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Part 4

PPL Electric Utilities Corporation d/b/a PPL Utilities

TRANSMISSION PLANNING RELIABILITY CRITERIA
FOR
BULK POWER AND REGIONAL DELIVERY FACILITIES

BULK POWER DELIVERY FACILITIES

SCOPE

The bulk power system includes 500 kV and 230 kV lines, 500 kV and 230 kV switchyards, 500 kV-230 kV substations, and interconnection to generating facilities. The bulk power transmission system shall be planned and developed to meet the criteria designated herein. These criteria are based on the "MAAC Reliability Principles and Standards" as adopted by the Mid-Atlantic Area Council (MAAC)[1]. The Planning Principles and Practices described herein are compatible with the PPL Operating Principles and Practices as well as the Reliability Planning Criteria of the PJM Interconnection[2].

PRINCIPLES

The planning of the PPL bulk power system shall be coordinated with the planning of the PPL regional delivery (subtransmission) system as well as with the system development plans of PJM through the PJM Regional Transmission Expansion Plan (RTEP). This coordinated planning shall result in the cost-effective development of a reliable and highly efficient PPL regional and bulk power transmission system.

The planning process shall take into account the interrelationships that exist among the components of the bulk power system, the effects upon the underlying regional delivery system, the environment in which the system and its components will exist, and the resources required to construct, operate and maintain the system.

General

- The bulk power system shall be planned so that, with all facilities in service and normal generator maintenance scheduling, all system components shall be within normal loading limits, stability limits, and voltage limits.

- The system shall be designed to absorb the initial power swing due to the loss of any one system component, and all facility loadings shall be within short time emergency ratings and voltage limits.

- PPL bulk power development plans, specifically any PPL proposed additional bulk power system facilities, shall be coordinated with and approved by PJM within the RTEP process.

[1] The purpose of MAAC is to ensure the adequacy, reliability and security of the bulk electric delivery systems of the council members through coordinated operations and planning of their generation and transmission facilities. The MAAC Reliability Criteria are posted at http://www.maac-rc.org.

[2] The PJM Interconnection is the FERC-approved regional transmission organization which plans and operates the bulk transmission system and administers the wholesale electricity market for PJM signatories.

- The bulk power system shall be planned to enable any bulk power facility to be taken out of service at some time for scheduled maintenance without adversely affecting system reliability.

- The planned functional arrangement of the system shall be standardized and non-complex in order to:

  - minimize outage durations and related reliability risks during planned maintenance and forced outages.

  - accommodate the timely and orderly expansion of the system without excessive facility outage durations and resulting reliability risks.

- Bulk power reinforcement projects shall be placed in service just prior to the date the reinforcement is needed. In special circumstances, where manpower or equipment availability or facility outages are critical concerns, project completion in advance of the required date shall be acceptable to allow the efficient coordination of projects, the levelization of manpower resources, and the reliable operation of the system.

Planning Principles

The bulk power system shall be planned so that it can be operated at all load levels and during normal scheduled outages to withstand specific unscheduled contingencies without: exceeding equipment capability; causing instability or cascade tripping; or exceeding voltage tolerances.

1. Bulk power facilities shall have adequate capability so that the system can withstand the following unscheduled contingencies:

   - The outage of any single generating unit, transmission line, transformer, bus or one pole of bipolar DC line or the opening of a circuit breaker. Following the disturbance, no facility loading shall exceed the applicable emergency rating and the system shall be capable of readjustment to restore equipment loadings to within applicable normal ratings.

   - After the outage and readjustment specified above, the subsequent outage of any remaining generator or line shall not cause loadings on remaining facilities to exceed applicable emergency ratings. After this subsequent outage, the system must be capable of readjustment to restore loadings to within applicable emergency ratings for the expected duration of the outage.

   - The loss of any double circuit line, or the combination of a line fault and stuck breaker, or a fault with an overtrip and a successful reclosing of the overtripped terminal. After any of the above disturbances, no facility loading shall exceed its applicable emergency rating and the system shall be capable of readjustment to restore loadings to within applicable emergency ratings for the expected duration of the outage. Tripping of a

unit or automatic runback will be considered acceptable to prevent facility loadings in excess of applicable emergency ratings in lieu of constructing additional transmission facilities which would be needed solely to meet these contingencies. Unit tripping or runback may only be applied within the bounds of the MAAC A-3 document, "Special Protection System Criteria. In addition, manual runback of generation is acceptable to restore facility loadings to within applicable emergency ratings for the expected duration of the outage.

2. Reactive Supply sources shall be provided on the bulk power system to maintain acceptable normal and post-contingency voltage levels.

Careful siting of reactive sources can also reduce real power losses. Historically, generators have been the primary bulk power reactive source. While generators are expected to remain the major reactive source, the evaluation and installation of other sources shall be done where justified.

Recognizing the above, adequate reactive reserve will be installed to maintain scheduled bulk power transmission voltages at regulated buses for the loss of the largest reactive supply to the study area. With one facility out of service, the next contingency shall not cause more than a 5% voltage deviation at critical bulk power buses.

