December 2, 2005

Mr. Joseph E. Conen
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SUBJECT: REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING THE BOILING WATER REACTOR OWNERS GROUP (BWROG) TOPICAL REPORT (TR) NEDO-33148, "SEPARATION OF LOSS OF OFFSITE POWER FROM LARGE BREAK LOCA [LOSS-OF-COOLANT ACCIDENT]" (TAC NO. MC3042)

Dear Mr. Conen:

By letter dated April 27, 2004, the BWROG submitted for NRC staff review TR NEDO-33148, "Separation of Loss of Offsite Power From Large Break LOCA." The NRC staff has completed its preliminary review of your submittal and has identified a number of items for which additional information is needed to continue its review. The NRC staff requires responses to the enclosed RAI questions in order to continue our review.

In our acceptance letter for TR NEDO-33148, the NRC staff agreed to a review completion date of August 2006. To support the above completion date, in the telephone conversation held between the NRC staff and Fred Emerson of your staff, BWROG stated that the NRC staff will receive your response to the enclosed RAI questions by February 24, 2006.

Additional RAI questions from other technical review branches will be submitted under separate cover letter at a later date. Please call me at 301-415-1774, if you have any questions on this issue.

Sincerely,

/RA/

Michelle C. Honcharik, Project Manager
Special Projects Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 691

Enclosure: RAI

cc w/encl: See next page

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Accession No.:ML053330380 **NRR-088** *** No Substantial change from the Memorandum**

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REQUEST FOR ADDITIONAL INFORMATION

BOILING WATER REACTOR (BWR) OWNERS GROUP

TOPICAL REPORT (TR) NEDO-33148, "SEPARATION OF LOSS OF OFFSITE POWER FROM LARGE BREAK [LOSS-OF-COOLANT ACCIDENTS] (LOCA)"

PROJECT NO. 691

All Section, page, table, or Reference numbers in the questions below refer to items in NEDO-33148, unless specified otherwise.

Scope of the Licensing Topical Report (LTR)

1. Section 3.0 states: "It is possible that other plant changes that are not explicitly described in this report can be justified using the analyses presented herein." The NRC staff cannot review hypothetical changes, nor would such an open-ended scope meet the intent of the topical report program process. Please ensure that the LTR includes the complete desired scope for which NRC review and approval is sought.

2. In at least one place (e.g., page 10) the LTR refers to LOCA up to "large recirculation loop pipe breaks." In other places (e.g., Section 6.0) it refers to 10-inch and larger breaks. Please clarify the break size that will be used in the anticipated exemption requests, and whether the break size refers to a single- or double-ended break. Do all seven options presented in the LTR assume the same break size, above which an exemption from the loss of offsite power (LOOP)/LOCA regulations would be requested?

Generic Risk of LOOP with Large Break LOCA

3. Reference 3 does not support using a single, BWR generic probability of a consequential LOOP as the result of a LOCA. It provides both a plant-specific and generic methodology for determining LOOP/LOCA frequency. It states: "The generic approach for identifying alternative Emergency Core Cooling System (ECCS) configurations that meet established risk guidelines requires that the operating nuclear power plants be placed in groups that have similar configurations." Further, the generic methodology in Reference 3 describes plant-specific characteristics relating to the electrical system design and operation that have a major effect on the conditional probability. Please provide the basis for the proposed generic probability of consequential LOOP assumed in the LTR. Alternatively, if BWR plants were grouped by similar configurations, as discussed in Reference 3, please provide the basis for the generic probability proposed for each group. Describe how the generic probability of consequential LOOP bounds each plant-specific electrical design, such as configuration of switchyards, auxiliary transformers, start-up transformers, and fast transfer schemes.

4. Reference 10 does not support a generic probability of a consequential LOOP as the result of a LOCA. For example, it assumes that one division of ECCS is normally powered from the grid. However, this is not true for many plants. Reference 10 also

states, in reference to the consistency between a plant's voltage analyses and the actual plant setup, "… it is recommended that this consistency be verified as part of any plant change that relies on this probabilistic assessment." Please describe how the LTR factored in the variability of connections between the offsite and onsite electrical distribution system in determining the proposed single-generic or group-generic probability of consequential LOOP. How would the consistency between analyses and the full range of actual plants be verified?

