Enclosure 1

MFN 15-073, Revision 1

GEH Revised Response to RAI 08.02-2

IMPORTANT NOTICE REGARDING CONTENTS OF THIS DOCUMENT
Please Read Carefully

NRC Request for Additional Information 08.02-2:

In Request for Additional Information (RAI) response dated August 29, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14241A558), GE Hitachi Nuclear Energy, the applicant, discussed its response to RAI 08.02-1 concerning the recent operating experience that involved the loss of one of the three phases of the offsite power circuit (single-phase open circuit condition) at Byron Station and the loss of 2 phases at Forsmark, Sweden.

Based on the review of applicant's response, staff identified the following issues:

Enclosure 1, "Description of the Protection Design Features not included in DCD" states:

This section explains the design features of the protective relays that provide for monitoring and alarms for detecting the loss of one or more phases or a ground in the electrical system at the UAT or RAT inputs and on the safety-related medium voltage busses and alarming in the Main Control Room so that operators can take manual action, as appropriate, and initiate corrective actions to address the loss of phase condition.

Enclosure 1, "Summary of Monitoring and Alarms Design Features" states:

Because the ABWR offsite and onsite high and medium voltage circuits will be monitored and alarmed in the Main Control Room, operators can take manual action, as necessary, and initiate corrective actions to address a loss of phase condition.

Enclosure 2, DCD, Section 8.3.1.1.6.3, "Bus Protection" states:

6.9 kV bus incoming circuits have inverse time over-current, ground fault, bus differential and under-voltage protection. The under-voltage monitoring is responsive to all three phases. The monitoring is effective for both load shedding and emergency diesel start and protection of the safety-related bus loads for grounds and loss of one or more phases.

Based on the above, the staff determined that the applicant did not provide sufficient design information for staff to conclude that all open phase conditions (OPCs) would be automatically detected and alarmed in the main control room under all operating electrical system configurations and plant loading conditions. In addition, the applicant did not provide sufficient design information concerning the automatic protective features that would be provided to transfer the offsite power circuits to the 6.9 kV safety related buses Division I (E), Division II (F), and Division III (G) if they are functionally degraded due to open-phase conditions. Furthermore, the staff's review of operating reactor licensees' NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," responses and interactions with the industry representatives in various public meetings revealed that undervoltage detection and protection schemes cannot detect all OPCs and mitigate the consequences of OPCs under all operating electrical system configurations and plant loading conditions.

Therefore, the applicant is requested to provide the design basis and ITAAC information in accordance with § 52.47, "Contents of applications; technical information," for the Electrical Engineering Branch staff to determine whether it meets the 10 CFR 50 Appendix A, GDC 17, "Electric power systems," requirements regarding the offsite power circuits and onsite electrical

power distribution system to provide adequate capacity and capability in view of the design vulnerability identified in Bulletin 2012-01. The information should have sufficient details for the combined operating license applicants to complete the detailed design (e.g., location of relays) and analyses (e.g., setpoints) in final safety analysis report in accordance with §52.79, "Contents of applications; technical information." In addition, GEH is requested to provide the delineation of scope between the DCD and COL applicants in regards to the BL.

The NRC staff position for new reactors with active design safety features, reviewed under 10 CFR Part 50 and 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," the following criteria should be satisfied when evaluating OPCs:

a. *The OPC should be automatically detected and alarmed in the main control room under all operating electrical system configurations and plant loading conditions. The detection circuits should be sensitive enough to identify OPCs under all operating electrical system configurations and plant loading conditions for which the offsite power supplies are required to be operable in accordance with plant technical specifications (TSs) and licensing basis for safe shutdown.*

b. *The detection circuit should minimize spurious indications for an operable offsite power source in the range of voltage perturbations such as switching surges, transformer inrush currents, load or generation variations, lightning strikes, etc., normally expected in the transmission system. If there is potential for OPCs on the high voltage and low voltage side of transformers and interconnecting onsite auxiliary power circuits, the OPCs) should be alarmed in the main control room for operators to take corrective action within reasonable time. Any connections not required to be evaluated, should be documented with adequate justification. In such cases, the consequences of not isolating the degraded power source immediately should be evaluated to demonstrate that any subsequent design bases conditions that require offsite power circuit (s) for safe shutdown do not create plant transients or abnormal operating conditions. Also, the alternate power source(s) can be connected to the safety related buses within in the time assumed in the accident analysis.*

c. *If offsite power circuit(s) is (are) functionally degraded due to open-phase conditions, and safe shutdown capability is not assured, then the safety related buses should be designed to be transferred automatically to the alternate reliable offsite power source or onsite standby power system within the time assumed in the accident analysis and without actuating any protective devices, given a concurrent design basis event.*

d. *The design of protection features for open-phase conditions should address the following:*

    (i) *Power quality issues caused by OPCs such as unbalanced voltages and currents, sequence voltages and currents, phase angle shifts, and harmonic distortion that could affect Class 1E safety-related buses. The Class 1E loads should not be subjected to power quality conditions specified in industry standards such as Institute of Electrical and Electronic Engineers (IEEE) Standard (Std) 308-2001, "Criteria for Class 1E Power Systems for Nuclear Power Generating Stations," Section 4.5, "Power Quality," with respect to the design and operation of electrical*

systems as indicated in Regulatory Guide (RG) 1.32 "Criteria for Power Systems for Nuclear Plants."