3. Stability of the system shall be maintained without significant loss of generation for the following types of faults occurring at the most critical location at any load level:

- A permanent three phase fault cleared by normal primary relay action, including reclosing, if applicable.
- A permanent single phase to ground fault and the failure of a protective device to operate properly causing a stuck circuit breaker, delayed clearing, or events having a similar probability of occurrence.
- The loss of any single facility with no fault.

4. Certain tests of abnormal contingencies will be conducted to measure the ability of the system to withstand disturbances beyond those that can reasonably be expected. While it is impossible to anticipate or test the bulk power system for all the contingencies and load levels that could occur, the following list of abnormal contingencies will be evaluated.

- Sudden loss of the entire generating capability at a station.
- Simultaneous loss of two critical transmission lines with no system readjustment between outages.

- Sudden loss of all lines emanating from a single switching station.
- Simultaneous loss of all lines on a given right of way.
- Occurrence of a three phase fault with delayed clearing.

In testing the system for these types of contingencies, only one contingency shall be considered to occur at a time. The decision regarding the action to be taken, if any, will be based on the following fundamental considerations:

- Consequences of the disturbance.
- Probability of the disturbance.
- Cost of significantly changing the consequences or the probability.

5. An emergency source of AC power will be provided on site or be available from an accessible remote source for bulk power locations where equipment, critical to the timely and orderly restoration of the system, would not otherwise be in an operable state for 24 hours of system blackout conditions.

   The PPL Reliability Principles and Practices provide guidelines for establishment and operation of a reliable electric delivery system. When applying these guidelines, the impact of unscheduled contingencies as well as routine maintenance is taken into account. For the unlikely occurrence of multiple and severe contingencies on bulk power facilities, a blackout is possible. After a blackout, the system can be restored in a timely and orderly fashion provided the necessary generation and transmission is available in a short period of time.

   Restoration becomes increasingly difficult as the duration of the blackout increases. Various pieces of equipment become inoperative due to lack of power and must be restored to operating status prior to use in restoring the system. Industry experience has indicated that sufficient generation can be made available to restore the system within 24 hours after the occurrence of a blackout.

   The system is capable of restoration beyond even 24 hours of blackout conditions but various pieces of equipment will have to be restored to an operable state prior to returning to service. This will hinder orderly restoration but will not prevent restoration of service.

6. Projects which are not specifically required to maintain system reliability may also be installed by PPL in coordination with PJM Regional Transmission Expansion Plans. These projects may be required to satisfy safety regulations, replace deteriorated equipment or improve system economy. Projects to improve system economy may be provided if sufficient operating savings can be achieved to justify the capital expenditure. Projects to replace deteriorated equipment shall be evaluated as described in Appendix 1.

REGIONAL DELIVERY FACILITIES

SCOPE

The regional delivery system includes all facilities to supply and operate the 69 kV and 138 kV portion of the system. The 69 kV system extends from the high side of 230-69 kV and 138-69 kV transformers to the high side of 69-12 kV transformers and includes 69 kV lines and switchyards, interconnection to 69 kV generating facilities, and delivery to 69 kV customers. The 138 kV system extends from the high side of the 500-138 kV and 230-138 kV transformers to the high side of the 138-69 kV and 138-12 kV transformers and includes all 138 kV lines and switchyards, interconnection to 138 kV generating facilities, and delivery to 138 kV customers.

PRINCIPLES

General

Planning of the regional and bulk power systems shall be coordinated to achieve the most economical balance of construction and operating expenditures. Consideration will be given to the degree of risk, amount and type of load interrupted and cost of reinforcement. This includes evaluation of island versus network operation and the use of peak load (normal, pre or post contingency) reduction options for the regional system. An evaluation of the probability and consequences of failure during peak load conditions and a probabilistic evaluation of alternative configurations will be made where appropriate to aid in the selection of the preferred reinforcement alternative.

Various segments of the delivery system will be planned with varying degrees of reliability as a direct consequence of maintaining a proper balance between service reliability and the cost of service. The regional delivery system shall be planned to supply the entire regional load during the most adverse combination of seasonal peak load and facility capabilities. Failure of the regional delivery system facilities may result in customer interruptions but the extent and duration of each interruption shall be limited. The amount of load permitted to be interrupted for various facility failures is related to the expected repair time for the failed facility. Generally any typical regional line failure is expected to be repairable within one normal extended work shift - generally defined as within 10 hours. However, failures of major equipment such as circuit breakers, transformers and underground cables generally have long repair times such that facilities will be provided to bypass the failed facility and/or transfer the interrupted load to an alternate supply for major equipment failures. Mitigative measures will be taken to limit the duration of customer interruptions for those extraordinary failures that require more than 24 to 48 hours to repair.

Where generation is connected to the regional system the most adverse combination of generator operation and system load will be considered. Adequate facilities shall be planned and constructed to be consistent with these Principles and Practices relative to transmission requirements for generation.

