of Alternative 2 relative to the regulatory baseline. Alternative 2 will continue the best practice of regulation through rulemaking instead of exemption requests, where practical. This rulemaking will reduce the effort that the industry would expend generating exemption requests and considering alternative means to accomplish the goals of current regulation. In addition, this rulemaking's performance-based framework will reduce the volume of EP LARs submitted for SMRs and ONTs and the complexity of EP plans. Additionally, applicants and licensees will gain efficiencies in developing EP plans, and the NRC will gain efficiencies in reviewing these EP plans, because of the improved stability, predictability, and clarity that will result from the final rule.

Attributes that are not expected to be affected under either of the alternatives include public health (routine), occupational health (accident), occupational health (routine), offsite property, onsite property, industry implementation, other government, general public, safeguards and security considerations, and environmental considerations. The attributes of other government and general public were not analyzed because, even though a reduced EPZ size would impact these attributes, the same effects would occur under both Alternatives 1 and 2 so that there would be no net difference. The NRC expects that a change in EPZ size determination has no effect on public health (accident) because an equivalent level of safety is maintained, therefore the public health (accident) attribute was also not analyzed further.

4.2 Analytical Methodology

This section describes the process used to evaluate costs and benefits associated with the alternatives. The benefits include any desirable changes in affected attributes (e.g., monetary savings, improved safety, and improved security). The costs include any undesirable changes in affected attributes (e.g., monetary costs, increased exposures).

Of the five affected attributes, the analysis evaluates three attributes—(1) industry operation, (2) NRC implementation, and (3) NRC operation—on a quantitative basis. Quantitative analysis requires a baseline characterization of the affected society, including factors such as the number of affected entities, the nature of the activities currently performed, and the types of systems and procedures that applicants or licensees would consider or would no longer implement because of the alternatives. Where possible, the NRC calculated costs for these attributes using three-point estimates to quantify the uncertainty. One variable uses a geometric estimate and another a discreet estimate, instead. The individual sections for each of the provisions include the detailed cost tables that the NRC used in this regulatory analysis. The NRC evaluated the remaining two attributes on a qualitative basis because the benefits related to consistent policy application are not quantifiable or because the data necessary to quantify and monetize the impacts on these attributes are not available.

The NRC documents its assumptions throughout this regulatory analysis. Appendix B to this regulatory analysis summarizes the key assumptions and inputs.

4.2.1 Regulatory Baseline

This regulatory analysis provides the incremental impacts of the final rule relative to a baseline that reflects anticipated behavior if the NRC does not undertake regulatory or nonregulatory action. The regulatory baseline assumes full compliance with existing NRC requirements, including current regulations and relevant orders. Section 5. of this regulatory analysis presents the estimated costs and benefits of the alternatives relative to this baseline.

4.2.2 Affected Entities

The NRC estimates that the final rule affects 12 applicants who plan to submit license applications for SMRs or ONTs over the next several years. The NRC is not providing the names, companies, technologies, locations, or other identifying information for these SMRs and ONTs because this information is proprietary at this time. Currently, the NRC expects that 9 of these 12 SMRs and ONTs will each submit a license application after the rule goes into effect in 2022. (One applicant already has submitted its application, and the NRC expects that 2 other applications submitted prior to publication of the final rule will request a plume exposure pathway EPZ of less than 10 miles using the exemption request process.) Based on current information, the NRC expects 9 other applications to be submitted in the 2022 through 2025 timeframe. The regulatory analysis incorporates the submittal of 12 applications as input into the cost model and analyzes the impact if some applicants cancel or delay their applications. If additional SMR and ONT applications are submitted after the final rule is published, then the final rule becomes even more cost beneficial with each additional applicant.

4.2.3 Base Year

All monetized costs are expressed in 2021 dollars. The analysis assumes that ongoing costs of operation related to the alternative being analyzed will begin no earlier than 30 days after publication of the final rule in the NRC's regulations unless otherwise stated. The analysis assumes that the publication of the final rule will occur in 2022.

Estimates are made for applicant implementation and recurring annual operating expenses. The values for annual operating expenses are modeled as a constant expense for each year of the analysis horizon. The NRC performed a discounted cash flow calculation to discount these annual expenses to 2021 dollar values.

4.2.4 Discount Rates

In accordance with NUREG/BR-0058, net present value (NPV) calculations are used to determine how much society will need to invest today to ensure that the designated dollar amount is available in a given year in the future. By using NPVs, costs and benefits are valued to a reference year for comparison, regardless of when the cost or benefit is incurred in time. The choice of a discount rate and its associated conceptual basis is a topic of ongoing discussion within the Federal Government. Based on U.S. Office of Management and Budget (OMB) Circular No. A-4, "Regulatory Analysis," dated September 17, 2003 (OMB, 2003), and consistent with NRC past practice and guidance, present-worth calculations in this analysis use 3-percent and 7-percent real discount rates. A 3-percent discount rate approximates the real rate of return on long-term Government debt, which serves as a proxy for the real rate of return on savings to reflect reliance on a social rate of time preference discounting concept.[3] A 7-percent discount rate approximates the marginal pretax real rate of return on an average investment in the private sector and is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector. A 7-percent rate is

3 The "social rate of time preference discounting concept" refers to the rate at which society is willing to postpone a marginal unit of current consumption in exchange for more future consumption.

consistent with an opportunity cost[4] of capital concept to reflect the time value of resources directed to meet regulatory requirements.

4.2.5 Cost/Benefit Inflators

The NRC estimated the analysis inputs from sources as referenced in Appendix B, which are provided in prior-year dollars. To evaluate the costs and benefits consistently, these inputs are put into base-year dollars. The most common inflator is the consumer price index for all urban consumers (CPIU) developed by the U.S. Department of Labor, Bureau of Labor Statistics (BLS). Using the CPI-U, the prior-year dollars are converted to 2021 dollars. For 2021, the currently reported CPI-U values have been averaged together; the entirety of CPI-U for 2021 has not been determined by BLS. The formula to determine the amount in 2021 dollars is as follows:

$$\frac{CPI-U_{2021}}{CPI-U_{Base\ Year}} x\ Value_{Base\ Year} = Value_{2021}$$

Table 1 summarizes the values of CPI-U used in this regulatory analysis.

Table 1 CPI-U Inflator

Base Year	CPI-U Annual Average[a]	Percent Change from Previous Year
2020	258.811	
2021	263.395	1.77%

Sources:
[a] BLS, "Archived Consumer Price Index Supplement Files: April 2021 Historical CPI-U, Table 24, Historical Consumer Price Index for All Urban Consumers (CPI-U): U.S. City Average, All Items" (BLS, 2021b).

4.2.6 Labor Rates

For the purposes of this regulatory analysis, the NRC developed labor rates that include only labor and material costs that are directly related to the implementation and operation and maintenance of the final rule requirements. This approach is consistent with the guidance in NUREG/CR-3568, "A Handbook for Value-Impact Assessment," issued December 1983 (NRC, 1983b), and general cost-benefit methodology. The NRC incremental labor rate is $137 per hour for fiscal year 2021.[5]

The regulatory analysis used data from BLS, "SOC Code: Standard Occupational Classification Code" (BLS, 2021a), which provides labor categories and the mean hourly wage rate by job

4 "Opportunity cost" represents what is foregone by undertaking a given action. If the applicant or licensee personnel were not engaged in producing exemption requests, they would be engaged in other work activities. Throughout the analysis, the NRC estimates the opportunity cost of performing these incremental tasks as the industry personnel's pay for the designated unit of time.

5 The NRC labor rates presented herein differ from those developed under the NRC's license fee recovery program (10 CFR Part 170, "Fees for facilities, materials, import and export licenses, and other regulatory services under the Atomic Energy Act of 1954, as amended"). NRC labor rates for fee recovery purposes are appropriately designed for full-cost recovery of the services rendered and as such include nonincremental costs (e.g., overhead, administrative, and logistical support costs).

type, and used the inflator discussed above to inflate these labor rate data to 2021 dollars. The labor rates used in the analysis reflect total hourly compensation, including wages and nonwage benefits (using a burden factor of 2.4, which is applicable for contract labor and conservative for utility employees). The NRC used the BLS data tables to select appropriate hourly labor rates for performing the estimated procedural, licensing, and utility-related work necessary during and following implementation of the alternative. In establishing this labor rate, wages paid for the individuals performing the work plus the associated fringe benefit component of labor cost (i.e., the time for plant management over and above those directly expensed) are considered incremental expenses and are included. Table 2 summarizes the BLS labor categories that were used to estimate industry labor costs to implement this final rule, and Appendix B lists the industry labor rates used in the analysis. This analysis assumes industry personnel, not contractors, perform the modeled activities. Section 5.9 discusses the NRC's uncertainty analysis. Appendix B to this regulatory analysis provides labor rates and other supporting input data.

