

2.3 Meteorology

2.3.1 Regional Climatology

2.3.1.1 Regulatory Criteria

In accordance with U.S. Nuclear Regulatory Commission (NRC) regulations, nuclear plants must be designed so that they remain in a safe condition under extreme meteorological events, including those that could result in the most extreme wind events (tornadoes and hurricanes) that could reasonably be predicted to occur. The applicant added hurricane wind speed and hurricane missile spectra to the list of site parameter values presented in Tier 1, Section 5.0, and Tier 2, Section 2.0, of the General Electric-Hitachi (GEH) Advanced Boiling-Water Reactor (ABWR) Design Control Document (DCD). A combined license (COL) applicant that references the GEH ABWR Design Certification (DC) will assess whether the actual site characteristics fall within the site parameters specified for the ABWR design.

The proposed changes are being made to provide criteria for a COL applicant to determine whether an ABWR located at a particular site is appropriately protected against the effects of hurricane winds and missiles. In interim staff guidance (ISG), DC/COL-ISG-024, "Implementation of Regulatory Guide 1.221 on Design-Basis Hurricane and Hurricane Missiles," issued May 2013, the NRC staff explicitly addressed the ABWR and concluded that hurricane winds and missiles needed to be addressed to provide reasonable assurance of adequate protection of the public health and safety and ensure compliance with General Design Criteria (GDC) 2 and 4. Therefore, in accordance with Title 10 *Code of Federal Regulations* (10 CFR) 52.59(a) the proposed changes in this regard are defined as "modifications," as described in Chapter 1 of this staff safety evaluation report (SER) supplement, and will correspondingly be evaluated using the regulations applicable and in effect at the initial ABWR certification.

The acceptance criteria are given in 10 CFR Part 50, Appendix A, GDC, and are summarized below. Guidance on the staff's review of DC renewal applications with respect to hurricane wind and hurricane missile site parameters can be found in DC/COL-ISG-024.

1. GDC 2 (1997), "Design bases for protection against natural phenomena," requires, in part, that structures, systems, and components (SSCs) important to safety be designed to withstand the effects of natural phenomena such as tornadoes and hurricanes without loss of capability to perform their safety function.
2. GDC 4 (1997), "Environmental and dynamic effects design bases," requires, in part, that SSCs important to safety to be appropriately protected against dynamic effects, including the effects of missiles that may result from equipment failures and from events and conditions outside the nuclear power unit.
3. 10 CFR 52.47(a)(1)(iii) (1997) states that DC applications must include the site parameters postulated for the design, and an analysis and evaluation of the design in terms of such parameters.

2.3.1.2 Summary of Technical Information

Revision 4 to the ABWR DCD (which is referenced in the first ABWR design certification rule, Appendix A to 10 CFR Part 52) contained tornado site parameters which included maximum tornado wind speed and missile spectra. Prior to 2007, the general engineering assumption was that tornado phenomena controlled design with respect to wind loads and wind generated missiles and that these tornado site parameters bounded hurricane wind loads and hurricane missiles. Revision 1 to Regulatory Guide (RG) 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," which was released in March 2007, resulted in a decrease in tornado design-basis wind speeds due to the adoption of the Enhanced Fujita scale for classifying tornado intensity. Since design-basis tornado wind speeds were decreased as a result of the analysis performed to update RG 1.76, it was no longer clear that the revised tornado design-basis wind speed would bound design-basis hurricane wind speeds in all areas of the United States. This prompted studies into extreme wind gusts during hurricanes and their relations to design-basis hurricane wind and missiles, which ultimately resulted in the issuance of RG 1.221, Revision 0, "Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants," in October 2011.

