UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 18, 2018

To the Petitioners on the Enclosed List

Dear Sir or Madam:

Your petition dated February 19, 2016, addressed to the Executive Director for Operations, has been reviewed by the U.S. Nuclear Regulatory Commission (NRC) staff pursuant to Section 2.206, "Requests for action under this subpart," of Title 10 of the *Code of Federal Regulations*. You requested that the NRC either: (1) issue orders to require immediate corrective actions including compensatory measures to address the operability of electric power systems in accordance with their plant technical specifications, and to implement plant modifications in accordance with current NRC regulatory requirements and staff guidance provided in the references within the 2.206 petition, or (2) issue orders to immediately shut down the nuclear power plants that are operating without addressing the significant design deficiency identified in NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System," dated July 27, 2012 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12074A115), since the licensees are not in compliance with their Technical Specifications (typically Section 3.8.1) related to onsite and offsite power systems.

On September 18, 2017, the NRC issued a proposed director's decision which denied your petition requests to seek enforcement action against operating reactor licensees (ADAMS Accession No. ML17156A180). The NRC sent a copy of the proposed director's decision to you by letter dated September 18, 2017 (ADAMS Accession No. ML17156A197) and to all operating reactor licensees for comment (ADAMS Accession No. ML17156A214).

You provided comments by letter dated October 11, 2017 (ADAMS Accession No. ML17291A040), and the Nuclear Energy Institute provided comments, on behalf of licensees, by letter dated October 16, 2017 (ADAMS Accession No. ML17291A846). The staff's final director's decision denied your petition requests to seek enforcement action against operating reactor licensees and is enclosed for your reference. The NRC staff's responses to all of the comments received are included as an attachment to this director's decision.

On December 12, 2017, the NRC issued a final director's decision (ADAMS Accession No. ML17304A893). Subsequently, the NRC was informed of a minor error in the final director's decision. Specifically, Section D of the final director's decision refers to a December 2015 open phase condition event at Oconee and states, "Two separate transformers required for safe shutdown of the three operating Oconee nuclear units were identified with open phase conditions." This statement is in error because only one Oconee transformer experienced an open phase condition. Although this error does not change the decision in the director's decision, the NRC revised it, as appropriate, for accuracy.

Please feel free to contact Ms. Tanya Mensah at 301-415-3610 to discuss any question related to this petition. I would like to express my appreciation for your effort in working toward a final resolution of this matter.

Sincerely,

Brian E. Holian, Acting Director
Office of Nuclear Reactor Regulation

Docket Nos.: See Enclosure 3

Enclosures:
1. List of Petitioners
2. Revised Final Director's Decision
3. List of Power Reactor Licensees and Holders of Construction Permits in Active or Deferred Status

cc: Listserv

REVISED FINAL DIRECTOR'S DECISION ON OPEN PHASE CONDITION 2.206 – ALL CURRENT OPERATING NUCLEAR PLANTS, DATE: January 18, 2018

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ADAMS Accession Nos.
Package: ML18005A052
Acknowledgement Letter: ML16069A214
Revised Transmittal Letter to Petitioners: ML18005A055
Revised FRN: ML18005A054
Incoming petition: ML16050A223
Proposed Director's Decision: ML17156A180
Revised Final Director's Decision ML18005A053
*Concurrence via e-mail

OFFICE	DIRS/IRGB/PM	DIRS/IRGB/LA	NRR/DORL/ LSPP/PM*	NRR/DE/D*	NRO/DCIP/D (PRB Chairman)*	NRR/DORL/D*
NAME	TMensah	ELee	MBanic	EBenner	TMcGinty	JGiitter
DATE	01/09/18	01/08/2018	01/09/18	01/09/18	01/10/18	01/10/18
OFFICE	OGC*	NRR/D				
NAME	DCylkowski	BHolian				
DATE	01/11/18	01/18/18				

OFFICIAL RECORD COPY

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Enclosure 2

Revised Final Director's Decision

ADAMS Accession No. ML18005A053

[7590-01-P]
DD-17-04

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION

Brian E. Holian, Acting Director

In the Matter of	)
	)
All Operating Reactor Licensees	)
	)

REVISED DIRECTOR'S DECISION UNDER 10 CFR 2.206

I. Introduction

By letter dated February 19, 2016 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16050A223), Roy Mathew, Sheila Ray, Swagata Som, Gurcharan Singh Matharu, Tania Martinez Navedo, Thomas Koshy, and Kenneth Miller (Petitioners), filed a petition pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR) Section 2.206, "Requests for action under this subpart." The Petitioners requested that the U.S. Nuclear Regulatory Commission (NRC) either: (1) issue orders to require immediate corrective actions including compensatory measures to address the operability of electric power systems in accordance with their plant technical specifications, and to implement plant modifications in accordance with current NRC regulatory requirements and staff guidance provided in the references within the 2.206 petition, or (2) issue orders to immediately shut down the nuclear power plants that are operating without addressing the significant design deficiency identified in NRC Bulletin (BL) 2012-01, "Design Vulnerability in Electric Power System," dated July 27, 2012

(ADAMS Accession No. ML12074A115), since the licensees are not in compliance with their Technical Specifications (typically Section 3.8.1) related to onsite and offsite power systems.

Management Directive (MD) 8.11, "Review Process for 10 CFR 2.206 Petitions" (ADAMS Accession No. ML041770328), describes the NRC's review process for 10 CFR 2.206 petitions. On February 24, 2016, the NRC's petition manager acknowledged receipt of the petition and offered the Petitioners an opportunity to address the Petition Review Board (PRB). The Petitioners declined an opportunity to address the PRB on the basis that the petition already contained all of the relevant facts to support the PRB's review.

On March 14, 2016, the PRB met internally to discuss the request for immediate action, and to make an initial recommendation to either accept or reject the petition for review. The PRB denied the request for immediate action on the basis that the petition presented no significant new information, and only raised issues that had already been the subject of NRC staff review for regulatory and safety significance. The PRB also made an initial recommendation that the petition met the criteria for review in accordance with MD 8.11, Section III.C (1), "Criteria for Reviewing Petitions Under 10 CFR 2.206."

