Black Start Definitions & Procurement Process

PJM State & Member Training Dept.

Objectives

Students will be able to:

- Describe the process and requirements associated with Black Start Generation resources

Defining a Black Start Unit

PJM defines a Black Start Unit as:

- A generating unit that has equipment enabling it to start without an outside electrical supply or a generating unit with a high operating factor (subject to Transmission Provider concurrence) with the demonstrated ability to automatically remain operating, at reduced levels, when disconnected from the grid

NERC Requirements for Critical Black Start (EOP-005-2)

- Each GOP shall participate in the RC's restoration drills, exercises, or simulations as requested by the Reliability Coordinator
- Each GOP with a Blackstart Resource shall have documented procedures for starting each Blackstart Resource and energizing a bus
- Each GOP with a Blackstart Resource shall notify its TOP of any known changes to the capabilities of that Blackstart Resource affecting the ability to meet the TOP's restoration plan within 24 hours following such change

NERC Requirements for Critical Black Start (EOP-005-2)

- Each TOP shall have Blackstart Resource testing requirements to verify that each Blackstart Resource is capable of meeting the requirements of its restoration plan. These Blackstart Resource testing requirements shall include:
  - The frequency of testing such that each Blackstart Resource is tested at least once every three calendar years

NERC Requirements for Critical Black Start (EOP-005-2)

- Each GOP with a Blackstart Resource shall perform Blackstart Resource tests, and maintain records of such testing, in accordance with the testing requirements set by the TOP to verify that the Blackstart Resource can perform as specified in the restoration plan
  - Testing records shall include at a minimum: name of the Blackstart Resource, unit tested, date of the test, duration of the test, time required to start the unit, an indication of any testing requirements not met under Requirement 9
  - Each GOP shall provide the Blackstart test results within 30 calendar days following a request from its RC or TOP

NERC Requirements for Critical Black Start (EOP-005-2)

Each GOP with a Blackstart Resource shall provide a minimum of two hours of training every two calendar years to each of its operating personnel responsible for the startup of its Blackstart Resource generation units and energizing a bus.

The training program shall include training on the System restoration plan including coordination with the TOP.

PJM Requirements for Critical Black Start: Capability

- The unit must have the ability to close its output breaker to a dead bus within three hours of the request from the local TO or PJM
- Based on critical load timing requirements, some Black Start resources may be required to adhere to less than a three hour start time
  - These units will be notified of the timing requirement and tested to it during the annual Black Start testing

PJM Requirements for Critical Black Start: Capability

- Designated critical black start generation is identified as such in each Transmission Owners restoration plan
- The generating unit owner and PJM have agreed that the unit should be designated as black start capable
- The unit is located where black start capability is determined by PJM and all affected TOs to be useful to the restoration process and will be incorporated into the restoration plans of the affected TOs

PJM Requirements for Critical Black Start: Performance Standards

- Ability to self-start without any outside source of power within three hours, or the time defined in the TOs restoration plan can be demonstrated:
  - Through testing or the ability to operate at reduced levels when automatically disconnected from the grid
- Ability to close into a de-energized bus can be demonstrated by either:
  - Physically closing the generator breaker connected to a dead bus while the unit is running ***or***
  - A test that simulates closing the generator breaker while only the generator side of the breaker is energized

PJM Requirements for Critical Black Start: Performance Standards

- Ability to operate at reduced levels when automatically disconnected from the grid can be demonstrated by:
  - Physically removing the unit from the grid while the unit is running or,
  - A test that simulates removing the unit from the grid
- Capability to maintain frequency under varying load can be demonstrated by:
  - Picking up an isolated block of load
  - Dynamic off-line testing of the unit's governor controls

PJM Requirements for Critical Black Start: Performance Standards

- Capability to maintain voltage under varying load can be demonstrated by:
  - Picking up an isolated block of load or,
  - Producing both leading and lagging VARs by varying the voltage setting while the unit is synchronized to the system or,
  - Dynamic off-line testing of the voltage controls
- Ability to maintain rated output for a duration as identified by the TO's restoration plan
  - Specific gas supply requirements for gas fueled black start units should be considered in the TO's restoration plan such as:
    - Electric feed to gas gate valves
    - Local gas compressors needed to maintain supply

