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

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Abstract

The current emergency preparedness (EP) regulations and guidance do not consider the advances in designs and more recent safety research, particularly with respect to small modular reactors (SMRs) and other new technologies (ONTs). 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 SMRs and ONTs. The proposed rule and guidance could affect existing and future SMR and ONT applicants and licensees, such as non-light water reactors (non-LWRs) and non-power production or utilization facilities (NPUFs), and SMRs, non-LWRs, and NPUFs that would be licensed after the effective date of the final rule. These applicants and licensees would 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 draft regulatory analysis of the benefits and costs of the proposed rule requirements relative to the baseline case (i.e., the no action alternative) and the associated regulatory guidance document DG-1350, "Performance-Based Emergency Preparedness For Small Modular Reactors, Non-Light Water Reactors, and Non-Power Production Or Utilization Facilities."

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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	<i>Code of Federal Regulations</i>
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
ERO	emergency response organization
ESP	early site permit
FEMA	Federal Emergency Management Agency
FY	fiscal year
IPZ	ingestion pathway emergency planning zone
km	kilometer or 1,000 meters
LAR	license amendment request
LOE	level of effort
LWR	light-water reactor
MHTGR	modular high-temperature gas-cooled reactor (an advanced nuclear reactor concept)
Mo-99	molybdenum-99
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)
NPP	nuclear power plant
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
PAR	protective action recommendation
PERT	program evaluation and review technique
PIUS	process inherent ultimate safety (a Swedish design concept for a light-water reactor)
PRISM	power reactor innovative small module (a General Electric Hitachi Nuclear Energy International, LLC, reactor)
rem	roentgen equivalent man (the centimeter-gram-second system unit of equivalent dose, effective dose, and committed dose)
REP	radiological emergency preparedness

RG	regulatory guide
SECY	Secretary of the Commission
SMR	small modular reactor
SOC	standard occupational classification (code)
SRM	staff requirements memorandum

Executive Summary

The NRC is proposing to amend its regulations to introduce a new alternative EP regulatory framework for SMRs and ONTs. The new EP requirements would appear in a new section of the 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 proposed rule, 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 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.” In this proposed rule, the NRC is using the term “other new technologies” to refer to new technologies, such as non-LWRs and proposed medical radioisotope facilities that would be licensed under 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities.” This proposed rule would also define “non-power production or utilization facility” to clarify the applicability of the proposed performance-based EP framework. As used in this proposed rule, the term “non-power production or utilization facility” would be defined to have the same meaning as the definition used in the NRC’s proposed rule, “Non-Power Production or Utilization Facility License Renewal” (82 FR 15643). The definition of NPUF would include non-power reactors and other production or utilization facilities licensed under 10 CFR 50.21(a) or (c), or 10 CFR 50.22, that are not nuclear power reactors or fuel reprocessing plants. Proposed medical radioisotope facilities that would be licensed under 10 CFR Part 50 would also be included within this definition of NPUF.

This regulatory analysis discusses two alternatives – alternative 1, the no action or status quo and alternative 2, pursuant of the proposed rule. For alternative 2, the regulatory analysis analyzes the costs and benefits of the proposed rule requirements and development of the regulatory guidance document, DG-1350. It makes the following key findings:

- Proposed Rule Analysis. The proposed rule would be 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 \$4.72 million using a 7-percent discount rate to \$7.56 million using a 3-percent discount rate. Relative to the regulatory baseline, the NRC would realize a net averted cost of \$1.17 million using a 7-percent discount rate and \$2.16 million using a 3-percent discount rate. Table 1 shows the total costs and benefits to the industry and the NRC of proceeding with the proposed rule. The proposed rule alternative would result in net averted costs to the industry and the NRC ranging from \$5.89 million using a 7-percent discount rate to \$9.71 million using a 3-percent discount rate.

Table 1 Total Costs and Benefits for Alternative 2

Attribute	Costs		
	Undiscounted	7% NPV	3% NPV
Total Industry Costs:	(\$149,000)	(\$140,000)	(\$145,000)
Total NRC Costs:	(\$650,000)	(\$690,000)	(\$670,000)
Total Costs:	(\$800,000)	(\$830,000)	(\$820,000)
Attribute	Benefits		
	Undiscounted	7% NPV	3% NPV
Total Industry Benefits:	\$12,590,000	\$4,860,000	\$7,700,000
Total NRC Benefits:	\$4,507,000	\$1,860,000	\$2,833,000
Total Benefits:	\$17,097,000	\$6,720,000	\$10,533,000
Attribute	Net Benefits (Costs)		
	Undiscounted	7% NPV	3% NPV
Industry	\$12,441,000	\$4,720,000	\$7,555,000
NRC	\$3,857,000	\$1,170,000	\$2,163,000
Total	\$16,297,000	\$5,890,000	\$9,713,000

Note: NPV = net present value and it is expressed in 2020 dollars.

These costs result from the NRC's activities to complete the rulemaking.

According to Executive Order 12866 (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 proposed rulemaking does not reach this threshold.

- **Nonquantified Benefits.** Alternative 2 would 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 would provide greater regulatory predictability and efficiency to industry. In addition to regulatory efficiency, licensing SMRs and ONTs through rulemaking instead of through the exemption request process would increase public confidence in the NRC's ability to adapt to new technology and new regulatory needs and would maintain the NRC's role as an effective industry regulator.
- **Sensitivity Analysis.** The regulatory analysis looks at the possibility that some of the SMRs and ONTs from the eight that have informed the NRC of plans to submit a license application after the proposed rule goes into effect, may decide to cancel their applications. Additionally the regulatory analysis looks into the possibility that the remaining applications could be delayed a few years. The regulatory analysis concludes from the sensitivity analysis if nearly half of the initial SMRs and ONTs cancel their applications and the remaining ones are delayed by a decade, the proposed rule would still be cost beneficial, with averted costs ranging from \$2.23 million at a 7-percent discount rate to \$4.45 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 proposed rule is \$5.83 million with a greater than 90-percent confidence that the proposed rule is net beneficial using a 7-percent discount rate. A reasonable inference from the uncertainty analysis is that

proceeding with the proposed rule represents an efficient use of resources and would result in significant averted costs to the NRC and the industry.

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

1. Introduction

This document presents the regulatory analysis for the proposed rule to revise the EP requirements for SMRs and ONTs and develop the new regulatory guidance document DG-1350.

