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Losses of Offsite Power at U.S. Nuclear Power Plants

Summary of Experience Through 2016

2017 TECHNICAL REPORT

Losses of Offsite Power at U.S. Nuclear Power Plants

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Final Report, September 2017

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ABSTRACT

This report describes loss of offsite power (LOOP) experience at U.S. nuclear power plants for events that occurred in 2016. Additionally, this report provides trending and insights from the 10-year period 2007 through 2016. This report serves as a valuable source of information for understanding the types of challenges that can lead to a LOOP. The results are useful as inputs to probabilistic risk assessments, for which the potential of a LOOP is an important consideration. This information can be used in calculating site- and unit-specific frequencies of LOOP and in characterizing the duration of such losses for evaluations of recovery potential. The event summaries and analyses can also be used to evaluate the factors contributing to LOOP events.

Keywords

LOOP
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PRIMARY AUDIENCE: Probabilistic risk assessment (PRA) practitioners seeking current, industrywide loss of offsite power (LOOP) frequencies and durations that can be used as inputs for updating PRAs.

SECONDARY AUDIENCE: Plant, Engineering, and Transmission and Distribution staff interested in factors affecting the reliability of offsite power supplies for nuclear power plants.

KEY RESEARCH QUESTIONS

The availability of offsite power is a key component in the defense-in-depth strategy for safe operation of a nuclear power plant. The probability of losing offsite power is an important factor in conducting safety assessments and PRAs. The research that is the subject of this report provides recent experience on the frequency, cause, and duration of LOOP events to support PRA.

RESEARCH OVERVIEW

This report compiled and analyzed information from the U.S. Nuclear Regulatory Commission (NRC) event notifications and licensee event reports for LOOP events as well as direct communications with utility staff members familiar with LOOP events that occurred at their plants. The primary intent of this work was to provide current information on LOOP event frequency and duration. In the course of examining LOOP events, insights are also derived regarding the causes and associated factors that contribute to the severity of such events. Such insights might also be useful in identifying areas where improvement might be appropriate.

Experience is tracked over a rolling 10-year period. The reason for choosing a 10-year period is that it is important to base projections of LOOP experience on the most recent and relevant operating experience, reflecting current plant and grid configurations and operating practices, which can be subject to change.

KEY FINDINGS

2016 was an average year during which there were four events involving a total LOOP. There were two very short-duration events where the initiating event was severe weather, associated with Hurricane Matthew. The two hurricane-related events resulted in short-duration LOOPs caused by switchyard and transmission component failures. If these failures had not occurred, LOOPs might not have occurred. One LOOP event was directly caused as a result of a workmanship or design error. The remaining LOOP event was caused by failure of essential equipment susceptible to degradation.

There were a number of lower-level (partial LOOP) events that occurred during the year, resulting from various causes, including equipment failure, human errors, and one wildlife intrusion. These events are studied to provide insight into the associated failures and the fact that such events can be precursors to more serious full LOOPs.

Results are presented for the past year and a rolling 10-year period to provide a perspective on recent relevant experience. Frequency and duration of the full LOOP events appear to be decreasing from a multiyear perspective. This decrease can reflect multiple industry efforts, including grid improvements.

WHY THIS MATTERS

Utilities that operate nuclear power plants are increasingly using their PRAs to make day-to-day decisions on design, operations, and maintenance and to support risk-informed applications. These applications require high-quality and complete PRAs to ensure that the decisions and proposed changes are technically well founded. This report provides inputs to calculate site- and unit-specific frequencies of LOOP and in characterizing the duration of such losses for recovery potential. These inputs are useful to support and maintain nuclear power plants PRAs with current industry data.

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ABBREVIATIONS

Abbreviation	Description
ANO	Arkansas Nuclear One
CCW	Component cooling water
CSST	Common station service transformer
DC	Direct current
EDG	Emergency diesel generator
EN	Nuclear regulatory commission event notification report
EPRI	Electric Power Research Institute
ERAT	Emergency reserve auxiliary transformer
ESF	Engineered safety feature
HPCI	High pressure coolant injection
IC	Integrated circuit
IER	INPO event report
INPO	Institute of Nuclear Power Operations
LER	Licensee event report
LOOP	Loss of Offsite Power
MSIV	Main steam isolation valve
MT	Main transformer
NRC	Nuclear Regulatory Commission
PINPG	Prairie Island Nuclear Generating Plant
PNPS	Pilgrim Nuclear Power Station
RAT	Reserve auxiliary transformer
RCP	Reactor coolant pump
RFO	Refueling outage
RHR	Residual heat removal

RPS	Reactor protection system
RSST	Reserve station service transformer
SAT	System/station auxiliary transformer
SBO	Station blackout
SUT	Startup transformer
SVC	Static VAR (volt-ampere-reactive) compensator
T&D	Transmission and distribution
UAT	Unit auxiliary transformer

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1
REVIEW AND CATEGORIZATION OF EVENTS

In examining the events that have occurred, EPRI employs the best information available to characterize how long all offsite power remains unavailable. This is in contrast to the actual elapsed time taken to connect offsite source(s) to safety buses following a loss of offsite power (LOOP) event. When offsite power becomes available, it may not be used immediately. For example, emergency diesel generators (EDGs) automatically supply safety buses when offsite power is lost at many plants. It is often possible to reenergize safety buses from offsite power in a short time. In some cases, however, with offsite power available, operators may exercise appropriate caution by allowing the EDGs to continue to supply power to safety loads while dealing with plant situations that may require more immediate attention. In such instances, when offsite power is available, operators may then transfer back to offsite power in an orderly manner.

Another circumstance that could involve delayed reconnection with an operable and available grid is if there is uncertainty regarding grid stability. With the emergency buses supplied by EDGs, operators may delay reconnection until it is known that the grid is available and stable. This situation has occurred in the past during winter storms and hurricanes.

Table 1-1 presents categories used in this report for classification of LOOP and LOOP-related events. These categories were revised in 2016 and are discussed in *Losses of Offsite Power at U.S. Nuclear Plants: Summary through 2015* [1]. Table 1-1 of this report is identical to Table 1-2 of Reference 1 with the exception that the Risk/Safety PRA Category for "Events of Interest" now includes all operating modes including cold shutdown and re-fueling.

Table 1-1
LOOP Event Category Definitions

The definitions of the categories to which the events are assigned are as follows:	
Risk/Safety Event Description	**Risk/Safety PRA Category**
With the unit in power operation, startup, hot standby, or hot shutdown, there is an actual (total) loss of all offsite power sources to all emergency buses; duration >30[1] minutes.	Category I.a LOOP
With unit in power operation, startup, hot standby or hot shutdown, there is an actual (total) loss of all offsite power sources to all emergency buses; duration >15[2] seconds, <30 minutes.	Category I.b LOOP
With the unit in power operation, startup, hot standby, or hot shutdown a significant degradation of offsite power sources occurs and the sources have been declared inoperable by the licensee.	Category I.c LOOP
With the unit in power operation, startup, hot standby, or hot shutdown, an actual loss of power source(s) available to all emergency buses occurs and loss of an additional power source will result in a Category I LOOP OR an actual loss of all offsite power sources supplying an emergency bus or train. Note: If the available power source(s) are not connected to the bus(es), it should be possible to connect them by operation of available equipment, such as breakers or motor-operated disconnects.	Category II LOOP
With the unit in power operation, startup, hot standby, or hot shutdown the potential exists for a significant degradation or loss of offsite power sources, or their availability is uncertain based on grid system evaluations.	Category III LOOP
With the unit in cold, or refueling shutdown, the loss or significant degradation of offsite power sources to the emergency bus(es) required to be operable in the shutdown mode.	Category IV.a LOOP
No offsite power available to emergency buses during cold shutdown or refueling because of special maintenance and/or testing conditions that do not occur during other operating modes.	Category IV.b LOOP
With the unit in power operation, startup, hot standby, hot shutdown, cold shutdown, or refueling shutdown one offsite power source supplying one redundant emergency bus is lost. A LOOP event of less significance than those in categories I-IV, and may involve a reactor trip or safety system actuation.	Event of Interest

[1] Thirty minutes has been used to differentiate between events with lower safety significance (<30 minutes) and greater safety significance (>30 minutes).

[2] Fifteen seconds provides specific criteria for classifying an event as a LOOP or non-LOOP event for situations in plants where there could be a short lag in transfer of available offsite power sources for the emergency buses.

2
SUMMARY OF SIGNIFICANT OCCURRENCES FOR 2016

Each of the events involving at least a partial interruption of offsite power and reported to the NRC as an Event Report and/or Licensee Event Report was reviewed. Where relevant, each of the events was assigned to one of the categories (I.a, I.b, I.c, II, III, IV.a, IV.b, and "of interest") described in Table 1-1. This section provides a description of the events that occurred in calendar-year 2016, starting with those that involved a total loss of offsite power to the affected unit(s). Partial losses and those events not assigned to a specific category are also described.

2.1 Total Losses of Offsite Power

During the year 2016, there were four LOOPs at U.S. nuclear power plants (category I.a or I.b). These four events are summarized in Table 2-1 and described further below. The number of such events in a given year has historically ranged from zero to seven. Therefore, experience for 2016 is in the mid-portion of the expected range.

Table 2-1
Category I Losses of All Offsite Power at U.S. Nuclear Plants in 2016

Date and Category	Plant Name	Duration (hr:min:sec)	Summary
2/7/2016 I.a	Brunswick Unit 1	3:16:00	A fault and explosion in non-segregated breaker cubicle caused by moisture intrusion resulted in lockout of startup auxiliary transformer, followed by loss of recirculation pumps and manual reactor trip. LOOP resulted with EDGs starting and loading.
8/21/2016 I.b	St. Lucie Unit 1	00:25:00	During power ascension at 38% power, main generator inadvertent energization lockout relay actuated causing a reactor trip and blocking automatic transfer to emergency buses. This resulted in a LOOP.
10/8/2016 I.b	Harris	00:00:16.5	While in hot shutdown at the beginning of a planned refueling outage, high winds associated with hurricane Matthew caused damage to an offsite transmission line. This, coupled with existing substation relay malfunctions resulted in delayed clearing of the line fault and in a low voltage condition at the plant. EDGs started and assumed emergency bus loads. Offsite power was available after 16.5 seconds and was considered stable 7:33 hours after the initiating event.
10/8/2016 I.b	Robinson	00:00:19.7	While at 100% power during hurricane Matthew, a severe voltage depression at the plant occurred due to a grid fault and relay failure. The plant tripped and EDGs started and powered emergency buses. Offsite power was available after 19.7 seconds and connected 10:21 hrs after the initiating event.

Brunswick Unit 1 (February 7, 2016) [Category I.a]

On February 7, 2016 with the unit at 88% power, an electrical fault and explosion on a non-segregated (all three phases lie within a single housing) 4.16 kV bus occurred at 13:12 hours resulting in the lockout of the startup auxiliary transformer (SAT) and loss of both reactor recirculation pumps. Operators inserted a manual scram in accordance with procedures, which shut down the turbine and generator and resulted in the loss of the unit auxiliary transformer (UAT) supply to the emergency busses. Since the SAT was already locked out, a LOOP existed on the emergency busses. Diesel generators were running as a result of the SAT lockout, and then tied to the emergency buses. At 16:28 hours, offsite power was restored to the emergency buses from the UAT (which is the normal source for the emergency buses). The duration of the LOOP was 3:16 hours.

The initiating event was two arc flashes that occurred in a non-segregated bus, and in a circuit breaker cubicle associated with a reactor recirculation system pump, respectively. The first arc flash occurred in an area of the 4.16 kV bus housing outdoors where water accumulated. This caused a voltage imbalance leading to the second arc flash in the breaker cubicle where cable insulation was found to be degraded.

The root cause of the moisture intrusion was inspection procedures did not contain sufficient specific detail based on the highest risk locations (i.e., specifically horizontal surfaces through which bars penetrate) to ensure deficiencies that can lead to water intrusion are identified and corrected. The root cause of the damaged cable insulation was failure to specify and use a depth-limiting cutting tool for removing semiconducting material from cable insulation.

Sources

LER 325-2016-001-00, Electrical Bus Fault Results in Lockout of Startup Auxiliary Transformer and Loss of Offsite Power

NRC Event Report No. 51715, Manual Scram and Alert Declaration Due to Electrical Fault Resulting in Fire/Explosion

St. Lucie Unit 1 (August 21, 2016) [Category I.b]

On August 21, 2016 at 19:26 hours, with the unit at 38% power during power ascension testing an actuation of the Main Generator Inadvertent Energization Lockout relay caused a generator trip and reactor trip. The lockout blocked automatic transfer of the emergency buses to the startup transformers resulting in a LOOP. EDGs started and assumed the emergency bus loads.

The LOOP de-energized the power supply for the four reactor coolant pumps which resulted in decay heat removal by natural circulation with auxiliary feedwater and atmospheric steam dump valves.

During the event, offsite power was available to the switchyard. At 20:21 hours offsite power was restored to the unit. Offsite power was restored in about 55 minutes; however, operations staff indicated they were in a position to restore offsite power at approximately 25 minutes into the event but conservatively delayed restoration.

The cause of the lockout initiation was a latent error introduced during a 2013 design modification. A wire for the inadvertent energization lockout relay reset circuit was incorrectly removed, allowing the relay to remain energized and undetected following manual synchronization to the grid.

Sources

LER 335-2016-003-00, Generator Lockout Relay Actuation During Power Ascension Testing Results in Reactor Trip, October 20, 2016

NRC Event Report No. 52191, Unusual Event – Loss of Offsite Power, August 22, 2016

Shearon Harris (October 8, 2016) [Category I.b]

On October 8, 2016 at 13:10 hours (EDT), with the unit in hot shutdown (Mode 4) for a planned refueling outage, the plant experienced undervoltage conditions (68% of nominal) in the switchyard for about 1.5 seconds. This resulted in opening the breakers supplying the 6.9 kV emergency and some non-safety 6.9 kV buses. Both EDGs started and loaded as designed. At the time of this event, the site was experiencing high winds and rain from hurricane Matthew. The emergency buses were powered from the EDGs until 21:54 hours, although connection with the grid was physically possible after the undervoltage condition was cleared and the diesels were connected to the busses, (approximately 1.5 seconds plus about 15 seconds for the diesels to start and load or 16.5 seconds), the grid was not declared stable by the Energy Control Center and verified by the operating staff until 20:33 hours. Offsite power was not connected to the emergency buses for (20:33-13:10) 7:23 hours. Since offsite power could have been restored following the EDGs loading, a LOOP duration time was 16.5 seconds is used.

The fault occurred on the Cape Fear 230 kV line due to a fallen tree. Existing malfunctions of substation relays resulted in delayed clearing of the line fault, and the subsequent decrease in grid voltage at the plant for approximately 1.5 seconds. This resulted in opening several 6.9 kV supply breakers due to actuation of undervoltage relays.

Sources

LER 400-2016-005-00, Offsite Power Undervoltage Caused Actuation of Several Systems, December 7, 2016

NRC Event Report No. 52291, Unusual Event Declared due to Loss of Offsite Power, October 8, 2016

H. B. Robinson Unit 2 (October 8, 2016) [Category I.b]

On October 8, 2016 at 1302 hours (EDT), with the unit at 100% power, a severe voltage depression occurred in the Robinson 2 switchyard during hurricane Matthew. The undervoltage condition existed in the 4kV emergency busses, causing an automatic reactor trip and starting and loading of the EDGs. The apparent cause of the voltage depression and resultant LOOP was a failed relay in the phase-to-phase portion of the line trip circuitry, which prevented the grid fault from being immediately isolated in the Robinson 2 switchyard.

After grid stability was achieved and confirmed by plant personnel at approximately 23:23 hours, plant operations personnel commenced restoration of offsite power to the emergency buses to allow shutdown of the EDGs. The LOOP duration was about 19.7 seconds (4.7 seconds plus about 15 seconds for the diesels to start and load) based on the emergency busses availability for connection to the grid. However, the connection to the grid was not initiated until 23:23 hours because of uncertainty regarding grid stability.

Sources

LER 261-2016-005-00, Reactor Trip and Automatic System Actuation Due to Weather-Related Loss of Offsite Power, December 7, 2016

LER 261-2016-005-01, Reactor Trip and Automatic System Actuation Due to Weather-Related Grid Disturbance, February 22, 2017

NRC Event Report No. 52290, Unusual Event Declared due to Loss of Offsite Power, October 8, 2016

2.2 Category II, III, and IV (Partial) Losses of Offsite Power

Events involving a partial LOOP (Categories II - IV.a) are summarized in Table 2-2 and described further below. There were ten such events in 2016.

Table 2-2
Partial Losses of Offsite Power at U.S. Nuclear Plants in 2016

Date and Category	Plant Name	Summary
4/22/2016 II	Browns Ferry Unit 1	During transfer of power supplies for the shutdown bus, the normal feeder breaker failed to close automatically as designed when the alternate feeder breaker was manually tripped. The bus was de-energized and resulted in starting of EDGs. The EDGs did not tie to the bus because operators quickly re-closed the alternate feeder breaker.
3/30/2016 II	Clinton	Emergency Reserve Auxiliary Transformer Static VAR Compensator (required for operability of 138 kV offsite power source) tripped when 138 kV breakers cycled open and re-closed due to a voltage transient caused by a lightning strike. The Static VAR Compensator was restored in about 3 hours and 41 minutes.
4/2/2016 II	Clinton	Failure of insulator on circuit switcher caused trip of Reserve Auxiliary Transformer and loss of one of two offsite sources. The loads automatically transferred to the Emergency Reserve Auxiliary Transformer.
2/11/2016 II	Ginna	One of two offsite sources unavailable due to internal failure of 46 year old station auxiliary transformer. Due to the undervoltage condition, EDG A started and assumed load. The affected busses were transferred to the second offsite source.

Table 2-2 (continued)
Partial Losses of Offsite Power at U.S. Nuclear Plants in 2016

Date and Category	Plant Name	Summary
1/23/2016 II (two events)	North Anna Units 1 and 2	Switchyard supply breaker for "C" reserve station transformer opened due to moisture on internal switch. Opening the breaker de-energized the transformer and one vital bus on each unit. Associated EDGs started and assumed emergency bus loads.
4/29/2016 II	North Anna Unit 1	Wildlife (raccoon) contacted load side of Switchyard Transformer 3 causing a fault and lockout of transformer and loss of one offsite source. The associated EDG started and assumed the emergency bus loads.
5/17/2016 II	Watts Bar Unit 1	At 100% power during restoration from a "loss of phase" circuitry modification, one bus was de-energized as it was separated from its offsite power source. The associated EDG was removed from service at the time for planned maintenance. Offsite power was restored in about 1 1/2 hours.
2/11/2016 IV.a	Perry	With the plant in cold shutdown, a failed potential transformer fuse on degraded voltage circuitry caused the breaker supplying the startup transformer to open, strip the bus and start the associated EDG. The EDG was tripped after about two minutes due to a lack of cooling water. Shutdown cooling was lost for about 42 minutes due to the loss of the RHR train "A" associated with the interrupted bus. RHR train "B" was placed in service to resume shutdown cooling.
1/29/2016 IV.a	River Bend	With transmission technicians working in switchyard, one offsite line was de-energized because of execution of a deficient work instruction. The associated EDG started and loaded.

Browns Ferry Unit 1 (April 22, 2016) [Category II]

On April 22, 2016, at 13:58 CDT, during the transfer of 4kV Shutdown Bus 2 from the Alternate to Normal supply, the Normal Feeder Breaker failed to close when the Alternate Feeder Breaker was manually tripped. 4kV Shutdown Bus 2 de-energized, resulting in the loss of 1B and 2B Reactor Protection System (RPS) as well as steam jet air ejector 1B. EDGs C and D started, but did not tie to the 4kV Shutdown Boards due to operations personnel immediately re-closing the Alternate feeder breaker and re-energizing 4kV Shutdown Bus 2. Invalid actuations of several containment isolation valves also occurred during this event due to the loss of RPS. At 15:30 CDT, EDG C and D were shut down.

The cause of this event was loose wires terminated with spade connectors in the closing control circuit for the normal feeder breaker due to work in the vicinity of the control circuit termination points. Corrective actions were to terminate the loose wires, using a ring type lug instead of a forked spade type lug in the closing control circuit for the normal feeder breaker and verification of successful transfer of Shutdown Bus 2 from the alternate to normal supply.

Sources

LER 259-2016-001, "Failure of 4kV Shutdown Board Normal Feeder Breaker Results in Actuations of Emergency Diesel Generators and Containment Isolation Valves", June 21, 2016

NRC Event Report No. 51878, Partial Loss of Power Experienced During Electrical Bus Transfer

Clinton (March 30, 2016) [Category II]

On March 30, 2016, at 15:45 CDT, the Emergency Reserve Auxiliary Transformer (ERAT) Static VAR Compensator (SVC) tripped when the associated 138 kV line circuit breakers cycled open and re-closed due to a voltage transient most likely caused by a lightning strike. Operations staff entered Clinton procedures for Loss of AC, and Automatic Isolation, and Technical Specification (TS) Limiting Condition for Operation (LCO) 3.8.1, AC Sources — Operating, Required Actions A.1 and A.2.

The ERAT SVC tripped due to a momentary loss of substation feed when the 138kV line circuit breakers cycled open and re-closed. The breaker cycling was due to a voltage transient most likely caused by a lightning strike. During the event, the ERAT relay scheme worked as designed and ERAT circuit switcher remained closed allowing the ERAT transformer to re-energize when the 138 kV line breakers re-closed. No equipment failures or malfunctions were experienced during this event; however the secondary containment isolation dampers closed due to the momentary loss of power. This resulted in the secondary containment vacuum exceeding 0 inches water gauge.

The ERAT SVC was restored at 19:26 and TS LCO 3.8.1 Required Actions A.1 and A.2 were exited.

Clinton requires the ERAT SVC to be functioning properly for the 138kV line to be an operable offsite power source. The Tech Spec for an inoperable offsite power source was entered at 15:45 and exited at 19:26 for a total inoperable period of 3 hours and 41 minutes.

Sources

LER 461-2016-004-00, "Trip of Emergency Reserve Auxiliary Transformer Static VAR Compensator Causes Positive Secondary Containment Pressure Following Lightning Strike on 138 kV Offsite Source", May 27, 2016

NRC Event Report No. 51836, "Secondary Containment Differential Pressure Outside Required Technical Specification Value", March 30, 2016

Clinton (April 2, 2016) [Category II]

On April 2, 2016 at approximately 12:57 hours, the Reserve Auxiliary Transformer (RAT) and associated Static VAR Compensator tripped due to a failure of the "A" phase insulator for the RAT 345 kV circuit switcher in the switchyard. The supply to the safety busses was automatically transferred to the Emergency Reserve Auxiliary Transformer (ERAT). This constituted a reduction in offsite power paths to the safety busses from two to one.

The unit continued to operate at 99% power. There was a voltage transient caused by the automatic transfer of the buses from the RAT to the ERAT which affected several plant systems, including secondary containment ventilation, main control room ventilation, and some radiation monitors.

The RAT was successfully returned to service following replacement of the broken 345 kV insulator associated with the circuit switcher. The insulator failed due to a manufacturing defect, although there were high winds in the vicinity at the time and the configuration of the bus bar connection to the insulator was susceptible to wind-induced loads.