PJM Requirements for Critical Black Start: Performance Standards

- Each black start generation owner must maintain procedures for the start-up of black start generation at each station
  - These standards shall remain in effect for the duration of the commitment

PJM Black Start Unit Requirements

- Must be tested annually
  - To ensure unit can start when requested from a “blackout” state
  - To ensure personnel are familiar with procedure
  - Have the ability to self-start without any outside source of power
  - Have the ability to close unit onto a dead bus within 3 hours of the request to start
  - Have the ability to run for 16 hours, or as defined by TO restoration plan
    - GOs must notify PJM and the TO if a critical blackstart fuel resource at max output falls below 10 hours
  - Have the ability to maintain frequency and voltage under varying load
  - The company must maintain black start procedures for each unit

PJM Black Start Unit Requirements

- Exceptions or additions to the criteria above will be allowed with PJM approval:
    - SOS-T endorsement will be sought for these exceptions and additions
    - One example could be to address coping power needs for steam units that cannot be supplied by resources other than black start
    - Exceptions to critical cranking power are made for intermittent generation (i.e. wind, solar)
    - Exceptions to critical cranking power will be considered on a case by case basis for:
        - Complex cranking paths for minimum ICAP gain
        - Non-dispatchable units or units with very high minimum limits

PJM Black Start Unit Requirements

- Minimum Critical Black Start Requirement for each transmission zone consists of the following components:
  - Critical cranking power load
    - Units with a hot-start time of 4 hours or less (including the load required to supply scrubbers, where necessary)
  - Off-site Nuclear Station Light and Power (to maintain safe shutdown) as defined in each plant's Nuclear Plant Interface Requirements (NPIR) document
  - Critical Natural Gas Infrastructure (such as electric compressors)
    - A list of critical substations that serve Gas Infrastructure critical load will be documented in the Transmission Owner's Restoration Manual

Critical Load

- Critical load provided by black start generation
  - Cranking power for generation
    - Units with a hot-start time of 4 hours or less
  - Off-site nuclear station light and power (maintain a safe shutdown)
    - Including units off-line prior to disturbance
  - Gas infrastructure
    - Key in quick restoration of critical steam and combustion turbine units

Priority Load

- Priority load provided by black start or other generation
  - Cranking power to generation with a greater than 4-hour start-up time
  - Power to electric infrastructure
    - Light and power to substations
    - Pumping plants for underground cable systems
  - Critical communication equipment
  - Critical command and control facilities
  - Underfrequency load shed circuits

Black Start Procurement Process

Black Start Unit Procurement

- Required Black Start = 110% (Critical Load Requirement) on a locational basis
  - Accounts for an average forced outage rate (5%) plus an allowance for additional, unexpected Critical Load (5%)
  - Allows for redundancy for restoration even if some Black Start resources are unavailable, and a variance between Critical Load calculations and actual needs
- PJM will ensure, at a minimum, an allocation of two Black Start resources to each Transmission zone with a Critical Load requirement
  - Black start resources are not required to be physically located within the zone to which they are allocated (Cross Zonal Coordination)

Black Start Unit Procurement

PJM Actions:

- In its role as Transmission Operator (TOP), is responsible for selecting the Black Start resources for a system restoration plan
- Would work closely with the TOs to identify these units based on:
  - Critical Load requirements
  - Available Black Start resources
  - Minimum number of Black Start resources allocated to a zone
  - Possible cross zonal coordination opportunities
    - Manual 36: System Restoration Attachment A: Minimum Critical Black Start Requirement

Black Start Unit Procurement

PJM Actions:

- Utilize the start time parameters and test data to evaluate the Black Start resources and whether these resources will meet the requirements of the restoration plans
  - May require some Black Start resources to adhere to less than a 3 hour start time given critical load restoration timing requirements
    - These units will be notified of this timing requirement and tested to it during annual Black Start testing
  - Recognizes that Black Start resources with three hour start times may not appropriate to meet nuclear power off-site safe-shutdown load restoration requirements. The target restoration time for off-site power to nuclear stations is 4 hours