On March 15, 2016, the Petitioners were informed of the PRB's decision to deny the request for immediate action and of the initial recommendation to accept the petition for review. The Petitioners declined a second opportunity to address the PRB on the basis that the petition already contained all of the relevant facts to support the PRB's review. Therefore, consistent with its initial recommendation, the PRB declared its final recommendation to accept the petition for review.

In its March 21, 2016, acknowledgement letter (ADAMS Accession No. ML16069A214), the NRC staff informed the Petitioners that although their request for immediate action was denied, the petition was accepted for review.

The NRC sent a copy of the proposed director's decision to the Petitioners and to the licensees for comment by letters dated September 18, 2017 (ADAMS Accession Nos. ML17156A197 and ML17156A214). The Petitioners and the licensees were given the opportunity to provide comments on any part of the proposed director's decision that was considered to be erroneous or any issues in the petition that were not addressed. The Petitioners provided comments by letter dated October 11, 2017 (ADAMS Accession No. ML17291A040), and the Nuclear Energy Institute (NEI) provided comments, on behalf of licensees, by letter dated October 16, 2017 (ADAMS Accession No. ML17291A846). No new information was provided. To enhance the clarity of the director's decision, the NRC staff revised the description on the NRC's accident sequence precursor (ASP) program provided in Section D of this director's decision, to differentiate between condition and event assessments. The comments from the Petitioners and NEI, along with the NRC staff's responses to the comments are included as an attachment to this director's decision. The attachment identifies any updates to the director's decision, as a result of comments received from the Petitioners and NEI.

On December 12, 2017, the NRC issued a final director's decision (ADAMS Accession No.ML17304A893). Subsequently, the NRC was informed of a minor error in the final director's decision. Specifically, Section D of the final director's decision refers to a December 2015 open phase condition event at Oconee and states, "Two separate transformers required for safe shutdown of the three operating Oconee nuclear units were identified with open phase conditions." This statement is in error because only one Oconee transformer experienced an open phase condition. Although this error does not change the decision in the director's decision, the NRC revised it, as appropriate, for accuracy.

The petition and other references related to this petition are available for inspection in the NRC's Public Document Room (PDR), located at O1F21, 11555 Rockville Pike (first floor), Rockville, Maryland 20852. Publicly available documents created or received at the NRC are accessible electronically through ADAMS in the NRC Library at http://www.nrc.gov/reading-rm/adams.html. Persons who do not have access to ADAMS or who encounter problems in accessing the documents located in ADAMS should contact the NRC's PDR reference staff by telephone at 1-800-397-4209, or 301-415-4737, or by e-mail to pdr.resource@nrc.gov.

II. Discussion

Based on the NRC's comprehensive activities related to the resolution of open phase conditions in the electric power system for current operating nuclear power plants, the NRC's review took longer than the standard of 120 days for reaching a decision on the petition. This section includes a discussion of the relevant operating experience, NRC and industry actions, applicable regulatory requirements and guidance, the safety significance of the issue underlying the petition, and the NRC's actions and decisions on the Petitioners' requests.

A. Summary of Byron Station, Unit 2 Event

As the basis for this petition, the Petitioners refer to the Byron Station, Unit 2, operating event. On January 30, 2012, Byron Station, Unit 2, experienced an automatic reactor trip from full power because the reactor protection scheme detected an undervoltage condition on the 6.9-kV buses that power reactor coolant pumps (RCPs) B and C (undervoltage on two of four RCPs initiate a reactor trip). The undervoltage condition was caused by a broken insulator for the phase C conductor for the 345-kV power circuit that supplies both station auxiliary transformers (SAT). The insulator failure resulted in an open circuit for the phase C conductor, which supplies the high voltage side of the SATs. The open circuit created an unbalanced

voltage condition on two 6.9-kV nonsafety-related RCP buses and the two 4.16-kV engineered safety features (ESF) buses. Some ESF loads that were energized relied on equipment protective devices to prevent damage from the resulting unbalanced overcurrent condition. The phase overcurrent condition resulted in a trip of several ESF loads.

Approximately 8 minutes after the reactor trip, the control room operators manually opened circuit breakers to separate the unit buses from the offsite power source. When the operators opened the SAT feeder breakers to the two 4.16-kV ESF buses, the loss-of-voltage relays started the emergency diesel generators (EDGs) and the EDGs restored power to the ESF buses. If the condition had been allowed to persist for an additional few minutes, damage to the RCP seals could have occurred due to loss of RCP seal cooling water. This in turn could have resulted in excessive leakage of reactor coolant from the RCP seals in the containment building.

B. Summary of NRC and Industry Actions

Following this event, the NRC completed a reactive inspection pursuant to Inspection Procedure 93812, "Special Inspection," at Byron Station, Unit 2. The special inspection (ADAMS Accession No. ML12087A213) reviewed the circumstances surrounding the January 30, 2012, electrical insulator failure in the Byron switchyard, which resulted in a Unit 2 automatic reactor trip and notice of unusual event emergency declaration.

On February 16, 2012, the Institute of Nuclear Power Operations (INPO) issued a Level 2 INPO Event Report describing the Byron event and requiring a review of the lessons learned and corrective actions for applicability by all licensees. As a result of the Byron event, every affected U.S. nuclear power plant now has compensatory measures in place to ensure that control room operators are aware of the issue and are trained to respond, and has modified power source switching procedures to ensure that plants have emergency power, if needed.

On March 1, 2012, the NRC issued Information Notice 2012-03, "Design Vulnerability in Electric Power System," (ADAMS Accession No. ML120480170) to inform the licensees operating and constructing commercial power reactors of the operating experience involving the loss of one of the three phases of the offsite power circuit.

On July 27, 2012, the NRC issued BL 2012-01 to confirm licensee compliance with 10 CFR Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, General Design Criteria (GDC) 17, "Electric Power Systems," or principal design criteria specified in the updated final safety analysis report (UFSAR), 10 CFR 50.55a(h)(2), and 10 CFR 50.55a(h)(3). Each licensee's response to BL 2012-01 was submitted to the NRC by October 25, 2012, and can be found in ADAMS under each licensee's docket number.

