



## System Restoration Strategy Senior Task Force (SRSTF) Manual Updates

4/24/22/13

The following Manuals were reviewed and updated as necessary based on the SRSTF recommendations.

[M-10 PreScheduling Operations](#) – Reviewed Section 2.2.4 on Planned Outage Restrictions for BS units. No changes required.

[M-14D Generator Operational Requirements](#) – 5 Year Selection Process will be added to Section 10.

[M-12 Balancing Operations](#) – Section 4.6 – Wording edits. Deleted Section 4.6.8 and 4.6.9 due to elimination of 3 BS unit per plant restriction

[M-27 Open Access Transmission Tariff Accounting](#) – Updated Section 7 to reflect Cost Allocation changes and TO Revenue requirements for cranking paths

[M-36 – System Restoration](#) – Minor updates to sections 6.2, Cranking Power and 8.1.1 Ascertain System Status. Created new section 9 on Cross Zonal Coordination. Major edits to Attachment A to reflect changes in critical load, Black Start requirements and the reliability backstop process. Minor changes to Attachment D – Drill Guide

### Required Manual Updates

The following Manuals were reviewed for updates based on the SRSTF proposal.

- **Manual M-10 Pre-Scheduling Operations**

Section 2.2.4 – Planned Outage Restrictions for Black Start Units

**NO CHANGES REQUIRED**

- **Manual M-14D Generator Operational Requirements**

Section 10 – Black Start Replacement Process

~~Dave Schweizer to add details of 5 Year Selection Process to this section.~~

### **Section 10: Black Start Generation Procurement**

Welcome to the *Black Start Generation Procurement* section of the ***PJM Manual for Generator Operational Requirements***. In this section you will find the following information:

[Description of the PJM black start selection process.](#)

[Description of the PJM incremental black start RFP process.](#)

#### **10.1 Black Start Selection Process**

The following section outlines the PJM black start selection process.

##### **10.1.1 Frequency**

[PJM will issue an RFP for black start generation every five \(5\) years, which would be open to all existing and potential new black start units on a voluntary basis. The first five year selection process will result in black start solutions that will be effective as of 4/1/2015. Black start solutions from subsequent five year selection processes will be effective on April 1 each five years thereafter.](#)

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### **10.1.2 Selection Process**

The following steps A-H outline the various selection process phases to be implemented prior to the effective date for each five year selection process. The timeframes indicated represent time estimates (in calendar days or months) for each major phase (or multiple overlapping phases). Based on the aggregate of timeframes indicated, the selection process will be initiated no later than 24 months prior to each five year selection process effective date.

#### **A. Validate Critical Load**

PJM will send critical load data to GO / TO for validation. Critical Load requirements will be in accordance with Manual M36 Attachment A. PJM to work with GO / TO to reconcile differences and update accordingly.

Targeted time: 30 days

#### **B. Develop Technical Requirements for RFP**

PJM will coordinate technical requirements for RFP with TOs, including MW requirements, MVAR capability, and geographic details.

Targeted time: 30 days

#### **C. Issue RFP for resources interested in supplying new Black Start**

PJM will post the black start Request for Proposal (RFP) on the PJM website with notifications to the appropriate stakeholder groups. Interested bidders should review the guidelines posted on the PJM Black Start Services RFP page titled "General Guidance: Black Start RFP Response Content" for guidelines on content of proposals.

The RFP notification will also advise that all bids submitted for black start resources must be cost-based bids consistent with Schedule 6A of the PJM OATT. Details of the required cost components for each prospective black start replacement bid are provided in Manual M27.

Prospective RFP proposals:

Existing black start units would offer at the current rate. Existing compensated black start units do not need to respond to the RFP - the assumption is that they will continue to provide black start service at the current rate (Formula Rate or Cost Recovery Rate), but are not guaranteed to be selected to provide black start going forward, if reductions in critical load indicate that the black start service is no longer needed.

If existing units are not interested in supplying black start service going forward, they would need to submit a black start termination notice in accordance with the black start incremental RFP process.

