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ENHANCED DESIGN FEATURES AGAINST AIRCRAFT IMPACT

BLUE ENERGY GLOBAL, INC.

REVISION 0

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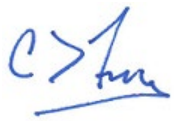
Approver	C.J. Fong VP, Reg Affairs		5/30/25

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Information Notice

This is a non-proprietary version of the Blue Energy (BE) document BE-AIAWP-01-P Revision 0. Portions of this document in the non-proprietary version will indicate the removed information by an open and closed double bracket as shown here: [[ ]].

The design, engineering, and other information contained in this document is furnished for the purpose of obtaining Nuclear Regulatory Commission (NRC) review and determination of acceptability for the Blue Energy Small Modular Reactor design and licensing basis information contained herein. The use of this information by anyone for any purpose other than that for which it is intended is not authorized; and with respect to any unauthorized use, Blue Energy makes no representation or warranty, and assumes no liability as to the completeness, accuracy, or usefulness of the information contained in this document.

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Executive Summary

All nuclear reactors (power) are licensed to operate as utilization facilities under Title 10 in accordance with the Atomic Energy Act (AEA or Act) of 1954. Additional requirements regarding the safe operation of power reactors are provided in 10 CFR Part 50, and 10 CFR Part 52. Blue Energy will submit construction permit and operating license applications.

For modular design nuclear power plants, Title 10, Part 52.47(c)(3) requires an evaluation of the module operating configurations, considering the shared systems and interactions, and interface requirements, as well as identifying any potential restrictions necessary during module construction and startup; similar requirements are included under Title 10, Part 50.34(a)(11) and Part 50.34(b)(6)(xii).

The NRC's "Efficiency" Principle of Good Regulation states, "Where several effective alternatives are available, the option which minimizes the use of resources should be adopted." By applying this principle to the Blue Energy project, Blue Energy will focus its design on ensuring it meets the underlying intent of the applicable Title 10 regulations, which is to provide reasonable assurance of adequate protection of the public health and safety.

This white paper summarizes the enhanced design features of the Blue Energy Global, Inc. (Blue Energy) Integrated Monopile System (IMS) against an aircraft impact. Which include [[ ]]^{adf} prior to any aircraft challenging the containment or core cooling and the spent fuel pool.]]^{abdf}. It will also outline the strategy and approach Blue Energy will implement to request an exemption from requirements in 10 CFR 150, *Aircraft Impact Assessment,* for future license applications under Part 50. The exemption would remove the requirements for performing an assessment of aircraft impact for the Blue Energy IMS. Blue Energy will base the exemption request on the review of a future topical report and its results.

1.0 Introduction

1.1 Purpose

The purpose of this white paper is to demonstrate that the inherent design features of the Blue Energy facility provide robust protection for the nuclear power module against the impact of a large commercial aircraft. The IMS has [[ ]][adf] prior to any aircraft challenging the containment or core cooling and the spent fuel pool. [[ ]][abdf]. In addition, Blue Energy has utilized risk insights to show that the likelihood of such an impact is very low. Specifically, this white paper considers the likelihood of a successful malicious airplane impact as well as the potential consequences.

In accordance with the regulatory requirements of 10 CFR 50.150, *Aircraft Impact Assessment* (Reference 1), applicants must evaluate the potential effects of a large commercial aircraft impact on the facility. The intent is to ensure that design features are in place to maintain key safety functions—specifically core cooling, containment integrity, spent fuel pool integrity, and spent fuel cooling—in the event of such an impact.

By submitting this white paper, Blue Energy is requesting NRC feedback on the facility's inherent design features, which already address aircraft impact requirements and require no further assessment or design modifications. This review will support a future topical report and exemption request.

1.2 Regulatory Strategy

Blue Energy plans to submit a construction permit application for its IMS, which will house a small modular reactor. The intent of this white paper is to provide a basis for a future exemption request from the requirements of 10 CFR 50.150, *Aircraft Impact Assessment*.

In accordance with 10 CFR 50.12, *Specific Exemptions*, Blue Energy will seek an exemption from the requirement in 10 CFR 50.150 that mandates a design-specific assessment of the effects of a large commercial aircraft impact on the facility for future

license applications under Part 50. Specifically, the exemption would relieve Blue Energy from performing a new, design-specific aircraft impact assessment, provided that the future application conforms to the design features and limitations and conditions described in this white paper and affirmed in the NRC's future safety evaluation of a topical report.

The basis for this exemption request is that applying the full requirements of 10 CFR 50.150 in this case is not necessary to achieve the underlying safety objectives of the rule, given the inherent protective features of the Blue Energy design.