2. Statement of the Problem and Objective

The current EP regulations and guidance, initially developed for large light-water reactors (LWRs), do not consider the advances in designs and safety research and their application to existing and future operation of SMRs and ONTs. Through this proposed rulemaking, the NRC is proposing to amend its regulations to create an alternative EP framework for SMRs and ONTs. At this time, medical radioisotope facilities licensed as utilization or production facilities under 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” are included within the scope of this proposed rule. However, no such facilities are expected to submit license applications after 2020, when this proposed rule is expected to become final.

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 for SMRs and ONTs represents an important facet of the NRC’s plan to be ready to efficiently and effectively review potential licensing applications for SMRs and ONTs.

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-LWR technology. Advanced designs using non-LWR technology include liquid metal-cooled, gas-cooled reactors, and molten-salt-cooled reactors. These advanced designs range from small to very large 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 would result in lower impacts to public health and safety from any radiological emergency, as compared to large LWRs.

Historically, as 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 proposed 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 or 10 CFR 50.22. The proposed

rulemaking defines the term “small modular reactor” to clarify the applicability of EP requirements for these facilities. The definition of SMR would be based, in part, on the definition of SMR in 10 CFR 170.3, “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 (ESP), 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 50.33, 10 CFR 50.34, and 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 provide for the 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 preparedness. 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] 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 (PARs), 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 protective actions 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) for emergency planning. 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 path 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 ingestion pathway, 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 should 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 actions 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

Although NPUFs must meet the emergency planning requirements of 10 CFR 50.34(a)(10) and (b)(6)(v); 10 CFR 50.54(q); and 10 CFR Part 50, Appendix E, the requirements of 10 CFR 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 Regulatory Guide (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 megawatt 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/American Nuclear Society (ANSI/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 RTRs ranging from the operations boundary 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 credible 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-roentgen-equivalent-man (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, collocation of facilities, and multimodule designs.

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 determination of the appropriate

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 industry involve 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 proposed rule would 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, 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 (REP) is not required for specific facilities where the EPZs do not extend beyond the site boundary, FEMA findings and determinations regarding reasonable assurance under 10 CFR 50.54(s)(3) would likely not be needed. In such cases, even in the absence of NRC requirements for offsite radiological emergency planning, the NRC believes that 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 the 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., multireactor) 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 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 the public health and safety. In particular, the NRC's objective for this rulemaking is to create alternative EP requirements that would: (1) continue to provide reasonable assurance that an SMR or ONT licensee can and will implement adequate protective measures, (2) promote regulatory stability, predictability, and clarity, (3) reduce requests for exemptions from EP requirements, (4) recognize technology advancements embedded in design features, (5) credit safety enhancements in evolutionary and passive systems, and (6) credit smaller sized reactors' and non-LWRs' potential benefits associated with postulated accidents, including slower transient response times, and the 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 would use the existing regulatory framework supplemented by existing guidance on how to apply for exemptions from the EP regulations.
- (2) Alternative 2 would 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 nonrulemaking alternative. This alternative would retain the current EP provisions in 10 CFR Part 50. Certain existing EP requirements could impose regulatory burdens 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 likely request EP exemptions, this alternative would require a site-specific analysis by the applicant or licensee and a review by the NRC for each exemption request. The applicant's use of the exemption process would not likely result in efficiency gains or predictable regulatory outcomes because of the variations in SMR and ONT designs and submittals. Alternative 1 would not relieve the burden imposed on applicants, licensees, and the NRC resulting from the case-by-case exemption process to address EPZ size and emergency plans.

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

This alternative would provide EP regulations and guidance developed specifically for SMR and ONT facilities. In particular this alternative would develop the regulatory guidance document DG-1350 and establish a regulatory framework for determining the size of the plume exposure

pathway EPZ and ingestion response planning requirements for SMRs and ONTs. EP planning standards and requirements would be established commensurate with EPZ size determinations. The new framework would be performance-based, would be expected to result in fewer license amendments and exemption requests, and would provide 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, 2011a), 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 a size of EPZs based on the projected source term, which is a function of the specific reactor design being considered. The NRC is proposing a scalable method for determining EPZ size for these facilities, instead of the fixed 10-mile (16-km) and 50-mile (80-km) EPZs 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 would 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. The NRC would require applicants proposing site-specific EPZs to demonstrate in their application that the projected dose from a spectrum of credible accidents (design-basis accidents, 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. These applicants would also need to show a substantial reduction in risk to public health and safety at the chosen plume exposure pathway EPZ outer boundary for very severe accidents similar to the evaluation in NUREG-0396. After receiving site- and design-specific information from an SMR or ONT applicant, the NRC would then assess the accident scenarios being considered and could follow up with requests for additional information as currently in the status quo.

As part of this alternative, the NRC is reviewing the emergency plans for NPUFs intending to produce medical radioisotopes, such as molybdenum-99 (Mo-99), using the guidance in ANSI/ANS-15.16-2015 (ANSI, 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 Mo-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.

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 proposed 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

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 would apply to licensees and applicants for nuclear power plants (NPPs) and NPP design certifications. The NRC believes that NPP licensees would be the primary beneficiaries. The NRC developed an inventory of the impacted attributes using the list in NUREG/BR-0058, Revision 5, Chapter 5, “Details of a Cost-Benefit Analysis.”

The rule would affect four attributes:

- (1) Industry Operation. This attribute accounts for the projected net economic effect caused by routine and recurring activities required by the proposed alternative on all affected entities. For example, costs could include annual drills or other recurring tasks. 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 proposed alternative into operation. The NRC’s implementation of the proposed alternative would include the agency’s cost to develop and issue the rule and any RGs that support the rule.
- (3) NRC Operation. This attribute accounts for the projected net economic effect caused by routine and recurring activities required by the proposed alternative on the NRC after implementation of the proposed 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 would continue the best practice of regulation through rulemaking instead of exemption requests, where practical. This rulemaking would 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 would reduce the volume of EP LARs submitted for SMRs and ONTs and the complexity of EP plans resulting from the performance-based framework. Additionally, applicants and licensees would gain efficiencies in developing EP plans, and the NRC would gain efficiencies in reviewing these EP plans because of the improved stability, predictability, and clarity that would result from the proposed rule.

Attributes that are not expected to be affected under any of the alternatives include: public health (accident); 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.

4.2 Analytical Methodology

This section describes the process used to evaluate costs and benefits associated with the proposed 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 proposed alternatives. Where possible, the NRC calculated costs for these attributes using three-point estimates to quantify the uncertainty in these estimates. 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 proposed 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

There are a total of nine SMRs and ONTs that would be affected by the proposed rule. The names, companies, technologies, locations, and other identifying information for these SMRs and ONTs are not provided because this information is considered proprietary at this time. Currently it is expected that eight of these nine SMRs and ONTs will each be submitting a license application after the rule goes into effect in 2020. Based on current information, the NRC expects that eight SMR and ONT applications will be submitted between years 2020 and 2023. The regulatory analysis incorporated these eight applicants in the cost model and addressed the possibilities that some of the eight applicants may cancel their applications or be delayed. Additional SMR and ONT applications may follow after 2023, and if so, the regulatory analysis will be revised during the rulemaking to account for any additional applicants.

