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

Summary of Experience Through 2015

2016 TECHNICAL REPORT

Losses of Offsite Power at U.S. Nuclear Power Plants: Summary of Experience Through 2015

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PRODUCT DESCRIPTION

This report describes losses of offsite power that occurred during 2015 at nuclear power plants operating in the U.S., and offers insights into the causes of such events for the ten-year period 2006 through 2015.

Background

This report is one in an annual series that describes events in which some of the sources of offsite power were lost for nuclear power plants operating in the U.S. This report extends previous summary reports, including Electric Power Research Institute (EPRI) report 3002005291, *Losses of Offsite Power at U.S. Nuclear Power Plants: Summary of Experience Through 2014*.

Objectives

To examine and document the causes of losses of offsite power (LOOPs) at U. S. nuclear power plants in 2015, and to examine and document LOOP event trends in the ten-year period from 2006-2015.

Approach

The project team reviewed available information from Nuclear Regulatory Commission (NRC) public data (Event Notification Reports and Licensee Event Reports (LER)) describing each of the events involving a partial or total loss of offsite power (LOOP) during 2015 to determine the nature of the events. Each significant LOOP event that occurred from 2006–2015 is appropriately categorized and described.

Results

During 2015, there was a single event involving loss of all offsite power at one U.S. nuclear power plant. This was a relatively short duration event of less than one minute. However, it affected both units at one site for a total of two total losses of offsite power. Both units at the site automatically tripped as a result of this event.

In 2016, the category definitions for LOOP events were amended to improve clarity and consistency with other industry definitions as described in Section 1 of this report. These changes have resulted in minor impacts to the statistics, although the last ten years' events have been adjusted as necessary, to align with the 2016 definitions.

While there are unusual years such as 2010 in which there were no total losses of offsite power, there were seven total offsite power loss events in 2011, three in 2012, five in 2013, and two each in 2014 and 2015. No weather-related total losses of offsite power occurred in 2015. In 2013, there were three events in which weather contributed to losses of offsite power. On average, the frequency of losing all offsite power was approximately 0.029 per year per unit for the period 2006–2015. For the rolling ten-year summary periods, however, there had been an upward trend in both event frequency and event duration to the period of 2013-2014. In 2013, the event frequency was at a maximum and was lower in 2014 and 2015. In 2014, the event duration

was at a maximum and decreased in 2015. The upward trend was in part due to a higher contribution from weather-related events in recent years.

Applications, Values, and Use

This report serves as a valuable source of information for understanding the types of challenges that can lead to a loss of offsite power. This information is useful as an input to probabilistic risk assessments (PRAs), for which the potential of a loss of offsite power is often an important consideration. The information in this report can be used in calculating site- and unit-specific frequencies of loss of offsite power and in characterizing the duration of such losses for evaluations of recovery potential. It can also be used to evaluate the factors leading to LOOP conditions.

To improve the usefulness of the report, it has been expanded to better reflect and clarify the nature of the events that occurred. These changes more clearly address the two major uses of the LOOP event data: the designation “Risk/Safety Category” is intended primarily for use in PRA analyses, while “Industry Category” provides insights into equipment performance and operational issues.

EPRI would like to thank Frank Rahn, Christopher Kerr, and John Gyrath for their input to this report, particularly with respect to the aforementioned category changes and classification of events. It is expected that these changes will provide a more usable and informative source of information in this and future LOOP reports.

Keywords

Offsite power
Risk analysis
LOOP
Safety analysis
Loss of offsite power

EXECUTIVE SUMMARY

Since the mid-1970's the Electric Power Research Institute (EPRI) has performed research and periodically published information regarding Loss of Offsite Power (LOOP) events that have occurred and affected nuclear power plants, with annual updates since about the year 2000.

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 probabilistic risk assessments (PRAs). The frequency and duration of LOOP events are updated based on recent experience. 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.

2015 was a good year insofar as there was only one event that involved a total loss of offsite power. Although this event was of short duration, it did impact both units at a station. Similarly, there were a number of lower level events that occurred during the year. Weather was not a large factor in causing or complicating these events, with only one event associated with extreme weather that resulted in a partial loss of offsite power.

The definitions used to categorize the events were reviewed this year. The purpose of this review and ensuing changes was to clarify the categorization guidelines and to make them more aligned with other industry and regulatory guidance. These changes provide report results that can be used to address the two major uses of the LOOP event data: the designation "Risk/Safety Category" is intended primarily for use in PRA analyses, while the "Industry Category" provides insights into equipment performance and operational issues.

Results are presented for the past year and a rolling ten-year period. Frequency and duration of these events appear to be decreasing from both the yearly and multi-year perspective. This decrease may reflect multiple industry efforts.

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
RSST	Reserve Station Service Transformer
SAT	System Auxiliary Transformer

Abbreviation	Description
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 elapsed time taken to connect offsite source(s) to safety buses. 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.

In 2016, EPRI reviewed the categories assigned to events. The purpose of this review and ensuing changes was to clarify the categorization guidelines and to make them more aligned with other industry and regulatory guidance. These changes provide report results that can be used to address two major uses of the LOOP event data: the designation "Risk/Safety Category" is intended primarily for use in PRA analyses, while the "Industry Category" provides insights into plant and transmission grid asset management issues. Table 1-1, Loss of Offsite Power (LOOP) Category Changes summarizes the pre-2016 guidance and the guidance that was established in 2016, including the correspondence between the Risk/Safety and Industry categories. Table 1-2 summarizes the current (2016) Risk/Safety guidance used to categorize the events of 2015, as well as the events in the preceding ten–year period, 2006-2015. Following are key points for the changes to the event categories and definitions:

- Category I.a and I.b: No significant change, but emphasis added indicating the events occurred in Modes 1-4, and were actual, total losses of offsite power to all emergency buses.
- Category I.c: Added to provide a category and definition for events involving significant degradation of offsite sources, and the plant has declared the source(s) inoperable. If, during the event, the source cannot be connected, or has been disconnected, the event becomes category I.a or I.b. These events are not included in the category I frequency and duration statistics, insofar as they do not involve a disconnection of an offsite source.
- Category II: Added indication that events occurred in Modes 1-4 and involved an actual loss of offsite power for one source to all buses or all sources to one bus. Loss of an additional source would result in a total loss of offsite power. Remaining available sources can be connected with available equipment. This subsumes previous category III.
- Category III: Subsumes previous category II.b and is intended to apply to events where there is a potential for significant degradation of offsite sources or there is uncertainty based on grid system evaluations. If plant declares the source inoperable, it becomes category I.c .
- Category IV.a: Establishes a category to cover events where there is a loss of offsite power sources to buses required to be operable in cold or refueling shutdown.