Black Start Unit Procurement

PJM Actions:

- In collaboration with the TOs, will select Black Start units to meet Critical Load requirements during the 5 year Black Start Selection process described in PJM Manual M-14D, Generator Operational Requirements
- Will utilize the Black Start Replacement Process, as described in PJM Manual M-14D for changes to Black Start availability or Critical Load requirements that occur within the 5 year period

Black Start Unit Procurement

Member Actions:

- Adjust their system restoration plan based on the Black Start units allocated to it from this selection process
- Has the option of procuring additional Black Start resources (if not already procured by PJM), but the costs of these resources will be recovered, if necessary, outside of the PJM Open Access Transmission Tariff (OATT)
- Underfrequency Islanding Schemes and Load Rejection Schemes are considered an acceptable alternative to solely maintaining critical black start units, or can be utilized in conjunction with critical black start units as a means to serve critical load during restoration

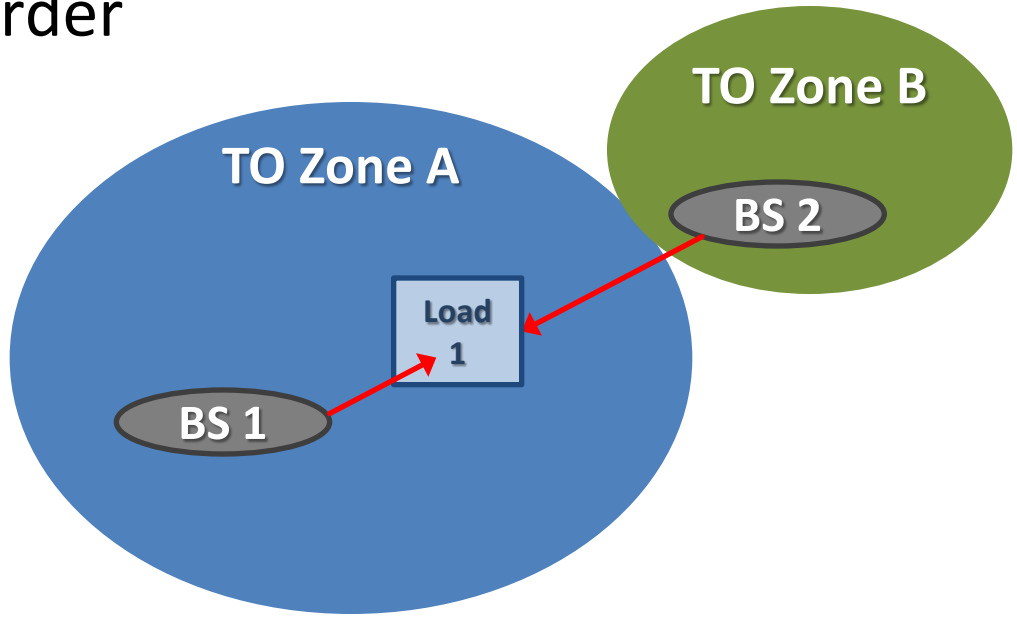
Black Start Unit Procurement

Member Actions:

- Should there be a disagreement about the location, amount or number of Black Start resources, or disagreement between the supplying TO, receiving TO or PJM about cross zonal coordination, the following process will be followed:
  - The parties involved would bring the issue to the SOS-T for consultation
  - If the parties continue to disagree, the issue would be referred to the Dispute Resolution Process as detailed in Schedule 5 of the PJM Operating Agreement
  - General notification of initiation and result of Dispute Resolution process will be given to the Operating Committee

