

**Critical Energy Infrastructure Information**  
**Withhold from Public Disclosure Under 10 CFR 2.390**  
**This letter is decontrolled when separated from Enclosures 1, 2, and 3**



Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

CNL-17-015

January 20, 2017

10 CFR 50.90

ATTN: Document Control Desk  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555-0001

Browns Ferry Nuclear Plant, Units 1, 2, and 3  
Renewed Facility Operating License Nos. DPR-33, DPR-52, and DPR-68  
NRC Docket Nos. 50-259, 50-260, and 50-296

Subject: **Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 36, Transmission System Update – Safety Aspects**

- References:
1. Letter from TVA to NRC, CNL-15-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU)," dated September 21, 2015 (ML15282A152)
  2. Letter from TVA to NRC, CNL-16-091, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 18, Responses to Requests for Additional Information and Updates associated with Interconnection System Impact Study," dated May 27, 2016 (ML16197A563)
  3. Letter from TVA to NRC, CNL-16-150, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 31, Revised Responses to Requests for Additional Information," dated September 21, 2016 (ML16267A374)
  4. Letter from TVA to NRC, CNL-16-169, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 35, Consolidated Power Uprate Safety Analysis Report Revision," dated October 28, 2016 (ML16302A441)

5. Letter from TVA to NRC, CNL-16-114, "Proposed Technical Specifications (TS) Change TS-505 - Request for License Amendments - Extended Power Uprate (EPU) - Supplement 24, Response to Requests for Additional Information and Containment Accident Pressure Credit Elimination Update," dated August 3, 2016 (ML16216A699)

By the Reference 1 letter, Tennessee Valley Authority (TVA) submitted a license amendment request (LAR) for the Extended Power Uprate (EPU) of Browns Ferry Nuclear Plant (BFN) Units 1, 2 and 3. The proposed LAR modifies the renewed operating licenses to increase the maximum authorized core thermal power level from the current licensed thermal power of 3458 megawatts to 3952 megawatts. The Reference 2 letter supplemented the BFN EPU LAR and submitted Revision 1 of the interconnection System Impact Study (SIS). Revision 1 of the interconnection SIS identifies the need to replace six breaker failure relays, install 764 megavolt-ampere reactive (MVAR) capacitor banks in five locations throughout the TVA transmission system, and modify the excitation system of all three BFN main generators. The Reference 2 letter also provided associated updates to information previously submitted in the BFN EPU LAR, responses to Requests for Additional Information (RAIs), and updates to responses to RAIs. During the development of implementation guidance for the stability studies at EPU power levels, and subsequent to the submittal of the Reference 2 letter, an error was identified in generator field parameters used in the development of the interconnection SIS. This legacy error involved data contained in a recently updated generator performance computer code used by the original equipment manufacturer. This condition has been entered into the TVA Corrective Action Program. As a result of this error, the following changes to the information provided in Reference 2 letter are required.

- The static exciters described in BFN EPU LAR Supplement 18 will not be installed on the BFN units. Instead, the existing exciters on the BFN units will each be modified to be self-excited using a shaft driven alternator. The existing exciters on the BFN units are bus-fed through transformers.
- BFN EPU LAR Supplement 18 described installing 764 MVAR capacitor banks at five substation locations. Instead, capacitor banks will be installed at four of the five identified substations. In addition, a static volt-ampere reactive (VAR) compensator will be installed at an existing substation near BFN. The combination of the static VAR compensator and the additional capacitor banks will provide a minimum reactive compensation of 764 MVAR.

This letter provides BFN EPU LAR Supplement 36. This supplement addresses the safety aspects associated with the above changes. Environmental aspects associated with the above changes will be submitted in a separate supplement (i.e., Supplement 37). Supplement 37 is expected to be submitted by February 3, 2017.

Enclosure 1 of this letter provides Revision 3 of the interconnection SIS. Enclosure 1 supersedes and replaces the interconnection SIS submitted in Enclosure 3 of the Reference 3 letter, dated September 21, 2016.

Enclosure 2 of this letter provides the updated BFN EPU Transmission System Stability Evaluation (Revision 4) that has been revised to reflect the modifications resulting from the revised interconnection SIS provided in Enclosure 1 of this letter. The BFN EPU Transmission System Stability Evaluation study evaluates the effect of BFN operation at EPU conditions with respect to continued compliance with 10 CFR Part 50, Appendix A, General Design Criterion (GDC) 17, Electric Power Systems. Enclosure 2 supersedes and replaces the BFN EPU Transmission System Stability Evaluation submitted in Enclosure 4 of the Reference 3 letter, dated September 21, 2016.