Sources

LER 461-2016-005-00, "Insulator Failure on the Reserve Auxiliary Transformer Results in a Loss of Secondary Containment Vacuum", May 31, 2016

NRC Event Report No. 51845, "Insulator Failure on Reserve Auxiliary Transformer", April 2, 2016

Ginna (February 11, 2016) [Category II]

On February 11, 2016 at 23:05 hours with the plant at 100% power, Station Auxiliary Transformer 12A was lost due to an internal fault. Prior to the event, the offsite electrical system was in the normal mode with each of the two off-site circuits providing power to two of the four 480 V safeguards buses via the two station auxiliary transformers. The fault rendered one of the two off-site power paths to the safeguards busses inoperable. At the time of the event, EDG A started and assumed its safeguards bus loads.

At 00:32 hours on February 12th, Station Auxiliary Transformer 12A was removed from service and off-site power provided to the affected busses via the remaining off-site source and Station Auxiliary Transformer 12B. Off-site power was unavailable to the affected buses for 1:27 hours. EDG A was secured at 00:53 hours on February 12th. The faulted transformer was replaced and re-energized and the normal off-site power lineup restored at 00:18 hours on February 20, 2016.

The cause of the transformer failure was determined to be a high side internal fault on one phase. The failed transformer had been in service for 46 years.

Sources

LER 244-2016-001-00, "Loss of Station Auxiliary Transformer 12A resulting in automatic start of Emergency Diesel Generator A due to undervoltage signals to safeguards buses 14 and 18", April 7, 2016

NRC Event Report No. 51730, "Emergency Diesel Generator Auto-Started Due to the Loss of a Station Service Transformer", February 12, 2016

North Anna Units 1 and 2, (January 23, 2016) [Category II]

On January 23, 2016 at approximately 17:03 hours and Units 1 and 2 at 100% power, the 34.5 kV offsite feed to the "C" Reserve Station Service Transformer was lost due to the inadvertent opening of the switchyard supply breaker L102. This resulted in loss of power to one emergency bus on each unit (1H and 2J), and the automatic start and load of the associated diesel generators.

The 1H bus was promptly switched to the alternate supply from the 1B Station Service Transformer and the associated diesel generator shut down. The 2J bus remained energized by its associated diesel generator until the "C" Reserve Station Service Transformer was re-energized at 15:28 hours on January 24, 2016. The 2J diesel generator was secured at 15:41 hours.

The cause for the opening of the L102 breaker was failure due to moisture on the internal switch contact for SF_6 gas pressure. Snow and moisture intruded and were present inside the cabinet. The pressure switch was replaced and weather sealant applied to prevent moisture intrusion in the most likely intrusion areas.

Sources

LER 338-2016-001-00, "Emergency Diesel Generators Automatic Start Due to Loss of Power to "C" Reserve Station Service Transformer", March 16, 2016

NRC Event Report No. 51678, "Partial Loss of Power Results in Emergency Diesel Generators Starting", January 23, 2016

North Anna Unit 1, (April 29, 2016) [Category II]

On April 29, 2016 at approximately 22:14 hours, with the Unit at 100% power, a fault occurred on the Switchyard Transformer 3 34.5 kV leads which resulted in the 34.5 kV bus to lock out and loss of offsite power to the "A" Reserve Station Service Transformer. This resulted in loss of the "J" Emergency Bus and the automatic start and load of the associated diesel generator. The emergency bus was transferred to its alternate supply (2B Station Service) and the diesel generator was secured.

The cause of the fault was wildlife (raccoon) contacting the load side leads of Switchyard Transformer 3. Post-incident inspection and testing of Transformer 3 and Bus 5 were completed satisfactorily and the transformer and bus were subsequently returned to service.

Sources

LER 338-2016-003-00, "Engineered Safety Feature Actuation Due to Loss of Power to "A" Reserve Station Service Transformer", June 16, 2016

NRC Event Report No. 51892, "Loss of Offsite Power to the "A" Reserve Station Service Transformer", April 30, 2016

Watts Bar Unit 1 (May 17, 2016) [Category II]

On May 17, 2016, at 16:30 hours with the unit at 100% power and while restoring from a plant modification related to new 'loss of phase' circuitry, the 1 B-B 6.9kV bus de-energized resulting in a loss of voltage on the bus. The loss of voltage was caused by actuation of the “loss of voltage” relays that separated offsite power from the 1 B-B 6.9kV bus. At the time, the 1 B-B EDG was removed from service for planned maintenance.

Operators, in accordance with abnormal operating instructions, started EDGs 1 A-A, 2 A-A, and 2 B-B. All equipment operated properly. The EDGs were not required to be paralleled to their respective buses.

Offsite power was restored to the 1 B-B 6.9kV bus at 18:02 hours on May 17, 2016. The duration of the loss of offsite power to the 1 B-B 6.9kV bus was 1 hour and 32 minutes.

Sources

LER 390-2016-008-00, “Emergency Diesel Generator Manual Start Due to Loss of Voltage on 6.9kV Shutdown Board 1B-B”, July 15, 2016

NRC Event Report No. 51940, Specified System Actuation – Loss of 1 B-B Electrical Bus

Perry Unit 1 (February 11, 2016) [Category IV.a]

On February 11, 2016, at 15:05 hours with the plant in cold shutdown, a sensed loss of power to the Division 1 4.16 kV bus, EH11, occurred. At the time the bus was being supplied by offsite power via a Startup Transformer. A bus potential transformer secondary fuse, which supplies the undervoltage and degraded voltage circuitry, failed. Bus supply breaker, EH 1115, tripped open based upon the sensed invalid undervoltage signal, and the bus loads were shed as designed, including the division 1 Shutdown Cooling Pump, part of residual heat removal (RHR) train A, which was supplying shutdown cooling at the time. The invalid EH11 undervoltage signal resulted in the Division 1 EDG starting and loading the EH11 bus. The Emergency Service Water A (ESW A) pump, which supplies cooling water to the EDG did not start due to the sensed loss of bus voltage. Due to the absence of cooling water to the EDG, operators secured the Division 1 EDG. Shutdown cooling was re-established at 15:47 using the Division 2 shutdown cooling pump (RHR train B).

Troubleshooting determined the cause of the loss of the Division 1 bus was a failed bus potential transformer secondary fuse that supplies the undervoltage and degraded voltage protection circuitry. The fuse was found to exhibit intermittent continuity. The failure analysis revealed that the fuse internals were not soldered correctly during the manufacturing process.

Sources

LER 440-2016-003-00, Loss of Safety Related Electrical Bus Results in a Loss of Shutdown Cooling

NRC Event Report No. 51729, Automatic Start of Emergency Diesel Generator and Loss of Shutdown Cooling

River Bend (January 29, 2016) [Category IV.a]

With the unit in cold shutdown, on January 29, 2016 at 15:18 hrs, power was lost on reserve station service (RSS) line No. 1. This line provides one of the two sources of offsite power required by the license for the cold shutdown operating mode. This loss de-energized the Division 1 onsite safety-related switchgear causing an automatic start of the associated EDG. At the time, shutdown cooling power was provided by the Division 2 safety-related switchgear, and was not affected. The plant response to the loss of RSS line No. 1 was appropriate.

The cause of the loss was due to company transmission department personnel working in the switchyard and executing a deficient work instruction while modifying relay settings.

Sources

LER 458-2016-04-00, "Actuation of the Division 1 Emergency Diesel Generator and Primary Containment Isolation Logic Due to Partial Loss of Offsite Power", March 29, 2016

NRC Event Report No. 51701, "Specified System Actuation After Loss of One Offsite Power Source", January 29, 2016

2.3 Other Events of Interest

One event entailed partial losses of offsite power that was not assigned to one of the categories described above. This event is summarized in Table 2-3. Because of the possibility that it could be a precursor to more serious events, it has been included for information.

Table 2-3
Other Selected Events Involving Partial Losses of Offsite Power in 2016

Plant Name and Date	Summary
Grand Gulf 6/30/2016	With the unit in cold shutdown, a loss of power to the Division 2 and 3 electrical buses occurred, resulting in associated EDGs starting and loading and affecting several plant systems. Decay heat removal was maintained throughout the event. The event was initiated by a faulted transformer power supply cable.

Grand Gulf (June 30, 2016) [Event of Interest]

On June 30, 2016 at 17:15 CDT the Unit experienced an electrical power supply loss from uService Transformer 21 which resulted in power supply being lost to the Division 2 and the Division 3 ESF buses. This resulted in a valid actuation of the Division 2 and Division 3 EDGs on bus under-voltage. Both EDGs automatically started and energized their respective ESF buses as designed.

At the time of the event, the unit was in Mode 4, Cold Shutdown. During this event, the loss of power to the Division 2 resulted in a power loss, which actuated a Division 2 RPS half SCRAM signal.

The loss of power was caused by a failure of the taped insulation on the 'C' phase 34.5 kV Service Transformer 21 power supply cable to the Balance of Plant 23 Transformer, due to an outer tape wrap insulation failure between the braid, connecting the splice, and the center conductor. Disassembly and visual inspection of the cable splice showed that the insulation had voids and a moisture path through the split in the outer tape wrap.

Sources

LER 416-2016-006-01, Multiple Valid Engineered Safety Feature Actuations

NRC Event Report No. 52057, Multiple Valid Specified System Actuations Due To Loss of Service Transformer 21

3
EVALUATION OF OPERATING EXPERIENCE

This section consists of two parts: A summary of the frequency (rate) and duration of LOOP events occurring in 2016 and 2007-2016 and trends over this ten-year period.

3.1 Experience for 2016

Table 3-1 summarizes the loss-of-offsite-power experience for the year 2016. The number of Category I LOOPs in a given year has, in the recent ten years, been seven or less, depending on weather and other initiating events. Four Category I.a and I.b LOOPs occurred in the past year (2016), including two short duration LOOP events that occurred in October 2016, initiated by grid faults resulting from Hurricane Matthew coupled with transmission relay failures.

Category I.c, II, III, and IV events involving partial losses of offsite power are also important and are included in the table, as these events reflect events that are near to a LOOP (for example, loss of one more offsite source for a category II event would result in a LOOP). One uncategorized event involving a partial loss of offsite power has been included for information, as it may have involved circumstances or conditions that could be precursors to more serious events.

Table 3-1
LOOP Events, Categories, and Frequencies at U.S. Nuclear Plants for Year 2016

Category	Category Definition	Number of Events	Rate (per unit calendar-yr)*
I.a LOOP	At power - hot shutdown, loss off all offsite power to emergency buses > 30 minutes.	1	0.0101
I.b LOOP	At power - hot shutdown, loss off all offsite power to emergency buses 15 sec to < 30 minutes.	3	0.0303
	Total for categories I.a and I.b	**4**	**0.0404**
I.c LOOP	With the unit in power operation, startup, hot standby, or hot shutdown a significant degradation of offsite power sources occurs and the sources have been declared inoperable by the licensee.	0	0.000
II LOOP	With the unit in power operation, startup, hot standby, or hot shutdown actual loss of power source(s) available to all emergency buses occurs and loss of an additional power source will result in a Category 1 or full LOOP -OR- an actual loss of all offsite power sources supplying an emergency bus or train.	8	0.0808

Table 3-1 (continued)
LOOP Events, Categories, and Frequencies at U.S. Nuclear Plants for Year 2016

Category	Category Definition	Number of Events	Rate (per unit calendar-yr)*
III LOOP	With the unit in power operation, startup, hot standby, or hot shutdown the potential exists for a significant degradation or loss of offsite power sources or their availability is uncertain based on grid system evaluations.	0	0.000
IV.a LOOP	With the unit in cold, or refueling shutdown, the loss or significant degradation of offsite power sources to the emergency bus(es) required to be operable in the shutdown mode.	2	0.0202
IV.b LOOP	No offsite power available to emergency buses during cold or refueling shutdown because of special maintenance and/or testing conditions that do not occur during other operating modes.	0	0.000
Event of Interest	With the unit in power operation, startup, hot standby, hot shutdown, cold shutdown, or refueling shutdown one offsite power source supplying one redundant emergency bus is lost. A LOOP event of less significance than those in categories I-IV, and may involve a reactor trip or safety system actuation.	1	Not included in statistics
	Total for categories I-4 in 2016	**14**	**0.1414**

*Based on 99.01 unit calendar-years of operation in 2016.

3.2 Summary of Experience for 2007–2016

Experience is tracked over a rolling ten-year period. The reason for choosing a 10 year period is that it is important to base projections of LOOP experience on the most recent and relevant operating experience, reflecting current plant and grid configurations and operating practices, which may be subject to change.

Tables 3-2 and 3-3 and Figure 3-1 illustrate the overall experience involving LOOPs for the 10-year period 2007 through 2016. There were 30 total LOOPs (categories I.a and I.b) in a total of 1022.97 generating unit years (Table 3-6). This is equivalent to **0.0293 events per generating unit-year**. The frequency and duration of (full) LOOPs may be used for risk-based analyses.

Data collected over the long term (rolling ten-year periods) indicates a reduction in event duration and a leveling of event frequency for the period of 2014-2016. The event frequency was lower in 2014 and 2015, than in 2013. The event duration also decreased in 2015 and 2016, as depicted in Figure 3-1. It appears that the frequency of losses of offsite power is affected by many factors including plant failures, errors, and weather and grid conditions at and beyond the plant switchyards (see Figure 3-2).

Table 3-2
LOOP Events, Categories and Frequencies at U.S. Nuclear Plants for (2007 Through 2016)

Category	Category Definition	Number of Events	Rate (per unit calendar-yr)*
I.a LOOP	At power - hot shutdown, loss off all offsite power to emergency buses > 30 minutes.	24	0.024
I.b LOOP	At power - hot shutdown, loss off all offsite power to emergency buses 15 sec to < 30 minutes.	6	0.0059
	Total for categories I.a and I.b	**30**	**0.0293**
I.c LOOP	With the unit in power operation, startup, hot standby, or hot shutdown a significant degradation of offsite power sources occurs and the sources have been declared inoperable by the licensee.	3	0.0029
II LOOP	With the unit in power operation, startup, hot standby, or hot shutdown actual loss of power source(s) available to all emergency buses occurs and loss of an additional power source will result in a Category 1 or full LOOP -OR- an actual loss of all offsite power sources supplying an emergency bus or train.	56	0.0547
III LOOP	With the unit in power operation, startup, hot standby, or hot shutdown the potential exists for a significant degradation or loss of offsite power sources or their availability is uncertain based on grid system evaluations.	0	0
IV.a LOOP	With the unit in cold, or refueling shutdown, the loss or significant degradation of offsite power sources to the emergency bus(es) required to be operable in the shutdown mode.	16	0.0156
IV.b LOOP	No offsite power available to emergency buses during cold or refueling shutdown because of special maintenance and/or testing conditions that do not occur during other operating modes.	0	0.000
Event of Interest	With the unit in power operation, startup, hot standby, hot shutdown, cold shutdown, or refueling shutdown one offsite power source supplying one redundant emergency bus is lost. A LOOP event of less significance than those in categories I-IV, and may involve a reactor trip or safety system actuation.	23	Not included in statistics
	Total for categories I-4 in 2007-2016	**105**	**0.1026**

* Based on 1022.97 unit calendar-years of operation from 2007-2016.

Table 3-3
Numbers of LOOP events at U.S. Nuclear Plants by Category and Year for (2007 Through 2016)

Year	I.a	I.b	I.c	II	III	IV.a	IV.b	Interest	Total
2007	0	0	0	1	0	3	0	0	4
2008	4	0	1	2	0	2	0	3	12
2009	2	1	0	4	0	0	0	0	7
2010	0	0	0	5	0	0	0	0	5
2011	7	0	2	4	0	1	0	0	14
2012	3	0	0	9	0	4	0	8	24
2013	5	0	0	11	0	2	0	4	22
2014	2	0	0	8	0	1	0	2	13
2015	0	2	0	4	0	1	0	5	12
2016	1	3	0	8	0	2	0	1	15
Total	**24**	**6**	**3**	**56**	**0**	**16**	**0**	**23**	**128**

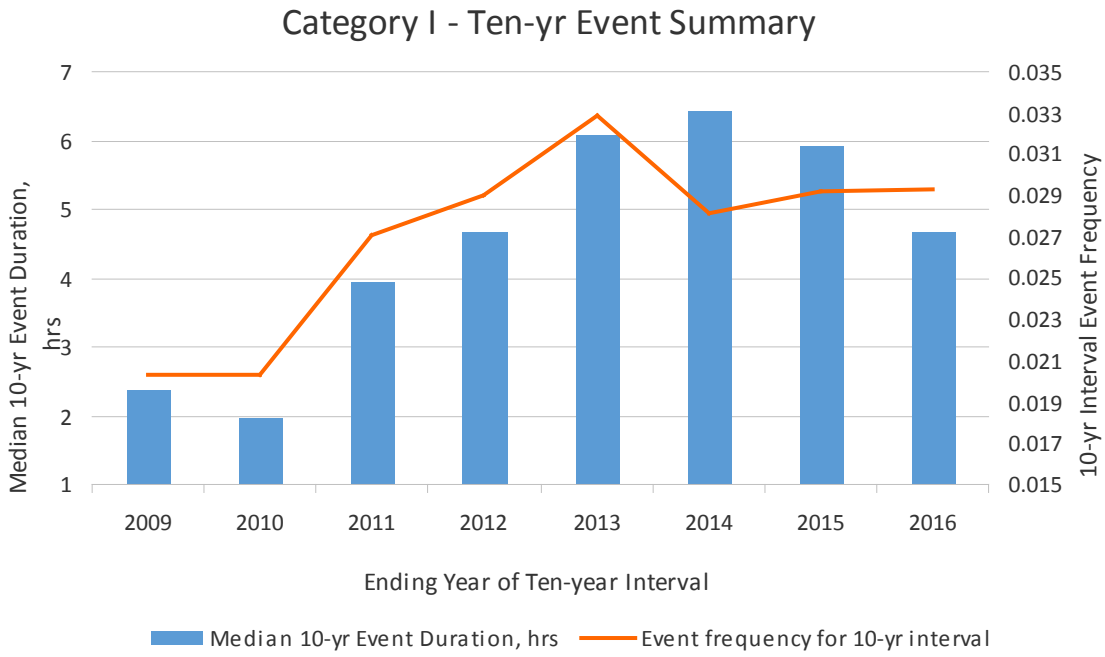
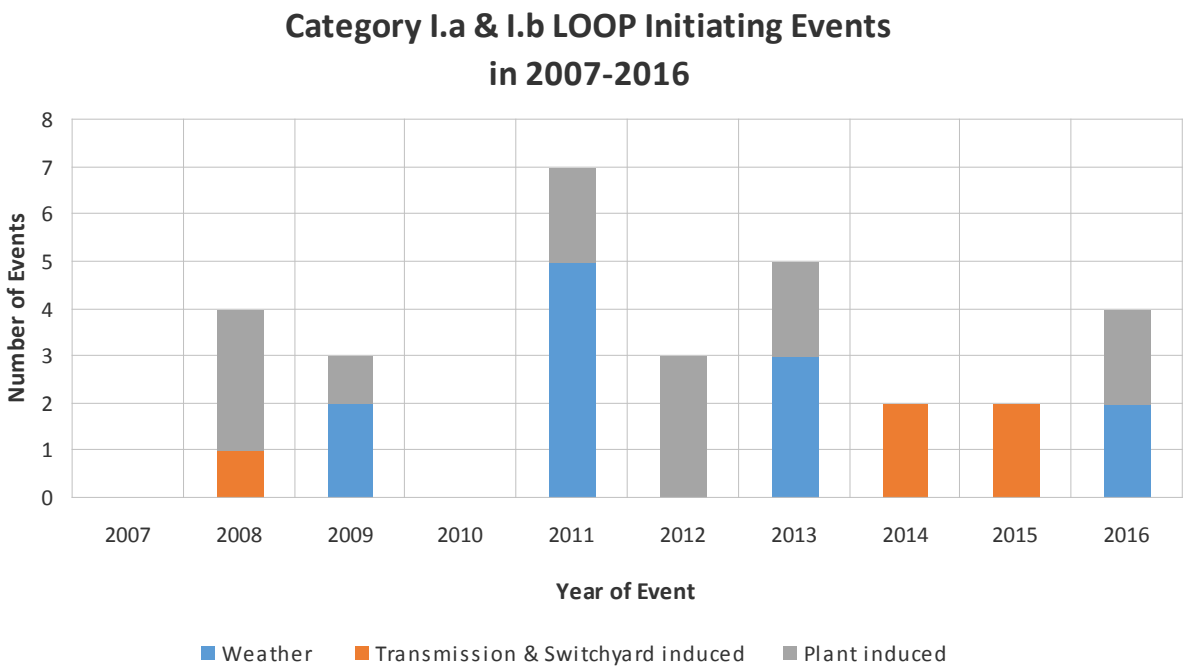


Figure 3-1
Ten Year Category I Frequency and Duration Summary

Figure 3-2 presents the number of LOOPs and initiating events in each year from 2007-2016.



* In 2011 the two plant events were caused by seismic activity.

Figure 3-2
Category I.a and I.b LOOP Initiating Events in 2007-2016

It is instructive to examine the distribution of events involving the total loss of offsite power and their duration (Category I.a and I.b) during the 10-year period 2007 through 2016. This is shown below in Table 3-4 and in Figure 3-2, In Table 3-4, the letters following the durations (W= weather related; S=seismic related, P=Plant Induced, and X=Transmission and Distribution Induced) indicate the types of events. Figure 3-2 presents this type of information graphically.

In the past ten-year period, a significant fraction (about half) of LOOPs were not directly caused by initiating events. Additional events such as equipment failures, improper setpoints, and improperly restored wiring combined with initiating event conditions to result in a (full) LOOP.

Table 3-4
Category I LOOPs, Initiating Events and Durations at U.S. Nuclear Plants for (2007 Through 2016)

Year	Number of Events	Durations (HH:mm:ss)
2007	0	—
2008	4	0:37(X), 0:57(P), 1:29(P), 27:36 (P)
2009	3	2:00(P), 1:30(W) , 0:00:55 (W)
2010	0	—
2011	7	3:49(S), 3:57(S), 5:46(W), 7:04(W), 124:00(W), 124:00(W), 124:00(W)
2012	3	2:57(P), 5:26(P), 33:53 (X)
2013	5	8:02 (W), 8:02 (W), 27:36(P), 27:36(P), 30:43 (W)
2014	2	5:55 (X), 5:55(X)
2015	2	0:00:47(X), 0:00:47(X)
2016	4	0:00:16.5 (W), 0:00:19.7 (W), 0:25(P), 3:16 (P)

A compilation of the initiating events and contributing factors for the 30 events in Category I.a and I.b that occurred in the ten-year period from 2007 through 2016 is presented in Tables 3-5 and 3-7. An “error” as referred to in the following discussion includes direct workmanship errors including inadvertently cutting cables or leaving wires loose, as well as improperly set protection devices, design errors, and set-point errors. Seventeen of the thirty events were potentially avoidable and involved circumstances noted in the tables. Three of these avoidable events involved errors that initiated the LOOPs, and the remainder manifested following the initiating event and contributed to the progression of the initiating event to a Category I LOOP.

The median duration of all 30 events involving a total loss of offsite power during the past 10 years was 4.69 hr. The median duration of the 12 weather-related events during the most recent ten-year period was about 7.55 hours, while the median duration of the 18 non-weather-related LOOPs was 3.54 hours. Equipment failures in the plant and switchyard caused losses with median durations of 3.54 hours. The median duration of losses associated with transmission system failures was 3.27 hours. It should be noted that with the passage of hurricane Matthew, although there were many outages, the grid was available to most nuclear plants in the affected area.

