8.2 OFFSITE POWER SYSTEM

8.2.1 DESCRIPTION

8.2.1.1 Transmission System

The bulk power transmission system of PPL operates at 230 kV and 500 kV. Unit 1 of the Susquehanna Steam Electric Station supplies power to the 230 kV system through a 230 kV switchyard and Unit 2 supplies power to the 500 kV system through a separate 500 kV switchyard. The offsite power system for the plant is supplied through the 230 kV portion of the bulk power system. The bulk power supply system in the vicinity of Susquehanna Steam Electric Station is shown in Figure 8.2-2.

Dwg. D159760, Sh. 1 shows the Susquehanna 230 kV and 500 kV switchyards and the transmission lines associated with each yard and in the vicinity of the plant. The drawing shows the line arrangement with both units in operation. The two switchyards are physically separate and are tied together by a 230 kV yard tie line with a 230-500 kV transformer in the 500 kV yard.

Two independent offsite power sources are supplied to the Susquehanna plant via Transformer T10 and second source T20, and are shared by both units. One source is supplied from the Susquehanna T10 230 kV Switchyard located to the west of the plant; a single-circuit 230 kV line connects the Susquehanna T10 230 kV Switchyard to startup transformer #10 terminal equipment. The Susquehanna T10 230 kV Switchyard consists of three 230 kV bays, all of which can be expanded to a circuit breaker and a half configuration. A total of seven 230 kV circuit breakers are installed. Bay 1 is configured as a double bus double circuit breaker bay and terminates the Susquehanna 230 kV Line. Bay 2 is configured as a circuit breaker and a half bay and terminates the Mountain 230 kV Line and the Susquehanna T10 230 kV Tap to the Unit 1 Start Up Transformer #10. Bay 3 is configured as a double bus double circuit breaker bay and terminates the Montour 230 kV Line.

The Susquehanna T10 230 kV Switchyard is supplied by three 230 kV transmission lines, the Susquehanna T10-Mountain, the Montour-Susquehanna T10, and the Susquehanna-Susquehanna T10 lines. The Susquehanna T10-Mountain line and the Montour-Susquehanna 230 kV line share double circuit structures from the Susquehanna T10 230 kV Switchyard northeast to a point where the Mountain-Susquehanna 230 kV line branches off to the east. Four spans northeast and east of this point, the Susquehanna T10-Mountain 230 kV line and Susquehanna-Susquehanna T10 line begin sharing double circuit structures due east, to where the two circuits split as shown in Dwg. D159760, Sh. 1. The Susquehanna T10-Mountain 230 kV line extends north on double structures with the Susquehanna-Mountain 230 kV line and terminates in the Mountain Substation. The Susquehanna-Susquehanna T10 230 kV Line extends south on double circuit structures with the Susquehanna-Mountain 230 kV Line and terminates in the Susquehanna 230 kV Switchyard.

Two spans from the Susquehanna T10 230 kV Switchyard, the Montour-Susquehanna T10 230 kV line joins the Montour-Susquehanna 230 kV circuit on double circuit structures and extends to final termination point in the Montour Switchyard.

The total distance of the Susquehanna T10-Mountain line from the Susquehanna T10 230 kV Switchyard to the Mountain Substation is 18.9 miles. The total distance of the

Montour-Susquehanna T10 line from the Montour Switchyard to the Susquehanna T10 230 kV Switchyard is 29.9 miles. The total distance of the Susquehanna-Susquehanna T10 Line from Susquehanna 230 kV Switchyard to the Susquehanna T10 230 kV Switchyard is approximately 3 miles.

Several lines feed the Montour 230 kV Switchyard and Mountain 230-69 kV Substation (Figure 8.2-4). These lines offer a multitude of possible supplies for the Susquehanna startup transformer #10. Montour Switchyard is supplied directly by generation from the Montour Steam Electric Station. Other generating stations are indirectly linked by the bulk power grid system. The conductors for the Montour-Susquehanna T10, Susquehanna T10-Mountain lines and the conductors for the Susquehanna-Susquehanna T-10 Line are 1590 kcmil 45/7 ACSR and are supported by single string insulator assemblies. Maximum conductor tension is limited to 16,000 pounds on steel pole line sections and 21,900 pounds on lattice tower sections under maximum anticipated loading conditions.

The second offsite power source is supplied at 230 kV from the yard tie circuit between the Susquehanna 500 kV and 230 kV Switchyards south of the Susquehanna Steam Electric Station. The source is provided one span tap from the 230 kV yard tie circuit to startup transformer #20.

The yard tie line consists of 230 kV double circuit structures, in which both circuits are electrically tied together to form one high capacity 230 kV Line. The circuits are tied together to form a two conductor per phase single circuit line. The single span tap to transformer #20 is composed of single-conductor per phase line. The distance from the tap point west to the 500 kV yard is 1500 ft. The distance from the tap point east to the 230 kV yard is 1.6 miles. Maximum conductor tension is limited to 16,000 pounds in the yard tie line under maximum loading conditions.

The second offsite power supply is furnished by the multiple sources throughout the bulk power grid system through the 230 kV and 500 kV lines emanating from the Susquehanna 230 kV and 500 kV switchyards. See Figure 8.2-3.

