8.2 Offsite Power System

8.2.1 Description

8.2.1.1 Offsite Power

The offsite power system provides power from the transmission system, via the station switchyard, to the plant Class 1E and non-Class 1E electrical distribution system. The offsite power system includes all transmission lines connected to the switchyard, the switchyard equipment (overhead buses, circuit breakers, disconnect air switches), auxiliary transformers, and ends at the input terminals of the switchgear circuit breakers. The preferred power supply (PPS) is the offsite power from the transmission system to the Class 1E emergency power supply system (EPSS) that is preferred to provide power under accident and post-accident conditions. The offsite transmission system and connections to the station switchyard are site-specific. A COL applicant that references the U.S. EPR design certification will provide site-specific information regarding the offsite transmission system and connections to the station switchyard.

The switchyard has connections to at least two transmission lines. The normally energized transmission lines are physically independent circuits that minimize the likelihood of their simultaneous failure under operating and environmental conditions and postulated events, including transmission tower or transmission line failure. These lines do not cross, and no other transmission lines cross above these two lines. Each offsite power circuit is sized to supply the station safety-related and non-safety-related loads during normal and abnormal operation.

The PPS supplies the station Class 1E EPSS buses from two independent overhead lines between the switchyard and the station transformer area via two emergency auxiliary transformers (EAT). The station remains connected to the offsite power sources during normal plant operation regardless of main generator status, without transferring buses or power sources during startup, full power operation, or shutdown. Each PPS circuit is normally in service through its respective EAT.

Three additional overhead lines provide power to three normal auxiliary transformers (NAT) for the station non-Class 1E normal power supply system (NPSS) buses.

Each auxiliary transformer is provided with two on-load tap changers to maintain the supplied bus voltage at the nominal value during transmission system voltage fluctuations, or voltage changes as a result of changes in bus loading. The reference voltage for the on-load tap changer operation is provided by voltage transformers at the respective bus to which the secondary winding is connected. Momentary bus voltage transients (e.g., motor starting) do not result in tap changers affecting bus voltage due to the short nature of the voltage transient. The voltage regulating range is based on the results of the load flow/voltage regulation studies described in Section 8.3.1.3.1.

Each EAT supplies the alternate power to the EPSS buses supplied by the other EAT. Each EAT has capacity to supply all four EPSS divisions during postulated events to support core cooling, containment integrity and maintain other safety-related function capability. An EAT failure results in the other EAT power source automatically accepting the load of the EPSS buses originally connected to the failed EAT. The EAT protection features and EPSS bus transfer are described in Section 8.3.1.1.1.

The three normally inservice NATs provide power to six NPSS 13.8 kV trains. The offsite source to the NPSS switchgear is arranged so that there is an alternate supply to each bus (similar to the EAT configuration). NAT protection features and NPSS bus transfer are described in Section 8.3.1.1.2.

A COL applicant that references the U.S. EPR design certification will provide site-specific information regarding the communication agreements and protocols between the station and the transmission system operator, independent system operator, or reliability coordinator and authority. Additionally, the applicant will provide a description of the analysis tool used by the transmission system operator to determine, in real time, the impact that the loss or unavailability of various transmission system elements will have on the condition of the transmission system to provide post-trip voltages at the switchyard. The information provided will be consistent with information requested in NRC generic letter 2006-02 (Reference 1).

Indications available in the MCR to indicate capability of the PPS to perform its intended function include:

- Status indication (open-close) of the incoming PPS supply breakers at the EPSS switchgear.
- Undervoltage alarms for the Class 1E uninterruptible power supply system, which provides the control power to the PPS supply breakers at the EPSS switchgear.
- Degraded voltage alarm, as sensed at the EPSS bus which is connected to the PPS.
- PPS voltage indication.

Surge and lightning protection of plant equipment, including the auxiliary transformers, is described in Section 8.3.1.3.5. Likewise, equipment grounding is addressed in Section 8.3.1.3.8.

The U.S. EPR does not use an automatic load dispatch system, which eliminates any interference with safety-related actions that may be required of the protection system described in Section 7.1.1.4.1.

8.2.1.2 Station Switchyard

The switchyard layout is site-specific. A COL applicant that references the U.S. EPR design certification will provide site-specific information for the switchyard layout design.

The switchyard provides the connection between the transmission lines, main generator output, PPS to the EPSS buses and the offsite power supply to the NPSS buses. [[The switchyard provides independent circuits and connections for the main step-up transformers (MSU), the three NATs, and the two EATs. Additionally, each of the two circuits from the switchyard connection to the EATs have the capacity and capability to meet power requirements of the safety-related loads for the four divisions of the EPSS distribution system during accident and post-accident conditions.]]