Table 3-5
Avoidable Events, Initiating events, and Median Durations for Category I.a and I.b Events in U.S. Nuclear Plants (2007 Through 2016)

Nature of Initiating Event	Number of Events	Median Duration. (hr)	No. Events Potentially Avoidable	Avoidable Event Error Summaries
Weather - related	12	7.55	6	Switchyard grounding system degradation due to poor workmanship during construction, Relay settings and operation
Equipment failure/ degradation in plant	8	3.11	4	Legacy errors from construction, bus bar connections and insulating boots, Inadequate bus condition monitoring; Design errors – Inadequate protection for single phase; Improper relay settings specified by vendor;
Equipment failure/ degradation in switchyard or transmission system	5	3.27	4	Legacy errors, Incorrect relay settings; Incorrect relay settings did not recognize coupling of adjacent transmission lines;
Earthquake	2	3.88	0	Not applicable
Workmanship	3	27.6	3	Vendor workmen cut cable, Wiring error
Total	**30**		**17**	

Figure 3-1 presents the median LOOP duration (in hours) and the event frequency for the ten-year periods ending in 2009 through 2016. The graphs utilized data from a ten-year period, and some data was not available for the year 2007 and 2008. While weather was a predominant cause of these events in several of the years, it is not the only significant factor. As presented in Table 3-5, seventeen errors were noted associated with the thirty Category I events occurring between 2007 and 2016 that significantly contributed the progression of an event to a total LOOP.

Effects from Hurricane Matthew, combined with relay malfunctions resulted in two short-duration Category I LOOPs in 2016. Weather continues to be an important factor in long-term offsite power experience. In the ten-year period from 2007 through 2016, 12 of the 30 Category I LOOP events were influenced by weather.

It is appropriate to recall that severe weather can cause multiple failures over an extended transmission system area and can affect many facilities. Transmission system degradation, failure diagnostics and corrective actions are not under the immediate control of nuclear plant personnel. It can require considerable effort and time to locate and recover from such failures. At plants near the ocean, salt spray can impact entire switchyards. In contrast, non-weather related LOOPs typically involve single equipment failures. There is usually redundant equipment available that can be placed in service to recover from such LOOPs. Thus, it is reasonable to

expect that weather-caused LOOPs last longer than non-weather caused LOOPs. With the passage of hurricane Matthew, although there were many outages, the grid was available to most nuclear plants in the affected area. This indicates a significant improvement in grid performance in the south-eastern coastal areas of the United States.

With respect to the ten-year LOOP event data and associated frequencies, EPRI considers the preceding ten-year period for reporting information for good reason. Ongoing changes and improvements to the United States grid and transmission system would indicate that older data may not reflect current realistic transmission grid conditions. An indication of current conditions, including data from the previous 10 years, is appropriate. A single large occurrence (such as widespread severe weather or cascading blackouts) can result in multiple plant events. Such events are not independent, and can significantly impact LOOP frequency and duration. These major grid disruptions appear to have occurred in the past about once a decade, so analysts should keep this in mind when using this report.

For reference purposes, the number of unit calendar-years for operating plants is summarized by year in Table 3-6.

Table 3-6
Number of Generating Unit Calendar Years for 2007-2016

Year	Unit Calendar-Years
2007	103.66
2008	104
2009	104
2010	104
2011	104
2012	104
2013	101.31
2014	99.99
2015	99
2016	99.01*
Total - 2007-2016	**1022.97**

*** Notes:**
Watts Bar Unit 2 commenced commercial operation 10/19/2016
Ft. Calhoun closed 10/24/2016

Table 3-7
Events Involving Loss of All Offsite Power at U.S. Nuclear Plants for 2007-2016

Unit	Date	LER No.	Cate-gory	Power %	Duration hrs	Initiating Event	Contributing Factors	Root Cause
Point Beach 1	01/15/08	266-2008-001	I.a	100	27.6	Loss of station auxiliary transformer		4 kV cable fault
Byron 2	03/25/08	455-2008-001	I.a	100	1.48	Insulator failure on auxiliary transformer		Insulator failure
Nine Mile Point 1	05/13/08	220-2008-001	I.a	100	0.61	Offsite fault in transmission line		One of two lines supplying vital buses cleared, loss of second line interrupted offsite power to vital busses.
Millstone 2	05/24/08	336-2008-004	I.a	0.1	0.95	Startup transformer breakers open		Spurious audio tone trip signal
Oyster Creek	07/12/09	219-2009-005	I.a	100	1.5	Lightning strike on transmission line	Breaker mechanical failure	Breaker on line failed to open promptly due to mechanical binding
Braidwood 2	07/30/09	457-2009-002	I.a	100	2	Fault of system aux. transformer	RCP overcurrent relay out of tolerance	Transformer fault
Wolf Creek	08/19/09	482-2009-002	I.b	100	0.015	Lightning strike caused ground fault	Offsite carrier signal system failure	Carrier signal failure caused relays to open transmission line
Surry 1	04/16/11	280-2011-001	I.a	100	5.77	Switchyard damage due to tornado		Tornado
Surry 2	04/16/11	280-2011-001	I.a	98.3	7.07	Switchyard damage due to tornado		Tornado
Browns Ferry 1	04/27/11	259-2011-001	I.a	75	124	Loss of all seven 500 kV lines connecting station to grid during severe weather		Severe weather including tornados and grid instability

Table 3-7 (continued)
Events Involving Loss of All Offsite Power at U.S. Nuclear Plants for 2007-2016

Unit	Date	LER No.	Cate-gory	Power %	Duration hrs	Initiating Event	Contributing Factors	Root Cause
Browns Ferry 2	04/27/11	259-2011-001	I.a	75	124	Loss of all seven 500 kV lines connecting station to grid during severe weather		Severe weather including tornados and grid instability
Browns Ferry 3	04/27/11	259-2011-001	I.a	100	124	Loss of all seven 500 kV lines connecting station to grid during severe weather		Severe weather including tornados and grid instability
North Anna 1	08/23/11	338-2011-003	I.a	100	3.82	Earthquake caused auxiliary transformers to lock out due to sudden pressure relay actuation. Reactor trip also occurred.		Earthquake
North Anna 2	08/23/11	338-2011-003	I.a	100	3.95	Earthquake caused auxiliary transformers to lock out due to sudden pressure relay actuation. Reactor trip also occurred.		Earthquake

Table 3-7 (continued)
Events Involving Loss of All Offsite Power at U.S. Nuclear Plants for 2007-2016

Unit	Date	LER No.	Cate-gory	Power %	Duration hrs	Initiating Event	Contributing Factors	Root Cause
Wolf Creek	01/13/12	482-2012-001-00	I.a	100	2.95	Main generator output breaker failure	Relay action de-energized startup transformer	Phase to phase short circuit between CT high side taps. Insulation sleeves removed during outage work and not replaced.
Byron 2	01/30/12	455-2012-001-00	I.a	100	33.88	Insulator failure on auxiliary transformer	Design insufficient - failure caused sustained open phase not automatically detected	Manufacturing defect in insulator, design vulnerabilities in protective relay schemes and lack of single open phase detection
Catawba 1	04/04/12	413-2012-001	I.a	100	5.43	Unit trip due to RCP motor ground fault	Under-frequency relay action isolated unit from grid	Inadequate vendor control in conjunction with underfrequency relay modifications
Pilgrim	02/08/13	293-2013-003-00	I.a	100	30.72	Loss of offsite transmission line during severe winter storm Nemo		Severe weather - winter storm Nemo
LaSalle 1	04/17/13	373-2013-002-01	I.a	100	8.03	Lightning strike on transmission line in switchyard	Grounding system degradation leads to opening all oil circuit breakers in switchyard	Grounding system degradation due to poor construction and inadequate lightning shielding of switchyard
LaSalle 2	04/17/13	373-2013-002-01	I.a	100	8.03	Lightning strike on transmission line in switchyard	Grounding system degradation leads to opening all oil circuit breakers in switchyard	Grounding system degradation due to poor construction and inadequate lightning shielding of switchyard
Comanche Peak 1	12/04/13	445-2013-003-00	I.a	100	27.6	Incorrectly cut cable supplying safeguards transformer	Other safeguards transformer out of service	Workmanship error

Table 3-7 (continued)
Events Involving Loss of All Offsite Power at U.S. Nuclear Plants for 2007-2016

Unit	Date	LER No.	Cate-gory	Power %	Duration hrs	Initiating Event	Contributing Factors	Root Cause
Comanche Peak 2	12/04/13	445-2013-003-00	I.a	100	27.6	Incorrectly cut cable supplying safeguards transformer	Other safeguards transformer out of service	Workmanship error
Millstone 2	05/25/14	336-2014-006-00	I.a	100	5.92	Insulator failure at offsite substation and inadvertent trip of second line	One of four offsite lines out of service, relay setting	Line instantaneous overcurrent set without consideration to mutual coupling of adjacent lines
Millstone 3	05/25/14	336-2014-006-00	I.a	100	5.92	Insulator failure at offsite substation and inadvertent trip of second line	One of four offsite lines out of service, relay setting	Line instantaneous overcurrent set without consideration to mutual coupling of adjacent lines
Calvert 2	04/07/15	317-2015-002-00	I.b	100	0.013	Transmission Line fault	Relay wiring	Failure of substation breaker to open after the fault due to loose connection in trip relay aux. coil
Calvert 1	04/07/15	317-2015-002-00	I.b	100	0.013	Transmission line fault	Relay wiring	Failure of substation breaker to open after the fault due to loose connection in trip relay aux. coil
Brunswick 1	02/07/16	325-216-001-00	I.a	88	3.27	Electrical fault in non-segregated bus caused lockout of SAT	Degraded cable insulation	Two: (1) inspection detail insufficient to prevent water intrusion; (2) failure to limit depth cutting for semiconducting material from cable insulation
St. Lucie 1	08/21/16	335-2016-003-00	I.b	38	0.42	Actuation of generator lockout relay		Latent error introduced during a 2013 design modification when a wire was incorrectly removed.

Table 3-7 (continued)
Events Involving Loss of All Offsite Power at U.S. Nuclear Plants for 2007-2016

Unit	Date	LER No.	Cate-gory	Power %	Duration hrs	Initiating Event	Contributing Factors	Root Cause
Harris	10/08/16	400-2016-005-00	I.b	Mode 4	0.0046	Loss of offsite transmission lines during Hurricane Matthew	Relay failures	Grid fault caused by hurricane and failure of substation relays resulted in delayed clearing of fault.
Robinson	10/08/16	261-2016-005-00	I.b	100	0.0055	Hurricane Matthew caused fault on offsite transmission line	Transmission relay failure delayed clearing fault	Grid fault caused by hurricane not isolated due to failure of fault detection relay

Losses of All Offsite Power not occurring in Modes 1-4								
Unit	**Date**	**LER No.**	**Cate-gory**	**Power %**	**Duration hrs**	**Initiating Event**	**Contributing Factors**	**Root Cause**
Duane Arnold	02/24/07	331-2007-004	Iv.a	0	17.46	During refueling, severe winter storm in area, grid was degraded and isolated plant from offsite sources		Severe winter weather
Point Beach 1	11/27/11	266-2011-001-00	IV.a	0	4.20	With the unit in cold shutdown following a refueling outage, electrical alignment in progress. A LOOP occurred during switching operations.		Circuit switcher internal contacts were not properly made up in any of the three phases resulting in limited capacity current pathway
Catawba 2	04/04/12	413-2012-001	IV.a	0	5.57	Unit 2 was in cold shutdown being powered from unit 1, when a unit 1 LOOP occurred		Differential relay actuation because shorting bars not removed as required by work order. Design drawing was also in error.

Table 3-7 (continued)
Events Involving Loss of All Offsite Power at U.S. Nuclear Plants for 2007-2016

Losses of All Offsite Power not occurring in Modes 1-4								
Unit	**Date**	**LER No.**	**Cate-gory**	**Power %**	**Duration hrs**	**Initiating Event**	**Contributing Factors**	**Root Cause**
Fitzpatrick	10/05/12	333-2012-005	IV.a	0	7.17	During refueling and replacement of reserve station transformers, a transformer trip occurred during maintenance testing causing a LOOP		Differential relay actuation because shorting bars not removed as required by work order.
Oyster Creek	10/29/12	219-2012-002-00	IV.a	0	14.35	In cold shutdown for refueling, high winds from hurricane Sandy caused switchyard and transmission equipment damage		Hurricane Sandy
Pilgrim	02/10/13	293-2013-003-00	IV.a	0	40	Winter storm Nemo flashovers occurred while in cold shutdown		Winter Storm NEMO
ANO-1	03/31/13	313-2013-001-01	IV.a	0	126	Stator dropped during refueling outage		Physical damage to electrical busses from stator drop onto turbine deck
Byron 1	03/15/14	454-2014-003-00	IV.a	0	10.21	During refueling, aux transformer tripped de-energizing safety buses		Unexpected underfrequency relay operation in unit 1 caused loop, impacted unit 2 being powered from unit 1.

4
REFERENCES

1. *Losses of Offsite Power at U.S. Nuclear Power Plants: Summary of Experience Through 2015*: EPRI, Palo Alto, CA: 2016. 3002008101.

A
LOSS OF OFFSITE POWER EVENTS 2007–2016

A.1 Category I.a Events

One category I.a event occurred in 2016.

Braidwood 2: 07/30/09

Restore time: 12:36 hours;
Power: 100%
LER (457) 09-002, 09/28/09

On 07/30/09 at 20:59 hours, Braidwood Unit 2 lost all offsite power and tripped off-line from 100% power. The initiating cause of this event was a sudden pressure relay actuation at one of the Unit's two system auxiliary transformers. Unit 2 has two system auxiliary transformers (SATs) that are powered from a common line from a 345kV switchyard and two unit auxiliary transformers (UATs) that are powered from the generator output. A fault on either SAT will cause loss of the common line and isolate both SATs. The plant is designed that on a loss of the SATs, the non-ESF (4.1- and 6.9kV) buses will transfer to the UATs.

During normal operation, two of the four reactor coolant pumps (RCPs) are powered from the SATs and two from the UATs. When there is a SAT or UAT failure, the affected RCP should automatically switch to receive its power from the alternate source.

During this event, the 2C RCP tripped on overcurrent following the bus transfer because elements of its overcurrent relay were out of tolerance. In turn, the main unit tripped off-line because there were less than four RCPs in operation while reactor power was above 30%. Loss of the main unit de-energized both UATs. Hence, both the two SATs and two UATs were de-energized, and the unit was without a source of normal offsite power. The 2A and 2B emergency diesel generators successfully started and loaded.

The safety buses at both Braidwood 1 and 2 can manually be switched in less than two hours to receive power from the comparable buses of their sister unit. No bus alterations are required. This option was available throughout this event. However because the EDGs were operating as intended, the safety buses were not switched back to offsite until later at a less stressful time. In this situation, the duration of the LOOP is the period until offsite power could have been restarted which was less than about 2 hours. The restoration of normal offsite power required significant testing, analysis and bus alterations. Normal offsite power was restored on 08/02/09 at 12:36 hours.

Browns Ferry 1, 2, and 3: 4/27/11

Restore Time: 5 days, 4 hours (124 hours);
Power: 75%, 75%, and 100%
LER (259) 11-001, 6/27/11.

On 04/27/11, severe weather, including tornadoes and accompanying grid instability caused the loss of all seven 500kV offsite lines that connect the three generating units at the Browns Ferry site to the grid. The first 500kV line was lost at 15:39 hours and the last (seventh) at 16:36 hrs at which time all three main generating units automatically tripped off-line. Prior to tripping, Units 1 and 2 were at about 75% power and Unit 3 was at full power. One of the sites two incoming 161kV transmission lines was lost at 16:22 hrs. The other 161kV transmission line remained in service throughout this event and provided offsite power to a selected, limited number of plant loads. The four EDGs (A, B, C and D) for Units 1 and 2 started and loaded. Three of Unit 3's EDGs (3A, 3C and 3D) started and loaded. The Unit 3B EDG was out of service for maintenance.

At 23:38 on 04/28/2011, about 31 hours after the event began, the Units 1 and 2 "C" EDG developed a governor oil tubing leak which caused frequency fluctuations and required that the EDG be shutdown. The Unit 2 RHR pump was started within about 4 minutes. During this period, the Unit 2 reactor coolant system temperature did not change. The Unit 1 Group 2 signal was reset after 47 minutes, which restored cooling. During this period, the Unit 1 reactor coolant temperature had increased about 20ºF.

At 06:30 on 05/02/11, about 4 ½ days after the event began, the Unit 1 "A" EDG tripped due to a faulty overspeed sensing switch. This shutdown the spent fuel cooling pumps and the water cleanup system and control rod drive system pumps. After about 54 minutes, these loads were restored from the sites second source of 161kV power. During this period, Unit 1 reactor coolant system temperatures increased about 25ºF. The spent pool temperature did not change.

By 20:50 on 05/02/11, about 5 days and 4 hours after the event began, all plant loads (Unit 1, Unit 2 and Unit 3) had been restored to offsite power and all EDGs to standby readiness and the site exited the declaration of a "Notice of Unusual Event." This occurred five days and a little over four hours after the event began.

The overall response of the three Browns Ferry generating Units to this LOOP event can be summarized as follows:

- There were no safety system functional failures.
- For Units 1 and 3, offsite power losses resulted in a loss of RPS power which led to MSIV closure and subsequent loss of feedwater flow and main condenser vacuum. Decay heat was transferred to the suppression chamber (torus) via manual operation of the steam relief values and HPCI in its pressure control mode.
- For Unit 2, there was no loss of normal heat removal capability.

Brunswick Unit 1: 02/07/2016

Restore Time: 3:16 hours
Power: 88%
LER (325) 2016-001-00

On February 7, 2016 with the unit at 88% power, an electrical fault and explosion on a non-segregated (all three phases lie within a single housing) 4.16 kV bus occurred at 13:12 hours resulting in the lockout of the startup auxiliary transformer (SAT) and loss of both reactor recirculation pumps. Operators inserted a manual scram in accordance with procedures, which shut down the turbine and generator and resulted in the loss of the unit auxiliary transformer (UAT) supply to the emergency busses. Since the SAT was already locked out, a loss of offsite power (LOOP) existed on the emergency busses. Diesel generators were running as a result of the SAT lockout, and then tied to the emergency buses. At 16:28 hours, offsite power was restored to the emergency buses from the unit auxiliary transformer (which is the normal source for the emergency buses). The duration of the LOOP was 3:16 hours.

The initiating event was two arc flashes that occurred in a non-segregated bus, and in a circuit breaker cubicle associated with a reactor recirculation system pump, respectively. The first arc flash occurred in an area of the 4.16 kV bus housing outdoors where water accumulated. This caused a voltage imbalance leading to the second arc flash in the breaker cubicle where cable insulation was found to be degraded.

The root cause of the moisture intrusion was inspection procedures did not contain sufficient specific detail based on the highest risk locations (i.e., specifically horizontal surfaces through which bars penetrate) to ensure deficiencies that can lead to water intrusion are identified and corrected. The root cause of the damaged cable insulation was failure to specify and use a depth-limiting cutting tool for removing semiconducting material from cable insulation.

Byron 2: 03/25/08

Restore Time: 1:29 hours;
Power: 100%;
LER (455) 08-001, 03/27/08.

Unit 2 offsite power is supplied from the transmission system. From the switchyard two electrically and physically separated lines provide power through two system auxiliary transformers (SATs) to the two Engineered Safety feature (ESF) buses. The two SATs have a common feed in the switchyard. Each ESF bus also has a reserve offsite power feed via a crosstie to a corresponding Unit 1 bus. In addition each ESF bus has a dedicated emergency diesel generator (EDG).

In this event, an insulator on one phase of one of the two system auxiliary transformers failed. Because the two SATs have a common feed from the switchyard, both became de-energized. Both the 2A and 2B EDGs started and loaded and re-energized the safety feature buses. 1:29 hrs after the event began, the safety feature buses were cross-tied to the Unit 1 ESF buses and the EDGs were shutdown. Unit 2 remained at full power throughout this event. Unit 1 was in the refueling mode and was unaffected.

Byron 2: 01/30/12

Restore Time: 33:53 hours;
Power: 100%;
LER (455) 2012-001-00, 03/30/2012;

NRC Information Notice 2012-03, Design Vulnerability in Electric Power System, March 1, 2012.

The Byron Unit 2 electrical system consists of four non-safety-related 6.9kV buses, two non-safety-related 4.16kV buses, and two 4.16kV engineered safety features (ESF) buses. The two 4.16kV ESF buses and two of the non-safety-related 6.9kV station buses normally are supplied by one of the two station auxiliary transformers (SATs) connected through one 345kV offsite circuit.

The remaining two non-safety-related 6.9kV station buses and two non-safety-related 4.16kV station buses normally are supplied by one of two unit auxiliary transformers (UATs) when the main generator is online. The four reactor coolant pumps (RCP) are powered from four 6.9kV buses. Each 4.16kV ESF bus has a dedicated standby emergency diesel generator.

On 01/30/2012 at approximately 10:02 CST, Byron Unit 2 experienced a mechanical failure of an underhung porcelain insulator on one phase of the 345kV switchyard supply connecting to the system auxiliary transformers (SAT). The nature of the failure resulted in a sustained open phase event to the SAT supply and a low level ground fault on the SAT side of the open phase. The SATs normally supply the two 4.1kV ESF buses and two non-safety related buses that supply two reactor coolant pumps (RCP).

The insulator failure caused an open phase in the supply to the SATs, resulting in an undervoltage condition on the associated RCP buses which caused a reactor trip. The open phase also caused an unbalanced condition on the ESF buses which was not automatically detected and did not result in an automatic start of the associated emergency diesel generators. At this time, the ESF bus supply from the SATs was inoperable. Following the reactor trip, the main generator tripped, resulting in a transfer of the buses fed from the unit auxiliary transformer (UAT) to the SATs that were still energized with two phases from the 345kV system. The unbalanced condition caused all four RCPs and other equipment on the non-safety buses to trip on overcurrent. (With the main unit, SATs and RCPs unavailable, the plant was in a condition requiring natural circulation for decay heat removal and cooldown.)

Operators recognized the problem with the non-safety buses and were verifying the ESF buses, and noted that one of the phase to phase voltages was abnormally low. Based on this information, and operator observation of what appeared to be smoke (later diagnosed as water vapor) coming from the vicinity of the SAT, operators opened the SAT feeder breakers to the ESF buses. This intentionally caused an undervoltage condition on all three phases of the ESF buses, resulting in the associated diesel generators starting and all safe shutdown loads sequenced on to the buses, as designed. The 4.1kV non-safety buses were then cross-tied to the ESF buses and the SAT 345KV supply breaker was opened. For the ~8 minutes from the insulator failure until opening of the SAT feeder breakers to the ESF buses, the buses were not connected to an operable power source and this event was determined to be a category I event.

The unit was in cold shutdown at 02:28 hours on January 31, 2012. The failed insulator was replaced and at 19:55 hours on January 31, 2012, the diesel generators were secured and offsite power was restored to the ESF buses.

The insulator failure was caused by service propagation of a large manufacturing material defect, and all inverted insulators associated with the SATs and main power transformers have been replaced with insulators from a different manufacturer. Also, design vulnerabilities existed in the protective relaying schemes regarding the lack of single open phase detection that complicated operator response by not automatically isolating all three phases of the affected line. The vulnerability will be addressed with a means to eliminate this vulnerability in single open phase detection scheme.

Catawba 1 and 2: 04/04/12

Unit 1 – Restore Time: 5:26 hours; Power: 100%; Category I.a
Unit 2 – Restore Time: 5:34 hours; Power: 0%, cold shutdown; Category IV.a
LER (413) 2012-001-0, 06/04/2012 for both units.