Enclosure 3 of this letter provides the updated response (Revision 2) to the NRC RAI EEEB-RAI 1. The update has been made to reflect the changes to the transmission system upgrades included in Revision 3 of the interconnection SIS. Enclosure 4 of this letter provides a public version of Revision 2 of NRC RAI EEEB-RAI 1 and updated response, with critical energy infrastructure information removed. Enclosures 3 and 4 of this letter supersede and replace the response to NRC RAI EEEB-RAI 1 submitted in Enclosures 3 and 4 of the Reference 2 letter, dated May 27, 2016.

Enclosure 5 of this letter provides a revised addendum to the BFN EPU Probabilistic Risk Assessment (PRA). This revised addendum to the BFN EPU PRA addresses the impact of the main generator excitation system modification included in Revision 3 of the interconnection SIS. Enclosure 5 supersedes and replaces the PRA addendum submitted in Enclosure 7 of the Reference 2 letter, dated May 27, 2016.

Enclosure 6 of this letter provides an update to the last paragraph of the Technical Evaluation subsection of Power Uprate Safety Analysis Report (PUSAR) (NEDC-33860P, Revision 1, and NEDO-33860, Revision 1) Section 2.5.1.2.2, which was provided in Enclosures 1 and 2 of the Reference 4 letter. This update to PUSAR Section 2.5.1.2.2 addresses the impact of the main generator excitation system modification included in Revision 3 of the interconnection System Impact Study. The information provided in Enclosure 6 to this letter supersedes and replaces the last paragraph of the Technical Evaluation subsection of PUSAR Section 2.5.1.2.2 submitted in Enclosures 1 and 2 of the Reference 4 letter.

Enclosure 7 of this letter provides Revision 4 to the BFN EPU List and Status of Plant Modifications. The BFN EPU List and Status of Modifications is revised to reflect the main generator excitation system modification included in Revision 3 of the interconnection SIS and modifications that have been completed since the BFN EPU LAR was submitted. Enclosure 7 supersedes and replaces the BFN EPU List and Status of Modification submitted in Enclosure 5 of the Reference 5 letter, dated August 3, 2016.

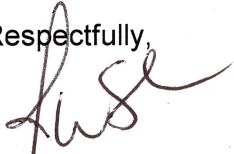
Enclosures 1, 2, and 3 contain critical energy infrastructure information that is considered sensitive, unclassified (non-safeguard) information. As a result, TVA requests that Enclosures 1, 2, and 3 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390(d)(1).

TVA has reviewed the information supporting a finding of no significant hazards consideration provided to the NRC in the Reference 1 letter. The supplemental information provided in this submittal does not affect the bases for concluding that the proposed license amendment does not involve a significant hazards consideration. Additionally, in accordance with 10 CFR 50.91(b)(1), TVA is sending a copy of this letter, without the critical energy infrastructure information or proprietary information, to the Alabama State Department of Public Health.

There are no new regulatory commitments associated with this submittal. If there are any questions or if additional information is needed, please contact Mr. Edward D. Schrull at (423) 751-3850.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 20th day of January 2017.

Respectfully,



J. W. Shea  
Vice President, Nuclear Licensing

Enclosures:

1. Interconnection System Impact Study, Revision 3: Browns Ferry Nuclear Plant Extended Power Uprate (Critical Energy Infrastructure Information)
2. BFN EPU LAR, Attachment 43, Transmission System Stability Evaluation, Revision 4 (Critical Energy Infrastructure Information)
3. Response to NRC Request for Additional Information EEEB-RAI 1, Revision 2 (Critical Energy Infrastructure Information)
4. Response to NRC Request for Additional Information EEEB-RAI 1, Revision 2 (Without Critical Energy Infrastructure Information)
5. BFN EPU LAR, Attachment 44, Probabilistic Risk Assessment, Addendum (Revised)
6. Power Uprate Safety Analysis Report (PUSAR), Section 2.5.1.2.2 Update
7. BFN EPU LAR, Attachment 47, List and Status of Plant Modifications, Revision 4.

cc:

NRC Regional Administrator - Region II  
NRC Senior Resident Inspector - Browns Ferry Nuclear Plant  
State Health Officer, Alabama Department of Public Health (w/o Enclosures 1, 2, and 3)