4.2.3 Base Year

All monetized costs are expressed in 2020 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 2020.

The NRC assumes that the agency will incur one-time implementation costs for the development of the rule and supporting guidance documents unless otherwise noted. Estimates are made for 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 2020 dollar values.

4.2.4 Discount Rates

In accordance with NUREG/BR-0058 (NRC, 2017c), NPV calculations are used to determine how much society would 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 (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.² 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 consistent with an opportunity cost³ of capital concept to reflect the time value of resources directed to meet regulatory requirements.

4.2.5 Cost/Benefit Inflatoms

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 (CPI-U) developed by the U.S. Department of Labor, Bureau of Labor Statistics (BLS). Using the CPI-U, the prior-year dollars are converted to 2020 dollars. The formula to determine the amount in 2020 dollars is as follows:

$$\frac{CPI - U_{2020}}{CPI - U_{Base Year}} \times Value_{Base Year} = Value_{2020}$$

² 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.

³ “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.

Table 2 summarizes the values of CPI-U used in this regulatory analysis.

Table 2 CPI-U Inflator

Base Year	CPI-U Annual Average^a	Forecast Percent Change from Previous Year^b
2017	245.120	
2018	251.003	2.40%
2019	257.027	2.40%
2020	263.196	2.40%

Sources:

- ^a BLS Statistics, "Archived Consumer Price Index Supplement Files: April 2018 Historical CPI-U, Table 24, Historical Consumer Price Index for All Urban Consumers (CPI-U): U.S. City Average, All Items," (BLS, 2018).
^b Congressional Budget Office, "The Budget and Economic Outlook: 2017 to 2027," issued January 2017 (Congressional Budget Office, 2017).

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 proposed 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 \$131 per hour for fiscal year (FY) 2018,⁴ which this analysis has inflated to \$134 per hour for FY 2020 using an inflator of 2.40%.

The regulatory analysis used data from the BLS, "SOC Code: Standard Occupational Classification Code," (BLS, 2017), which provides labor categories and the mean hourly wage rate by job type, and used the inflator discussed above to inflate these labor rate data to 2020 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 regular 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 proposed 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 3 summarizes the BLS labor categories that were used to estimate industry labor costs to implement this proposed rule, and Appendix B lists the industry labor rates used in the analysis. This analysis assumes industry personnel, not contractors, will perform the modeled activities. The NRC performed an uncertainty analysis, which is discussed in Section 5.9. Appendix B to this regulatory analysis provides labor rates and other supporting input data.

⁴ 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).

Table 3 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 Statistics, "SOC Code: Standard Occupational Classification Code," issued January 2017.

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 the average operating lifetime for nine of the SMR and ONT reactors is 40 years. The operating costs of each reactor is estimated individually based on the anticipated first year of operation. The NRC expects eight of the nine SMR and ONT reactors to submit an application in the 2020–2023 period, with 2 applications in 2020, four applications in 2021, one application in 2022 and one application assumed in 2023.

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 (LOE) for each required activity and used a blended labor rate to develop bottom-up cost estimates.

The NRC gathered data from several sources and consulted working group members to develop LOE 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 proposed 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 LOE 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. A total of nine SMRs and ONTs were accounted for in the cost estimate.

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 proposed alternative. The NRC used data 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 proposed regulatory framework alternatives in the proposed rule were obtained from the NRC and from comments on the regulatory analyses provided with the proposed rule. The NRC considered the potential differences between the new requirements and the current requirements and incorporated the proposed 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 proposed 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”⁵ 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.⁶ 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 NRC is pursuing a rulemaking because it would establish a comprehensive regulatory framework that would result in enhanced regulatory stability, predictability, and clarity in the licensing process, and an opportunity for stakeholder input on the regulatory framework. This is also in keeping with the implementation of the Commission’s direction in Staff Requirements Memorandum

⁵ An “ex ante cost-benefit analysis” is prepared before the implementation of a policy, program, or alternative and can assist in the decision about whether resources should be allocated to that alternative.

⁶ The NRC considered the incremental impact of the proposed rule for other entities, including Tribal, State, and local government organizations, but it does not expect such entities to be affected.

(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, 2015c), 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 would 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 costs to the NRC for rulemaking and the development of associated guidance documents

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, maintenance of the siren stations, and various EP activities that affect protective actions outside the site boundary.

The benefits and costs described in this regulatory analysis are subject to further refinement and input from stakeholders. The NRC expects that public comment and feedback on the proposed rule and related guidance would allow it to further refine these analyses.

5.1. Industry Operation

Alternative 2 would 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 would have been otherwise required for the current EP regulations. 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 4 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 would 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 \$127 per hour. Appendix B to this document provides a detailed table showing all the input costs that the NRC used for this analysis. While there are nine SMRs and ONTs used in this analysis, three of them have characteristics that would allow them to be evaluated on a case-by-case basis under current regulations (without need for exemption requests) and one has already submitted an exemption request as part of its initial application process. Therefore, only five exemption requests are averted by the proposed rule in the cost estimate of this regulatory analysis.

Table 4 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
2020	Exemption Requests for SMRs and NLWRs	1	1,483	\$127	\$189,000	\$189,000	\$189,000
2021	Exemption Requests for SMRs and NLWRs	2	1,483	\$127	\$377,000	\$352,000	\$366,000
2022	Exemption Requests for SMRs and NLWRs	1	1,483	\$127	\$189,000	\$165,000	\$178,000
2023	Exemption Requests for SMRs and NLWRs	1	1,483	\$127	\$189,000	\$154,000	\$173,000
Total:					\$944,000	\$860,000	\$906,000

Note: Values are in base year 2020 dollars, rounded to the nearest \$1,000.

The proposed rule would change the EP framework to a more performance-based framework, which would 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 of these lessons being learned, time would be saved by existing and future applicants on preparing their license applications. The current framework results in approximately 500 pages of an emergency plan submitted within each license application. The NRC estimates that industry personnel would take approximately 3,019 hours of 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 subsequent application submissions the NRC expects an efficiency gain of approximately 5 percent per industry submission resulting from the lessons learned related to the new performance-based framework. The NRC expects the first two SMR or ONT applicants (proprietary information) to work through the license application process in 2020, with four more applicants in 2021, another one in 2022, and the last one in 2023. The NRC also assumed for this analysis that none of these eight SMRs or ONTs will be co-located near any existing NPP.