On 04/04/2012 at 20:03 hrs, Unit 1 tripped from 100% power as a result of low reactor coolant system flow following loss of a reactor coolant pump due to a ground fault. As anticipated, a unit/generator trip ensued, followed by isolation of the unit from the grid due to unexpected instantaneous underfrequency relay action. Isolation from the grid created a LOOP situation. Unit 2 was in cold shutdown with its essential buses powered from Unit 1, and the Unit 1 LOOP also resulted in a Unit 2 LOOP. Both emergency diesels on each unit started and powered their respective essential buses. A residual heat removal pump was started to restore core cooling for Unit 2, and Unit 1 was stabilized on natural circulation with residual heat removal via auxiliary feedwater and secondary steam relief.

Approximately 5 ½ hours later, after confirming that the sources of the electrical fault were cleared offsite power was restored to one essential bus on each unit. The LOOP occurred as a result of inadequate design input specification and insufficient control over vendor outsourcing in conjunction with underfrequency relay modifications.

Comanche Peak Units 1 and 2: 12/04/13

Restore Time: 27:36 hours
Power: 100%;
LER (445) 2013-003-00, 01/30/2014.

On 12/04/2013 at 13:41 hrs, with both units at 100% power and one offsite power- safeguards transformer (138kV XST1) out of service for modifications, Comanche Peak Nuclear Power Plant experienced a loss of offsite safeguards power to both units due to an incorrectly cut cable supplying safeguards loads from 345kV transformer XST2.

All four EDGs automatically started and re-energized all safeguards buses. Both units continued operation at approximately 100% power. Non-safeguards electrical power remained energized by auxiliary transformers supplied by each unit's main generator. Additionally, 345kV switchyard power was available for the non-safeguards electrical buses if required.

The XST2 transformer safeguards cable was repaired with an in-line splice and XST2 was declared operable at 17:17 hours on December 5.

LaSalle Units 1 and 2: 4/17/13

Restore Time: 8:02 hours
Power: 100%;
LER (373) 2013-002-01, 07/26/2013.

On 04/17/2013 at 14:59 hours with both units operating at 100% power, a severe thunderstorm was in progress and a lightning strike on 138kV Line 0112 resulted in a phase to ground fault. At this time, all 345kV oil circuit breakers (OCB) in the main switchyard opened, resulting in a LOOP and reactor scrams on both units. All emergency diesel generators automatically started and loaded on to their respective ESF buses.

Offsite power was restored to all ESF buses by 23:01 hours on 4/17/2013.

The initiating event was a lightning strike on 138KV line 0112 in the main 345/138kV switchyard. Line 0112 was inspected in the field and had sustained heavy damage to phase "C" insulators.

The root cause of the LOOP event was determined to be degradation of the 138KV switchyard grounding system that allowed a lightning induced fault to flash over onto the DC protective system. The grounding system degradation was due to poor workmanship during original construction. The degradation allowed a fault initiated by a lightning strike on the L0112C phase capacitance coupled voltage transformer in the 138kV switchyard to damage the shared DC protection system. A contributing cause to the event was determined to be inadequate lightning shielding of the 138kV switchyard. The ground system in the 138kV switchyard was repaired, and corrective actions included improving lightning shielding.

Millstone Units 2 and 3: 5/25/14

Restore Time: 5:55 hours;
Power: 100% for Units 2 and 3;
LER 336/2014-006-00, July 24, 2014.

At approximately 07:01 hrs on May 25, 2015 with both units operating at 100% power, a total loss of offsite power occurred as both units disconnected from all offsite sources (345kV lines) at the Millstone Power Station switchyard. This event was initiated by an insulator failure at an offsite substation causing the loss of two of the four offsite sources (one source tripped as a direct result of the insulator failure phase to ground fault, and the second tripped due to the protection system for the source sensing the fault as an instantaneous ground). Another offsite source was out of service for scheduled work by the Transmission Owner (Connecticut Light & Power), and with only one line/source remaining; it was overloaded by the output of both units and tripped, resulting in the loss of all offsite power. Both units experienced turbine trip/reactor trips. Both units' emergency diesel generators started and supplied power to the respective safety buses. Offsite power was restored at 12:56 on May 25, 2014 for LOOP duration of 5:55 hours.

The Millstone Power Station switchyard connects the Units 2 and 3 generators to the grid through four 345kV transmission line circuits (line Nos. 310, 348, 371, and 383). The offsite circuits are controlled by the Transmission Owner, Connecticut Light & Power. At the time of the event, Line 371 was out of service for scheduled maintenance when a phase to ground fault on one of the phases of Line 383 occurred due to an insulator failure at a motor-operated disconnect switch at an offsite substation. The Transmission Owner had incorrectly set the Line 310 ground instantaneous over-current element without full consideration given to the effect of mutual coupling with adjacent lines. This resulted in a setting that resulted in tripping the 310 line as well as the 383 line.

Millstone Unit 2: 05/24/08

Restore Time: 0:57 hours;
Power: 0.01%,
LER (336) 08-004, 07/14/08.

At the time of this event, reactor startup was in progress and power was below the point of adding heat. Plant power was being supplied from the reserve station service (startup) transformer (RSST). The loss of offsite power occurred when the low side breakers from the RSST to the 4.16kV and 6.9kV buses unexpectedly opened. This resulted in a reactor trip. The two emergency diesel generators started and repowered the vital (safety) buses. The most probable cause for the RSST low side breakers opening was a spurious primary audio tone trip signal that was not sufficiently filtered by the audio tone circuitry due to filter circuitry degradation.

Offsite power was restored to the “C” 4.16kV vital bus 0:57 hrs after the event began. Unit 3 was unaffected by this incident.

Nine Mile Pt. 1: 05/13/08

Restore Time: 0:37 hours;
Power: 100%;
LER (220) 08-001, 07/07/08.

Offsite power is supplied to Unit 1 via two 115kV lines (Line 1 and Line 4). Prior to this event, Line 1 had been removed from service for planned maintenance. Line 4 continued to supply offsite power to Unit 1 and its vital buses. While in this electrical configuration, Line 4 experienced a fault at an offsite location and de-energized. This resulted in de-energization of Unit 1’s two 4.16kV vital buses. Both of their emergency diesel generators started and loaded. Line 1 was placed back in service 0:37 after the event began. Unit 1 remained online throughout this event. Unit 2 was unaffected.

North Anna 1 and 2: 08/23/11

Restore Time: 3:49 and 3:57 hours;
Power: 100%;
LER (338) 11-003, 10/20/11.

On 08/23/11 at 13:51 hours with both Units 1 and 2 at 100% power output, a magnitude 5.8 earthquake occurred approximately 11 miles WSW of North Anna Power Station. The earthquake caused the automatic trip off-line of both units from various signals.

The earthquake caused multiple auxiliary transformers to lock out due to activation of their sudden pressure relays. The sudden pressure relays operated as a result of earthquake-induced pressure pulses, not electrical faults. The de-energization of the auxiliary transformers in the switchyard removed the source of operating power for the main units. The emergency diesel generators started and loaded as designed.

It is significant that the grid remained energized and there was offsite power to the plant switchyard throughout the event, although the switchyard breakers tripped open and auto-reclosed after design time delays. But because key auxiliary transformers were open, there was a loss of offsite power for operating plant equipment. Offsite power for plant equipment was restored when the auxiliary transformers were reenergized. The listed outage durations indicate when the first safety bus on each unit was reenergized from offsite power. For both units, the second safety bus was energized from offsite power about 7 hours after the event began.

Oyster Creek: 07/12/09

Restore Time: 1:30 hours;
Power: 100%;
LER (219) 09-005, 09/10/09.

On 07/12/09 the Oyster Creek nuclear unit lost all 34.5kV offsite power for duration of 1:30 hours. The main unit also tripped off-line from 100% power at the time offsite power was lost.

Oyster Creek has two startup transformers. Both are fed from the 34.5kV switchyard. The initiating event was a lightning strike on a 34.5kV transmission line that is owned and operated by a neighbor company and that terminates at Oyster Creek. A 34.5kV breaker that is maintained by the neighbor company at the remote terminal of the line failed to open as quickly as required due to mechanical binding. This caused the plant's 34.5kV bus expanded zone backup relays to actuate which de-energized the 34.5kV switchyard at Oyster Creek. The resulting grid disturbances caused voltage swings and elevated voltage that caused a main unit trip due to over-excitation.

Pilgrim Two Related Events: 2/8/13 and 2/10/13

First Event (2/8/2013) – Restore Time: 30:43 hours; Power: 100%; Category I.a
Second Event (2/10/2013) – Restore Time: 40:00 hours; Power: 0%, cold shutdown; Category IV.a
LER (293) 2013-003-00, 4/8/2013.

On 02/08/2013 at 21:17 hours, Pilgrim Nuclear Power Station (PNPS) experienced a loss of offsite power (LOOP) associated with severe winter storm NEMO; a subsequent load rejection from 85% power and a reactor scram. Emergency diesel generators automatically started and powered the two safety-related buses. All other safety systems functioned as required and the plant stabilized in Hot Shutdown.

PNPS is connected to the grid by two 345kV lines connected to a ring bus located within the station's 345kV switchyard. The ring bus also connects to the main transformer and the startup transformer (SUT). The ring bus design locates the power transmission bus sections such that a failure of any one bus section will not result in the loss of the other bus section. Either of the two 345kV lines is capable of carrying full station output and supplying station loads via the SUT.

In addition to the preferred 345kV offsite power lines, PNPS has a secondary offsite power source, a 23kV line that provides power to a shutdown transformer. In anticipation of a major winter storm impacting PNPS, the station entered procedures for dealing with severe weather. Station risk level was elevated to yellow. On Friday 02/08, meteorological instruments at PNPS recorded sustained wind speeds between 42 and 49 mph through 22:28 hours at which time the plant information system stopped recording weather data until the following day.

On Friday, 02/08/2013 at 20:18 hours, the shutdown transformer was declared inoperable due to repeated offsite alarms and reports regarding power loss at the line's terminal point, and offsite substation.

At 21:02 hours, a major fault occurred on line 342 (one of the two 345kV lines) and the line remained de-energized for the remainder of the storm. At 21:17 hours a fault on line 355 (the second 345kV line) occurred resulting in a LOOP.

The LOOP was initiated by severe weather causing faults on both 345kV transmission lines connected to the PNPS ring bus. One of the 345kV transmission lines was restored to reenergize the SUT at 22:11 hours. However, two subsequent bus faults associated with the SUT precluded energizing the safety buses from offsite power until one safety bus was reenergized at 04:00 hours on February 10, followed by energizing the second safety bus at 08:30 hours.

On 2/10/2013 at 14:01 hours with the unit in cold shutdown, a second LOOP occurred initiated by a flashover fault on one phase of the SUT bus section. The flashover fault was due to salt-contaminated ice bridging on the phase insulator. The single remaining breaker on the 345kV ring bus supplying the SUT opened, resulting in a loss of power to the two safety-related buses, followed by starting of the associated diesel generators and powering the safety-related buses. At 06:01 hours on 2/12/2013 offsite power was restored to one safety-related bus through the Main/Unit auxiliary transformers. Offsite power was restored to all 4.16kV buses at 21:47 hours on 02/12/2013.

Point Beach 1: 01/15/08

Restore Time: 27:36 hours;
Power: 100%;
LER (266) 08-001, 03/16/08.

On 01/15/08 Point Beach 1 experienced a loss of the Low Voltage Station Auxiliary Transformer 1x04 (13.8/4.16kV). This transformer supplies power for the two Unit 1 safeguard buses 1A05 and 1A06. The emergency diesel generators successfully started and repowered the safeguard buses.

The nature and location of the fault was not readily apparent. While the Unit 1 safeguard buses can be fed from Unit 1's unit auxiliary transformer and also via crossties from Unit 2's 4.16kV buses 2A03 and 2A04, the prime consideration was to proceed cautiously so as to not make switching errors that could reclose on the fault or further damage equipment, or endanger the backup offsite sources. With the EDGs performing well, proceeding cautiously was the prudent approach. Unit 1 was manually shutdown 24 hours after the event began, to meet a Limited Condition for Operation requirement.

Offsite power was restored to the Unit 1 safeguard buses via cross connections from Unit 2, 27:36 hrs after the event began. Unit 2 was unaffected by this event and remained at full power. Shutdown began on Unit 1, 24 hours after the event began to satisfy an LCO. The fault was ultimately determined to be in a 4.16kV cable that goes from transformer 1x04 to non-safeguard bus 1A03. Transformer 1x04 was undamaged.

Surry 1 and 2: 04/16/11

Restore Time: 5:46 and 7:04 hours;
Power: 100%;
LER (280) 11-001, 06/14/11.

On 04/16/11 at 18:49 with Unit 1 at 100% power and Unit 2 at 98.3%, a tornado touched down in the station's switchyard. Both units tripped off-line and experienced a LOOP. The Unit 1 reactor was tripped by a loss of coolant flow as a result of loss of power to the station service buses. Unit 2 was tripped by a unit output 500kV differential relay.

The plant has three EDGs for the plant's four safety buses (two safety buses per unit). The plant also has what is called a station blackout diesel (SBO diesel).

When this event occurred, the three EDGs and the SBO diesel started and repowered the four safety buses (two per unit). Offsite power was restored to the plant's two reserve station service transformers 5:03 hrs after the event began. A Unit 1 safety bus had offsite power restored 5:46 hrs after the initial loss, and a Unit 2 safety bus had offsite power after 7:04 hrs. The second safety bus for each unit was energized from offsite a half day later.

The switchyard suffered substantial damage. In the 500kV switchyard, there was damage to transformers and other components. The condensate systems of both units experienced water hammer as a result of the sudden loss of flow and pressure in the condensate and feed systems. Immediately following the trip of the Unit 2 turbine/ generator, the emergency bus that powers the bearing lift pump was de-energized. This resulted in damage to the main generator bearings.

Wolf Creek: 1/13/12

Restore time: 2:57 hours;
Power: 100%;
LER (482) 2012-001-00, 3/12/2012.

On 01/13/2012 at 14:03 CST, Wolf Creek experienced an unplanned automatic shutdown from full power operation followed by/coincident with a loss of all offsite power.

The initiating event was a failure of a main generator output breaker due to an internal flashover across the "C" phase of the breaker and associated ground fault. Internal particulate contamination has been identified as the cause of the breaker failure.

Although the offsite transmission lines were energized during this event, offsite power was not available to the emergency buses as described below: following the main generator breaker failure, the East 345kV Bus was automatically isolated, resulting in the LOOP to emergency bus NB01. Also, the generator trip resulted in interruption of power to the unit auxiliary transformer (the normal supply to the non-safety related buses), and initiated a fast transfer to the startup transformer, which was powered from offsite sources. The startup transformer de-energized due to relay action, which also locked out the West 345kV bus and its offsite sources. At this time all offsite power to the station was lost, and emergency diesel generators started and powered the emergency buses.

After 2 hours and 57 minutes, offsite power was restored to emergency bus NB01 at 17:00 hours, and the diesel generator powering NB01 was placed in standby. However, the startup transformer remained unavailable. With the main unit off line, the startup transformer is necessary for operation of reactor coolant pumps, therefore, a natural circulation cooldown was initiated with Mode 4 entered on 01/14/2012 at 01:12 CST, and Mode 5 was entered at 0750 CST on 01/14/2012. Only one offsite power source is required in Mode 5.

Emergency bus NB02 remained powered by its diesel generator until 1/15/2012 at 06:26 hrs, at which time the bus was powered by its alternate offsite power supply. The cause of the relay action that de-energized the startup transformer was not determined until after 02/13/2012 when power was again lost to the startup transformer during an attempt to start a reactor coolant pump for troubleshooting. The cause of the relay action was subsequently determined to be a phase-to-phase short circuit between two unused high side current transformer taps. The taps had missing insulation sleeves that apparently were removed and not replaced during previous outage work.

On 03/27/2012 the plant was restarted following completion of repairs to the electrical distribution system.

A.2 Category I-b Events

Three category I-b events occurred in 2016.

Calvert Cliffs Units 1 and 2 04/07/15

Restore time: ~ 47 seconds
Power: 100%, both units
LER: 317-2015-002-00

On April 7, 2015 at 12:39:03 hrs Calvert Cliffs experienced a grid disturbance from a transmission line fault resulting in an undervoltage (approximately an 11% drop) condition at the plant that caused all four Engineered Safety Features (ESF) Buses to trip at about 12:39:43 hrs. Both main units tripped at this time. Unit 1 generator output breakers tripped due to loss of excitation. Excitation was lost when the associated Unit 1 4kV safety buses de-energized resulting in loss of dual auctioneered power feeds to the excitation system. The loss of the Unit 2 Safety busses caused loss of redundant power feeds to the Unit 2 turbine control system, resulting in an immediate turbine trip followed by a trip of the generator output breakers at approximately 12:40:32 hrs. All of the EDGs started and loaded with the exception of 2B EDG which started but tripped due to a failed electronic speed switch in the startup circuitry. Because of the EDG trip, the associated 4kV ESF bus was de-energized for about 20 minutes.

At 12:40:14, the breakers associated with the faulted transmission line opened, and at 12:40:30 hrs the 500 kV switchyard voltage returned to normal levels. The time duration of the degraded voltage condition was about 47 seconds (Loss of Offsite Power event duration = [12:40:30-12:39:43]). After restoration of voltage levels, offsite power was available and approximately 20 minutes later at 12:59 hours the 24 4kV ESF bus was reenergized by manually restoring offsite power from an alternate feeder to the bus.

The 2B EDG started but failed to energize the 24 4 kV ESF bus following the Unit 2 trip. The cause of the failure was a failed speed switch due to a failed integrated circuit (IC) chip. A new speed switch was installed and tested satisfactorily prior to its return to operation. The 2B EDG was inoperable for approximately 29 hours.

The cause of the reactor trip event was determined to be an off-site grid undervoltage condition from a transmission line fault that resulted in an undervoltage condition at the plant with transient under voltage relays actuated on the 4 kV ESF buses. Unit 1 lost field excitation, causing a turbine trip on loss of load and subsequent reactor trip. Unit 2 also experienced a loss of load causing a reactor trip. The plant safety significance of this event was that Calvert Cliffs experienced an undervoltage condition on each unit's safety related 4 kV ESF buses that resulted in automatic actuation of the reactor protection system and the emergency diesel generators to safely shutdown each unit. While Unit 1 equipment performed their required safety functions, the Unit 2 2B diesel generator failed to energize its respective safety bus. Despite this complication, operators were able to effectively perform a safe shutdown of the unit.

The event was classified as Category I.b, “With unit in power operation, startup, hot standby or hot shutdown, there is an actual (total) loss of all offsite power sources to all emergency buses; duration >15 seconds, <30 minutes.”

The root cause of the long transmission system undervoltage condition was failure of a substation breaker to re-open as designed following reclosure after the fault, re-energizing the fault and allowing it to be sustained for 58 seconds. The breaker failed to re-open due to a loose connection in a trip relay auxiliary coil.

Shearon Harris: 10/08/16

Restore time: 16.5 seconds
Power: Cold shutdown, Mode 4
LER (400) 2016-005-00

On October 8, 2016 at 13:10 hours EDT, with the unit in hot shutdown (Mode 4) for a planned refueling outage, the plant experienced undervoltage conditions (68% of nominal) in the switchyard for about 1.5 seconds. This resulted in opening the breakers supplying the 6.9 kV emergency and some non-nuclear safety 6.9 kV buses. Both EDGs started and loaded as designed. At the time of this event, the site was experiencing high winds and rain from hurricane Matthew. The emergency buses were powered from the EDGs until 21:54 hours., Although connection with the grid was physically possible after the undervoltage condition was cleared and the diesels were connected to the busses, (approximately 1.5 seconds plus about 15 seconds for the diesels to start and load or 16.5 seconds), the grid was not declared stable by the Energy Control Center and verified by the operating staff until 2033 hours. Offsite power was not connected to the emergency buses for (20:33-13:10) 7:23 hours. The LOOP duration time was 16.5 seconds.

A fault occurred on the Cape Fear 230 kV line due to a fallen tree. Existing malfunctions of substation relays resulted in delayed clearing of the line fault, and the subsequent decrease in grid voltage at the plant for approximately 1.5 seconds. This resulted in opening several 6.9 kV supply breakers due to actuation of undervoltage relays. Plant systems functioned as designed to mitigate the event.

H. B. Robinson Unit 2: 10/08/16

Restore time: 19.7 seconds
Power: 100%
LER (261) 2016-005-01

On October 8, 2016 at 13:02 hours EDT, with the unit at 100% power, a severe voltage depression occurred in the HBRSEP2 switchyard during hurricane Matthew. The undervoltage condition existed in the 4kV emergency busses, causing an automatic reactor trip and starting and loading of the EDGs. The apparent cause of the voltage depression and resultant LOOP was a failed relay in the phase-to-phase portion of the line trip circuitry, which prevented the grid fault from being immediately isolated in the HBRSEP2 switchyard.

The reactor trip was initiated by the 4160 volt buses undervoltage relays. The voltage depression was caused by a fault on the Robinson-Rockingham 230kV transmission line that was not immediately isolated due to a failed fault detector (50L) relay in the HBRSEP2 switchyard relay building. Failure of the 50L relay prevented the transmission of a trip signal to the Rockingham 230kV line circuit breakers in the HBRSEP2 switchyard. The reduced voltage was then transferred to all of the HBRSEP2 auxiliary electrical buses, including the 4kV buses.

After grid stability was achieved and confirmed by plant personnel at approximately 23:23 hours, plant operations personnel commenced restoration of offsite power to the emergency buses to allow shutdown of the EDGs. The LOOP duration was about 19.7 seconds (4.7 seconds plus about 15 seconds for the diesels to start and load) making the emergency busses available for connection to the grid. However, the connection to the grid was not initiated until 23:23 hours because of uncertainty regarding grid stability.

St. Lucie Unit 1: 8/21/16

Restore Time: 0.42 hours
Power: 38%
LER (335) 2016-003-00

On August 21, 2016 at 19:26 hours, with the unit at 38% power during power ascension testing an actuation of the Main Generator Inadvertent Energization Lockout relay caused a generator trip and reactor trip. The lockout blocked automatic transfer of the emergency buses to the startup transformers resulting in a LOOP. Diesel generators started and assumed the emergency bus loads.

Because of the LOOP condition, the four reactor coolant pumps were de-energized resulting in natural circulation for decay heat removal with auxiliary feedwater and atmospheric steam dumps.

During the event, offsite power was available to the switchyard. At 20:21 hours offsite power was restored to the unit. Offsite power was restored in about 55 minutes, however operations staff indicated they were in a position to restore offsite power at approximately 25 minutes into the event but conservatively delayed restoration.

The cause of the lockout initiation was a latent error introduced during a 2013 design modification. A wire for the inadvertent energization lockout relay reset circuit was incorrectly removed, allowing the relay to remain energized and undetected following manual synchronization to the grid.

Wolf Creek: 08/19/09

Restore time: 55 sec.
Power: 100%;
LER (482) 09-002, 10/17/09.

On 08/19/09 the Wolf Creek Nuclear unit experienced a momentary loss of all offsite power (~ 55 seconds) and a main unit trip. The suspected initiating cause was a lightning strike that caused a transient ground fault on one of the three 345kV transmission lines that terminate at Wolf Creek. During the fault, which cleared the first 345kV line, a carrier signal system failed on the second 345kV line and caused the distance relays to extend their reach and open the second 345kV line and left Wolf Creek connected to the grid on the last remaining line. This had always been understood to be an unstable unit condition and resulted in the remote relays tripping the last remaining line due to three-phase instability. This resulted in the momentary LOOP and a main unit trip because of the loss of load. Within one minute, the 345kV switchyard was reenergized by reclosing one of the 345kV lines. The input from the remaining two lines was restored minutes later. Any one of the plant's three 345kV lines can supply all safeguard loads.