- Category IV.b: Same as previous category IV.
- Event of Interest: A LOOP event that is less significant than those of categories I-IV, and may involve a reactor trip or safety system actuation.

Tables 1-3 and 1-4 summarize the effect of these changes on the annual and ten-year composite LOOP event frequencies. Note that for the most important categories (I.a and I.b LOOP), the changes are relatively minor. The increase in the number of events in categories I through IV is mainly due to the change in category definitions, as some events involving loss of on offsite power source were uncategorized (but reported as "of interest") before 2016, and are now categorized as Category II. It is recommended that the 2016 category frequencies be used in risk and PRA analyses now and in the future. With the minor changes in event frequency, re-visitation of past risk and safety analyses may not be necessary.

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.

Table 1-1
Loss of Offsite Power (LOOP) Category Changes

Risk/Safety Category and Description - 2016	Industry Category and Description - 2016	Pre-2016 Categories	Change	Reason
Category I.a LOOP: 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 minutes.	Full LOOP: A functional or physical disruption of all credited off-site power paths to the emergency /safety buses for a unit, duration >30 minutes.	I.a: No offsite power available for 30 minutes or longer to the safety buses.	Add all emergency buses, add applicable operating modes. (total) LOOP is understood to mean the offsite sources are not connected and/or actual power and/or voltage available from offsite sources is insufficient for operating the emergency equipment.	Clarification, application of this classification to most risk-sensitive operating modes.
Category I.b 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 seconds, <30 minutes.	Full LOOP: A functional or physical disruption of all credited off-site power paths to the emergency /safety buses for a unit, duration >15 seconds, <30 minutes.	I.b: No offsite power available for less than 30 minutes to the safety buses.	Add all emergency buses, add applicable operating modes.	Clarification, application of this classification to most risk-sensitive operating modes.
Category 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.		II.b: Offsite sources for safety buses become in question.	Added category	This is really an extension of 2016 category III, except that the offsite source(s) have been declared inoperable by the plant.

Table 1-1 (continued)
Loss of Offsite Power (LOOP) Category Changes

Risk/Safety Category and Description - 2016	Industry Category and Description - 2016	Pre-2016 Categories	Change	Reason
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 -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.	Partial LOOP: Same as full LOOP except that at least one required credited off-site power path is still in service, -OR- all offsite power sources supplying an emergency bus or train are lost. Note: If the available power source(s) are not connected to the bus(es), it should be possible to connect them by operation of appropriate designated devices, such as breakers or motor-operated disconnects.	II.a: With the unit on-line, the startup/shutdown sources of offsite power for the safety buses become deenergized. The main generator remains on-line (connected to the offsite grid) and power for the safety buses is available from a unit auxiliary transformer. III: The unit auxiliary source of power for the safety buses becomes deenergized or unavailable, but offsite power for the safety buses remains available, or can be made available, from a startup/shutdown source.	Add one offsite path or one emergency bus is still in service, add applicable operating modes. Pre-2016 Category III deleted, as it is included in Category II.	Clarification for risk sensitivity. Loss of additional offsite power source or emergency bus may result in a category I or full LOOP. It is not needed to address unit auxiliary sources.
Category 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.	Category III LOOP: There is unstable grid voltage or such a condition could result if the unit were to trip or if it tripped coincident with a LOCA and ESF actuation.	II.b: With the unit on-line, the startup/shutdown sources of offsite power for the safety buses remain energized but in question. There is low or unstable grid voltage, or there might be if the unit trips, or trips along with a LOCA and emergency safety feature actuation.	Defined to reflect grid conditions, different category.	Clarification, this category is intended to identify those events where there is a potential loss or significant degradation of offsite power sources. However, the potential loss or degradation has not manifested as a loss of active plant resources, or have been declared inoperable by the plant.

Table 1-1 (continued)
Loss of Offsite Power (LOOP) Category Changes

Risk/Safety Category and Description - 2016	Industry Category and Description - 2016	Pre-2016 Categories	Change	Reason
Category 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.			Added, as previous practice classified these events as Category I, although the risk significance is different.	
Category 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.				No change to original category IV description.
Uncategorized; Interest: Uncategorized events which may be of interest. 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: Uncategorized events which may be of interest. For example, With the unit in power operation, startup, hot standby, or hot shutdown one offsite power source supplying one redundant emergency bus is lost.	Uncategorized		

Table 1-2
Loss of Offsite Power (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 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 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 such that 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 or refueling shutdown 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, or hot 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

Table 1-3
LOOP Event Frequency Comparison for 2015

Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for Year 2015 -PRE 2016 categories				Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for Year 2015 - 2016 Categories			
Category	**Number of Events**	**Rate (per unit calendar-yr)***		**Category**	**Category Definition**	**Number of Events**	**Rate (per unit calendar-yr)***
Ia. Total loss longer than 30 min	0	0.000		Ia LOOP	At power - hot shutdown, loss off all offsite power to emergency buses > 30 minutes.	0	0.000
Ib. Total loss less than 30 min	2	0.020		I.b LOOP	At power - hot shutdown, loss off all offsite power to emergency buses 15 sec to < 30 minutes.	2	0.020
Total for categories I.a and I.b	**2**	0.020			Total for categories Ia and I.b	**2**	0.020
I.c. Included in II.b for pre-2016	0	0.000		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.a. Loss of startup/shutdown source; main generator remains online and power available to safety buses from auxiliary transformer.	1	0.010		II LOOP	With the unit in power operation, startup, hot standby, or hot shutdown loss of power source(s) available to all emergency buses such that loss of an additional power source will result in a Category 1 or full LOOP -OR- all offsite power sources supplying an emergency bus or train are lost.	4	0.040
II.b. Questionable supply from startup/shutdown source; main generator remains online and power available to safety buses from auxiliary transformer.	1	0.010		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 for the emergency buses or their availability is uncertain based on grid system evaluations.	0	0.000