Control of switchyard configuration and components is site-specific. A COL applicant that references the U.S. EPR design certification will provide site-specific information regarding indication and control of switchyard components. [[Control power for switchyard breakers required to connect or disconnect any component of the U.S. EPR from the transmission system is provided by the switchyard batteries. There is a dual set of batteries located inside the switchyard control house. Switchyard breakers operate to clear main generator faults, auxiliary transformer faults, and to clear transmission system faults such as switchyard bus differential or transmission line faults.]]

[[The relay schemes provided for the protection of switchyard equipment include primary and backup relay systems. Switchyard breakers are equipped with dual trip coils. Each relay system is powered from a separate DC power source.]] A COL applicant that references the U.S. EPR design certification will provide site-specific information for the protective devices that control the switchyard breakers and other switchyard relay devices.

8.2.1.3 Transformer Area

The PPS circuits to the EATs are routed to minimize the possibility of simultaneous failure. [[Power cables from the EATs to the EPSS switchgear are contained in underground duct banks. Service from the NATs to the NPSS switchgear is by non-segregated bus duct.]] Where cables are routed through underground cable ducts, provisions are provided to minimize moisture intrusion and capability is provided to periodically monitor and test to detect possible cable degradation as described in Section 8.3.1.1.8.

The physical separation that is provided among the MSUs, NATs and EATs power feeds and control circuits includes these:

- A separate takeoff structure is provided for each preferred power circuit overhead line from the switchyard to the EAT to reduce the likelihood of simultaneous failure of both circuits.
- Power cables between the EATs and 6.9 kV Class 1E switchgear buses are physically independent (to the extent practical) to minimize the likelihood of simultaneous failure.
- Control power to each EAT is separated from each other and the PPS power circuits.
- Each phase of the main generator output is routed to the MSU in an isolated phase bus.
- MSUs and auxiliary transformers are separated from plant buildings in accordance with the guidance provided by RG 1.189.
- EATs are separated from each other and the NATs and MSUs by at least 50 feet or by a one hour rated fire barrier.

The station auxiliary transformer distribution to the EPSS and NPSS is illustrated in Figure 8.3-2—Emergency Power Supply System Single Line Drawing and Figure 8.3-3—Normal Power Supply System Single Line Drawing. Transformer ratings are included in Table 8.3-1—Onsite AC Power System Component Data Nominal Values.

[[The MSU and auxiliary transformers have a deluge fire protection system that provides a distribution spray pattern over the respective transformer for fire suppression. The deluge system is automatically actuated by a heat-sensing device located around the perimeter of the respective transformer or manually activated from the transformer valve station. Additionally, each transformer has an oil retention pit.]]

8.2.2 Analysis

Offsite power meets the acceptance criteria established in 10 CFR 50, Appendix A. Additionally, conformance with the regulations and the recommendations of RGs, BTPs, as well as industry codes and standards adopted by the RGs, is described in Section 8.2.2.1 through Section 8.2.2.7.

8.2.2.1 Compliance with GDC 2

Offsite power system components are designed in accordance with GDC 2 to withstand effects of natural phenomena (excluding seismic, tornado, and flood) without loss of capability to perform their intended functions within the bounding conditions as provided in Table 2.1-1—U.S. EPR Site Design Envelope for conditions such as atmospheric temperatures, wind, rainfall, and snow. Lightning protection of the offsite power components is described in Section 8.3.1.3.5.

8.2.2.2 Compliance with GDC 4

The layout of the offsite power system components is such that they are not subjected to the dynamic effects of missiles that may result from equipment failures during normal operation, maintenance, testing and postulated accidents.

8.2.2.3 Compliance with GDC 5

Because the U.S. EPR design is a single-unit station, there are no shared safety-related structures, systems or components.

8.2.2.4 Compliance with GDC 17

Offsite power complies with GDC 17. This design criterion requires that each plant onsite electrical distribution system is supplied by at least two physically independent circuits designed and located to minimize, to the extent practical, the likelihood of their simultaneous failure during operating and postulated accident and environmental conditions.

The switchyard is connected to a minimum of two independent transmission lines. Two normally energized circuits are provided to connect the switchyard to the EAT high-side connections that provide immediate availability of each offsite power supply to the Class 1E buses. The offsite circuits are independent so that a loss of one circuit, main generator, or onsite power source does not affect the other circuit or sources. The offsite power system function capability is detailed in Table 8.2-1—Offsite Power Failure Modes and Effects Analysis.