Table 5 below 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 5 Unit Time 95% Learning Curve for Industry Development of EP plan

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, eight SMRs and ONTs will result in averted costs as shown in Table 6. Only eight of the nine SMRs and ONTs are included because one has already submitted its EP plans to the NRC.

Table 6 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
2020	EP Plans Submitted	2	5,736	302	\$127	\$38,000	\$38,000	\$38,000
2021	EP Plans Submitted	4	10,576	1,499	\$127	\$191,000	\$179,000	\$185,000
2022	EP Plans Submitted	1	2,614	405	\$127	\$51,000	\$45,000	\$48,000
2023	EP Plans Submitted	1	2,588	431	\$127	\$55,000	\$45,000	\$50,000
Total:						\$335,000	\$307,000	\$321,000

Furthermore, licensees will submit fewer LARs for EP over the reactor lifetime because the performance-based framework of the proposed rule will result in less prescriptive requirements for personnel, equipment lists, and other currently existing EP requirements. While operating power reactor licensees are not included within the scope of the proposed rule, the NRC reviewed operating EP LARs submitted between 2014 and 2017 to inform the potential averted costs associated with LARs for SMRs and ONTs. The NRC estimated that the number of LARs ranges from 18 to 32 LARs per year for all operating sites, with an average of 25. The NRC used this LAR rate, calculated based on the LAR rate for 60 operating power reactors sites, in this regulatory analysis as analogous data in order to estimate the future number of LARs per SMR or ONT per year if the NRC did not issue the proposed rule and assumed that a licensee expends approximately 593 labor hours per LAR. Table 7 shows the resulting estimated averted costs to industry using this method, for all nine SMRs and ONTs.

Table 7 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
2020-2079	Reduction in LAR work	2	0.42	593	\$127	\$2,514,000	\$838,000	\$1,453,000
2021-2080	Reduction in LAR work	5	0.42	593	\$127	\$6,284,000	\$2,094,000	\$3,631,000
2022-2081	Reduction in LAR work	1	0.42	593	\$127	\$1,257,000	\$391,589	\$704,854
2023-2082	Reduction in LAR work	1	0.42	593	\$127	\$1,257,000	\$365,971	\$684,325
Total:						\$11,312,000	\$3,689,560	\$6,473,179

Under current regulations, the default plume exposure pathway EPZ size is about 10 miles (16 km). However, for SMRs and ONTs with potentially smaller source terms and with passive design features, the NRC is proposing to amend the regulations to adopt a scalable plume exposure pathway EPZ size approach without the need for exemption requests or the case-by-case approach in 10 CFR 50.47(c)(2). 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 nuclear hazard posed by the NRC-licensed facility. 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.

In other cases, the plume exposure pathway EPZ could be determined to be outside of the site boundary, but with a radius of less than ten miles. In such cases, the applicant or licensee would be 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 plume exposure pathway EPZ offsite emergency plan, for example, would be different from the costs of establishing the current 10-mile plume exposure pathway EPZ offsite emergency plan. This averted cost would depend on factors, including 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 could result in an incremental averted cost to applicants and licensees when compared to the regulatory baseline; however, both Alternative 1 and Alternative 2 would 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 and Alternative 2 is not significant.

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 \$4.86 million (7-percent NPV) to \$7.70 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:	\$12,590,000	\$4,860,000	\$7,700,000
Total Industry Cost:	\$12,590,000	\$4,860,000	\$7,700,000

Note: Values are in 2020 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 a final rulemaking stage would result in incremental costs to the NRC. After publishing the proposed rule, the NRC would incur costs associated with public comment resolution, preparation of the final rule, finalizing the regulatory guidance document, and preparing other supporting documentations for the rulemaking (e.g. the *Federal Register* notice). The NRC has committed a significant number of technical staff to develop the rulemaking and related guidance over a 4-year period; however, at the proposed rule stage, these costs are sunk, and the remaining costs are due to development and issuance of the final rule. Table 9 estimates the costs for each action at a labor rate of \$134 per hour.

Table 9 NRC Implementation: Rulemaking Costs

Year	Activity	Number of Actions	Hours	Weighted Hourly Rate	Cost		
					Undiscounted	7% NPV	3% NPV
2019	Finalize Reg Guide for Final Rule	1	805	\$134	(\$108,000)	(\$116,000)	(\$111,000)
2019	Develop/Issue Final Rule	1	4,025	\$134	(\$539,000)	(\$577,000)	(\$555,000)
Total:					(\$650,000)	(\$690,000)	(\$670,000)

Note: Values are in 2020 dollars, rounded to the nearest \$1,000.

5.4. NRC Operation

The NRC will receive averted costs (benefit) from the expected five 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 10 shows these averted costs, assuming 713 hours of effort for each request and a labor rate of \$134 per hour.

Table 10 NRC Operation: Averted Costs for NRC Exemption Request Reviews

Year	Activity	Number of Requests	Hours	Weighted Hourly Rate	Cost		
					Undiscounted	7% NPV	3% NPV
2020	Review exemption requests	1	713	\$134	\$96,000	\$96,000	\$96,000
2021	Review exemption requests	2	713	\$134	\$191,000	\$179,000	\$185,000
2022	Review exemption requests	1	713	\$134	\$96,000	\$84,000	\$90,000
2023	Review exemption requests	1	713	\$134	\$96,000	\$78,000	\$88,000
Total:					\$479,000	\$437,000	\$459,000

In addition, the NRC will benefit from the performance-based framework of the proposed rule as described above in the industry operation section. This regulatory analysis assumes 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 11 below 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 11 Unit Time 95% 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 will avert costs, ranging from \$161,000 (7-percent NPV) to \$169,000 (3-percent NPV), as shown in Table 12, as a result of lessons learned from processing these SMR and ONT EP submissions.

Table 12 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
2020	Review EP plans	2	2,868	151	\$134	\$20,000	\$20,000	\$20,000
2021	Review EP plans	4	5,288	750	\$134	\$100,000	\$93,000	\$97,000
2022	Review EP plans	1	1,307	202	\$134	\$27,000	\$24,000	\$25,000
2023	Review EP plans	1	1,294	215	\$134	\$29,000	\$24,000	\$27,000
Total:						\$176,000	\$161,000	\$169,000

As shown in Table 13, the NRC will also have averted costs resulting from the reduced LAR submissions.

