APPENDIX I
NATIONAL ENVIRONMENTAL POLICY ACT
COST-BENEFIT ANALYSIS GUIDANCE

Enclosure 4

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ABBREVIATIONS AND ACRONYMS

ADAMS	Agencywide Documents Access and Management System
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
COL	combined license
CP	construction permit
EA	environmental assessment
EIS	environmental impact statement
EO	Executive Order
EPRI	Electric Power Research Institute
ER	environmental report
ESRP	environmental standard review plan
FONSI	finding of no significant impact
FR	*Federal Register*
FSAR	final safety analysis report
IPE	individual plant examination
LWR	light water reactor
NEI	Nuclear Energy Institute
NEPA	National Environmental Policy Act of 1969
NMSS	Office of Nuclear Material Safety and Safeguards
NRC	U.S. Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
NUREG	NRC technical report designation
NUREG/BR	NUREG brochure
OL	operating license
PRA	probabilistic risk assessment
RG	regulatory guide
SAMA	severe accident mitigation alternative
SAMDA	severe accident mitigation design alternative
SECY	Office of the Secretary of the Commission, NRC Commission paper
SER	safety evaluation report
SOARCA	State-of-the-Art Reactor Consequence Analyses
SMR	small modular reactor
U.S.C.	United States Code

NATIONAL ENVIRONMENTAL POLICY ACT
COST-BENEFIT ANALYSIS GUIDANCE

I.1 PURPOSE

This appendix describes the methods used by the U.S. Nuclear Regulatory Commission (NRC) when conducting cost-benefit analyses to satisfy the requirements of the National Environmental Policy Act of 1969, as amended (NEPA) (42 U.S.C. 4332 et seq.) during rulemaking or licensing reviews. The purpose of NEPA is to ensure that each Federal agency considers, along with other factors, the impacts of its actions on the environment and the health and welfare of the public. In implementing NEPA, Federal agencies must evaluate the environmental effects of their actions before they make decisions and prepare a detailed statement for major Federal actions that significantly affect the quality of the human environment.

Title 10 of the *Code of Federal Regulations* (10 CFR) Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," contains the NRC's regulations for implementing NEPA. The NEPA requires Federal agencies to conduct a detailed assessment of the environmental effects of a proposed action, alternatives to the action, and irreversible commitments of resources involved with the action. A comparative evaluation of the proposed action and alternatives includes the identification, characterization, and analysis of both monetized (i.e., those measured in dollars) and qualitative (i.e., descriptive or nonmonetized) costs and benefits of environmental effects.

A cost-benefit analysis is one component of the NRC's analytical requirements under NEPA. Under 10 CFR 51.71, "Draft environmental impact statement—contents," and 10 CFR 51.75, "Draft environmental impact statement—construction permit, early site permit, or combined license," the NRC's regulations require the staff to consider and weigh the environmental, technical, and other costs and benefits of a proposed action and alternatives, and, "to the fullest extent practicable, quantify the various factors considered" (10 CFR 51.45(c)).[1] The Commission has found that if important factors cannot be quantified, they may be discussed qualitatively (*Louisiana Energy Services* (Claiborne Enrichment Center), CLI-98-3, 47 NRC 77 (1998)).

At the license renewal stage for a nuclear power plant under 10 CFR 51.95(c), a discussion of the economic or technical costs and benefits of either the proposed action or alternatives is not required unless costs and benefits are either (1) essential for determining whether to include an alternative in the range of alternatives considered or (2) relevant to mitigation of severe accidents.[2]

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[1] The NRC fulfills its NEPA analytical requirements by preparing draft and final EIS as required by 10 CFR 51.20, citing to the appropriate categorical exclusion established by 10 CFR 51.22, or performing an environmental assessment that ultimately concludes with a finding of no significant impact.

[2] According to Table B-1, "Summary of Findings on NEPA Issues for License Renewal of Nuclear Power Plants," in Appendix B to Subpart A, "Environmental Effect of Renewing the Operating License of a Nuclear Power Plant," of 10 CFR Part 51, severe accident mitigation alternatives (SAMAs) must be considered for all plants that have not previously considered such alternatives.

I.2 COST-BENEFIT ANALYSIS FOR NATIONAL ENVIRONMENTAL POLICY ACT REVIEWS

This section describes the process for conducting cost-benefit analyses in support of NEPA reviews for NRC licensing actions. Section I.4 presents the methods used for conducting cost-benefit analyses in evaluations of severe accident mitigation alternatives (SAMAs) and severe accident mitigation design alternatives (SAMDAs).

I.2.1 Regulatory Requirements

The regulations at 10 CFR Part 51 provide the NRC's requirements for implementing NEPA. The regulations at 10 CFR 51.20, "Criteria for and identification of licensing and regulatory actions requiring environmental impact statements," list the actions that require an environmental impact statement (EIS). Similarly, 10 CFR 51.21, "Criteria for and identification of licensing and regulatory actions requiring environmental assessments," lists the actions that require an environmental assessment (EA). In 10 CFR 51.22, "Criterion for categorical exclusion; identification of licensing and regulatory actions eligible for categorical exclusion or otherwise not requiring environmental review," the NRC lists the actions eligible for categorical exclusion from the requirement to prepare an EIS or EA or otherwise not requiring an environmental review.