Both EDGs started and reenergized their safety buses at the time of the momentary interruption. While offsite power was again available in less than a minute, if needed, the plant remained on the EDGs until more urgent recovery steps were completed and an appropriate moment became available for switching back to offsite power. This occurred several hours after the interruption.

A.3 Category I.c Events

No category I.c events occurred in 2016.

River Bend: 09/01/08

Power: Shutdown;
LER: None.
NRC Significant Event No. 44457

At 18:02 on 09/01/08, the River Bend unit was taken off-line due to the potential for grid instability in the area due to Hurricane Gustav and because of the reduced need for power. Offsite power was declared inoperable at 15:20 based on grid status notification by the grid operator. The plant remained connected to the grid and the EDGs were never needed and were never started or loaded. More than 70% of the turbine building siding was blown off by high winds. A piece of siding landed on the main transformer, with some of it on a transformer bushing.

The River Bend unit was returned to service at 07:52 on 9/23/08.

Sequoyah 1 and 2: 04/27/11

Unit 1 – Power: 100%
Unit 2 - Power: 92%;
NRC Significant Event No. 46797, 04/27/11

At 19:29 on 04/27/11, both of the AC power sources to Sequoyah Unit 1 and Unit 2 were declared inoperable due to the effects of severe storms on the TVA transmission system. This determination was made after a review of grid conditions confirmed that pre-analyzed grid/offsite power requirements could not be met. Although offsite power did not meet pre-analyzed requirements, the offsite sources remained connected to Sequoyah and Unit 1 remained at 100% output and Unit 2 at 92%. During this precautionary declaration, neither unit's EDGs ran or were required to run. The precautionary condition existed for 5 hours and 50 minutes.

A.4 Category II Events

Eight category II events occurred in 2016.

ANO Units 1 and 2: 12/09/13

Restore time: 30:37 hours;
Power: 100%;
LER (313) 2013/004/00, 2/5/2014.

On 12/09/2013 at approximately 07:47 CST, with the unit at 100% power, ANO-2 experienced an electrical fault on the Unit Auxiliary Transformer buses, resulting in catastrophic failure of the transformer and fire. This event caused a reactor and turbine trip, loss of one source of offsite power by lockout of the switchyard auto transformer which provides one source of offsite power to both ANO Unit 1 and ANO Unit 2.

ANO 1 continued operation at about 100% power during the event, with power supplied from the unit's auxiliary transformer, and one offsite source available. The second offsite source was restored at 14:24 hrs on 12/10/2013.

The loss of one of the two offsite sources for ANO 2 resulted in an auto-start of one EDG which then supplied one safety bus. The event also resulted in loss of reactor coolant pumps and circulating water pumps, necessitating a natural circulation cooldown with emergency feedwater system actuation and steam generator dump to atmosphere. The fire was extinguished about 1 ½ hours following the initial event. The plant was cooled down to Mode 5 at about 05:23 hrs on 12/10/2013. The second offsite source was restored at 14:24 hrs on 12/10/2013, and the diesel generator was secured. The duration for the loss of one offsite power source was approximately 30:37 hours.

A root-cause evaluation determined that a flexible link for the Unit Auxiliary Transformer was not properly installed which led to an insulation breakdown at a bolted connection. The subsequent explosion and fire resulted from a non-landed wire due to a human performance error most likely occurring in 1996 that failed to connect the DC conductor to the output contacts for the associated protective relays. The relays, designed to isolate the bus from an electrical fault actuated but because of the disconnected lead, the Main Generator lockout relays failed to actuate, leading the Auxiliary Transformer failure.

ANO Unit 2: 03/31/13

Restore time: 42:04 hours;
Power: 100%;
LER (313) 2013-001-01, 8/22/2013.

At approximately 07:50 hrs on 03/31/2013 with Arkansas Nuclear One Unit 1 (ANO 1) in MODE 6 (refueling) and Unit 2 (ANO 2) in MODE 1 at approximately 100% power, during lifting and removal of the ANO 1 original Main Generator Stator, the temporary lift assembly collapsed due to failure of one of the structural columns. This resulted in the stator falling onto the turbine deck and rolling down into the ANO 1 train bay adjacent to ANO 2; causing one fatality, multiple injuries, structural damage to the turbine buildings, electrical equipment and non-vital systems. Vibration from the dropped stator resulted in actuation of relays in the ANO 2

switchgear located adjacent to the train bay, subsequently tripping a reactor coolant pump (RCP) motor breaker and initiating a reactor trip. The initial plant response to the trip was normal; however, at 09:23 hrs on 03/31/2013, water from a ruptured firewater pipe migrated into a Startup Transformer 4.1 kV feeder breaker cubicle, resulting in an electrical short and Startup Transformer lockout. The downstream bus was de-energized as designed, which, in turn de-energized one of two 4.1kV safety buses. The associated diesel generator automatically started and connected to the safety bus. The second safety bus supply was transferred to the second offsite power source. With the loss of the Startup Transformer, the remaining RCPs were lost resulting in the need to commence a natural circulation cooldown of ANO 2 using the atmospheric dump valves to remove heat from the steam generators. ANO 2 achieved cold shutdown on 04/03/2013. The safety bus was reenergized from offsite power at 03:27 hrs on 04/02/2013.

Browns Ferry Unit 1: April 22, 2016

Power: 100%
LER 259-2016-001, 6/21/2016

On April 22, 2016, at 13:58 CDT, during the transfer of 4kV Shutdown Bus 2 from the Alternate to Normal supply, the Normal Feeder Breaker failed to close when the Alternate Feeder Breaker was manually tripped. 4kV Shutdown Bus 2 de-energized, resulting in the loss of 1B and 2B Reactor Protection System (RPS) as well as Steam Jet Air Ejector 1B. EDG C and D started, but did not tie to the 4kV Shutdown Boards due to operations personnel immediately re-closing the Alternate feeder breaker and re-energizing 4kV Shutdown Bus 2. Invalid actuations of several Containment Isolation Valves also occurred during this event due to the loss of RPS. At 15:30 CDT, EDG C and D were shut down.

The cause of this event was loose wires terminated with spade connectors in the closing control circuit for the normal feeder breaker due to work in the vicinity of the control circuit termination points. Corrective actions were to terminate the loose wires, using a ring type lug instead of a forked spade type lug in the closing control circuit for the normal feeder breaker and verification of successful transfer of Shutdown Bus 2 from the alternate to normal supply.

Byron 1: 02/28/12

Restore time: 4:24 hours;
LERs 454/2012-001-00 and - 01, 09/28/2012.

The Byron Unit 1 electrical system consists of four non-safety-related 6.9(kV buses, two non-safety-related 4.16kV buses, and two 4.16kV engineered safety features (ESF) buses. The two 4.16kV ESF buses and two of the non-safety-related 6.9kV station buses normally are supplied by one of the two station auxiliary transformers (SATs) connected through one 345kV offsite circuit. The remaining two non-safety-related 6.9kV station buses and two non-safety-related 4.16kV station buses normally are supplied by one of two unit auxiliary transformers (UATs) when the main generator is online. The four reactor coolant pumps (RCPs) are powered from four 6.9kV buses. Each 4.16kV ESF bus has a dedicated standby emergency diesel generator.

On 02/28/2012 at approximately 17:30 hrs, Byron Unit 1 experienced a failure of an underhung porcelain insulator in the switchyard on one phase of the 345kV supply connecting to the system auxiliary transformers (SAT). The failure caused one phase to open and a short.

In this event, an insulator failed on one phase of the common feed to the SATs. Because the two SATs have a common feed from the switchyard, both became de-energized resulting in the loss of the offsite power supply to the safety buses. The 1B EDG was running as part of a planned monthly surveillance and the 1A EDG started and the EDGs loaded and re-energized the ESF buses. At 21:54 hours, 4:24 hours after the event began, the ESF buses were cross-tied to the Unit 2 ESF buses and the EDGs were shutdown. The reserve offsite power source, via the Unit 2 SAT was operable and available during this event. Unit 1 remained at full power throughout this event. Unit 2 was at full power during this event. On 02/29/2012 at 18:17, switchyard repairs were completed and the normal offsite power source to Unit 1 was restored.

Calvert Cliffs 1 and 2: 02/18/10

Unit 1 – Power: 92.8%; LER (317) 10-001, 04/15/10;
Unit 2 – Power: 99.5%; LER (318) 10-001, 04/15/10.

On 02/18/10 both Unit 1 and Unit 2 experienced a partial loss of offsite power and both units tripped off-line. Unit 1 tripped from a power output of 92.8% and Unit 2 from 99.5% Each unit lost offsite power to one of its two safety buses while on each unit the other safety bus continued to be powered from offsite.

The initiating causes of this upset were a ground fault in the 13kV feed to one of Unit 1's reactor coolant pumps, and in addition, a ground protection relay for this feed failed to operate. As a result, the faulted feed to this pump was not isolated as it should have been and backup relaying activated that de-energized a wide scope of equipment.

All plant power for Units 1 and 2 comes from two 500kV to 13kV Service Transformers. The plant loads for Unit 1 and Unit 2 are divided strategically between these two transformers. For example, one of the safety buses on each unit is normally fed from one of the Service Transformers and the other safety bus from the other Service Transformer.

In this event, the failure of Unit 1's faulted reactor pump circuit to open caused one of the two 500kV to 13kV Service Transformers to isolate in order to clear the fault. This removed offsite power from one of each unit's two safety buses. It also removed power from reactor coolant pumps on each unit and caused main unit trips because of low reactor flow.

While offsite power was interrupted to one of each unit's two safety buses at the time of this event, backup offsite power was available and there existed alternate paths for bringing this power to these two buses. These paths could be placed in service by operator-initiated switching.

Calvert Cliffs 1 and 2: 1/31/14

Unit 1 – Power: 100%;
LER (317) 2014-001-00, 3/20/2014;
Unit 2 – Power: 99.5%;
LER (318) 2014-001-00, 3/20/2014

At 21:25 hrs on January 21, 2014, Unit 2 tripped from 99.5% when 13kV Service Bus 21 de-energized due to a ground fault, causing a of loss power to non-safety related buses and loss of circulating water pumps and loss of condenser vacuum. Power was also lost to 4.1kV safety-related Bus 24 causing an automatic start of the associated diesel generator to power the bus. Offsite power was restored to safety-related 4.1kV bus 24 at 23:23 hrs. Offsite power was unavailable to the bus for 1:58 hours.

The loss of power to 13kV Service Bus 21 was caused by water intrusion when an air filter assembly located at the back of an outdoor associated breaker cubicle became dislodged during a snow storm, allowing snow to enter the cubicle, melt, and cause a ground fault. The root cause was determined to be the outdoor 13kV metal clad switchgear louver and filter configuration did not provide adequate protection against weather related water intrusion as the weather condition was not anticipated. A new filter housing with additional bracing support was fabricated and installed on the breaker cubicle.

Before the event, 13kV Bus 21 was also supplying Unit 1 4kV Bus 14. The loss of power to this bus caused an automatic start of the 1B Diesel Generator to repower the bus. When the bus 14 was repowered, the resultant voltage spike caused the main turbine controls to re-boot. This initiated turbine control valve closure further resulting in a reactor trip on high reactor coolant system pressure at 21:25 hrs on January 21, 2014. Offsite power was restored to safety-related Bus 14 at 22:30. Offsite power was unavailable to Bus 14 for 1:05 hours.

Clinton: 03/30/16

99% Power
LER 461-2016-004-00, 5/27/2016

On March 30, 2016, at 15:45 CDT, the Emergency Reserve Auxiliary Transformer (ERAT) Static VAR Compensator (SVC) tripped when the associated 138 kV line circuit breakers cycled open and re-closed due to a voltage transient most likely caused by a lightning strike. Operations staff entered Clinton procedures for Loss of AC, and Automatic Isolation, and Technical Specification (TS) Limiting Condition for Operation (LCO) 3.8.1, AC Sources — Operating, Required Actions A.1 and A.2.

The ERAT SVC tripped due to a momentary loss of substation feed when the 138kV line circuit breakers cycled open and re-closed. The breaker cycling was due to a voltage transient most likely caused by a lightning strike. During the event, the ERAT relay scheme worked as designed and ERAT circuit switcher remained closed allowing the ERAT transformer to re-energize when the 138 kV line breakers re-closed. No equipment failures or malfunctions were experienced during this event; however the secondary containment isolation dampers closed due to the momentary loss of power. This resulted in the secondary containment vacuum exceeding 0 inches water gauge.

The ERAT SVC was restored at 19:26 and TS LCO 3.8.1 Required Actions A.1 and A.2 were exited.

Clinton requires the ERAT SVC to be functioning properly for the 138kV line (ERAT) feed to be an operable offsite power source. The Tech Spec for an inoperable offsite power source was entered at 1545 and exited at 1926 for a total inoperable period of 3 hours and 41 minutes.

Clinton: 04/02/16

Power: 99%;
LER (461) 2016-005-00, 5/31/2016

On April 2, 2016 at approximately 12:57 hours, the Reserve Auxiliary Transformer (RAT) and associated Static VAR Compensator tripped due to a failure of the "A" phase insulator for the RAT 345 kV circuit switcher in the switchyard. The supply to the safety busses was automatically transferred to the Emergency Reserve Auxiliary Transformer (ERAT). This constituted a reduction in offsite power paths to the safety busses from two to one.

The unit continued to operate at 99% power. There was a voltage transient caused by the automatic transfer of the buses from the RAT to the ERAT which affected several plant systems, including secondary containment ventilation, main control room ventilation, and some radiation monitors.

The RAT was successfully returned to service following replacement of the broken 345 kV insulator associated with the circuit switcher. The insulator failed due to a manufacturing defect, although there were high winds in the vicinity at the time and the configuration of the bus bar connection to the insulator was susceptible to wind-induced loads.

Diablo Canyon 1 and 2: 05/12/07

Power: Unit 1: 0%, shutdown for refueling; Category IV.a
Unit 2:100 % ; Category II
LER (275) 07-001, 07/11/07.

On May 12, 2007 at 10:25, with Diablo Canyon Unit 1 shutdown and the reactor defueled, and Unit 2 at 100% power, 230kV startup power for both units was lost due to an offsite transmission system insulator failure and an unanticipated protective relay response. Unit 2 remained at 100% power. During normal operation, the 4.16kV vital buses for each unit are powered from the unit auxiliary power system. The 230kV transmission system provides offsite power for each unit's startup, shutdown; emergencies and other times when the unit auxiliary sources are not available.

Unit 1 EDGs 1-1 and 1-2 started and loaded because alternate power from the normal Unit 1 source was not available due to scheduled maintenance underway on the 500kV main output transformers. Unit 2's EDGs started but did not load since its vital buses remained energized from their normal source.

The 230kV offsite power source was reenergized 1:02 hrs after the fault occurred and offsite power to Unit 2 was restored 0:14 hrs after this for a total loss of the standby 230kV offsite source of about 1:16 hrs. The Standby 230kV offsite power was also available to Unit 1 at about this time, however because the unit was shutdown for refueling, final switching was carried out later at a more convenient moment in the overall recovery effort.

For Unit 1, this was a Category IV event because the plant was in a shutdown condition.

For Unit 2 this was a Category II event wherein the startup/shutdown source of offsite power for all safety buses became de-energized but the main generator remained on-line and normal and the second source of offsite power for the safety buses is available from a unit auxiliary transformer.

Diablo Canyon 1: 05/17/11, 05/26/11, 05/27/11

Power: 100%;
LER (275) 11-004, 06/30/11 and (275) 11-005, 11/08/11.

At most plants, the safety buses are powered from one or several startup transformers that receive their power from the offsite grid. If the main unit trips, the safety buses will continue to be powered from offsite sources. At a fewer number of plants, the safety buses are normally powered from a unit auxiliary transformer that receives its power from the main generator output. If the main unit trips, the safety buses automatically transfer to startup sources that receive their offsite power from the grid.

In the three occurrences that comprise this entry, offsite power was unavailable to the safety buses for the indicated period. Work was being performed during a refueling outage for Unit 2. The work being performed resulted in a loss of offsite power to Unit 1, which was at 100% power and supplied power to its emergency buses. Diesel generators started and were available to assume vital loads if required.

Date – Duration (hr:min)	Cause
05/17/11 – 1:31	Vibration during work on a relay panel caused a relay to actuate and open a breaker to a 12kV startup bus.
05/26/11 – 14:44	Test equipment was misconnected. Diagnosis of the problem required an extensive and time-consuming effort.
05/27/11 – 1:25	Test equipment was misconnected.

Diablo Canyon Units 1 and 2: 06/23/13

Restore Time: 5:40 hours;
Power: 100%:
LER (323) 2013/003/00, 8/22/2013.

On 06/23/2013 with both units 1 and 2 at 100% power, the 230kV offsite power source was lost at 20:20 hrs due to an offsite transmission relay actuation. This resulted in a valid anticipatory start of all six EDGs, three per unit. Although available for loading, the EDGs did not load onto the associated vital buses because the buses remained energized by unit auxiliary power. The EDGs were restored to standby service later on 06/23/2013, and the 230kV system was restored and declared operable at 02:00 hrs on 06/24/2013. Heavy fog and precipitation caused several insulator flashovers at an offsite switchyard (Morro Bay Power Plant), resulting in a sustained loss of key transmission facilities including the loss of the 230kV offsite power source to Diablo Canyon.

Diablo Canyon Unit 1: 8/15/13

Restore time: 47:46 hours;
Power: 100%;
LER 275/2013/006/00, 10/14/2013.

On 08/15/2013 at 18:24 hrs, with Unit No. 1 at 100% power, the Unit 1 230kV offsite power source was lost due to failure of the startup transformer 1-1 load tap changer diverter switch. This resulted in a valid anticipatory start of all three EDGs. Although available for loading, the EDGs did not load onto the associated vital buses because the buses remained energized by unit auxiliary power. The EDGs were restored to standby at 19:21 hrs.

A failed bolted connection between a flex link and a stationary contact caused the load tap changer diverter switch to fail. The startup transformer load tap changer was replaced, and testing confirmed that the transformer windings and bushings were not damaged during the event, and that the transformer was no longer degraded. The transformer was placed into service at approximately 18:10 hrs on 08/18/2013. The duration of the startup power source outage was approximately 47:46 hours.

Diablo Canyon Units 1 and 2: 10/31/14

Restore Time: 8:49 hours;
Unit 1 – Power: 100% , Category II
Unit 2 – Power: 0%, cold shutdown; Event of interest
LER 275/2014-004-00, 12/30/14

On October 31, 2014 at 17:40 hours with Unit 1 at 100% power and Unit 2 in cold shutdown, the plant experienced a loss of the 230kV offsite power source due to a flashover of an insulator in the 230kV switchyard during a light rainstorm. This resulted in the valid start of all Unit 1 and Unit 2 emergency diesel generators, three per unit. The emergency diesel generators started, but did not load because all associated buses remained energized by auxiliary power. The 230kV offsite power source was restored and declared operable at 02:29 hours on November 1, 2014.

Corrective actions include revision of insulator preventive maintenance protocols (insulator greasing, washing, etc.).

Farley Unit 1: 6/11/13

Power: 100%;
LER (348) 2013/001/00, 8/8/2013;

NRC Event Report No. 49106, “Unit 1 Automatic Reactor Trip Due to the Loss of a Start-Up Transformer,” 06/12/2013.

At 21:05 hours on 06/11/2013 with Farley Unit 1 operating at 100%, the Unit 1 B-Train Startup Transformer was automatically de-energized by protective relay actuation. This resulted in a B-Train Engineered Safety Bus Loss of Offsite power. The associated diesel generator automatically started and reenergized the B train ESF buses, and the associated loss of offsite power loads started. The loss of the transformer also resulted in loss of power to the 1B and 1C reactor coolant pump buses and an automatic reactor trip.

The A-train ESF buses remained energized from an operable offsite power source via the 1A Startup Transformer throughout the event.

Investigation of the event determined that the lightning arrester on the phase 2 230kV terminal of the 1B startup transformer had shorted to ground resulting in protective relay actuation which opened the switchyard supply breakers to the startup transformer.

All three lightening arresters on the 1B Startup Transformer were replaced and the transformer was returned to service, supplying the B-Train ESF buses on 06/13/2013 at 04:29 hours. Offsite power was unavailable to the B-Train ESF buses for 31:24 hours.

Farley Unit 2: 10/14/14

Power: 82%;
LER (364) 2014-002-00, 12/12/2014.

At 03:41 on October 14, 2014 Unit 2 was manually tripped due to a loss of component cooling water (CCW) to the reactor coolant pumps. The events leading to the loss of component cooling water were:

- The train 2B EDG was out of service for a planned maintenance outage.
- A lightning strike caused a phase to ground fault on a 500kV transmission line.
- The fault resulted in de-energizing of the 2B Startup Auxiliary Transformer and loss of the power to the B train. The 2B Startup Auxiliary Transformer was de-energized by instantaneous overcurrent relay actuation sensed by a current transformer associated with a power circuit breaker that supplied the Startup Auxiliary Transformer. The current transformer had a loose termination due to a missing 5/16" nut. The root cause of this event was determined to be inadequate verification practices during the wiring installation that led to a nut not being installed on the terminal.
- With the associated diesel generator unavailable and loss of power from the Startup Auxiliary Transformer, the B train was unable to provide power to the component cooling water pumps that were supplying the reactor coolant pumps. In accordance with the Abnormal Operating Procedures for loss of CCW and loss of electrical power were entered and the reactor was manually tripped and the reactor coolant pumps were secured.
- Power was restored to the B train at 05:23, for an outage duration of 1:42 hours.

Fermi 2: 06/06/10

Power: 100%;
LER (341) 10-002, 08/03/10.

On 06/06/10, Fermi 2 experienced a partial loss of offsite power and tripped offline from full power. Two of the unit's four safety buses lost offsite power while the other two safety buses continued to be powered from offsite. Their EDGs repowered the two safety buses that lost offsite power.

The initiating cause of this event was severe weather that caused failure of the two 345kV lines that connect the Fermi generator to the grid. The National Weather Service identified a tornado in the Fermi area when power was lost. With no path for its output, the main generator tripped off. These two 345kV lines are also a source of power for two of the unit's four safety buses, hence the loss of offsite power to these two safety buses.

Fermi also has three 120kV supply lines. These lines serve as an additional source of power for plant loads and normally power the other two of the four safety buses. Two of these 120kV lines were also lost due to the storm. However, one of the 120kV lines remained in service and powered the two safety buses that depend on the 120kV source.

This was a severe storm and caused some damage to the plant's buildings and structures. All plant equipment operated as designed during the event.

Fermi 2: 09/14/12

Restore time: 03:27 hours;
Power: 68%;
LER (341)2012-005-00, 11/05/2012.

With the unit at 68% power, a fault occurred on the 13.2kV side of 120kV Transformer 1 at approximately 16:03 hrs. This caused a loss of emergency buses 64B and 64C and balance of plant bus 64A, and resulted in a reactor trip. Diesel generators automatically started and loaded the emergency buses and isolations and actuations occurred as expected.

The cause of the fault was determined to be animal (bird) intrusion that initiated a ground fault at the Z-phase surge arrestor on the secondary side of Transformer 1. The surge arrestor and associated jumpers were replaced.

Offsite power was restored to the buses at 21:22 hours on 9/14/2012, for an offsite power outage duration of 5:19 hours. Power was restored to the switchyard on 9/16/2012 at 00:08 hours.