Table 13 Averted Costs for Reduced EP LARs

Year	Activity	Number of Entities	Hours	LARs per year	Weighted Hourly Rate	Cost		
						Undiscounted	7% NPV	3% NPV
2020-2079	Review EP LARs	2	192	0.42	\$134	\$856,000	\$285,000	\$495,000
2021-2080	Review EP LARs	5	192	0.42	\$134	\$2,140,000	\$713,000	\$1,237,000
2022-2081	Review EP LARs	1	192	0.42	\$134	\$428,000	\$133,645	\$239,806
2023-2082	Review EP LARs	1	192	0.42	\$134	\$428,000	\$124,902	\$232,821
Total:						\$3,852,000	\$1,257,000	\$2,205,000

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 \$1.17 million (7-percent NPV) to \$2.16 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:	(\$650,000)	(\$690,000)	(\$670,000)
Total NRC Operation Cost:	\$4,510,000	\$1,860,000	\$2,830,000
Total NRC Cost:	\$3,860,000	\$1,170,000	\$2,160,000

Note: Values are in base year 2020 dollars, rounded to the nearest \$1,000.

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 incremental costs for this rulemaking action (Alternative 2) by the NRC. 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 Costs		
	Undiscounted	7% NPV	3% NPV
Industry Implementation	(\$149,000)	(\$140,000)	(\$145,000)
Industry Operation	\$12,590,000	\$4,860,000	\$7,700,000
Total Industry Cost	\$12,441,000	\$4,720,000	\$7,555,000
NRC Implementation	(\$650,000)	(\$690,000)	(\$670,000)
NRC Operation	\$4,510,000	\$1,860,000	\$2,830,000
Total NRC Cost	\$3,860,000	\$1,170,000	\$2,160,000
Net	\$16,301,000	\$5,890,000	\$9,715,000

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 \$5.89 million (7-percent NPV) to \$9.72 million (3-percent NPV). The rulemaking alternative (Alternative 2) would apply to any existing and future SMR and ONT applicants and licensees and would 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 would exceed the costs of the rulemaking process.

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 for SMRs and ONTs

The regulatory analysis looks at the possibility that some of the SMRs and ONTs, from the eight that have plans to submit applications after the proposed rule goes into effect, may decide not to begin the application process. Additionally the regulatory analysis looks into the possibility that the remaining applications could be delayed a few years.

One scenario analyzed has four SMRs and ONTs deciding not to begin the application process while the remaining four that do submit an application would have their applications delayed by ten years. The total net averted cost for this scenario was found to be \$2.23 million at a 7-percent discount rate and \$4.45 million at a 3-percent discount rate. In comparison to the 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 \$5.89 million at a 7-percent discount rate and \$9.71 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 applications and the remaining ones are delayed by a decade, the proposed rule would still be cost beneficial.

5.9. Uncertainty Analysis

The NRC completed a Monte Carlo uncertainty analysis for this regulatory analysis using the specialty software @Risk. 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. To perform this analysis, the NRC used a Monte Carlo simulation analysis using the @Risk software program.⁷

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’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 the (1) minimum, most likely, and maximum values of a program evaluation and review technique (PERT) distribution,⁸ (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 that were used in the uncertainty analysis.

⁷ Information about the @Risk software is available at <http://www.palisade.com>.

⁸ 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
<u>SMRs and ONTs</u>					
Number of SMRs/ONTs	9	DISCRETE	5	9	9
Number of delayed years of submission of application	0	GEOMETRIC	0	0	10
<u>Industry Submittals of Exemption Requests</u>					
Hourly rate	\$127	PERT	\$101	\$127	\$152
Hours to generate and submit	1,483	PERT	1,250	1,500	1,650
<u>Reduced EP Plan Complexity (Industry)</u>					
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%
<u>Averted LAR for EP (Industry)</u>					
Hours to generate and submit a LAR	593	PERT	280	580	960
Current EP LARs per year	25	PERT	18	25	32
Historical number of sites	60	PERT	60	60	60
Average number of LARs per site-year	0.42	PERT	0.3	0.42	0.53
SMR reactor life	40	PERT	20	40	60
<u>Averted LAR for EP (Industry)</u>					
Hours to approve a LAR	192	PERT	100	200	250
<u>Reduced EP Plan Complexity (NRC)</u>					
Hours to review EP-related submissions	1,509	PERT	1,181	1,313	2,625
Efficiency factor for learning	5%	PERT	0%	5%	10%
<u>Review Exemption Requests (NRC)</u>					
Hourly rate	\$134	PERT	\$133	\$134	\$135
Hours to review	713	PERT	620	710	820
<u>Final Rule Stage</u>					
<u>Finalize/Issue Regulatory Guide (NRC)</u>					
Hourly rate	\$134	PERT	\$133	\$134	\$135
Hours to finalize	805	PERT	630	700	1400
Number of years	1	PERT	1	1	1
<u>Develop/Issue Final Rule (NRC)</u>					
Hourly rate	\$134	PERT	\$133	\$134	\$135
Hours to finalize	4,025	PERT	3,150	3,500	7,000
Number of years	1	PERT	1	1	1

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 addresses the possibility that some of the eight applicants may cancel or delay their EP submissions. Nevertheless the analysis shows that the proposed rule would be cost beneficial.