All PPL EU transmission lines are engineered in accordance with PPL EU design criteria, which meets or exceeds design requirements set forth by the National Electric Safety Code (NESC) and other industry standards. PPL EU lines are designed to sustain extreme weather events such as high winds and heavy ice, lines also comply with the Army Corps of Engineers requirements for clearance over flood levels. Overhead shield wires or optical ground wires are employed on the transmission lines above the phase conductors to provide lightning protection. A relay protection system is used to protect the public safety and welfare, as well as equipment on the transmission system in the event of a fault.

Talen Energy transmission lines which are installed for a future tap from the 500 kV generator tie line to the future Talen Energy 500 kV Substation are engineered in accordance with PJM design criteria and the National Electric Safety Code (NESC). The Talen Energy transmission lines are designed to sustain extreme weather events such as high winds and heavy ice. Overhead shield wires are employed on the transmission lines above the phase conductors to provide lightning protection.

No transmission lines cross over the Susquehanna 500 kV to 230 kV yard tie line or the two tap lines supplying transformers #10 and #20. The Montour-Susquehanna 230 kV Line crosses over both the Mountain-Susquehanna T10 230 kV line and the Montour-Susquehanna

T10 230 kV Line where they share double circuit structures. The Susquehanna-Susquehanna T10 230 kV Line crosses over the Montour- Susquehanna 230 kV line. The Susquehanna-Lackawanna 500 kV Line crosses over the Montour-Susquehanna 230 kV Line and the Montour-Susquehanna T10 230 kV Line.

No single disturbance in the bulk power grid system will cause complete loss of offsite power to the Susquehanna SES. This is a basic system design criteria.

8.2.1.2 Transmission Interconnection

PPL is a member of PJM, Inc. which permits exchanges of power with neighboring utilities and provides emergency assistance under Independent System Operator (ISO) direction. Direct bulk power ties are between PPL and PECO Energy (formerly Philadelphia Electric), Luzerne Electric Division of UGI, Metropolitan Edison, Pennsylvania Electric, Jersey Central Power and Light, Public Service Electric and Gas, and Baltimore Gas and Electric Companies.

8.2.1.3 Switchyards

8.2.1.3.1 Startup Transformers #10 and #20

The Susquehanna T10 Tap 230 kV line from the Susquehanna T10 230 kV Switchyard and the 230 kV yard tie line supply power to startup transformers #10 and #20, respectively, through motor operated air break switches. High speed positive ground switches are installed between the motor operated air break switches (MOABs) and the startup transformers. The startup transformers and low side bus connections are discussed in Section 8.3.1. The startup transformer yards are physically separated from each other, the Unit 1 and #2 main transformer yards and the 230 kV and 500 kV switchyards can be seen on Dwg. D159760, Sh. 1. 1590 kcmil 45/7 ACSR conductors connect the air switches to the startup transformers. 13.8 kV cables are installed in underground conduit between the startup transformers and the turbine building. Non-segregated phase bus ducts establish the tie to the 13.8 kV startup buses within the turbine building. See Figure 8.2-3 for a one line diagram of the offsite power system.

Primary protection of the Susquehanna T10 Tap 230 kV line is provided by a microprocessor based phase and ground distance scheme with inherent ground overcurrent backup systems and fault locating capabilities. Backup protection of this circuit is provided by a microprocessor based phase distance and directional ground overcurrent schemes with fault locating capabilities. Both primary and backup schemes are continuously self-monitored and alarm to the Alarm Management System (AMS) at the Susquehanna T10 230 kV Switchyard. Line relay protection for the 230 kV Yard Tie circuit is provided by fully independent primary and backup relay systems. The primary protection system is a microprocessor-based line differential scheme, and the backup protection system is a microprocessor-based permissive overreaching transfer trip scheme with inherent two-zone phase-distance and directional ground-overcurrent protection in the event of channel failure. Both primary and backup systems and their associated communication channels are continuously self-monitoring for maximum reliability (security and dependability). These relaying schemes detect faults on the transmission line and isolate the power sources to the transformers by tripping the power circuit breakers (CBs) at the line terminals. Breaker failure relaying, applied at each line terminal, detects a failure to trip or failure to interrupt condition at the line terminal and trips all associated CBs necessary to isolate the line. Control power to the line relaying facilities is supplied from the local switchyard 125 V DC power supplies.

Startup transformers #10 and #20 are protected by high speed percentage differential, sudden pressure and overcurrent relaying. Direct transfer trip facilities are utilized as the primary relaying scheme to open the CBs at the transmission line remote terminals in the event of transformer trouble. Backup protection is provided by the high speed ground switch on the 230 kV side of the startup transformer. This switch is closed to place a positive fault on the 230 kV transmission line which will be detected by the remote line terminal relaying systems if the primary direct transfer trip scheme fails to function correctly. The motor operated air switch automatically opens after the 230 kV system is de-energized to isolate the startup transformer from the transmission system and permit reclosing of the transmission line terminal CBs.

