# Supplemental Regulatory Analysis for Proposed Rulemaking: Mitigation of Beyond-Design-Basis Events

U.S. Nuclear Regulatory Commission

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## Abbreviations and Acronyms

| | |
|---|---|
| ac | alternating current |
| APR | advanced light water reactor |
| APWR | advanced pressurized-water reactor |
| BLS | U.S. Bureau of Labor Statistics |
| CFR | *Code of Federal Regulations* |
| CPI | consumer price index |
| ELAP | extended loss of ac power |
| EPR | evolutionary pressurized-water reactor |
| EPRI | Electric Power Research Institute |
| FY | fiscal year |
| FR | Federal Register |
| KHNP | Korea Hydro and Nuclear Power |
| LOE | level of effort |
| LUHS | loss of ultimate heat sink |
| NEI | Nuclear Energy Institute |
| NRC | Nuclear Regulatory Commission |
| NUREG | NRC technical report designation |
| SAMG | severe accident management guidance |
| SFP | spent fuel pool |
| SOC | standard occupational classification |
| SSC | structures, systems, and components |

# 1 Statement of the Problem and Objective

The NRC staff has developed this regulatory analysis in order to assess whether there is sufficient design incentive and regulatory guidance for future applicants for a construction permit, operating license, standard design approval, design certification, manufacturing license, or combined license to incorporate into the plant design those design features that enhance coping durations and minimize reliance on human actions to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities during an extended loss of all ac power concurrent with a loss of normal access to the ultimate heat sink.

The regulatory objective is for applicants for a future license, certification, or approval for a nuclear power plant design to consider the effects of an extended loss of all ac power early in the design process and incorporate design features that provide enhanced capabilities for addressing these events. The term "design features" means structures, systems, and components (SSCs), including the physical arrangement of such SSCs, and their functional capabilities – key characteristics of the SSCs that result in their contribution to maintain or restore the key safety functions. The objective is for these applicants to consider these design features early in the design process because a specific extended loss of ac power (ELAP) design feature would be more difficult to incorporate into the facility or site design once the facility is licensed and constructed.

# 2 Backfit Rule Screen

The NRC staff has determined that the backfit rule does not apply because none of the alternatives contain any provisions that would impose backfitting as defined in the backfit rule, 10 CFR 50.109, "Backfitting." These alternatives would not constitute backfits because they are provide guidance, clarification of policy, or establish requirements that are prospective in nature and the backfit rule was not intended to apply to every NRC action that substantially changes the expectations of future applicants. The proposed rule would impose no new requirements on (1) an applicant that obtains a permit or license before the effective date of the final rule, (2) a design certification rule in Appendices A through E to 10 CFR Part 52, or (3) the current fleet of operating nuclear power reactors.

# 3 Identification of Regulatory Alternatives

In addition to the proposed rule (identified as Option 2 in the base regulatory analysis), the NRC has identified three sub-alternatives for consideration.

- Base regulatory analysis Option 2: Undertake rulemaking to make Order EA-12-049, Order EA-12-051, and industry initiatives generically applicable and establish an expectation that new reactor applicants would incorporate into the plant design those design features that enhance coping durations and minimize reliance on human actions to maintain or restore core cooling, containment, and SFP cooling capabilities during an ELAP concurrent with a LUHS.[1]

[1] An ELAP event in the context of this regulatory analysis means any event that could lead to an extended loss of alternating power and subsequently to fuel damage for which the additional design features are intended to mitigate.

- Alternative 2a: Take no action unique to new reactor entities
- Alternative 2b: Issue guidance for new application and license reviews
- Alternative 2c: Revise the Regulation of Advanced Reactors Policy Statement
- Alternative 2d: Add paragraph 50.155(d) to the rule

## *3.1 Alternative 2a: Take no action unique to new reactors entities*

This alternative baseline (i.e., the proposed rule) would address NRC's objective to make the requirements in Order EA-12-049, Order EA 12-051, and industry initiatives generically applicable, while also requiring SAMGs. Under this alternative, the "Policy Statement on the Regulation of Advanced Reactors" (73 FR 60612, October 14, 2008), the "Policy Statement on the Regulation of Advanced Nuclear Power Plants" (59 FR 35461; July 12, 1994), and the "Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants" (50 FR 32138; August 8, 1985) would apply.

Under alternative 2a, no further NRC action would be taken to impose requirements on reactor applicants to incorporate into the plant design those design features that enhance coping durations and minimize reliance on human actions to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities during an extended loss of all ac power concurrent with a loss of normal access to the ultimate heat sink. This alternative is equivalent to the proposed rule (Alternative 2) status quo and serves as a baseline to measure the costs and benefits against the other identified sub-alternatives.

Requiring applicants for new nuclear power reactors to identify and incorporate into their design those design features and functional capabilities that address the effects of beyond-design-basis events is consistent with the NRC's historic approach to beyond-design-basis events and with the NRC's position in its "Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants." The policy statement notes, "The Commission expects that vendors engaged in designing new standard [or custom] plants will achieve a higher standard of severe accident safety performance than their prior designs." The NRC reiterated this regulatory approach in its "Policy Statement on the Regulation of Advanced Nuclear Power Plants," when it stated, "The Commission expects that advanced reactors would provide enhanced margins of safety and/or utilize simplified, inherent, passive, or other innovative means to accomplish their safety functions." These concepts continue to be NRC policy as reflected in the NRC's 2008 "Policy Statement on the Regulation of Advanced Reactors." This regulatory approach has demonstrated its success, as all designs subsequently submitted to and certified by the Commission represent substantial improvement in safety for operational events and accidents. Actions at the design stage to enhance the design's robustness to extend coping durations and minimize reliance on human actions for ELAP events will further enhance the safety of new nuclear power plants and is consistent with these policy statements.

This alternative avoids certain incremental costs that the other alternatives would impose, while benefits achieved through the Commission's policy statement on the Regulation of Advanced Reactors would remain. The advantages and disadvantages of this alternative are provided in Table 1.