I.2.1.1 Environmental Reports Prepared by License Applicants

By regulation, the NRC requires applicants that request NRC licensing actions to consider economic, technical, and other costs and benefits of the proposed action and its alternatives in environmental reports (ER). The regulations at 10 CFR 51.45(c) state:

> Except for an environmental report prepared at the early site permit stage, or an environmental report prepared at the license renewal stage under 51.53(c), the analysis in the environmental report should also include consideration of the economic, technical, and other benefits and costs of the proposed action and its alternatives. Environmental reports prepared at the license renewal stage under 51.53(c) need not discuss the economic or technical benefits and costs of either the proposed action or alternatives, except if these benefits and costs are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation.

The NRC is responsible for the independent evaluation of all information used in a NEPA review (see 10 CFR 51.41, "Requirement to submit environmental information").

For reactor license renewal, 10 CFR 51.53(c)(3)(ii)(L) requires the applicant to consider the costs and benefits of SAMAs in its ER if SAMAs were not previously considered in an EIS, a related supplement, or an EA. Conversely, a license renewal applicant for a nuclear power plant that has already conducted a SAMA analysis as part of an EIS, a supplement to an EIS, or an EA, does not need to provide another SAMA analysis in the subsequent license renewal (SLR) ER. Nevertheless, 10 CFR 51.53(c)(3)(iv) requires the applicant's ER to include "any new and significant information regarding the environmental impacts of license renewal of which the applicant is aware." For license renewal applicants or subsequent license renewal applicants that have previously conducted SAMA or SAMDA analyses as part of an EIS, supplemental EIS, or an EA, the ER must include new and significant information that would

impact the previously conducted analysis. Guidance is provided in Nuclear Energy Institute (NEI) 17-04, Revision 1, "Model SLR New and Significant Assessment Approach for SAMA," dated August 2019 as endorsed by the NRC (NRC, 2019). Under 10 CFR 51.54, "Environmental report—manufacturing license," and 10 CFR 51.55, "Environmental report—standard design certification," the NRC requires applicants for manufacturing licenses and design certifications under 10 CFR Part 52 to address the costs and benefits of SAMDAs and the bases for not incorporating SAMDAs in the design. Under 10 CFR 51.45(c), an environmental report for a construction permit (CP), operating license (OL), or combined license (COL) application must discuss "alternatives available for reducing or avoiding adverse environmental effects." As discussed below in Section I.4, EISs for power reactor OL and COL applications have included consideration of SAMAs since a 1989 court decision. A power reactor CP application has not been submitted since 1989, but the NRC staff expects a CP application environmental report to address SAMAs, as discussed below.[3]

I.2.1.2 National Environmental Policy Act Documents Prepared by the NRC Staff

The regulations at 10 CFR 51.71 require an EIS to include the "consideration of the economic, technical, and other benefits and costs of the proposed action and alternatives." The EIS includes recommendations regarding the proposed action based on the information collected and the independent analyses conducted. These recommendations are generally based on the environmental effects of the proposed action, the consideration of reasonable alternatives, and an assessment of the costs and benefits of the proposed action.

Some differences in requirements exist depending on application type. Under 10 CFR 51.75(b), the NRC does not require an assessment of the economic, technical, or other costs and benefits of the proposed action in early site permit EISs unless the applicant chooses to include this information in the ER. Exceptions to the need for a cost-benefit analysis include supplemental EISs prepared at the license renewal stage under 10 CFR 51.95(c) and EISs developed for an early site permit under 10 CFR 51.75(c) "unless these matters are addressed in the early site permit environmental report," in which case, the early site permit EIS must include a cost-benefit analysis. The regulations at 10 CFR 51.30(d) require the design certification EA to consider the costs and benefits of SAMDAs and the bases for not incorporating SAMDAs in the design certification. Similar to a standard design certification, an EA for a manufacturing license must conduct a cost-benefit analysis in accordance with 10 CFR 51.30(e) under Subpart F, "Manufacturing Licenses," of 10 CFR 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

I.2.2 NRC Guidance

Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations," and NUREG-1555, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan," provide guidance on how to conduct cost-benefit analyses in support of NEPA reviews for new nuclear power reactors. The NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs," provides guidance for both applicants and NRC staff on how to conduct cost-benefit analyses in support of NEPA reviews for nuclear material license actions.

[3] An ESP application environmental report may, but is not required to, include a SAMA analysis.

I.2.2.1 Regulatory Guide 4.2 - Preparation of Environmental Reports for Nuclear Power Stations

In Regulatory Guide (RG) 4.2, the NRC provides general procedures to applicants for preparing cost-benefit analyses for ERs for the construction or operation of new nuclear power plants in accordance with 10 CFR Part 52. The environmental impacts of constructing and operating the new nuclear power plant, including the costs and benefits of the proposed action, must be assessed before the NRC can issue a COL, CP, or OL. Therefore, the NRC requires applicants to include cost-benefit information in ERs to assist the agency in analyzing the costs and benefits of the proposed action.