Table 2 Position Titles and Occupations

Position Title (in this Regulatory Analysis)	Standard Occupational Classification (SOC Code)
Managers	Top Executives (111000)
	Chief Executives (111011)
	General and Operations Managers (111021)
	Industrial Production Managers (113051)
	First-Line Supervisors of Mechanics Installers and Repairers (491011)
	First-Line Supervisors of Production and Operating Workers (511011)
Technical Staff	Nuclear Engineers (172161)
	Physicists (192012)
	Nuclear Technicians (194051)
	Industrial Machinery Mechanics (499041)
	Nuclear Power Reactor Operators (518011)
Administrative Staff	Office and Administrative Support Occupations (430000)
	First-Line Supervisors of Office and Administrative Support Workers (431011)
	Office Clerks, General (439061)
Licensing Staff	Lawyers (231011)
	Paralegals and Legal Assistants (232011)

Source: BLS, 2021a.

4.2.7 Sign Conventions

In this analysis, all favorable consequences for the alternative are positive and all adverse consequences for the alternative are negative. Negative values are shown using parentheses (e.g., negative $500 is displayed as ($500)).

4.2.8 Analysis Horizon

The NRC assumed that each of the 12 SMR and ONT reactor applicants receives the original 40-year operating licenses and then applies for and receives a 20-year license extension for a total of 60 years. The operating costs of each reactor are estimated individually, based on the anticipated first year of operation. The NRC expects 9 of the 12 SMR and ONT reactors to submit an application in the 2022–2025 period. The NRC has received one application and anticipates receiving 2 additional applications in 2021 prior to the issuance of the final rule.

4.2.9 Cost Estimation

To estimate the costs associated with the evaluated alternatives, the NRC used an engineering-buildup estimating method to deconstruct each requirement down to its mandated activities. For each required activity, the NRC further subdivided the work across labor categories (i.e., executives, managers, technical staff, administrative staff, and licensing staff). The NRC estimated the required level of effort for each required activity and used a blended labor rate to develop bottom-up cost estimates.

The NRC staff gathered data from several sources and consulted staff that developed the rule to develop level of effort and unit cost estimates. The NRC applied several cost estimation methods in this analysis. Additionally, the NRC used its collective professional knowledge and judgment to estimate many of the costs and benefits. For example, to calculate the estimated

averted costs of exemption requests and the costs for preparation of the final rule and accompanying regulatory guidance, the NRC used data from previous exemption request submittals to determine the labor categories of the staff who would perform the work and to estimate the amount of time required under each category to complete the work. If data were not available, the NRC used the level of effort method to estimate future costs based on similar steps in the process for which data were available. Additionally, the NRC used the expert-opinion method to fill data gaps when one or more experts were the only available sources of information. The cost estimate accounts for a total of 12 SMRs and ONTs.

To evaluate the effect of uncertainty in the model, the NRC used a Monte Carlo simulation, which is an approach to uncertainty analysis that expresses input variables as distributions. Section 5.9 describes the Monte Carlo simulation methods in more detail and presents the results.

4.3 Data

This analysis discusses the data and assumptions used in analyzing the quantifiable impacts associated with the alternative. The NRC used input from subject-matter experts, knowledge gained from past rulemakings, and information obtained during public meetings and from correspondence to collect data for this analysis. Quantitative and qualitative (i.e., nonquantified) information on attributes affected by the regulatory framework alternatives in the final rule were obtained from the NRC staff and from comments on the regulatory analysis provided with the proposed rule. The NRC considered the potential differences between the new requirements and the current requirements and incorporated the incremental changes into this regulatory analysis.

5. Presentation of Results

This section presents the quantitative and qualitative results by attribute for Alternative 2, relative to the regulatory baseline. As described in the previous sections, costs and benefits are quantified where possible and are shown to be either positive or negative, depending on whether the alternative has a favorable or adverse effect relative to the regulatory baseline (Alternative 1). Those attributes that are not easily represented in monetary values are discussed in qualitative terms. This "ex ante cost-benefit analysis"[6] provides useful information that the NRC can use to decide whether to select an alternative, even if the analysis is based on estimates of the future costs and benefits.

The potential benefits and costs of the alternatives are analyzed for (1) SMR and ONT applicants and licensees and (2) the NRC.[7] The analyses in this section are based on the NRC's assessment and input from stakeholders.

The NRC considered the exemption and guidance alternative to a rulemaking action. The agency is pursuing a rulemaking because such an action will establish a comprehensive regulatory framework that will result in enhanced regulatory stability, predictability, and clarity in the licensing process and provide an opportunity for stakeholder input on the regulatory framework. This is also in keeping with the implementation of the Commission's direction in

6 An "ex ante cost-benefit analysis" is prepared before the implementation of a policy, program, or alternative and can assist in the decisionmaking about whether resources should be allocated to that alternative.

7 The NRC considered the incremental impact of the final rule for other entities, including State, local, and Tribal government organizations, but it does not expect such entities to be affected.

Staff Requirements Memorandum (SRM)-SECY-15-0077, "Staff Requirements—SECY-15-0077—Options for Emergency Preparedness for Small Modular Reactors and Other New Technologies," dated August 4, 2015 (NRC, 2015b), and SRM-SECY-16-0069, "Staff Requirements—SECY-16-0069—Rulemaking Plan on Emergency Preparedness for Small Modular Reactors and Other New Technologies," dated June 22, 2016 (NRC, 2016b).

This section presents the incremental benefits and costs that the NRC, applicants, and licensees will incur from the rulemaking action. Incremental benefits and costs are calculated values and impacts that are above the baseline condition. The baseline condition for this rulemaking action includes the benefits and costs to comply with the current EP regulations in 10 CFR 50.34; 10 CFR 50.47(b); 10 CFR 50.54, "Conditions of Licenses"; 10 CFR Part 50, Appendix E; and 10 CFR 50.12, "Specific Exemptions" (as applicable). Based on the NRC's assessment, the incremental benefits and costs for this rulemaking action include the following:

- incremental averted costs to reduce the need for certain applicants to request exemptions from current EP regulations
- incremental averted costs due to simplified, performance-based EP planning, both in the EP plans themselves and in subsequent LAR submissions
- incremental costs to augment the probabilistic risk assessment (PRA) or provide an alternative type of analysis to justify the scaled-down EPZ

This cost estimate compares Alternative 1 (exemption requests) to Alternative 2 (rulemaking). Both alternatives have considerable averted costs when compared to compliance with the current EP regulations because both alternatives provide regulatory action to reduce the number of siren stations and their maintenance and various EP activities that affect protective actions outside the site boundary. The NRC believes that a plume exposure pathway EPZ at the site boundary will result in significant incremental averted costs to applicants and licensees. However, both Alternative 1 and Alternative 2 avert these EP related costs from each expected SMR or ONT applicant or licensee throughout its license term. This analysis does not provide a comparative cost estimate of this averted cost and the regulatory baseline because the averted cost difference between Alternative 1 and Alternative 2 is not significant.

The NRC requested input from stakeholders on the benefits and costs described in this regulatory analysis. Based on the public comments and feedback received on the proposed rule and related guidance, the NRC has refined this analysis to calculate and include the estimated additional costs on applicants and the NRC for PRA or other analyses to support the scalable plume exposure EPZ.

5.1. Industry Operation

Alternative 2 will amend the EP regulations specifically for SMRs and ONTs. These applicants and licensees would not have to incur the incremental costs associated with the exemption process that the current EP regulations would otherwise require. This includes the costs of preparing the exemption requests and responding to the NRC's requests for additional information through multifaceted interactions, such as correspondence, teleconferences, and meetings. The data on future license applications are based on the NRC's current knowledge of the affected entities' plans and the expected timing of the license applications. Table 3Table 3 shows these averted costs, using the NRC assumptions for the timing and number of the exemption requests and the proprietary application submittal information provided to the NRC.

The NRC estimates that each applicant will need 1,483 person-hours to prepare and submit an exemption request and that the weighted hourly labor rate for personnel preparing these documents is $121 per hour. Appendix B to this document provides a detailed table showing all the input costs that the NRC used for this analysis. While this analysis includes 12 SMRs and ONTs as input, 1 has already submitted an exemption request as part of its initial application process, and 2 more are expected to submit their applications along with exemption requests prior to the issuance of the final rule in 2022. Therefore, the final rule averts only 9 exemption requests in the regulatory analysis cost estimate.

Table 3 Industry Operation: Averted Costs for Emergency Planning Exemption Requests

Year	Activity	Number of Affected Entities	Per Entity		Cost		
			Labor Hours	Weighted Hourly Rate	Undiscounted	7% NPV	3% NPV
2022	Exemption Requests for SMRs and NLWRs	4	1,483	$121	$715,000	$668,000	$694,000
2023	Exemption Requests for SMRs and NLWRs	4	1,483	$121	$715,000	$625,000	$674,000
2024	Exemption Requests for SMRs and NLWRs	1	1,483	$121	$179,000	$146,000	$164,000
				Total:	**$1,609,000**	**$1,439,000**	**$1,532,000**

Note: Values are in base year 2021 dollars, rounded to the nearest $1,000.