The impact of open phase conditions (OPCs) on the capability of startup transformers #10 and #20 was evaluated. The conditions analyzed consisted of single (one of three) and double (two of three) open phase conductors on the high voltage (230 kV) side of the startup transformers. An Open Phase Detection (OPD) system is installed on each startup transformer that detects an open phase condition on the high side of the transformer from the offsite 230 kV transmission system. The OPD system was installed based on the NEI Open Phase Condition Initiative and NRC Bulletin 2012-01, "Design Vulnerability in Electric Power System."

A risk-informed assessment utilizing the Susquehanna specific electrical design configuration was performed in accordance with the guidance in NEI 19-02, "Guidance for Assessing Open Phase Condition Implementation Using Risk Insights." The assessment demonstrated that in the event of an OPC, the risk associated with an alarm only OPD system that is reliant on operator manual action versus the automatic isolation of OPCs was acceptably low. Based on the results of the risk-informed assessment, Susquehanna has determined that the station is adequately protected using the alarm feature of the OPD system in conjunction with operator manual actions.

A time delay undervoltage relay monitors the 13.8 kV startup bus voltage. On loss of offsite power the relay trips the startup bus incoming feeder breaker and initiates transfer of the bus loads to the other startup transformer through closure of the startup bus tie breaker. The time delay undervoltage relay also prevents unnecessary automatic trip of the incoming feeder breaker for short duration disturbances on the transmission line.

Power to transformer #10 and #20 switchgear, motor operated air break switches, and high speed ground switches is supplied from the station 125 V DC power supplies.

8.2.1.3.2 Susquehanna Unit 1 230 kV Main Transformer Leads

Overhead 1590 kcmil 45/7 ACSR conductors, bundled two per phase, tie the Unit 1 main stepup transformers, through a high voltage Disconnect switch-Synchronizing CB-Disconnect switch arrangement, to the 230 kV switchyard. The synchronizing breaker and disconnect switch arrangement is provided at the Susquehanna SES site to improve reliability in synchronization and flexibility of operating Unit 1. Steel pole structures support the strain bus and the 2.2-mile 230 kV tie with single string insulator assemblies. The tie line is capable of transmitting the full MVA output of the Unit 1 Generator.

Relay protection between the Unit 1 transformer and the synchronizing breaker is provided by high speed percentage differential relays which trip Unit 1 and the synchronizing breaker by the unit master trip lockout relays. A second protection scheme is provided by the Unit 1 overall differential relaying which also detects fault conditions between Unit 1 transformer and the synchronizing breaker. Fully independent primary and backup relay systems provide protection

between the 230 kV synchronizing circuit breaker and the Susquehanna 230 kV Switchyard. The primary protection system is a microprocessor-based line differential relay scheme, and the backup protection system is a microprocessor-based permissive overreaching transfer trip scheme with inherent two-zone phase-distance and directional ground-overcurrent protection in the event of channel failure. Both primary and backup systems and their associated communication channels are continuously self-monitoring for maximum reliability (security and dependability). Breaker failure protection relaying is applied at each terminal to detect a failure to trip or failure to interrupt condition and to electrically isolate the faulty component. Direct transfer trip facilities are utilized to open the CB's at the transmission line remote terminals for a breaker failure operation. Two fully independent transfer trip channels are provided.

Control power to the synchronizing power circuit breaker and power to the onsite relaying equipment are provided by the plant 125 V DC power supplies.

8.2.1.3.3 Susquehanna 230 kV Switchyard

The Susquehanna 230 kV switchyard is an outdoor steel structure, comprised of 6 bay positions containing 14-230 kV power circuit breakers configured as follows: Bay 0-double bus double circuit breaker; Bay 1-full circuit breaker and a half; Bay 2 full circuit breaker and a half; Bay 3-double bus double circuit breaker; Bay 4-full circuit breaker and a half; Bay 5-two single circuit breaker terminals and one breaker connected to the north end of the East Bus for 230 kV Capacitor Bank 2. Terminating positions are provided for eight lines, one generator lead, one 230 kV capacitor bank and a yard tie to the 500 kV switchyard. The switchyard breakers can be operated by remote supervisory control from the PPL EU Transmission Control Center.

Service power to the 230 kV switchyard is provided by three single phase bus potential devices on each bus in the 230 kV switchyard. Alternate sources of station service power are provided by a local 12 kV distribution line with a backup diesel generator in the 230 kV switchyard. An automatic thrower scheme is employed to restore service power from an alternate source in the event of one source failure. Line protection equipment power is provided by 125 VDC and 24 VDC switchyard service batteries. The 125 VDC system is supplied by two (2) nominal station batteries functioning as one primary and one backup supply. The 125 VDC primary supply has two battery chargers and the backup supply has one battery charger. The 24 VDC system also has two (2) battery systems each sized to carry one half of the station load. One 24 VDC system has two chargers and the other system has one charger.

8.2.1.3.4 Susquehanna Unit 2 500 kV Main Transformer Leads

Unit 2 generator output is connected to the 500 kV switchyard by a 1400 ft. overhead 500 kV transmission line. 2493 kcmil 54/37 ACSR conductors bundled two per phase are supported by V-string insulator assemblies on steel pole H-frame structures and individual steel pole structures.

The tie is capable of transmitting the full MVA generator operating output of Unit 2 to the 500 kV switchyard.