The study of extreme wind gusts during hurricanes, NUREG/CR-7005, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane Windspeeds for Nuclear Power Plants," (Agencywide Documents Access and Management System (ADAMS) Accession No. ML11335A031), concluded that it is possible that the wind speeds from the design-basis tornado may not be bounding for certain locations along the United States Gulf Coast and the southern Atlantic Coast. The study of missile speeds during hurricanes, NUREG/CR-7004, "Technical Basis for Regulatory Guidance on Design-Basis Hurricane-Borne Missile Speeds for Nuclear Power Plants," (ADAMS Accession No. ML11341A102), concluded that airborne missiles can fly faster in a hurricane wind field with the same 3-second gust wind speed at 10 meters (33 feet) above ground than in a tornado wind field. Because the size of the hurricane wind field with the highest winds is large relative to the size of the missile trajectory, the hurricane missile is subjected to the highest wind speeds throughout its trajectory. In contrast, the tornado wind field is smaller, so the tornado missile is subject to the strongest winds only at the beginning of its flight. This results in the same missile having a higher maximum velocity in a hurricane wind field than in a tornado wind field with the same maximum wind speed.

Revision 5 to the ABWR DCD, which GEH originally submitted in support of their ABWR design certification renewal application, contained tornado site parameters related to the maximum tornado wind speed and tornado-generated missile spectra, but did not contain site parameters related to hurricane wind speed or hurricane-generated missile spectra. If a nuclear power plant using the ABWR certified design is located at a site where the hurricane loads and/or the hurricane-generated missile spectra are not bounded by tornado loads and tornado-generated missile spectra, then safety-related structures may not be able to withstand hurricane loads and hurricane-generated missiles as required. Therefore, the nuclear power plant may not be in compliance with GDC 2 and GDC 4. Consequently, the staff issued a request for additional information (RAI) 02-1 (ADAMS Accession No. ML14267A352), requesting the applicant to add hurricane wind speed (e.g., 3-second gust at 10 m above ground in open terrain) and hurricane-generated missile spectra (including missile dimensions, mass, and velocity) to the list of site parameter values presented in Tier 1, Section 5.0, and Tier 2, Section 2.0 of the GEH ABWR DCD. The staff also requested in RAI 02-1 that the DCD be revised to show how structures, systems, and components important to safety are protected from the effects of hurricane winds and missiles.

The applicant's responses to the staff's RAI 02-1 ultimately resulted in the following hurricane wind speed related changes in Revision 6 to the ABWR Design Control Document (DCD):

DCD Tier 1: DCD, Tier 1, Table 5.0, "ABWR Site Parameters," contained changes to include a hurricane wind speed site parameter.

DCD Tier 2: DCD, Tier 2, Table 2.0-1, "Envelope of ABWR Standard Plant Site Design Parameters," contained changes to include a hurricane wind speed site parameter.

In a subsequent RAI 02-1 response, Supplement 5, dated April 13, 2017 (ADAMS Accession No. ML17103A125) which was provided after submission of Revision 6 of the ABWR DCD, the applicant provided the following hurricane wind speed value to the list of site parameter values presented in Tier 1, Section 5.0, and Tier 2, Section 2.0, of the ABWR DCD:

- Maximum hurricane wind speed: 257 km/h

Footnotes to be added by the applicant as part of Revision 7 of the DCD to both Tier 1, Table 5.0 and Tier 2, Table 2.0-1 of the DCD will state 257 km/h is a fastest-mile wind speed which corresponds to 286.5 km/h 3-second gust wind speed, as the design-basis hurricane wind speed parameter for the ABWR DC, in accordance with RG 1.221 measured at 10 meters above ground over open terrain (this is part of Confirmatory Item 2.3-1 discussed below). The staff notes that a wind speed of 286.5 km/h is equivalent to 178 mph or 79.6 m/s.

2.3.1.3 Technical Evaluation

In this SER section the staff evaluates the proposed hurricane wind site parameters. Subsections 3.5.1.4 and 3.3 of this SER provide the staff's evaluation of the missiles generated by hurricane winds and the resulting extreme wind loadings on structures important to safety, respectively.