Table 1-3 (continued)
LOOP Event Frequency Comparison for 2015

Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for Year 2015 -PRE 2016 categories				Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for Year 2015 - 2016 Categories			
Category	**Number of Events**	**Rate (per unit calendar-yr)***		**Category**	**Category Definition**	**Number of Events**	**Rate (per unit calendar-yr)***
III. Unit auxiliary source of power for the safety buses becomes de-energized or unavailable, but offsite power is available from a startup/shutdown source.	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.	1	0.010
IV. Total loss of offsite power during cold shutdown due to outage-related maintenance activities.	1	0.010		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
Total for all Categories in 2015	**5**	0.051			Total for all Categories in 2015	**7**	0.071
Based on 99.0 unit calendar-years of operation in 2015.					Based on 99.0 unit calendar-years of operation in 2015.		

Table 1-4
LOOP Event Frequency Comparison for Years 2006-2015

Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for years 2006-2015 using -PRE 2016 categories			Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for Years 2006-2015 using 2016 Categories			
Category	**Number of Events**	**Rate (per unit calendar-yr)***	**Category**	**Category Definition**	**Number of Events**	**Rate (per unit calendar-yr)***
Ia. Total loss longer than 30 min	33	0.032	Ia LOOP	At power - hot shutdown, loss off all offsite power to emergency buses > 30 minutes.	27	0.026
Ib. Total loss less than 30 min	2	0.002	I.b LOOP	At power - hot shutdown, loss off all offsite power to emergency buses 15 sec to < 30 minutes.	3	0.003
Total for categories I.a and I.b	**35**	0.034		Total for categories I.a and I.b	**30**	0.029
I.c. Included in II.b for pre-2016			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.	4	.004
II.a Loss of startup/shutdown source; main generator remains online and power available to safety buses from auxiliary transformer.	12	0.012	II LOOP	With the unit in power operation, startup, hot standby, or hot shutdown loss of power source(s) available to all emergency buses such that loss of an additional power source will result in a Category 1 or full LOOP -OR- all offsite power sources supplying an emergency bus or train are lost.	47	0.046
II.b. Questionable supply from startup/shutdown source; main generator remains online and power available to safety buses from auxiliary transformer.	7	0.007	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 for the emergency buses or their availability is uncertain based on grid system evaluations.	1	0.001

Table 1-4 (continued)
LOOP Event Frequency Comparison for Years 2006-2015

Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for years 2006-2015 using -PRE 2016 categories				Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for Years 2006-2015 using 2016 Categories			
Category	**Number of Events**	**Rate (per unit calendar-yr)***		**Category**	**Category Definition**	**Number of Events**	**Rate (per unit calendar-yr)***
III. Unit auxiliary source of power for the safety buses becomes de-energized or unavailable, but offsite power is available from a startup/shutdown source.	8	0.008		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.	14	0.014
IV. Total loss of offsite power during cold shutdown due to outage-related maintenance activities.	8	0.008		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
Total for all Categories in 2006-2015	**70**	0.068			Total for all Categories in 2006-2015	**96**	0.093
Based on 1026.96 unit calendar-years of operation from 2006-2015.				Based on 1026.96 unit calendar-years of operation from 2006-2015.			

2
SUMMARY OF SIGNIFICANT OCCURRENCES FOR 2015

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 above. This section provides a description of the events that occurred in calendar-year 2015, 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.

Total Losses of Offsite Power

During the year 2015, there were two losses of all offsite power (LOOPs) at U.S. nuclear power plants (category I.a or I.b). These two events (one initiating condition affecting two units at one station) 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 2015 is in the lower portion of the expected range. It should also be noted that each unit that experiences a LOOP is accounted for as a separate event.

Table 2-1
Category I Losses of All Offsite Power at U.S. Nuclear Plants in 2015

Date and Category	Plant Name	Duration (hr:min)	Summary
4/7/2015 I.b (two events)	Calvert Cliffs Units 1 and 2	0:00:47 (47 seconds)	A fault on an offsite transmission line, resulted in an undervoltage (approximately 11% drop) condition at the plant, causing all four safety busses to isolate and both units to trip. Offsite power was not available to the buses due to the undervoltage condition. The faulted line was isolated from the plant and voltage was restored in about 47 seconds. Offsite power was available at this time and was reconnected to the safety busses 20 minutes later.

Calvert Cliffs Units 1 and 2 (April 7, 2015) [Category I.b]

On April 7, 2015 at 12:39:03 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. 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 deenergized 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. All of the emergency diesel generators (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 deenergized for about 20 minutes.

At 12:40:14, the breakers associated with the faulted transmission line opened, and at 12:40:30 the 500 kV switchyard voltages 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 a transmission line fault that resulted in an extended 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.

Sources

LER 317-2015-002-00, Calvert Cliffs Unit 1 and Unit 2 Automatic Reactor Trips Due to a Transmission System Disturbance.

NRC Event Report No. 50961, Dual Unit Automatic Reactor Trips Due to a Voltage Transient Resulting in Generator Trips.

NERC Report: Washington D. C. Area Low Voltage Disturbance Event of April 7, 2015; September 2015.

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

Events involving a partial loss off offsite power (Categories II - IV.a) are summarized in Table 2-2 and described further below. There were five such events in 2015.