The Unit 2 generator output lead is configured to accommodate future connection to the 500 kV Talen Energy transmission lines for the future Talen Energy 500 kV Substation. The Talen Energy 500 kV transmission lines are supported by single insulators at the location of future connection to the 500 kV transmission lines, and by V-string insulators at the mid-span and dead end structures.

Relay protection for the connection between the Unit 2 transformer and the Susquehanna 500 kV switchyard is provided by high speed differential relays which trip Unit 2 and the two 500 kV switchyard generator breakers by the Unit master trip lockout relays for a fault in the connection. An overall differential protection scheme provides a second system to trip Unit 2 and the two CBs connected to the generator in the 500 kV switchyard for a fault on the transformer leads. Breaker failure protection is applied at each terminal to detect a failure to trip or failure to interrupt condition and to electrically isolate the faulty component.

8.2.1.3.5 Susquehanna 500 kV Switchyard

The 500 kV switchyard is an outdoor steel structure, comprised of four bays containing eight 500 kV circuit breakers. A 230 kV circuit breaker terminates the T21 230 kV yard tie. Each bay, except for Bay 5, can be developed into a full circuit breaker and a half configuration. Bay 2 and Bay 3 are configured as double bus-double circuit breaker bays with each bay containing two 500 kV circuit breakers. Bay 4 contains three 500 kV power circuit breakers arranged in a breaker and a half configuration. Bay 5 contains a single 500 kV power circuit breaker scheme. Bay 1 is not populated. The switchyard provides for ultimate future expansion to 5 bays. Terminating positions are provided for three lines, one 500 kV generator lead circuit, a circuit to a bank of three single phase 500-230 kV autotransformers and a capacitor bank circuit. Manual operation of the 500 kV generator lead synchronizing circuit breakers is by the plant control room operator. The remaining CBs can be operated by remote supervisory control from the PPL EU Transmission Control Center.

Service power to the 500 kV switchyard is provided by two sources: one from the generating station, and the second from the tertiary winding of the yard tie autotransformers with an automatic low voltage thrower scheme in the event of one source failure. Primary and Backup Line protection equipment is powered by dual (primary & backup) 125V DC switchyard service batteries, each equipped with one full capacity battery charger. A third full capacity battery charger is provided with the ability to be connected to either of the above batteries. Further, during battery maintenance, replacement, or failure, the entire 125V DC station loads can be connected to the primary or backup DC battery system.

8.2.1.3.6 Montour and Mountain 230 kV Switchyards

Figure 8.2-4 shows a one line diagram of the off-site power system for Startup Transformer #10.

The Montour Switchyard is an outdoor steel structure comprised of six bay positions containing 14-230 kV power circuit breakers. Bays one through four are each arranged in a breaker and a half configuration. Bay 5 and 6 are initially developed as single bus single circuit breaker schemes. Two generating leads from the Montour Steam Electric Station and eight transmission lines are terminated in the yard. The switchyard breakers can be operated by remote supervisory control from the PPL EU Transmission Control Center.

The Mountain Substation is owned and operated by UGI Corporation Luzerne Electric Division. It is an outdoor steel structure with four bay positions each containing one 230 kV CB. Two CBs are arranged back to back between Susquehanna T10-Mountain and Mountain-Lackawanna 230 kV lines. The remaining two CBs are arranged back to back between Mountain-Stanton and Susquehanna–Mountain 230 kV lines. Between the CBs of the Susquehanna T10/Lackawanna terminal and the Susquehanna/Stanton terminals at Mountain is a normally open MOAB that can tie the bus section between the Susquehanna T10/Lackawanna 230 kV CBs to the bus section between the Susquehanna/Stanton 230 kV CBs. All the CBs and the

MOAB can be operated by remote supervisory control from the UGI Corporation System Operator's office. CB and MOAB status is monitored by PPL EU Transmission Control Center.

8.2.1.4 Offsite Power System Monitoring

PPL's Transmission lines associated with the Susquehanna switchyard are patrolled twice a year. The first patrol is an overhead comprehensive inspection which thoroughly reviews the structures and associated supports, hardware, insulators and conductors. The second patrol is a more general overhead inspection of the transmission lines with focus on vegetation related issues within and along the rights of way of these lines.

Monitoring of the Unit 1 and Unit 2 offsite power sources in the plant control room is via a hardwired mimic bus arrangement which shows startup transformers #10 and #20, the transformer #10 and #20 motor operated air break switches, the Susquehanna T10 230 kV Switchyard, the 13.8 kV start-up buses, the 13.8 kV bus feeder breakers, and the 13.8 kV bus tie breaker. Annunciation signals abnormal tripping to the control room operator. Control and status indication are provided for the 230 kV MOAB switches and the 13.8 kV breakers. Potential indication for the PPL grid and 13.8 kV bus and status indication of the 230 kV high speed ground switches are provided.

A display is provided by the plant computer system which provides the operator with additional information about the offsite power sources. The display is a mimic bus arrangement, similar to the hardwired mimic bus.

Monitoring of the Unit 1 main generator output leads to the 230 kV switchyard is provided in the control room. A hardwired mimic bus arrangement provides control and status indication of the synchronizing CB. Annunciation signals an abnormal change in status of the synchronizing circuit breaker and any failure of the transmission line relaying systems or their associated communications channels. Annunciation accompanies a failure of the supervisory system. Manual control of the 230 kV switchyard is by a supervisory system from the PPL EU Transmission Control Center.