Each EAT is normally aligned to two Class 1E divisional buses during normal plant operation. This configuration utilizes no intervening non-Class 1E buses. Class 1E buses do not share a common winding with the transformers supplying the non-Class 1E switchgear. This minimizes the potential effects on Class 1E equipment from non-safety-related load transients and it eliminates additional failure points between the offsite source and the Class 1E equipment. The NAT supply to the NPSS provides a normal and alternate offsite power supply to the non-safety-related plant loads.

Switchyard power system components provide reliable offsite power to plant safety-related systems. Offsite power system functional capability with component failures is demonstrated in Table 8.2-2—Switchyard 125 Vdc Battery System Failure Modes and Effects Analysis.

A COL applicant that references the U.S. EPR design certification will provide a site-specific grid stability analysis. The results of the analysis will demonstrate that:

- The PPS is not degraded below a level that will activate EPSS degraded grid protection actions after any of the following single contingencies:
  - U.S. EPR turbine-generator trip.
  - Loss of the largest unit supplying the grid.
  - Loss of the largest transmission circuit or inter-tie.
  - Loss of the largest load on the grid.
- The transmission system will not subject the reactor coolant pumps to a sustained frequency decay of greater than 3.5 Hz/s as bounded by the decrease in reactor coolant system flow rate transient and accident analysis described in Section 15.3.2.

The U.S. EPR is designed to operate within a transmission system operating voltage of ± 10 percent and not initiate the degraded voltage protection actions as described in Section 8.3.1.1.3. Degraded grid setpoints are provided in Chapter 16, Specification 3.3.1, Table 3.3.1-2. Regulation of the transmission system by the transmission system operator within these limits during normal operation and single contingencies provides sufficient voltage to safety-related loads during design basis events.

The PPS provides two circuits from the transmission system to the Class 1E distribution system through the station switchyard that are sized to supply the maximum expected coincident safety-related and non-safety-related loads during normal and abnormal operations as indicated in IEEE Std 308-2001 (Reference 2) and endorsed by RG 1.32.

8.2.2.5 Compliance with GDC 18

Offsite power complies with GDC 18. The offsite power system is designed to permit periodic testing and inspection of the system and components to assess its performance. A COL applicant that references the U.S. EPR design certification will provide site-specific information for the station switchyard equipment inspection and testing plan.

Surge arresters and the lightning protection system are capable of periodic inspection and testing as described in RG 1.204, Section C.2.

8.2.2.6 Compliance with GDC 33, GDC 34, GDC 35, GDC 38, GDC 41, and GDC 44

Compliance with the design requirements of GDC 33, GDC 34, GDC 35, GDC 38, GDC 41 and GDC 44, are satisfied as they relate to the operation of the offsite power system through compliance with GDC 17, as described in Section 8.2.2.4.

8.2.2.7 Compliance with 10 CFR 50.63

Station blackout diesel generators (SBODG) are provided as an alternate AC source (AAC) in accordance with RG 1.155 for station blackout mitigation if offsite power is lost and there is a subsequent failure of the emergency diesel generators (EDG). The preferred power protection and control schemes are designed such that a loss of offsite power will not prevent the use of the SBODGs. Additionally, preferred power source cables are routed independently of the AAC source such that a failure of the preferred power source does not prevent the use of the AAC. Section 8.4 provides a detailed description of the SBODGs and station blackout mitigation capability, including diversity between the SBODGs and the EDGs. A COL applicant that references the U.S. EPR design certification will provide site-specific information that identifies actions necessary to restore offsite power and use available nearby power sources when offsite power is unavailable.

8.2.2.8 Compliance with 10 CFR 50.65(a)(4)

The description of the program for implementation of 10 CFR 50.65 is described in Section 17.6.

8.2.2.9 Conformance with Branch Technical Position 8-3

Grid stability studies described in Section 8.2.2.4 will demonstrate grid availability as described in BTP 8-3 (Reference 3).

8.2.2.10 Conformance with Branch Technical Position 8-6

Degraded grid voltage protection is provided by a time-delayed degraded voltage monitoring scheme. The analysis, testing and selection of the undervoltage and degraded voltage setpoints and time delays are conducted as described in BTP 8-6 (Reference 4). Section 8.3.1.1.3 provides further information concerning safety-related load protection from degraded grid voltage. Section 8.3.1.3.1 describes distribution system voltage testing related to BTP 8-6.