Table 2-2
Partial Losses of Offsite Power at U.S. Nuclear Plants in 2015

Date and Category	Plant Name	Summary
1/27/2015 II	Pilgrim	Severe winter storm Juno caused faulting of both 345 kV main transmission (and offsite power) lines due to flashovers from snow and salt accumulation. Loss of these lines resulted in a generator load rejection and reactor scram. An alternate 23 kV shutdown power source remained available during the event.
09/17/2015 II	St. Lucie Unit 1	Protective boots for a bus bar bolted connection were not properly installed during initial plant construction. This caused a bus fault and the loss of an associated startup transformer on each unit. Unit 1 was at 100% power and Unit 2 was in Mode 5 at the beginning of a refueling outage. Shutdown cooling was not affected, and Unit 1 event involved the loss of one offsite power source to all trains.
11/18/2015 IV.a	Turkey Point Unit 3	With the unit in Mode 5 following refueling, an unexpected relay actuation in the switchyard caused loss of offsite power to both vital buses. Both buses were then supplied with power from diesel generators, although one had to be started and connected manually to the bus.
11/27/2015 II	River Bend	Animal waste deposition caused a single phase fault in one of the offsite supply circuits in the switchyard. This caused a loss of offsite power to one of two division safety buses with diesel generators starting and loading. The transient caused a loss of power to the reactor protection system and a reactor scram.
12/7/2015 II	Oconee Unit 3	With the unit at 100% power, a drop line connector cable from the 230 kV overhead supply to the unit startup transformer was discovered broken during a daily inspection in accordance with IER L2-12-14. The broken connector made the normal offsite power sources unavailable, however other offsite sources were available. Normal offsite power was restored later.

Pilgrim (January 27, 2015) [Category II]

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. Emergency diesel generators were started and loaded on the safety related busses. At 0235 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 off-site supply. This resulted in loss of power to all non-safety related buses. The alternate off-site 23 kV supply through the shutdown transformer (a credited source) remained available throughout the event, and the station did not experience a complete loss of off-site 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.

Sources

LER 293-2015-001-00, "Loss of 345kV Power Resulting in Automatic Reactor Scram During Winter Storm Juno", March 30, 2015.

NRC Event Report No. 70769, "Automatic Reactor Scram on Turbine Trip Due to Loss of Offsite Power."

NRC Preliminary Notification of Event or Unusual Occurrence – PNO-1-15,001, "Pilgrim Nuclear Power Station: Shutdown of Greater than 72 hours due to Reactor Scram Following a Partial Loss of Offsite Power."

St. Lucie Units 1and 2 (9/17/2015) [Loss of a Startup Transformer – Unit 1: Category II, Unit 2: Not Categorized, Of Interest]

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.

Sources

LER 389/2015-002-00, "2A Emergency Diesel Generator Actuation Logic," November 16, 2015.

NRC Event Report No. 51423, "Valid Actuation of UV Relays Following Loss of Unit 2 Startup Transformer," September 24, 2015.

Turkey Point Unit 3 (11/18/2015) LOOP to Required Safety Bus During Cold Shutdown following core reload (Category IV.a)

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 4160 V 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 historical 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.

Sources

LER 250/2015-001-00, "Diesel Generator Start Resulting From Switchyard Protective Relay Actuation," January 19, 2016.

NRC Event Report No. 51547, "Automatic Actuation of Emergency Diesel Generator," November 18, 2015.

NRC Event Report No. 51551, "After-the-Fact Notification of Unusual Event," November 19, 2015.

River Bend (9/17/2015) Category II

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."

Sources

LER 548/2015-009-00, "Automatic Reactor Scram Due to Partial Loss of Offsite Power Caused by Fault in Local Switchyard," January 26, 2016.

NRC Event Report No. 51568, "Automatic Reactor Scram Following Partial Loss of Offsite Power," November 27, 2015.

Oconee 3 (December 7, 2015) [Category II]

On December 7, 2015 at approximately 0820, 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 Loss of Offsite Power (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 0755 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.

Sources

LER 287-2015-002-00, "Broken Electrical Conductor Supplying Unit 3 Start-up Transformer," February 5, 2016.

Other Events of Interest

Four events entailed partial losses of offsite power that are not assigned to one of the categories described above. These events are summarized in Table 2-3. Because of the possibility that they could be precursors to more serious events, they have been included for information. The events are listed in chronological order.

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

Plant Name and Date	Summary
River Bend 3/7/2015	With the unit in cold shutdown, loss of offsite power to Division 2 electrical system occurred due to electricians making contact with abandoned trip circuitry wires while working in a cabinet. Division 1 power was not affected and shutdown cooling was maintained.
Clinton 6/25/2015	With the unit at 99% power and thunderstorms in the area, offsite power was momentarily lost to Division 1 following a lightning strike. The static VAR compensator associated with the emergency reserve auxiliary transformer tripped, but due to the short duration of the voltage reduction, the bus did not fast transfer nor did the associated diesel start.
Browns Ferry Unit 3 8/20/2015	With the unit at 100% power, while installing test equipment, the normal feeder breaker for shutdown board 3ED opened and the associated emergency diesel started and supplied the board. The cause of this event was not definitely identified, but may have been associated with human performance.
St. Lucie Unit 2 9/17/2015	Protective boots for a bus bar bolted connection were not properly installed during initial plant construction. This caused a bus fault and the loss of an associated startup transformer on each unit. Unit 1 was at 100% power and Unit 2 was in Mode 5 at the beginning of a refueling outage. Shutdown cooling was not affected, and Unit 1 event involved the loss of one offsite power source to one train.

River Bend (March 7, 2015) [Not Categorized; Event of Interest]

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 diesel generator (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.

Sources

LER 459/2015-002-00, "Emergency Diesel Generator Start Circuit Actuation Due to Loss of Power from Reserve Station Service No. 2," May 5, 2015.

NRC Event Report No. 50872, "Specified System Actuation Due to Loss of One Reserve Station Service Offsite Power Source," March 8, 2015.

Clinton (6/25/2015) Uncategorized, Of Interest

On 6/25/15 at 0301 CDT 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 from 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 0457 CDT 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.

Sources

LER 461-2015-004-00, "Trip of Emergency Reserve Auxiliary Transformer Static VAR Compensator Causes Positive Secondary Containment Pressure Following Lightning Strike on 138 kV Offsite Source," August 24, 2015.

NRC Event Report No. 51179, "Secondary Containment Pressure Increase due to Voltage Transient," June 25, 2015.

Browns Ferry Nuclear Plant Unit 3 (8/20/15) [Not Categorized, Of Interest]

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 Emergency Diesel Generator started and fast tied on to the board.

On August 21, 2015 at 01:36 hours, the Emergency Diesel Generator 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.

Sources

LER 296/2015-005-00, “Automatic Actuation of 3D Diesel Generator Due to 4kV Shutdown Board Trip During Testing”, October 19, 2015.

NRC Event Report No. 51333, “Automatic Start of an Emergency Diesel Generator on Low Bus Voltage”, August 20, 2015.