The NRC staff reviewed the licensee responses to BL 2012-01 and documented the details of this review in a summary report dated February 26, 2013 (ADAMS Accession No. ML13052A711). Based upon the licensee responses to BL 2012-01, the NRC staff determined that most nuclear power reactors are susceptible to this open phase design vulnerability and recommended that the NRC take regulatory actions to address this design vulnerability.

On October 9, 2013, the NEI notified the NRC that the industry's Chief Nuclear Officers had approved a formal initiative to address open phase conditions, and that the initiative represented a formal commitment among nuclear power plant licensees to address this design vulnerability for operating reactors and new reactor plant designs (ADAMS Accession No. ML13333A147).

By letter dated December 20, 2013 (ADAMS Accession No. ML13351A314), the NRC issued a Request for Additional Information (RAI) to licensees to verify that they had completed interim corrective actions and compensatory measures and to determine the status of each licensee's long-term corrective actions. The licensees' responses to the RAI are publicly available under each licensee's docket number in ADAMS. Their responses describe the

compensatory measures implemented at each plant (primarily enhancements to plant operating procedures and operator training) to minimize plant risk and to ensure adequate safety margins.

The NRC provided a response to the industry initiative, including a discussion of the planned open phase isolation system (OPIS) to be installed at each plant, in a letter to NEI dated November 25, 2014 (ADAMS Accession No. ML14120A203). The NRC noted that the capability of the onsite ESF power system to permit functioning of structures, systems, and components may depend upon successful operation of OPIS, and that the proposed solution needs to fully address GDC 17 or the principal design criteria specified in each plant's UFSAR. The NRC also communicated four functional criteria for demonstrating compliance with existing regulatory requirements. The letter stated that the NRC staff concluded that although existing NRC regulations have requirements for the onsite and offsite power systems to permit functioning of structures, systems, and components important to safety for any failures in the offsite power system including a single failure in the onsite power system, open phase conditions were not specifically identified as an issue during the licensing reviews of the current operating nuclear power plants. The letter stated that for this reason, the NRC staff had recommended to the Commission that the NRC grant enforcement discretion to operating reactor licensees and refrain from issuing an enforcement action for certain noncompliances which would require a reactor shutdown while addressing the design vulnerability related to open phase conditions within their electrical power system.

On March 16, 2015, NEI provided the NRC with a revised initiative, changing its implementation completion date for OPIS from December 31, 2017, to December 31, 2018, in order to provide adequate time for licensees to implement necessary plant modifications (ADAMS Accession Nos. ML15075A455 and ML15075A456).

On March 22, 2016, NEI provided the NRC with an update on the industry initiative regarding their proposed plans to resolve the open phase condition issue (ADAMS Accession

Nos. ML16091A099 and ML16091A100). Specifically, NEI reported that approximately one-third of the industry fleet had implemented open phase monitoring or protection systems (as of March 22, 2016) and that the remaining plants planned to complete implementation by the December 31, 2018, due date. This letter also contained a detailed discussion of the actions already taken by the nuclear industry to resolve the open phase condition vulnerability for operating reactors.

On May 31, 2016, the NRC staff submitted SECY-16-0068, "Interim Enforcement Policy For Open Phase Conditions In Electric Power Systems For Operating Reactors," to the Commission (ADAMS Accession No. ML15219A327). In SECY-16-0068, the NRC staff requested Commission approval of an Interim Enforcement Policy (IEP), associated with inoperable electrical power systems (offsite and onsite) caused by an open phase condition design vulnerability in the offsite electric power system that would require a reactor shutdown or prevent a reactor startup if a licensee could not come into conformance within the TS-required completion times.

While awaiting the Commission's decision on SECY-16-0068, the NRC staff issued Temporary Instruction (TI) 2515/192, "Inspection of the Licensee's Interim Compensatory Measures Associated With The Open Phase Condition Design Vulnerabilities In Electric Power Systems" (ADAMS Accession No. ML16181A170), on November 9, 2016. The objective of this performance-based inspection guidance is to verify implementation of interim compensatory measures associated with an open phase condition design vulnerability in electric power system for operating reactors that have not completed permanent plant design modifications. The inspections of the power reactors were completed on March 31, 2017.

On March 9, 2017, the Commission issued the staff requirements memorandum (SRM) for SECY-16-0068 (ADAMS Accession No. ML17068A297). The Commission disapproved the staff's request to establish an IEP "for the purpose of exercising enforcement discretion for

purported noncompliance with NRC requirements and nonconformance with design criteria during the pendency of licensee implementation of actions to address an open phase condition." The SRM for SECY-16-0068 provided direction to the NRC staff regarding the implementation of the voluntary industry initiative to support the closure of BL 2012-01. Specifically, the SRM for SECY-16-0068 stated:

> Going forward, the staff should verify that licensees have appropriately implemented the voluntary industry initiative. If the staff determines that a licensee does not adequately address potential OPCs [open phase conditions], including updating the licensing basis to reflect the need to protect against OPCs, the staff should consider the appropriate regulatory mechanism to impose the necessary requirements to protect against OPCs using the current guidance on such matters from the Office of the General Counsel.
>
> The staff should provide the Commission with a notation vote paper if this situation arises for any licensee or licensees, with options, including the staff's recommended path forward. In addition, if disagreements arise between the staff and the industry during implementation of the voluntary industry initiative, and the related issues have policy implications, the staff should promptly raise such issues to the Commission for resolution.
>
> Once satisfactory implementation of the technical resolution has been verified for each licensee, the associated NRC Bulletin should be closed. The staff should update the Reactor Oversight Process to provide periodic oversight of industry's implementation of the OPC initiative.

C. Applicable NRC Regulatory Requirements and Guidance

GDC 17 establishes requirements for the electric design of nuclear power plants for which a construction permit application was submitted after the Commission promulgated the GDC. GDC 17 states:

> An onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for each system (assuming the other system is not functioning) shall be to provide sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents...

...

> Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions...
>
> Provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies.