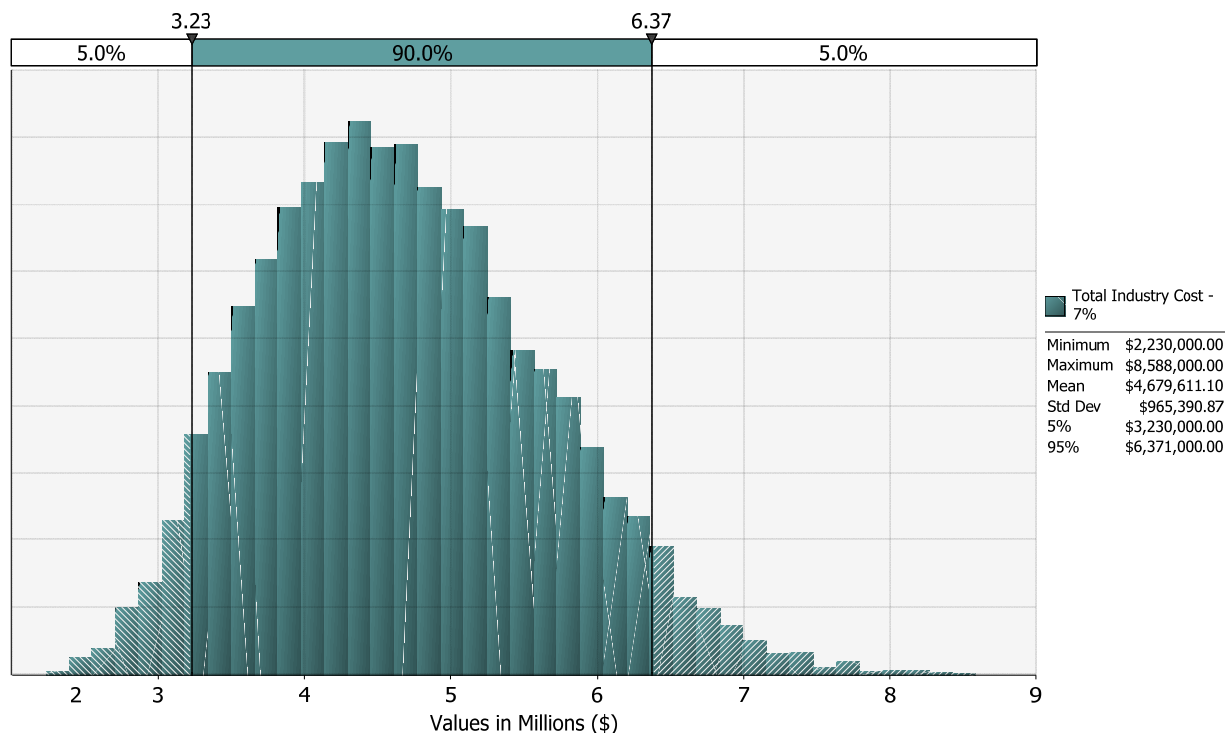


Figure 1 Total industry costs (7-percent NPV)—Alternative 2

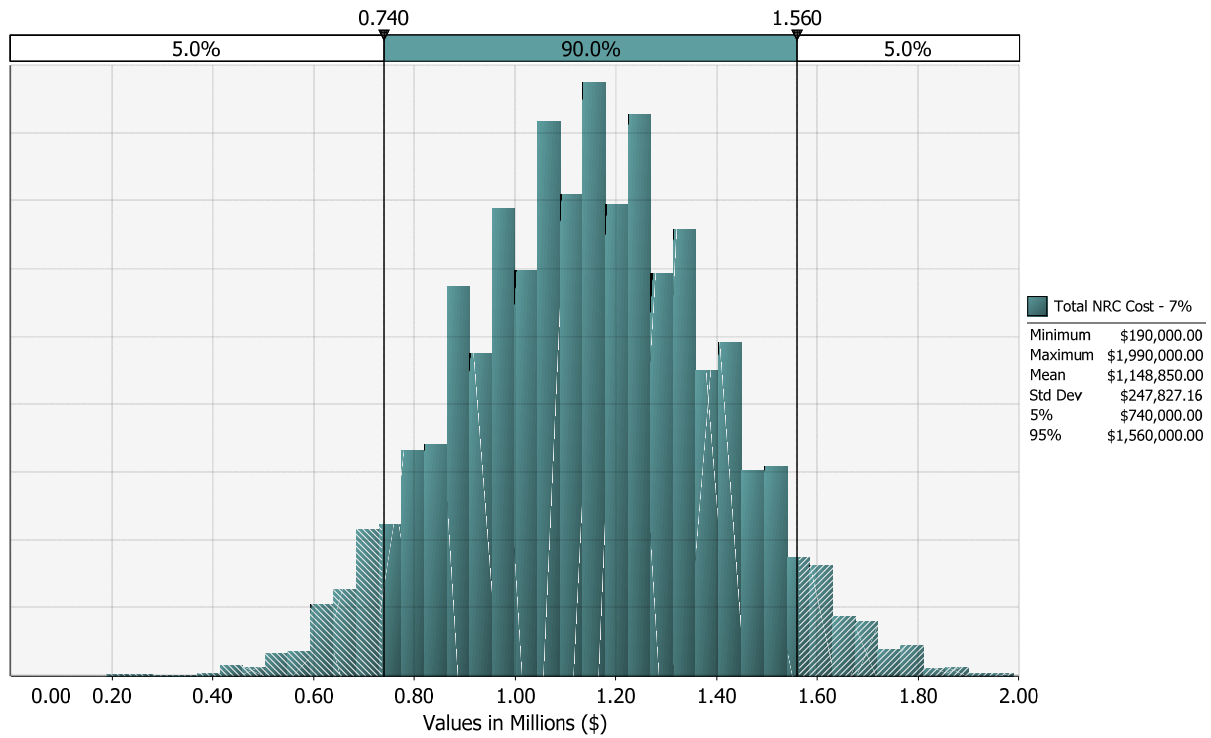


Figure 2 Total NRC costs (7-percent NPV)—Alternative 2

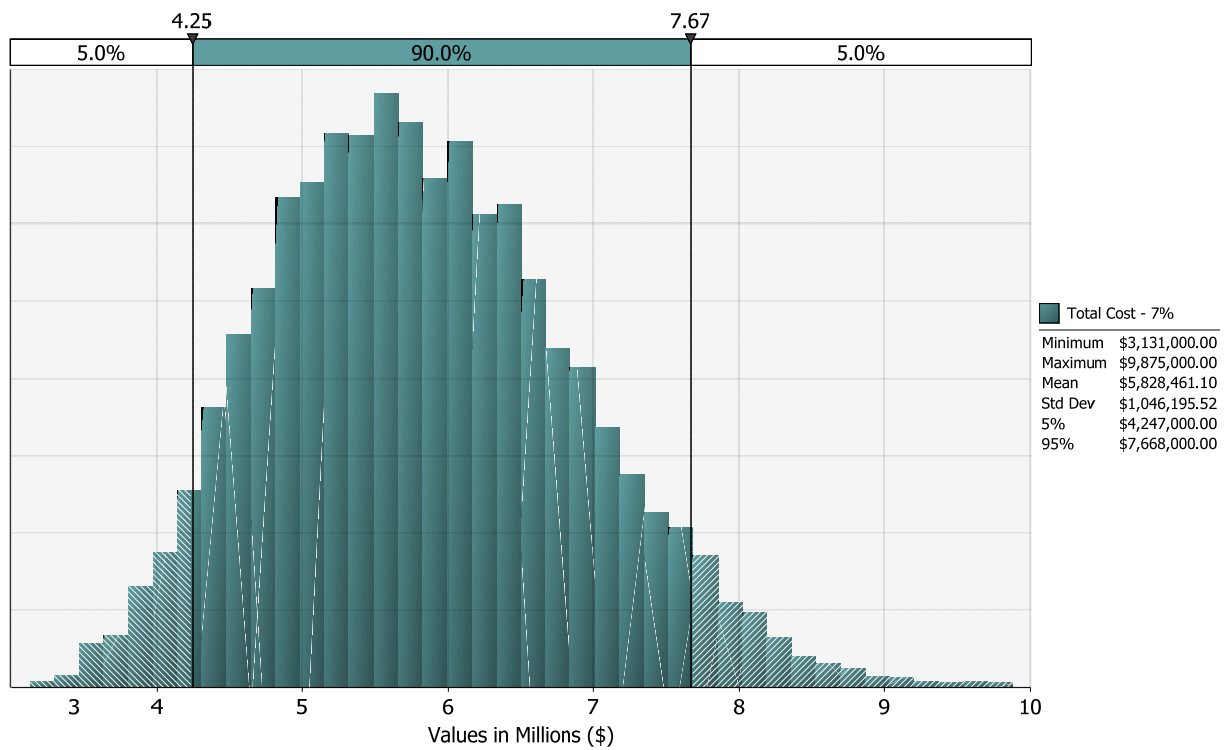


Figure 3 Total costs (7-percent NPV)—Alternative 2

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	\$2.23	\$4.68	\$0.97	\$8.59	\$3.23	\$6.37
Total NRC Cost	\$0.19	\$1.15	\$0.25	\$1.99	\$0.74	\$1.56
Total Cost	\$3.13	\$5.83	\$1.05	\$9.88	\$4.25	\$7.67

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 more confidently discuss the potential incremental costs and benefits of the regulatory basis. Table 15 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 have the largest impact on total costs (and averted costs) for this proposed rule. Figure 4 ranks the variables based on their contribution to cost uncertainty. Three variables—(1) cancellations of SMR or ONT applications, (2) the hours for a licensee to develop an LAR, and (3) the number of LARs per site-year—drive the most uncertainty in the costs. The remaining key variables show diminishing variation.

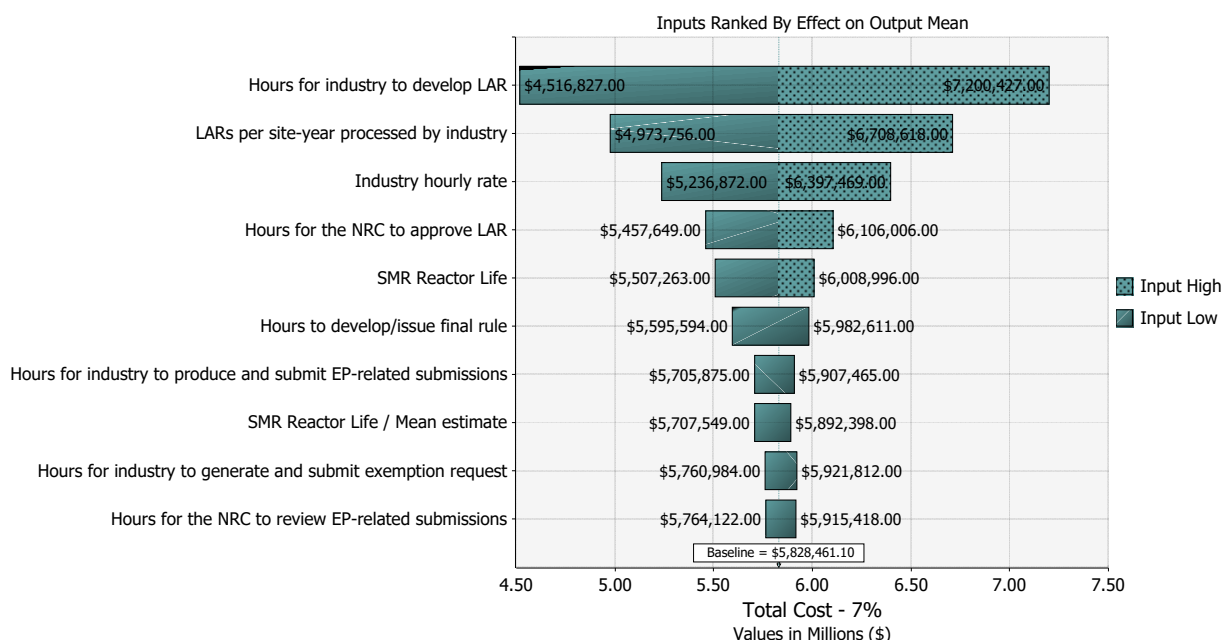


Figure 4 Tornado Diagram—Total Averted Costs—7-Percent NPV

The averted costs for industry and the NRC for this proposed rule has a mean value of \$5.83 million at a 7-percent discount rate. The uncertainty analysis shows a greater than

90-percent chance that the rulemaking would be 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 proposed 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 operating license for an NPUF 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 safety analysis report (PSAR) or final safety analysis report (FSAR). This regulatory framework includes technical and policy infrastructures that do not consider SMRs and ONTs reactor core sizes, lower power densities, lower probability of severe accidents, slower accident progression, and smaller accident offsite consequences due to advanced reactor designs. Hence a performance-based framework for SMRs and ONTs is being proposed that could allow for more regulatory flexibility, provide a basis for appropriate EP through 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 proposed performance-based framework, inspection and enforcement program, and design-specific review process would still provide reasonable assurance that protective actions can and will be taken in the event of an emergency at an SMR or ONT facility.