The companion document to RG 4.2 is NUREG-1555, which describes the types of information and the level of detail needed by the NRC to support the development of cost-benefit analyses in EISs for COL, CP, and OL applications. Applicants are encouraged to confer with the NRC as early as possible to avoid issues related to cost-benefit information in the ERs (see 10 CFR 51.40, "Consultation with NRC staff").

I.2.2.2 NUREG-1555 - Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan

The environmental standard review plans (ESRP) in NUREG-1555 consist of a series of instructions for conducting environmental reviews and preparing EISs and EAs for new reactor licensing actions. The use of these ESRPs provides for completeness and consistency of the environmental review, including the cost-benefit analyses prepared for EISs and EAs. The analyst should apply the guidance from the latest version of NUREG-1555.

After receiving a new reactor licensing application, the NRC performs an acceptance review to determine whether the information (including cost-benefit information) in the ER is sufficient to complete the NEPA review. Based on the NEPA review, the EIS and the cost-benefit analysis present the NRC staff's recommendations on the proposed licensing action.

The following sections summarize the applicable ESRPs in NUREG-1555 that direct the analysis, evaluation, and balancing of costs and benefits.

ESRP 10.4 Benefit-Cost Balance

In ESRP 10.4, the NRC provides guidance for identifying, characterizing, and gathering the expected costs and benefits associated with the proposed project from other parts of the EIS. In addition, the ESRP provides guidance on gathering the expected costs and benefits of any environmentally preferable alternatives, including energy alternatives, alternative sites, and system design alternatives. The analyst should follow the guidance in NUREG-1555, ESRP 10.4, for the assessment of costs and benefits.

ESRP 10.4.1 Benefits

In ESRP 10.4.1, the NRC describes the identification, evaluation, and tabulation of the benefits resulting from the construction and operation of the proposed project. The analyst may rely on an independent analysis of benefits by State or regional authorities, may review the applicant's analysis, or may prepare an independent assessment. If a review of the applicant's analysis is conducted, the analyst must ensure that the applicant's assumptions, data, and methods are acceptable. The scope should include the nuclear power plant's average annual

electrical-energy generation in kilowatt-hours, enhanced reliability of the electrical distribution system, technical benefits such as development of technology, the quantities of other products produced (e.g., steam used for commercial processes), and other benefits that have been identified (e.g., increased regional productivity, tax revenues, or new or improved recreational facilities). Benefits should be identified for the applicant's proposed project and for any of the NRC staff's identified alternatives to mitigate adverse impacts.

At the early site permit stage, 10 CFR 51.75(b) states that the draft EIS "must not include an assessment of the economic, technical, or other benefits... unless these matters are addressed in the early site permit environmental report."

The benefits of plant construction and operation should be summarized in tabular form similar to that shown in the benefits summary table in Chapter 10 of the EIS. Each benefit identified by the analyst should be discussed in the text and presented in the table.

ESRP 10.4.2 Costs

In ESRP 10.4.2, the NRC describes the identification and evaluation of the internal and external costs of construction and operation of the proposed project. The analyst may rely on any reasonable independent analysis of costs by State or regional authorities or on the applicant's analysis. The analyst may also prepare an independent assessment. The analyst must ensure that the applicant's assumption, data, and methods are acceptable. The scope should include (1) capital costs, fuel costs, operating and maintenance costs, decommissioning costs, and any other identified internal costs; (2) the external costs of impacts (e.g., loss of cropland productivity or loss of wildlife habitat) identified in previous environmental reviews; and (3) other external costs that are not associated with an identified environmental impact (e.g., effects of increased traffic, medical costs). Costs should be identified for the applicant's proposed project and for any of the NRC staff's identified alternatives to mitigate adverse impacts. The analysis should rely primarily on quantitative estimates where possible.

At the early site permit stage, 10 CFR 51.75(b) states that the draft EIS "must not include an assessment of the economic, technical, or other benefits... unless these matters are addressed in the early site permit environmental report."

The costs of plant construction and operation should be summarized in tabular form similar to that shown in the costs summary table in Chapter 10 of the EIS. Each cost identified by the analyst should be discussed in the text and presented in the table.

ESRP 8.4 Assessment of Need for Power

The need for power is a critical component of an EIS because it establishes a framework for the evaluation of project benefits and for the geographic boundaries of the relevant electricity market over which costs and benefits are distributed. The ESRP sections that assess the need for power discuss the proposed project in the context of the larger network of transmission and generation and the loads the system serves. This includes discussions on the electrical demand and demand growth in the region and electrical power supply options.

The Commission reaffirmed the importance of the NRC's need for power analyses in its response to a petition for rulemaking (NRC, 2002) and stated that the principal benefit of constructing and operating a power reactor is the generation of electric power. Consequently, the need for a power analysis in the EIS serves to establish the benefits of the project under

NEPA. The analyst should note that the analysis does not need to demonstrate a service-area-wide capacity deficit that is equal to or greater than the capacity of the proposed project to conclude that there is "some need for power."

The analyst should follow the guidance in NUREG-1555, ESRP 8.4, for assessing the need for power.

