ENVIRONMENTAL ASSESSMENT BY THE

U.S. NUCLEAR REGULATORY COMMISSION

RELATING TO THE CERTIFICATION OF THE

ESBWR STANDARD PLANT DESIGN

DOCKET NO. 52-010

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UNITED STATES NUCLEAR REGULATORY COMMISSION

ENVIRONMENTAL ASSESSMENT AND FINDING OF

NO SIGNIFICANT IMPACT

RELATING TO THE CERTIFICATION OF THE

ESBWR STANDARD PLANT DESIGN

DOCKET NO. 52-010

The U.S. Nuclear Regulatory Commission (NRC) is proposing a design certification for the Economic Simplified Boiling-Water Reactor (ESBWR) design in response to an application submitted on August 24, 2005, by GE-Hitachi Nuclear Energy (GEH). A design certification is a rulemaking; the NRC has decided to adopt design certification rules (DCRs) as appendices to Part 52 of Title 10 of the *Code of Federal Regulations* (10 CFR), "Licenses, Certifications, and Approvals for Nuclear Power Plants."

The NRC has performed the following environmental assessment (EA) of the environmental impacts of the proposed rule and has documented its finding of no significant impact in accordance with the requirements of 10 CFR 51.21 and the National Environmental Policy Act of 1969, as amended (NEPA). This EA addresses the severe accident mitigation design alternatives (SAMDAs) that the NRC has considered as part of this EA for the ESBWR design. This EA does not address the site-specific environmental impacts of constructing and operating any facility that references the ESBWR design certification at a particular site; those impacts will be evaluated as part of any application or applications for the siting, construction, or operation of such a facility.

As discussed in Section 4.0 of this EA, the NRC has determined that issuing this design certification does not constitute a major Federal action significantly affecting the quality of the human environment. This finding is based on the generic finding made in 10 CFR 51.32(b)(1) that there is no significant environmental impact associated with certification of a standard

design under 10 CFR Part 52, Subpart B, “Standard Design Certifications.” The action would not authorize the siting, construction, or operation of a facility using the ESBWR design. Rather, it would merely codify the ESBWR design in a rule that could be referenced in a future combined license (COL) application. Furthermore, because the certification is a rule rather than a physical action, it would not involve commitment of any resources that have alternative uses. As explained in the statements of consideration for “Licenses, Certifications, and Approvals for Nuclear Power Plants; Final Rule,” (72 FR 49352, 49427; August 28, 2007), the 10 CFR 51.32(b)(1) generic finding of no significant impact is legally equivalent to a categorical exclusion. Therefore, the NRC has not prepared an environmental impact statement (EIS) for the action.

Under 10 CFR 51.30(d), an EA for a design certification must identify the proposed action and is otherwise limited to consideration of the costs and benefits of SAMDAs and the bases for not incorporating SAMDAs in the design certification. As discussed in Section 4.0 of this EA, the NRC also reviewed GEH’s assessment of SAMDAs that generically apply to the ESBWR design and finds the GEH assessment considered a reasonable set of SAMDAs, and no additional SAMDAs beyond those currently incorporated into the ESBWR design are cost-beneficial. This finding applies whether SAMDAs are considered at the time of the certification of the ESBWR standard design or in connection with the licensing of a future facility referencing the ESBWR DCR; (10 CFR Part 52, Appendix E); provided that the plant referencing the ESBWR DCR is located on a site whose site characteristics fall within the postulated site parameters in NEDO-33306, Revision 4, Licensing Topical Report, “ESBWR Severe Accident Mitigation Design Alternatives,” issued October 2010 (ADAMS Accession No. ML102990433). These issues are considered resolved for the ESBWR design.

ENVIRONMENTAL ASSESSMENT

1.0 Identification of the Proposed Action

The proposed action is to issue a rule to certify the ESBWR design in Appendix E to 10 CFR Part 52. The new rule allows applicants to reference the certified ESBWR design as part of a COL application under 10 CFR Part 52.