3
EVALUATION OF OPERATING EXPERIENCE

This section summarizes the rate and duration of LOOP events that occurred in 2015 and describes the trends over the past 10 years. As described in Section 1, category definitions have been refined and changed this year, 2016. Events occurring in the previous ten-year period were examined and re-assigned categories consistent with the 2016 definitions. Most event category changes involved events previously uncategorized (of interest) to Category II.

Experience for 2015

Table 3-1 summarizes the loss-of-offsite-power experience for the year 2015. The number of Category I LOOPs in a given year has in recent years been seven or less, depending on weather and other initiating events. In the past year (2015) the number of Category I.a and I.b LOOPs has decreased to 2 from 5 in 2013 and remained at 2 in 2014 and 2 in 2015. In 2015, there were no Category I.a LOOPS, where the duration was greater than 30 minutes. The two Category I.b LOOPs (at a single plant) had durations of only 47 seconds.

Category I.c, II, III, and IV events involving partial losses of offsite power are also important. A common characteristic of previously reported partial losses of offsite power was that the main generating unit and the reactor tripped in the course of the event. In 2015, two of the four partial LOOP events included a trip of the main generating unit and/or a reactor trip. Other uncategorized events involving partial losses of offsite power have been included for information, as some of these may have involved circumstances or conditions that could be precursors to more serious events.

Summary of Experience for 2006 – 2015

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 illustrate the overall experience involving losses of offsite power for the 10-year period 2006 through 2015. There were 30 total losses of offsite power (categories I.a and I.b) in a total of 1026.96 generating unit years (Table 3-6). This is equivalent to 0.029 events per generating unit-year. Data collected over the long term (rolling ten-year periods) indicates an upward trend in both event frequency and event duration to the period of 2013-2014. In 2013, the event frequency was at a maximum and was lower in 2014 and 2015. In 2014, the event duration was at a maximum and decreased in 2015, as depicted in Figure 3-1. It is clear, however, that the frequency of losses of offsite power is affected significantly by weather and grid conditions beyond the plant switchyards (see Figure 3-2). The events caused by weather and grid conditions tend to be of longer duration.

Table 3-1
Number of Offsite Power Events at U.S. Nuclear Plants (By Generating Unit) for Year 2015

Category	Category Definition	Number of Events	Rate (per unit calendar-yr)*
Ia LOOP	At power - hot shutdown, loss off all offsite power to emergency buses > 30 minutes.	0	0.000
I.b LOOP	At power - hot shutdown, loss off all offsite power to emergency buses 15 sec to < 30 minutes.	2	0.020
	Total for categories Ia and I.b	**2**	0.020
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 such that 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.	4	0.040
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.	1	0.010
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
	Total for all Categories in 2015	**7**	0.071

*Based on 99.00 unit calendar-years of operation in 2015.

Table 3-2
Losses of Offsite Power at U.S. Nuclear Plants for (2006 through 2015)

Category	Category Definition	Number of Events	Rate (per unit calendar-yr)*
Ia LOOP	At power - hot shutdown, loss off all offsite power to emergency buses > 30 minutes.	27	0.026
I.b LOOP	At power - hot shutdown, loss off all offsite power to emergency buses 15 sec to < 30 minutes.	3	0.003
	Total for categories Ia and I.b	**30**	0.029
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.	4	0.004
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 such that 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.	47	0.046
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.	1	0.001
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.	14	0.014
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
	Total for all Categories in 2006-2015	**96**	0.093
	Based on 1026.96 unit calendar-years of operation from 2006-2015.		

* Based on 1026.96 unit calendar-years of operation from 2006-2015.

Table 3-3
Losses of Offsite Power at U.S. Nuclear Plants by Event Category and Year (2006 through 2015)

Year	I.a	I.b	I.c	II	III	IV.a	IV.b	Interest	Total
2006	4	0	1	0	1	0	0	2	8
2007	0	0	0	1	0	3	0	0	4
2008	4	0	1	1	0	2	0	3	11
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	11
Total	27	3	4	47	1	14	0	23	119

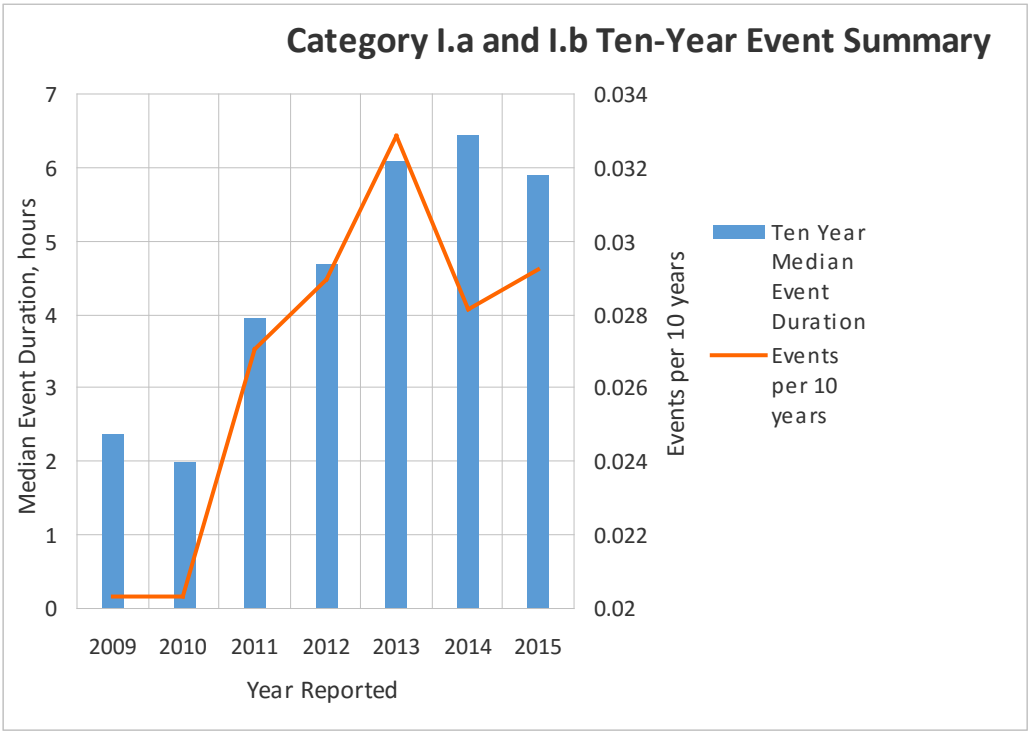

Figure 3-1
Ten-Year Category I Frequency and Duration: Summary

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 2006 through 2015. This is shown below in Table 3-4 and in Figure 3-2, “Category I Events by Initiating Situation”. In Table 3-4, the letters following the durations (W= weather related; S=seismic related) indicate the types of events. The chart presents this type of information graphically, by initiating situation, e.g., weather, plant problems, or switchyard/transmission system problems.