Monitoring of the Unit 2 main generator output leads is provided in the control room. A hardwired mimic bus arrangement provides control and status of the main generator synchronizing breakers along with potential indication. Annunciation signals an abnormal change in status of the synchronizing circuit breaker.

Manual control of the 500 kV switchyard is by a supervisory system from PPL EU Transmission Control Center except for the main generator synchronizing breakers which can be controlled only by the plant operator.

Preoperational and initial startup testing of all apparatus, equipment, relaying, and CBs is conducted at transformers #10 and #20 and the 500 kV and 230 kV switchyards to ensure compliance with design criteria and standards.

Protective relay testing, maintenance, and calibration in the 230 kV and 500 kV switchyards, Susquehanna T10 Switchyard and at transformers #10 and #20 will be performed in accordance with NERC, RFC, and PJM governing documents.

8.2.1.5 Industry Standards

The requirements, criteria and recommended practices set forth in the following documents are implemented in the design of the transmission system:

A. National Electric Safety Code.

B. PJM Interconnection Protective Relaying Philosophy and Design Standards

C. NERC Reliability Standards TPL-001-4.

D. In general, high voltage circuit breakers are manufactured and tested in accordance with the latest recommendations and rules of the ANSI, IEEE, NEMA, and AEIC.

E. PPL Substation and Relay and Control Engineering Instruction Manuals, Engineering and Construction Standards, Operating Principles and Practices; Relay and Control Facilities 3/3/76 and sound engineering Principles. The design criteria include consideration of aesthetics, reliability, economics, and safety.

8.2.2 Analysis

8.2.2.1 Grid Availability

The offsite power sources provide adequate capacity and capability to start and operate safety related equipment. In addition, the sources provide both redundancy and electrical and physical independence such that no single event is likely to cause a simultaneous outage of both sources in such a way that neither can be returned to service in time to prevent fuel design limits and design conditions of the reactor coolant pressure boundary from being exceeded. Each of the circuits from the off-site transmission network to the safety related distribution buses has the capacity and capability to supply the assigned loads during normal and abnormal operating conditions, accident conditions and plant shutdown conditions.

The PPL bulk electric system is planned in accordance with established PPL bulk power planning criteria. These criteria are based on North American Electric Reliability Council (NERC) planning standards TPL-001-4 and administered by Reliability First Corporation (RFC), the NERC registered Regional Reliability Organization for this portion of the United States. RFC replaced and has taken responsibility for bulk electric system reliability that was formerly addressed by the Mid-Atlantic Area Council (MAAC) and other regional reliability entities such as ECAR and MAIN. The primary objective of RFC is to augment reliability through a continuing review of all planning in connection with additions or revisions to Bulk Electric System Generating Plant and Transmission facilities. RFC accomplishes these reviews through PJM, the Regional Transmission Organization responsible for planning and operating the bulk electric system. PPL, as a member of PJM, supports PJM in these roles. The PPL bulk electric system is designed to meet NERC reliability criteria documented in NERC Standards TPL-001-4.

Power flow and transient stability studies were conducted to demonstrate that the bulk electric system is in compliance with the NERC Standards. The power flow studies included an

evaluation of all practical single contingency, including double circuit tower line, outage conditions and several abnormal system disturbance conditions.

Based upon historical operating data (1999-2008) for the northern PPL transmission network, the annual unplanned outage rate per 100 circuit miles for 500 kV and 230 kV lines is 1.46 and 1.50 outages respectively. Unplanned outages include 1) permanent interruptions where breakers are tripped by protective relays and remain open and 2) momentary outages where breakers are tripped by protective relays and reclose automatically to restore the line to service. The duration of the individual outages varies greatly (from seconds to time periods in excess of 8 hours) depending on the nature of the unplanned outage. The causes of unplanned outages during this time period is lightning related weather events. The major cause of unplanned sustained outages (greater than 3 minutes) during this time period is conductor failure.

8.2.2.2 Stability Analysis

Transient stability studies were conducted using a digital computer program. The initial study was conducted in 1976-77. A follow up study was conducted in 1980-81 and additional analyses were conducted in 1983, 1986, 1989, 1992, 1994, 1998, 2006, 2009, and 2012. These studies show that for various 230 kV and 500 kV bus and line faults, system stability and satisfactory recovery voltages are maintained resulting in uninterrupted supply to the offsite power system. Specifically, the system is stable for any three phase fault applied to a single 500 kV or 230 kV transmission facility cleared in normal clearing time and for any single phase to ground fault with delayed clearing. This satisfies the PPL Reliability Principles and Practices and the NERC Reliability Standards TPL-001-4. The system is also stable for any three phase fault applied to any single 500 kV or 230 kV transmission facility associated with the Susquehanna plant and cleared with delay. A transient stability case list is included in Table 8.2-1.