2.0 The Need for the Proposed Action

The proposed action is to issue a rule amending 10 CFR Part 52 to certify the ESBWR design. The amendment allows an applicant to reference the certified ESBWR design as part of a COL application under 10 CFR Part 52. Those portions of the ESBWR design included in the scope of the certification rulemaking are not subject to further safety review or approval in a COL proceeding. In addition, the DCR could eliminate the need to consider SAMDAs in connection with any future applications for facilities that reference the certified ESBWR design, in accordance with 10 CFR 51.50(c)(2).

3.0 The Environmental Impact of the Proposed Action

The proposed action constitutes issuance of an amendment to 10 CFR Part 52 to certify the ESBWR standard plant design. As stated in 10 CFR 51.32(b)(1), the NRC has determined that there is no significant environmental impact associated with issuance of a design certification. The amendment would merely codify the NRC's approval of the ESBWR design through its final safety evaluation report (FSER) on the design and any FSER supplement issued during rulemaking (refer to NUREG-1966, "Final Safety Evaluation Report Related to the Certification of the Economic Simplified Boiling-Water Reactor Standard Design"). Furthermore, because the certification of the design constitutes only a rule rather than a physical action, it would not involve the commitment of any resources that have alternative uses.

As described in Section 4.0 of this EA, the NRC reviewed alternative design features for preventing and mitigating severe accidents. NEPA requires consideration of alternatives to show that the DCR is the appropriate course of action. NRC regulations at 10 CFR 51.55(a)

ensure that the design referenced in rulemaking does not exclude any cost-beneficial design changes related to the prevention and mitigation of severe accidents.

Through its own independent analysis, the NRC concludes that GEH adequately considered an appropriate set of SAMDAs and that none were cost beneficial. Although GEH made no design changes as a result of considering SAMDAs, GEH had already incorporated certain features in the ESBWR design on the basis of probabilistic risk assessment (PRA) results. Section 4.2 of this EA gives examples of these features. These design features relate to severe accident prevention and mitigation, but were not considered in the SAMDA evaluation because they were already part of the ESBWR design (refer to Sections 19.3.1 and 19.3.2 of the design control document (DCD), “Severe Accident Preventative Features” and “Severe Accident Mitigative Features,” respectively).

Finally, the DCR by itself does not authorize the siting, construction, or operation of a nuclear power plant. An applicant for an early site permit or COL that references the ESBWR design will be required to address the environmental impacts of construction and operation at a specific site. The NRC will then evaluate the environmental impacts and issue an EIS in accordance with 10 CFR Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions.” However, the SAMDA analysis that has been completed as part of this EA can be incorporated by reference into an EIS related to an application for siting, construction, or operation of a nuclear plant that references the ESBWR design.

4.0 Severe Accident Mitigation Design Alternatives

The proposed action provides finality in licensing proceedings on an application referencing the ESBWR DCR and proposing a plant located on a site whose site characteristics fall within the postulated site parameters in NEDO-33306.

4.1 Severe Accident Mitigation Design Alternatives

Consistent with the objectives of standardization and early resolution of design issues, the Commission decided to evaluate SAMDAs as part of the design certification for the ESBWR design. In a 1985 policy statement (50 Fed. Reg. 32,138; August 8, 1985), the Commission defined the term severe accident as an event that is beyond the substantial coverage of design-basis events, including events where there is substantial damage to the reactor core (whether or not there are serious offsite consequences). Design-basis events are events analyzed in accordance with the NRC's Standard Review Plan (NUREG-0800) and documented in Chapter 15, "Safety Analyses," of the DCD.

As part of its design certification application, GEH performed a PRA for the ESBWR design to achieve the following objectives:

- Identify the dominant severe accident sequences, which are those that account for most of the core damage frequency (CDF) and associated source terms for the design.
- Modify the design, on the basis of PRA insights, to prevent severe accidents or mitigate their consequences and thereby reduce the risk of such accidents.
- Provide a basis for concluding that all reasonable steps have been taken to reduce the chances of occurrence, and mitigate the consequences, of severe accidents.