The final rule will change the EP framework to one that is more performance-based, which will result in averted costs from increases in efficiency. The NRC expects the application process, from design certification through OL or COL issuance, to gain efficiencies in the new framework with each additional SMR or ONT license application, due to lessons learned on prior applications by other licensees. As a result, existing and future applicants would save time preparing license applications. The current framework results in emergency plans of approximately 500 pages submitted within each license application. The NRC estimates that industry personnel would take approximately 3,019 labor hours to prepare an emergency plan with the new rule in place. Although the NRC expects that the new process will include requests for additional information and a similar level of work for applicants, licensees, and the NRC for the first SMR or ONT application submission (3,019 hours), with many of the subsequent application submissions, the NRC expects efficiency gains resulting from the lessons learned related to the new performance-based framework. Therefore, the NRC has averaged efficiency gains of approximately 5 percent over each of the subsequent industry submissions. The NRC expects two SMR or ONT applicants to submit their EP plans using the final rule framework in 2022, with four more applicants in 2023, another four in 2024, and the last one in 2025. The NRC expects all future SMR or ONT applicants would submit an application for a smaller EPZ, whether they collocate with an existing facility or not.

Table 4 shows the subsequent improvement in the development of the EP plans by industry resulting from an efficiency gain, assuming a 95-percent learning improvement.

Table 4 Unit Time 95-Pecent Learning Curve for Industry Development of EP Plans

Number of EP Plans	Average Resource Estimate per EP Plan (Hours)	Average Reduction in Resource Hours per EP Plan from Efficiency Gain
1	3,019	0
2	2,868	151
3	2,783	236
4	2,724	294
5	2,680	339
6	2,644	375
7	2,614	405
8	2,588	431
9	2,566	453

Note: The reduction in resource hours is obtained by equation $Y = T \cdot X^{\frac{\log_{10} 0.95}{\log_{10} 2}}$, where *Y*, found in column two, is the reduced number of hours needed to process an EP submission; *T* is the initial number of hours needed to develop the first EP submission (i.e., 3,019 hours); and *X*, found in column one, represents some future EP submission (e.g., *X = 3* would represent the third EP submission).

Taking into account the learning curve efficiency gain for developing the EP submission, 12 SMRs and ONTs will result in averted costs as shown in Table 5. However, only 11 of the 12 SMRs and ONTs are included because 1 has already submitted its EP plans to the NRC.

Table 5 Averted Costs Due to Reduced Complexity in Initial EP Plan

Year	Activity	Number of Affected Entities	Per Entity			Cost		
			Labor Hours	Labor Hour Savings from Efficiency Gain	Weighted Hourly Rate	Undiscounted	7% NPV	3% NPV
2022	EP Plans Submitted	2	6,038	0	$121	$0	$0	$0
2023	EP Plans Submitted	4	11,132	943	$121	$114,000	$100,000	$107,000
2024	EP Plans Submitted	4	10,456	1,619	$121	$195,000	$159,000	$178,000
2025	EP Plans Submitted	1	2,566	453	$121	$55,000	$42,000	$49,000
					Total:	**$364,000**	**$301,000**	**$334,000**

Furthermore, licensees will submit fewer LARs for EP over the reactor lifetime because the performance-based framework of the final rule will result in less prescriptive requirements for personnel, equipment lists, and other currently existing EP requirements. While the scope of this final rule does not include current operating power reactor licensees, the NRC reviewed operating EP LARs submitted between 2014 and 2017 to estimate the potential averted costs associated with LARs for SMRs and ONTs. The NRC estimated that the number of LARs ranges from 18 to 32 per year for all operating sites, with an average of 25. The NRC used this LAR rate, calculated based on data from 56 operating power reactors sites in this regulatory analysis as analogous data, to estimate the future number of LARs per SMR or ONT per year—if the NRC did not issue the final rule—and assumed that a licensee expends approximately 593 labor hours per LAR. Table 6 shows the resulting estimated averted costs to industry using this method, for all 12 SMRs and ONTs.

Table 6 Averted Costs for Reduction in EP LARs

Year	Activity	Number of Affected Entities	Per Entity			Cost		
			LARs per year	Labor Hours	Weighted Hourly Rate	Undiscounted	7% NPV	3% NPV
2023-2082	Reduction in LAR work	2	0.42	593	$121	$3,518,000	$731,000	$1,555,000
2024-2083	Reduction in LAR work	4	0.42	593	$121	$7,035,000	$1,367,000	$3,020,000
2025-2084	Reduction in LAR work	5	0.42	593	$121	$8,794,000	$1,596,000	$3,665,000
2026-2085	Reduction in LAR work	1	0.42	593	$121	$1,759,000	$298,000	$712,000
					Total:	**$21,106,000**	**$3,992,000**	**$8,952,000**

Under current regulations, the default plume exposure pathway EPZ size is about 10 miles (16 km). For SMRs and ONTs with potentially smaller source terms and with passive design features, the NRC approach is to amend the regulations to adopt a scalable plume exposure pathway EPZ size without the need for exemption requests. Using this approach, an SMR or ONT plume exposure pathway EPZ could be at the site boundary in some cases. The NRC believes that a plume exposure pathway EPZ at the site boundary would result in significant incremental averted costs to applicants and licensees. For example, applicants and licensees would only need to establish an onsite emergency plan with demonstrable performance objectives and metrics for the NRC to find reasonable assurance that adequate protective measures can and will be taken in the event of a radiological emergency. Averted costs in this scenario would remove the requirements for (1) evacuation time estimates and corresponding annual and decennial updates, (2) public alert and notification system installation and annual maintenance, (3) FEMA annual user fees, (4) annual offsite drills and exercises, and (5) State agreement and licensing annual fees intended to support development and maintenance of offsite response capabilities particular to the nuclear hazard posed by the NRC-licensed facility.

Both Alternative 1 with approved exemptions and Alternative 2 avert these EP-related costs from each expected SMR or ONT applicant or licensee throughout its license term. These averted costs would result in millions of dollars of savings, annually, but are not estimated in this regulatory analysis because they are not incremental costs between Alternative 1 and 2.

In other cases, the plume exposure pathway EPZ could be determined to be outside the site boundary, but with a radius of less than 10 miles (16 km). In such cases, the applicant or licensee is required to include offsite response coordination in its emergency plans in accordance with 10 CFR 50.54(q), 10 CFR 50.47(b), and 10 CFR Part 50, Appendix E. The costs for establishing a 2-mile (3.2-km) plume exposure pathway EPZ offsite emergency plan, for example, would be different from the costs of establishing the current 10-mile (16-km) plume exposure pathway EPZ offsite emergency plan. This averted cost depends on such factors as the complexity of emergency planning caused by the geographical areas associated with governmental organizations and OROs and the magnitude of the public alert and notification system required. This aspect of the rule results in an incremental averted cost to applicants and licensees when compared to the regulatory baseline; however, both Alternative 1 with approved exemptions and Alternative 2 result in approximately the same averted cost. This analysis does not provide a comparative cost estimate of this averted cost and the regulatory baseline because the averted cost difference between Alternative 1 with approved exemptions and Alternative 2 is not significant.

To justify a scalable EPZ size, whether smaller than the default plume exposure pathway EPZ size of 10 miles (16 km) under current regulations but beyond the site boundary, or fully inside the site boundary, applicants will have to perform additional analyses and present these results to the NRC. The final rule allows applicants to decide whether to augment the existing PRA process or to use other forms of analysis to make this justification. However, in either case, this results in additional incremental costs on applicants, which the staff estimated at 120 labor

hours as a best estimate. For the 9 applicants that are expected to submit their analyses after the issuance of the final rule, this results in costs as shown in Table 7.

Table 7 Industry Costs for Additional PRA or Other Analysis

Year	Activity	Number of Affected Entities	Per Entity		Cost		
			Labor Hours	Weighted Hourly Rate	Undiscounted	7% NPV	3% NPV
2022	Additional EPZ analysis	4	127	$110	($56,000)	($52,000)	($54,000)
2023	Additional EPZ analysis	4	127	$110	($56,000)	($49,000)	($53,000)
2024	Additional EPZ analysis	1	127	$110	($14,000)	($11,000)	($13,000)
				Total:	**($126,000)**	**($112,000)**	**($120,000)**

Note: Values are in 2021 dollars, rounded to the nearest $1,000.

5.2. Total Industry Costs

Based on the cost estimate with an EPZ inside the site boundary, the rulemaking alternative (Alternative 2) results in estimated net averted costs to the industry that range from $5.62 million (7-percent NPV) to $10.7 million (3-percent NPV), when compared to Alternative 1, as shown in Table 8.

Table 8 Total Industry Costs

Attribute	Undiscounted	7% NPV	3% NPV
Total Industry Implementation Cost:	$0	$0	$0
Total Industry Operation Cost:	$22,950,000	$5,620,000	$10,700,000
Total Industry Cost:	**$22,950,000**	**$5,620,000**	**$10,700,000**

Note: Values are in 2021 dollars, rounded to the nearest $10,000.

5.3. NRC Implementation

The NRC's development and implementation of EP regulations for SMRs and ONTs through the final rulemaking stage resulted in incremental costs to the agency. The NRC has committed a significant number of technical and legal staff to develop the rulemaking and related guidance over a 4-year period. However, at this stage of the final rule, these costs are sunk, and, therefore, there are no NRC implementation costs.

5.4. NRC Operation

The NRC will receive averted costs (benefit) from the 9 exemption requests that will not be submitted by industry (under Alternative 2 when compared to Alternative 1) and, therefore, will not be reviewed by the NRC. Table 9 shows these averted costs, based on an estimated 713 hours of effort to review each request and a labor rate of $137 per hour.