As stated in 10 CFR 51.71(f), a draft EIS must include a preliminary recommendation as to whether to approve the permit application after weighing the results of the information and analyses included in the EIS. The review conducted under the need for power will aid this determination by providing input that can be used to evaluate the potential costs and benefits of a COL, CP, or OL permit.

I.2.2.3 NUREG-1748 - Environmental Review Guidance for Licensing Actions Associated with Office of Nuclear Material Safety and Safeguards Programs

In NUREG-1748, the NRC provides general procedures for the environmental reviews of nuclear materials uses conducted by the Office of Nuclear Material Safety and Safeguards (NMSS). The costs and benefits with respect to nuclear materials licenses should not be limited to a simple financial accounting of project costs for the proposed action and each alternative. The analysis should also consider costs and benefits that are analyzed qualitatively, such as mitigation, environmental degradation, and enhancement. Project costs can be reviewed using cost-estimating databases. Socioeconomic costs and benefits should be reviewed and compared against those of similar projects to determine their reasonableness. For each alternative, the analysis should include a quantitative discussion of the costs and benefits and a qualitative discussion of environmental impacts, including assumptions and uncertainties. The analyst should apply the guidance from the latest version of NUREG-1748.

I.3 ENVIRONMENTAL JUSTICE

Executive Order (EO) 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," mandates that Federal agencies make environmental justice part of their respective missions by addressing disproportionately high and adverse human health or environmental effects of Federal programs, policies, and activities on minority populations and low-income populations. In December 1997, the President's Council on Environmental Quality issued guidelines, titled "Environmental Justice Guidance under the National Environmental Policy Act," on how to integrate environmental justice into the NEPA process. Independent agencies, such as the NRC, are not bound by the terms of EO 12898 but are, as stated in paragraph 6-604 of the order, "requested to comply with the provisions of [the] order."

In a letter to the President dated March 31, 1994, NRC Chairman Ivan Selin wrote, "NRC would endeavor to carry out the measures set forth in the Executive Order [EO 12898] … as part of NRC's efforts to comply with the requirements of NEPA."

I.3.1 The Commission's Policy Statement

On August 24, 2004, the Commission issued a "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions" (69 FR 52040) which states, "The Commission is committed to the general goals set forth in EO 12898, and strives to meet those goals as part of its NEPA review process." The Commission's policy statement confirms that NEPA is the legal basis for analyzing environmental justice matters, including the human health and environmental effects of NRC licensing and other regulatory actions on minority or low-income communities. The NRC procedures incorporate the Commission's policy statement on environmental justice into the NEPA review process.

I.3.2 NRC Guidance

The NRR Office Instruction LIC-203, "Procedural Guidance for Preparing Categorical Exclusions, Environmental Assessments, and Considering Environmental Issues," provides staff guidance on how to incorporate environmental justice in the NEPA review process for reactor licensing actions. The office instruction is the basis for the environmental justice review process used for new reactor licensing in NUREG-1555 and license renewal in NUREG-1555, Supplement 1, "Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal." In addition, NUREG-1748 provides staff guidance on how to incorporate environmental justice in the NEPA review process for materials licensing actions.

I.3.2.1 Guidance for Conducting Environmental Justice Reviews for Reactors

Specifically, LIC-203 provides the basic framework for meeting the NRC's responsibility to comply with 10 CFR Part 51. This document provides guidance for conducting environmental justice reviews for all actions that require the preparation of an EIS (or a supplement thereto). An environmental justice review is not usually required for an EA in which a finding of no significant impact (FONSI) is made. Special circumstances may warrant an environmental justice review even for actions that might result in a FONSI, typically if there will be significant site modification with an identifiable impact on the environment or substantial public interest. In such circumstances, NRC senior management should be informed so that it can decide, on a

case-by-case basis, whether the circumstances warrant an environmental justice review for an EA. If there is a clear potential for significant offsite impacts from the proposed action to minority and low-income communities, an environmental justice review may be appropriate to provide a basis for concluding that there are no unique or significant impacts. If significant impacts are identified, a FONSI may not be possible, and an EIS should be considered. Appendix D in LIC-203, "Environmental Justice in NRR NEPA Documents," provides a detailed description and flow chart characterizing the steps in the environmental justice review.

I.3.2.2 Guidance for Conducting Environmental Justice Reviews for Nuclear Materials Uses

General procedures for conducting environmental justice reviews for material licensing actions are presented in NUREG-1748. Specifically, environmental justice reviews should follow guidance in NUREG-1748, Chapter 5, and Appendix C, "Environmental Justice Procedures." Impacts that may have environmental justice implications include those associated with human health, ecological (including water quality and water availability), social, cultural, economic, and aesthetic resources. The EIS should discuss the methods used to identify and quantify impacts on low-income and minority populations, the location and significance of any environmental impacts during construction on populations that are particularly sensitive, and any additional information pertaining to mitigation of these impacts.