2.0 Scope

This white paper addresses the structural design features of the Blue Energy Integrated Monopile System relevant to aircraft impact resilience. The scope of this white paper is limited to demonstrating that the IMS design features inherently satisfy the safety objectives of 10 CFR 50.150 and can serve as the basis for a topical report and future exemption request under 10 CFR 50.12.

3.0 Technical Basis and Methodology

3.1 Background

3.1.1 10 CFR 50.150 Requirements

10 CFR 50.150 (AIA Rule) requires:

"Assessment. Each applicant listed in paragraph (a)(3) shall perform a design-specific assessment of the effects on the facility of the impact of a large, commercial aircraft. Using realistic analyses, the applicant shall identify and incorporate into the design those design features and functional capabilities to show that, with reduced use of operator actions:

(i) The reactor core remains cooled, or the containment remains intact; and

(ii) spent fuel cooling or spent fuel pool integrity is maintained."

Within this rule are the implicit assumptions that:

There is a reasonable threat of malevolent use of a commercial aircraft to target a nuclear facility,

The characteristics of the aircraft are such that:

- they pose a security threat to the nuclear facility;
- the aircraft could hit the nuclear facility, including consideration of the flight skills of a malevolent actor; and
- such an impact of the aircraft on the nuclear facility would cause damage that potentially leads to off-site radiological consequences in excess of NRC limits.

3.1.2 Blue Energy Integrated Monopile System

The Blue Energy IMS is a versatile, technology-neutral design compatible with various reactor types. Its primary advantage is its [[ ]][abdf].

3.2 Technical Evaluation

3.2.1 Supporting Qualitative Analysis

This analysis will leverage risk-informed principles to demonstrate that the inherent design of the IMS meets the underlying intent of the regulation as it pertains to 10 CFR 50.150, *Aircraft Impact Assessment.* The analysis will leverage key principles from Regulatory Guide 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis” (Reference 2), to demonstrate that defense-in-depth is maintained, the likelihood of an aircraft impact

is very low, and the consequences of such an impact would not challenge the key safety functions described in the regulation. In addition, the analysis will leverage the endorsed guidance from Regulatory Guide 1.217, “Guidance for the Assessment of

[[[redacted]

[redacted]

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Beyond-Design-Basis Aircraft Impacts" (Reference 3), and NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs" (Reference 4), to ensure any areas of concern related to an aircraft impact assessment are considered and addressed in this analysis.

3.2.2 Defense-in-Depth Maintained

As discussed above, the IMS is a robust structure [[ ]][adef].

3.2.2.1 Other Considerations

The Blue Energy concept is technology-neutral. The nuclear power module must meet the following conditions to ensure that defense-in-depth is maintained:

- The reactor that will be housed in the IMS [[ ]]

[redacted]]]adef.

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- In the unlikely event of an aircraft impact and subsequent failures of safety related functions to cool the reactor and spent fuel, Blue Energy will still comply with provisions of 10 CFR 50.54(hh) and 10 CFR 50.155. This provides

additional measures to ensure any potential consequences resulting from such an event are mitigated.

3.2.3 Safety Margins

For this application, Blue Energy will be requesting an exemption from the regulatory requirement to perform an assessment of aircraft impact. The exemption will not change the license basis of the facility, and any accidents evaluated for the design of the nuclear power module are bound by those analyses. Therefore, safety margins would be maintained.

3.2.4 Risk Insights

The analysis evaluated a representative sample of various containments licensed in the United States to understand the likelihood of an aircraft impact and the hitability of the Blue Energy IMS. NUREG/CR-5640 “Overview and Comparison of US Commercial Nuclear Power Plants” (Reference 5) contains a comparison of different reactor and containment types. [[

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Figure 3-3 presents a rendering that that emphasizes the compact design of the IMS, illustrating its [[[redacted]]]adf compared to a conventional PWR containment structure. [[[redacted]]]adf.

A key aspect of the Blue Energy concept is the separation of the nuclear island from the balance of plant, enhancing overall safety and flexibility. Additionally, the nuclear power module passive safety features [redacted]]]adf, ensure defense-in-depth is maintained.

3.2.4.1 Other Considerations

The Blue Energy concept is technology-neutral. The nuclear power module must meet the following conditions to ensure risk is sufficiently very low:

- The impact of an aircraft to the IMS [[[redacted]]]adef.

[[[redacted]

]][abf]

3.2.5 Performance Monitoring

Blue Energy will monitor any changes to the design that could impact the assumptions and characteristics defined in this exemption. Those changes will be evaluated and addressed to ensure they do not challenge the conclusions of this evaluation. This will ensure that the conclusions drawn from this evaluation remain valid.