Table 1 Alternative 2a – Advantages and Disadvantages

| Advantages | Disadvantages |
|---|---|
| 1. Low cost alternative – The proposed rule and the policy statement provide the Commission's expectations for future applicants for new nuclear power plant designs. | |
| 2. The existing Advanced Reactor Policy Statement attributes that could encourage such enhancements to a proposed advance reactor design are:<br>a. Use of inherent or passive means to accomplish shutdown and decay heat removal<br>b. Longer time constants<br>c. Simplified safety systems, that where possible, reduce required operator actions<br>d. Designs that reduce potential radiation exposures to plant personnel<br>e. Designs that incorporate the defense-in-depth philosophy<br>f. Designs that include considerations for safety and security requirements together such that the formulation of mitigation measures have reduced reliance on human actions | 1. The listing of these design attributes in a policy statement does not necessarily mean that any specific design attribute would be addressed. That is, the policy statement would encourage, rather than require, such enhancements. |
| 3. Implementation requires early staff interaction with applicants, vendors, etc. to identify how the design would address these design objectives | 2. The lack of guidance may contribute to the lack of regulatory stability and predictability in the licensing and regulation of advanced reactors.<br>3. The lack of specific direction may not achieve the desired outcome.<br>4. External stakeholders may perceive a lack of transparency on what the acceptance criteria is for new nuclear power plant designs. |
| 4. May achieve the objective of enhancing the design's inherent robustness to extend coping durations and minimize reliance on human actions at the design stage. | 5. The lack of a regulatory requirement would allow applicants to include no or few design features and may not achieve the desired outcome.<br>6. NRC could not require enhancements to the proposed reactor design. |

## *3.2 Alternative 2b: Issue guidance for new application and license reviews*

This alternative would develop and issue guidance that would be used by NRC staff in reviewing the acceptability of new reactor applicant design features for maintaining or restoring core cooling, containment, and SFP cooling capabilities during an ELAP concurrent with a LUHS.

This alternative would impose costs on industry and the NRC and mitigates the issue that may contribute to the perception of the lack of regulatory stability and predictability. New applicants would review and provide feedback and comments on NRC developed guidance material.

During the implementation of this alternative, the NRC would need to establish survivability and treatment criteria for installed equipment. The advantages and disadvantages of this alternative are provided in Table 2.

Table 2 Alternative 2b – Advantages and Disadvantages

| Advantages | Disadvantages |
|---|---|
| 1. This alternative has the same advantages 2 through 4 as Alternative 2a | 1. This alternative costs marginally more than Alternative 2a to develop and issue guidance. |
| 2. The development of guidance mitigates the issue regarding the lack of guidance contributing to the perception of the lack of regulatory stability and predictability (Alternative 2a, disadvantages 2, 3, and 4)<br><br>3. This alternative enables stakeholders to participate in public meetings that discuss guidance development. | 2. NRC staff and industry staff resources are needed to develop and issue this policy statement. NRC staff resources are needed to review future applications against the guidance.<br><br>3. The lack of a regulatory requirement would allow applicants to include no or few design features and may not achieve the desired outcome.<br><br>4. NRC could not require enhancements to the proposed reactor design. |

## *3.3 Alternative 2c: Revise the Regulation of Advanced Reactors Policy Statement*

This alternative would revise the Policy Statement on the Regulation of Advanced Reactors to communicate the Commission expectations that new nuclear reactor designs include design features to address ELAP concurrent with a LUHS.

Table 3 Alternative 2c – Advantages and Disadvantages

| Advantages | Disadvantages |
|---|---|
| 1. This alternative has the same advantages 2 through 4 as Alternative 2a | 1. This alternative costs more than Alternatives 2a and 2b to revise and issue the Policy Statement on the Regulation of Advanced Reactors. |
| 2. Issuing a revised Policy Statement on the Regulation of Advanced Reactors may provide more specific encouragement to applicants to include design features to achieve the desired objective to mitigate the lack of specific direction. (Alternative 2a, disadvantage 3) | 2. NRC staff and industry staff resources are needed to develop and issue this policy statement. NRC staff resources are needed to review future applications against the guidance.<br><br>3. The lack of a regulatory requirement would allow applicants to include no or few design features and may not achieve the desired outcome even if a policy statement is issued.<br><br>4. The lack of guidance may contribute to the lack of regulatory stability and predictability in the licensing and regulation of advanced reactors. |

### *3.4 Alternative 2d: Add Paragraph 50.155(d) in the proposed rule*

In this alternative, the regulations in 10 CFR Part 50 would be amended to require applicants for a construction permit, operating license, design certification, standard design approval, manufacturing license, or combined license to incorporate into the plant design those design features that enhance coping durations and minimize reliance on human actions to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities during an ELAP concurrent with a LUHS.

The staff's intent is that safety be examined in a holistic manner considering the facility design, the site, and in light of uncertainties associated with external hazards. The staff recognizes that future power reactors could be made safer and less reliant on human operator actions through design features that enhance coping durations and minimize reliance on human actions to maintain or restore safety systems and functions, perhaps reducing the reliance on mitigating strategies during the early stages of the event.

Because this type of consideration needs to occur while the design is being developed, requirements are proposed for applicants in the design phase. Accordingly, under the proposed 10 CFR 50.155(d), applicants would have to assess design features by: (1) identifying candidate structures, systems, and components, (2) applying a risk evaluation methodology that includes the identification of scenarios considered, (3) using screening assessment parameters to evaluate candidate design features, and (4) using a systematic screening process to determine the practicality of these candidate design features. The systematic screening process would consider (1) the impact on plant operations, (2) the benefits achieved through additional hardening, capacity, flexibility, safety margin, or passive and diverse design features, and (3) the costs of these design features. Furthermore, applicants would need to explain how the design features incorporated into the facility design enhance the coping durations and minimize reliance on human operator actions, how any increased complexity or greater reliance on installed SSCs does not adversely affect mitigation of beyond-design-basis events, and why the implementation of certain design features would not be practical. The staff does not expect applicants to demonstrate that design features alone are sufficient to mitigate all such circumstances for all potential plant sites because of the challenges a designer would face in defining the site envelope for the design, and in anticipating all possible events which could lead to the ELAP/LUHS.

Applicants would need to demonstrate that practical design features were included in their design documentation. As a result, design features incorporated into the design will be subject to the formal change process as described in 10 CFR 50.54, "Conditions of licenses," 10 CFR 50.90, "Application for amendment of license, construction permit or early site permit," or the Part 52 appendix for a design certification. NRC review and approval of an applicant's design features assessment described in the licensing application would be required before issuing a combined license under 10 CFR Part 52 that does not reference a standard design approval or standard design certification, a construction permit under 10 CFR Part 50, an operating license under 10 CFR Part 50, a standard design approval under Part 52, a design certification rulemaking under 10 CFR Part 52, or a manufacturing license under 10 CFR Part 52 that does not reference a standard design approval or standard design certification.

The staff would prepare a new regulatory guide that describes an acceptable method of complying with the requirements for these design features at the design certification, standard design approval, manufacturing license, construction permit, and operating license stages. Development of this guidance would proceed in parallel with the rulemaking—the draft guidance

document issued with the proposed rule for public comment and the final guidance document is planned to be published with the final rule.