For current operating power plants designed before the promulgation of GDC 17, the plant-specific UFSAR sets forth criteria similar to GDC 17, which requires, among other things, that plants have an offsite and an onsite electric power system with adequate capacity and capability to permit the functioning of structures, systems, and components important to safety in the event of anticipated operational occurrences and postulated accidents.

10 CFR 50.55a(h)(2) requires nuclear power plants with construction permits issued after January 1, 1971, but before May 13, 1999, to have protection systems that meet the requirements in Institute of Electrical and Electronics Engineers (IEEE) Standard 279-1968, "Proposed IEEE Criteria for Nuclear Power Plant Protection Systems; IEEE Standard 279-1997, "Criteria for Protection Systems for Nuclear Power Generating Stations"; or IEEE Standard 603-1991, "Criteria for Safety Systems for Nuclear Power Generating Stations," and the correction sheet dated January 30, 1995. For nuclear power plants with construction permits issued before January 1, 1971, protection systems must be consistent with their licensing basis or meet the requirements of IEEE Standard 603-1991 and the correction sheet dated January 30, 1995.

10 CFR 50.55a(h)(3) requires that applications filed on or after May 13, 1999, for construction permits and licenses under 10 CFR Part 50, or for design approvals, design

certifications, and combined licenses under 10 CFR Part 52, meet the requirements for safety systems in IEEE Standard 603-1991 and the correction sheet dated January 30, 1995. These IEEE standards state that the protection systems must automatically initiate appropriate protective actions whenever a condition the system monitors reaches a preset level. Once initiated, protective actions should be completed without manual intervention to satisfy the applicable requirements of the IEEE standards.

To support future licensing, the NRC staff also developed draft Branch Technical Position (BTP) 8-9, "Open Phase Conditions in Electric Power System Review Responsibilities" (ADAMS Accession No. ML14057A433), to provide design criteria and staff guidance consistent with applicable regulations and existing guidance found in Chapter 8 of the Standard Review Plan, "Electric Power Systems." Public comments requested through a *Federal Register* notice on June 5, 2014 (79 FR 32580) were addressed when finalizing the BTP. The final BTP 8-9 was published in July 2015 (ADAMS Accession No. ML15057A085), and the NRC staff plans to use this guidance for future licensing actions to verify compliance with applicable regulations related to electric power systems.

D. Safety Assessment

In the petition, the Petitioners stated that operating experience demonstrates that the open phase condition is a significant safety concern since a design basis event concurrent with an open phase condition would in most cases result in the plant exceeding criteria specified in 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors." The Petitioners also stated that the NRC's ASP analysis for the Byron event indicated the risk, Conditional Core Damage Probability, as 1×10^{-4}.

At the time that the petition was filed with the NRC, several open phase events had been identified over the last 14 years in the United States and internationally. Since the time that

compensatory measures were implemented at nuclear power plants, the licensee for Oconee, Unit 3, identified and reported the discovery of an open phase condition at the Oconee facility on December 7, 2015. Specifically, the licensee determined that a Unit 3 startup transformer was inoperable because of an open phase condition. On February 5, 2016, the licensee reported this event in Licensee Event Report 287/2015-002, Revision 0 (ADAMS Accession No. ML16041A170). The Petitioners concluded that this event indicates that the lessons learned and manual compensatory actions implemented after the Byron event by licensees were ineffective.

The NRC conducted a special inspection of this event (ADAMS Accession No. ML16057A062) and determined that, contrary to the event at Byron, Unit 2, on January 30, 2012, no effects were experienced on the Unit 3 plant buses because the plant buses were energized by the auxiliary transformer (supplied by the main generator) and no reactor trip signal occurred to transfer the plant buses to the startup transformer. If a reactor trip signal had occurred, it would have been similar to the Byron event, in that when the operators recognized power supply to the safety buses was deficient (one phase degraded), they could have energized the safety buses from an onsite emergency power source.

At Oconee, the onsite emergency power source is the Keowee hydro generators. The NRC inspectors determined that interim compensatory measures were in place at the facility at the time of the event and that the open phase condition was identified during a routine walk-down surveillance, not from automatic alarms in the control room. The inspectors noted in the inspection report that when the startup transformer is not supplying the plant buses, there is not enough current flow for the installed relays to detect an open phase condition. The fact that operators failed to receive alarms in the control room intended to alert them of an open phase condition during the December 7, 2015, event at Oconee highlights the importance of implementing permanent design changes at all affected facilities.

The events that occurred at Byron Station, Unit 2, and Oconee Nuclear Station are considered by the NRC to be safety significant because the occurrence of the open phase condition either resulted or could have resulted in a design basis event (i.e., loss of offsite power), and a condition by which electric power from the onsite emergency power system was not automatically distributed to safety-related equipment needed to mitigate the consequences of the event. The events were also significant in that plant operators were presented with circumstances they did not immediately understand and they did not have adequate procedures for addressing an open phase condition.

Operating experience has shown that an open phase condition may result in one of many possible impacts on the plant and that the other actual open phase events in the United States have resulted in conditions much less severe from a safety perspective than the Byron event. There has been no instance of a design basis accident occurring independent of—yet simultaneously with—an open phase condition. This is to be expected given the low likelihood of an open phase condition and a design basis accident occurring during the same time interval.

Given the current range of estimates of these likelihoods for operating reactors, the risk associated with a design basis accident occurring independently yet simultaneously with an open phase condition is expected to be small. Therefore, the likelihood of a design basis accident concurrent with an open phase condition resulting in the plant exceeding criteria specified in 10 CFR 50.46 would accordingly be small.

The importance of implementing permanent design changes at all affected facilities is further supported by information in a white paper prepared by the NRC staff to provide risk insights on the impact of a postulated loss of a single phase in a three phase high voltage offsite power circuit (ADAMS Accession No. ML17234A631). The white paper assessed the change in core damage frequencies for specific plants emphasizing the plant type (boiling water reactor or pressurized water reactor) and the electrical switchyard configurations. In summary, the white

paper demonstrates that an undetected open phase condition, as modeled in the study, has the potential to introduce an additional increase in core damage frequency. Taking conservatism into account as outlined in the white paper, this assessment estimates that without modifications to install an OPIS, the core damage frequency contribution from open phase condition for the plants evaluated increased significantly (i.e., beyond an order of magnitude, from their base core damage frequencies). Based on risk insights derived from the assessment, the NRC staff concluded that the use of visual inspection rounds in switchyard areas alone will have minimal benefit for decreasing the impact of open phases. However, the use of a detection system and/or automatic actuation system (i.e., OPIS) would greatly reduce this vulnerability. Additional plant modifications, such as RCP seal loss of coolant accident mitigation systems in pressurized water reactor plants (i.e., RCP shutdown seals and/or independent diesel-driven seal injection pumps), can also provide an additional measure of safety.