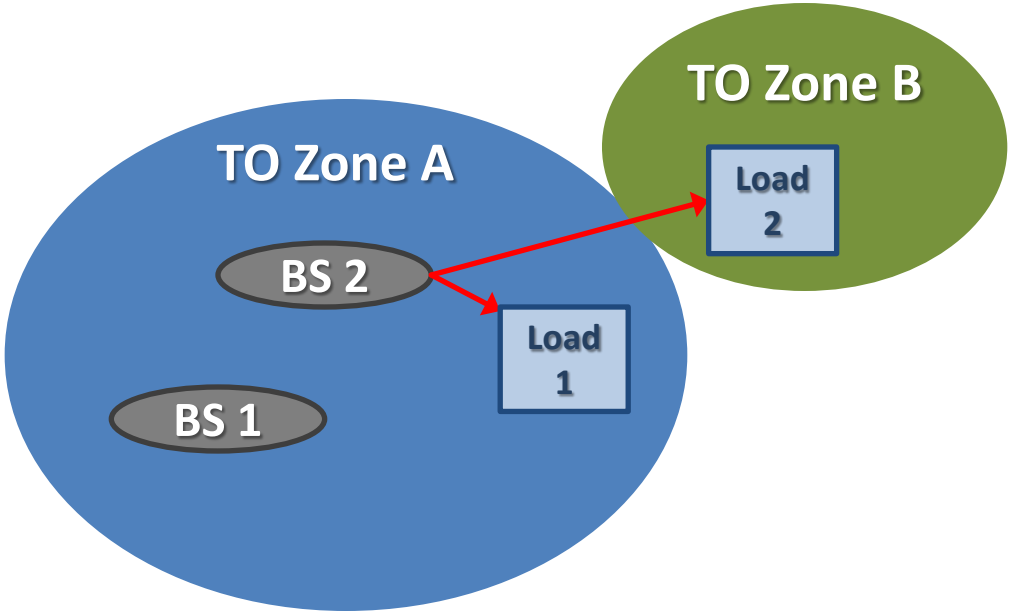
Cross Zonal Coordination

- Level One Cross Zonal Coordination
  - Supplying Black Start generation from outside of a TO zone to meet that zones critical load requirements
  - Both supplier and receiver will document the cranking path to their respective border