GEH's PRA analysis is described in Chapter 19 of the ESBWR DCD.

In addition to these safety considerations, applicants for reactor design certification or COLs must also consider alternative design features for severe accidents in the context of the NRC's environmental review. These requirements can be summarized as follows:

- 10 CFR 52.79 requires a COL applicant to perform a plant/site-specific PRA, the aim of which is to seek such improvements in the reliability of core and containment heat removal systems as are significant and practical and do not impact excessively on the plant.

- 10 CFR 51.30(d) requires consideration of SAMDAs in an EA for a design certification, while 10 CFR 51.50(c) sets forth the general requirements for an environmental report accompanying a COL application, which include the requirement to evaluate SAMDAs.

Although these requirements are not directly related, they share common purposes, which are to consider alternatives to the proposed design, to evaluate whether potential alternative improvements in the plant design might enhance safety performance during severe accidents, and to prevent reasonable alternatives from being foreclosed.

The NRC has determined that generic evaluation of SAMDAs for the ESBWR standard design is both practical and warranted for two significant reasons. First, the design and construction of all plants referencing the certified ESBWR design will be governed by the rule certifying a single design. Second, the site parameters in NEDO-33306 establish the consequences for a reasonable enveloping set of SAMDAs for the ESBWR design. The low residual risk of the ESBWR design and the limited potential for further risk reduction provides high confidence that additional cost-beneficial SAMDAs would not be found for sites within the site parameter envelope. If an actual characteristic for a particular site does not fall within the postulated site parameters, then SAMDAs that could be materially affected by the value of the site characteristic must be re-evaluated in the site-specific environmental report and the EIS prepared in connection with the application. If the actual characteristics of a proposed site fall within the postulated site parameters, then the SAMDA analysis can be incorporated by reference in the site-specific EIS and SAMDAs need not be re-evaluated in the EIS.

4.2 Potential Design Improvements Identified by GEH

In NEDO-33306, Revision 4, Licensing Topical Report, “ESBWR Severe Accident Mitigation Design Alternatives,” issued October 2010, the applicant identified 177 candidate design alternatives based on a review of design alternatives for other plant designs, including the license renewal environmental reports and the GEH Advanced Boiling-Water Reactor (ABWR) SAMDA study. The applicant eliminated certain design improvements from further

consideration on the basis that the ESBWR design already incorporates them. The following are examples of design enhancement features currently included in the design:

- improved isolation condenser design
- automatic depressurization valves
- alternating current (ac)-independent fire water pumps for makeup and injection
- passive containment cooling system
- basemat internal melt arrest and coolability device and gravity-driven cooling system deluge function
- improved direct current (dc) power reliability
- improved actuation logic reliability
- motor-driven feedwater pumps
- water pool above drywell head
- high containment ultimate strength and maximum design pressure
- incorporation of flood mitigation into design
- reactor water clean-up heat exchanger sized for decay heat removal
- 72-hour coping period for station blackout (SBO)
- upgraded low-pressure piping for the reactor coolant pressure boundary
- digital instrumentation and controls

The applicant's screening process eliminated 39 potential alternatives as being inapplicable, 71 design alternatives were considered to be similar to those already included in the ESBWR design, 28 items were marked as procedural or administrative as opposed to design features (whose benefits were considered to be unlikely to exceed those of alternatives evaluated relative to their potentially high costs), and 37 items were ruled out for cases where other design features already perform the proposed function or obviate its need. The applicant assessed the remaining two items and determined them to have very low benefit because their insignificant contribution to reducing risk did not outweigh their excessive implementation costs.

4.3 NRC Evaluation of Potential Design Improvements

The set of potential design improvements considered for the ESBWR includes those from generic boiling-water reactor (BWR) severe accident mitigation alternatives reports and

from the ABWR design. The ESBWR design already incorporates several design enhancements relative to severe accident mitigation. These design improvements have resulted in a CDF that is about an order of magnitude less than that of the ABWR design. For example, the ESBWR design can cope with an SBO for 72 hours (i.e., no reliance on ac power for the first 72 hours), eliminating CDF sequences that contributed more than 40 percent of CDF in the ABWR design.