In addition, NUREG-1748, Appendix C, states that the results of an environmental justice evaluation should be documented in the EIS or an EA conducted in special cases. The results should indicate whether a disproportionately high and adverse human health or environmental impact is likely to result from the proposed action and any alternatives that could be considered. The document should be written in nontechnical plain language. The NEPA document should contain a distinct section on environmental justice even if the demographics do not indicate a potential for an environmental justice concern.

I.3.2.3 Procedures for Rulemaking Activities

The staff should address environmental justice in the preamble to each proposed and final rule that requires an EIS, a supplement to an EIS, or a generic EIS or, if warranted by a special case or circumstance, an EA and FONSI.

If it is known in advance that a particular rulemaking might disproportionately affect a minority or low-income population or community, the population should be made aware of the rulemaking and have the opportunity to participate. Such actions may include translating the *Federal Register* notice into a language other than English for publication in a local newspaper and holding public outreach meetings in the potentially affected community.

If the staff performs an environmental justice review for a rulemaking activity, pages 67–68 of NUREG/BR-0053, "United States Nuclear Regulatory Commission Regulations Handbook," provides a template to seek public comments on environmental justice. The template would be part of either the proposed rule or a draft FONSI issued under 10 CFR 51.33, "Draft Finding of No Significant Impact; Distribution." NUREG/BR-0053, Revision 6, page 64, discusses environmental justice issues in rulemaking activities. An environmental justice review conducted for an operating reactor action should follow LIC-203, Appendix D, Steps 2 through 5 under "Procedures for Licensing Actions," and NUREG-1748, Appendix C, Section III, "Policy Implementation for Licensing Actions," for licensing actions involving nuclear materials.

Public comments on the environmental justice review should be addressed in the preamble to the final rule. Comments on the environmental justice review should be addressed at the same level of detail and in the same location as comments received on other parts of the rule.

When a rule that is under modification or development contains siting evaluation factors or criteria for siting a new facility, the staff should consider including specific language in the rule or supporting regulatory guidance to state that an environmental justice review will be performed as part of the licensing process.

I.4 SEVERE ACCIDENT MITIGATION ALTERNATIVES

The implementation of the NEPA requirements for certain nuclear reactor licensing reviews involves an evaluation of the costs and benefits of SAMA and SAMDA, including offsite property damage. Comparable analyses do not exist for the treatment of accidents and offsite consequences for materials, waste, and fuel cycle facility licensing.

A SAMA analysis is a systematic search for potentially cost-beneficial enhancements to further reduce nuclear power plant risk. A SAMA analysis evaluates additional features or actions that would prevent or mitigate the consequences of severe accidents. The SAMA analysis considers: (1) hardware modifications, procedure changes, and training program improvements; (2) both prevention of core damage and mitigation of severe accident consequences; and (3) the full scope of potential accidents (i.e., accidents initiated by internal or external events). The scope of the analyses is the same for SAMAs and SAMDAs, except that SAMDA analyses generally focus on hardware modifications because design certification and manufacturing license applications are based on future reactor designs that would not be expected to have established procedures and training programs for operation.

Current NRC policy and guidance developed after the 1989 Limerick Generating Station (Limerick) court decision (*Limerick Ecology Action v. NRC*, 869 F.2d 719 (3rd Cir. 1989)) require that EISs prepared at the OL stage and at the COL stage consider SAMAs that mitigate the consequences of severe accidents. Consideration of SAMAs is required at the license renewal stage for plants for which a site-specific SAMA has not been included in an EIS or supplemental EIS. In addition, the NRC expects that a CP review would need to consider SAMAs; however, special factors discussed below should be considered.

Commission paper SECY-91-229, “Severe Accident Mitigation Design Alternatives for Certified Standard Designs,” dated July 31, 1991, identifies the design-related SAMAs or SAMDAs required by 10 CFR 52.47(b)(2). The EA for each design certification rule issued under 10 CFR Part 52 considers SAMDAs. If a COL application references a certified design, the SAMDA portion of the SAMA review should focus on whether the site characteristics are within the site parameters specified in the SAMDA evaluation. However, if a COL application references a reactor design that is still undergoing certification review, the NRC expects the applicant to provide a site-specific SAMDA analysis based on the known information of the selected design.

In NUREG-1555 for new reactor applications and NUREG-1555, Supplement 1 for license renewal applications, the NRC provides guidance to the staff on how to review SAMA and SAMDA analyses. The NEI 05-01A, “Severe Accident Mitigation Alternatives (SAMA) Analysis: Guidance Document,” which the NRC endorsed in license renewal Interim Staff Guidance LR-ISG-2006-03: “Staff Guidance for Preparing Severe Accident Mitigation Alternatives Analyses,” dated August 14, 2007, provides industry guidance for license renewals. For new reactor applications, RG 4.2 provides guidance to industry for the assessment of SAMAs, including SAMDAs. For license renewal applications, RG 4.2, Supplement 1, provides guidance to industry for the assessment of SAMAs.

The nuclear industry is developing advanced nuclear reactors with reduced risk profiles that are not based on the current light water reactor (LWR) technology and could operate at power levels as low as a couple of megawatt electric to power levels equivalent to the current LWRs.

The NRC is evaluating different methods to perform SAMA analyses for advanced reactors that take into account the much lower risk profiles and unique safety features.