Table 9 NRC Operation: Averted Costs for NRC Exemption Request Reviews

Year	Activity	Number of Requests	Hours	Weighted Hourly Rate	Cost		
					Undiscounted	7% NPV	3% NPV
2022	Review exemption requests	4	713	$137	$391,000	$365,000	$380,000
2023	Review exemption requests	4	713	$137	$391,000	$342,000	$369,000
2024	Review exemption requests	1	713	$137	$98,000	$80,000	$90,000
				Total:	**$880,000**	**$787,000**	**$839,000**

Note: Values are in 2021 dollars, rounded to the nearest $1,000.

In addition, the NRC benefits from the performance-based framework of the final rule as described above in the industry operation section. This regulatory analysis assumes that the review of the EP plans would occur in the same year following the submission of these plans by the applicants and that they would initially require approximately 1,509 labor hours to review.

Table 10 shows the subsequent improvement in the NRC's review of the EP plans as a result of an efficiency gain, assuming a 95-percent learning improvement.

Table 10 Unit Time 95-Percent Learning Curve for NRC Review of EP Plans

Number of EP Plans	Average Resource Estimate per EP Plan (Hours)	Average Reduction in Resource Hours per EP Plan from Efficiency Gain
1	1,509	0
2	1,434	75
3	1,392	118
4	1,362	147
5	1,340	169
6	1,322	187
7	1,307	202
8	1,294	215
9	1,283	227

Note: The reduction in resource hours is obtained by the equation $Y = T \cdot X^{\frac{\log_{10} 0.95}{\log_{10} 2}}$, where *Y*, found in column two, is the reduced number of hours needed to review an EP submission; *T* is the initial number of hours to review the first EP submission (i.e., 1,509 hours); and *X*, found in column one, represents some future EP submission (e.g., X = 3 would represent the third EP submission).

The NRC averted costs range from $172,000 (7-percent NPV) to $191,000 (3-percent NPV), as shown in Table 11, as a result of lessons learned from processing these SMR and ONT EP submissions.

Table 11 Averted Cost for Reduced EP Plans

Year	Activity	Number of Submissions	Hours	Labor Hour Savings from Efficiency Gain	Weighted Hourly Rate	Cost		
						Undiscounted	7% NPV	3% NPV
2022	Review EP plans	2	3,019	0	$137	$0	$0	$0
2023	Review EP plans	4	5,566	471	$137	$65,000	$57,000	$61,000
2024	Review EP plans	4	5,228	810	$137	$111,000	$91,000	$102,000
2025	Review EP plans	1	1,283	227	$137	$31,000	$24,000	$28,000
					Total:	**$207,000**	**$172,000**	**$191,000**

Note: Values are in 2021 dollars, rounded to the nearest $1,000.

As shown in Table 12, the NRC will also have averted costs resulting from the reduced LAR submissions, estimated at $1.47 million (7-percent NPV) and $3.29 million (3-percent NPV).

Table 12 Averted Costs for Reduced EP LARs

Year	Activity	Number of Entities	Hours	LARs per year	Weighted Hourly Rate	Cost		
						Undiscounted	7% NPV	3% NPV
2023-2082	Review EP LARs	2	192	0.42	$137	$1,291,000	$268,000	$571,000
2024-2083	Review EP LARs	4	192	0.42	$137	$2,582,000	$502,000	$1,108,000
2025-2084	Review EP LARs	5	192	0.42	$137	$3,228,000	$586,000	$1,345,000
2026-2085	Review EP LARs	1	192	0.42	$137	$646,000	$110,000	$261,000
					Total:	**$7,747,000**	**$1,466,000**	**$3,285,000**

Note: Values are in 2021 dollars, rounded to the nearest $1,000.

As shown in Table 13, the NRC will incur additional incremental costs resulting from reviewing the additional PRA or other analyses from applicants, for the scalable EPZ. These costs are estimated at ($71,000) using a 7-percent NPV and ($75,000) using a 3-percent NPV.

Table 13 NRC Review of Additional PRA or Other Analysis

Year	Activity	Number of Requests	Hours	Weighted Hourly Rate	Cost		
					Undiscounted	7% NPV	3% NPV
2022	Review EPZ Analysis	4	63	$137	($35,000)	($33,000)	($34,000)
2023	Review EPZ Analysis	4	63	$137	($35,000)	($31,000)	($33,000)
2024	Review EPZ Analysis	1	63	$137	($9,000)	($7,000)	($8,000)
				Total:	**($79,000)**	**($71,000)**	**($75,000)**

Note: Values are in 2021 dollars, rounded to the nearest $1,000.

5.5. Total NRC Costs

Combined, these costs and averted costs show an estimated net averted cost to the NRC as a result of this rulemaking ranging from $2.35 million (7-percent NPV) to $4.24 million (3-percent NPV), as shown in Table 14.

Table 14 Total NRC Costs

Attribute	NRC Costs		
	Undiscounted	7% NPV	3% NPV
Total NRC Implementation Cost:	$0	$0	$0
Total NRC Operation Cost:	$8,760,000	$2,350,000	$4,240,000
Total NRC Cost:	$8,760,000	$2,350,000	$4,240,000

Note: Values are in base year 2021 dollars, rounded to the nearest $10,000.

5.6. Total Costs

Relative to Alternative 1 (i.e., using the exemption process to request exemptions from the EP regulations for SMRs and ONTs), the NRC concludes that the averted incremental costs to the applicants and licensees justify the NRC's incremental costs for this rulemaking action (Alternative 2). Table 15 shows a net benefit (averted cost) for the quantitative factors discussed above.

Table 15 Total Costs with the Plume Exposure Pathway EPZ Inside the Site Boundary

Attribute	Total Averted Costs (Costs)		
	Undiscounted	**7% NPV**	**3% NPV**
Industry Implementation	$0	$0	$0
Industry Operation	$22,950,000	$5,620,000	$10,700,000
Total Industry Cost	*$22,950,000*	*$5,620,000*	*$10,700,000*
NRC Implementation	$0	$0	$0
NRC Operation	$8,760,000	$2,350,000	$4,240,000
Total NRC Cost	*$8,760,000*	*$2,350,000*	*$4,240,000*
Net	***$31,710,000***	***$7,970,000***	***$14,940,000***

Note: There may be small differences between tables as a result of rounding.

The net averted costs to industry and the NRC if the rulemaking alternative is pursued range from $7.97 million (7-percent NPV) to $14.9 million (3-percent NPV). The rulemaking alternative (Alternative 2) will apply to any existing and future SMR and ONT applicants and licensees and will result in averted costs for reductions in exemption requests, efficiencies gained in processing EP submissions, and reductions in LARs. The rulemaking alternative is cost justified because the averted costs for SMR and ONT applicants and licensees will exceed the costs of the rulemaking process. As previously stated, both Alternatives 1 and 2 will avert the substantial offsite EP costs delineated in the Industry Operation section of this regulatory analysis.

5.7. Potential Effect on Offsite Governmental Organizations

Offsite governmental organizations would incur the same costs to implement and maintain offsite EP under Alternative 1 (exemption requests) as they would under Alternative 2 (rulemaking).

5.8. Sensitivity Analysis of the Number of and the Timing for License Applications

The regulatory analysis looks at the possibility that some of the SMRs and ONTs, from the 12 entities that have plans to begin construction after the final rule goes into effect, may decide not to begin the application process. Additionally, the regulatory analysis discusses the possibility that the remaining applications could be delayed.

A scenario run for sensitivity has six SMRs and ONTs deciding not to begin the application process while the remaining six that do submit an application would have their applications delayed by 10 years. The total net averted cost for this scenario was found to be $2.20 million at a 7-percent discount rate and $5.82 million at a 3-percent discount rate. In the base case where all known SMR or ONT applications are submitted and there is no delay in the expected submissions of their applications, the total net averted cost was found to be $7.97 million at a 7-percent discount rate and $14.9 million at a 3-percent discount rate. The conclusion from this sensitivity analysis is that even if nearly half of the initial SMRs and ONTs cancel their plans for submitting applications and the remaining ones are delayed by a decade, the final rule is still cost beneficial.

5.9. Uncertainty Analysis

The NRC completed a Monte Carlo uncertainty analysis for this regulatory analysis using the specialty software @Risk.[8] The Monte Carlo approach answers the question, "What distribution of net benefits and costs results from multiple draws of the probability distribution assigned to key variables?"

5.9.1. Uncertainty Analysis Assumptions

Because this regulatory analysis is based on estimates of values that are sensitive to plant-specific cost drivers and plant dissimilarities, the NRC provides the following analysis of the variables that have the greatest amount of uncertainty. As noted above, the NRC performed this analysis with a Monte Carlo simulation analysis using the @Risk software program.

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

The probability distributions chosen to represent the different variables in the analysis were bounded by the range-referenced input and the NRC staff's professional judgment. When defining the probability distributions for use in a Monte Carlo simulation, summary statistics are needed to characterize the distributions. These summary statistics include (1) the minimum, most likely, and maximum values of a program evaluation and review technique (PERT) distribution,[9] (2) the minimum and maximum values of a uniform distribution, and (3) the specified integer values of a discrete population. The NRC used the PERT distribution to reflect the relative spread and skewness of the distribution defined by the three estimates.

Table 16 identifies the data elements, the distribution and summary statistic, and the mean value of the distribution used in the uncertainty analysis.