The NRC has concluded that the applicant's assessment of the potential SAMDAs and their impacts on the ESBWR design is acceptable. The NRC's review did not reveal any additional design alternatives that the applicant should have considered.

4.4 Risk Reduction Potential of SAMDAs

4.4.1 GEH Evaluation

The applicant assumed that each design alternative would work perfectly to completely eliminate all severe accident risk from evaluated internal events. This assumption is conservative as it maximizes the benefit of each design alternative. In NEDO-33306, the applicant reported results from the ESBWR Level 3 PRA, namely, an annual offsite population dose risk (W_{pha}) of 0.035 sievert per year and a maximum averted public exposure cost of $194,740. The applicant estimated the public exposure design alternative benefits on the basis of the reduction of risk expressed in terms of whole body person-rem per year received by the total population within an 80-kilometer (50-mile) radius of an ESBWR plant site.

The applicant used the cost-benefit methodology found in NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook," issued in 1997, to calculate the maximum attainable benefit associated with completely eliminating all risk for the ESBWR. This methodology considers averted onsite and replacement power costs. The applicant estimated the present worth of eliminating all severe accident risk to be approximately $397,863.

The applicant's risk reduction estimates are based on mean values of release frequencies and best-estimate parameter values, without consideration of uncertainties in CDF

or offsite consequences. Even though this approach is consistent with that used in previous design alternative evaluations, further consideration of these factors could lead to significantly higher risk reduction values, given the extremely small CDF and risk estimates in the baseline PRA. In assessing the risk reduction potential of design improvements for the ESBWR, the NRC staff has based its evaluation on the applicant's risk reduction estimates for the various design alternatives, in conjunction with an assessment of the potential impact of uncertainties on the results. Section 4.4.2 discusses this assessment further.

4.4.2 NRC Evaluation

The applicant's estimates of risk do not account for uncertainties either in CDF or in offsite radiation exposures resulting from a core damage event. The uncertainties in both of these key elements are fairly large because key safety features of the ESBWR design are unique, and with the features already incorporated in the ESBWR design, the ability to estimate CDF and risk approaches the limitations of probabilistic techniques. In view of the limits of PRA techniques, and because site-specific factors do not affect the uncertainties in CDF values and CDF is very low on an absolute scale as compared to currently operating plants, further evaluation of such uncertainties is not warranted.

For external events, GEH's analysis only includes high winds; however, the contribution to the CDF from external events not yet accounted for in the SAMDA analysis is not likely to be significant enough to cause a SAMDA that has previously been considered to become cost beneficial. While external events and accident sequences not yet accounted for in the SAMDA analysis may increase the total CDF in the plant-specific PRAs, the CDF for the design is very low, and the costs and benefits of SAMDAs that relate to the risk from external events are comparable to those of the SAMDAs related to internal risk evaluated in this EA. Any increase in CDF in a plant-specific PRA would not likely alter these facts. Accordingly, and in view of the features already incorporated in the ESBWR design and the margin between the cost of SAMDAs evaluated and their potential benefits, as described below, SAMDAs that relate to the

risk from external events are not cost-beneficial now, and are not likely to become cost beneficial based on a plant-specific PRA.

4.5 Cost Impacts of Candidate SAMDAs

4.5.1 GEH Evaluation

NEDO-33306 assessed the capital cost associated with two design alternatives evaluated by the applicant for the ESBWR. For both design alternatives, the implementation cost would be over $1 million, which is much greater than the maximum averted benefit, making any additional design modifications costly as compared to any potential benefits.