Table 4 Alternative 2d – Advantages and Disadvantages

| Advantages | Disadvantages |
|---|---|
| 1. This alternative has the same advantages 2 through 4 as Alternative 2a | 1. This alternative costs more than Alternatives 2a, 2b, and 2c to amend 10 CFR Part 50 and to develop and issue applicable guidance. |
| 2. Amending Part 50 to include the requirement to incorporate into the plant design those design features that enhance coping durations and minimize reliance on human actions to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities during ELAP concurrent with a LUHS would achieve the desired objective and mitigate the lack of specific direction. (Alternative 2a, disadvantages 3 and 4) | 2. NRC staff and industry staff resources are needed to develop and issue this proposed rule provision. NRC staff resources are needed to review future applications against this requirement.<br><br>3. The proposed rule provision defines a performance-based design goal (i.e., minimize reliance on human actions) without citing specific acceptance criteria. The proposed rule language and supporting statements of consideration may be subject to interpretation.<br><br>4. While there is sufficient detail and information to enable a designer comply with the proposed requirement, there remains an underlying issue regarding the designer's assumptions for the beyond design basis event conditions, and whether ultimately the design features would result in a benefit for safety.<br><br>5. The proposed rule provision imposes additional burden on the applicant, could increase the complexity of the plant design, and could result in designs that are less flexible in terms of preventing and mitigating beyond-design-basis external events. These additional burdens may not result in a compensatory increase in safety. |

# 4 Analysis of Benefits and Costs

## *4.1 Identification of Affected Attributes*

The attributes that the proposed rule could affect were identified by using the list of potential attributes provided in Chapter 5 of NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook," issued January 1997. Affected attributes include the following:

- Public Health (Accident) — The proposed action would reduce the risk that public health will be affected by radiological releases resulting from an ELAP event concurrent with a LUHS.

- Occupational Health (Accident) — The proposed action would reduce the risk that occupational health will be affected by radiological releases resulting from an ELAP event concurrent with a LUHS.

- Onsite Property — The proposed action would reduce the risk that onsite property will be affected by radiological releases resulting from an ELAP event concurrent with a LUHS.

- Offsite Property — The proposed action would reduce the risk that offsite property will be affected by radiological releases resulting from an ELAP event concurrent with a LUHS.

- Industry Implementation — The proposed action would require applications for a combined license under 10 CFR Part 52 that does not reference a standard design approval or standard design certification, a construction permit under 10 CFR Part 50, an operating license under 10 CFR Part 50, a standard design approval under Part 52, a design certification rulemaking under 10 CFR Part 52, or a manufacturing license under 10 CFR Part 52 that does not reference a standard design approval or standard design certification, to include design features that would enhance coping durations and minimize reliance on operational reliance on human actions to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities. The proposed action would resolve ELAP design feature issues at an early stage of the regulatory review process. This would result in a more robust mitigation capability for an ELAP event. Applicants would incur costs through the consideration and inclusion of design features in their application

- NRC Implementation — Under the proposed alternatives, the NRC would incur costs to develop guidance, policy, and/or rules for the design features requirement and to review applications addressing the design features requirement. The NRC would also incur the costs of completing this regulatory action.

- Regulatory Efficiency[2] — The proposed action would result in enhanced regulatory efficiency through regulatory and compliance improvements by ensuring that design features are included early in the regulatory review process. In addition, the proposed action would require applicants for new nuclear power reactors to include a discussion of these design features with their application.

- Other Considerations — Increase in Public Confidence — The NRC staff has not identified any impacts upon other stakeholders or the Agreement States. However, the proposed action could lead to an increase in public confidence because ELAP design features would have been addressed and incorporated into the facility design at the early stage of the regulatory review process.

Attributes that are not expected to be affected by this rulemaking provision include the following: public health (routine); occupational health (routine); industry operation; NRC operation; other

[2] The regulatory efficiency attribute is evaluated qualitatively, by definition, as discussed in Section 5.5.1.4 of NUREG/BR-0184, Regulatory Analysis Technical Evaluation Handbook." Specifically, this attribute attempts to measure regulatory and compliance improvements resulting from the proposed action. These may include changes in industry reporting requirements and the NRC's inspection and review efforts. Achieving consistency with international standards groups may also improve regulatory efficiency for both the NRC and the standards groups. This attribute is qualitative in nature.

government; general public; improvements in knowledge; antitrust considerations; safeguards and security considerations; and environmental considerations.

## *4.2 Analytical Method*

This section describes the process used to evaluate benefits and costs associated with the proposed rule provision. The benefits of the proposed rule provision include any desirable changes in affected attributes (e.g., monetary savings, improved safety) while the costs include any undesirable changes in affected attributes (e.g., monetary costs, increased exposures). This draft regulatory analysis was developed following the guidance contained in NUREG/BR-0058, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," Revision 4, issued September 2004 (ADAMS Accession No. ML042820192) and NUREG/BR-0053, Revision 6, "USNRC Regulations Handbook," 2005 (ADAMS Accession No. ML052720461).

As described in Section 4.1, only 2 attributes—industry implementation and NRC implementation—can be evaluated on a quantitative basis. Ideally, the benefit-cost analysis quantifies the overall benefits and costs of the regulatory options relative to each attribute. This analysis relies on a qualitative evaluation of several of the affected attribute (public health, occupational health, offsite property, onsite property, and regulatory efficiency[3] because of the difficulty in quantifying the impact of the proposed rule provision. These attributes would be affected by the proposed alternatives through the associated reduction in the risks of an ELAP event resulting in damage to the reactor core and the spent fuel.

The remaining attributes (industry implementation and NRC implementation) are evaluated quantitatively. This quantitative analysis requires a baseline characterization of the affected universe, including characterization of factors such as the number of affected entities and the application process that licensees would use relative to the alternative baseline identified as Alternative 2a.

Under Office of Management and Budget guidance and NUREG/BR-0058, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission" (Ref. 1), the analysis results are presented as discounted flows of funds using 3 and 7 percent real discount rates. Finally, the NRC staff sums the net present value estimates of the costs and the benefits for each alternative and compares them.

In addition to the extent that there are important qualitative considerations of factors that cannot be quantified, these considerations of factors are discussed in qualitative terms. Based on the quantified costs and benefits and the qualitative consideration of each attribute, the staff will make a recommendation.

Sections 4.2.1 through 4.2.9 describe the analytical method and assumptions used in the quantitative and qualitative analysis of these attributes.

[3] The regulatory efficiency attribute is evaluated qualitatively, by definition, as described in Section 5.5.1.4 of NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook." Specifically, this attribute attempts to measure regulatory and compliance improvements resulting from the proposed action. These may include changes in industry reporting requirements and the NRC's inspection and review efforts. Achieving consistency with international standards groups may also improve regulatory efficiency for both the NRC and the groups. This attribute is qualitative in nature.