8 Information about the @Risk software is available at http://www.palisade.com.

9 A PERT distribution is a special form of the beta distribution with specified minimum and maximum values. The shape parameter is calculated from the defined "most likely" value. The PERT distribution is similar to a triangular distribution in that it has the same set of three parameters. Technically, it is a special case of a scaled beta (or beta general) distribution. The PERT distribution is generally considered superior to the triangular distribution when the parameters result in a skewed distribution because the smooth shape of the curve places less emphasis in the direction of skew. Similar to the triangular distribution, the PERT distribution is bounded on both sides and, therefore, may not be adequate for some modeling purposes if the capture of tail or extreme events is desired.

Table 16 Uncertainty Analysis Variables

Data Element	Mean Estimate	Distribution	Low Estimate	Best Estimate	High Estimate
SMRs and ONTs					
Number of SMRs/ONTs	12	DISCRETE	6	12	12
Number of delayed years of submission of application	0	GEOMETRIC	0	0	10
Industry Submittals of Exemption Requests					
Hourly rate	$121	PERT	$96	$121	$144
Hours to generate and submit	1,483	PERT	1,250	1,500	1,650
Reduced EP Plan Complexity (Industry)					
Hours to produce and submit EP-related submissions	3,019	PERT	2,362	2,625	5,250
Efficiency factor for learning	5%	PERT	0%	5%	10%
Averted LAR for EP (Industry)					
Hours to generate and submit a LAR	593	PERT	280	580	960
Current EP LARs per year	25	PERT	18	25	32
Average number of LARs per site-year	0.42	PERT	0.3	0.42	0.53
SMR reactor life	60	PERT	40	60	80
Averted LAR for EP (NRC)					
Hours to approve an LAR	192	PERT	100	200	250
Reduced EP Plan Complexity (NRC)					
Hours to review EP-related submissions	1,509	PERT	1,181	1,313	2,625
Efficiency factor for learning	5%	PERT	0%	5%	10%
Review Exemption Requests (NRC)					
Hourly rate	$137	PERT	$136	$137	$138
Hours to review	713	PERT	620	710	820
Additional PRA or Other Analysis (Industry)					
Hourly rate	$110	PERT	$87	$110	$133
Hours to conduct	127	PERT	80	120	200

5.9.2. Uncertainty Analysis Results

The NRC performed the Monte Carlo simulation by repeatedly recalculating the results 10,000 times. For each iteration, the NRC chose the values identified in Table 16 randomly from the probability distributions that define the input variables. The NRC recorded the values of the output variables for each iteration and used these resulting output variable values to define the resultant probability distribution.

For the analysis shown in each figure below, the NRC ran 10,000 simulations in which it changed the key variables to assess the resulting effect on costs and benefits. Figure 1**,** 2, and 3 display the histograms of the incremental costs and benefits from the regulatory baseline (Alternative 1). The uncertainty analysis evaluates the impact if some of the 12 applicants

cancel or delay their EP submissions. Nevertheless, the analysis shows that the final rule will be cost beneficial even if half of the expected applicants do not submit and are delayed by 10 years.

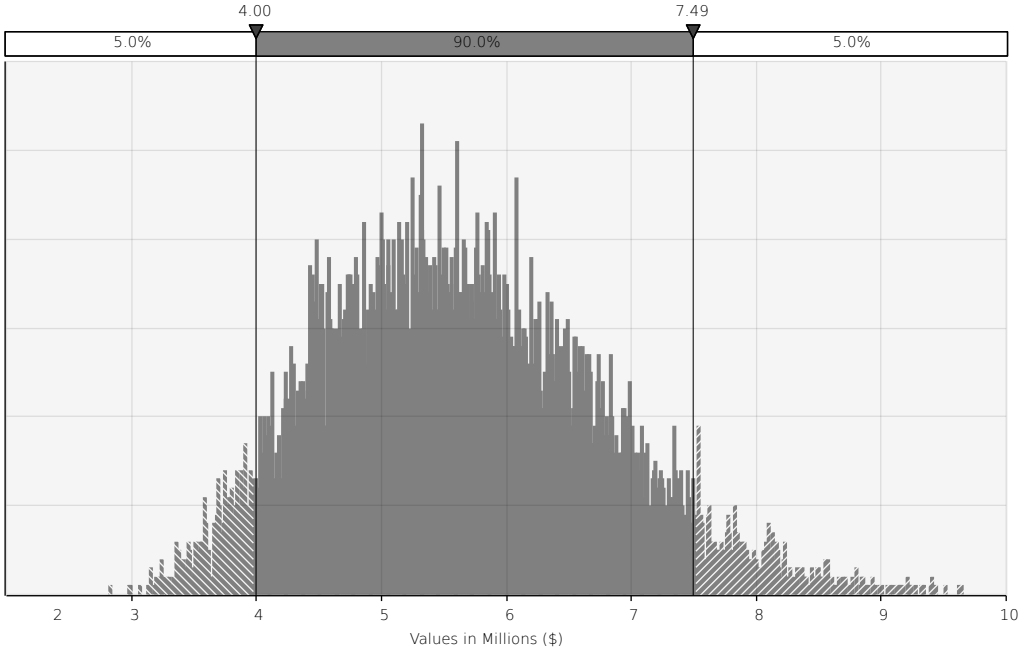

Figure 1 Total industry costs (7-percent NPV)—Alternative 2

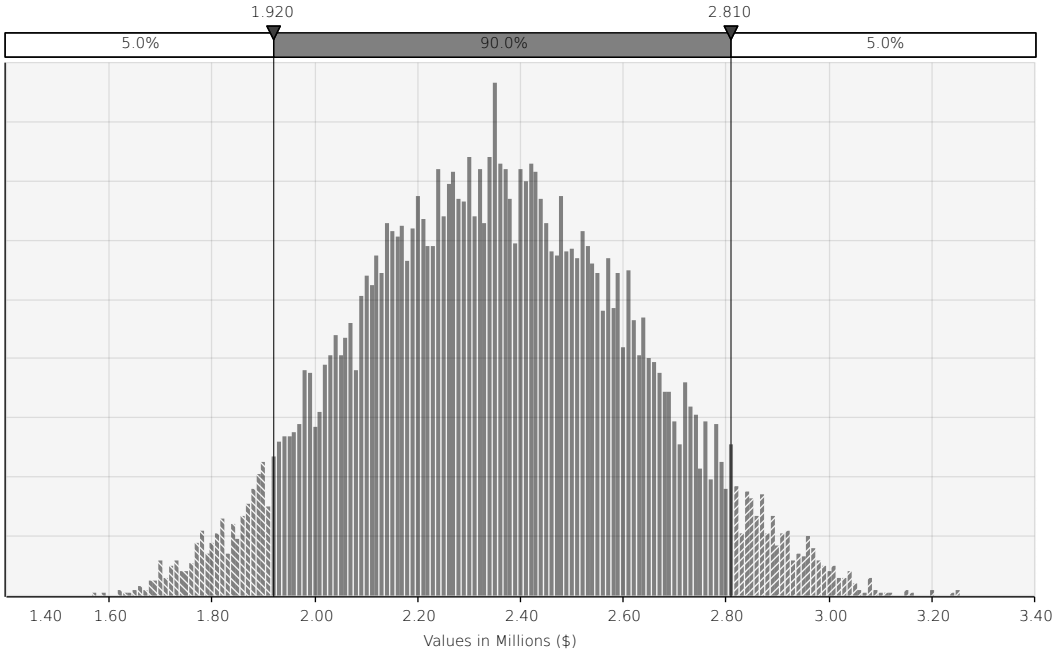

Figure 2 Total NRC costs (7-percent NPV)—Alternative 2

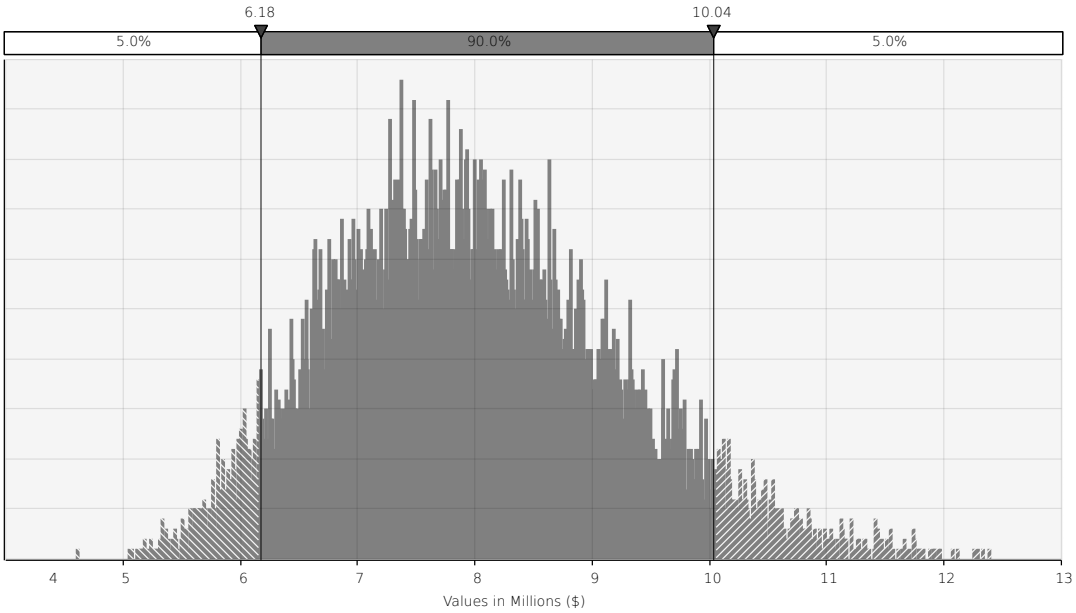

Figure 3 Total costs (7-percent NPV)—Alternative 2

Table 17 presents descriptive statistics on the uncertainty analysis. Table 17 (rounded) reflects the 5-percent and 95-percent values (in other words, the bands marked 5.0 percent on either side of the 90-percent confidence interval) that appear as numerical values on the top of the vertical lines in Figure 1, Figure 2, and Figure 3 as the 0.05 and 0.95 values, respectively.