(ii) Protection scheme should comply with applicable requirements including single failure criteria for Class 1E safety-related systems as specified in 10 CFR Part 50, Appendix A, GDC17 and 10 CFR 50.55a(h)(3) derived from IEEE Std 603-1991," Standard Criteria for Safety Systems for Nuclear Power Generating Stations, as endorsed by RG 1.153, "Criteria for Power, Instrumentation, and Control Portions of Safety Systems."

Questions:

a. *Explain the design features that would be provided for the OPCs to be automatically detected and alarmed in the main control room under all operating electrical system configurations and plant loading conditions.*

b. *Describe the design features that would be provided in the event that offsite power circuit(s) is (are) functionally degraded due to open-phase conditions, and safe shutdown capability is not assured, then the safety related buses should be designed to be transferred automatically to the alternate reliable offsite power source or onsite standby power system within the time assumed in the accident analysis and without actuating any protective devices, given a concurrent design basis event.*

c. *Provide an ITAAC that demonstrates and verifies the following, including setpoints:*

- *Monitoring/detecting/Alarming in the control room in the event of the OPCs*
- *Automatically separates the Class 1E safety-related buses from the off-site power source and transfers safety-related loads to the unaffected offsite power source or the emergency diesel generators.*

GEH Response to RAI 08.02-2:

GEH initially responded to RAI 08.02-2 in MFN 15-073 on September 25, 2015. The NRC issued the final Standard Review Plan Branch Technical Position (BTP) 8-9, "Open Phase Conditions in Electric Power System," Revision 0, July 2015. In a GEH/NRC public teleconference held on 4/6/2016, the NRC staff had additional concerns about GEH's response to RAI 08.02-2 transmitted in MFN 15-073. In response to this discussion held on 4/6/2016, GEH is issuing this revised response to RAI 08.02-2.

a) *Explain the design features that would be provided for the OPCs to be automatically detected and alarmed in the main control room under all operating electrical system configurations and plant loading conditions.*

The ABWR electrical system is normally aligned with the majority of the plant electrical load carried by the Unit Auxiliary Transformers (UATs) and one safety bus normally aligned to the Reserve Auxiliary Transformer (RAT). This ensures that at least one of the safety-related buses would not be affected by an open phase condition (OPC). In addition, to ensure that an OPC is automatically detected and alarmed in the main control room (MCR), the following design provisions will be added to the ABWR electrical distribution system:

- Instrumentation on the primary side of the Main Power Transformer (MPT),
- Instrumentation on the primary and secondary sides of the UATs and the RAT.

Furthermore, a micro-processor based relay protection scheme will be added to the primary and secondary sides of the UATs and RAT that automatically sense loss of a single phase (or multiple phases) and loss of phase with ground during all plant operating scenarios and loading conditions. Upon the detection of an OPC, an alarm will be indicated in the MCR. The protective relay schemes will be designed to add specific algorithms that will be utilized to detect faults via microprocessor based relays, and isolate the incoming power feed. The isolation of the incoming power feed will occur by opening the associated circuit breaker(s) that feed the class 1E busses, thereby protecting safety-related equipment. The Main Power Transformer (MPT) will be monitored on the primary side for OPC, over-current, ground fault, under voltage and unbalance phase on all three phases. Alarms in the MCR will alert the operator to an abnormal condition.

The scheme to monitor OPC for the UATs, RATs, and MPT is in addition to the traditional three phase absolute voltage monitoring, absolute current monitoring, and differential current monitoring. Additionally, detection of an unbalanced phase condition on the UAT and RAT will be detected on each of the safety related buses. The unbalanced phase condition will be automatically detected and alarmed in the main control room (MCR) under all operating electrical system configurations and plant loading conditions.

This description of the protective relaying, which defines the performance criteria and functional design requirements of the system, will be added to the ABWR Design Control Document (DCD), Tier 2, Sections 8.2.4.6 and 8.3.1.1.6.

b) Describe the design features that would be provided in the event that offsite power circuit(s) is (are) functionally degraded due to open-phase conditions, and safe shutdown capability is not assured, then the safety related buses should be designed to be transferred automatically to the alternate reliable offsite power source or onsite standby power system within the time assumed in the accident analysis and without actuating any protective devices, given a concurrent design basis event.