### 4.2.1 Baseline for Analysis

This draft regulatory analysis measures the incremental costs of the proposed rule provision relative to a "baseline" that reflects anticipated behavior in the event the NRC undertakes no additional regulatory action (Alternative 2a, the "Take no action unique to new reactor entities" (alternative baseline). As part of the alternative baseline used in this analysis, the NRC staff assumes full licensee compliance with existing NRC regulations and continued applicability of issued policy statements. This alternative baseline is equivalent to the status quo and serves as a baseline against which other sub-alternatives are measured. Section 4.3 presents the estimated incremental benefits and costs of the alternatives relative to this baseline.

### 4.2.2 Affected Entities

These requirements are applicable to the following entities:

- Applicants for construction permits
- Applicants for operating licenses that reference a new construction permit
- Applicants for standard design certifications
- Applicants for standard design approvals
- Applicants for manufacturing licenses that don't reference a standard design certification or standard design approval
- Applicants for combined licenses that don't reference a standard design certification, standard design approval, or manufactured reactor

This provision would not apply to applicants with new designs under either 10 CFR Part 50 or 52 prior to the effective date of the final rule. The proposed requirement would also not apply to a combined license or manufacturing license that references a standard design approval, standard design certification, or manufacturing license, as applicable; or renewal of a design certification.

#### *4.2.2.1 Construction Permit Applications*

The NRC staff does not expect any construction permit applications to be submitted over the next 10 years that would be affected by the proposed rule provision. The staff considered construction permit application forecasts beyond 2025 as too speculative for this analysis.

#### *4.2.2.2 Operating License Applications*

The NRC staff does not expect any operating license applications to be submitted over the next 10 years that would be affected by the proposed rule provision.[4] The staff considered forecasts beyond 2025 as too speculative for this analysis.

[4] The Bellefonte Nuclear Power Station is excluded from this proposed rule provision because this proposed requirement would only apply to applicants for new nuclear power designs. Specifically, it would not apply to current holders of permits or certifications for nuclear power plant designs (i.e., holder of a construction permit). Tennessee Valley Authority holds construction permits for Bellefonte Units 1 and 2 in which construction is indefinitely delayed under the Commission Policy Statement on Deferred Plants (52 FR 38077, October 14, 1987).

#### *4.2.2.3 Design Certification Applications*

For design certification applications, this analysis assumes that four applications would be submitted to and reviewed by the NRC. **Error! Reference source not found.**Table 6 presents information on the number and schedule of design certification applications that would be affected by the proposed rule provision.

Table 5 Design Certification Schedule

| Design Certification Applicant | Submittal date | Estimated Issue Date of Design Certification Rule |
|---|---|---|
| EPR | 2008 | 2018 |
| USAPWR | 2008 | 2018 |
| KHNP APR-1400 | 2015 | 2019 |
| NuScale Power | 2016 | 2020 |

[a.] Values from U.S. NRC webpage, "Application Schedule for New Reactors," updated as of 11/21/2014, retrievable at http://www.nrc.gov/reactors/new-reactors.html.

#### *4.2.2.4 Manufacturing License Applications*

The NRC staff does not expect any manufacturing license applications to be submitted over the next 10 years that would be affected by the proposed rule provision. The staff considered forecasts beyond 2025 as too speculative for this analysis.

#### *4.2.2.5 Standard Design Approvals*

The NRC staff does not expect any standard design approval applications to be submitted over the next 10 years that would be affected by the proposed rule provision. The staff considered forecasts beyond 2025 as too speculative for this analysis.

#### *4.2.2.6 Combined License Applications*

The NRC staff assumes that no additional combined license applications will be submitted over the next 10 years that would be affected by the proposed rule provision.[5] The staff considered forecasts beyond 2025 as too speculative for this analysis.

### 4.2.3 Cost Estimating Methodology and Accuracy

To estimate the costs associated for each sub-alternative, the NRC staff used a work breakdown structure approach to deconstruct the proposed rule provision requirements according to required activities. For each required activity, the NRC staff further sub-divided the work across labor categories (i.e., executive, manager, staff, clerical, licensing). The NRC staff

[5] For this regulatory analysis, the staff assumes that the review and license decision for COL applications already submitted to the NRC (i.e., Bell Bend, Calvert Cliffs Unit 3, South Texas Project Units 3 and 4) will be determined before the effective date of the final rule should this proposed rule provision become final. Furthermore, the staff assumes all submitted COL applications reference certified reactor designs or standard design approvals—no custom COLs are expected. COL applications for Comanche Peak Units 3 and 4, Nine Mile Pint Unit 3, and Victoria County Units 1 and 2 are not included in this analysis because the applications have been either suspended or withdrawn.

estimated the required level of effort (LOE) for each labor category for each required activity in order to develop the cost estimate.

For this regulatory analysis, the NRC staff developed an order-of-magnitude estimate for each cost and benefit based on the limited information available. Limited sensitivity analyses and no uncertainty analyses were performed for these initial estimates. These analyses will be included in subsequent updates as the rule package is developed and additional information is available.

#### 4.2.4 Timeframes for Alternatives

The NRC staff assumes that rulemaking activities (including a proposed and final rule and applicable guidance would be completed in fiscal year (FY) 2017. The NRC staff assumes that the proposed rule and associated draft guidance would be issued for public comment in FY 2016 and finalized in FY 2017. If a revised policy statement is prepared and issued, the policy statement would likely be published in FY 2017.

#### 4.2.5 Base Year of Analysis

The base year of this analysis is FY 2015. Therefore, all quantified benefits and costs are inflated or discounted to FY 2015.

#### 4.2.6 Labor Rates

The NRC staff gathered data from several sources to develop level of effort and unit cost estimates. Mean hourly wage rates for various industry labor categories were derived from 2013 Occupational Employment and Wages data and inflated to 2015 dollars using the consumer price index. Depending on the industry and the occupation, an appropriate mean hourly labor wage is selected. The wage is then increased using a multiplier of 2.0 to account for benefits (insurance premiums, pension, and legally required benefits) to calculate the burdened labor rate. Because exact hourly wages are difficult to obtain and may not be sufficiently recent, nationwide mean hourly wages are used.

For all licensee labor, the hourly wage is based on the U.S. Bureau of Labor Statistics (BLS) May 2013 Occupational Employment Statistics and is inflated to FY 2015 dollars using the BLS Consumer Price Index (CPI) inflation calculator to October 2014. Table 6 lists the occupations, their pay, and the source of the information. All of the wages from the BLS were multiplied by a multiplier of 2.0 to calculate the burdened labor rate.

NRC labor rates are determined by the calculation methodology in NUREG/CR-4627, “Generic Cost Estimates,” (Ref. 1). This methodology considers only variable costs that are directly related to the implementation, operation, and maintenance of the analyzed activity. Currently, the NRC hourly labor rate is $124 based on actual FY2014 incomes, fringe benefits, and other indirect expenses.