The loss of either Susquehanna Unit 1 or Unit 2 represents the loss of the largest single supply to the PPL EU Transmission Zone. For the loss of either Susquehanna unit, grid stability and the integrity of supply to the offsite power system are maintained. Grid stability and the integrity of supply to the offsite power system are also maintained for the loss of any other single generating unit in the PPL EU Transmission Zone. Supply to at least one of the offsite power sources is also maintained for the following abnormal disturbances:

1. The sudden loss of all lines emanating from the Susquehanna 230 kV Switchyard,

2. The sudden loss of all lines emanating from the Susquehanna 500 kV Switchyard.

No single occurrence is likely to cause a simultaneous outage of all offsite sources during operating, accident, or adverse environmental conditions. For the extremely unlikely occurrence of a complete loss of offsite power due to a system blackout, it is expected that offsite power could be restored to Susquehanna within 4 hours. While the loss of all offsite power is improbable, such an event would not prevent the safe shutdown of the station because the onsite batteries and standby diesel generators are able to supply the necessary power to systems required for safe shutdown.

TABLE 8.2-1

SUSQUEHANNA UNIT #1 & #2
STABILITY CASE LIST
(SUMMER LIGHT LOAD CONDITIONS)

CASE	DESCRIPTION	RESULT 2019 UPDATE
	Fault Tests **R**equired to be Stable (8.2.1.5.C)	
R-1	3 phase fault at Susquehanna 500 kV on the Sunbury 500 kV line. Fault cleared in primary clearing time.	Stable
R-5	Phase-ground fault at Susquehanna 500 kV on Sunbury 500 kV line with Sunbury South 500 kV circuit breaker stuck. Clear remote terminal in primary time. Delayed clearing of Susquehanna.	Stable
R-6	3 phase fault at Susquehanna 230 kV on the Susquehanna 500/230 kV transformer. Fault clearing in primary clearing time.	Stable
R-7	3 phase fault at Montour 230 kV on Susquehanna 230 kV line. Fault cleared in normal primary clearing time.	Stable
R-13	Phase-ground fault at Susquehanna 500 kV on Susquehanna-Wescosville-Alburtis 500 kV line with Wescosville South 500 kV circuit breaker stuck. Clear remote terminal in primary time. Delayed clearing at Susquehanna.	Stable
R-18	3 phase fault at Susquehanna 230 kV on Harwood #1 & #2 Double Circuit. Fault cleared in primary clearing time.	Stable
	Fault Tests Not Required to be Stable (8.2.1.5.C)	
N-2	3 phase fault at Susquehanna 500 kV on the Sunbury 500 kV line with one breaker pole stuck at Sunbury. Clear Susquehanna in primary time. Delayed clearing at remote terminal.	Stable
N-3	3 phase fault at Susquehanna 500 kV on the Susquehanna-Wescosville-Alburtis 500 kV line with one Susquehanna 500/230 kV transformer breaker pole stuck. Clear remote terminal in primary time. Delayed clearing of Susquehanna.	Stable
N-4	3 phase fault at Susquehanna 500 kV on the Sunbury 500 kV line with one Susquehanna 500/230 kV transformer breaker pole stuck. Clear remote terminal in primary time. Delayed clearing of Susquehanna.	Stable
N-8	3 phase fault at Susquehanna 230 kV on Montour line with stuck west bus breaker. Clear remote terminal in primary time, clear Susquehanna with delay (lose Susquehanna-Susq T10 230 kV line).	Stable

TABLE 8.2-1

SUSQUEHANNA UNIT #1 & #2
STABILITY CASE LIST
(SUMMER LIGHT LOAD CONDITIONS)

CASE	DESCRIPTION	RESULT 2019 UPDATE
N-9	3 phase fault at Susquehanna 230 kV on Jenkins line with stuck east bus breaker. Primary clearing at remote terminal. Delayed clearing at Susquehanna (lose Susquehanna-Mountain 230 kV line).	Stable
N-10	3 phase fault at Susquehanna 230 kV on the 500/230 kV transformer with stuck west bus breaker pole. Clear two poles in primary time. Primary clearing at remote terminal (Susquehanna 500 kV Switchyard). Clear stuck pole in delayed clearing time (lose Susquehanna-Susq T10 230 kV line).	Stable
N-11	3 phase fault at Susquehanna 230 kV on Harwood #1 line with stuck tie breaker. Clear stuck breaker in delayed clearing time (lose Sunbury-Susquehanna 230 kV line).	Stable
N-12	3 phase fault at Susquehanna 230 kV on Harwood #2 line with stuck west bus breaker. Clear stuck breaker in delayed clearing time (lose Susquehanna-Susq T10 230 kV line).	Stable
N-14	Susquehanna-Wescosville-Alburtis 500 kV and Susquehanna-Harwood #1 & #2 Double Circuit 230 kV crossing failure (3 phase fault on all circuits). Automatically trip Susquehanna Unit #1. Clear Susquehanna-Wescosville-Alburtis 500 kV line in primary time. Clear Susquehanna-Harwood #1 #2 230 kV lines in primary time.	Stable
N-15	3 phase fault near E. Palmerton on all lines in E. Palmerton-Harwood RW corridor. Clear Susquehanna-Wescosville-Alburtis 500 kV line in primary time. Primary clearing of E. Palmerton-Harwood and Harwood-Siegfried 230 kV lines.	Stable
N-16	3 phase fault near Susquehanna on both lines in Sunbury-Susquehanna R/W corridor. Clear Sunbury-Susquehanna #2 500 kV line in primary time. Primary clearing of Sunbury-Susquehanna #1 230 kV line.	Stable
N-17	3 phase fault near Susquehanna 500 kV at Sunbury 230 kV line crossing. Trip Susquehanna-Wescosville-Alburtis 500 kV, Sunbury-Susquehanna #2 500 kV, and Unit #2 in primary time. Trip Sunbury-Susquehanna #1 230 kV in primary clearing time.	Stable
N-19	3 phase fault at Columbia-Frackville 230 kV line crossing. Trip Sunbury-Susquehanna #2 500 kV line in primary time. Trip Columbia-Frackville and Sunbury-Susquehanna #1 230 kV lines in primary time.	Stable