If existing units want to change their rate utilized for cost recovery, they would need to terminate their current agreement and submit a proposal for consideration as an RFP response.

New black start resources in Generation Interconnection Queue would be eligible to respond to the RFP.

Existing units that would require upgrades to provide black start service would be eligible to respond to the RFP

Market window for RFP bids to be submitted: 90 days

#### D. RFP Proposal Evaluation

PJM will work with the TOs to evaluate proposals and select viable black start solutions based on the basis of Critical Load requirements, location, cost and operational considerations (amount, start time, etc.).

Units on a cost recovery rate would automatically be selected for the length of the recovery period. Units on bilateral contracts with TOs would be automatically selected for use in those zones.

PJM will work in collaboration with TOs to select black start solutions for each zone based on the following criteria (black start units do not need to be located in the same physical zone).

Required criteria shall include:

1. Meet critical load requirements in accordance with Manual M36 Attachment C.
2. Minimum of two black start units allocated to each zone with a critical load requirement.
3. Ability to supply critical loads within targeted timeframes (ie. nuclear loads with 4 hours).
4. Technical Feasibility:
  - a. Maintain voltages along cranking path within limits.
  - b. Maintain transmission flows along cranking path within thermal limits.
  - c. Maintain dynamic stability along cranking path.

Preferred options considered:

1. Operational Considerations:
  - a. Length of cranking path
  - b. Geographic diversity
  - c. Redundancy
2. Electrical proximity to critical loads
3. Timing requirements to serve critical load.
4. Test history and performance history of black start resource
5. Diversity and firmness of fuel source ~~and gas pipeline proximity.~~
6. Complexity considerations (ie. amount of switching to establish cranking path)
7. Black Start costs
8. Timing of black start resource availability

Opportunity for cross zonal coordination

PJM will work with the TOs to identify areas to identify cross-zonal opportunities in as detailed in Manual M36 Section 9. Potential cross-zonal options include:

Level 1 – Allow black start from outside TO zone to meet critical load.

Level 2 – Allow critical load and customer load pockets to be restored across TO zones.

Level 3 – Identify opportunities to fully aggregate TO restoration plans.

#### E. Verify Feasibility of Black Start Units Selected

PJM, with TO input, will identify black start cranking paths and black start units to source Critical Loads.

PJM, with TO input, will perform dynamic simulations and reactive/voltage studies on cranking paths, and if issues are identified on cranking paths, other black start units will be considered.

#### F. Review of Cost Recovery components

PJM will perform cost evaluation for each option and review cost recovery components provided for proposed black start solutions in accordance with OATT Schedule 6A.

Length of commitment would remain a minimum of 2 years (or longer based on capital recover time). Compensation for units not electing to recover black start capital costs is based on the PJM OATT Schedule 6A formula rate. Compensation for units electing to recover black start capital costs would be based on the PJM OATT Schedule 6A Capital Recovery rate based on the age of the unit. Black Start unit owners may also choose to file for recovery of actual costs directly with FERC.

IMM will verify cost data during selection process and verify annual revenue requirement (actual cost).

#### G. Review Selection Process Results with TOs

If reliability criteria are met, PJM will discuss any localized reliability issues, or any other special considerations with TOs, and address accordingly.

If reliability criteria are not met, proceed to Reliability Backstop Option, detailed in PJM Manual M36 Attachment A.1.3

If reliability criteria are met, but there is disagreement on units selected, PJM will work with TOs to resolve differences. If differences cannot be resolved the Dispute Resolution Process may be initiated.

TO may elect to procure additional black start outside of PJM OATT and Selection Process.

PJM will inform State Commissions about the results of selection process (general results, not unit specific)

Targeted time for Steps D through G: 6 months

#### H. Implementation of Black Start Solutions

PJM will notify new black start solutions resulting from the selection process. This notification will include authorizing construction work to proceed as required for any new black start resources selected.

TOs will incorporate the use of black start generation and cranking paths into their restoration plans and submit revised restoration plans to PJM.