The insights in the white paper are derived from performing a condition assessment resulting in an annualized core damage frequency, whereas the 10^{-4} conditional core damage probability estimate cited by the Petitioners is the result of an event assessment using the NRC's ASP analysis. Although both provide an acceptable characterization of risk, the condition assessment used in the white paper is more appropriate for evaluating the impact of OPC on the operating fleet. The NRC's ASP program is one of three agency programs that assess the risk significance of operational events that have occurred at licensed U.S. commercial nuclear power plants. The ASP program systematically evaluates the risk significance of precursor events. An accident sequence precursor is an initiating event or degraded condition that, when coupled with one or more postulated failures of mitigating structures, systems or components, or operator errors, could result in a plant condition involving inadequate core cooling and severe reactor core damage. Consequently, the results of calculations made in an ASP analysis only reflect the probability that a core damage event could

have occurred due to the combination of actual and postulated events. ASP analysis results do not reflect the expected frequency of core damage events. This differs from the results produced in a plant-specific probabilistic risk assessment (PRA), which is an estimate of the frequency of core damage for the plant that accounts for the frequency of events that could initiate a sequence of equipment failures/unavailabilities or human errors leading to the occurrence of core damage.

Analyses performed as part of the NRC's ASP program can be used to identify trends that may contribute to increased risk to the safety of operating reactors, and the results can be used to explore areas that may require additional evaluation to determine the appropriate regulatory response. Due to their conditional nature, the numerical result of an ASP analysis is not used by the NRC staff as a risk metric in determining the acceptability of changes to a facility's licensing basis.

The Petitioners further stated that based upon the applicable codes, standards, and regulations, the licensing bases and design bases for all U.S. nuclear power plants require that both offsite and onsite power systems must be operable and capable of supporting design bases functions. In the SRM for SECY-16-0068, the Commission directed the NRC staff to address the open phase condition concern by verifying that licensees have appropriately implemented the voluntary industry initiative. The Commission stated that if a licensee does not adequately address potential open phase conditions, including updating the licensing basis to reflect the need to protect against open phase conditions, then the staff should consider the appropriate regulatory mechanism to impose the necessary requirements to protect against open phase conditions. In accordance with this direction, implementation of a second TI for the open phase condition in the NRC Inspection Manual will focus NRC inspections on the evaluation of the industry initiative associated with the open phase condition design vulnerabilities. This effort will verify that licensees have appropriately implemented the

voluntary initiative and updated the plant licensing basis. Consistent with the Commission's direction in the SRM, if the staff determines that a licensee does not adequately address potential open phase conditions, including updating the licensing basis to reflect the need to protect against open phase conditions, the staff will consider the appropriate regulatory mechanism to impose the necessary requirements to protect against open phase conditions.

E. Evaluation of the Petitioners' Requests

This section includes both the Petitioners' requests and the NRC's decisions.

Petitioners' Request 1: **Issue orders which require immediate corrective actions including compensatory measures to address the operability of electric power systems in accordance with their plant technical specifications, and to implement plant modifications in accordance with current NRC regulatory requirements and staff guidance provided in the references within the 2.206 petition.**

Petitioners' Request 2: **Issue orders to immediately shutdown the nuclear power plants that are operating without addressing the significant design deficiency identified in BL 2012-01, "Design Vulnerability in Electric Power System," since the licensees are not in compliance with their Technical Specifications Limiting Condition for Operation 3.8.1 (typical) requirements related to onsite and offsite power systems.**

NRC Decision for Petitioners' Requests 1 and 2:

The NRC staff has decided not to issue orders at this time to operating reactor licensees regarding an open phase condition, as requested by the Petitioners. This decision is based upon the licensee responses to BL 2012-01, subsequent licensee responses to the NRC's RAI, the actions taken by licensees in response to the industry open phase condition voluntary formal initiative (which included immediate compensatory measures and a commitment to install

permanent design modifications), and the completion of NRC inspections using TI 2515/192 to verify whether the licensee has implemented the compensatory measures specified in TI Section 03.01 to mitigate the potential impact of an open phase condition. These comprehensive actions resolve the Petitioners' request to issue orders to licensees.

III. Conclusion

Based upon the information summarized above, the NRC found the petition insufficient to warrant the enforcement actions in the Petitioners' Requests 1 and 2. The Petitioners' concerns related to the open phase condition vulnerability for operating reactors represent a safety issue that the Commission agreed should not be left unaddressed, and these concerns are currently being resolved through the implementation of the industry's open phase condition initiative. This approach is consistent with the Commission's direction to the NRC staff in the SRM for SECY-16-0068, recognizing that the nuclear industry is already implementing the voluntary industry initiative (permanent modifications such as OPIS). The NRC staff will determine each licensee's final actions through plant inspections, and the results will be made public in ADAMS, as appropriate.

On this basis, the Petitioners' requests are denied. The NRC does not plan to take the enforcement actions specified in the Petitioner's request. Therefore, the NRC is closing this petition.

As provided for in 10 CFR 2.206(c), a copy of this Director's Decision will be filed with the Secretary of the Commission for the Commission to review. The decision will constitute the final action of the Commission 25 days after the date of the decision unless the Commission, on its own motion, institutes a review of the decision within that time.