**ENCLOSURE 4**

**Response to NRC Request for Additional Information EEEB-RAI 1, Revision 2**

**(Without Critical Energy Infrastructure Information)**

## EEEB-RAI-1

*In Section 3.0 of Attachment 43, the licensee states:*

*The [TSS] study evaluated the performance of the 500 kV [kilovolt] and 161 kV offsite power systems during a DBE [design-basis event] under EPU [extended power uprate] conditions. Bus voltages observed during the simulation are compared to acceptance criteria to determine adequacy of the offsite power supply. The TSS considered a loss of the largest single supply to the grid, loss of the largest single load, loss of the nuclear unit, and loss of each bulk transmission line in the TVA transmission system, including all the lines coming into the BFN switchyard. The study used base cases from both 2015 (pre-EPU) and 2019 (post-EPU) to address the load flow analysis at EPU conditions.*

- A. Provide acceptable voltage range of BFN 500 kV and 161 kV offsite power acceptance criteria. Also, clarify whether the voltage criteria corresponding to post EPU conditions has been agreed upon by the transmission system operator.*
- B. Provide summary of cases studied with diagrams to verify that the voltage criteria is met under the following post-EPU conditions:*
  - i. loss of the largest load (identify the load),*
  - ii. loss of the largest generator (identify the generator), and*
  - iii. loss of the most critical transmission line (identify the line).*

## TVA Response:

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improves the 500 kV offsite power system shutdowns. The most



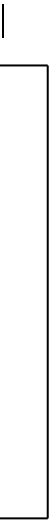
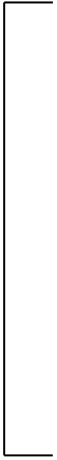


Figure 1 - Interconnection Map



Figure 2 - Interconnection Arrangement



Figure 3 - BFN 161 kV Substation



**ENCLOSURE 5**

**BFN EPU LAR, Attachment 44, Probabilistic Risk Assessment,  
Addendum (Revised)**

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## 1.0 EXECUTIVE SUMMARY

Tennessee Valley Authority (TVA) has proposed to uprate Browns Ferry Nuclear Plant (BFN) Units 1, 2, and 3 from the current licensed thermal power (CLTP) to approximately 120 percent of the original licensed thermal power (OLTP). The material modification will uprate each BFN unit electrical output by approximately 155 megawatts ~~electric~~ (MWe). TVA performed an Interconnection System Impact Study (SIS) for the extended power uprate (EPU) of all three BFN units. The Interconnection SIS documents the transmission system and BFN main generator excitation system upgrades required to support the BFN EPU. Modification to the BFN main generator excitation system potentially affects the initiating event frequency used in the probabilistic risk assessment (PRA) previously performed for the BFN EPU project. This addendum serves to document evaluation of the effect on the PRA conclusion for the proposed main generator excitation system upgrades.

## 2.0 INTRODUCTION

The existing BFN main generator excitation system uses an alternating current (AC) generator to supply power to a rectifier assembly which produces a direct current (DC) output. The resultant DC voltage is supplied to the generator field via brushes and collector rings. The automatic voltage regulator (AVR) controls the output of exciter ~~and is powered from an external source.~~ The existing AVR is being modified. The scope of the modification includes modifying the AVR to receive power from the exciter generator (self-excited) instead of an external power source (separately excited). The previously proposed modification to transition to a static exciter is no longer being considered. ~~excitation system (AVR, AC generator, and rectifier) are to be replaced with an AVR/static exciter and dry transformer. The new excitation system will provide the field current directly to the brushes and collector rings eliminating the need for the rotating exciter.~~

BFN License Amendment Request (LAR) Attachment 44, Section 4.1.1, Initiating Events, describes the transient initiators and initiator frequencies. BFN LAR Attachment 44, Section 5.7, Sensitivity Analysis and Uncertainties, describes the effect of varying the frequency of the turbine trip transient initiator on the PRA results and conclusions. ~~The modification to the main generator excitation system potentially affects the turbine trip transient initiator frequency. The turbine trip initiator includes turbine trips caused by main turbine steam admission components, the main turbine and its auxiliaries, and the main generator and its auxiliaries. The NRC Licensee Event Reports and INPO significant operating experience reports were reviewed to confirm that failures to the main generator exciter have previously caused events that are categorized as turbine trip transients. Replacing the main generator excitation system potentially affects the turbine trip transient initiator frequency.~~