Table 6 presents the industry wage rates used in this analysis.

Table 6 Wage Rate Estimates by Labor Category

| Labor Category [a] | Mean Wage Rate | Loaded Wage Factor | Loaded Wage Rate |
|---|---|---|---|
| | A | B | C = A x B |
| Industry Executives [b] | $79.82 | | $159.63 |
| Industry Managers | $52.11 | | $104.21 |
| Industry Staff [c] | $41.93 | 2 | $83.85 |
| Industry Clerical Staff [d] | $26.34 | | $52.68 |
| Industry Licensing Staff | $64.36 | | $128.71 |
| NRC Staff | | | $124.00 [e] |

[a] The loaded wage rates for Industry Managers, Industry Staff, and Industry Licensing Staff are based on those used in the NRC MBDBE base regulatory analysis.

[b] The mean wage rate for Industry Executives was calculated as the average of the mean hourly wage (in the Electric Power Generation, Transmission, and Distribution Industry) for Top Executives (SOC 11-1011) and Chief Executives (SOC 11-0000) from BLS.

[c] Sourced from NRC Containment Protection and Release Reduction Rulemaking Public Meeting, 10/14/14. The Mechanical Engineer Technician mean hourly wage.

[d] The mean wage rate for Clerical Staff was calculated as the average of the mean hourly wage (in the Electric Power Generation, Transmission, and Distribution Industry) for Office and Administrative Support Occupations (SOC 43-0000), Office Clerks, General (SOC 43-9061), and First-line Supervisors of Office and Administrative Support Workers (SOC 43-1011) from BLS.

[e] The NRC staff labor rates are estimated to be $124 per hour (2015 dollars) calculated based on actual labor and benefit costs from the prior fiscal year detailed by office and grade.

### 4.2.7 Sign Conventions

The sign convention used in this analysis is that 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 Data

Information on the number of nuclear power plant applications docketed or expected to be submitted to the NRC for approval has been derived from industry announcements.

### 4.2.9 Assumptions

The proposed regulations would apply only to applicants for a combined license under 10 CFR Part 52 that does not reference a standard design approval or standard design certification, a construction permit under 10 CFR Part 50, an operating license under 10 CFR Part 50, a standard design approval under Part 52, a design certification rulemaking under 10 CFR Part 52, or a manufacturing license under 10 CFR Part 52 that does not reference a standard design approval or standard design certification. They would not apply to (1) any permit, certification, or license issued before the effective date of the final rule, (2) to a combined license or manufacturing license that references a standard design approval, standard design certification, or manufacturing license, as applicable; or renewal of a design certification, a license application that incorporates by reference a construction permit, design certification, or manufacturing license.

All alternatives entail continuing the rulemaking that would make Orders EA-12-049 and Order EA-12-051, and industry initiatives generically applicable, and would require severe accident management guidelines (SAMG).

The NRC staff expects that vendors engaged in designing new nuclear power plants will achieve a higher standard of severe accident safety performance than their prior designs and would provide enhanced margins of safety and/or utilize simplified, inherent, passive, or other innovative means to accomplish their safety functions consistent with the Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants and as the NRC reiterated this regulatory approach in its Policy Statement on the Regulation of Advanced Nuclear Power Plants. These concepts apply to all four alternatives. Therefore, the NRC staff assumes that the incremental costs to implement the resulting design features into the plant design are similar for each alternative.

## *4.3 Analysis*

This analysis is based on NRC staff's assessment of the future business scenario for each category of applicant. In each case, only industry and NRC implementation costs would be incurred. Furthermore, because all of the benefits are measured qualitatively in this analysis, only costs are estimated in these subsections.

### 4.3.1 Industry Implementation

#### *4.3.1.1 Alternative 2a: Take no action unique to new reactors entities*

This alternative baseline would amend 10 CFR Part 50 to make the requirements in Order EA-12-049, Order EA 12-051, and industry initiatives generically applicable, while also requiring SAMGs. Under this alternative, the "Policy Statement on the Regulation of Advanced Reactors" (73 FR 60612, October 14, 2008), the "Policy Statement on the Regulation of Advanced Nuclear Power Plants" (59 FR 35461; July 12, 1994), and the "Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants" (50 FR 32138; August 8, 1985) would apply. This alternative baseline includes completing the rulemaking (i.e. complete the proposed rule, analyze public comments, hold public meeting(s), and develop the final rule and regulatory guidance for SAMG-related requirements).

New applicants for new nuclear power reactors could identify and incorporate into their design those design features and functional capabilities that address the effects of beyond-design-basis events. This is consistent with the NRC's historic approach to beyond-design-basis events and with the NRC's position in its "Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants." Within the application, new applicants could explain how the design features incorporated into the plant design enhance the coping durations and minimize reliance on human actions during an ELAP.

The NRC staff would use existing tools, review criteria, and templates to review the licensing application and the acceptability of design features and functional capabilities that address the effects of beyond-design-basis events and prepare and issue a safety evaluation.

This alternative is equivalent to the proposed rule (Alternative 2) status quo and serves as a baseline to measure the costs and benefits against the other identified sub-alternatives.

#### *4.3.1.2 Alternative 2b: Issue guidance for new application and license reviews*

This alternative would develop and issue guidance that would be used by NRC staff in reviewing the acceptability of new reactor applicant design features for maintaining or restoring core cooling, containment, and SFP cooling capabilities during an ELAP concurrent with a LUHS. The guidance would include a structured method by which NRC reviewers would evaluate reactor design features to maintain or restore the key safety functions.

The NRC staff assumes that NEI, EPRI, reactor vendors, and future applicants interested in referencing one of the new reactor designs would follow the development of this guidance, provide feedback during public meetings, and comment on the NRC draft guide when issued for public comment. Costs to perform these activities include procedural and administrative activities.

Table 7 presents the industry labor breakdown and miscellaneous incremental costs to implement this sub-alternative. Table 8 presents the discounted costs. The NRC staff estimates that industry will incur a one-time cost of approximately $0.2 million.

Table 7 Alternative 2b – Industry Implementation Inputs

| Required Activity | Cost Category | Unit Cost | Units | No. of entities involved |
|---|---|---|---|---|
| Review and provide feedback and comments on NRC guidance document | Executive | $160/hr | 50 hrs | 6 |
| | Manager | $104/hr | 100 hrs | 6 |
| | Staff | $84/hr | 150 hrs | 6 |
| | Licensing | $53/hr | 100 hrs | 6 |
| | Travel and miscellaneous expenses | | ($15,224) | |

Table 8 Alternative 2b – Industry Implementation Costs

| Fiscal Year | Activity | Cost (2015 dollars) | | |
|---|---|---|---|---|
| | | Undiscounted | 3% Discount | 7% Discount |
| 2015 | Review and provide feedback and comments on NRC guidance document | $ (151,263) | $ (151,263) | $ (151,263) |
| 2016 | | $ (81,449) | $ (79,077) | $ (76,121) |
| **Total** | | **$ (230,000)** | **$ (230,000)** | **$ (230,000)** |

* Total values are rounded to two significant figures.