TABLE 8.2-1

SUSQUEHANNA UNIT #1 & #2
STABILITY CASE LIST
(SUMMER LIGHT LOAD CONDITIONS)

CASE	DESCRIPTION	RESULT 2019 UPDATE
N-20	3 phase fault on 230 kV side of Unit #1 main transformer. Trip Unit #1 main transformer. Trip Unit #1 and overtrip Unit #2 in primary time.	Stable
N-21	3 phase fault at Susquehanna 230 kV on Unit #1 generator leads with a stuck west bus breaker. Trip Unit #1 and Susquehanna T10 line.	Stable
N-23	Sudden loss of all lines from Susquehanna 230 kV Switchyard.	Stable
N-24	3 Phase fault on Susquehanna-Jenkins 230 kV line 80% towards Jenkins with pilot relaying out. Fault cleared in Zone 2 (backup) time at Susquehanna and Zone 1 time at Jenkins.	Stable

FIGURE 8.2-1 WAS REPLACED BY DWG. D159760, SH.1. THIS DOCUMENT WAS DETERMINED TO CONTAIN CRITICAL ENERGY INFRASTRUCTURE INFORMATION (CEII) AND IS BEING HANDLED AS A CONFIDENTIAL DOCUMENT PER CP 404.

FSAR REV. 67

SUSQUEHANNA STEAM ELECTRIC STATION
UNITS 1 & 2
FINAL SAFETY ANALYSIS REPORT

FIGURE 8.2-1 REPLACED BY CONFIDENTIAL
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FIGURE 8.2-1, Rev. 57

AutoCAD Figure 8_2_1.doc

FIGURE 8.2–2 WAS REPLACED BY DWG. D159760, SH.2. THIS DOCUMENT WAS DETERMINED TO CONTAIN CRITICAL ENERGY INFRASTRUCTURE INFORMATION (CEII) AND IS BEING HANDLED AS A CONFIDENTIAL DOCUMENT PER CP 404.

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FIGURE 8.2-2 WAS REPLACED BY CONFIDENTIAL DWG. D159760, SH.2

FIGURE 8.2-2, Rev 57

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FIGURE 8.2–3 WAS REPLACED BY DWG. D159760, SH.3. THIS DOCUMENT WAS DETERMINED TO CONTAIN CRITICAL ENERGY INFRASTRUCTURE INFORMATION (CEII) AND IS BEING HANDLED AS A CONFIDENTIAL DOCUMENT PER CP 404.

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FIGURE 8.2-3 WAS REPLACED BY CONFIDENTIAL DWG.
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FIGURE 8.2-3, Rev 57

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FIGURE 8.2-4 WAS REPLACED BY DWG. D159760, SH.4. THIS DOCUMENT WAS DETERMINED TO CONTAIN CRITICAL ENERGY INFRASTRUCTURE INFORMATION (CEII) AND IS BEING HANDLED AS A CONFIDENTIAL DOCUMENT PER CP 404.

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FIGURE 8.2-4 WAS REPLACED BY CONFIDENTIAL DWG.
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FIGURE 8.2-4, Rev 51

AutoCAD: Figure Fsar 8_2_4.dwg

APPENDIX 8.2A
MID-ATLANTIC AREA COUNCIL (MAAC)

RELIABILITY PRINCIPLES AND STANDARDS FOR PLANNING THE BULK ELECTRIC SUPPLY SYSTEM OF MAAC GROUP

(As adopted on July 18, 1968, by the Executive Board constituted under the MAAC Agreement, dated December 26, 1967 and Revised March 30, 1990)

PRINCIPLES

The bulk electric supply system shall be planned and constructed in such manner that it can be operated so the more probable contingencies can be sustained with no loss of load. Less-probable contingencies will be examined to determine their effect on system performance. These standards apply only to those facilities which affect reliability of the MAAC system and not to facilities affecting the reliability of supply only to local system loads. Automatic load relief shall be provided to minimize the probability of the total shutdown of an area which becomes isolated by multiple contingencies, thereby facilitating rapid restoration of the interconnected systems.

RELIABILITY STANDARDS

I. Installed Generating Capacity Requirements

Sufficient megawatt generating capacity shall be installed to ensure that in each year for the MAAC system the probability of occurrence of load exceeding the available generating capacity shall not be greater, on the average, than one day in ten years. Among the factors to be considered in the calculation of the probability are the characteristics of the loads, the probability of error in load forecast, the scheduled maintenance requirements for generating units, the forced outage rates of generating units, limited energy capacity, the effects of connections to other pools, and network transfer capabilities within the MAAC systems.