In the TVA response to NRC request for additional information (RAI) APLA-RAI 08 (Reference 1), a combined sensitivity case was calculated to assess the sensitivity of the base core damage and large early release risk and change in core damage and large early release risk to a simultaneous increase in the annual frequency of several initiating events. In particular, the annual frequency of turbine trip (0.436/yr) was increased by 15% to account for possibility of more turbine trips resulting from operating at EPU conditions. ~~The 15% increase in the initiating event frequencies is based on a postulated 10-year average of increased event frequencies where the frequency during the first year was increased 100% over the baseline value and the second year was increased 50% over the baseline value to estimate effects of the plant adjusting to the higher power level. The frequencies for the remaining years remained at the baseline value to obtain the 15% increase over 10 years.~~ Calculations supporting the response to APLA-RAI 08 from Reference 1 showed that the combined sensitivity is within RG 1.174 risk acceptance guidelines. This combined sensitivity case did not ~~explicitly include consideration of a modification to the~~

~~exciter include changing the rotating brush exciter to a static exciter.~~ The following analysis is provided to demonstrate that the previous sensitivity envelops any changes in risk due to the modification to the generator excitation system.

### 3.0 ANALYSIS

The reliability of the proposed modified exciter can be compared with the existing exciter to provide insights into the expected change in equipment reliability. The significant difference between the existing and proposed exciter systems is the power supply arrangement for the AVR. The current system uses external power supplied from redundant excitation transformers, while the modified system will obtain power from the output of the exciter generator through redundant transformers. The removal of the external power source reduces the number of potential component failures which could lead to a consequential generator exciter failure that results in a turbine trip. With the proposed modification, the AVR will receive power from the exciter stator, which is already required for the exciter to function. The modification to the AVR itself is not expected to impact the reliability of the exciter.

The effect of the modification on the overall reliability of the main generator exciter system is an insignificant improvement to the stator reliability. While there may be some improvement in reliability now that external power supply failures no longer impact the device, the improvement is judged to be minor relative to the total reliability of the generator. Additionally, the turbine trip initiating event frequency has many contributors which are unrelated to the reliability of the main generator excitation system. These contributors include turbine valve admission failures, turbine control failures, generator cooling failures, etc. Therefore, a minor change in the reliability of the generator exciter has a negligible impact on the turbine trip initiating frequency. The impact of the modification is bounded by the previous sensitivity case, since the change in initiating event frequency is expected to be both small and positive. ~~The proposed static excitation system has a projected mean time between failure (MTBF) of 72 years (yr). Converted to a frequency, the failure frequency of the static excitation system is  $1.4 \times 10^{-2}$ /yr. The failure frequency for the existing excitation system (AVR and rotating exciter assembly) is not available, however the failure frequency for a like-kind, more reliable AVR is available. The MTBF of this more reliable version is used as a surrogate MTBF for the existing excitation system. The MTBF for the surrogate AVR is 61 years. Converted to a frequency, this reported failure frequency of the surrogate AVR is  $1.6 \times 10^{-2}$ /yr which, for the purpose of this analysis, is used as the failure frequency of the entire existing excitation system.~~

~~The failure frequency of the proposed static excitation system is lower than the failure frequency applied to the existing excitation system and therefore would be more reliable than the existing system. As a result, the turbine trip frequency in calculations supporting BFN EPU LAR Attachment 44 is conservative and is not increased by the proposed static excitation system modification.~~

### 4.0 CONCLUSION

The proposed modification to the generator ~~Replacing the existing rotating brush exciter with a static~~ excitation system does not result in a baseline risk increase nor a change in risk from CLTP to EPU power. The ~~modified static~~ excitation system is ~~considered to be~~ more reliable than the current excitation system. The effect of changing the turbine trip frequency due to replacing the excitation system is bounded by the sensitivity case presented to the NRC in response to APLA-RAI 08 (Reference 1).



## 5.0 REFERENCES

1. Letter from TVA to NRC, CNL-16-077, "Proposed Technical Specifications (TS) Change TS-505 – Request for License Amendments – Extended Power Uprate (EPU) – Supplement 14, Responses to Requests for Additional Information," dated April 27, 2016 (ML16118A298)

**ENCLOSURE 6**

**Power Uprate Safety Analysis Report (PUSAR),  
Section 2.5.1.2.2 Update**

**Replace the last paragraph of the Power Uprate Safety Analysis Report (PUSAR) (NEDC-33860P, Revision 1, and NEDO-33860, Revision 1), “Turbine-Generator,” “Technical Evaluation” section with the following insert:**