Dated at Rockville, Maryland, this 18th day of January 2018.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Brian E. Holian, Acting Director
Office of Nuclear Reactor Regulation

Attachment:
Responses to Petitioners' Comments and Licensee's Comments on Proposed Director's Decision

COMMENTS RECEIVED FROM THE PETITIONERS AND THE LICENSEES ON THE PROPOSED DIRECTOR'S DECISION DATED SEPTEMBER 18, 2017

Comments from the Petitioners:

Comments were received from the Petitioners by letter dated October 11, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17291A040). The Petitioners' seven page response described concerns with the proposed director's decision. The comments below are paraphrased by the petition review board (PRB) in order to consolidate the concerns into distinct topics.

Comment 1:
The open phase isolation systems (OPIS) should be required to be a safety-related OPIS, and an order should be issued to the applicable licensees requiring this.

Response 1:
The staff requirements memorandum (SRM) for SECY-16-0068 allowed for the voluntary industry initiative to be implemented to provide detection of open phase conditions (OPC). Most licensees are implementing a non-safety-related OPIS. The PRB has not concluded that a safety-related OPIS is necessarily required. The U.S. Nuclear Regulatory Commission (NRC) regulations do not require licensees to assume the failure of all non-safety-related protection on electrical supply systems to safety-related buses. For example, there are typically no safety-related relays for underfrequency or overfrequency monitoring the safety buses.

Comment 2:
The NRC's actions to resolve the OPC safety issue are not timely, responsive, and consistent with safety goals of protecting the health and safety of the public from nuclear accidents. It is a concern to us that the resolution to OPC still remains unresolved as of 2017. We note that there is no existing precedence where a safety issue was resolved by the Commission via a voluntary industry initiative.

Response 2:
Since the receipt of the petition, the Commission issued an SRM which directs the NRC staff to address the OPC safety concern by verifying licensee implementation of the voluntary industry initiative. The staff is proceeding with this verification. Approximately 50 percent of the affected reactors have already installed an OPIS.

Comment 3:
The OPC voluntary industry initiative is not adequate in addressing this significant safety issue in the nuclear power plants' electric power systems. The voluntary industry initiative issued on March 16, 2015 (ADAMS Accession No. ML15075A454) did not contain all applicable requirements and references to industry consensus standards for design requirements as well as clear acceptance criteria for licensees to design the OPC detection and protection schemes. The Petitioners also quote from an NRC letter dated November 25, 2014.

Response 3:
The PRB notes that licensees have provided the NRC with extensive design information on their OPISs, including data from field tests. There are also design and engineering reports from the Electric Power Research Institute analyzing the industry designs. The NRC staff has reviewed

some of these designs. The PRB notes that the SRM directs the NRC staff to address the OPC concern by verifying licensee implementation of the voluntary industry initiative, thereby superseding some of the information in the NRC letter of November 25, 2014. The technical question to be answered now is whether the OPISs are capable of detecting and alarming or isolating an OPC, not whether the OPIS is designed as a safety-related system. The NRC staff will conduct onsite inspections to review the final OPIS installations.

Comment 4:
The risk assessment in the proposed director's decision for the non-accident condition (an OPC without a simultaneous accident) has results for core damage frequency (CDF) that are too low, and inconsistent with the NRC safety goal of reducing quantitative CDF to less than $1x10^{-4}$/year.

Response 4:
The PRB notes that actual safety significance, and therefore CDF, can vary widely depending on the facility, as different designs and different configurations can have a large effect on the CDF. However, as licensees implement their OPIS, the core damage frequency will drop significantly. The relatively simple operator action (or OPIS actuation) of opening the safety bus supply breaker (which will result in actuation of the onsite emergency power supply) can be done in the control room and will restore the capability of the safety bus to power safety equipment.

Comments from the Licensees:

Comments were received from the Nuclear Energy Institute (NEI), on behalf of licensees, by letter dated October 16, 2017 (ADAMS Accession No. ML17291A846).

Comment 1:
On page 6, the NRC provided a letter to NEI containing the four functional requirements for demonstrating compliance with existing regulatory requirements.

Response 1:
Revised page 6, third paragraph, to say "The NRC also communicated four functional criteria..."

Comment 2:
On page 9, 10 CFR 50.55a(h)(2) and (3) is listed under the header of "Applicable NRC Regulatory Requirements and Guidance." This section appears to set expectations that designs to address the OPC vulnerability should meet IEEE Class 1E requirements, which apply only to safety-related structures, systems, and components. The majority of stations are implementing Non-1E (non-safety related) OPC modifications, in accordance with the VII [voluntary industry initiative]. In our view, it is inappropriate to apply IEEE Standard Std. 279, or IEEE Std. 603, to an open phase isolation system installed on a Non-Class 1E circuit, because such systems do not scram or trip the reactor, or actuate an engineered safety feature. References to 10 CFR 50.55a(h)(2) and 10 CFR 50.55a(h)(3), along with IEEE Std. 279 and IEEE Std. 603 should be removed from this section.

Response 2:
The PRB agrees that some OPISs installed on a Non-Class 1E circuit may be satisfactory without meeting IEEE Class 1E requirements. However, some licensees intend to install OPISs

on Class 1E (safety-related) buses. The references are given to provide guidance where it applies.

Comment 3:
Referring to page 9, open phase events and design basis events are independent and should not be considered simultaneously. This type of review has already been documented in GSI-171 [Generic Safety Issue-171] and clarification of independence of events should be clearly stated.

Response 3:
Postulating an open phase condition simultaneously with a design basis event was done in the context of a probabilistic risk assessment of CDF. A valid calculation of CDF requires that all adverse conditions be evaluated. The PRB notes that GSI-171 (loss-of-coolant accident with a delayed loss of offsite power) was closed based on the NRC staff's decision that the CDF was low enough that a backfit was not justified.

Comment 4:
Referring to page 11, Oconee's response to NRC Bulletin 2012-01 (ADAMS Accession No. ML12300A426) stated open phase was not part of their original design and licensing basis. Modifications are not complete at this time; therefore, automatic alarms in the main control room (MCR) should not have been expected. Add to the Oconee event description that open phase was not part of Oconee's original design and licensing basis; therefore, automatic alarms in the MCR should not have been expected.

Response 4:
The PRB acknowledges that although the Oconee response to Bulletin 2012-01 stated that:

> In both voltage monitoring schemes, 230 kV and 4160 V, there are control room indications provided for a single phase condition (open circuit). The control room would receive annunciators and computer points of an under voltage condition on that phase, but no automatic trip would be initiated.