Table 17 Uncertainty Results Descriptive Statistics—7-Percent NPV

Uncertainty Result	Incremental Cost Benefit (2020 million dollars)					
	Minimum	Mean	Std. Dev.	Maximum	5%	95%
Total Industry Cost	$2.83	$5.62	$1.08	$9.64	$4.00	$7.49
Total NRC Cost	$1.57	$2.35	$0.27	$3.25	$1.92	$2.81
Total Cost	$4.61	$7.98	$1.17	$12.4	$6.18	$10.0

Note: There may be small differences between tables as a result of rounding.

Examining the range of the resulting output distribution provided in Table 17 makes it possible to discuss the potential incremental costs and benefits of the regulatory basis more confidently. This table displays the key statistical results, including the 90-percent confidence interval in which the net benefits would fall between the 5- and 95-percentile values.

Figure 4 shows a tornado diagram that identifies the key variables whose uncertainty has the largest impact on total costs (and averted costs) for this final rule. Figure 4 ranks the variables based on their contribution to cost uncertainty. Four variables—(1) cancellations of SMR or ONT applications (determined by sensitivity analysis), (2) the hours for a licensee to develop an LAR, (3) the number of LARs per site-year, and (4) the industry hourly rate—drive the most uncertainty in the costs. The remaining key variables show diminishing variation.

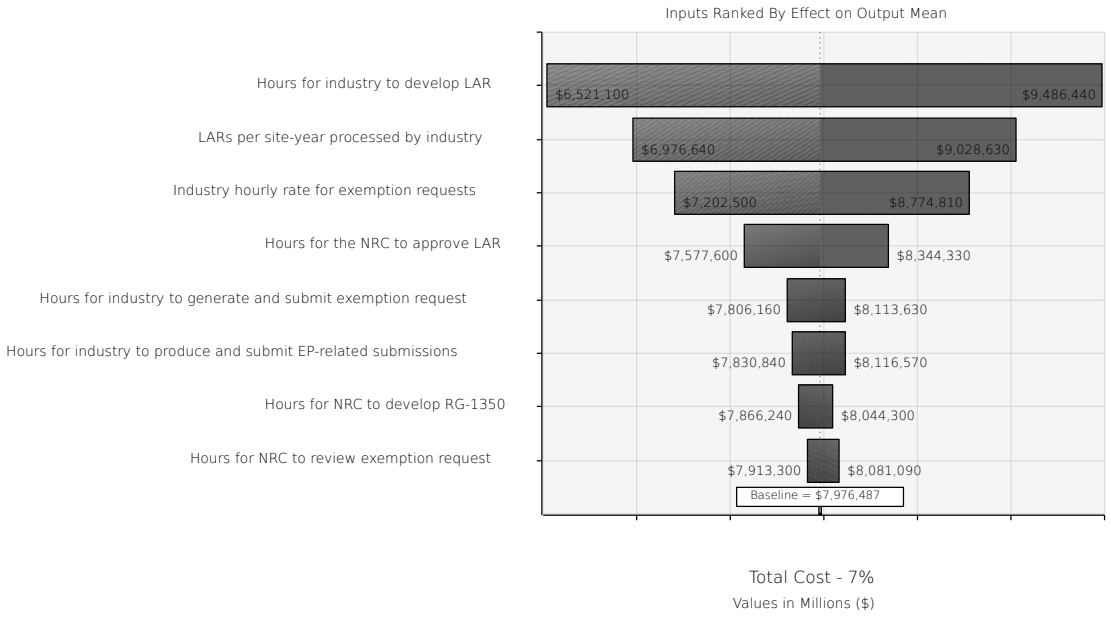

Figure 4 Tornado Diagram—Total Averted Costs—7-Percent NPV

The averted costs for industry and the NRC for this final rule has a mean value of $7.97 million at a 7-percent discount rate. The uncertainty analysis shows all 10,000 simulations for the rulemaking are cost effective. This is the primary reason for concluding that the benefits of this rulemaking outweigh the costs.

5.10. Disaggregation

To comply with the guidance in NUREG/BR-0058, Section 4.3.2, "Criteria for the Treatment of Individual Requirements," the NRC performed a screening review to determine whether the final rule would be unnecessary to achieve the objectives of the rulemaking. Under the NRC's current regulatory framework, all applications for a construction permit or OL under 10 CFR Part 50 and all COL applications submitted under 10 CFR Part 52 must provide plans for coping with emergencies as part of either a preliminary or a final safety analysis report. This regulatory framework includes technical and policy infrastructures that do not consider reactor core sizes, lower power densities, lower probability of severe accidents, slower accident progression, and smaller accident offsite consequences due to advanced reactor designs for SMRs and certain ONTs. Hence, the performance-based framework for SMRs and ONTs in the final rule could allow for more regulatory flexibility, provide a basis for appropriate EP through the review of design- and site-specific accident scenarios, and minimize the need for exemption requests that would otherwise be anticipated under the current regulatory framework. In this context, performance-based means basing the adequacy of EP upon the NRC's identification of emergency response functions that affect the protection of public health and safety and the licensee's successful execution of those functions. The NRC's performance-based framework, inspection and enforcement program, and design-specific review process will still provide reasonable assurance that protective measures can and will be taken in the event of a radiological emergency at an SMR or ONT facility.

The review process changes in the final rule will result in averted exemption request costs to the NRC and the industry, estimated to range from $2.23 million at a 7-percent discount rate to

$2.37 million at a 3-percent discount rate. The inspection and enforcement program changes in the final rule will result in averted LAR costs to the NRC and the industry, estimated to range from $5.46 million at a 7-percent discount rate to $12.2 million at a 3-percent discount rate. The performance-based framework in the final rule will result in simplified EP plan benefits to the NRC and the industry, estimated to range from $473,000 at a 7-percent discount rate to $525,000 at a 3-percent discount rate.

Therefore, the NRC concludes that the final rule will be 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.

5.11. Summary

This regulatory analysis identified both quantifiable and nonquantifiable costs and benefits that will result from conducting the rulemaking to address EP requirements for SMRs and ONTs. Although quantifiable costs and benefits appear to be more tangible, the NRC urges decisionmakers not to discount costs and benefits that are unquantifiable. Such benefits or costs can be just as important as, or even more important than, benefits or costs that can be quantified and monetized.

5.11.1. Quantified Net Benefit

As shown in Table 15, the estimated quantified incremental averted costs for Alternative 2 relative to the regulatory baseline (Alternative 1) over the remaining term of the OLs of the affected entities range from approximately $7.97 million (7-percent NPV) to $14.9 million (3-percent NPV). The sensitivity analysis showed that, even if half of the 12 expected SMR and ONT applications do not occur and the remaining 6 are delayed by 10 years, the final rule results in averted costs ranging from approximately $2.20 million (7-percent NPV) to $5.82 million (3-percent NPV).

5.11.2. Nonquantified Benefits

In addition to the quantified costs discussed in this regulatory analysis, the attributes of regulatory efficiency and public confidence will produce nonquantified benefits for industry and the NRC as summarized below.

5.11.3. Regulatory Efficiency

The NRC is pursuing an alternative process through rulemaking because it will establish a performance-based, comprehensive regulatory framework that will result in enhanced regulatory stability, predictability, and clarity in the licensing process by reducing reliance on exemption requests. As a result, the rulemaking will provide stability by establishing a consistent EP framework rather than allowing the regulatory approach to vary from application to application.

Additionally, the NRC traditionally attempts to avoid regulating by exemption when an issue can be addressed through generic actions such as rulemaking. The estimated benefits of the final rulemaking action include (1) fewer exemption requests as compared to those under current regulations, (2) fewer LARs to maintain EP documentation during the operation of the facility, (3) consistent regulatory applicability and efficiencies gained in the review of EP plans, and (4) the use of a more risk-informed and performance-based EP framework. This final rulemaking framework (1) recognizes advances in design and technological advancements

embedded in SMR and ONT design features, (2) credits the SMR and ONT safety enhancements existing in evolutionary and passive systems, and (3) credits the potential benefits of smaller sized reactors and non-LWRs associated with postulated accidents (e.g., slower transient response times and relatively small and slow release of fission products).