Unit Auxiliary Transformers

In the normal lineup (all plant electrical loads are on the UATs except for one safety bus on the RAT), the following would occur in the event of a fault (including loss of phase, which is easily and reliably detected on a loaded transformer) on any one of the UATs:

- The switchyard, main generator, and UAT medium voltage breakers open.
- The safety busses originally on the UATs will fast transfer to the RAT and one predetermined set of Power Generation/Plant Investment Protection (PG/PIP) busses will also fast transfer to the RAT.
- The plant will scram and the main turbine will trip.

These events and the safety bus fast transfer are alarmed in the MCR, however no operator action is necessary to protect the safety-related electrical loads. Operator action will be focused on scram recovery and monitoring the correct sequencing of the safety systems. The event will be mitigated by the safety busses and one set of PG/PIP busses. If the fast transfer of the safety busses is not successful, the safety bus feeders will open, the Emergency Diesel Generators (EDG) will start automatically, and the loads will be sequenced as described in DCD Tier 2, Chapter 8.

It should be noted that the safety bus feeders are independently monitored whatever the status of the UATs and RAT. Specifically, the safety busses are normally loaded (by the RCW, RSW and chillers) such that a fault (including a phase loss) is easily and reliably detected. The result will be a fast transfer at the safety bus level. If the fast transfer is successful, the safety electrical loads will be sequenced to the RAT. If the fast transfer is not successful, the EDGs will be started automatically and the safety electrical loads will be sequenced on to the safety related buses as part of the EDG loading sequence. All of the above will occur within the time frame assumed in the accident analysis and without actuating any unnecessary protective devices, given a concurrent design basis event.

Reserve Auxiliary Transformer

The RAT is also monitored for faults and loss of phase and a detected fault/loss of phase will be appropriately alarmed in the MCR. The detected fault/loss of phase will prohibit a fast transfer to the RAT. No operator action is necessary since most loads are normally on the UATs and the connected safety bus feeder fault/loss of phase detection will fast transfer that bus to the associated UAT. No plant scram or turbine trip will result, and the operator would initiate repair of the RAT.

In the case where the OPC protection circuitry fails to isolate the offsite power source from the safety related buses and the feeder breaker fails to open, the unbalanced phase condition detection circuitry located on the safety related buses provides protection to the safety related

loads. This protection scheme causes the offsite supply breaker to open, thereby providing defense against a single failure of the offsite power OPC.

An unsuccessful fast transfer of the RAT to the associated UAT on a particular bus will result in the associated diesel starting and sequencing the loads as a loss of power/no LOCA event. A fault/loss of phase on the RAT should be reliably detected and alarmed since the transformer is normally loaded by the connected safety bus. Even if a fault is not detected in normal operation, as soon as the fast transfer loads the RAT, the loss of phase will be detected at both the transformer protective relaying and at the safety bus level as described above.

In all these scenarios, the safety busses will not "see" a loss of phase nor require any immediate operator action. Finally the individual safety bus loads are individually protected against OPC or faults such that their breakers will individually open to protect the motor or power center (as with any individual load fault). At the individual load level, loss of a phase is reliably detected and the safety loads are therefore protected twice (at the bus level and at the individual load level), independent of the transformer protection.

c) *Provide an ITAAC that demonstrates and verifies the following, including setpoints:*

- *Monitoring/detecting/Alarming in the control room in the event of the OPCs*
- *Automatically separate the Class 1E safety-related buses from the off-site power source and transfers safety-related loads to the unaffected offsite power source or the emergency diesel generators.*

ITAAC items will be added to the DCD, Tier 1, Section 2.12.1, to address the monitoring, detection, MCR alarm and the automatic transfer of loads to the unaffected offsite power source or the emergency diesel generators in the event of an OPC. Please refer to DCD markups contained in Enclosure 2.

Impact on DCD:

The following ABWR DCD, Revision 6, Tier 1 and Tier 2 Subsections and Table are impacted by this RAI response:

Tier 1 Section 2.12.1,
Tier 1 Table 2.12-1 (Item No. 26 and 27),
Tier 2 Table 1.9-1 (Item No. 8.16 for Section 8.3.4.10 and Item No. 8.17 for Section 8.3.4.11).
Tier 2 Subsection 8.3.1.1.6.3,
Tier 2 Subsection 8.3.4.10 and 8.3.4.11

The ABWR DCD, Revision 6, Tier 1 and Tier 2 Subsections and Table are revised as shown in the markups in Enclosure 2.

Note: ABWR DCD Revision 5 markups from MFN 15-073 that are not updated by MFN 15-073, Revision 1 are listed below. The following ABWR DCD Revision 5 markups have not been included with this response as markups because the changes are included in the ABWR DCD Revision 6:

Tier 1, Table 2.12-1, Items #28, #29, and #30, and
Tier 2, Section 8.3.1.1.6.3, 1st paragraph and Item (6).