#### *4.3.1.3 Alternative 2c: Revise the Regulation of Advanced Reactors Policy Statement*

This alternative would revise the Policy Statement on the Regulation of Advanced Reactors to communicate the Commission expectations that new nuclear reactor designs include design features to address ELAP concurrent with a LUHS.

The NRC staff assumes that NEI, EPRI, reactor vendors, and future applicants interested in referencing one of the new reactor designs would follow the development of this policy statement, provide feedback during public meetings, and comment on the NRC draft policy statement when issued for public comment. Costs to perform these activities include procedural and administrative activities.

Table 9 presents the industry labor breakdown and miscellaneous incremental costs to implement this sub-alternative. Table 10 presents the discounted costs. The NRC staff estimates that industry will incur a one-time cost of approximately $0.4 million.

Table 9 Alternative 2c – Industry Implementation Inputs

| Required Activity | Cost Category | Unit Cost | Units | No. of entities involved |
|---|---|---|---|---|
| Review and provide feedback and comments on revised NRC policy statement document | Executive | $160/hr | 100 hrs | 6 |
| | Manager | $104/hr | 150 hrs | 6 |
| | Staff | $84/hr | 200 hrs | 6 |
| | Licensing | $53/hr | 150 hrs | 6 |
| | Travel and miscellaneous expenses | | ($23,634) | |

Table 10 Alternative 2c – Industry Implementation Costs

| Fiscal Year | Activity | Cost (2015 dollars) | | |
|---|---|---|---|---|
| | | Undiscounted | 3% Discount | 7% Discount |
| 2015 | Review and provide feedback and comments on NRC guidance document | $ (180,630) | $ (180,630) | $ (180,630) |
| 2016 | | $ (126,441) | $ (122,758) | $ (118,169) |
| 2017 | | $ (54,189) | $ (51,078) | $ (47,331) |
| **Total** | | **$ (360,000)** | **$ (350,000)** | **$ (350,000)** |

* Total values are rounded to two significant figures.

#### *4.3.1.4 Alternative 2d: Add Paragraph 50.155(d) in the proposed rule*

In this alternative, the regulations in 10 CFR Part 50 would be amended to require applicants for a construction permit, operating license, design certification, standard design approval, manufacturing license, or combined license to incorporate into the plant design those design features that enhance coping durations and minimize reliance on human actions to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities during an ELAP concurrent with a LUHS. Accordingly, under the proposed 10 CFR 50.155(d), applicants would choose design features by: (1) identifying candidate structures, systems, and components, (2) applying a risk evaluation methodology that includes the identification of scenarios considered, (3) using screening assessment parameters to evaluate candidate design features, and (4) using a systematic screening process to determine the practicality of these candidate design features. The systematic screening process would consider (1) the impact on plant operations,

(2) the benefits achieved through additional hardening, capacity, flexibility, safety margin, or passive and diverse design features, and (3) the costs of these design features. Furthermore, applicants would need to explain how the design features incorporated into the facility design enhance the coping durations and minimize reliance on human operator actions and why the implementation of certain design features would not be practical.

Applicants would need to demonstrate that practical design features were included in their design documentation. As a result, design features incorporated into the design will be subject to the formal change process as described in 10 CFR 50.54, "Conditions of licenses," 10 CFR 50.90, "Application for amendment of license, construction permit or early site permit," or the Part 52 appendix for a design certification. NRC review and approval of an applicant's design features assessment described in the licensing application would be required before issuing a combined license under 10 CFR Part 52 that does not reference a standard design approval or standard design certification, a construction permit under 10 CFR Part 50, an operating license under 10 CFR Part 50, a standard design approval under Part 52, a design certification rulemaking under 10 CFR Part 52, or a manufacturing license under 10 CFR Part 52 that does not reference a standard design approval or standard design certification.

The staff would prepare a new regulatory guide that describes an acceptable method of complying with the requirements for these design features at the design certification, standard design approval, manufacturing license, construction permit, and operating license stages. Development of this guidance would proceed in parallel with the rulemaking—the draft guidance document issued with the proposed rule for public comment and the final guidance document is planned to be published with the final rule.

Table 11 Alternative 2d – Industry Implementation Inputs for each Entity

| Required Activity | Cost Category | Unit Cost | Units | No. of entities involved |
|---|---|---|---|---|
| Review and provide feedback and comments on rule provision | Executive | $160/hr | 40 hrs | 6 |
| | Manager | $104/hr | 80 hrs | 6 |
| | Staff | $84/hr | 200 hrs | 6 |
| | Licensing | $53/hr | 40 hrs | 6 |
| | Travel and miscellaneous expenses | | ($14,113) | |
| Review and provide feedback and comments on NRC guidance document | Executive | $160/hr | 50 hrs | 6 |
| | Manager | $104/hr | 100 hrs | 6 |
| | Staff | $84/hr | 150 hrs | 6 |
| | Licensing | $53/hr | 100 hrs | 6 |
| | Travel and miscellaneous expenses | | ($15,225) | |
| Perform and document design feature assessment | Executive | $160/hr | 150 hrs | 4 |
| | Manager | $104/hr | 300 hrs | 4 |
| | Staff | $84/hr | 1,000 hrs | 4 |
| | Licensing | $53/hr | 500 hrs | 4 |
| | Travel and miscellaneous expenses | | ($46,315) | |

Table 12 Alternative 2d – Industry Implementation Costs

| Fiscal Year | Activity | Cost (2015 dollars) | | |
|---|---|---|---|---|
| | | Undiscounted | 3% Discount | 7% Discount |
| 2015 | Review and provide feedback and comments on draft rule provision | $ (183,368) | $ (183,368) | $ (183,368) |
| 2016 | | $ (32,359) | $ (31,417) | $ (30,242) |
| 2015 | Review and provide feedback and comments on NRC guidance document | $ (116,366) | $ (116,366) | $ (116,366) |
| 2016 | | $ (81,456) | $ (79,083) | $ (76,127) |
| 2017 | | $ (34,910) | $ (32,906) | $ (30,491) |
| 2017 | EPR & APWR perform and document design feature assessment | $ (176,991) | $ (166,831) | $ (154,591) |
| 2018 | | $ (176,991) | $ (161,972) | $ (144,477) |
| 2017 | KHNP perform and document design feature assessment | $ (70,796) | $ (66,732) | $ (61,836) |
| 2018 | | $ (70,796) | $ (64,789) | $ (57,791) |
| 2019 | | $ (35,398) | $ (31,451) | $ (27,005) |
| 2018 | NuScale perform and document design feature assessment | $ (70,796) | $ (64,789) | $ (57,791) |
| 2019 | | $ (70,796) | $ (62,902) | $ (54,010) |
| 2020 | | $ (35,398) | $ (30,535) | $ (25,238) |
| | **Total** | **$ (1,200,000)** | **$(1,100,000)** | **$ (1,000,000)** |

* Total values are rounded to two significant figures.