4.5.2 NRC Evaluation

On the basis of the analyses performed by GEH, the NRC has concluded that the applicant's assertion of potential costs for the ESBWR as acceptable because it is reasonable to conclude that the cost of implementing (design, procurement, installation, testing, etc.) the design alternatives that were considered, such as constructing a building connected to the containment building or installing limit switches on all containment isolation valves, would far exceed GEH's $1 million minimum cost estimate.

4.6 Cost-Benefit Comparison

4.6.1 GEH Evaluation

The methodology used by GEH was based primarily on the NRC's guidance for performing cost-benefit analysis outlined in NUREG/BR-0184. The guidance involves determining the net value for each SAMDA according to the following formula:

Net Value = (APE + AOC + AOE + AOSC) - COE

Where:

APE	= present value of averted public exposure ($)
AOC	= present value of averted offsite property damage costs ($)
AOE	= present value of averted occupational exposure costs ($)
AOSC	= present value of averted onsite costs ($). This includes cleanup and decontamination and long-term replacement power costs.
COE	= cost of enhancement ($)

If the net value of a SAMDA is negative, the cost of implementing the SAMDA is larger than the benefit associated with the SAMDA and it is not considered to be cost beneficial. Table 4.6-1 summarizes the applicant's and the NRC's estimates of each of the associated cost elements.

The NRC issued Revision 4 of NUREG/BR-0058, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," in August 2004, to reflect the agency's policy on discount rates. NUREG/BR-0058, Revision 4, states that two sets of estimates should be developed —one at 3 percent and one at 7 percent. The applicant provided estimates using a 3-percent discount rate, since it represented a more conservative estimate.

Table 4.6-1 Summary of Estimated Averted Costs

Quantitative Attributes		**Present Value Estimate ($)**		
		NRC Best Estimate [a]	**GEH Maximum** [b]	**NRC Maximum** [c]
Health	Public	100,000 [d]	194,740	197,720 [d]
	Occupational	56	249	250
Property	Offsite	27,200 [d]	53,720 [d]	53,770 [d]
	Onsite	NA [e]	NA [e]	NA [e]
Cleanup and Decontamination	Onsite	1,710	4,674	4,060
Replacement Power		4,520	144,480	148,020
Total		**133,486**	**397,863**	**403,820**

[a] "Best estimate" is based on mean release frequency and "best estimate" parameter values.

[b] Maximum estimate is based on mean release frequency (from Revision 5 of the PRA), high estimate parameter values, and a 3-percent discount rate.

[c] NRC maximum is based on parameter values used in b, release frequency (from Revision 5 of the PRA), and a 3-percent discount rate.

[d] Estimated using the applicant-provided Electric Power Research Institute Advanced Light-Water Reactor Utilities Requirement Document, property damage, and the new release category frequencies.

[e] Not Analyzed.

It is important to note that the monetary present value estimate for each risk attribute does not represent the expected reduction in risk resulting from a single accident. Rather, it is the present value of a stream of potential losses extending over the projected lifetime (in this case, 60 years) of the facility. Therefore, it reflects the expected annual loss resulting from a single accident, the possibility that such an accident could occur at any time over the licensed life, and the effect of discounting these potential future losses to present value.

As indicated above, the applicant estimated the total present dollar value equivalent associated with complete elimination of severe accidents at a single ESBWR unit site to be $397,863. The estimated averted health exposure has the largest effect on the averted cost. For any SAMDA to be cost beneficial, the enhancement cost must be less than $397,863. Based on this, the applicant concluded that none of the SAMDA candidates are cost beneficial.

4.6.2 NRC Evaluation

The NRC's analyses of the total present value using the mean CDF and release frequencies from Revision 5 of the PRA and a 3-percent discount rate indicate a maximum value of about $403,820. This compares well to the GEH estimate of the maximum benefit from the elimination of all CDF of $397,863. Accordingly, the NRC concludes that the GEH estimate of maximum benefit from any SAMDA is reasonable.