There was also a paragraph that stated:

> However, in certain cases it is not known if the loss of phase would be detected by the current relaying protection schemes to give control room indication. In general, there will be no plant response for an unloaded (e.g., ESF [engineered safety features] buses normally aligned to unit auxiliary transformer) power source in the event of a single-phase open circuit on a credited off-site power circuit because there is insufficient current to detect a single-phase open circuit for this configuration."

The alignment at Oconee during this event was with an unloaded power source. Therefore, we have removed the phrase "as expected by the licensee."

Comment 5:
Referring to page 11, Oconee's response to NRC Bulletin 2012-01 provided the following information for Question 1:

> In both voltage monitoring schemes, 230 kV and 4160 V, there are control room indications provided for a single phase condition (open circuit). The control room would receive annunciators and computer points of an under voltage condition on that phase, but no automatic trip would be initiated. The control room operators would respond per the appropriate Alarm Response Guide. See Attachment 3 Table 6 for associated alarms.
>
> However, in certain cases it is not known if the loss of phase would be detected by the current relaying protection schemes to give control room indication. In general, there will be no plant response for an unloaded (e.g., ESF buses normally aligned to unit auxiliary transformer) power source in the event of a single-phase open circuit on a credited off-site power circuit because there is insufficient current to detect a single-phase open circuit for this configuration...

The Oconee Bulletin 2012-01 RAI [Request for Additional Information] Response (ADAMS Accession No. ML14035A453) provided the following information for Response 1:

> ...ONS Operations personnel perform daily rounds of the switchyards. This is a general observation performed on the equipment to note any out of normal conditions and take appropriate actions. The daily switchyard rounds procedure was revised to incorporate specific points to look for areas of degraded off site power vulnerabilities.

As predicted in the bulletin response, control room alarms were not received due to the lack of current available because of the source being unloaded at the time of the event. In addition, the RAI response provided an interim corrective action for operations staff to perform daily switchyard rounds which proved to be the method of discovery. The interim corrective actions in their entirety were put in place to allow adequate time for each station to assess specific vulnerabilities and to address them to the level appropriate. The results of these assessments will determine to what degree additional modifications are required.

It should be noted that the interim corrective actions implemented at Oconee were successful in discovering the open phase which prompted appropriate responses.

The following revision is suggested:

> "The fact that operators failed to receive alarms in the control room intended to alert them of an open phase condition during the December 7, 2015, event at Oconee highlights the need to assess potential vulnerabilities in order to respond and/or implement modifications accordingly per the NEI Initiative."

Response 5:
The current sentence reads:

> The fact that operators failed to receive alarms in the control room intended to alert them of an open phase condition during the December 7, 2015, event at Oconee highlights the importance of implementing permanent design changes at all affected facilities.

The PRB notes that this sentence refers to permanent design changes at all affected facilities. In order for a licensee to know whether a facility is affected, it would have to assess the facility's vulnerabilities. The PRB concludes that the current sentence is appropriate, since it expresses the agency's concern that this potential component failure be addressed at all affected facilities.

Comment 6:
Referring to page 12, equating a design basis event to a loss of offsite power in the case of an OPC is incorrect due to the fact that disconnection of faulted offsite power circuits is the protective action. Generally, loss of offsite power is considered loss of the grid, and subsequent reliance on the standby power sources. An open phase is a fault that requires the upstream breaker to be opened to isolate the fault from onsite circuits. Recommend detailing the actual safety significance basis rather than the protective action.

Response 6:
The PRB concludes that the current description is appropriate. If an operator's only reasonable choice for recovery is to open circuit breakers such that offsite power is lost and the onsite emergency power source (typically diesel generators) is activated, than the result is a loss of offsite power. The actual safety significance can vary widely depending on the facility, and the PRB considers it unnecessary in this forum to address the safety significance for each of the 99 reactors currently licensed to operate.

Comment 7:
Referring to page 12, excessive conservatisms were included in the risk analysis. Actual risk has already been presented and discussed in public meetings. The NRC representatives indicated that this overly conservative analysis was only to be used for the methodology to determine real plant risks. Recommend removing specific risk values in the letter.

Response 7:
The PRB notes that the risk analysis varies widely based on the specific design of each affected facility. However, as noted in Response 3 above relative to GSI-171, there have been times that the NRC staff determined that the CDF of a system response was low enough that a backfit would not be justified. The PRB revised the paragraph to remove specific risk values but still convey that the NRC staff has determined that the CDF is high enough that corrective action is necessary for affected facilities.

Comment 8:
Referring to page 13, use of visual inspection in conjunction with maintenance intervals is the standard method for ensuring many of the components in the plant protection system (PPS) has the capability to allow current to flow to the safety related components. Recommend removing the inconsistent reference to automatic detection of the event.

Response 8:
The PRB concurs with the NRC staff's assessment that operating experience has demonstrated that visual inspection alone is likely to be inadequate at detecting an open phase condition in a timely manner. Based on the NRC special inspection conducted at Oconee following the OPC event, the licensee could not identify if the open phase condition had existed for an hour or a day. Therefore, the reference to installing automatic detection for an OPC event is appropriate.