5. Reference 8 does not provide a basis for a generic BWR large LOCA frequency estimate. It examines the potential distribution of LOCAs as a function of size and location, but presents only limited information regarding the frequency of LOCA events. While generic pressurized-water reactor and BWR frequencies for large break LOCA events could be appropriate, this reference does not develop such frequencies. Please clarify which quantitative estimates from the referenced reports were combined to develop the LOCA frequency used to develop the range of large break LOCA/LOOP frequencies of 3.0E-7 to 1.2E-6 per year (Section 4.2). Please include recent information on estimating LOCA frequencies developed since NEDO-33148 was written (e.g., "Estimating Loss-of-Coolant Accident (LOCA) Frequencies Through the Elicitation Process," (NUREG-1829) - Draft Report for Comment).

6. Generic Safety Issue (GSI)-171, "ESF [Engineered Safety Feature] Failure from LOOP Subsequent to a LOCA," questioned whether plant design deficiencies existed that could fail ESFs if a LOOP occurred shortly after a LOCA event. Plant-specific design features were identified that could impact the probability that offsite power will be lost given a LOCA. Please describe how these vulnerabilities are addressed in the proposed single generic estimate. Alternately, please describe the steps a plant would take to ensure there are no GSI-171 vulnerabilities that could result in a higher than assumed consequential LOOP probability given a LOCA. The GSI-171 vulnerabilities include overloading of emergency diesel generators (EDGs), non-recoverable damage to EDG and ECCS pump motors, lockout energization of circuit breakers because of anti-pump circuits, lockup of load sequencers, fast bus transfer failure during load sequencing, and restarting of ECCS pumps with unanticipated system configuration (e.g., discharge valve open) that results in higher than design starting currents. Many of these concerns appear to rely on plant-specific details that would need to be addressed in a specific licensee's submittal.

7. As discussed above in questions 3 through 6, the referenced documents and the GSI-171 work does not support a generic BWR LOCA/LOOP frequency. One option would be for the LTR to provide the methodology for plants to use to determine the plant-specific LOCA/LOOP frequency. If a generic LOCA/LOOP estimate is to be referenced in plant-specific exemption requests, the LTR needs to provided further evaluation and analyses. These analyses need to support the use of a generic estimate for LOCA/LOOP frequency and derive the estimate of consequential LOOP probability given a LOCA. The evaluation should include a detailed assessment of plant-specific characteristics that control the conditional probability of consequential LOOP. This discussion should include a summary of the plant-specific features discussed in the referenced documents, and in GSI-171, and how each reference incorporated that feature into the estimate used to support the generic estimate in the LTR. The

discussion should also include recent industry experience with degraded grid voltages. Include a discussion of the uncertainty in this estimate. Describe how a plant that desires to reference the LTR would demonstrate that the analysis provided in the LTR is appropriately applied at their plant.

Use of Generic Probabilistic Risk Assessment (PRA) and Acceptance Criteria

8. Section 9.2 provides the thermal-hydraulic assumptions a plant must meet in order to be covered by the topical report. It is assumed that reactor power for a BWR-4 implementing this LTR is less than or equal to 3042 Megawatts thermal (MWt). The LTR states: "Plants with lower power levels can accommodate a lower ECCS injection flow." A cursory review by the NRC staff indicates that almost 58 percent (11 of 19) of BWR-4 plants currently have rated power levels greater than 3042 MWt - in some cases, excluding any increase due to power uprate. How would the LTR be applied by BWR-4 plants with rated thermal power above 3042 MWt? Will the thermal-hydraulic assumptions accommodate future power uprates? What power levels apply for BWR-2, BWR-3 and BWR-5 plants?

9. In Section 1.0, the LTR states: "It is intended that this LTR can be referenced by any BWR licensee in a specific 10 CFR 50.12 exemption request without the need to perform extensive plant specific analyses …." A generic PRA was used for the risk assessments in the LTR.