Table 3-4
Category I Losses of Offsite Power at U.S. Nuclear Plants for (2005 through 2015)

Year	Number of Events	Durations
2006	4	6:40, 6:27, 7:19, 12:00
2007	0	
2008	4	0:37, 0:57, 1:29, 27:36
2009	3	2:00, 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, 5:26, 5:34, 33:53
2013	5	8:02 (W), 8:02 (W), 27:36, 27:36, 30:43 (W)
2014	2	5.55
2015	2	0:00:47

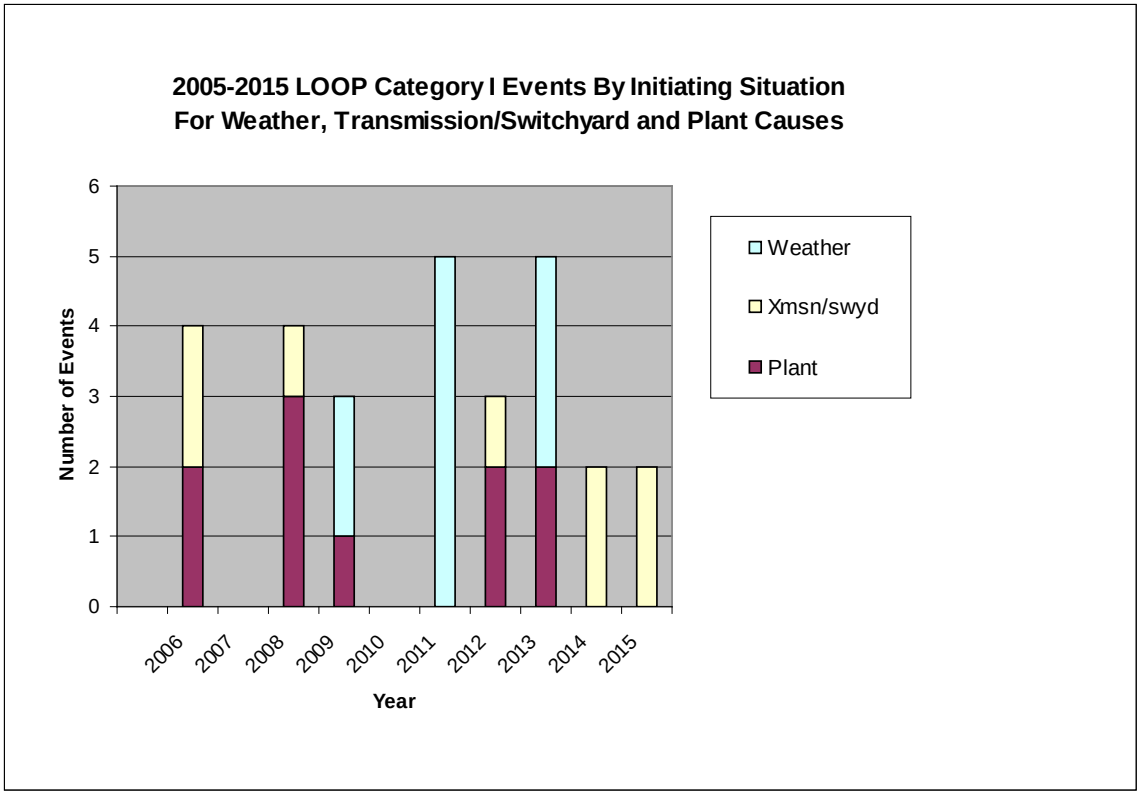

Figure 3-2
Category I Events by Initiating Situation (2006–2015)

A compilation of the initiating events and complicating factors for the 30 events in Category I.a and I.b that occurred in the ten-year period from 2006 through 2015 is presented in Table 3-5. Thirteen of the thirty events were potentially avoidable and involved errors noted in the table. Three of these errors were related to the initiating cause of the event, and the remaining ten manifested following the initiating event and contributed to the progression of the initiating event to a Category I or total LOOP. There were no events in 2015 where error was a factor in total Category I LOOPs. However, two Category II events and two events of interest occurred in 2015 where errors contributed to the events.

The median duration of all 30 events involving a total loss of offsite power during the past 10 years was 5.92 hr. The median duration of the 10 weather-related events during the most recent ten-year period was about 8.03 hours, while the median duration of the 20 non-weather-related losses of all offsite power was 5.68 hours. Equipment failures in the plant and switchyard caused losses with median durations of 5.68 hours. The median duration of losses associated with transmission system failures was 5.92 hours.

Table 3-5
Initiating events causes for Category I.a and I.b events in U.S. Nuclear Plants (2006 through 2015)

Nature of Initiating Event	Number of Events	Median Dur. (hr)	No. Events Potentially Avoidable	Avoidable Event Error Summaries
Weather - related	10	8.03	2	Switchyard grounding system degradation due to poor workmanship during construction
Equipment failure/ degradation in plant	8	4.19	3	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	8	5.92	6	Legacy errors, Incorrect relay settings; Incorrect relay settings did not recognize coupling of adjacent transmission lines;
Earthquake	2	3.5	0	Not applicable
Workmanship	2	27.6	2	Vendor workmen cut cable
Total	**30**		**13**	

Figure 3-1 presents the median LOOP duration (in hours) and the event frequency for the ten-year periods ending in 2009 through 2015. The graphs utilized data from a ten-year period, and some data for years 1999 and 2000 was not available for the year 2009 and 2010 points. Note that with the exception of the past two years (2014 and 2015) since 2010 there has been an increasing trend both in the duration of category I LOOP events and in their frequency. While weather was a predominant cause of these events in several of the years, it is not the only significant factor. As discussed above regarding Table 3-5, thirteen errors were noted associated with the thirty Category I events occurring between 2006 and 2015 that significantly contributed the progression of an event to a total LOOP.