LIST OF OPERATING REACTOR LICENSEES

Arkansas Nuclear One, Units 1 and 2
Entergy Operations, Inc.
Docket Nos. 50-313 and 50-368
License Nos. DPR-51 and NPF-6

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Beaver Valley Power Station, Units 1 and 2
FirstEnergy Nuclear Operating Company
Docket Nos. 50-334 and 50-412
License Nos. DPR-66 and NPF-73

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Braidwood Station, Units 1 and 2
Exelon Generation Company, LLC
Docket Nos. STN 50-456 and STN 50-457
License Nos. NPF-72 and NPF-77

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Browns Ferry Nuclear Plant, Units 1, 2, and 3
Tennessee Valley Authority
Docket Nos. 50-259, 50-260, and 50-296
License Nos. DPR-33, DPR-52, and DPR-68

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Browns Ferry Nuclear Plant
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Chattanooga, TN 37402-2801

Brunswick Steam Electric Plant, Units 1 and 2
Duke Energy Progress, LLC
Docket Nos. 50-325 and 50-324
License Nos. DPR-71 and DPR-62

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Byron Station, Units 1 and 2
Exelon Generation Company, LLC
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License Nos. NPF-37 and NPF-66

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Callaway Plant, Unit 1
Union Electric Company
Docket No. 50-483
License No. NPF-30

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Callaway Plant
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Fulton, MO 65251

Calvert Cliffs Nuclear Power Plant, Units 1
and 2
Calvert Cliffs Nuclear Power Plant, LLC
Docket Nos. 50-317 and 50-318
License Nos. DPR-53 and DPR-69

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Catawba Nuclear Station, Units 1 and 2
Duke Energy Carolinas, LLC
Docket Nos. 50-413 and 50-414
License Nos. NPF-35 and NPF-52

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Clinton Power Station, Unit 1
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Columbia Generating Station
Energy Northwest
Docket No. 50-397
License No. NPF-21

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Comanche Peak Nuclear Power Plant,
Units 1 and 2
TEX Operations Company, LLC
Docket Nos. 50-445 and 50-446
License Nos. NPF-87 and NPF-89

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Pacific Gas and Electric Company
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License Nos. DPR-80 and DPR-82

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Donald C. Cook Nuclear Plant, Units 1 and 2
Indiana Michigan Power Company
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License Nos. DPR-58 and DPR-74

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Dresden Nuclear Power Station, Units 2 and 3
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Duane Arnold Energy Center
NextEra Energy Duane Arnold, LLC
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License No. DPR-49

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License Nos. DPR-57 and NPF-5

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DTE Electric Company
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License No. NPF-43

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Fort Calhoun Station, Unit 1
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License No. DPR-40

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Grand Gulf Nuclear Station, Unit 1
Entergy Operations, Inc.
Docket No. 50-416
License No. NPF-29

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Port Gibson, MS 39150

H. B. Robinson Steam Electric Plant, Unit 2
Duke Energy Progress, LLC
Docket No. 50-261
License No. DPR-23

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Hope Creek Generating Station
PSEG Nuclear, LLC
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Indian Point Nuclear Generating Units 1, 2, and 3
Entergy Nuclear Operations, Inc.
Docket Nos. 50-247 and 50-286
License Nos. DPR-26 and DPR-64

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License Nos. NPF-2 and NPF-8

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License Nos. NPF-11 and NPF-18

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License Nos. NPF-39 and NPF-85

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McGuire Nuclear Station, Units 1 and 2
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Docket Nos. 50-369 and 50-370
License Nos. NPF-9 and NPF-17

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Millstone Power Station, Units 2 and 3
Dominion Nuclear Connecticut, Inc.
Docket Nos. 50-336 and 50-423
License Nos. DPR-65 and NPF-49

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Monticello Nuclear Generating Plant
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Docket No. 50-263
License No. DPR-22

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Nine Mile Point Nuclear Station, Units 1 and 2
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License Nos. DPR-63 and NPF-69

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North Anna Power Station, Units 1 and 2
Virginia Electric and Power Company
Docket Nos. 50-338 and 50-339
License Nos. NPF-4 and NPF-7

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Palisades Nuclear Plant
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Palo Verde Nuclear Generating Station, Units
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Docket Nos. STN 50-528, STN 50-529,
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Point Beach Nuclear Plant, Units 1 and 2
NextEra Energy Point Beach, LLC
Docket Nos. 50-266 and 50-301
License Nos. DPR-24 and DPR-27

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Northern States Power Company - Minnesota
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License Nos. DPR-42 and DPR-60

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PSEG Nuclear, LLC
Docket Nos. 50-272 and 50-311
License Nos. DPR-70 and DPR-75

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Seabrook Station, Unit 1
NextEra Energy Seabrook, LLC
Docket No 50-443
License No. NFP-86

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Sequoyah Nuclear Plant, Units 1 and 2
Tennessee Valley Authority
Docket Nos. 50-327 and 50-328
License Nos. DPR-77 and DPR-79

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Shearon Harris Nuclear Power Plant, Unit 1
Duke Energy Progress, LLC
Docket No. 50-400
License No. NPF-63

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South Texas Project, Units 1 and 2
STP Nuclear Operating Company
Docket Nos. 50-498 and 50-499
License Nos. NPF-76 and NPF-80

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St. Lucie Plant, Units 1 and 2
Florida Power and Light Company
Docket Nos. 50-335 and 50-389
License Nos. DPR-67 and NPF-16

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Surry Power Station, Units 1 and 2
Virginia Electric and Power Company
Docket Nos. 50-280 and 50-281
License Nos. DPR-32 and DPR-37

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Susquehanna Steam Electric Station, Units 1 and 2
Susquehanna Nuclear, LLC
Docket Nos. 50-387 and 50-388
License Nos. NPF-14 and NPF-22

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Three Mile Island Nuclear Station, Unit 1
Exelon Generation Company, LLC
Docket No. 50-289
License No. DPR-50

Mr. Bryan C. Hanson
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Turkey Point Nuclear Generating Units 3 and 4
Florida Power and Light Company
Docket Nos. 50-250 and 50-251
License Nos. DPR-31 and DPR-41

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Virgil C. Summer Nuclear Station, Unit 1
South Carolina Electric & Gas Company
Docket No. 50-395
License No. NPF-12

Mr. George Lippard, III
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South Carolina Electric & Gas Company
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Vogtle Electric Generating Plant, Units 1 and 2
Southern Nuclear Operating Company, Inc.
Docket Nos. 50-424 and 50-425
License Nos. NPF-68 and NPF-81

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Waterford Steam Electric Station, Unit 3
Entergy Operations, Inc.
Docket No. 50-382
License No. NPF-38

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Watts Bar Nuclear Plant, Units 1 and 2
Tennessee Valley Authority
Docket No. 50-390 and 50-391
License No. NPF-90 and NPF-96

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Wolf Creek Generating Station
Wolf Creek Nuclear Operating Corporation
Docket No. 50-482
License No. NPF-42

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