   The LTR as submitted does not provide an acceptable basis for using a generic risk assessment to support the potential plant changes presented in the LTR. Please provide in detail how this generic risk assessment provides assurance to a level equivalent to Regulatory Guide (RG) 1.174 that any increases in risk are small and are consistent with the intent of the Commission's Safety Goal Policy Statement. This should, as a minimum, answer the following questions:

   a. How will the generic risk assessment identify the overall risk impact of the specific combinations of changes adopted by a given plant, when it is not known which changes a given plant will choose to implement?

   b. How will a licensee demonstrate that the LTR satisfies the RG 1.174 guideline that the PRA is of sufficient scope, level of detail, and technical acceptability commensurate with this application, relative to their specific plant design and licensing basis?

10. The LTR as submitted does not provide an acceptable basis for using a generic approach to risk-informed decision making to support the potential plant changes presented in the LTR. What information would a BWR referencing the LTR submit to demonstrate that the five key principles stated in RG 1.174, Section 2 and RG 1.177, Section B are met? For example, the LTR does not provide any guidance on performance measurement strategies. Also, Sections 7 and 8 provide generic discussions of defense-in-depth and safety margin. Would a specific BWR licensee that referenced this LTR be expected to provide plant-specific discussions of these areas for any changes it intended to make?

11. Section 2.2 , under "Use of a 'Generic' PRA Model," states: "The input for the changes to 'genericize' the model comes from surveys of BWR licensees to describe those attributes of their PRA models that are germane to this study …." The NRC staff notes that the plant designated "N" in the table on page C-152 did not provide a response for "number of Diesel Generators [DGs] per unit." How responsive were BWRs to the other surveys referred to in the LTR? How many BWRs were surveyed out of the total population? Of those, how many fully responded to the surveys? Describe the quality assurance process used to create the generic PRA model. How were inputs based on the surveys of BWR licensees controlled and validated?

12. The sensitivity study in Section C.6.2.4 shows that not inhibiting the automatic depressurization system (ADS) causes an increase in core damage frequency (CDF) for the “LPCI [Low pressure coolant injection] Does Not Start With On [sic] Offsite Power” case. This same case shows a CDF decrease if ADS inhibit is credited. However, Table C.6-1, on page C-63, states for the ADS assumption: “The results show that this assumption does not impact the conclusions of this report.” Please justify that the conclusions are unaffected and explain how the sensitivity results support this assertion.

13. Table C.6-1 lists the generic PRA model assumptions and attributes. The “assessment” column provides justification as to whether plant-specific validation is required. The justification provided for not requiring a plant-specific validation of a given assumption is typically based on judgment, sensitivity analyses, or an observation that the assumption is standard across all BWRs. Please provide a quantitative basis, such as risk achievement worth, in support of the judgment used to assert that plant-specific validation is not required. As a minimum, this basis should be provided for the following assumptions and attributes deemed to be unimportant; in each case, justify that the assumption would have a negligible impact on the risk assessment conclusions:

    a. Four high pressure injection systems (page C-54). Consider plants that have an isolation condenser design.

    b. Room cooling is required for high pressure coolant injection (HPCI) to run greater than 2 hours (page C-54). For example, are there plants where HPCI room cooling is required before 2 hours?

    c. Alternate, AC independent, room cooling is available for HPCI (page C-55).

    d. Low pressure core spray (LPCS) requires room cooling (page C-58).

    e. LPCI electrical configuration (page C-59). For example, what is the impact if a plant design uses AC power for the LPCI injection valves?

    f. One standby liquid control pump is sufficient if main steam is available (page C-64).

    g. Presence or absence of service water booster pumps (page C-65).

14. The LTR says that an applicant need not provide a plant-specific PRA analysis if it meets 17 assumptions provided in Section 9.1. These 17 are a subset of the assumptions and attributes provided in Table C.6-1. The remaining assumptions were evaluated in the table one at a time. The LTR as submitted does not provide an acceptable basis for using a generic risk assessment, especially given the large number of possible combinations of plant design and licensing bases. It is possible that a given BWR could fail to match a number of the assumptions presented. If a plant is similar to the generic model with respect to the major issues but differs from the generic model for some or many minor issues, how is the potentially major synergistic and cumulative impact addressed?

15. The generic PRA assumes the plant electrical system has a fast transfer from the main generator to the start-up transformer and a slow transfer to an emergency transformer if the start-up transformer is not available. Not all plants have this design. Table C.6-1, page C-66, states "... all plants incorporate similar failure modes." However, crediting both sources in the generic PRA reduces the probability of a consequential LOOP from transfer failures following a plant event, such as a LOCA. Please provide quantitative justification that the generic risk assessment is bounding across the BWR fleet.