In its response to RAI 2.0-1 dated November 19, 2014 (ADAMS Accession No. ML14324A082), GEH provided (1) Tier 1 site parameters related to hurricane maximum wind speed, maximum pressure drop, and missile spectra and (2) Tier 2 site parameters related to hurricane maximum wind speed, maximum rotational speed, translational velocity, radius, maximum pressure drop, and missile spectra.

Subsequently, GEH revised its RAI 02-1 response in Supplement 1 dated June 26, 2015 (ADAMS Accession No. ML15177A038) by eliminating the following site parameters for the hurricane: (1) maximum pressure drop from the list of Tier 1 site parameters and (2) maximum rotational speed, translational velocity, radius, and maximum pressure drop from the list of Tier 2 site parameters. As discussed in DC/COL-ISG-024, the load from the hurricane atmospheric pressure change is assumed to be small. The rate of pressure change at a specific location from the passage of a hurricane is slow compared to the passage of a tornado because the large pressure drop within a hurricane occurs over a distance of several miles whereas the large pressure drop within a tornado occurs over a few hundred feet. Consequently, the staff concludes that listing hurricane maximum rotational speed, translational velocity, radius, and maximum pressure drop as site parameters is not necessary as these site parameters are used to determine the rate of hurricane atmospheric pressure drop which is assumed to be small.

GEH further revised its RAI 02-1 response in Supplement 5, dated April 13, 2017, by proposing to modify the DCD to indicate that the severe wind and extreme hurricane wind site parameter values are fastest-mile values, consistent with the wind loading methodology at the time of initial certification as presented in American National Standards Institute/American Society of Civil Engineers (ASCE) Section 7-88, 1990, "Minimum Design Loads for Buildings and Other Structures." Additionally, as part of its response to RAI 02-1, the applicant proposed changes to the DCD that state the extreme maximum tornado wind speed site parameter value is a fastest quarter mile value that is consistent with the wind loading methodology at the time of initial certification as presented in the NRC approved Bechtel Topical Report BC-TOP-3-A, Revision 3, "Tornado and Extreme Wind Design Criteria for Nuclear Power Plants" (ADAMS Accession No. ML14093A218). The corresponding equivalent 3-second gust values are also provided in DCD Tier 1, Table 5.0 and Tier 2, Table 2.0-1 to assist future COL applicants in comparing these site parameter values to the 3-second gust values in later versions of ASCE 7, RG 1.221, and RG 1.76.

The staff reviewed the hurricane wind speed contour maps in RG 1.221 and concluded that, except for certain locations along the Gulf and the Atlantic coasts, a design-basis hurricane 3-second wind speed site parameter value of 286.5 km/h (178 mph) is bounding. Because the proposed ABWR design-basis hurricane wind speed site parameter value bounds a reasonable number of potential COL sites, the staff finds the proposed site parameter value acceptable. For those cases where the site-specific hurricane wind speed site characteristic value exceeds the design-basis hurricane wind speed site parameter value, it will be necessary for the COL applicant to submit analyses to demonstrate that the site-specific hurricane wind speed value does not exceed the capability of the design. The incorporation of these markups in Revision 7 of the DCD is being tracked as **Confirmatory Item 2.3-1**.

2.3.1.4 Conclusion

Based on the evaluation provided in this final SER section supplement, the staff concludes that the proposed changes to add a maximum hurricane wind speed as a Tier 1 and Tier 2 site parameter to the ABWR DCD is acceptable and does not alter the safety findings made in the ABWR DC NUREG-1503 and meets the applicable regulations in effect at initial certification, including the requirements of GDC 2 (1997) and GDC 4 (1997).

The staff's review concludes that the applicant added an appropriate design-basis hurricane wind speed site parameter for the GEH ABWR and therefore complies with 10 CFR 52.47(a)(1)(iii) (1997) and is consistent with the guidance in RG 1.221, Revision 0, for design-basis hurricane wind speeds for nuclear power plants and therefore is acceptable. Inclusion of the proposed changes in the DCD is being tracked by the **Confirmatory Item 2.3-1** discussed above.