8.2.3 References

1. NRC Generic Letter 2006-02, "Grid Reliability and the Impact on Plant Risk and the Operability of Offsite Power," U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, February 1, 2006.

2. IEEE Std 308-2001, “IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations,” Institute of Electrical and Electronics Engineers, 2001.

3. BTP 8-3, “Stability of Offsite Power Systems,” U.S. Nuclear Regulatory Commission, Standard Review Plan, Branch Technical Position, Rev. 3, 2007.

4. BTP 8-6, “Adequacy of Station Electric Distribution System Voltages,” U.S. Nuclear Regulatory Commission, Standard Review Plan, Branch Technical Position, Rev. 3, 2007.

Table 8.2-1—Offsite Power Failure Modes and Effects Analysis
Sheet 1 of 2

Item No.	Component Identification	Function	Failure Mode	Failure Mechanism	Effect On System Safety-Related Function	Remarks
1.	Transmission system.	Receives main generator output during plant operation, provides offsite power to plant loads during plant shutdown.	Transmission system becomes de-energized, main generator is available and supplies power to switchyard.	Fault, failure, or operating condition on the transmission system that causes all transmission lines to the switchyard to become de-energized.	None, system does not have a safety-related function.	Transmission system is isolated from switchyard by protective relaying.
2.	Transmission system.	Receives main generator output during plant operation, provides offsite power to plant loads during plant shutdown.	Transmission system becomes de-energized and main generator is not in operation.	Fault, failure, or operating condition on the transmission system that causes the switchyard to become de-energized.	None, system does not have a safety-related function.	Transmission system is isolated from switchyard by protective relaying. Onsite distribution system switchgear is separated from auxiliary transformers on an undervoltage signal. EDGs automatically start to re-energize EPSS buses. SBODGs automatically start and re-energize select NPSS buses. NPSS loads are manually started as needed.

Table 8.2-1—Offsite Power Failure Modes and Effects Analysis
Sheet 2 of 2

Item No.	Component Identification	Function	Failure Mode	Failure Mechanism	Effect On System Safety-Related Function	Remarks
3.	Single transmission line	Receives main generator output during plant operation, provides offsite power to plant loads during plant shutdown.	Loss of single transmission line to switchyard.	Fault or failure on transmission line.	None, system does not have a safety-related function.	Faulted transmission line is isolated by protective relaying. Service to the EATs and NATs is uninterrupted.
4.	PPS circuit from switchyard to EAT	Provides offsite power from the transmission system to the EPSS during normal, accident and post-accident conditions.	Loss of single circuit.	Circuit failure, including ground fault or short circuit.	None, system does not have a safety-related function.	Faulted circuit is isolated by protective relaying. Affected EPSS switchgear aligned to other EAT source via high speed transfer.
5.	Offsite power circuit from switchyard to NAT	Provides offsite power from the transmission system to the NPSS during normal and off normal conditions.	Loss of single circuit.	Circuit failure, including ground fault or short circuit.	None, system does not have a safety-related function.	Faulted circuit is isolated by protective relaying. Affected NPSS switchgear aligned to other NAT source via high speed transfer.

Table 8.2-2—Switchyard 125 Vdc Battery System Failure Modes and Effects Analysis

Item No.	Component Identification	Function	Failure Mode	Failure Mechanism	Effect On System Safety-Related Function	Remarks
1.	Switchyard 480 Vac MCC	AC power source for switchyard battery charger.	Loss of AC bus voltage	MCC failure such as bus fault, cable failure.	None, system does not have a safety-related function.	a. Backup switchyard DC system maintains control and protection capability to switchyard breakers and components.
2.	Switchyard 125 Vdc system battery charger	Maintain respective switchyard 125 Vdc battery charged.	Battery charger failure	Battery charger fault that results in battery charger output failure.	None, system does not have a safety-related function.	a. Backup switchyard DC system maintains control and protection capability to switchyard breakers and components.
3.	Switchyard 125 Vdc battery	Supplies switchyard 125 Vdc control power.	Battery failure	Battery failure resulting in low or no output.	None, system does not have a safety-related function	a. Backup switchyard DC system maintains control and protection capability to switchyard breakers and components. b. Battery charger in affected train continues to carry assigned switchyard loads.
4.	Switchyard DC bus	Supplies switchyard 125 Vdc control power from battery output.	Loss of voltage	DC bus fault such as short circuit.	None, system does not have a safety-related function.	a. Backup switchyard DC system maintains control and protection capability to switchyard breakers and components.

Next File