### 4.3.2 NRC Implementation

#### *4.3.2.1 Alternative 2a: Take no action unique to new reactors entities*

The NRC would incur costs to complete procedural and administrative activities to issue the final rule. These activities include developing and issuing the proposed and final rule, becoming familiar with the owners group's SAMGs, developing SAMG oversight materials, reviewing new scenarios and observing initial drills, as well as revising existing inspection procedures.

As described in the NRC report, "Report to Congress: Advanced Reactor Licensing (Ref. 3), the NRC's advanced reactor program is focused on preparing the agency for reviews of applications related to the design, construction, and operation of advanced reactor. These efforts include engaging reactor designers, potential applicants, and industry in meaningful pre-application interactions. These early discussions between NRC staff and potential applicants can lead to the staff identifying and addressing potential regulatory and technical issues early in the licensing process, which provides an opportunity to stress the importance of integrating the use of risk insights into pre-application activities and minimizing human operator action in response to beyond-design-basis external events.

As new applications are submitted and accepted for review, the NRC would use the new rule and existing policies, procedures and guidance to evaluate the acceptability of the submitted design, including design features for maintaining or restoring core cooling, containment, and SFP cooling capabilities during an ELAP concurrent with a LUHS. The NRC anticipates that these designs will incorporate to a greater extent the Commission's expectation for advanced reactors and the lessons learned from the Fukushima accident.

#### *4.3.2.2 Alternative 2b: Issue guidance for new application and license reviews*

This alternative would develop and issue guidance that would be used by NRC staff in reviewing the acceptability of new reactor applicant design features for maintaining or restoring core cooling, containment, and SFP cooling capabilities during an ELAP concurrent with a LUHS. The guidance would include a structured method by which NRC reviewers would evaluate these design features in concert with portable equipment and operator actions as part of the mitigation strategies.

Table 13 Alternative 2b: NRC Implementation Costs

| Fiscal Year | Activity | Cost (2015 dollars) | | |
|---|---|---|---|---|
| | | Undiscounted | 3% Discount | 7% Discount |
| 2015 | Prepare and issue draft guide | $ (38,921) | $ (38,921) | $ (38,921) |
| 2016 | | $ (25,947) | $ (25,191) | $ (24,250) |
| 2017 | Issue final regulatory guide | $ (21,623) | $ (20,381) | $ (18,886) |
| **Total** | | **$ (86,000)** | **$ (84,000)** | **$ (82,000)** |

* Total values are rounded to two significant figures.

#### *4.3.2.3 Alternative 2c: Revise the Regulation of Advanced Reactors Policy Statement*

This alternative would revise the Policy Statement on the Regulation of Advanced Reactors to describe the Commission's policy to resolve safety issues for events more severe than design basis accidents that challenge maintaining or restoring core cooling, containment, and SFP cooling capabilities. The staff would prepare and issue a draft policy statement for public comment followed by issuing the final policy statement.

Table 14 Alternative 2c: NRC Implementation Costs

| Fiscal Year | Activity | Cost (2015 dollars) | | |
|---|---|---|---|---|
| | | Undiscounted | 3% Discount | 7% Discount |
| 2015 | Prepare and issue draft policy statement | $ (102,337) | $ (102,337) | $ (102,337) |
| 2016 | | $ (68,225) | $ (66,238) | $ (63,761) |
| 2017 | Issue final policy statement | $ (56,854) | $ (53,590) | $ (49,658) |
| **Total** | | **$ (230,000)** | **$ (220,000)** | **$ (220,000)** |

* Total values are rounded to two significant figures.

#### *4.3.2.4 Alternative 2d: Add Paragraph 50.155(d) in the proposed rule*

This alternative would amend 10 CFR Part 50 to require applicants for a construction permit, operating license, design certification, standard design approval, manufacturing license, or combined license to incorporate into the plant design those design features that enhance coping durations and minimize reliance on human actions to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities during an ELAP concurrent with a LUHS.

Table 15 Alternative 2d – NRC Implementation Costs

| Fiscal Year | Activity | Cost (2015 dollars) | | |
|---|---|---|---|---|
| | | Undiscounted | 3% Discount | 7% Discount |
| 2015 | Draft rule provision and issue for public comment | $ (42,160) | $ (42,160) | $ (42,160) |
| 2016 | | $ (7,440) | $ (7,223) | $ (6,953) |
| 2017 | Finalize rule provision | $ (7,440) | $ (7,013) | $ (6,498) |
| 2015 | Prepare and issue draft guide | $ (38,921) | $ (38,921) | $ (38,921) |
| 2016 | | $ (25,947) | $ (25,191) | $ (24,250) |
| 2017 | Issue final regulatory guide | $ (21,623) | $ (20,381) | $ (18,886) |
| 2017 | Develop NRC staff reviewer guidance for design feature assessment review | $ (86,490) | $ (81,525) | $ (75,544) |
| 2017 | Review EPR & APWR design feature assessments and issue SERs | $ (56,854) | $ (53,590) | $ (49,658) |
| 2018 | | $ (56,854) | $ (52,029) | $ (46,410) |
| 2017 | Review KHNP design feature assessment and issue SER | $ (22,742) | $ (21,436) | $ (19,863) |
| 2018 | | $ (22,742) | $ (20,812) | $ (18,564) |
| 2019 | | $ (11,371) | $ (10,103) | $ (8,675) |
| 2018 | Review NuScale design feature assessment and issue SER | $ (22,742) | $ (20,812) | $ (18,564) |
| 2019 | | $ (22,742) | $ (20,206) | $ (17,349) |
| 2020 | | $ (11,371) | $ (9,809) | $ (8,107) |
| | **Total** | **$ (460,000)** | **$ (430,000)** | **$ (400,000)** |

* Total values are rounded to two significant figures.

### 4.3.3 Qualitative Benefits and Costs

The following discussion provides a discussion of the tradeoffs for pursuing any of the sub-alternatives identified in this analysis.