Insert 1

The main generator excitation systems that existed on all three units, were GE Alterrex Excitation systems. The energy for excitation of the generator field was derived from the turbine using a self-excited shaft driven alternator. The output of the alternator was rectified by a set of water cooled stationary diode bridges mounted in the doghouse of the generator. The resultant DC voltage was supplied to the generator field via brushes and collector rings. Between 2011 and 2013, TVA replaced the voltage regulators in the Alterrex Excitation systems with new ABB Unitrol 5000 automatic voltage regulators which were no longer fed by the Alterrex but rather were bus fed through auxiliary transformers. The Interconnection System Impact Study (SIS), performed for BFN at EPU conditions, determined that main generator stability issues exist for a 3-phase fault on one of several BFN transmission lines coincident with certain transmission lines already out of service (N-1-1 event). The present excitation system cannot raise the field voltage fast enough and high enough to prevent the main generator from becoming unstable during the N-1-1 event. To address the transient stability issue, BFN will modify the AVR and return the Alterrex system to a self-excited, shaft driven alternator. The AVR will be supplied power with exciter fed, redundant excitation transformers. In addition, a Static VAR Compensator (SVC) sized at +450 MVAR/-400 MVAR, will be installed at the Limestone substation. Additional computer simulations of the N-1-1 event for the SIS, with the modified excitation system and the new SVC modeled, have shown that the generators remain stable. Until the excitation systems can be modified and the SVC installed, administrative controls will be implemented to limit unit output whenever transmission system conditions exist that could make generator instabilities possible during an N-1-1 event. Once the excitation systems are modified and the SVC installed, the administrative controls will no longer be necessary. Use of administrative controls to prevent transient instabilities, prior to the excitation systems being modified and SVC installed, is allowed by North American Reliability Council (NERC) standards.

**ENCLOSURE 7**

**BFN EPU LAR, Attachment 47, List and Status of Plant Modifications, Revision 4**

## **Browns Ferry Units 1, 2 and 3 EPU Modifications, Revision 43**

The modifications required to support Extended Power Uprate (EPU) for Browns Ferry Nuclear Power Station (BFN) Units 1, 2 and 3 have been compiled and are shown in Table 1. The modifications reported as 'Complete' in Table 1 are fully implemented, for all other modifications a schedule for full implementation is provided. All EPU modifications, either completed or being prepared, are in accordance with the TVA Plant Modifications and Engineering Change Control process.

Further evaluations may identify the need for additional modifications or obviate the need for some modifications. As such, Table 1 listings are not a formal commitment to implement the modifications exactly as described or per the proposed schedule. Additionally, various minor modifications and adjustments to plant equipment, which may be necessary, are not listed.

**Table 1: BFN EPU Planned Modifications and Current Schedule**

<b>Modification</b>	<b>Description</b>	<b>Scheduled Completion (Note 1)</b>
Replacement Steam Dryer	<p>New steam dryers will be installed with increased structural design margin to accommodate EPU operation.</p> <ul style="list-style-type: none"><li>• Replacement steam dryers are curved hood six-bank dryers analyzed for fatigue resulting from flow induced vibration and hydrodynamic loads.</li><li>• Main steam line strain gages were previously installed to obtain measurements at CLTP conditions which were used to design the replacement steam dryers.</li><li>• New main steam line strain gages will be installed to replace the existing strain gages which have reached end of life to obtain measurements during power ascension testing of the replacement steam dryers.</li></ul>	<p>Unit 1 – Fall 2018 Unit 2 – Spring 2019 Unit 3 – Spring 2018</p>
Main Turbine	<p>Replace the High Pressure Turbine rotor. Incorporate GE's Advanced Design Steam Path which is designed for the increased flow associated with EPU.</p> <ul style="list-style-type: none"><li>• Replace High Pressure Turbine diaphragms and rotor buckets.</li><li>• Modify the cross around relief valves (CARVs) to permit increased set pressure.</li><li>• Replace and/or recalibrate Main Steam system flow and pressure instruments.</li></ul>	<p>Unit 1 – Fall 2018 Unit 2 – Spring 2019 Unit 3 – Spring 2018</p> <p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete</p> <p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete</p>
Turbine Sealing Steam	<p>Increase the size of the Steam Packing Unloader Valves (SPUVs) and associated piping to enable the turbine sealing system to accommodate EPU flow requirements.</p> <ul style="list-style-type: none"><li>• Increase SPUVs and piping from 8-inch to 10-inch components.</li><li>• Replace and rescale steam flow and steam pressure transmitters.</li></ul>	<p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete</p>