The estimated averted health exposure is a major contributor to the estimated benefits. This arises from relatively high release frequencies for internal and high-wind events during shutdown. The high releases are assumed because the containment would be open during most of the shutdown period. Additionally, if one were to adjust annual replacement power cost for future energy cost increase, the total present dollar value would be even higher. Nonetheless, CDF is very low on an absolute scale as compared to currently operating plants. Moreover, in view of the features already incorporated in the ESBWR design and the margin between the cost of SAMDAs evaluated and their potential benefits, any increase in benefits due to increased replacement power costs would not be significant enough to render any

SAMDAs evaluated in this EA cost-beneficial. Therefore, further evaluation of future energy cost increases is not warranted.

GEH indicated that any of the potential design modifications considered would cost a minimum of $1 million to implement, as indicated above. As described in Section 4.5.2 of this EA, the NRC concluded that the GEH estimate of $1 million per modification is conservative. The minimum cost of $1 million is approximately 2.5 times the maximum benefit of $397,863, and therefore, the NRC agrees with the applicant's conclusion that none of the potential design modifications evaluated could be justified on the basis of cost-benefit considerations. The NRC further concludes that it is unlikely that any other design changes would be justified at any particular site on the basis of person-rem exposure considerations because the estimated CDF would remain very low on an absolute scale.

4.7 Conclusions on SAMDAs

As discussed in Section 19.1, "Introduction," of the ESBWR FSER, the applicant made extensive use of the results of the PRA to arrive at a final ESBWR design. As a result, the estimated CDF and risk calculated for the ESBWR design are very low. The low CDF and risk for the ESBWR design are a reflection of the applicant's efforts to systematically minimize the effect of initiators/sequences that have been important contributors to CDF in previous BWR PRAs. This minimization has been done largely through the incorporation of a number of hardware improvements in the ESBWR design. Section 19.1 of the ESBWR FSER discusses these improvements and the additional ESBWR design features that contribute to low CDF and risk for the ESBWR.

Because the ESBWR design already contains numerous plant features directed toward reducing CDF and risk, the benefits and risk reduction potential of additional plant improvements is significantly reduced. This reduction is true for both internally and externally initiated events. Moreover, with the features already incorporated in the ESBWR design, the ability to estimate CDF and risk approaches the limitations of probabilistic techniques.

The NRC concludes that none of the potential design modifications evaluated is justified on the basis of cost-benefit considerations. The NRC further concludes that it is unlikely that any other design changes would be justified in the future on the basis of person-rem exposure because the estimated CDFs are very low on an absolute scale.

5.0 Public Comments and NRC Responses

On March 24, 2011 (76 FR 16549), the NRC issued the draft EA for public comment. The comment period expired on June 7, 2011, and the NRC considered any public comments submitted on or before July 31, 2011. The NRC received public comments related to the draft EA, but those comments did not include anything to suggest that i) a rule certifying the ESBWR standard design would be a major Federal action, or ii) the SAMDA evaluation omitted a design alternative that should have been considered or incorrectly considered the costs and benefits of the alternatives it did consider. Therefore, no changes were made to the final EA.

6.0 Finding of No Significant Impact

On the basis of the EA, the NRC concludes that the proposed agency action – issuance of a final design certification rule for the ESBWR – will not have a significant effect on the quality of the human environment. Accordingly, the NRC has decided not to prepare an EIS for the proposed action.

For further details with respect to the proposed action, see the design certification final rule and the documents referenced in the *Federal Register* notice for the final rule (ADAMS Accession No. ML111730446). Documents may be examined, and/or copied for a fee, at the NRC's Public Document Room (PDR), located at One White Flint North, 11555 Rockville Pike (first floor), Rockville, Maryland, 20852. Publicly available records will be accessible electronically from the ADAMS Public Electronic Reading Room on the NRC Web site at http://www.nrc.gov/reading-rm/adams.html. Persons who do not have access to ADAMS or who encounter problems in accessing the documents in ADAMS should contact the NRC PDR reference staff at 1-800-397-4209 or 301-415-4737 or send an e-mail to pdr.resource@nrc.gov.