II. Transmission Requirements

The bulk transmission system shall be developed so that it can be operated at all load levels to meet the following unscheduled contingencies without instability, cascading or interruption of load:

A. The loss of any single transmission line, generating unit, transformer, bus, circuit breaker, or single pole of a bipolar DC line in addition to normal scheduled outages of bulk electric supply system facilities without exceeding the applicable emergency rating of any facility or applicable voltage criteria. After the outage, the system must be capable of readjustment so that all equipment (on the MAAC and neighboring systems) will be loaded within normal ratings.

B. After occurrence of the outage and the readjustment of the system specified in A, the subsequent outage of any remaining generator or line without exceeding the short time emergency rating of any facility. After this outage, the system must be capable of readjustment so that all remaining equipment will be loaded within applicable emergency ratings and voltage criteria for the probable duration of the outage.

C. The loss of any double circuit line, bipolar DC line, faulted circuit breaker or the combination of facilities resulting from a line fault coupled with a stuck breaker in addition to normal scheduled generator outages without exceeding the short-time emergency rating of any facility or applicable voltage criteria. After the outage, the system must be capable of readjustment so that all equipment will be loaded within applicable emergency ratings for the probable duration of the outage.

In determining the bulk transmission requirements, recognition shall be given to the occurrence of similar contingencies in neighboring systems and their effect on the MAAC system.

III. <u>General Requirements</u>

Sufficient megavar capacity with adequate controls shall be installed in each system to supply the reactive load and loss requirements in order to maintain acceptable emergency transmission voltage profiles during all of the above contingencies.

Installation of generation and transmission facilities shall be coordinated to ensure that in each year for each member system the probability of occurrence of load exceeding the available capacity resources shall not be greater, on the average, than one day in ten years. Available capacity resources consist of the generating

capability available internal to the member system and the capacity that can be transmitted into the member system. (See Section VII.)

IV. Stability Requirements

The stability of the system shall be maintained without loss of load during and after the following types of contingencies occurring at the most critical location at all load levels.

A. A three-phase fault with normal clearing time.

B. Single phase-to-ground fault with a stuck breaker or other cause for delayed clearing.

C. The loss of any single facility with no fault.

V. Tests for Ability of MAAC System to Withstand Abnormal Disturbances

The MAAC group recognizes that it is impossible to anticipate or test for all the contingencies that can occur on the present and future MAAC system. These tests, therefore, serve primarily as a means to measure the ability of the system to withstand less probable contingencies, some of which may not be readily apparent. These tests are prescribed not on the basis of a high level of probability, but rather as a practical means to study the system for its ability to withstand disturbances beyond those which can reasonably be expected. The MAAC system, therefore, will be tested to determine the effect of various types of contingencies on system performance, including stability. Examples of less probable contingencies to be studied are:

A. Sudden loss of the entire generating capability of any station for any reason.

B. The outage of the most critical transmission line on any one of the interconnected systems as the result of a three-phase fault immediately following (i.e., before adjustment) the tripping of another critical line on the same or on an adjacent system.

C. Single phase-to-ground fault coupled with the malfunction of a protective device.

D. The sudden loss of all lines of one voltage emanating from a substation.

E. The sudden loss of all lines on a single right of way.

F. The sudden dropping of a large load or a major load center.

G. The occurrence of a multi-phase fault with delayed clearing.

Recognition should be given to the occurrence of similar contingencies in neighboring systems and their effect on the MAAC system.

VI. Relaying and Protective Devices

Independent devices shall be installed to the extent necessary to provide backup for the primary protective devices and components so as to limit equipment damage, to limit the shock to the system and to speed restoration of service. The design of a particular line's relay protective scheme shall recognize the need for an appropriate balance between dependability (assurance that relays will operate when required) and security (protection against relay operation when not required). In cases where requirements of Sections IVB and/or V are not met, additional security against the overtripping of critical facilities may be considered.

Relaying installed shall not restrict the normal or the necessary realizable network transfer capabilities of the system.

System preservation measures, such as underfrequency load shedding relays, shall be installed to provide additional insurance against widespread system disturbances. System preservation measures shall not be used to satisfy the contingencies listed under Sections I through IV.

VII. Network Transfer Capability

The amounts of power to be interchanged between areas within MAAC and between MAAC and neighboring pools shall be limited such that applicable ratings and stability, voltage and relay limitations are not exceeded.

A. Extended Period Transfer

The amount of power that can be delivered from one area to another for economy interchange in normal day-to-day operations shall be limited as follows:

1. With all transmission facilities in service and normal generator maintenance scheduling, all system components shall be within normal loading limits.

2. With the outage of any single facility, the provisions of Section 11 shall apply.

B. Capacity Emergency Transfer

The amount of power planned to be transferred from one area to another for capacity shortages shall be limited as follows:

1. With all transmission facilities in service and normal generator maintenance schedules, the loadings of all system components shall be within normal ratings, stability limits and normal voltage limits.

2. The interconnected systems shall then be able to absorb the initial power swing resulting from the sudden loss of any one transmission line or generating unit.

3. After the initial swing period, the loadings of all system components shall be within short time emergency ratings and voltage limits.