Modification	Description	Scheduled Completion (Note 1)
Condensate Pumps	<p>Upgrade Condensate pumps with new impellers and motors to accommodate the increased flows that will be required for EPU operation.</p> <ul style="list-style-type: none"> <li>• Replace impellers in each pump (3 pumps per Unit).</li> <li>• Replace 900 HP motors with 1250 HP motors.</li> <li>• Add orifice plate to the Condensate Recirculation line to reduce pressure drop across the flow control valve to minimize cavitation and vibration.</li> <li>• Replace existing pump discharge check valves with different style check valves having lower pressure drop and better transient response.</li> <li>• Replace pump suction strainers with stronger mesh screen to prevent screen deformation with the increased EPU flow conditions.</li> <li>• Change motor protection relay settings.</li> <li>• Recalibrate/replace pump and motor instrumentation.</li> </ul>	Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete
Condensate Booster Pumps	<p>Replace the Condensate Booster (CB) pumps and motors to increase pump capacity to accommodate the increased flows that will be required for EPU operation.</p> <ul style="list-style-type: none"> <li>• Replace CB pumps with higher capacity pumps.</li> <li>• Replace air-cooled 1750 HP motors with water-cooled 3000 HP motors.</li> <li>• Replace existing pump discharge check valves with different style check valves having lower pressure drop and better transient response.</li> <li>• Change motor protection relay settings.</li> <li>• Recalibrate/replace pump and motor instrumentation.</li> </ul>	Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete
Condensate Pump and Condensate Booster Pump Area Ventilation	<p>Provide additional cooling/ventilation in vicinity of the Condensate and Condensate Booster pumps to accommodate the increased heat load resulting from larger air-cooled Condensate Pump motors and supplement cooling requirements for the hydrogen water chemistry (HWC) main control panel.</p> <ul style="list-style-type: none"> <li>• Replace 3-position switches for operation of the Air Handling Units (AHUs) with 4-position switches that will allow parallel operation of the AHUs.</li> <li>• Addition of a balancing damper to the Condensate Pump motors to provide better balancing of air flow.</li> <li>• Addition of a branch duct and balancing damper to the HWC main control panel.</li> </ul>	Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete

Modification	Description	Scheduled Completion (Note 1)
Feedwater Pumps and Turbines	<p>Upgrade the Feedwater system to provide increased Feedwater flow for EPU operation.</p> <ul style="list-style-type: none"> <li>• Replace pumps with higher capacity pumps.</li> <li>• Replace turbine rotor, diaphragms and buckets.</li> <li>• Replace turbine/pump coupling.</li> <li>• Upgrade seal water injection subsystem.</li> <li>• Update Feedwater control system software for EPU conditions.</li> </ul>	<p>Unit 1 - Complete Unit 2 - Complete Unit 3 - Complete</p> <p>Unit 1 – Fall 2018 Unit 2 – Spring 2019 Unit 3 – Spring 2018</p>
Moisture Separators	<p>Modify the internals of the moisture separators to increase moisture removal and accommodate increased flows at EPU conditions.</p> <ul style="list-style-type: none"> <li>• Change vanes and added perforated plate on moisture separators.</li> <li>• Modify internal drains as needed.</li> </ul>	<p>Unit 1 - Complete Unit 2 - Complete Unit 3 - Complete</p>
Feedwater Heaters	<p>Upgrade Feedwater Heaters to support EPU operating conditions.</p> <ul style="list-style-type: none"> <li>• Re-rate the number 1, 2 and 3 Feedwater Heater shells to meet higher pressures, temperatures and flows under EPU conditions by modification of selected nozzles and replacement of shell relief valves to meet ASME code requirements.</li> <li>• Replace level control instrumentation on the number 1, 2 and 3 Feedwater Heaters to reduce susceptibility to flow induced turbulence (pressure transients).</li> <li>• Provide additional welds and bracing to the pass partition plates for Nos. 1, 2, 3, and 5 Feedwater Heaters. (Number 4 Feedwater Heaters' pass partition plates will be addressed with replacement of the tube bundle and channel head.)</li> <li>• Due to the increase in tube-side design pressure with the increase head capacity of the Condensate Booster pumps, replace channel head relief valves for No. 3 Feedwater Heaters with valves having higher setpoints, and install a reinforcement ring on the manways for the number 3 and number 5 Feedwater Heaters.</li> <li>• On each of the number 3 Feedwater Heaters, replace the upper shell and install an extraction steam inlet duct to minimize heater shell erosion and preclude tube damage from steam jet impingement.</li> <li>• Replace tube bundle and channel head in the number 4 Feedwater Heaters with a design less susceptible to damage from flow induced vibration.</li> </ul>	<p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Spring 2018</p> <p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete</p> <p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Spring 2018</p> <p>Unit 1 – Complete Unit 2 – Spring 2017 Unit 3 – Complete</p> <p>Unit 1 – Fall 2018 Unit 2 – Spring 2019 Unit 3 – Spring 2018</p>
Main Condenser Extraction Steam Bellows	<p>Replace Main Condenser Extraction Steam bellows #2, #3, #4 and #5 with bellows accommodating higher design temperatures and pressures for EPU.</p>	<p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete</p>