The review process changes in the proposed rule will result in averted exemption request costs to the NRC and Industry, estimated to range from \$1.30 million at a 7-percent discount rate to \$1.37 million at a 3-percent discount rate. The inspection and enforcement program changes in the proposed rule will result in averted LAR costs to the NRC and Industry, estimated to range from \$4.95 million at a 7-percent discount rate to \$8.68 million at a 3-percent discount rate. The performance-based framework in the proposed rule will result in simplified EP plan benefits to the NRC and Industry, estimated to range from \$468,000 at a 7-percent discount rate to \$490,000 at a 3-percent discount rate.

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

5.11. Summary

This regulatory analysis identified both quantifiable and nonquantifiable costs and benefits that would result from conducting 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 affected entities' OLS range from approximately \$5.89 million (7-percent NPV) to \$9.71 million (3-percent NPV). The sensitivity analysis showed that even if half of the eight expected SMR and ONT applications do not occur and the remaining are delayed by 10 years, the proposed rule results in averted costs ranging from approximately \$2.23 million (7-percent NPV) to \$4.45 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 would 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 would establish a performance-based, comprehensive regulatory framework that would result in enhanced regulatory stability, predictability, and clarity in the licensing process by reducing reliance on exemption requests. As a result 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 proposed 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 proposed rulemaking framework (1) recognizes technology advancements embedded in SMR and ONT design features, (2) credits the SMR and ONT safety enhancements existing in evolutionary and passive systems, and (3) appropriately considers SMR and ONT response to 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 would provide the widest range of viewpoints for Commission consideration in the development of the final rule.