4.0 Regulatory Evaluation

4.1 Applicable Regulatory Requirements

Appendix A to Part 50, General Design Criteria (GDC) for Nuclear Power Plants

10 CFR 50.54(hh), Conditions of License,

(1) Each licensee shall develop, implement and maintain procedures that describe how the licensee will address the following areas if the licensee is notified of a potential aircraft threat:

(i) Verification of the authenticity of threat notifications;

(ii) Maintenance of continuous communication with threat notification sources;

(iii) Contacting all onsite personnel and applicable offsite response organizations;

(iv) Onsite actions necessary to enhance the capability of the facility to mitigate the consequences of an aircraft impact;

(v) Measures to reduce visual discrimination of the site relative to its surroundings or individual buildings within the protected area;

(vi) Dispersal of equipment and personnel, as well as rapid entry into site protected areas for essential onsite personnel and offsite responders who are necessary to mitigate the event; and

(vii) Recall of site personnel.

10 CFR 50.150, Aircraft Impact Assessment, requires:

“Assessment. Each applicant listed in paragraph (a)(3) shall perform a design-specific assessment of the effects on the facility of the impact of a large, commercial aircraft. Using realistic analyses, the applicant shall identify and incorporate into the design those design features and functional capabilities to show that, with reduced use of operator actions:

(i) The reactor core remains cooled, or the containment remains intact; and

(ii) spent fuel cooling or spent fuel pool integrity is maintained.”

The statements of considerations state:

“The NRC regards the aircraft impact and 10 CFR 50.54(hh) rulemakings to be complementary in scope and objective. The aircraft impact rule focuses on enhancing the design of future nuclear power plants to withstand large, commercial aircraft impacts, with reduced use of operator actions. The provisions of 10 CFR 50.54(hh) focus on ensuring that the nuclear power plant's licensees will be able to implement effective mitigation measures for large fires and explosions, including (but not explicitly limited to) those caused by the impact of a large, commercial aircraft.

The final rule requires designers of new facilities to describe how the design features and functional capabilities identified in performance of the aircraft impact assessment show, with reduced use of operator action, that the facility can withstand the effects of an aircraft impact (i.e., that the rule's acceptance criteria are met). Plant structures critical to maintaining facility safety functions should be designed such that an impact does not result in structural failure, and aircraft parts and jet fuel do not enter the structures. In circumstances in which an impact results in aircraft parts and jet fuel entering structures or affecting equipment, plant structures and layouts should be evaluated with respect to maintaining key safety functions (core cooling, containment, spent fuel cooling, and spent fuel pool integrity) by addressing equipment survivability following the entry of aircraft parts and jet fuel. Key safety functions should be accomplished notwithstanding the resulting internal damage from structural loads, shock and vibration, and fire."

This evaluation demonstrates that the Blue Energy IMS design features do not rely on any operator actions, have passive cooling functions, and [[ ]][adf] to prevent structural failure, aircraft parts, and jet fuel from impacting key safety functions inside the IMS. The key safety functions of core cooling, containment, and spent fuel pool integrity are maintained in the unlikely event of an aircraft impact, given the IMS' smaller footprint [[ ]][adf].

10 CFR 50.155, *Mitigation of beyond-design-basis events,* requires in part:

(b) *Strategies and guidelines*. Each applicant or licensee shall develop, implement, and maintain:

(1) Mitigation strategies for beyond-design basis external events—Strategies and guidelines to mitigate beyond-design-basis external events from natural phenomena that are developed assuming a loss of all ac power concurrent with either a loss of normal access to the ultimate heat sink or, for passive reactor designs, a loss of normal access to the normal heat sink. These strategies and guidelines must be capable of being implemented site-wide and must include the following:

(i) Maintaining or restoring core cooling, containment, and spent fuel pool cooling capabilities; and

(ii) The acquisition and use of offsite assistance and resources to support the functions required by paragraph (b)(1)(i) of this section indefinitely, or until sufficient site functional capabilities can be maintained without the need for the mitigation strategies.

(2) Extensive damage mitigation guidelines—Strategies and guidelines to maintain or restore core cooling, containment, and spent fuel pool cooling capabilities under the circumstances associated with loss of large areas of the plant impacted by the event, due to explosions or fire, to include strategies and guidelines in the following areas:

(i) Firefighting;

(ii) Operations to mitigate fuel damage; and

(iii) Actions to minimize radiological release.

(c) *Equipment*.

(1) The equipment relied on for the mitigation strategies and guidelines required by paragraph (b)(1) of this section must have sufficient capacity and capability to perform the functions required by paragraph (b)(1) of this section.