16. Section C.6.2 presents seven sensitivity analyses. Several apparent errors and a non-intuitive presentation format renders this section very difficult to understand. Please provide an updated version of Section C.6.2 or otherwise address the following issues:

    a. All of the tables in C.6.2 use "CDF Decrease" as the metric; this is difficult to interpret as discussed in specific cases below. All of the tables have a column, "LPCI Does Not Start With On Offsite Power." Please provide a more descriptive heading.

    b. Tables C.6.2.2 through C.6.2.4 have the same two row labels, which are apparently meant to define the base case and sensitivity case conditions. The latter two tables should have rows related to "Service Water Injection Source" and "ADS Actuation," respectively.

    c. For the sensitivities involving "LPCI Does Not Start With On Offsite Power," Tables C.6.2.2, C.6.2.3, C.6.2.5, and C.6.2.7 appear to show an improvement in risk (a larger "CDF Decrease") as a result of model changes that would be expected to increase risk.

    d. For sensitivities involving "Increased DG Reliability," Tables C.6.2.1, C.6.2.3, C.6.2.5, and C.6.2.7 appear to show an improvement in risk (a larger "CDF Decrease") as a result of model changes that would be expected to increase risk.

    e. The results for Tables C.6.2.1 and C.6.2.2 are opposite for the two model changes shown; i.e., risk goes up for one change and down for the other as a result of the same sensitivity analysis.

17. Section 9.1 lists 17 assumptions that licensees would have to meet in order to use the results of the generic risk assessment.

    a. Assumption 9 is that containment venting must be possible and procedures available. Some BWR plants credit containment overpressure for ensuring adequate net positive suction head (NPSH) for their ECCS pumps. How is containment overpressure factored into the generic PRA model to ensure it covers all BWR plants? How is the interrelationship between venting and NPSH modeled if a plant credits overpressure?

    b. Assumption 13 says that individual licensees must confirm that there is no evidence of recirculation piping degradation that would result in a large break LOCA frequency significantly greater than 1E-4. How will this frequency estimate be determined? How would a licensee confirm this? How has the uncertainty in the generic large break LOCA frequency estimate been addressed in the generic risk assessment?

    c. Assumptions 15, 16, and 17 relate to fires, floods and seismic events, and state that a plant must review these areas and, if necessary, perform a risk assessment. Does the LTR require that plants submit the results of their fire, flood and seismic review, and of any required plant specific risk analyses? Describe how a specific licensee could demonstrate acceptable risk guidelines are met for these initiating events, using the generic PRA results provided.

18. The first 11 assumptions in Section 9.1 relate to specific plant design features. Some of the assumptions would not be correct for some plants because of unique designs of many systems; e.g., AC and DC electrical power, service water. How many (or what percentage) of BWRs meet each of these 11 assumptions? (A matrix showing plant versus assumption would be a helpful format in determining the relative applicability to the BWR fleet.)

19. The generic PRA uses a probability of 0.38 for non-recovery of AC power within 1 hour. The same number is used for both LOCA and non-LOCA consequential LOOPs. Please provide justification that this number bounds both LOCA and non-LOCA consequential LOOP events across the BWR fleet or discuss how a licenses would determine a plant-specific value. Include any impact of apparent increases in the duration of offsite power unavailability, as discussed in NUREG/CR-INL/EXT-05-00501, "Reevaluation of Station Blackout Risk at Nuclear Power Plants - Analysis of Offsite Power Events, 1986 - 2004," (November 2005).

20. Section C.3.4 says that a "one-top gate" PRA model was used for CDF, and that non-minimal cutsets were subsumed. Section C.3.5 says core damage sequences were binned into plant damage states for the large early release frequency analysis. The NRC staff notes that there may be cases where a one-top CDF model loses sequence information (through subsuming) that is subsequently necessary for Level 2. Provide examples of subsumed core damage sequences. How did the LTR analysis ensure that information in non-minimal Level 1 sequences important to the Level 2 analysis were not lost as a result of the subsume process?