Although weather did not result in any Category I LOOPs in 2015, it continues to be an important factor in long-term offsite power experience. In the ten-year period from 2006 through 2015, 10 of the 30 Category I LOOP events were related to weather. In 2015, there were two partial losses of offsite power that were weather related. During 2008, Hurricane Gustav caused a unit to be taken off-line for an extended period but did not cause a loss of all offsite power.

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.

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 2005-2015

Year	Unit Calendar-Years
2006	103.0
2007	103.66*
2008	104.00
2009	104.00
2010	104.00
2011	104.00
2012	104.00
2013	101.31**
2014	99.99***
2015	99.00
Total	1026.96

*Browns Ferry 1 returned to service in May of 2007.
** The following four plants ceased operation in 2013:
- Crystal River (2/5/2013)
- Kewaunee (5/7/2013)
- San Onofre 2 & 3 (6/6/2013)

*** Vermont Yankee ceased operation in 2014 (12/29/2014).

A
LOSS OF OFFSITE POWER EVENTS 2006-2015

Category I-a Events

No category I-a events occurred in 2015.

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 deenergized both UATs. Hence, both the two SATs and two UATs were deenergized, 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 properly the period until offsite power could have been restarted which was something 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);
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 2: 11/01/06

Restore Time: 12:00 hours;
Power: 100%;
LER (324) 06-002, 12/29/06.

With Unit 2 at 100% power output, one of the output bus bar connections of the Unit's startup transformer failed. Because the reactor recirculation pumps were being powered from the startup transformer, the Unit was manually tripped to preclude potential thermal-hydraulic instability. The Unit trip in-turn deenergized the unit auxiliary transformer. With deenergization of both the startup and unit auxiliary transformers, there was a loss of all offsite power to the Unit's safety buses. Both of Unit 2's emergency diesel generators started and loaded. The high voltage switchyard remained energized from offsite power throughout this event.

Had the need existed, offsite power could have been restored to the Unit 2 safety buses in something less than 12 hours, perhaps substantially less. However, to be conservative, the LOOP duration has been indicated at 12 hours. Because the Unit's two EDGs were operating without problems, the transfer back to offsite power was made later at a less stressful time in the overall recovery effort. This occurred 23:22 hrs after the event began.

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: 33:52 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: 05/20/06

Unit 1 – Restore Time: 6:40 hours; Power: 100%;
Unit 2 – Restore Time: 6:27 hours; Power: 100%;
LER (413) 06-001, 07/19/06.

Both Catawba Units tripped automatically from 100% power and there was a loss of all offsite power to both units. The two Catawba Units feed into a 230kV switchyard. The switchyard is also the offsite power source for the plant loads of both units. The switchyard has a breaker and a half arrangement with two main buses and twenty four 230kV circuit breakers.

The event was initiated by the failure of a current transformer associated with one of the switchyard breakers. Per the design and without further problems, this fault would have isolated without either Unit tripping or losing offsite power. However the initial fault conditions somehow also induced a failure in a current transformer at another breaker. Also certain of the differential relay tap settings were incorrect due to a change notice oversight in 1981. The combined result was that various differential relays activated and both main 230kV switchyard buses were isolated. Both Units 1 and 2 tripped automatically and were disconnected from their sources of offsite power. Each Unit has two emergency diesel generators (EDGs). All four EDGs started and loaded.

Offsite power was restored to the Unit 1 6.9kV buses that power plant loads 6:40 hrs after the event began. Offsite power was restored to the Unit 2, 6.9kV buses after 6:27 hrs. Because the EDGs were operating successfully and offsite power was available if needed, the transfer of the 4.16kV essential auxiliary (safeguard) buses to offsite power could be initiated at a more convenient moment in the overall recovery effort. This occurred several hours later.

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 loss of offsite power (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 Emergency Diesel Generators 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 loss of offsite power (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 deenergized. This resulted in deenergization 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 deenergization 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 deenergized 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 4.16kV 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: 10/07/06

Restore Time: 7:19 hours;
Power: 100%;
LER (281) 06-002, 12/05/06.

With both Units 1 and 2 at 100% power, a spurious protection signal momentarily closed the Unit 2 turbine governor and intercept valves. They immediately reopened when the signal cleared. About 20 seconds after the initial alarms, and after learning of a steam leak in the turbine building, operators manually tripped Unit 2.

The reported steam leak was actually the lifting of the Unit 2 cross-under safety valves. The safety valve discharge caused turbine building siding to detach and contact the bus bars on 2 of the plant's 3 Reserve Station Service Transformers. The result was that offsite power was lost to both of Unit 1's two safety buses and one of Unit 2's two safety buses. The other Unit 2 safety bus continued to be energized from offsite power throughout the event. EDG 3 repowered the Unit 2 safety bus that lost offsite power. EDG 1 repowered one of the Unit 1 safety buses that lost offsite power. Reenergization of the other Unit 1 safety bus from an AAC EDG was delayed about 2 hours because its EDG load breaker would not close due to a control circuit design deficiency.

Offsite power was available to power both units' safety buses 7:19 hrs after the event began. Because the EDGs were successfully powering the Unit 1 safety buses, and one Unit 2 safety bus had offsite power, and EDG 2 had become available to power the other Unit 2 safety bus, the transfer back to offsite power for all the safety buses was made at a later more convenient moment in the overall recovery effort. This occurred 9:01hrs after the event began.

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 loss of all offsite power. 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 emergency diesel generators (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 loss of offsite power 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 0112 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 0626 hrs, at which time the bus was powered by its alternate offsite power supply. The cause of the relay action that deenergized 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.

Category I-b Events

Two category I-b events occurred in 2015.

Calvert Cliffs Units 1 and 2 (April 7, 2015)

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 deenergized 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 emergency diesel generators (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 deenergized 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.

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 emergency diesel generators (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.

Category I.c Events

No category I.c events occurred in 2015.