5.12. Safety Goal Evaluation

The proposed rule alternative would 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'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 NRC does not regard this proposed rule for SMRs and ONTs to be backfitting or to represent an inconsistency with any issue finality provisions in 10 CFR Part 52 because the proposed rule would not be imposed upon applicants and licensees and would 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 charter (NRC, 2011b) is presented in this regulatory analysis or in the *Federal Register* notice for the proposed 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 Charter Citation (NRC, 2011b)	Information Item for Inclusion in a Regulatory Analysis Prepared for CRGR Review	Where the Item Is Discussed
Appendix C, (i)	The new or revised generic requirement or the staff's position as it is proposed to be sent out to licensees or issued for public comment	Proposed rule text in <i>Federal Register</i> notice for the proposed rule
Appendix C, (ii)	Draft papers or other documents supporting the requirements or staff positions	<i>Federal Register</i> notice for the proposed rule
Appendix C, (iii)	The sponsoring office's position on each proposed requirement or the staff's position as to whether the proposal would modify, implement, or relax or reduce existing requirements or staff positions.	Regulatory Analysis, Section 5, and Backfitting and Issue Finality, Section XIII, <i>Federal Register</i> notice for the proposed rule
Appendix C, (iv)	The proposed method of implementation	Regulatory Analysis, Section 7
Appendix C, (vi)	Identification of the category of power reactors, new reactors, or nuclear materials facilities or activities to which the proposed generic requirement or staff position applies	Regulatory Analysis, Section 4.2.2
Appendix C, (vii)–(viii)	If the proposed action involves a power reactor backfit and the exceptions in 10 CFR 50.109(a)(4) do not apply, include the items required in 10 CFR 50.109(c) and the required rationale in 10 CFR 50.109(a)(3).	Backfitting and Issue Finality, Section XIII, <i>Federal Register</i> notice for the proposed rule
III	For proposed generic relaxations or decreases in current requirements or the staff's positions, provide a determination, along with the rationale, that (1) the public health and safety and the common defense and security would be adequately protected if the proposed relaxations were implemented and (2) the cost savings attributed to each action would be significant enough to justify the action.	<i>Federal Register</i> notice for the proposed rule

CRGR Charter Citation (NRC, 2011b)	Information Item for Inclusion in a Regulatory Analysis Prepared for CRGR Review	Where the Item Is Discussed
Appendix C, (xi)	Preparation of an assessment on how the proposed action relates to the Commission's Safety Goal Policy Statement.	Regulatory Analysis, Section 5.16

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: \$4.72 million using a 7% discount rate \$7.56 million using a 3% discount rate NRC: \$1.17 million using a 7% discount rate \$2.16 million using a 3% discount rate Net Benefit (Cost): \$5.89 million using a 7% discount rate \$9.72 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 would 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, 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.

Industry and the NRC would benefit from the proposed rulemaking Alternative 2 primarily because of the averted costs from applicants and licensees submitting fewer EP exemption requests and LARs. As a result, there would be additional averted costs from the NRC reviewing and processing these fewer EP exemption requests and LARs. Additionally, efficiencies would 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 would result in a net benefit (averted cost) to

industry that ranges from \$4.72 million (7-percent NPV) to \$7.56 million (3-percent NPV). The NRC's net averted costs range from \$1.17 million (7-percent NPV) to \$2.16 million (3-percent NPV). Thus, the total quantitative net averted costs of the rulemaking would range from \$5.89 million (7-percent discount rate) to \$9.72 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 proposed rule regulatory action would exceed the costs of the proposed 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 proposed rule outweigh the identified quantitative and qualitative impacts attributable to the proposed rule.

7. Implementation Schedule

The NRC assumes that the final rule would become effective 30 days after its publication in the *Federal Register* in 2020.

8. References

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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,”⁹ dated April 8, 1993 (NRC, 1993), the U.S. Nuclear Regulatory Commission (NRC) staff suggested that the existing regulations governing 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 LWR 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 onshift emergency response organization’s (ERO’s) performance of many competencies necessary for emergency response, and (4) the augmented EROs’ performance of the emergency response competencies specific to the emergency response facility.

Following public meetings with industry and stakeholders and a review of other 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, 2011a). 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, dose-based, consequence-oriented EP framework for SMR sites that would take into account the various designs, modularity, and collocation 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.”

⁹ “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.

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 committed to a performance-based oversight regimen to simplify EP regulations. However, at that time, the staff recommended that the existing framework continue to be used 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 ONT 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, 2015c), 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 ONTs 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	2020	year	NRC input
Analysis base year	2020	year	NRC input
Number of Entities			
Number of SMR and non-LWR reactors	9	units	Assumption NRC, proprietary information from industry
License term applicability period (years)			
New SMR or ONT license term	40	years	Assumption based on a 40-year OL
Labor Rates			
Industry engineer or plant supervisor	\$132	Dollars per hour	The labor rates used are from the, "SOC Code: Standard Occupational Classification Code," data set (2017 values). These hourly rates were inflated to 2020 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	\$152	Dollars per hour	
Administrative staff	\$82	Dollars per hour	
Licensing staff	\$148	Dollars per hour	
NRC staff	\$134	Dollars per hour	"NRC Labor Rates for Use in Regulatory Analyses" (2018), inflated to 2020

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

SUBJECT: REGULATORY ANALYSIS FOR THE PROPOSED RULE: EMERGENCY
PREPAREDNESS FOR SMALL MODULAR REACTORS AND OTHER NEW
TECHNOLOGIES (RIN 3150-AJ68) DATED:

ADAMS Accession Nos.: PKG: ML18134A086; SECY: ML18134A077

*concurred via e-mail

OFFICE	NMSS/DRM/RASB*	QTE*	NMSS/DRM/RASB/RAT*	NMSS/DRM/RASB/BC*	NMSS/DRM/RRPB/BC*
NAME	CHowell	KAzariah-Kribbs	FSchofer	CBladey	MKhanna
DATE	5/10/18	5/8/18	5/29/18	5/31/18	6/11/18
OFFICE	NMSS/DRM/D*	NRR/D*	RES/D*	NSIR/D*	OGC*
NAME	PHolahan	BHolian (LDudes for)	RFurstenau	BMcDermott (JLubinski for)	HBenowitz
DATE	6/21/18	7/27/18	7/23/18	7/26/18	9/13/18
OFFICE	NRO/D				
NAME	FBrown (V.Ordaz for)				
DATE	9/17/18				

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