Planning Principles

Regional facilities shall be planned and constructed to provide power delivery at acceptable voltage for all load levels throughout the daily load cycle under the following conditions:

1. Normal operation of the system shall not load any facility beyond its normal rating.

2. No customer load is to remain interrupted for routine maintenance of facilities.

3. System configuration shall prevent single contingencies from causing generation to be automatically isolated with customer load.

4. The maximum acceptable normal loading on a facility is determined by the sustained loading capability of the most limiting piece of equipment composing that facility.

5. The amount of customer load which may be exposed to interruption is determined by the normal capability of the current standards for the type of equipment supplying the load, the cost of reinforcement and the probability of a failure.

6. The contingency outage of any single facility (single or double circuit line, transformer or bus) shall not cause loadings on remaining facilities to exceed applicable emergency ratings to prevent equipment damage and cascading outages.

7. Any typical single facility line failure is expected to be fully repairable within one extended work shift - nominally defined as 10 hours. Failures due to tornadoes, severe widespread ice storms, etc. are not considered typical.

8. Where customer load is served by underground radial delivery, two circuits are required to protect against lengthy load interruption for cable repairs.

9. Regional supply to large customers shall match the customer's reliability needs while maintaining the balance between cost and failure probability. The customer shall be informed of the supply details and the types of events that would result in a total interruption. Unacceptable situations may require additional facilities at some cost to the customer.

10. Where generation is connected to the regional network, the outage of the most critical generator unit shall be treated as a normal condition for analysis of delivery to load. Various scenarios, including generator maintenance, will be evaluated to determine the load supply capability requirements.

11. Failure of a second critical facility while the first is still out of service (except as in 10) may result in overloaded facilities and loss of load. Following a single failure, it is expected that appropriate switching and/or load shedding procedures will be implemented in accordance with Operating Principles and Practices to prevent damage to equipment should a second failure occur.

12. For a single contingency facility failure during a maintenance or construction outage that has an emergency return to service time of less than 10 hours, load may be dropped in accordance with Operating Principles and Practices.

13. Large-scale, long term or frequent interruptions will be prevented or mitigated because of the adverse effects on and hazards to the public.

14. The determination of a reinforcement's required date shall include the verification that projected light load conditions will allow the needed construction outages to occur.

15. Lengthy scheduled outages for construction or maintenance shall be considered individually, and the need to implement abnormal measures for the scheduled outage interval shall be based on the probability and consequences of another contingency. Scheduled outages which have a greater than 10-hour return to service time may require reinforcements to reduce the amount of exposure during these outages.

16. Stability of the system shall be maintained for the following types of faults occurring at the most critical location at any load level:

- A permanent three-phase fault cleared by normal primary relay action.
- A permanent single phase to ground fault and the failure of a protective device to operate properly causing a stuck circuit breaker, delayed clearing or events having a similar probability of occurrence.

17. Projects to replace deteriorated equipment shall be evaluated as described in Appendix 1.

18. Power quality guidelines for voltage fluctuation and harmonics shall be according to established and approved PPL standards.

These principles are implemented through a set of standard practices which are discussed on the pages that follow. Analysis of experience with the component parts of the regional delivery system allows a judgement evaluation of the probable risk of interruptions relative to their severity and duration.

Non-Utility Generation/Independent Power Producer (NUG/IPP) Principles

Adequate regional delivery facilities for accommodating the connection of NUG/IPPs shall be planned and constructed in coordination with PJM to meet the regional system planning principles in the Reliability Principles & Practices, except as modified herein. It should be recognized that, since NUG/IPPs generally have station service requirements supplied from the PPL regional system when the NUG/IPPs are not generating, the planning of the regional system should be conducted for system normal conditions with NUG/IPPs on and with NUG/IPPs off (but applicable station service load connected).

For the connection of a NUG/IPP to the PPL regional delivery system, adequate facilities should be provided to ensure:

1. that the synchronous stability of the PPL system is maintained without significant loss of generation, and

2. that the impact of a NUG/IPP loss of synchronism does not cause a significant adverse impact on either PPL customers or PPL facilities.

3. that the exposure of the PPL system to unstable NUG/IPP operation is minimized (the installation of protective relaying to automatically trip the NUG/IPP unit for the occurrence of a predetermined unstable condition for the NUG/IPP may be specified).

Unless specific facilities are provided to permit operation during abnormal system conditions (facility forced outages or planned maintenance outages),

NUG/IPPs will be curtailed as necessary in accordance with the associated Operating Principles and Practices. To minimize the exposure to NUG/IPP curtailments, every reasonable effort should be made by the NUG/IPP owner to coordinate unit maintenance with planned maintenance outages to PPL regional and bulk power facilities.

APPENDIX 1

PRINCIPLES

1. General

Deteriorated equipment will be replaced when there is a continuing and a long term need for the function served by the deteriorated equipment and replacement is the best alternative to maintain the needed function. If the function served by the deteriorated equipment is no longer needed or the function can be performed at competitive economics elsewhere, then removal (without replacement) of the deteriorated equipment is generally the preferred option. Repair, replacement and/or retirement decisions will generally be performed, without bias, on a case-by-case basis, particularly for larger projects, to reflect the circumstances unique to those projects.