5.11.4. Increased Public Confidence

In addition to regulatory efficiency, processing SMRs and ONTs through rulemaking instead of through the exemption request process will increase public confidence in the NRC's ability to adapt to new technology and new regulatory needs, will provide opportunities for stakeholder input into the changes to the EP acceptance criteria, and will maintain the NRC's role as an effective industry regulator. Additionally, the rulemaking process includes the greatest opportunity for Commission and public engagement on the issues related to EP for advanced reactors. Public notice and comment during rulemaking provides the widest range of viewpoints for Commission consideration in the development of the final rule.

5.12. Safety Goal Evaluation

The NRC's safety goal evaluation only applies to regulatory initiatives that the agency considers to be a generic safety enhancement backfit subject to the substantial additional protection standard at 10 CFR 50.109(a)(3). The final rule alternative will allow SMR and ONT applicants to apply for licenses without including exemption requests to scale the EP requirements appropriately for the SMR or ONT. The NRC does not regard this final rule for SMRs and ONTs to be backfitting or to affect the issue finality of any approval issued under 10 CFR Part 52 because the final rule will not be imposed upon applicants and licensees and will not prohibit applicants and licensees from following existing requirements. Based on these reasons, a safety goal evaluation is not appropriate for this regulatory analysis.

5.13. Results for the Committee to Review Generic Requirements

This section addresses regulatory analysis information requirements for rulemaking actions or staff positions subject to review by the Committee to Review Generic Requirements (CRGR). All information called for by the CRGR procedures (NRC, 2018) is presented in this regulatory analysis or in the *Federal Register* notice for the final rule. Table 18 cross-references the relevant information to its location in this document or the *Federal Register* notice.

Table 18 Specific CRGR Regulatory Analysis Information Requirements

CRGR Procedures Citation (NRC, 2018)	Information Item To Be Included in a Regulatory Analysis Prepared for CRGR Review	Where Item Is Discussed
Appendix B, (i)	The new or revised generic requirement or staff position as it is issued as a final rule	Final rule text in *Federal Register* notice for the final rule
Appendix B, (ii)	Draft papers or other documents supporting the requirements or staff positions	*Federal Register* notice for the final rule

CRGR Procedures Citation (NRC, 2018)	Information Item To Be Included in a Regulatory Analysis Prepared for CRGR Review	Where Item Is Discussed
Appendix B, (iii)	The sponsoring office's position on each requirement or staff position as to whether it would modify, implement, relax, or reduce existing requirements or staff positions	Regulatory Analysis, Section 5, and Backfitting and Issue Finality, Section XIII, *Federal Register* notice for the final rule
Appendix B, (iv)	The method of implementation	Regulatory Analysis, Section 7
Appendix B, (vi)	Identification of the category of power reactors, new reactors, or nuclear materials facilities or activities to which the generic requirement or staff position applies	Regulatory Analysis, Section 4.2.2
Appendix B, (vii)–(viii)	If the action involves a power reactor backfit and the exceptions at 10 CFR 50.109(a)(4) are not applicable, the items required at 10 CFR 50.109(c) and the required rationale at 10 CFR 50.109(a)(3)	Backfitting and Issue Finality, Section XIII, *Federal Register* notice for the final rule
Appendix B, (xvi)	An assessment of how the action relates to the Commission's Safety Goal Policy Statement	Regulatory Analysis, Section 5.15

6. Decision Rationale

Table 19 provides the quantified and qualified costs and benefits for Alternative 2. The quantitative analysis used best estimate values.

Table 19 Summary of Totals

Net Monetary Savings or (Costs)— Total Present Value	Nonquantified Benefits or (Costs)
Alternative 1: No Action - $0	None
Alternative 2: Conduct rulemaking to provide alternative EP requirements for SMRs and non-LWRs Industry: $5.62 million using a 7% discount rate $10.7 million using a 3% discount rate NRC: $2.35 million using a 7% discount rate $4.24 million using a 3% discount rate Net Benefit (Cost): $7.97 million using a 7% discount rate $14.9 million using a 3% discount rate	Benefits: • **Regulatory Efficiency:** By regulating emergency planning for SMRs and ONTs through rulemaking instead of through the exemption process, the NRC will establish a performance-based, comprehensive regulatory framework that will result in enhanced regulatory stability, predictability, and clarity in the licensing process and an opportunity for stakeholder input on the regulatory framework. • **Increased Public Confidence:** In addition to regulatory efficiency,

Net Monetary Savings or (Costs)— Total Present Value	Nonquantified Benefits or (Costs)
	processing SMRs and ONTs through rulemaking instead of the exemption request process will increase public confidence in the NRC's ability to adapt to new technology and new regulatory needs.

Note: There may be small differences between tables as a result of rounding.

The industry and the NRC will benefit from the final rulemaking Alternative 2 primarily because of the averted costs from applicants and licensees submitting fewer EP exemption requests and LARs. As a result, there will be additional averted costs from the NRC reviewing and processing these fewer EP exemption requests and LARs. Furthermore, efficiencies will be gained from applicants submitting EP plans and from the NRC reviewing these plans because of the enhanced clarity in the licensing process. Table 19 shows that, relative to the regulatory baseline, Alternative 2 will result in a net benefit (averted cost) to industry that ranges from $5.62 million (7-percent NPV) to $10.7 million (3-percent NPV). The NRC's net averted costs range from $2.35 million (7-percent NPV) to $4.24 million (3-percent NPV). Thus, the total quantitative net averted costs of the rulemaking will range from $7.97 million (7-percent discount rate) to $14.9 million (3-percent discount rate).

Based solely on quantified costs and benefits, the regulatory analysis shows that the rulemaking is justified because the total quantified benefits of the final rule regulatory action will exceed the costs of the final action, for all discount rates up to 7 percent. Considering nonquantified costs and benefits, the regulatory analysis shows that the rulemaking is justified because the number and significance of the nonquantified benefits outweigh the nonquantified costs. Therefore, integrating both quantified and nonquantified costs and benefits indicates that the benefits of the final rule outweigh the identified quantitative and qualitative impacts attributable to the final rule.

7. Implementation Schedule

The NRC assumes that the final rule will become effective 30 days after its publication in the *Federal Register* in 2022.

8. References

American National Standards Institute (ANSI)/American Nuclear Society (ANS)-15.16-2015, "Emergency Planning for Research Reactors," ANS, LaGrange Park, IL.

Bureau of Labor Statistics (BLS), "SOC Code: Standard Occupational Classification Code," U.S. Department of Labor, January 2021a. Available at http://www.bls.gov/soc/home.htm; last accessed on March 16, 2021.

BLS, "Archived Consumer Price Index Supplement Files: March 2021 Historical CPI-U, Table 24, Historical Consumer Price Index for All Urban Consumers (CPI-U): U.S. City Average, All Items," U.S. Department of Labor, April 2021b. Available at http://www.bls.gov/cpi/tables.htm; last accessed on April 10, 2021.

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

CFR, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Part 52, Chapter I, Title 10, "Energy."

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."

U.S. Environmental Protection Agency (EPA), "PAG Manual: Protective Action Guides and Planning Guidance for Radiological Incidents," EPA-400/R-17/001, January 2017. Available at https://www.epa.gov/sites/production/files/2017-01/documents/epa_pag_manual_final_revisions_01-11-2017_cover_disclaimer_8.pdf; last accessed on April 30, 2018.

Executive Order 12866, "Regulatory Planning and Review," October 4, 1993; Volume 58 of the *Federal Register* (FR), page 51735 (58 FR 51735).

U.S. Nuclear Regulatory Commission (NRC)/EPA Agency Task Force on Emergency Planning, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants," NUREG-0396 (EPA 520/1-78-016), December 1978, Agencywide Documents Access and Management System (ADAMS) Accession No. ML051390356.

NRC, "Standard Review Plan for the Review and Evaluation of Emergency Plans for Research and Test Reactors," NUREG-0849, October 1983a, ADAMS Accession No. ML062190191.

NRC, "A Handbook for Value-Impact Assessment," NUREG/CR-3568 (PNL-4646), December 1983b, ADAMS Accession No. ML062830096.

NRC, "Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements," SECY-93-092, April 8, 1993, ADAMS Accession No. ML040210725.

NRC, "Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors," SECY-97-020, January 27, 1997, ADAMS Accession No. ML992920024.

NRC, “Staff Requirements—SECY-04-0236—Southern Nuclear Operating Company’s Proposal to Establish a Common Emergency Operating Facility at Its Corporate Headquarters,” SRM-SECY-04-0236, February 23, 2005, ADAMS Accession No. ML050550131.

NRC, “Results of the Review of Emergency Preparedness Regulations and Guidance,” SECY-06-0200, September 20, 2006, ADAMS Accession No. ML061910707.

NRC, “Development of an Emergency Planning and Preparedness Framework for Small Modular Reactors,” SECY-11-0152, October 28, 2011, ADAMS Accession No. ML112570439.

NRC, “Final Interim Staff Guidance Augmenting NUREG-1537, Part 1, ‘Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content,’ for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors,” October 17, 2012a, ADAMS Accession No. ML12156A069.

NRC, “Final Interim Staff Guidance Augmenting NUREG-1537, Part 2, ‘Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria,’ for Licensing Radioisotope Production Facilities and Aqueous Homogeneous Reactors,” October 17, 2012b, ADAMS Accession No. ML12156A075.