I.4.1 Analysis Methodology

Both SAMA and SAMDA analyses follow the same methodology. The steps outlined below that refer to SAMAs also apply to SAMDAs.

I.4.1.1 Identification and Characterization of Leading Contributors to Risk

The SAMA analysis begins with an offsite consequence analysis based on a plant-specific risk model[4] that provides accident frequency and source term information from the applicant's final safety analysis report (FSAR) Chapter 19, "Probabilistic Risk Assessment." In practice, maximum use is made of the plant-specific probabilistic risk assessment (PRA) models (e.g., Level 1 and Level 2 PRAs) for characterizing the dominant contributors to risk and identifying candidate SAMAs to address these contributors. The contribution of external events is considered to the extent that it can be supported by available risk methods because external events can affect whether a SAMA is cost beneficial (i.e., greater reduction of risk). Appendix H, "Severe Accident Risk Analysis," to this document provides guidance for performing the offsite consequence analysis (i.e., the limited Level 3 PRA).

I.4.1.2 Identification of Candidate Severe Accident Mitigation Alternatives

The next step is to identify the potential SAMA candidates that prevent core damage and that prevent significant releases from containment. Insights from the plant-specific risk model, compilations of potentially cost-beneficial SAMAs from similar reactor designs, and improvements to training and procedures can inform the selection of potential SAMA candidates. For license renewal, NEI 05-01, Revision A, "Severe Accident Mitigation Alternatives (SAMA) Analysis, Guidance Document," Section 5, "SAMA Identification," as endorsed by the NRC and incorporated by reference in RG 4.2, Supplement 1, dated June 2013, provides guidance for developing a list of SAMA candidates. Tables 13 and 14 of NEI 05-01A provide standard lists of SAMA candidates for boiling-water reactors and pressurized-water reactors, respectively.

In new reactor applications, Chapter 19, "Probabilistic Risk Assessment," of the FSAR typically discusses potential design improvements. These potential design improvements could be derived based on PRA criteria through the relative risk ranking of systems, structures, and components and human actions, including the Fussell-Vesely Importance (e.g., greater than 0.005), Risk Reduction Worth, or Risk Achievement Worth. Other PRA-identified SAMA candidates could come from a review of dominant sequences or cutsets (e.g., the top 100 cutsets) for failures that an enhancement to the plant could address. Additionally, an expert panel that is very familiar with the reactor design could serve as a source to identify SAMAs.

Other candidate SAMAs can be considered based on input from members of the public during the scoping phase of the NEPA review, if appropriate for the licensing action (see 10 CFR 51.27(a)(4) for a description of the scoping process).

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[4] The plant-specific risk model could be related to one of several probabilistic safety analysis methodologies that include individual plant examinations (IPE), IPE of external events recommendations, and Level 1 and Level 2 PRAs.

I.4.1.3 Estimation of Risk Reduction and Implementation of Cost Estimates

With a listing of candidate SAMAs, an initial screening is performed to determine which SAMAs are not cost beneficial and can be eliminated from further consideration. Section 6 of NEI 05-01A, "Phase I Analysis," lists screening criteria that may be applied: (1) not applicable to the reactor design, (2) already implemented, (3) combined with another SAMA, (3) excessive implementation cost (i.e., a dollar value of the SAMA should be given to justify elimination), and (4) very low benefit. These screening criteria have been applied in most license renewal and new reactor applications that require a SAMA.

For the SAMAs that remain, a rough implementation cost estimate (or cost of enhancement) is developed for each SAMA (NEI, 2005). Cost estimates for hardware modifications can be based on estimates from past studies performed for a similar plant or developed on a plant-specific basis. These cost estimates do not include certain cost factors (e.g., surveillance/maintenance, the cost of replacement power during implementation) and thus tend to increase the number of potentially cost-beneficial SAMAs to provide for a full consideration of alternatives. Typically, screening estimates are used for initial assessments and are refined as appropriate if a SAMA is potentially cost beneficial. Hardware costs could range from several hundred thousand to a few million dollars. Procedure changes could range from several tens of thousands of dollars for simple changes to several hundred thousand dollars for complex changes with analysis and operator training impacts.

I.4.1.4 Identification of Severe Accident Mitigation Alternatives That Are Potentially Cost Beneficial

To identify SAMAs that may be cost beneficial, the estimate of the net value of each SAMA is based on the maximum benefit that can be achieved by avoiding an accident using an assumption that the SAMA could eliminate all risk of a severe accident. Namely, the net present value of the SAMA is reached by comparing the maximum benefit to the cost of the SAMA.