21. It is unlikely that the NRC staff will approve the LTR solely on the basis of a risk assessment using a generic PRA. However, it is possible that the generic PRA results may provide the basis for some portions. It would benefit the level of effort and schedule review to develop the scope and attributes a licensee's PRA would need in order to adequately assess the risk of the various changes identified in the LTR. Please provide a description of the scope and attributes that a licensee's PRA would need in order to reference the LTR using a plant-specific risk assessment.

Enabled Changes

3.1 Allow EDG Warm Up Prior to Loading

22. Section 3.1 states that fast starting of EDGs decreases their reliability and increases their unavailability. It states that a warm up of 30 to 60 seconds would increase reliability. It further states that many maintenance outages are focused on degradation associated with fast starts. What is the technical basis for the claim that 30 to 60 seconds warm up will increase reliability? Please provide data to support the statement that "many" EDG maintenance outages are attributable to diesel fast starts.

23. Please provide a basis for a 10 percent reduction in EDG unavailability, a 10 percent reduction in operator action failure rates, and a 10 percent improvement in EDG reliability postulated in Section 4.3.4 . Demonstrate that these generic assumptions will bound licensees' expected performance for any combination of plant changes identified in Sections 3.1 through 3.7 . Describe the performance measurement strategies for monitoring the EDG performance and the process for feeding back the results into the risk assessment.

24. Any improvement in EDG availability and reliability can be expected to improve risk. However, the magnitude of the risk improvement will depend not only on the magnitude of the EDG improvement, but also on the relative contribution of the EDGs to plant risk. Using the assumed value of 10 percent EDG improvement, what range of CDF reduction would be expected across the BWR fleet, based on plant-specific numbers? How does this compare to the risk benefit of the same assumed EDG improvement using the generic PRA model? How does this range compare to the uncertainties associated with the assumption that a 30 to 60 second warm up of the EDGs will in fact increase reliability and availability

3.2 Optimize the Loads Sequenced on to the EDGs

25. Section 3.2 states: "If the requirement for automatic loading of all LPCI pumps or LPCS pumps onto the DGs were eliminated, licensees would perform analyses to determine which equipment would be most beneficial to have automatically loaded." Does the LTR require that more beneficial loads be added on, or does it allow licensees to simply remove loads? What changes to the automatic sequencing of loads on to the EDGs were modeled in the generic risk assessment? How was the net change in risk resulting from the assumed sequencing determined? Please show how this assumed load

sequencing appropriately models (or bounds) any specific changes BWR licensees might contemplate.

3.3 Start EDGs Only When Needed

26. Section 3.3 states that one of the safety benefits of revising the EDG start logic "… comes from the reduction of operator burden following accidents and transients." Please describe how this was modeled in the generic PRA model. Does the generic PRA model include action for operators to secure equipment that started but is not needed for the specific accident? Please provide the basis for the stated assumption that "… other post initiator operator actions assessed in the PRA would be somewhat more reliable."

27. Section 3.3 says that eliminating the anticipatory starting of the EDGs increases diesel availability and reliability, because spurious starts will be reduced. Provide data regarding the number of spurious EDG starts that have occurred that are attributable to ECCS starting logic, and justify the expected improvement in this frequency. Provide justification for any improvement in EDG reliability assumed as the result of implementing this change. Describe how the improvement in EDG reliability from this source was considered in the generic PRA risk assessment.

28. Section 3.3 states: "If the power loss occurred concurrent with or a few seconds following the LOCA, the current accident analysis would be virtually unchanged. If the power loss occurred more than a few minutes after the LOCA, reflood would have been substantially complete, peak clad temperature would have already been reduced, and the additional time to start the EDGs would not affect long-term cooling." Please define more accurately the time between "a few seconds" and "a few minutes." What is the plant response to a LOCA if offsite power is lost during this time period under the present accident analyses? How would this change if the EDGs are modified to not start until offsite power is lost; i.e., during that period of a few seconds to a few minutes?

29. Are there any synergistic effects that could adversely impact risk if a licensee adopted both the Section 3.1 change ("allow EDG warm-up") and the Section 3.3 change ("start EDGs only when needed")? How was the most adverse time to lose offsite power after a LOCA determined? Would this time be generic for all BWRs, or will plant-specific characteristics lead to large differences? How was the additive delay caused by this time and the EDG warm-up time factored into the risk assessment? If increased motor operated valve (MOV) stroke times (Section 3.5 of LTR) were also adopted, will this further delay adequate core cooling?