<b>Modification</b>	<b>Description</b>	<b>Scheduled Completion (Note 1)</b>
Condensate Demineralizers	Install a 10th condensate demineralizer (and associated valves and controls) on each unit to accommodate the increased condensate flow associated with EPU operation.	Unit 1 - Complete Unit 2 - Complete Unit 3 - Complete
Steam Packing Exhauster Bypass	Increase the capacity of the steam packing exhauster bypass line to accommodate increased flow under EPU conditions. <ul style="list-style-type: none"> <li>Install larger piping and flow control valve.</li> </ul>	Unit 1 - Complete Unit 2 - Complete Unit 3 - Complete
Torus Attached Piping	Modification to reinforce an existing pad at an ECCS ring header branch connection to address higher pipe stresses associated with EPU conditions. Required only on Units 2 and 3 as sufficient stress margin exists on Unit 1.	Unit 1 – N/A Unit 2 – Complete Unit 3 – Complete
Main Steam Supports	Modify one Unit 2 Main Steam pipe support due to increased loads resulting from turbine stop valve closure at EPU steam flow rates. All other existing Unit 2 Main Steam pipe supports, and all Main Steam pipe supports on Units 1 and 3, were determined to have sufficient design margin to accommodate the increased turbine stop valve closure loads.	Unit 1 – NA Unit 2 – Complete Unit 3 – NA
Reactor Recirculation Pumps & Motors	Upgrade the reactor recirculation system for EPU core flow operating conditions. <ul style="list-style-type: none"> <li>Perform analyses/evaluations to increase the design ratings for the recirculation pumps and motors.</li> <li>Upgrade the Variable Frequency Drive (VFD) control system.</li> <li>Perform pump and motor instrumentation upgrades - jet pump head, RCW flow, motor winding temperatures, VFD protective relay settings.</li> <li>Revise Upper Power Runback setting for EPU conditions.</li> </ul>	Unit 1 - Complete Unit 2 - Complete Unit 3 - Complete  Unit 1 – Fall 2018 Unit 2 – Spring 2019 Unit 3 – Spring 2018
Jet Pump Sensing Line Clamps	Install jet pump sensing line clamps to reduce pipe vibration under EPU conditions.	Unit 1 - Complete Unit 2 - Complete Unit 3 - Complete
Main Generator System	Upgrade main generator to 1330 MVA (Unit 1) / 1332 MVA (Units 2 & 3). <ul style="list-style-type: none"> <li>Install rewind stator to support higher generator output capacity.</li> <li>Replace/modify stator water cooling (SWC) instruments and change SWC flow, pressure, DP and temperature settings to support increased stator water cooling requirements.</li> </ul>	Unit 1 - Complete Unit 2 - Spring 2019 Unit 3 - Complete
Main Generator Hydrogen Pressure	Increase generator hydrogen pressure from 65 psig to 75 psig to support EPU operation. <ul style="list-style-type: none"> <li>Change pressure regulating valve settings and pressure alarm setting.</li> <li>Replace pressure switches as needed for new operating range.</li> <li>Change generator field over-excitation relay settings.</li> <li>Eliminate hydrogen flow integrator to mitigate hydrogen leakage.</li> </ul>	Unit 1 – Fall 2018 Unit 2 – Spring 2019 Unit 3 – Spring 2018