This portion of the SAMA methodology for the evaluation of the maximum benefit follows the guidance of Section 4.6.1.2, "Severe Accident Mitigation Design Alternatives," of NUREG/BR-0058. The analyst then assesses the appropriate attributes listed in Section 5.3, "Quantification of Attributes," of NUREG/BR-0058 as follows:

- *APE* = present value of averted public exposure (dollars) (Section 5.3.2.1)
- *AOC* = present value of averted offsite property damage costs (dollars) (Section 5.3.2.3)
- *AOE* = present value of averted occupational exposure costs (dollars) (Section 5.3.2.5)
- *AOSC* = present value of averted onsite costs (dollars), including cleanup, decontamination, and long-term replacement power costs (Section 5.3.2.6)

The analyst then assesses the net present value of the SAMA by adding the four attributes together and subtracting the cost of the enhancement (i.e., the implementation cost of the SAMA) from this total.

$$Net\ Present\ Value = (APE + AOC + AOE + AOSC) - COE,$$

where

COE = cost of enhancement (dollars)

If the net value is positive, the SAMA is potentially cost beneficial and may be considered for additional screening. If the net value is negative, the SAMA is not cost beneficial and is removed from further consideration.

The NEI 05-01A, Section 4, "Cost of Severe Accident Risk/Maximum Benefit," provides examples of estimating these attributes to obtain the maximum benefit in regard to license renewals.

I.4.1.5 Screening Analysis for Remaining Severe Accident Mitigation Alternatives

After identifying SAMAs that are potentially cost beneficial, the analyst should then perform a more in-depth analysis of the SAMAs. This analysis may include a detailed (i.e., more realistic and less bounding) evaluation of the potential benefits of the SAMA. Rather than assuming that the SAMA eliminates all core damage frequency contributors, the analysis should include only those sequences relevant to the SAMA, thus resulting in a maximum benefit according to the fraction of risk that the SAMA actually can affect. It may also include a more detailed development of the cost associated with the proposed modification, including engineering support, training, hardware costs, and implementation costs.

Additionally, a sensitivity analysis is recommended to evaluate how changes in SAMA analysis assumptions would affect the cost-benefit analysis. The NEI 05-01A, Section 8, "Sensitivity Analyses," provides several areas for this type of analysis, including plant modifications, uncertainty, peer review findings or observations, evacuation speed, real discount rate, and analysis period. However, additional sensitivity categories could be relevant depending on the reactor design, bases for assumptions, the site being considered, and dollar per person-rem conversion factor values.

I.4.1.6 Disposition of Potentially Cost-Beneficial Severe Accident Mitigation Alternatives

Any SAMAs that remain potentially cost beneficial are retained for possible implementation. Given the potential for cost-beneficial risk reduction, the staff expects the applicant to evaluate the remaining potentially cost-beneficial SAMA candidates to determine whether further action is warranted.

For license renewals, the remaining SAMAs would be evaluated to determine whether any of the potentially cost-beneficial SAMAs identified are subject to aging management such that they would be within the scope of license renewal. This evaluation would consider whether any structures, systems, and components associated with these SAMAs would perform their intended functions without moving parts or without a change in configuration or properties and would not be subject to replacement based on a qualified life or specified time period. If the potentially cost-beneficial SAMAs do not relate to the adequate management of the effects of aging during the period of extended operation, the licensee does not need to implement the SAMAs as part of its license renewal in accordance with 10 CFR Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

For new reactor applications, PRAs have been an integral tool in the development of the reactor design. Therefore, the overall severe accident risk may be significantly lower when compared to the current operating reactors. As a result, generically identified SAMDAs (i.e., SAMDAs previously identified for a class of reactors such as pressurized-water reactors and boiling-water reactors) would likely not be potentially cost beneficial for new reactor designs.

I.4.2 Specific Considerations for Severe Accident Mitigation Alternatives

This section provides guidance for the consideration of the unique aspects of new reactor SAMA reviews. The NRC has received or expects to receive new reactor applications for various sizes and types of reactor designs, such as small modular reactors with reduced risk profiles that could be of LWR or non-LWR based designs. From these developments, the staff could be assessing different analysis methodologies or processes for determining risks through PRAs, and new reactor applications may propose to use sites that differ from previously licensed sites for large LWRs. Also, the staff would for the first time be reviewing a CP application that would have been submitted under the current guidance for addressing severe accident mitigation (i.e., a SAMA assessment).

I.4.2.1 New Reactor Probabilistic Risk Assessment Acceptability

The NRC's "Policy Statement on the Use of Probabilistic Risk Assessment Methods in Nuclear Regulatory Activities" encourages greater use of this analysis technique to improve safety decisionmaking and regulatory efficiency. The NRC expects new reactor applications under 10 CFR Part 52 to have a PRA with results and insights that address the full scope of operations for internal events at full power, external events at full power, and events during other operating modes (e.g., low power and shutdown). The relevant regulatory requirements depend on the type of application (e.g., standard design certification or COL) and are discussed in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 19.0, "Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors." In addition to this guidance, RG 1.200, "Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities," describes acceptable methods that the new reactor applicant and the analyst can apply to assess the technical information in, and adequacy of, the PRA. Although a license renewal application may apply RG 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," the analyst may determine that, for an existing operating reactor's PRA, this less than full scope PRA information is acceptable.

With a more complete set of risk information, the scope of the offsite consequence analysis may be greater for a new reactor SAMA review than it would for a license renewal SAMA review given comparable design specifications (i.e., reactor power) and site conditions. The NRC expects new reactor applicants to develop a reasonable set of source term releases that will be more expansive over a larger set of hazard groups, including internal and external release categories for at-power and low-power shutdown modes of operation.