3.4 Simplified EDG Testing

30. Section 3.4 states: "There is an additional benefit that some of the tests could be simplified, which in turn could result in fewer operator distractions during plant operation." Please provide a breakdown of typical testing that is being discussed in this section , as well as the plant mode of operation in which such testing is performed. Provide a qualitative discussion describing how the simplified tests, specifically, would

result in fewer operator distractions during plant operation. Was a quantitative assessment of the risk reduction from this source performed?

31. Section 3.4 states: "The timing relays which accomplish this loading have tight tolerances, both to assure reflood times are within those assumed in the accident analyses, and also to ensure that the DG can recover adequately before the next load is applied." The LTR does not appear to address the potential impact of reduced timing relay tolerances on the second point; i.e., preventing loads from starting too close together. Please discuss how this second design requirement would be ensured by a plant desiring to implement the simplified testing option. What is the change in risk if relaxing the tolerances creates an increased potential for overloading the EDGs?

3.5 Increased MOV Stroke Times

32. The LTR does not provide a quantitative or qualitative risk assessment for this option. The NRC staff notes that required stroke time may be only one design input that impacts the size of an MOV operator; others may include ability to open or shut against design basis differential pressures, or to acceptably isolate to minimize containment leakage. What is the estimated risk impact of increasing MOV stroke times? Which MOVs were considered in the generic assessment of this risk? How will plant-to-plant variations in deciding which MOVs to modify be bounded by the generic risk assessment?

3.6 Automatically Start One Residual Heat Removal (RHR) Loop in Suppression Pool Cooling Mode

33. Section 3.6 discusses the risk benefit from automatically starting one RHR loop in suppression pool cooling mode. In the event of a LOCA and failure of the RHR loop that is aligned for injection, the operator would have to align the other loop (e.g., the one aligned to start in suppression pool cooling mode) to inject. Please describe how adequate defense-in-depth is maintained for this proposed change. Justify why the manual action for the above scenario is not "over-reliance on programmatic activities to compensate for weaknesses in plant design." How was the potential asymmetry in plant design, and attendant impact on operator training complexity, considered in assessing the human error probabilities? Describe how the potential for RHR system water hammer was considered in this proposed change?

3.7 Eliminate LPCI Loop Select

34. Section 3.7 says that some BWRs have LPCI loop select logic. Can an LPCI loop select plant elect to keep that logic unchanged and still implement the Section 3.6 option to start one train in suppression pool cooling mode? If "yes," how was the risk impact of that configuration determined?

35. The footnote in Section 4.4 says that elimination of the LPCI loop select logic is a risk increase. A plant could choose to implement only that option under the LTR. Please describe how such a decision would be consistent with the "risk balance" approach presented in the LTR.

Miscellaneous Comments

36. The LTR contained a number of administrative and clerical errors, including:

    a. Section C.4.5, first paragraph, refers to General Design Criteria (GDC) 16 vice GDC 17.

    b. Section C.4.5 states "Figure C.4-3 shows the generic model logic for loss of offsite power events." However, figure C.4-3 is entitled "Medium LOCA Conditional Core Damage Frequency [sic]." The correct reference appears to be Figure C.4-1.

    c. Section 9.1 contains 17 PRA assumptions to be validated by plants referencing the LTR. There are 18 assumptions listed in Section C.6.1. It appears that numbers 5 and 14 in Section C.6.1 were combined in the Section 9.1 list. It would be clearer if these lists were consistent.

    d. Section 2.2, page 6 cites References 3, 8, and 10 as the basis for the consequential LOOP probability used in the LTR. Section 4.2, page 16 cites References 2, 3, and 10.

    e. Table C.6-1, page C-66 discusses offsite power configurations. The “assessment” column states: “Section C.3.5 discusses this aspect of the generic model as it applies to other plant configurations.” However, Section C.3.5 is “Simplified Level 2" and does not appear to address offsite power configurations.

    f. Table C.6-1, page C-6 discusses battery depletion time: “Section C.3 discusses the impact that different battery ratings have on the analysis.” The NRC staff could not find this discussion in the LTR.