Ginna: 06/03/12

Power: 100%;
LER (244) 2012-001-00, 07/26/2012.

With the unit at full power at 02:39 hrs, offsite Power Circuit 767 and safeguards Buses 16 and 17 were de-energized due to a fault caused by wildlife (raccoon) intrusion. The associated emergency diesel generator started and reenergized the safeguards buses. Offsite power from the second offsite source remained available, and was connected to the safeguards buses at 03:18 hrs and the diesel generator was subsequently shut down. The offsite power outage duration was about 39 minutes.

Ginna: 02/11/16

Power: 100%
LER (244) 2016-001-00

On February 11, 2016 at 23:05 hours with the plant at 100% power, Station Auxiliary Transformer 12A was lost due to an internal fault. Prior to the event, the offsite electrical system was in the normal mode with each of the two off-site circuits providing power to two of the four 480 V safeguards buses via the two station auxiliary transformers. The fault rendered one of the two off-site power paths to the safeguards busses inoperable. At the time of the event, EDG A started and assumed its safeguards bus loads.

At 00:32 hours on February 12, Station Auxiliary Transformer 12A was removed from service and off-site power provided to the affected busses via the remaining off-site source and Station Auxiliary Transformer 12B. Off-site power was unavailable to the affected buses for 1:27 hours.

EDG A was secured at 00:53 hours on February 12. The faulted transformer was replaced and re-energized and the normal off-site power lineup restored at 00:18 hours on February 20, 2016.

The cause of the transformer failure was determined to be a high side internal fault on one phase. The failed transformer had been in service for 46 years.

Monticello: 09/11/08 and 09/17/08

09/11/08 – Power: 100%; Category II
LER (263) 08-005, 11/10/08;
09/17/08 – Power: 0%; Event of interest
LER (263) 08-006, 11/14/08.

On the above two dates, two similar partial loss of offsite power events occurred. The plant has three transformers that can power the plant's safety buses. All three have adequate capacity to power all safe shutdown loads. The three transformers are:

- Primary Station Auxiliary Transformer 2R. It is fed from a 345kV source.
- Reserve Transformer 1R. It is fed from a 115kV source.
- Reserve Auxiliary Transformer 1AR. It is fed from two separate 13.8kV sources.

On 09/11/08 while the plant was operating at 100% power with transformer 1R out of service for planned maintenance, transformer 2R tripped open because of a fault in its incoming cable. A main unit trip occurred and the safety buses were automatically repowered from transformer 1AR. Both EDGs started but did not need to load.

On 09/17/08 the plant was still shutdown for recovery from the transformer loss on 09/11/08 and transformer 2R was still out of service with the safety buses being powered from transformer 1R. While in this configuration a man-lift came in contact with a 115kV line which de-energized transformer 1R. Again, transformer 1AR was available to power the safety buses, however the relaying is such that in these particular circumstances the EDGs automatically start and load, with transformer 1AR providing a backup offsite source.

Nine Mile Point Unit 2: 10/29/12

Power: 100%;
LER (410) 2012-005-00, 12/21/2012.

With Nine Mile Point (NMP) Unit 2 at 100% power, a loss of one source of offsite power occurred on 10/29/2012 at 21:00 hours. Line 5, the 115kV offsite power source for Division I was de-energized due to a faulted condition when high winds associated with hurricane Sandy caused a lightning mast to fall in close proximity to the Scriba substation bus supplying the line. The Division I diesel generator actuated automatically in response to the loss of offsite power. The unit continued to operate at 100% throughout the event, and Line 5 was restored at 03:26 hours on 10/30/2012. The diesel generator was secured at 04:47 hours on 10/30/3012. The duration of the offsite power outage was 6:26 hrs.

The Scriba substation faulted condition also contributed to a trip of NMP Unit 1 from 100% power. A polarity wiring error within the generator step up transformer neutral ground current transformers also contributed to the event. However, the unit trip response was not complicated, and offsite power was available to the unit.

Nine Mile Point Unit 2: 2/16/14

Power: 100%;
LER (410) 2014-001-00, 4/7/2014.

On February 16, 2014 at 12:16 hrs, a loss of one of two offsite power sources (Line 5) resulted in actuation of two EDGs and assumption of associated safety-related loads. The safety-related loads are normally supplied by the offsite power sources. The unit was at 100% power during the event.

The loss of offsite power Line 5 was due to a fault and fire on a National Grid current transformer associated with a breaker on the line. Line 5 was restored to operable status at 16:28 on February 17, 2014.

North Anna 1 and 2: 12/09/09

Unit 1 – Power: 100%;
Unit 2 – Power: 97%
LER (338) 09-004, 02/03/10.

On 12/09/09 both North Anna Unit 1 and Unit 2 experienced a partial loss of offsite power and Unit 2 tripped off-line. At the time of the event, Unit 1 was operating at 100% power and Unit 2 at 97%. The event was initiated by the inadvertent opening of a switchyard breaker during the testing of protective relay circuitry. The opening of this breaker removed offsite power to the "C" Reserve Station Service Transformer (RSST). Both North Anna Unit 1 and Unit 2 each have two emergency buses. At the time of this event, the "C" RSST was powering one of the two emergency buses on each unit. The other emergency bus on each unit was being powered by an RSST that was unaffected by this event, and these did not lose offsite power. When offsite power was lost to the one of two emergency buses on each unit, their EDGs started and repowered these buses. Offsite power remained and was at all times available for each unit's non-affected emergency bus.

The de-energization of the "C" RSST and loss of offsite power to one of its two emergency buses was not the direct cause of Unit 2 tripping off-line. These losses by themselves would not cause a main unit trip. The unit trip was caused by a secondary problem. A fast-transfer relay should have automatically transferred the Unit 2 circulating water pump loads from the "C" RSST to the "B" RSST when under-voltage occurred. However, the fast transfer breaker did not close prior to an under-voltage relay lockout operation because the under-voltage relay's timer was mis-calibrated. The loss of these pumps resulted in a loss of condenser vacuum and this caused the automatic turbine and reactor trips.

North Anna 2: 05/28/10

Power: 100%;
LER (339) 10-002, 07/26/10.

On 05/28/10, North Anna 2 experienced a partial loss of offsite power and main unit trip from full power. One of the unit's two safety buses lost offsite power at a time that its EDG was out of service for planned maintenance.

The initiating cause of this event was a lightning strike in the high voltage switchyard which caused a differential relay actuation. This resulted in the de-energization of various transformers and buses including the above referenced safety bus.

The loss of power to the safety bus resulted in a complex sequence of events that improperly caused the standby main feedwater pump to auto start. This auto start resulted in a voltage dip and series of interactions that caused a reactor coolant pump to shutdown.

This in turn caused the reactor and hence main unit to trip. Post-event analysis showed that the main unit trip was caused by specified undervoltage relay setpoints for the safety buses and reactor coolant pumps that did not properly coordinate.

North Anna Units 1 and 2: 5/15/14

Power: 100% for both units;
LER (338) 2014-001-00, 7/14/2014.

At 19:20 on May 15, 2014 with both units at 100% power, the load side of switchyard transformer No. 3 experienced a fault, causing a loss of the "C" Reserve Station Service Transformer (RSST). The cause of the event was a crow making contact with Bus No. 5 "A" phase to ground. The loss of the "C" RSST caused offsite power losses to Unit 1 "H" emergency bus and Unit 2 "J" emergency bus. The associated diesel generators automatically started and reenergized the emergency buses. At 20:46 on May 15, emergency bus 1H offsite power was restored for a loss of offsite power event duration of 1:26 hours. At 04:10 on May 16, the "C" RSST was energized and normal offsite power was restored to emergency bus 2J for a loss of offsite power duration of 8:30 hours. Both units continued to operate at power during the event, although Unit 2 power was reduced to 96% because of moisture separator reheater flow control valves closing. The valves were re-opened after the RSST was re-energized, and power returned to approximately 100%.

North Anna Units 1 and 2: 01/23/16

Power: 100% for both units
LER (338) 2016-001-00

On January 23, 2016 at approximately 17:03 hours and Units 1 and 2 at 100% power, the 34.5 kV offsite feed to the "C" Reserve Station Service Transformer was lost due to the inadvertent opening of the switchyard supply breaker L102. This resulted in loss of power to one emergency bus on each unit (1H and 2J), and the automatic start and load of the associated diesel generators.

The 1H bus was promptly switched to the alternate supply from the 1B Station Service Transformer and the associated diesel generator shut down. The 2J bus remained energized by its associated diesel generator until the "C" Reserve Station Service Transformer was re-energized at 15:28 hours on January 24, 2016. The 2J diesel generator was secured at 15:41 hours.

The cause for the opening of the L102 breaker was failure due to moisture on the internal switch contact for SF_6 gas pressure. Snow and moisture intrusion was present inside the cabinet. The pressure switch was replaced and weather sealant applied to prevent moisture intrusion in the most likely intrusion areas.

North Anna Unit 1: 04/29/16

Power: 100%
LER (338) 2016-003-00

On April 29, 2016 at approximately 22:14 hours, with the Unit at 100% power, a fault occurred on the Switchyard Transformer 3 34.5 kV leads which resulted in 34.5 kV bus to lock out and loss of offsite power to the "A" Reserve Station Service Transformer. This resulted in loss of the "J" Emergency Bus and the automatic start and load of the associated diesel generator. The emergency bus was transferred to its alternate supply (2B Station Service) and the diesel generator was secured.

The cause of the fault was wildlife (raccoon) contacting the load side leads of Switchyard Transformer 3. Post-incident inspection and testing of Transformer 3 and Bus 5 were completed satisfactorily and the transformer and bus were subsequently returned to service.

Oconee 3: 12/07/15

Power: 100%
LER 287-2015-002-00.

On December 7, 2015 at approximately 08:20, with Unit 3 at 100% power, a severed conductor was discovered during an inspection of the Unit 3 startup transformer conductors in accordance with INPO IER L2-12-14. The severed conductor ran between the overhead 230 kV switchyard power line and the CT-3 unit startup transformer. This condition resulted in the normal offsite power source, the 230 kV switchyard unavailable to CT-3, as well as an emergency power source path from the Keowee Hydro Station via the 230 kV switchyard and CT-3 unavailable. However, offsite power remained available via the Unit 2 startup transformer and from the Lee Combustion Turbine via the CT-5 transformer.

This event has been classified as a category II LOOP: “With the unit in power operation, startup, hot standby, or hot shutdown, an actual loss of power source(s) available to all emergency buses such that loss of an additional power source will result in a Category I LOOP.”

Before the CT- 3 inspection, at 0500 on December 7, the Unit 3 Keowee (underground) path to the Unit 3 emergency buses was declared inoperable for planned maintenance. The path was considered inoperable because one of the two license-required supply breakers was tagged out. The breaker tag-out process had commenced, and the automatic function of one of these supply breakers was placed in manual, but the tag-out was not complete and no physical work had been performed. Although the second breaker remained operable, the license required two breakers for this path. With the loss of the path through the startup transformer, CT- 3, the emergency busses did not have a technically operable emergency power path. The tag out was stopped and the underground path to the Unit 3 emergency buses was restored. The duration of the event from the time CT- 3 was known to be inoperable to restoration of the underground path was approximately 21 minutes. The CT-3 startup transformer was returned to service at 07:55 on December 8, 2015 for an outage duration of 24 ½ hours.

The failure of the drop line conductor occurred at the connection point to the transformer bushing and was due to fatigue cracking/shearing. Over the span of the plant's commercial operation, environmental conditions created occurrences of overhead bus line movement which was transmitted to the drop line and created the fatigue loading that caused the failure.

Oyster Creek: 07/23/12

Power: 100%;
LER (219) 2012-001-02, 12/12/2012.

On 07/23/2012 at 03:29 AM, with the unit at 100% power, a reactor trip occurred after all 230kV transmission paths from the station tripped following a single phase to ground fault on one of the three lines. The fault was caused by a tree contacting one transmission line, and the other two 230kV lines tripped on an incorrect directional overcurrent signal. Subsequently, the 34.5 bus feeder (an offsite power source) was overloaded by the Main Generator output. The overloaded line tripped, however the 34.5kV system was available for operator connection immediately following the trip of the Main Generator. The loss of the 230kV lines is considered to be a loss of one offsite power source. Both EDGs automatically started and assumed loads on the safety buses. All safety systems functioned as required. Offsite power was restored at 04:57 am on 07/23/2012. The safeguards buses were not connected to offsite power for 1:28 hours.

The cause of this event was the current transformer used to provide a directional signal for fault indication was incorrectly landed. The root cause was determined to be a failure to adequately maintain configuration and validate the proper functionality of transmission system protective relays following transformer replacement activities in 2010.

Pilgrim: 12/20/2008

Power: 0%;
LER (293) 2008-007, 2/12/2009.

On 12/20/2008 at 10:14 hours with the plant in hot standby (the plant had tripped the previous day due to snow and ice buildup on one of the main generator breaker bushing during a severe winter storm), the switchyard breakers supplying the startup transformer opened interrupting power to the safety busses. The associated diesel generators started and re-energized the safety busses. An offsite source from the 23 kV shutdown transformer remained available during the event, which was classified as a category II LOOP event. (With the unit in power operation, startup, hot standby, or hot shutdown, an actual loss of power source(s) available to all emergency buses such that loss of an additional power source will result in a Category I LOOP.)

The initiating event was a flashover on an arc horn on one phase of the offsite line bus section that caused the associated breaker, ACB 102 to open. The second offsite power source was interrupted due to breaker ACB-103 opening in response to a transfer trip signal caused by an inadequate relay setting on the line 342.

Pilgrim: 10/14/13

Restore Time: 23:02 hours;
Power: 100%;
LER (293) 2013-009-00, 12/13/2013.

On 10/14/2013 at 21:21 hours with the reactor critical at 100% power and one of two 345kV offsite power lines (342) out of service for a scheduled upgrade, a loss of offsite power occurred due to the loss of the second 345kV line (355). The cause of the loss of the second line was failure of an offsite wooden transmission pole. Following the LOOP, the reactor scrammed and EDGs automatically started and supplied power to all 4.16kV buses.

The offsite wooden pole was replaced and line 355 was energized, restoring offsite power to Pilgrim Station at 20:23 hours on October 15, for an outage duration of 23:02 hours.

PNPS is connected to the grid by two 345kV lines connected to a ring bus located within the station’s 345kV switchyard. The ring bus also connects to the main transformer and the startup transformer (SUT). The ring bus design locates the power transmission bus sections such that a failure of any one bus section will not result in the loss of the other bus section. Either of the two 345kV lines is capable of carrying full station output and supplying station loads via the SUT. The alternate offsite 23 kV supply through the shutdown transformer remained available throughout the event, and the station did not experience a complete loss of offsite power.

Pilgrim: 01/27/15

Power: 52%
LER 293-2015-001-00.

On January 25 with the unit at 100% power, the National Weather Service issued a blizzard warning for winter storm Juno. High wind speeds (40 mph with gusts to 50 mph) and heavy snows were forecast. Pilgrim Nuclear Power Station (PNPS) entered its procedures for "Operation During Severe Weather" and "Costal Storm Preparations and Actions" and commenced making preparations for the arrival of the storm. Preparations were completed on January 26.

At 01:32 hours on January 27, 2015 the bus associated with one of the two 345kV offsite transmission lines (355) faulted for the first of five times. A reactor shutdown was commenced at 01:34 hours. EDGs were started and loaded on the safety related busses. At 02:35 hours the Line 355 bus faulted for the final time, leaving PNPS with only one preferred offsite transmission line connected to the grid. At 04:02 hours on January 27 with the reactor at 52% power, the remaining preferred 345kV Line 342 faulted resulting in a generator load rejection and reactor scram. The faulted conditions resulted from flashovers in the PNPS switchyard. The plant entered cold shutdown at 16:26 hours, after some difficulty encountered during the cooldown.

Prior to restoration of offsite power to the switchyard, the switchyard bus insulators and bushings were cleaned of snow and salt contamination to prevent further flashovers. Offsite power was restored to the switchyard and the startup transformer on January 29, 2015 at 16:43 hours. The duration of this loss of preferred offsite power was 60:41 hours.

During this event, power was lost from the 345 kV lines, the preferred offsite supply. This resulted in loss of power to all non-safety related buses. The alternate off-site 23 kV supply through the shutdown transformer remained available throughout the event, and the station did not experience a complete loss of offsite power. The event was classified as Category II: "With the unit in power operation, startup, hot standby, or hot shutdown, an actual loss of power source(s) available to all emergency buses such that loss of an additional power source will result in a Category I LOOP."

The cause of the event however was related to the design of the PNPS switchyard as it does not prevent flashovers when impacted by certain weather conditions experienced during severe winter storms. Corrective action included implementing a switchyard design change to minimize switchyard flashovers during snow storms.

Point Beach Unit 1: 02/06/13

Restore Time: 2:08 hours;
Power: 100%;
LER (266) 2013/001/00, 4/5/2013.

On 02/06/2013 at 11:32 hours, the high voltage station auxiliary transformer high side switcher opened spuriously. This resulted in an undervoltage condition on both safety-related buses; separation of the safety-related buses from offsite power as designed; starting of all four EDGs and automatic loading of the safety-related bus loads.

Offsite power was restored to the safety-related buses from an alternate feed from a redundant offsite power circuit at 13:40 hours. Both Units 1 and 2 continued to operate at 100% throughout the event. Although the offsite power feed to the Unit 1 safety-related buses was interrupted for 2:08 hours, offsite power was continuously available from the alternate feed during this event.

The root cause of the spurious operation of the switcher was found to be the original design of the control logic circuitry lacking robustness to mitigate spurious actuations. Modification of the control logic to remove the spurious actuation has been entered into the corrective action program.

Prairie Island 2: 06/27/11

Power: 100%;
LER (306) 11-003, 08/23/11.

At Prairie Island 2, there are four possible paths between the offsite transmission system and the 4.16kV safety buses. On 06/27/11, a bus phase to ground fault resulted in breaker operations that resulted in a single path from the transmission system to the safety buses. Subsequently, the transmission system operator determined that, due to summer grid conditions, the 345kV grid voltage could not be maintained at the minimum level needed to assure specified safety bus voltage levels and capacities. Eleven hours and twenty eight minutes (11:28) after the bus fault, by shutting down a cooling tower pump and fans, the required minimum transmission system voltage was met and determined to be sustainable. The path to the transmission system was declared operable. Unit 2's EDGs were available but not required to run during the period of inoperability.

River Bend: 09/17/15

Power: 100%
LER 548/2015-009-00

On September 11, 2015 at 04:31 AM with the plant operating at 100% power, an automatic reactor scram occurred due to the loss of power to the reactor protection system (RPS). The RPS power loss was due to cascading effects from a single-phase fault in the local switchyard. The north 230 kV bus (one of the two offsite power supply circuits) failed due to deposition of animal waste. The north bus breakers opened, resulting in a loss of offsite power to the Division 1 safety bus. Two emergency diesel generators started and assumed their safeguards loads. The Division 2 safety bus remained connected and supplied by offsite power. Offsite power was restored to the Division 1 safety bus at 07:30 PM. The outage duration was 14:59 hours.

The plant was placed in cold shutdown pending investigation of the cascading effects from the fault. The fault in itself should not have cascaded into a full reactor scram, but did because the RPS power supply alignment to an alternate power source made the RPS vulnerable to an electrical transient.

This event was classified as Category II: "An actual loss of all offsite power sources supplying an emergency bus or train."

Robinson: 03/28/10

Power: 99.5%;
LER (261) 10-002, 05/27/10.

On 03/28/10 the Robinson unit experienced a partial loss of offsite power and the main unit tripped from a 99.5% power level. The unit lost offsite power to one of its two safety buses while the other safety bus continued to be powered from offsite. The safety bus that lost offsite power was re-energized by its EDG.

From a loss of offsite power perspective, this was not a particularly notable event. Offsite power was at all times available from the grid through the plant's 115kV switchyard via the startup transformer. These kept one safety bus energized from offsite during and following the event. However, this upset has received considerable attention because of operational problems that occurred during or were identified by the incident.

All plant operating power for the Robinson unit comes from two sources. These are the unit auxiliary transformer which is fed from the main generator output and the startup transformer which is fed from the 115kV switchyard. The initiating cause of this event was the failure of a cable that feeds non-vital 4.1kV, Bus 5. The failure occurred where the cable enters Bus 5. When the fault occurred, the power for Bus 5 was coming from the unit auxiliary transformer which in turn is connected to the main generator output. The 4.1kV circuit breaker just upstream of Bus 5 should have opened and cleared the fault. But it did not because its trip circuit power supply was de-energized due to mechanical failure of the fuse that feeds the trip circuit.

As a result, the fault persisted and caused the unit auxiliary transformer to fail. Since the unit auxiliary transformer is fed directly from the main generator output, the main generator and unit auxiliary transformer isolated together to clear the fault and the unit tripped off-line. The unit auxiliary transformer's loads, along with the fault were automatically transferred to the startup transformer. The breaker that was now feeding Bus 5 from the startup transformer sensed the fault and opened, clearing the fault.

Several hours later, when operators were attempting to reset the generator lockout relay, this same breaker was inadvertently sent a signal to reclose. This re-energized the faulted cable and switchgear compartment from the startup transformer and caused additional collateral damage. The fault caused the breaker to re-open.

While this was a complex event, offsite power was at all times available.

South Texas Unit 2: 02/08/13

Restore Time: 2:03 hours,
Power: 100%;
LER (499) 2013-002-00, 3/7/2013.

On 01/08/2013 at 16:40 hours, a fault occurred in the "C" phase of Main Transformer 2A (MT2A). The fault resulted in a main generator lock out, reactor trip, and partial LOOP. The partial LOOP de-energized two of the three safety buses and the associated standby diesel generators started and loaded as designed. Power was also lost to the non-safety related buses that supplied the reactor coolant pumps, resulting in a natural circulation cooldown/decay heat removal situation.

The fault caused a sudden pressure in the transformer tank, rupturing the tank. Spilled oil ignited, causing a fire which was extinguished about 16 minutes later. Offsite power was restored to the safety buses at 18:43 hours and the diesel generators were secured. Power was also restored to the non-safety buses and a reactor coolant pump was started and provided forced coolant circulation. The LOOP time for the safety buses was 2:03 hours, although Unit 1 was operating at 100% power throughout the event and offsite power could have been connected.

Sequoyah 1 and 2: 03/26/09

Unit 1 – Power: 96%;
Unit 2 – Power: 100%;
LER (327) 09-003, 05/22/09.

On 3/26/09 both Sequoyah Unit 1 and Unit 2 tripped off-line and experienced a partial LOOP. At the time of the event, Unit 1 was operating at 96% power and Unit 2 at 100%. The underlying cause of this event was a fault on the output bus (6.9kV) of common station service transformer (CSST) D. The 161kV source that feeds CSST D also feeds CSST C, hence when CSST D was isolated to clear the fault, CSST C was also de-energized. CSST C was powering 2 of the 4 reactor coolant pumps (RCPs) on each unit. The loss of power to these RCPs caused both Unit 1 and Unit 2 to trip off-line. At the time of this event, CSST C was also feeding the A train safety/shutdown buses on both units. These lost offsite power and were repowered by their EDGs. The B train safety bus on each unit continued to be powered by offsite power from CSST B throughout this event. Hence, at no time did either unit experience a loss of all offsite power.

The above failure would not have caused any loss of offsite power had not, prior to this event, preparations been underway for a Unit 1 refueling outage. Unit 1 was coasting down, and as part of these preparations, CSST A which normally is one source for the safety buses of both Units 1 and 2 had been removed from service, and the buses transferred to their backup source (CSST B). Hence, the backup offsite source was already being utilized at the time of this event and was not available to automatically accept (fast transfer) the CSST C loads including power to the safety bus on each unit that lost its source of offsite power.