I.4.2.2 Considerations Regarding Sources of Site Information

A key difference between the SAMDA analyses provided in a standard design certification review versus a COL application SAMA analysis is the basis for the site information being applied to the offsite consequence calculation that supports the analysis. Because the standard design certification review only assesses the design itself, the site information would be based

on postulated site parameters. This could be accomplished either by applying information based on an industry document such as the Electric Power Research Institute's (EPRI) "Advanced Light Water Reactor Utility Requirements Document," Volume III, Annex B, "ALWR Reference Site," Revisions 5 and 6, or by obtaining the site information from a publicly available source.[5] Similar considerations apply to the SAMDA analysis for a manufacturing license application. For all other licensing actions that require a SAMA analysis, the site information applied is specific to the location.

Regardless of the type of application, the site information could be dated in various ways. Therefore, to ensure that the submitted ER applied the best information, the staff should verify that the applicant properly adjusted the relevant information to present values.

I.4.2.3 Construction Permits and Operating Licenses

Since the Limerick decision in 1989, the NRC has not received a nuclear power plant CP application under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." Thus, all prior SAMA analyses for a 10 CFR Part 50 license relate to an OL or an OL renewal under 10 CFR Part 54. If an applicant submits a CP application under 10 CFR Part 50, the NRC's regulations require the applicant and the staff to assess SAMAs as part of this licensing action.

Enclosure 1 to SECY-15-0002, "Proposed Updates of Licensing Policies, Rules, and Guidance for Future Reactor Applications," discusses unique challenges to developing a PRA and assessing SAMAs for a CP application. First, Enclosure 1 states the requirements in 10 CFR Part 52 for a PRA do not currently apply to new reactor license applications submitted under 10 CFR Part 50, such as a CP, although Commission policy sets an expectation that CP applications include a preliminary risk analysis. Second, Enclosure 1 further states a CP can be issued leaving some technical or design details for later consideration. However, the PRA methodology has been proven to be a key reactor design tool, and a full-scope PRA could still be part of the CP application. Thus, a CP application should provide the best available risk information to assess SAMAs or SAMDAs.

For the subsequent OL, 10 CFR 51.53(b) states that each applicant for a license to operate a production or utilization facility under 10 CFR 51.20 shall submit with its application a "Supplement to Applicant's Environmental Report—Operating License Stage," which will update the "Applicant's Environmental Report—Construction Permit Stage." Unless otherwise required by the Commission, the applicant for an OL for a nuclear power reactor submits this report only in connection with the first licensing action authorizing full power operation. In the report, the OL applicant would discuss SAMAs but only to the extent that they differ from those discussed or reflect new information in addition to that discussed in the final EIS prepared by the NRC in connection with the CP based on the completed nuclear power plant.

I.4.3 Nuclear Material Licenses

[5] Standard design certification applicants have also selected sites that were not generic but were either previously analyzed or were being evaluated under another licensing action. Examples of such sites include one of the sites analyzed in NUREG-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants, Final Summary Report," Volume 1, or NUREG-1935, "State-of-the-Art Reactor Consequence Analyses (SOARCA) Report," or the site for the first COL application for the design.

The NUREG-1748 provides guidance on the review of a material licensing action to focus environmental review documents (e.g., EAs and EISs) on the environmental impacts of the proposed action and reasonable alternatives. Typically, the staff prepares a safety evaluation report (SER) to evaluate and document the safety of the proposed action and compliance with NRC regulations. The agency conducts the safety and environmental reviews in parallel. Although the content of a SER and the NEPA document overlaps to some extent, each document has a different purpose. The NEPA document does not address accident scenarios; instead, it addresses the environmental impacts that would result from an accident and, therefore, depends on certain information from the SER. The SER addresses accident scenarios (i.e., frequency, probability).

The applicant's ER and the NRC's NEPA document (an EIS or EA) should list reasonably foreseeable and credible accidents (e.g., design-basis events for licenses under 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," and credible consequence events for licenses under 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material") identified as having a potential for releases to the environment and the analysis of offsite radiological doses from these accidents. However, the environmental review document would not analyze beyond-design-basis events for 10 CFR Part 72 licenses and their potential environmental impacts because these events are typically not considered reasonably foreseeable. Thus, material applicants and licensees do not determine whether a cost-beneficial design alternative could mitigate a severe accident.

The analyst should use existing guidance from the latest version of NUREG-1748 to address the environmental effects of accidents.

I.5 REFERENCES

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CFR, "Domestic Licensing of Production and Utilization Facilities," Part 50, Chapter 1, Title 10, "Energy."

CFR, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," Part 51, Chapter 1, Title 10, "Energy."

CFR, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Part 52, Chapter 1, Title 10, "Energy."

CFR, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants," Part 54, Chapter 1, Title 10, "Energy."

CFR, "Domestic Licensing of Special Nuclear Material," Part 70, Chapter 1, Title 10, "Energy."

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NRC, “An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities,” RG 1.200 (current version).

NRC, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” RG 1.174 (current version).

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