NRC, “Performance-Based Framework for Nuclear Power Plant Emergency Preparedness Oversight,” SECY-14-0038, April 4, 2014a, ADAMS Accession No. ML13238A018.

NRC, “Staff Requirements—SECY-14-0038—Performance-Based Framework for Nuclear Power Plant Emergency Preparedness Oversight,” SRM-SECY-14-0038, September 16, 2014b, ADAMS Accession No. ML14259A589.

NRC, “Options for Emergency Preparedness for Small Modular Reactors and Other New Technologies,” SECY-15-0077, May 29, 2015a, ADAMS Accession No. ML15037A176.

NRC, “Staff Requirements—SECY-15-0077—Options for Emergency Preparedness for Small Modular Reactors and Other New Technologies,” SRM-SECY-15-0077, August 4, 2015b, ADAMS Accession No. ML15216A492.

NRC, “Rulemaking Plan on Emergency Preparedness for Small Modular Reactors and Other New Technologies,” SECY-16-0069, May 31, 2016a, ADAMS Accession No. ML16020A388.

NRC, “Staff Requirements—SECY-16-0069—Rulemaking Plan on Emergency Preparedness for Small Modular Reactors and Other New Technologies,” SRM-SECY-16-0069, June 22, 2016b, ADAMS Accession No. ML16174A166.

NRC, “NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness,” December 2016c, ADAMS Accession No. ML16356A670.

NRC, “Rulemaking for Emergency Preparedness for Small Modular Reactors and Other New Technologies,” Final Regulatory Basis, September 2017a, ADAMS Accession No. ML17206A265.

NRC, “Emergency Planning for Research and Test Reactors and Other Non-Power Production and Utilization Facilities,” Regulatory Guide 2.6, Revision 2, September 2017b, ADAMS Accession No. ML17263A472.

NRC, “Committee to Review Generic Requirements Procedures and Internal Administrative Process,” June 2018. Available at (ADAMS Accession No. ML17355A533).

NRC, 2019. SECY-19-0062, “Final Rule: Non-Power Production or Utilization Facility License Renewal,” June 17, 2019. Available at ADAMS Accession No. ML18031A000.

NRC, 2020. “Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission,” Draft Final Report, NUREG/BR-0058, draft Revision 5, January 28, 2020, ADAMS Accession No. ML19261A277.

NRC, “Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities,” Regulatory Guide 1.242, Revision 0, 2022, ADAMS Accession No. ML20345A345.

Office of Management and Budget (OMB) Circular No. A-4, “Regulatory Analysis,” September 17, 2003.

APPENDIX A
HISTORICAL NRC CONSIDERATIONS OF EMERGENCY PREPAREDNESS FOR ADVANCED REACTOR DESIGN

In SECY-93-092, "Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements,"[10] dated April 8, 1993 (NRC, 1993), the U.S. Nuclear Regulatory Commission (NRC) staff suggested that the existing regulations governing emergency preparedness (EP) for advanced reactors should not be changed and stated that regulatory direction would be given at or before the start of the design certification phase to address design implications for EP.

In SECY-97-020, "Results of Evaluation of Emergency Planning for Evolutionary and Advanced Reactors," dated January 27, 1997 (NRC, 1997), the NRC staff determined that the rationale upon which EP for current reactor designs is based—that is, potential consequences from a spectrum of accidents—is appropriate for use as the basis for EP for evolutionary and passive advanced light-water reactor designs and is consistent with the Commission's defense-in-depth safety philosophy.

In Staff Requirements Memorandum (SRM)-SECY-04-0236, "Staff Requirements—SECY-04-0236—Southern Nuclear Operating Company's Proposal to Establish a Common Emergency Operating Facility at its Corporate Headquarters," dated February 23, 2005 (NRC, 2005), the Commission recognized the importance of performance-based EP. In SECY-06-0200, "Results of the Review of Emergency Preparedness Regulations and Guidance," dated September 20, 2006 (NRC, 2006), the staff sought Commission approval to explore the feasibility of a voluntary, performance-based EP regulatory regimen. The staff outlined high-level concepts for performance-based EP in SECY-06-0200, such as (1) the staff's development of a set of overarching performance goals to guide the design of the performance-based framework, (2) the staff's development of several key performance indicators to support the performance goals, (3) the on-shift emergency response organization's performance of the many competencies necessary for emergency response, and (4) the augmented emergency response organizations' performance of the emergency response competencies specific to the emergency response facility.

Following public meetings with industry and stakeholders and a review of other small modular reactor (SMR) issues, the staff issued SECY-11-0152, "Development of an Emergency Planning and Preparedness Framework for Small Modular Reactors," dated October 28, 2011 (NRC, 2011). This paper informed the Commission of the NRC staff's proposed actions to develop an emergency planning and preparedness framework for SMR facilities. In the document, the NRC staff stated its intent to develop a technology-neutral (now technology-inclusive), dose-based, consequence-oriented EP framework for SMR sites that would take into account the various designs, modularity, and co-location of these facilities, as well as the size of the EPZs. The staff also stated that "[t]he staff will work with stakeholders to develop general guidance on calculating the offsite dose, and is anticipating that the industry will develop and implement the detailed calculation method for review and approval by the staff."

In SECY-14-0038, "Performance-Based Framework for Nuclear Power Plant Emergency Preparedness Oversight," dated April 4, 2014 (NRC, 2014a), the staff further endorsed and

10 "PRISM," "MHTGR," "PIUS," and "CANDU" are abbreviations for power reactor innovative small module; modular high-temperature, gas-cooled reactor; process inherent ultimate safety; and Canadian deuterium-uranium, respectively.

committed to a performance-based oversight regimen to simplify EP regulations. However, at that time, the staff recommended that continued use of the existing framework with operating plants because changing the EP approach for those plants would require significant resources for implementing a performance-based framework and could introduce regulatory uncertainty. Additionally, the staff recognized that existing EP programs provided reasonable assurance of adequate protection of public health and safety; therefore, the staff recommended maintaining the current EP regimen.

In SRM-SECY-14-0038, "Staff Requirements—SECY-14-0038—Performance-Based Framework for Nuclear Power Plant Emergency Preparedness Oversight," dated September 16, 2014 (NRC, 2014b), the Commission approved the staff's recommendation and specified that the staff "should be vigilant in continuing to assess the NRC's EP program and should not rule out the possibility of moving to a performance-based framework in the future. The Commission notes the potential benefit of a performance-based EP regimen for SMRs, and the staff should return to the Commission if it finds that conditions warrant rulemaking."

In 2015, the staff sought Commission approval to initiate rulemaking to revise EP regulations and guidance for SMRs, non-LWRs, and medical radioisotope facilities. In SECY-15-0077, "Options for Emergency Preparedness for Small Modular Reactors and Other New Technologies," dated May 29, 2015 (NRC, 2015a), the staff proposed a consequence-oriented approach to establishing requirements commensurate with the potential consequences to public health and safety and the common defense and security at SMR and other new technology facilities. The staff stated that the need for EP is based on the projected offsite dose in the unlikely occurrence of a severe accident. In SRM-SECY-15-0077, "Staff Requirements—SECY-15-0077—Options for Emergency Preparedness for Small Modular Reactors and Other New Technologies," dated August 4, 2015 (NRC, 2015b), the Commission directed the staff to proceed with the rulemaking.

In SECY-16-0069, "Rulemaking Plan on Emergency Preparedness for Small Modular Reactors and Other New Technologies," dated May 31, 2016 (NRC, 2016a), the staff provided a proposed rulemaking schedule, outlining the need to develop EP requirements for SMRs and other new technology facilities, commensurate with the potential consequences to public health and safety posed by these facilities. In SRM-SECY-16-0069, "Staff Requirements—SECY-16-0069—Rulemaking Plan on Emergency Preparedness for Small Modular Reactors and Other New Technologies," dated June 22, 2016 (NRC, 2016b), the Commission approved the staff's proposed rulemaking plan.

APPENDIX B
MAJOR ASSUMPTIONS AND INPUT DATA

Data Element	Best Estimate	Unit	Source or Basis of Estimate
Key Analysis Dates			
Final rule effective date	2021	year	NRC input
Analysis base year	2021	year	NRC input
Number of Entities			
Number of SMR and non-LWR reactors	12	units	NRC estimate informed by industry-supplied proprietary information
License term applicability period (years)			
New SMR or ONT license term	60	years	Assumption based on a 40-year OL and 20-year renewal
Labor Rates			
Industry engineer or plant supervisor	$126	Dollars per hour	The labor rates used are from the data set, "SOC Code: Standard Occupational Classification Code" (2020 values). These hourly rates were inflated to 2021 dollars using values of CPI-U. The NRC then applied a multiplier of 2.4, which included fringe and indirect management costs, resulting in the displayed labor rates.
Managers	$145	Dollars per hour	
Administrative staff	$78	Dollars per hour	
Licensing staff	$140	Dollars per hour	
NRC staff	$137	Dollars per hour	Calculated Value

Note: SMR = small modular reactor, non-LWR = non-light-water reactor, ONT = other new technology, NRC = U.S. Nuclear Regulatory Commission, OL = operating license, and CPI-U = consumer price index for all urban consumers.