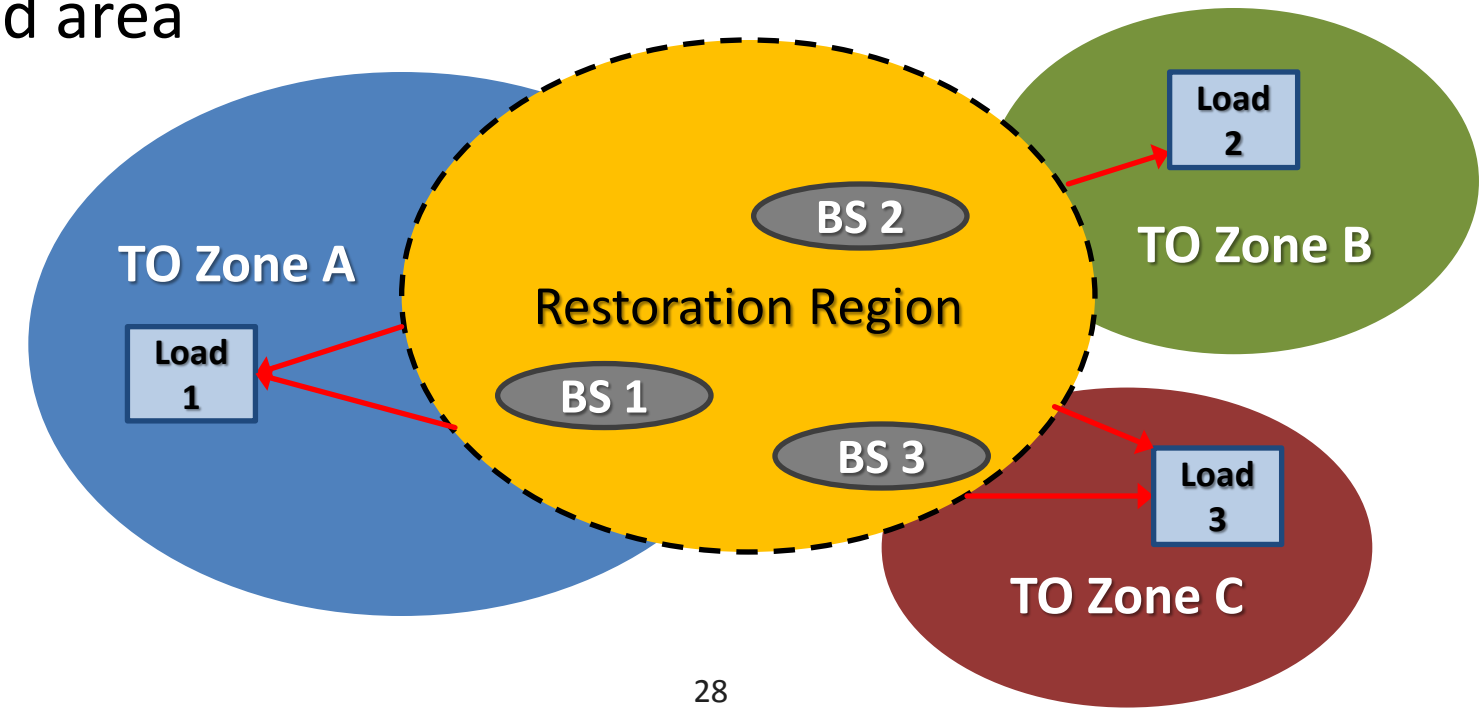
Cross Zonal Coordination

- Level Two Cross Zonal Coordination
  - Supplying Black Start generation to critical and/or customer load pockets across TO zones
  - Both TOs will document this coordination in their restoration plans



Cross Zonal Coordination

- Level Three Cross Zonal Coordination
  - Fully aggregate TO restoration plans into a combined plan for a newly defined Restoration region
  - Merging two or more existing TO zones, only one restoration plan for the aggregated area



Cross Zonal Coordination

- Level One, Two, and Three Cross Zonal Coordination would be pursued to:
  - Eliminate a Black Start shortage within the zone
  - Meet critical load restoration timing requirements
  - Improve restoration speed and/or efficiency
  - Significantly reduce Black Start cost

Cross Zonal Coordination

- The criteria for this analysis include:
  - Reliability Requirements
    - Procuring sufficient Black Start resources to meet critical load requirements
    - Meeting critical load restoration timing requirements
    - Meeting redundancy requirements (equipment failures)
  - Efficiency Opportunities
    - Cost Savings (1/2 benefit to cost required savings ratio)
      - Black Start unit cost difference
      - Potential additional TO costs including coordination costs, CIP related costs and other costs the TO might incur
    - Potential for increased efficiency and speed of restoration

Cross Zonal Coordination

- The following considerations will be evaluated when analyzing cross-zonal coordination options:
  - Technical feasibility requirements:
    - Maintaining voltages within limits
    - Maintaining MW flows within thermal limits
    - Maintaining dynamic stability of generation
    - Timing requirements of serving critical load
    - Test history and performance history of Black Start resource

Cross Zonal Coordination

- The following considerations will be evaluated when analyzing cross-zonal coordination options (cont.):
  - Complexity considerations
    - Amount of switching to establish cranking path(s)
    - Characteristics of cranking path (length, geography, travel time, number of substations, voltage level, etc)
    - Staffing availability (field/control room) to support building cranking path to neighboring area

Cross Zonal Coordination

- The following considerations will be evaluated when analyzing cross-zonal coordination options (cont.):
  - SCADA versus Manual control
    - Logistical coordination
    - Adjacent TO zones only (do not cross 3 or more zones)
    - Type of load restored in each TO zone
    - Potential additional TO costs incurred to enable cross zonal coordination
    - Number of TO zones in coordination with a single TO zone
  - TO/State Relationship considerations
    - States may want priority of restoration to remain local

Questions?

PJM Client Management & Services
Telephone: (610) 666-8980
Toll Free Telephone: (866) 400-8980
Website: www.pjm.com

The Member Community is PJM's self-service portal for members to search for answers to their questions or to track and/or open cases with Client Management & Services

Resources and References

- PJM. (2013). *PJM Manual 36: System Restoration* (rev. 20). Retrieved from http://pjm.com/~/media/documents/manuals/m36.ashx
- NERC. (2013). *Standard EOP-005-2 – System Restoration from Blackstart Resources*. Retrieved from http://www.nerc.com/pa/Stand/Reliability%20Standards%20Complete%20Set/RSCompleteSet.pdf