<u>How important is implementing any of the sub-alternatives in minimizing reliance on human actions during an ELAP concurrent with a LUHS for new reactor designs?</u>

For advanced reactor technologies, it is important to note that the characteristics of advanced reactors have evolved over past decades, and the NRC expects that this evolution will continue. However, the NRC's regulatory expectations regarding advanced reactors remain clear. The Commission's Policy Statement on the Regulation of Advanced Reactors states the following:

> Regarding advanced reactors, the Commission expects, as a minimum, at least the same degree of protection of the environment and public health and safety and the common defense and security that is required for current generation light-water reactors [i.e., those licensed before 1997]. Furthermore, the Commission expects that advanced reactors will provide enhanced margins of safety and/or use simplified, inherent, passive, or other innovative means to accomplish their safety and security functions.[6]

This policy was carried forward to the Generation III+ reactor designs (i.e., LWR designs such as the AP1000 and the Economic Simplified Boiling-Water Reactor and is communicated to all potential licensing applicants and stakeholders.

The inclusion of additional regulatory footprint through revising the policy statement (Alternative 2c) or adding new rule provision for new applicants (Alternative 2d) may have diminishing marginal returns in increased plant safety for the costs to achieve this increase.

<u>Does establishing new reactor requirements in proposed paragraph 50.155(d) further incentivize reactor designers to incorporate designs less reliant on human operator actions that result in a safer plant?</u>

This is a difficult question to answer but is not considered likely for the following reasons:

- The design features that would result from proposed § 50.155(d) may only be beneficial when an ELAP combined with the loss of the ultimate heat sink and the resulting loss of key safety functions occur, a very low probability event particularly with regard to new reactors that are sited and designed robustly for external events as further discussed below.

- These design features would principally benefit the mitigation of an ELAP event before core damage occurs. This is the same objective that EA-12-049 requires but which allows for operator actions.

- The likelihood of a new reactor experiencing those conditions is extremely low. The likelihood that an internal event leads to an ELAP condition is almost certainly less that $10^{-7}$ per reactor-year. The likelihood that an external event leads to this condition is also extremely unlikely and probably also on the order of $10^{-7}$ per reactor year due to robust siting and external event design.[7] Such an event must first occur and result in loss of the key functions.

[6] U.S. Nuclear Regulatory Commission, "Policy Statement on the Regulation of Advanced Reactors," 73 FR 60612 (October 14, 2008), page 60615

[7] For example, a beyond-design-basis external flood or seismic event would require an event exceeding RG 1.59 or an earthquake that is greater than 1.67 times SSE, respectively.

- These design features only have a net benefit if they substantially reduce plant risk when measured against the base case which incorporates the MBDBE final rule, the Order EA-12-049 type mitigation, and the evolutionary type of improvements expected under the policy statement on the regulation of advanced reactors (73 FR 60612). The design features would need to result in the prevention of more of these beyond-design-basis events leading to core damage. While these design features may reduce plant risk, it is not expected that this reduction would be significant, considering the risk profile for new reactors is significantly lower than that of operating reactors (approximately two orders of magnitude).

- The new design features may introduce new risk challenges through the incorporation of added equipment and control interlocks. The addition of new equipment may result in marginal improvements due to equipment failures when exposed to these beyond-design-basis challenges. A designer would need to consider whether any new equipment would introduce associated equipment failure rates that then must be weighed against a design that relies more on human action for mitigation. In other words, the equipment failure rates must be assessed versus human failure rates. As discussed above, the differences are not expected to result in a significant reduction in risk.

### 4.3.4 Totals

Table 16 summarizes the incremental quantified benefits and costs as compared to the baseline.

Table 16 Summary of Quantified Costs and Benefits

| Alternative No. | Description | Total Costs | | |
|---|---|---|---|---|
| | | One -Time Cost | Present Value (7 percent) | Present Value (3 percent) |
| 2a | Take no action unique to new reactors entities | 0 | 0 | 0 |
| 2b | Issue guidance for new application and license reviews | $ (320,000) | $ (310,000) | $ (310,000) |
| 2c | Revise the Regulation of Advanced Reactors Policy Statement | $ (590,000) | $ (580,000) | $ (560,000) |
| 2d | Add Paragraph 50.155(d) in the proposed rule | $ (1,600,000) | $ (1,500,000) | $ (1,400,000) |

* Values are rounded to two significant figures.

### 4.3.5 Disaggregation

The NRC staff has evaluated the alternatives to determine whether specific requirements have to be considered separately, but has determined that the requirements are narrowly focused, meaning the benefits and costs can be reasonably and practically evaluated, and disaggregation would not result in the meaningful implications on the analysis results. Therefore, the analysis of disaggregated requirements is not appropriate.

## 5 Decision Rationale

As discussed in this regulatory analysis, none of the regulatory alternatives are expected to result in a significant safety enhancement for a new reactor design, largely as a result of the already low risk associated with new reactors. All of the alternatives, with the exception of

alternative 2a, would result in incremental costs, with the highest estimated cost being for alternative 2d which is the proposed MBDBE rule (i.e., the addition of 10 CFR 50.155(d)). As such, this analysis would tend to support the lower costs alternatives. However, the NRC staff recommends that, before this decision is reached, the Commission consider stakeholder feedback on the issue. Of particular importance would be the views of reactor designers, and whether they believe that safety enhancements can be achieved (i.e., is it possible to achieve the objective of the new reactor policy for this application), and if so, what approach should be taken.

# 6 Implementation

The MBDBE final rule is expected to be issued in 2017. Several design certification applications are expected to be submitted or under review around that time. The staff would take steps to keep potential applicants aware of the development of this proposed rule and its associated implementation guidance through pre-application interactions with the applicants. Additionally, potential near-term applicants (i.e., applications filed up to 6 months after the effective date of the rule) would have had the opportunity to review the proposed *Federal Register* document and the draft rule language on the NRC's rulemaking web site.

For applications filed after the effective date of the final rule, the design features would be required to be included described in the application. However, if an application is expected to be submitted within 6 months of the effective date of the rule, the NRC could decide whether the applicant could describe the design features in a subsequent revision to its application. Normally, an incomplete application would not be accepted for docketing. If this circumstance is expected to occur, the staff believes it is reasonable to provide time for the applicant to perform the assessment and incorporate the design features in the application. This process would allow the staff to begin reviewing the application, while the applicant completes the design process for determining the appropriate design features.

# 7 References


1. U.S. Nuclear Regulatory Commission, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," NUREG/BR-0058, Revision 4, September 2004, ADAMS Accession No. ML042820192.

2. U.S. Nuclear Regulatory Commission, "Generic Cost Estimates," NUREG/CR-4627, Revision 2, January 1992, ADAMS Accession No. ML13137A259.

3. U.S. Nuclear Regulatory Commission, "Report to Congress: Advanced Reactor Licensing," August 2012, ADAMS Accession No. ML12153A014.