<b>Modification</b>	<b>Description</b>	<b>Scheduled Completion (Note 1)</b>
Isophase Bus Duct Cooling	<p>Modify isophase bus duct cooling system to remove increased bus duct heat under EPU conditions.</p> <ul style="list-style-type: none"> <li>• Replace cooling fans and motors.</li> <li>• Replace cooling coils.</li> </ul>	<p>Unit 1 - Complete Unit 2 - Complete Unit 3 - Complete</p>
Main Bank Transformers	<p>Upgrade main bank transformers to account for the higher power output from the main generators at EPU conditions.</p> <ul style="list-style-type: none"> <li>• Replace three 500 MVA transformers per unit.</li> <li>• Replace one Units 1 and 2 500 MVA spare transformer.</li> <li>• Install new dedicated Unit 3 500 MVA spare transformer.</li> </ul>	<p>Unit 1 - Complete Unit 2 - Complete Unit 3 - Installation complete, post-modification testing of the Unit 3 Spare Transformer pending</p>
Vibration Monitoring	<p>Install mounting brackets/supports and temporary instrumentation for vibration monitoring during EPU power ascension in accordance with Attachment 45 (Flow Induced Vibration Analysis and Monitoring Program).</p>	<p>Unit 1 – Fall 2018 Unit 2 – Spring 2019 Unit 3 – Spring 2018</p>
Main Steam Isolation Valves (MSIV)	<p>Modify MSIVs to support steam flow increase at EPU conditions.</p> <ul style="list-style-type: none"> <li>• Install longer stroke actuators to move the poppet further out of the flow stream. This modification reduced valve pressure drop to accommodate EPU conditions.</li> <li>• Perform additional modifications to improve performance of the MSIVs including new bonnets, nose guided poppets (trimmed profile), and larger diameter valve stems.</li> </ul>	<p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete</p>
Electro-Hydraulic Control (EHC) Software	<p>Revise EHC software to address changes in plant parameters required to support EPU.</p> <ul style="list-style-type: none"> <li>• Electrical Overspeed set point, Intermediate Pressure, Power Load Unbalance, Turbine First Stage Pressure, and Megawatt (MW) Control</li> </ul>	<p>Unit 1 – Complete Unit 2 – Complete Unit 3 – Complete</p>
Technical Specification Instrument Respan	<p>Technical Specification Instrument respan and setpoint changes for EPU</p> <ul style="list-style-type: none"> <li>• Turbine 1st stage pressure scram bypass permissive setpoint change</li> <li>• Main steam line high flow isolation channel respan</li> <li>• APRM flow biased and setdown instrument respan and setpoint change</li> </ul>	<p>Unit 1 - Fall 2018 Unit 2 - Spring 2019 Unit 3 - Spring 2018</p>
Balance of Plant Instrument Respan	<p>Respan balance of plant (BOP) instruments for EPU.</p> <ul style="list-style-type: none"> <li>• Update hydrogen water chemistry programmable logic controller (PLC) software for control of hydrogen and oxygen injection at EPU.</li> <li>• Replace and respan hydrogen water chemistry flow instruments.</li> <li>• Replace and respan extraction steam pressure instruments.</li> <li>• Replace and respan feedwater heater pressure and level instruments.</li> <li>• Recalibrate setpoints for reactor feedwater low suction and steam jet air ejector stage I/II/III low pressure switches.</li> <li>• Respan high pressure turbine exhaust intermediate pressure.</li> <li>• Replace and respan offgas condenser cooling water temperature instruments.</li> </ul>	<p>Unit 1 - Complete Unit 2 - Complete Unit 3 - Complete</p>



Modification	Description	Scheduled Completion (Note 1)
Self-Excited Excitation System	To address a transient stability issue resulting from the increased electrical generation at EPU, the Excitation System on Units 1, 2, and 3 will be upgraded. The Alterrex excitation system will be returned to a self-excited, shaft driven alternator and the Automatic Voltage Regulator (AVR) will be modified. The AVR will be supplied power with exciter fed, redundant excitation transformers. (See also Note 2 below.)	Unit 1 - Fall 2020 Unit 2 - Spring 2021 Unit 3 - Spring 2020
Alternate Leakage Treatment Pathway	Provide a highly reliable Alternate Leakage Treatment Pathway that routes 99.5% of the leakage from the primary containment MSIVs directly to the condenser. The modification on each unit will include replacement of five motor operated valves on the Main Steam drain lines with air operated valves. Also, an additional Main Steam drain line valve will be installed, with an air operator, to address single failure criteria. All the new air operated valves will fail open on loss of electrical power or control air.	Unit 1 – Fall 2018 Unit 2 – Spring 2019 Unit 3 – Spring 2018

Notes:

- 1) The expected completion timeframes reported in Table 1 correspond to the following refuel outages: For BFN Unit 1, Fall of 2016 is RFO-U1R11, Fall of 2018 is RFO-U1R12 and Fall of 2020 is RFO-U1R13. For BFN Unit 2, Spring of 2017 is RFO-U2R19, Spring of 2019 is RFO-U2R20 and Spring of 2021~~2023~~ is RFO-U2R21~~U2R242~~. For BFN Unit 3, Spring of 2018 is RFO-U3R18 and Spring of 2020~~2024~~ is RFO-U3R19~~24~~.
- 2) The ~~Self-Excited Excitation System~~~~Static-Excitation System~~ is not required to be installed prior to EPU operation. During the interim period of EPU operation preceding installation of the ~~Self-Excited Excitation System~~~~Static-Excitation System~~, transmission system grid stability will be maintained through use of a detailed temporary operating guide.