Sequoyah 1 and 2: 02/12/12

Power: 100%, both units;
Significant Event No. 47660.

On 2/12/12 at 07:56 EST, both Unit 1 and Unit 2 experienced a common loss of one offsite power source due to the catastrophic failure of one phase of a PCB in the 161kV switchyard.

Both units remained stable at 100% power, and the ESF buses for both units remained energized, being powered from the main units through the unit auxiliary transformers. The second source of offsite power was verified as available.

At 02/12/12 at 10:19 EST, the faulted condition was cleared and the offsite power source was restored. The offsite source was inoperable for 02:23 hours.

St. Lucie Unit 1: 10/03/12

Power: 100%;
LER (389) 2012-002-00, 11/27/2012

On 10/3/2012 at 08:43 hrs, with unit-2 in a defueled condition, a fault on the 6.9kV non-segregated bus for the 2B startup transformer resulted in loss of the transformer and a partial loss of offsite power to Unit 2. Unit 1 continued operation at power with one offsite circuit out of service.

The 2-B diesel generator started and loaded, and all equipment responded as expected. The startup transformer was returned to service within the time period specified by the Technical Specifications.

The fault was caused by collapse of a corroded bus vent assembly onto the bus bars. Corrective actions include improving periodic maintenance of associated bus run vent assemblies.

St. Lucie Unit 1: 09/17/15

Restore time: 32:41 hrs
Power: 100%
LER 389/2015-002-00, 11/16/2015

On September 17, 2015 at 12:22 hours, with Unit 1 at 100% power and Unit 2 in mode 5 at the beginning of a refueling outage, an electrical fault on the 2A 6.9 kV bus resulted in a differential relay trip of the 1A and the 2A startup transformers, separating them from offsite power. The loss of the 1A startup transformer resulted in the loss of one source of offsite power to both trains, and the associated safety and non-safety related buses were powered by the auxiliary transformer. Unit 1 continued operation at 100% power throughout the event. The 1A startup transformer was returned to service on September 18, 2015 at 21:03 hours.

The loss of the 2A startup transformer and its associated safety and non-safety related busses resulted in de-energizing these buses because the associated 2A diesel generator had been removed from service for scheduled maintenance. However, the 2B startup transformer and associated buses were not affected by the event. The 2B train of shutdown cooling was in operation during the event and remained in service and was not affected by the event. The 2A shutdown cooling train was de-energized during the event and was restored and made available on September 19, 2015 at 00:30 hours.

The root cause of the electrical fault was the protective boots for a bus bar bolted connection were not installed properly from the initial plant construction, a legacy human performance error.

The event was determined to be a category II event for Unit 1, as it involved the loss of one offsite source to all emergency trains. The event was not categorized for Unit 2, as the unit was in cold shutdown and the affected 2A bus was not the protected (2B) shutdown bus. Decay heat continued to be removed throughout the event.

Susquehanna 1 and 2: 06/28/12

Unit 1 – Power: 0%, cold shutdown; Category IV.a
Unit 2 – Power: 100%; Category II
LER (388) 2012-008-00, 08/24/2012.

On 06/28/2012 at 13:53 hours, with Unit 1 in cold shutdown and the Unit 2 at full power, the station experienced a loss of one (of two) offsite power sources for both units when startup transformer (T-20) was de-energized.

All ESF buses powered by this transformer automatically transferred to the second startup transformer (T-10) which was in service and supplied by a second offsite source.

The de-energization interrupted power to several plant systems including the shutdown unit's residual heat removal (RHR) system. This system was restored within one hour. The operating unit continued to operate at power.

The de-energization of the transformer was initiated by a defective selector switch for electrical current indication. The switch had foreign material from the manufacturing process that prevented a switch contact from closing. This, in turn, caused an invalid phase current imbalance indication that was detected by protective relaying resulting in loss of the transformer. One of the contributing causes of the event was in the design of the protective relaying scheme that included a shared metering function.

Turkey Point Unit 4: 4/19/13

Restore Time: 1:03 hours:
Power: 29%, testing in progress;
LER (251) 2013/002/00, 6/18/2013.

On 04/19/2013 with the unit at approximately 29% of rated power, generator testing was in progress after an extended power uprate outage. The testing included lowered exciter voltage to establish generator protective relay settings. At 17:21 hours, a degraded voltage signal was received from the 480 volt load centers, which initiated vital bus load shedding; starting of EDGs and loading on to the vital buses.

The reactor tripped due to the loss of reactor coolant pumps. Because the reactor coolant pumps were unavailable, it was necessary to employ natural circulation for core cooling.

The vital buses were energized from the startup transformer at 18:24 hours. The vital buses were not powered by offsite power for approximately 1:03 hours, however, offsite power was available.

The causes of this event were established as: 1). The test instruction did not provide adequate precautions and limitations and did not identify 480 V load centers as possible limiting conditions, and did not specify the proper method for monitoring load center voltage. 2). Personnel failed to identify the risk associated with performance of this test.

Watts Bar Unit 1: 05/17/16

Power: 100%
NRC Event Report No. 51940

On May 17, 2016, at 1630 hours with the unit at 100% power and while restoring from a plant modification related to new 'loss of phase' circuitry, the 1 B-B 6.9kV bus de-energized resulting in a loss of voltage on the bus. The loss of voltage was caused by actuation of the “loss of voltage” relays that separated offsite power from the 1 B-B 6.9kV bus. At the time, the 1 B-B emergency diesel generator was removed from service for planned maintenance.

Operators, in accordance with abnormal operating instructions, started emergency diesel generators 1 A-A, 2 A-A, and 2 B-B. All equipment operated properly. The emergency diesel generators were not required to be paralleled to their respective buses.

Offsite power was restored to the 1 B-B 6.9kV bus at 1802 hours on May 17, 2016. The duration of the loss of offsite power to the 1 B-B 6.9kV bus was 1 hour and 32 minutes.

A.5 Category III Events

No category III events occurred in 2016 or in the ten-year period.

A.6 Category IV-a Events

Two category IV-a events occurred in 2016.

ANO Unit 1: 03/31/13

Restore Time: 150:57 hours;
Power: 0%, refueling shutdown;
LER (313) 2013-001-01, 08/22/2013;
NRC “Arkansas Nuclear One Augmented Inspection Team Report 05000313/2013011 and 05000368/ 2013011”, June 7, 2013.

At approximately 07:50 hrs on 03/31/2013 with Arkansas Nuclear One Unit 1 (ANO-1) in Mode 6 (refueling) and Unit 2 (ANO-2) in Mode 1 at approximately 100% power, during lifting and removal of the ANO-1 original Main Generator Stator, the temporary lift assembly collapsed due to failure of one of the structural columns. This resulted in the stator falling onto the turbine deck and rolling down into the ANO-1 train bay adjacent to ANO-2; causing one fatality, multiple injuries, structural damage to the turbine buildings, electrical equipment and non-vital systems. When the stator impacted the ANO-1 turbine deck floor, part of the concrete and steel floor structure collapsed onto electrical buses beneath the turbine deck, resulting in a loss of all offsite power to ANO-1. Both ANO-1 EDGs automatically started and connected to their respective 4.1kV safety buses as designed. ANO-1 decay heat removal flow was reestablished after being lost for approximately four minutes. The spent fuel pool temperature increased less than three degrees during the interruption. Offsite power was restored to the ANO-1 safety buses at 13:47 hrs on April 6, 2013.

Browns Ferry 3: 05/05/08

Power: 0%, shutdown for refueling;
LER (296) 08-001, 07/07/08.

At the time of this event, Unit 3 was shutdown and in a refueling outage. Operations personnel were in the process of returning one of the Unit 3, 4kV buses (Unit Board 3B) to service after planned maintenance activities. While transferring the bus to the normal feed there was an indication of disagreement between the desired breaker position and the actual breaker position. The cause was later found to be misalignment of the breaker indicating switch mechanism. An attempt was made to return bus 3B to the alternate power supply but the alternate breaker failed to close. Because bus 3B powers 4.1kV shutdown boards (safety buses) 3EC and 3ED, they also lost offsite power. Their EDGs 3EC and 3ED, started and repowered these buses. Offsite power was restored to these buses approximately 6:12 hrs after the event began. Unit 3's other safety buses did not lose offsite power. Unit 3 has a total of four safety buses and four EDGs and also has extensive interties to the Units 1 and 2 safety buses and EDGs. This is a Category IV event because the plant was in an electrical configuration and had a scope of activities underway that wouldn't occur when at power. The safety consequences of this event were not significant.

Byron Unit 1: 03/15/14

Power: 0%, shutdown for refueling;
LER 454/2014-003-00, 5/14/2014.

On March 15, 2014 at 11:02 hours Byron Unit 1 experienced a loss of offsite power to the two safety-related buses. At the time, the Unit was in Mode 6 and core offload and maintenance activities were in progress.

Relay calibrations for the buses associated with the Station Auxiliary Transformer (SAT), the offsite power source, were being performed in accordance with approved work instructions. During this relay calibration activity, a SAT differential relay actuation occurred that initiated a trip and lockout of the SAT feed breakers de-energizing the safety buses and resulting in starting of the associated diesel generators and loading on the buses. Offsite power was restored to the safety buses at 20:33 hours and 21:15 hours for safety related Buses 141 and 142, respectively. The LOOP duration was 9:31 and 10:13 hours.

The cause of the event was indeterminate, but the most probable cause was a combination of equipment failures involving a faulty test switch.

Catawba 1 and 2: 04/04/12

Unit 1 – Restore Time: 5:26 hours; Power: 100%; Category I.a
Unit 2 – Restore Time: 5:34 hours; Power: 0%, cold shutdown; Category IV.a
LER (413) 2012-001-0, 06/04/2012 for both units.

On 04/04/2012 at 20:03 (EDT), Unit 1 tripped from 100% power as a result of low reactor coolant system flow following loss of a reactor coolant pump due to a ground fault. As anticipated, a unit/generator trip ensued, followed by isolation of the unit from the grid due to unexpected instantaneous underfrequency relay action. Isolation from the grid created a LOOP situation. Unit 2 was in cold shutdown with its essential buses powered from Unit 1, and the Unit

1 LOOP also resulted in a Unit 2 LOOP. Both EDGs on each unit started and powered their respective essential buses. A residual heat removal pump was started to restore core cooling for unit 2, and unit 1 was stabilized on natural circulation with residual heat removal via auxiliary feedwater and secondary steam relief.

Approximately 5 ½ hours later, after confirming that the sources of the electrical fault were cleared offsite power was restored to one essential bus on each unit. The LOOP occurred as a result of inadequate design input specification and insufficient control over vendor outsourcing in conjunction with underfrequency relay modifications.

Diablo Canyon 1: 05/12/07

Power: 0%;
LER (275) 07-001, 07/11/07.

On May 12, 2007 at 10:25 hrs, with Diablo Canyon Unit 1 shutdown and the reactor defueled, and Unit 2 at 100% power, 230kV startup power for both units was lost due to an offsite transmission system insulator failure and an unanticipated protective relay response. Unit 2 remained at 100% power.

During normal operation, the 4.16kV vital buses for each unit are powered from the unit auxiliary power system. The 230kV transmission system provides offsite power for each unit's startup, shutdown; emergencies and other times when the unit auxiliary sources are not available.

Unit 1 EDGs 1-1 and 1-2 started and loaded because alternate power from the normal Unit 1 source was not available due to scheduled maintenance underway on the 500kV main output transformers. Unit 2's EDGs started but did not load since its vital buses remained energized from their normal source.

The 230kV offsite power source was reenergized 1:02 hrs after the fault occurred and offsite power to Unit 2 was restored 0:14 hrs after this for a total loss of the standby 230kV offsite source of about 1:16 hrs. The standby 230kV offsite power was also available to Unit 1 at about this time, however because the unit was shut down for refueling, final switching was carried out later at a less stressful time in the overall recovery effort.

For Unit 2 this was a Category II event wherein the startup/shutdown sources of offsite power for the safety buses become de-energized but the main generator remains on-line and power for the safety buses is available from a unit auxiliary transformer.

For Unit 1 this was a Category IV event because the plant was in a condition and configuration that does not occur when at power. If Unit 1 had been at power this would have been a Category II event.

Duane Arnold: 02/24/07

Restore Time: 17:28 hours;
Power: 0%, shutdown for refueling;
LER (331) 07-004, 04/26/07.

On February 24, 2007, while the Unit was shut down for refueling, a severe winter storm brought rain, ice and high winds to the Duane Arnold plant's transmission grid area. At 16:54 hrs on 02/24/07, transmission lines to the plant began to be lost due to the severe weather. At 18:20 hrs, both EDGs loaded as the result of a degraded voltage condition that lasted about 8 seconds. The EDGs powered the essential buses throughout the event. The startup transformers remained energized from offsite power and the non-essential buses continued to be powered from offsite power throughout the event.

While the offsite sources at the plant remained energized, the storm put the grid in a degraded condition. The plant became isolated from most offsite sources and at times only one or two of the 6 transmission lines into the plant were energized. Grid repair and recovery allowed an essential bus to be transferred from its EDG back to offsite power at 11:48 hrs on 02/25/07. This was 17:28 hrs after the event began.

FitzPatrick: 10/05/12

Power: 0%, refueling
LER 333/2012-005-00

On October 5, 2012, at 13:01 EDT, FitzPatrick was in a refueling outage when it experienced a LOOP. The event occurred after both reserve station transformers were replaced. Several hours after installation, a maintenance activity which applied a load to the transformer caused a trip of transformer 71T-3. All four EDGs started in response to the LOOP, but the output breaker for EDG A did not close. All systems functioned as required with the exception of emergency response communications systems. At 20:11 power was restored by a qualified backfeed from the 345 kV system. The duration of the LOOP was 7:10 hours.

Both reserve station service transformers were replaced during the outage. The LOOP was caused by a trip of 71T3 reserve station service transformer in response to a differential protection relay tripping because of shorting bars (a factory setting) that were not removed during installation. The root cause was determined to be not following the work order instructions as written. A contributing cause was an incorrect design drawing.

Millstone 3: 04/25/07

Power: 0%, shutdown for refueling;
LER (423) 07-002, 06/11/07.

On April 25, 2007, with the Millstone Unit 3 shutdown and the reactor defueled, a switching error in the offsite transmission system caused a loss of all offsite power to Unit 3. Millstone Unit 2 remained at 100% power and connected to the grid throughout the event. The Unit 3 A EDG started and loaded. The B EDG was out of service for planned maintenance.

At the time of this event the Reserve Station transformer (startup transformer) was out of service for maintenance as a part of outage activities. Power for the plant was being backfed through the main unit output transformer and then via a unit auxiliary transformer. Because of problems elsewhere on the transmission system, system operators needed to take one of the transmission lines to the Millstone switchyard out of service. During the switching for this, a switchyard breaker in the backfeed circuit for Unit 3 was inadvertently opened and the LOOP occurred. Offsite power was restored to Unit 3 after about one hour. The main Millstone switchyard buses remained connected to offsite power throughout this event.

Oyster Creek: 10/29/12

Restore Time: 14:21 hours;
Power: 0%, cold shutdown for refueling;
LER (219) 2012-002-00, 12/28/2012.

On 10/29/2013 at 20:18 hours, with the unit in cold shutdown during a planned refueling outage, a LOOP event was experienced due to equipment damage caused by the winds associated with hurricane Sandy. Upon loss of power, both EDGs associated with the safety buses started and reenergized the buses. Shutdown cooling and spent fuel pool cooling were interrupted during the LOOP, and were expeditiously restored with power from the diesel generators.

At 10:39 hours on 10/30/2013, power was restored on one emergency bus and the associated diesel generator was secured. At 03:46 hours on 10/31/2013 a planned contingency offsite power backfeed path was established to repower loads associated with the second emergency bus, and its diesel generator was secured. At 21:32 hours on 11/01/2013, the planned contingency offsite power backfeed was secured.

Perry: 02/11/16

Restore Time: 22 minutes
Power: 0%, cold shutdown
LER (440) 2016-003-00

On February 11, 2016, at 15:05 hours with the plant in cold shutdown, a sensed loss of power to the Division 1 4.16 kV bus, EH11, occurred. At the time the bus was being supplied by offsite power via a Startup Transformer. A bus potential transformer secondary fuse, which supplies the undervoltage and degraded voltage circuitry, failed. Bus supply breaker, EH 1115, tripped open based upon the sensed invalid undervoltage signal, and the bus loads were shed as designed, including the division 1 Shutdown Cooling Pump, part of residual heat removal (RHR) train A, which was supplying shutdown cooling at the time. The invalid EH11 undervoltage signal resulted in the Division 1 EDG starting and loading the EH11 bus. The Emergency Service Water A (ESW A) pump, which supplies cooling water to the EDG did not start due to the sensed loss of bus voltage. Due to the absence of cooling water to the EDG, operators secured the Division 1 EDG. Shutdown cooling was re-established at 15:47 using the Division 2 shutdown cooling pump (RHR train B).

Troubleshooting determined the cause of the loss of the Division 1 bus was a failed bus potential transformer secondary fuse that supplies the undervoltage and degraded voltage protection circuitry. The fuse was found to exhibit intermittent continuity. The failure analysis revealed that the fuse internals were not soldered correctly during the manufacturing process.

Pilgrim Two Related Events: 02/08/13 and 02/10/13

First Event (2/8/2013) – Restore Time: 30:43 hours;
Power: 100%; Category I.a
Second Event (2/10/2013) – Restore Time: 40:00 hours;
Power: 0%, cold shutdown; Category IV.a
LER (293) 2013-003-00, 4/8/2013.

On 02/08/2013 at 21:17 hours, Pilgrim Nuclear Power Station (PNPS) experienced a loss of offsite power (LOOP) associated with severe winter storm NEMO; a subsequent load rejection from 85% power and a reactor scram. EDGs automatically started and powered the two safety-related buses. All other safety systems functioned as required and the plant stabilized in Hot Shutdown.

PNPS is connected to the grid by two 345kV lines connected to a ring bus located within the station's 345kV switchyard. The ring bus also connects to the main transformer and the startup transformer (SUT). The ring bus design locates the power transmission bus sections such that a failure of any one bus section will not result in the loss of the other bus section. Either of the two 345kV lines is capable of carrying full station output and supplying station loads via the SUT.

In addition to the preferred 345kV offsite power lines, PNPS has a secondary offsite power source, a 23kV line that provides power to a shutdown transformer. In anticipation of a major winter storm impacting PNPS, the station entered procedures for dealing with severe weather. Station risk level was elevated to yellow. On Friday 02/08, meteorological instruments at PNPS recorded sustained wind speeds between 42 and 49 mph through 22:28 hours at which time the plant information system stopped recording weather data until the following day.

On Friday, 02/08/2013 at 20:18 hours, the shutdown transformer was declared inoperable due to repeated offsite alarms and reports regarding power loss at the line's terminal point, and offsite substation.

At 21:02 hours, a major fault occurred on line 342 (one of the two 345kV lines) and the line remained de-energized for the remainder of the storm. At 21:17 hours a fault on Line 355 (the second 345kV line) occurred resulting in the LOOP previously described.

The LOOP was initiated by severe weather causing faults on both 345kV transmission lines connected to the PNPS ring bus. One of the 345kV transmission lines was restored to reenergize the SUT at 22:11 hours. However, two subsequent bus faults associated with the SUT precluded energizing the safety buses from offsite power until one safety bus was reenergized at 04:00 hours on February 10, followed by energizing the second safety bus at 08:30 hours.

On 2/10/2013 at 14:01 hours with the unit in cold shutdown, a second LOOP occurred initiated by a flashover fault on one phase of the SUT bus section. The flashover fault was due to salt-contaminated ice bridging on the phase insulator. The single remaining breaker on the 345kV ring bus supplying the SUT opened, resulting in a loss of power to the two safety-related buses,

followed by starting of the associated diesel generators and powering the safety-related buses. At 06:01 hours on 2/12/2013 offsite power was restored to one safety-related bus through the Main/Unit auxiliary transformers. Offsite power was restored to all 4.160kV buses at 21:47 hours on 02/12/2013.

Point Beach 1: 11/27/11

Restore time: 04:12 hours;
Power: 0%, Mode 5 following refueling;
LER (266) 11-001-00, 01/25/12.

At Point Beach, offsite power is supplied by four transmission lines that connect the offsite transmission system to the switchyard. Offsite power can be supplied to the two 4.16KV safety buses on each unit through high voltage (345/13.8KV) and low voltage (13.8/4.16KV) station auxiliary transformers, including unit cross-ties from similar systems on the other unit. In addition, diesel generators, the unit's main step-up transformer and a gas turbine powered generator are capable of providing power to the safety buses.

Point Beach Unit 1 was in Cold Shutdown with the primary system filled, vented, and pressurized following a refueling shutdown. Restoration of the normal offsite electrical power switchyard alignment to the unit safeguards buses was in progress. The initial alignment consisted of offsite power being supplied to the Unit 1 safeguard buses from Unit 2 through a crosstie on the 13.8KV buses. The following events then occurred:

- With the 13.8kV crosstie closed, the Unit 1 offsite power supply was connected by paralleling to the energized Unit 1 and Unit 2 13.8kV buses by closing the high-side circuit switcher (1F89-112) on the Unit 1 high voltage (345/13.8KV) station auxiliary transformer.
- The crosstie from Unit 2 was opened at 02:26, and a low voltage condition was sensed on the Unit 1 safeguard buses, resulting in starting of diesel generators, separation of the Unit 1 safeguard buses from offsite power and loading a diesel generator on each of the two Unit 1 buses. Plant safety systems functioned as expected. Because the steam generators were available, decay heat removal capability was never lost. Residual heat removal pump forced flow was restored by starting a residual heat removal pump within 46 seconds. Unit 2 remained at power throughout the event with offsite power available and capable of supplying the Unit 1 safety buses. Investigation revealed that the high-side circuit switcher was overheating (glowing hot) and had failed. The switcher was isolated.
- Subsequent investigation of the circuit switcher failure revealed that the internal contacts were not properly made up in any of the three phases resulting in limited capacity current pathway. When the crosstie was opened the impaired current capacity of the switcher was exceeded resulting in a decrease of voltage on the safeguards buses.
- After assessing the cause of the loss of offsite power and confirming that the redundant (Unit 2) circuit for offsite power remained available, offsite power was restored to the Unit 1 safeguards buses by synchronizing the running EDGs to the grid and closing the alternate feed from offsite power (the Unit 2 crosstie) at 07:00 hrs. The duration of the loss of offsite power for this event was four hours and 12 minutes (04:12 hrs)

This was a classified as a category IV event because the unit was in cold shutdown with the offsite electrical supply in an alternate, permitted condition.

River Bend: 01/29/16

Power: 0%, cold shutdown
LER (458) 2016-04-00

With the unit in cold shutdown, on January 29, 2016 at 15:18 hrs, power was lost on reserve station service (RSS) line No. 1. This line provides one of the two sources of offsite power required by the license for the cold shutdown operating mode. This loss de-energized the Division 1 onsite safety-related switchgear causing an automatic start of the associated EDG. At the time, shutdown cooling power was provided by the Division 2 safety-related switchgear, and was not affected. The plant response to the loss of RSS line No. 1 was appropriate.

The cause of the loss was due to company transmission department personnel working in the switchyard and executing a deficient work instruction while modifying relay settings.