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 units' EDGs ran or were required to run. The precautionary condition existed for 5 hours and 50 minutes.

San Onofre 2 and 3: 02/03/06

Unit 1 – Power: 0%, shutdown for refueling; Not categorized
Unit 2 – Power: 100%; Category I.c
LER (361) 06-002, 04/03/06.

On 02/03/06 at 16:46 PST the Devers – Palo Verde 500kV transmission line tripped. Following this the Grid Control Center notified San Onofre that its nomograms indicated offsite power voltage at San Onofre would not be within limits if San Onofre 3 were to trip. Additional generation was added to the system and offsite power was declared operable 1:57 hrs after the Devers – Palo Verde line tripped.

Category II Events

Three category II events occurred in 2015.

ANO Units 1 and 2: 12/9/13

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 emergency diesel generator 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: 3/31/13

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 deenergized as designed, which, in turn deenergized 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.

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 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. Anew 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.

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 deenergized 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: 6/23/13

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 emergency diesel generators (EDG), 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 emergency diesel generators (EDG). 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 deenergized 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 2was 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 emergency diesel generator 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 deenergized 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.

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 deenergized 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 deenergized 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 emergency diesel generators 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 emergency diesel generators started and repowered these buses. Offsite power remained and was at all times available for each unit's non-affected emergency bus.

The deenergization 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 deenergization 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 autostart. This autostart 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%.

Oconee 3: December 7, 2015

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

On December 7, 2015 at approximately 0820, 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 Loss of Offsite Power (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 0755 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 Emergency Diesel Generators 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: 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 emergency diesel generators 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: January 27, 2015

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. Emergency diesel generators 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: 2/6/13

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 emergency diesel generators 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: 9/17/2015

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: 2/8/13

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 loss of offsite power (LOOP). The partial LOOP deenergized 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 loss of offsite power. 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 emergency diesel generators. 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: 9/17/2015

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.

Surry 2: 10/07/06

Restore Time: 7:19 hours;
Power: 100%;
LER (281) 06-002, 12/05/06.

With both Units 1 and 2 at 100% power, a spurious protection signal momentarily closed the Unit 2 turbine governor and intercept valves. They immediately reopened when the signal cleared. About 20 seconds after the initial alarms, and after learning of a steam leak in the turbine building, operators manually tripped Unit 2.

The reported steam leak was actually the lifting of the Unit 2 cross-under safety valves. The safety valve discharge caused turbine building siding to detach and contact the bus bars on 2 of the plant's 3 Reserve Station Service Transformers. The result was that offsite power was lost to both of Unit 1's two safety buses and one of Unit 2's two safety buses. The other Unit 2 safety bus continued to be energized from offsite power throughout the event. EDG 3 repowered the Unit 2 safety bus that lost offsite power. EDG 1 repowered one of the Unit 1 safety buses that lost offsite power. Reenergization of the other Unit 1 safety bus from an AAC EDG was delayed about 2 hours because its EDG load breaker would not close due to a control circuit design deficiency.

Offsite power was available to power both units' safety buses 7:19 hrs after the event began. Because the EDGs were successfully powering the Unit 1 safety buses, and one Unit 2 safety bus had offsite power, and EDG 2 had become available to power the other Unit 2 safety bus, the transfer back to offsite power for all the safety buses was made at a later more convenient moment in the overall recovery effort. This occurred 9:01 after the event began.

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 1353 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 deenergized.

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 deenergization 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 deenergization 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 Emergency Diesel Generators 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.

Category III Events

No category III events occurred in 2015.

Ginna: 07/17/06

Power: 100%;
LER (244) 06-002, 09/12/06.

The referenced LER describes 3 instances when a post-contingency low voltage alarm was received at Ginna for the offsite power system. These were received on 07/17/06 (duration 0:30 hrs), 08/01/06 (duration 8:21 hrs) and 08/02/06 (duration 5:28 hrs). They were reported in one LER and are reported in this one entry because of their common nature. Subsequent re-analysis demonstrated that on 07/17/06, post-trip voltages would have been above the alarm setpoints and that event has been retracted from the LER. The minimum required post-contingency 115kV switchyard voltage is 108.9kV. Below this the calculated post-contingency low voltage alarm is activated.

Ginna has initiated a number of actions to correct this problem. They have asked RG&E to review and where appropriate improve the accuracy of the state estimator model. One improvement is to have the estimator model make its determinations based on the grid's generator voltage regulators being on automatic. Another action is for the New York Independent System Operator to provide additional voltage support (reactive power) on the 345kV system when an alarm occurs. In the longer term RG&E plans to add substantial additional capacitor capacity to their transmission system and to strengthen the ties between Ginna and the 345kV transmission system.

Category IV-a Events

One category IV-a event occurred in 2015.

ANO Unit 1: 3/31/13

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 emergency diesel generators (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 emergency diesel generators (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: 3/15/14

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 loss of offsite power (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.

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 deenergized 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: October 5, 2012

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

On October 5, 2012, at 1301 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 2011 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 Loss of Offsite Power (LOOP) event was experienced due to equipment damage caused by the winds associated with hurricane Sandy. Upon loss of power, both emergency diesel generators 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.

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 deenergized 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.

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 1353 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 deenergized.

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 deenergization 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 deenergization 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 loss of offsite power event (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.

Uncategorized Events of Interest

Five uncategorized events of interest occurred in 2015.

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

deenergized 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 deenergized 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 deenergization 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 Nuclear Plant Unit 3: (8/20/15) [not categorized, of interest]

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 Emergency Diesel Generator started and fast tied on to the board.

On August 21, 2015 at 01:36 hours, the Emergency Diesel Generator 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: (6/25/2015)

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: 6/15/13

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 deenergized and were restored by Emergency Diesel Generators 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: 4/24/13

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

On 04/24/2013, Unit 1was 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 emergency diesel generator (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: 2/28/2013

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 deenergized, 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 deenergized 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 – Unit 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: 04/06/2012

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.

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 deenergized 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: 6/13/13

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 Unit 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 emergency diesel generator to a different offsite power source.

River Bend: (March 7, 2015)

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 diesel generator (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: 10/03/12

Unit 2 – 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 Unit 2: (9/17/2015)

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 emergency diesel generator 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 emergency diesel generators 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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