(2) The equipment relied on for the mitigation strategies and guidelines required by paragraph (b)(1) of this section must be reasonably protected from the effects of natural phenomena that are equivalent in magnitude to the phenomena assumed for developing the design basis of the facility.

(d) *Training requirements*. Each licensee shall provide for the training of personnel that perform activities in accordance with the capabilities required by paragraphs (b)(1) and (2) of this section.

(e) *Spent fuel pool monitoring*. In order to support effective prioritization of event mitigation and recovery actions, each licensee shall provide reliable means to remotely

monitor wide-range water level for each spent fuel pool at its site until 5 years have elapsed since all of the fuel within that spent fuel pool was last used in a reactor vessel for power generation. This provision does not apply to General Electric Mark III upper containment pools.

The provisions of 10 CFR 50.155 add additional layers for defense-in-depth to ensure any consequences from an aircraft impact are contained within the limits of 10 CFR Part 20 and 10 CFR Part 100.

4.2 Guidance

Regulatory Guide 1.217 “Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts” describes one acceptable approach to meet the requirements of 10 CFR 50.150 and endorsed industry guidance NEI 07-13 “Methodology for Performing Aircraft Impact Assessments for New Plant Designs.”

NEI 07-13 describes one acceptable method of conducting the aircraft impact assessment to identify any required enhanced design features and functional capabilities that could be needed to ensure the impacts of the aircraft do not prevent the key safety functions of core cooling, containment, spent fuel pool integrity, and spent fuel pool cooling. It’s important to note that the regulations require either core cooling or containment integrity and either spent fuel pool cooling or spent fuel pool integrity to be maintained. The guidance delineates, in order of preference, three categories of enhancements to meet the acceptance criteria:

1. Strengthen external structures to prevent damage or provide screening to prevent impact.

   This evaluation demonstrates that the IMS has [[ ]]adf prior to any aircraft challenging the containment or core cooling and the spent fuel pool. [[ ]]abdf. Any impact from an aircraft would challenge only the upper portion of the IMS[[,]]abdf.

2. Relocate equipment outside of the damage footprints to assure fuel cooling can be achieved and maintained or strengthen internal walls.

   As discussed above, the equipment needed to ensure core cooling [[ ]]adf.

3. Identify and incorporate design-specific system enhancements that can reduce use of operator actions.

This analysis demonstrates that the nuclear power module [[ ]]adef.

5.0 Conclusions

The inherent design of the Blue Energy IMS obviates the need for an aircraft impact assessment as required by 10 CFR 50.150. The location of the containment, reactor core, and spent fuel [[ ]]abdf and the very low likelihood of an aircraft impacting the IMS given [[ ]]adf provides reasonable assurance of adequate protection against aircraft impacts. Performing an aircraft impact assessment would not identify any additional design features that would require further consideration. This white paper will be used to support a future topical report and eventual exemption request from 10 CFR 50.150 during Blue Energy's application for a construction permit under 10 CFR Part 50. The exemption request would be permissible under 10 CFR 50.12 in that it is authorized by law, would not present undue risk to the health and safety of the public, and would be consistent with the common defense. In addition, this white paper supports the special circumstance that application

of the regulation would not be necessary to achieve the underlying purpose of the rule given the inherent design of the Blue Energy IMS and its enhanced design features.

6.0 Proposed Limitations and Conditions of Use

Prior to referencing a future topical report in any regulatory application, Blue Energy will ensure the nuclear power module that will be housed in the Integrated Monopile System will have the following design characteristics:

- [[ ]]adef.
- [[ ]]adef.
- [[ ]]
-]]abdf.

7.0 References

1. 74 FR 28111, “Consideration of Aircraft Impacts for New Nuclear Power Reactors; Final Rule,” Federal Register, Volume 74, Number 112, pp. 28111 and 28143, Washington, DC, June 12, 2009.
2. U.S. Nuclear Regulatory Commission, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis,” Regulatory Guide 1.174, Revision 3, January 2018 (ADAMS Accession No. ML17317A256).

3. U.S. Nuclear Regulatory Commission, “Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts,” Regulatory Guide 1.217, Revision 0, August 2011 (ADAMS Accession No. ML092900004).

4. Nuclear Energy Institute, “Methodology for Performing Aircraft Impact Assessments for New Plant Designs,” NEI 07-13, Revision 8, Washington, DC, April 2011 (ADAMS Accession No. ML111440006).

5. U.S. Nuclear Regulatory Commission, “Overview and Comparison of US Commercial Nuclear Power Plants,” NUREG/CR-5640, Washington, DC, September 1990.