Susquehanna 1 and 2: 06/28/12

Unit 1 – Power: 0%, cold shutdown; Category IV.a
Unit 2 – Power: 100%; Category II
LER (388) 2012-008-00, 08/24/2012.

On 06/28/2012 at 13:53 hours, with Unit 1 in cold shutdown and the Unit 2 at full power, the station experienced a loss of one (of two) offsite power sources for both units when startup transformer (T-20) was de-energized.

All ESF buses powered by this transformer automatically transferred to the second startup transformer (T-10) which was in service and supplied by a second offsite source.

The de-energization interrupted power to several plant systems including the shutdown unit's residual heat removal (RHR) system. This system was restored within one hour. The operating unit continued to operate at power.

The de-energization of the transformer was initiated by a defective selector switch for electrical current indication. The switch had foreign material from the manufacturing process that prevented a switch contact from closing. This, in turn, caused an invalid phase current imbalance indication that was detected by protective relaying resulting in loss of the transformer. One of the contributing causes of the event was in the design of the protective relaying scheme that included a shared metering function.

Turkey Point Unit 3: 11/18/2015

Power: 0; refueling
LER 250/2015-001-00.

On November 18, 2015 at approximately 23:23 hours with the unit in Mode 5 following core reloading, the supply breakers to the Unit 3 Startup Transformer opened due to an unexpected protective relay action in the switchyard. Offsite power was lost to the 3A and 3B 4.1kV buses, and the 3B Emergency Diesel Generator started and loaded on the 3B bus. Decay heat removal

was provided by the 3B Residual Heat Removal Loop. The 3A bus load sequencer was out of service, requiring the 3A EDG to be manually started and connected to the 3A bus. Offsite power was restored following completion of corrective actions necessary to resolve the unexpected protective relay action. The event was classified as Category IV.a: "With the unit in cold, or refueling shutdown, the loss or significant degradation of offsite power sources to the emergency bus(es) required to be operable in the shutdown mode."

The direct cause of the Unit 3 LOOP was actuation of the modified (GE-B30) Breaker Failure Trip relay protection scheme. Subsequent investigation revealed that a combination of conditions resulted in a spurious trip of the protective relay: 1) a previous modification in the switchyard by the transmission system operator did not properly isolate abandoned circuits which resulted in a ground in the circuit; 2) the presence of long unshielded copper conductors in the control circuits; and 3) a new more sensitive relay was installed during the RFO. During a switchyard switching evolution, a ground signal was introduced on the switchyard DC system which, coupled with the long unshielded copper conductor, initiated the spurious trip of the new relay.

Wolf Creek: 04/07/08

Restore Time: 2:16 hours;
Power: 0%, shutdown for refueling;
LER (482) 08-004, 06/06/08.

During preventive maintenance testing in the switchyard, a LOOP was initiated when incorrect trip links were closed during transmission line breaker failure trip testing. At the time of this LOOP the plant was in a refueling outage with the reactor fuel off-loaded to the spent fuel pool. One of the unit's two safety buses and its EDG (the "A" train) were out of service for maintenance. The other safety bus (the "B" train) was being energized from offsite power. When the LOOP occurred, this safety bus lost offsite power but was reenergized by its EDG which started and loaded.

Offsite power was restored to the in-service safety bus 2:16 hrs after the event began.

A.7 Uncategorized Events of Interest

One uncategorized event of interest occurred in 2016.

Beaver Valley 2: 02/4/12

Power: 100%.

On 2/4/12, at 00:16, Unit 2 experienced a loss of one offsite power source that supplies one of the two ESF buses. The source was lost when the Unit 2 Offsite Source Transformer 2A was de-energized when the breakers associated with the transformer opened. Approximately two minutes later, the breakers were reclosed and the offsite source was restored. This event was repeated during testing at 23:58 hrs on the same day, and the transformer was de-energized for approximately two hours until the associated breakers were reclosed.

The cause of the inadvertent opening of the transformer breakers was later determined to be actuation of breaker relays that occurred due to a DC ground of sufficient magnitude that was introduced when an unrelated annunciator panel test switch was actuated. A degraded wire contributed to this event.

Unit 2 remained at 100% power throughout these events.

Browns Ferry 3: 05/22/12

Power: 19% during startup, not connected to grid;
LER (296) 2012-003-00, 07/23/2012.

With Unit 3 at approximately 19% rated thermal power during startup and the unit not connected to the grid, at 02:49 hrs the reactor automatically scrammed due to de-energization of the reactor protection system. The power supply for the 4.1 kV unit 3 board 3C was being transferred from 161KV alternate power to 500KV normal power when a differential relay (387SA) actuated resulting in a loss of 500KV power. All Unit 3 diesel generators started and tied to their respective shutdown boards. Although not connected, 161kV offsite power remained available during the event. Subsequently, 500kV power was restored through alternate feeder breakers to unit 3 4kV unit boards at 04:30 hrs. Offsite power was restored in about 1:41 hours.

The differential relay that actuated was installed with incorrect design calculation settings. The root cause for this condition was inadequate procedural guidance.

Browns Ferry 3: 08/20/15

Power: 100%
LER 296/2015-005-00.

On August 20, 2015 at 10:32 hours with the unit at 100% power, while installing test equipment on the 3ED 4kV Shutdown Board for an online dynamic test of the 3D Residual Heat Removal pump motor, degraded voltage and undervoltage alarms were received for the 3ED 4kV Shutdown Board. The normal feeder breaker opened and the 3D EDG started and fast tied on to the board.

On August 21, 2015 at 01:36 hours, the EDG was secured for trouble shooting and the Shutdown Board was declared inoperable. On August 21, 2015 at 19:45 hours, offsite power was restored to the Shutdown Board.

During installation of test equipment, the Shutdown Board metering fuses were determined to have been cleared; however, a definitive cause could not be identified. A possible failure mode was identified that was related to human performance, shorting between two terminals when attempting to attach a clip.

As this event only impacted one safety-related Shutdown Board, this event was not classified as unit loss of offsite power. It is included as an event of interest because of the implications of removing a safety-related board from offsite power due to plant testing activities.

Brunswick 1: 04/09/12

Power: 0%, cold shutdown;
LER (324) 2012-003-00, 06/07/2012.

During diesel generator testing activities with the unit in cold shutdown, electrical power to the 4.16kV emergency bus E1 was lost at 05:29 hrs when the normal supply breakers to the bus opened on relay action as a result of connecting a recorder to incorrect terminals. The associated diesel generator started and reenergized the bus per the plant design. Normal power was restored to the bus and the diesel generator was shut down at 07:01 hrs. Although the bus supply breakers were opened, offsite power was available up to the breakers during this event.

Clinton: 6/25/15

Power: 99%
LER 461-2015-004-00

On 6/25/15 at 03:01 hrs with the plant operating at 99% power, offsite power was being supplied by the Emergency Reserve Auxiliary Transformer (ERAT) Static VAR Compensator (SVC) to Division 1. The ERAT SVC tripped due to a voltage transient on the 138 kV offsite source due to a lightning strike and thunderstorms in the area. The trip resulted in a momentary loss of one offsite power source to the Division 1 Safety Bus. There was no fast transfer to the normal source, the RAT, as the Division 1 Bus voltage recovered within a second. Later, the Division 1 Safety Bus was manually aligned from the reserve source to its normal source. As a result of the voltage transient, there was a loss of secondary containment pressure for about 19 minutes due to the loss of fuel handling building fans. The SVC was returned to service at about 04:57 hrs on 6/25/2015.

This event was classified as not categorized as the event involved a momentary loss of voltage on one division bus and its ERAT offsite source.

Columbia: 06/15/13

Restore Time: 0:37 hours;
Power: 0%, refueling shutdown;
LER (397) 2013-005-00, 8/12/2013.

On June 15, 2013, Columbia Generating Station was in a refueling outage in Mode 4 when power was lost from the 115kV offsite power source at 12:22 hrs due to a momentary line fault caused by a range fire under the line. There are two offsite sources; both were in service with the critical switchgear buses aligned to the 115kV source. The Division 1 and 2 critical switchgear buses de-energized and were restored by EDGs within 15 seconds. The Division 2 critical switchgear bus was transferred to the 230kV startup transformer (second offsite source) at 12:59 hrs. The Division 1 critical switchgear bus was transferred to the 230kV startup transformer at 13:13 hrs and the 115kV transformer was returned to service at 18:24 hrs.

Shutdown cooling was not in operation at the time of the power loss.

D.C. Cook: 04/24/13

Unit 1 – Power: 0%, refueling outage;
Unit 2 – Power: 100%;
LER (315) 2013/002/00, 6/24/2013.

On 04/24/2013, Unit 1 was in a refueling outage and defueled, and Unit 2 was at 100% power. At 14:11 hours, a fault on a 4KV cable connecting vital buses 1C and 1D caused fault protection circuitry to open the Train A offsite power supply to reserve feed auxiliary transformers (RAT) 1-TR101CD and 2TR201CD on Units 1 and 2, respectively.

The loss of Train A reserve feed caused a valid actuation of the Unit 1 CD EDG. The EDG started and loaded as designed. Unit 2 remained stable at 100% power during the event, although power was interrupted to the 2-TR201CD Reserve Feed Transformer. The associated vital bus remained energized by unit auxiliary power during the event.

The Unit 2 reserve feed transformer was restored to service following isolation of the fault. The Unit 1 reserve feed transformer was restored to service following repair of the faulted power cable.

Preceding the afore-described event on 04/16/2003, the supply breaker for the Unit 1 RAT tripped open when performing an equipment clearance restoration of transformer 1-TR-101CD. Based on an investigation, no failures were identified. Then, on 04/24/2013, the supply breaker for the units 1 and 2 RATs opened and reserve feed was lost to Train A for both units. Plant personnel in the vicinity of the Unit 1 RAT observed an arc flash and audible indication.

Subsequent investigation revealed a faulted power cable. The cause evaluation determined the power cable failure was a reduction of the insulation dielectric strength due to cable age combined with a stressor of a prolonged pressure point from the cable lay path.

Diablo Canyon 2: 02/28/2013

Power 0%, Refueling
LER 323-2013-001-00

On 02/28/2013, with Unit 2 in a refueling outage and defueled, electrical maintenance personnel were conducting troubleshooting activities on 4kV vital Bus G, to determine the cause of a failed potential fuse, and correct the situation. The activities were performed under a troubleshooting work order. At 21:54 hours the bus feeder opened, the bus was de-energized, and the associated diesel generator did not start. The unit was shut down and defueled, and spent fuel pool cooling was never lost during the event. Power was restored to the bus in approximately 6 hours.

Before the event, the vital bus was fed from the 500kV system through the unit auxiliary transformer. It was recognized that the troubleshooting activity would create an undervoltage signal which would open the normal bus feeder, start the associated diesel, and initiate a transfer to the startup source which was tagged out and unavailable due to maintenance on the startup bus. Therefore, steps were provided in the work order to prevent the transfer from the normal feeder to the unavailable startup bus and to prevent starting the diesel. During execution of the activity, the step to prevent transfer to the startup bus was not performed, and the undervoltage condition caused the normal bus feeder to open, with no alternative source or diesel generator resulting in a de-energized vital bus.

This event is uncategorized, however it is included because it is of interest as a possible precursor, and under different conditions may have resulted in more serious event.

Diablo Canyon 2: 10/31/14

Power: 0%, Cold shutdown
LER 275/2014-004-00.

At 17:40 on October 31, 2014, with Unit 1 at 100% power and Unit 2 in cold shutdown, the plant experienced a loss of the 230kV offsite power source due to flashover of an insulator in the 230kV switchyard during a light rainstorm. This resulted in the valid start of all Unit 1 and Unit 2 emergency diesel generators (three per unit). The emergency diesel generators started, but did not load because all associated buses remained energized by auxiliary power. The 230kV offsite power source was restored and declared operable at 02:29 hrs on November 1, 2014.

Corrective actions include revision of insulator preventive maintenance protocols (insulator greasing, washing, etc.).

Farley 1: 04/06/12

Power: 0%, refueling shutdown;
LER (348) 2012-004-00, 05/31/2012.

During a refueling shutdown on 4/6/12, maintenance/testing activities in the switchyard caused a feeder breaker to trip isolating offsite power to the 1B startup transformer and related 4.1 kV emergency bus at 14:44 hrs. The breaker on the redundant offsite source for the 1B startup transformer was open and out of service at the time. The emergency bus sequencer initiated a valid load shed/diesel start signal, however, the associated diesel was removed from service and none of the bus loads started. The residual heat removal pump on the redundant emergency train remained in service for shutdown cooling throughout the event.

The bus was restored to service at 15:42 hrs on 4/6/12. The bus was out of service for 58 minutes during this event. Investigation revealed technical inadequacy in the instructions used during the switchyard maintenance activity.

FitzPatrick: 11/11/12

Power: 100%;
LER (333) 2012-008-00, 01/10/2013.

On 11/11/2012 at 03:55 hours an electrical arcing fault occurred on James A. FitzPatrick Nuclear Power Plant Main Transformer 71T-1A. This fault resulted in a main turbine trip; an automatic reactor scram from 100% power; and a fire in the main transformer and associated ductwork. Auxiliary electrical loads (including the safety buses) automatically transferred to the normal reserve sources. Offsite power transmission lines were operable and onsite emergency power remained available during this event.

A failure analysis of Transformer 71T-1A is planned.

Grand Gulf: 04/02/12

Power: 0%, cold shutdown;
LER (416) 2012-003-00, 06/01/2012.

While in cold shutdown on 4/2/12 at 11:51 hrs, one of two 500kV offsite feeders tripped due to a lightning strike during severe weather on an offsite power source causing a drop in grid voltage and a trip of an ESF bus feeder. The associated high pressure core spray (HPCS) diesel generator automatically started and energized the bus. The other two ESF buses remained energized and shutdown cooling remained in service. Two additional offsite power sources remained in service.

The 500kV feeder was restored at 15:15 hrs and the ESF bus was transferred back to offsite power and the diesel secured. The 500kV feeder was out of service for 3:24 hours.

Grand Gulf: 06/30/2016

Power: 0%, cold shutdown
LER (416) 2016-006-01, 8/29/2016

On June 30, 2016 at 17:15 CDT the unit experienced an electrical power supply loss from Service Transformer 21 which resulted in power supply being lost to the Division 2 and the Division 3 ESF buses. This resulted in a valid actuation of the Division 2 and Division 3 EDGs on bus under-voltage. Both EDGs automatically started and energized their respective ESF buses as designed.

At the time of the event, the Unit was in Mode 4, Cold Shutdown. During this event, the loss of power to the Division 2 resulted in a power loss, which actuated a Division 2 RPS half SCRAM signal.

The loss of power was caused by a failure of the taped insulation on the 'C' phase 34.5 kV Service Transformer 21 power supply cable to the Balance of Plant 23 Transformer, due to an outer tape wrap insulation failure between the braid connecting the splice, and the center conductor. Disassembly and visual inspection of the cable splice showed that the insulation had voids and a moisture path through the split in the outer tape wrap.

Monticello: 09/11/08 and 09/17/08

On 09/11/08 – Power: 100%; Category II
LER (263) 08-005, 11/10/08;
On 09/17/08 – Power: 0%; Event of Interest
LER (263) 08-006, 11/14/08.

On the above two dates, two similar partial loss of offsite power events occurred. The plant has three transformers that can power the plant’s safety buses. All three have adequate capacity to power all safe shutdown loads. The three transformers are:

- Primary station Auxiliary Transformer 2R. It is fed from a 345kV source
- Reserve Transformer 1R. It is fed from a 115kV source.
- Reserve Auxiliary Transformer 1AR. It is fed from two separate 13.8kV sources.

On 09/11/08 while the plant was operating at 100% power with transformer 1R out of service for planned maintenance, transformer 2R tripped open because of a fault in its incoming cable. A main unit trip occurred and the safety buses were automatically repowered from transformer 1AR. Both EDGs started but did not need to load.

On 09/17/08 the plant was still shutdown for recovery from the transformer loss on 09/11/08 and transformer 2R was still out of service with the safety buses being powered from transformer 1R. While in this configuration a man-lift came in contact with a 115kV line which de-energized transformer 1R. Again transformer 1AR was available to power the safety buses, however the relaying is such that in these particular circumstances the EDGs automatically start and load, with transformer 1AR providing a backup offsite source.

Monticello: 06/13/13

Power: 0%, refueling shutdown;
LER 263/2013-004-00, 8/12/2013;
NRC Event Report No. 49113, "Emergency Diesel Generators Start", 06/13/2013.

On June 13, 2013, Monticello was in cold shutdown with a full scram inserted. Testing for modifications associated with an Extended Power Uprate were in progress; specifically, a momentary loading test to initiate rotation of a condensate pump. When the pump motor breaker was opened after being closed for a couple seconds, an arc fault occurred in the 13.8kV feeder bus bar and causing a lockout of the 2R station transformer and loss of normal offsite power. The safety buses automatically transferred to a second source of offsite power via the 1AR emergency offsite transformer. Both emergency diesels started, but did not load.

The loss of power also resulted in a Group II containment isolation with associated isolation valve closures. This resulted in a loss of shutdown cooling for the reactor and spent fuel pool. Shutdown cooling for the reactor was restored within 58 minutes and spent fuel pool cooling was restored 92 minutes after the start of the event. There was no significant temperature rise in either the reactor or the spent fuel pool.

No conclusive evidence has been found that would explain the cause of the arc fault. However, the fault was most likely caused as a result of multiple independent conditions existing during the modification testing.

Oconee 3: 05/15/06

Power: 0%, shutdown for refueling;
LER (287) 06-001, 07/14/06.

During an Oconee 3 refueling outage, relay maintenance was underway when a differential relay was inadvertently jarred and picked-up, causing the Unit 3 startup transformer to trip and lockout. The Keowee Hydro Station, which is the emergency power source at Oconee in lieu of emergency diesel generators, started and reenergized the Unit 3 emergency buses.

Offsite power was at all times available throughout this event. One available source was from either Central Switchyard or from Lee Steam Station via a 100kV line and transformer CT-5. Another source of offsite power was the Unit 2 startup transformer. These sources were at all time available if needed. Because Keowee was operating without problems, a transfer to offsite power via transformer CT-5 was made at a later convenient moment in the overall recovery effort.

Prairie Island 1: 6/23/14

Power: 100%;
LER (282) 2014-003-00, 8/20/2014.

On June 23, 2014 at 11:07 hrs, with the unit at 100% power, safeguards Bus 15 received a degraded voltage signal that resulted in a load shed and automatic start of emergency diesel generator D1. The bus was reenergized and voltage was returned to normal after the emergency diesel generator breaker was closed. The degraded voltage condition was initiated by the failure of a control relay associated with the load tap changer on the Prairie Island Nuclear Generating Plant (PINGP) transformer Bank 10. This affected voltage to the normal offsite power supply to safeguards Bus 15.

Transformer Bank 10 is owned by Transmission and Distribution (T&D) and is located in the PINGP switchyard. The failed control relay for the load tap changer was replaced in accordance with T&D procedures and process. At 11:39 hrs, the power supply to the safeguards bus was transferred from the EDG to a different offsite power source.

River Bend: 03/07/15

Power 0%, Cold shutdown
LER 459/2015-002-00.

On March 7, 2015 at 21:40 hours, with the plant in cold shutdown, power from the reserve station service line to the Division 2 onsite electrical system was lost. The Division 2 EDG received an automatic start signal due to the bus undervoltage condition, but did not start because it was out of service for maintenance. The Division 2 switchgear was reenergized from an alternate source at 03:40 hours on March 8, 2015.

The event did not involve interruption of the shutdown cooling function. Since Division 1 offsite power was available, and shutdown cooling was maintained, this event was not categorized. It is included as an event of interest. Division 2 standby service water pumps were operating for scheduled testing at the time of the loss of power and shut down. Realignment of the Division 1 standby service water system to carry the lost heat loads was accomplished at 22:34 hours on March 7, 2015 by operator action.

The cause of the event was determined to be inadequate work practices by electricians. Investigation had determined that electricians had inadvertently made contact with abandoned trip circuitry wires while working in a cabinet. This caused the loss of power to the Division 2 onsite electrical system.

St. Lucie 2: 10/03/12

Power: 0%, de-fueled;
LER (389) 2012-002-00, 11/27/2012.

On 10/3/2012 at 08:43 hrs, with Unit 2 in a defueled condition, a fault on the 6.9kV non-segregated bus for the 2B startup transformer resulted in loss of the transformer and a partial loss of offsite power to Unit 2. Unit 1 continued operation at power with one offsite circuit out of service.

The 2-B diesel generator started and loaded, and all equipment responded as expected. The startup transformer was returned to service within the time period specified by the Technical Specifications.

The fault was caused by collapse of a corroded bus vent assembly onto the bus bars. Corrective actions include improving periodic maintenance of associated bus run vent assemblies.

St. Lucie 2: 09/17/15

Power: Unit 2 – 0%, Refueling
LER 389/2015-002-00.

On September 17, 2015 at 12:22 hours, With Unit 1 at 100% power and Unit 2 in mode 5 at the beginning of a refueling outage, an electrical fault on the 2A 6.9 kV bus resulted in a differential relay trip of the 1A and the 2A startup transformers, separating them from offsite power. The loss of the 1A startup transformer resulted in the loss of one source of offsite power to all trains, and the associated safety and non-safety related buses were powered by the auxiliary transformer. Unit 1 continued operation at 100% power throughout the event. The 1A startup transformer was returned to service on September 18, 2015 at 21:03 hours.

The loss of the 2A startup transformer and its associated safety and non-safety related busses resulted in de-energizing these buses because the associated 2A diesel generator had been removed from service for scheduled maintenance. However, the 2B startup transformer and associated buses were not affected by the event. The 2B train of shutdown cooling was in operation during the event and remained in service and was not affected by the event. The 2A shutdown cooling train was de-energized during the event and was restored and made available on September 19, 2015 at 00:30 hours.

The root cause of the electrical fault was the protective boots for a bus bar bolted connection were not installed properly from the initial plant construction, a legacy human performance error.

The event was determined to be a Category II event for unit 1, as it involved the loss of one offsite source to all emergency trains. The event was not categorized for Unit 2, as the unit was in cold shutdown and the affected 2A bus was not the protected (2B) shutdown bus. Decay heat continued to be removed throughout the event.

Surry 2: 12/29/12

Power: 100%;
LER (281) 2013-001-00, 02/15/2013.

On 12/29/2012 at 08:03 hours, a pelican contacted the overhead lines from the switchyard to the B reserve station service transformer (RSST). The supply breaker to the RSST tripped open as a result of instantaneous overcurrent of the B and C phases. The B RSST locked out and resulted in a loss of normal off site power to one emergency bus - 2H. The associated EDG started and loaded on to the emergency bus as designed.

Visual inspections verified that there was no damage to the lines, supply breaker, or RSST. The normal source of offsite power to the emergency bus 2H was restored at 12:42 hours, for an outage duration of 4:39 hours.

Turkey Point 3 and 4: 02/26/08

Power: 100%, both units;
LER (250) 08-001, 04/25/08.

On February 26, 2008, a momentary grid voltage disturbance occurred that caused a trip of both Turkey Point Units 3 and 4. The undervoltage condition resulted from a 138kV transmission system fault at an offsite electrical substation. The fault remained on the system for approximately 1.7 seconds. The units tripped off-line because both channels of each unit's safety related 4.1kV bus undervoltage relays actuated after a one second time delay. The units automatically trip when both channels are activated. However the EDGs did not auto-start or load because the grid's voltage level at the plant recovered by the time switchyard breakers repositioned to place the startup transformers in service and repower the safety buses. There was at all times ample grid capacity available to supply the plants safe shutdown loads.

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