PJM and TO will add cranking paths to internal PJM tools

PJM will provide current black start units that are not selected with a one year termination notice.

*Targeted time for Step H: 13 months*

### **10.2 Black Start Incremental RFP Process**

- **Manual M-12 Balancing Operations**

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Section 4.6 – Black Start Service

#### **4.6 Black Start Service**

Black Start capability is necessary to restore the PJM transmission system following a blackout. Black Start Service shall enable PJM, ~~in collaboration with TOs, and LCCs~~ to designate specific generators whose location and capabilities are required to re-energize the transmission system.

These designated resources, called black start units, are generating units that are able to start without an outside electrical supply or the demonstrated ability of a unit with a high operating factor (subject to PJM approval) to remain operating, at reduced levels, when automatically disconnected from the grid. The planning and maintenance of adequate black start capability for restoration of the PJM balancing area following a blackout represents a benefit to all transmission customers. All transmission customers must therefore take this service from PJM.

Black Start Service can be provided by units that participate in system restoration. Such units may be eligible for compensation under the Black Start Service. If a partial or systemwide blackout occurs, Black Start Service generating units can assist in the restoration of the PJM balancing area. ~~Specific generating units identified in specific Transmission Owners' local restoration plan(s), have the capability and training required to start up without the presence of a synchronized grid to provide the necessary auxiliary station power. The Transmission Owner restoration plans are implemented if a partial or complete system blackout occurs.~~

##### **4.6.1 Additional PJM Requirements**

The following is a summary of PJM Manuals that include information about PJM requirements for providing Black Start Service:

###### ***PJM Manual M12: Balancing Operations***

· Attachment C: PJM Black Start Test Report Form - includes link to forms on PJM website:

- PJM Black Start Test Form
- PJM Auto Load Reject Test Report Form
- PJM Black Start Formulaic Cost Data Form
- PJM Black Start Actual Cost Data Form

###### ***PJM Manual M10: Pre-Scheduling Operations***

· Section 2: Outage Reporting, Planned Outage Restrictions for Black Start Units

###### ***PJM Manual M01: Control Center Requirements***

· Section 4: Meter Accuracy Standards

###### ***PJM Manual M14D: Generation Operational Requirements***

· Section 9: ~~Black Start Selection Process~~ / Black Start Replacement Process  
· Attachment E: PJM Generator Reactive Capability Testing

###### ***PJM Manual M27: Open Access Transmission Tariff Accounting***

· Section 7: Black Start Service Accounting

###### ***PJM Manual M36: System Restoration***

· Section 6: Generation  
· Section 8: System Restoration Plan Guidelines  
· Attachment A: Minimum Critical Black Start Requirement

##### **4.6.2 Restoration Assumptions**

Transmission customers must purchase black start capability from PJM. Generation resources providing this service must successfully pass the requirements for black start capability.

~~The LCCs in conjunction with PJM, in collaboration with the TOs, is-are~~ responsible for identifying the generating units that are critical for PJM balancing area system restoration. During restoration activities, the ~~LCC-TO~~ manages and deploys the black start capability, as needed, depending on the specific situation.

The ~~LCCs-TOs~~ have developed and shall ~~periodically-annually~~ review the Restoration Plan ~~at least once every five years~~. ~~The LCCs in conjunction with PJM may amend this restoration plan and determine black start requirements to account for changes in the system configuration if either determines that additional black start resources are needed. PJM has the flexibility to seek offers for new resources whenever it amends the current plan. The annual update of the TO restoration plan may highlight the need for changes to the Black Start requirement. The TO will alert PJM of these situations to allow PJM to acquire more Black Start generation, if needed, through the Black Start Incremental RFP Process documented in Manual M-14D.~~

PJM is responsible for coordinating payments for all black start capability directly to the generating facilities that provide the service. Credits and charges are determined as described in *PJM Manual 27: Open Access Transmission Tariff Accounting*. Cost recovery provisions for Black Start Service units are detailed in PJM Open Access Transmission Tariff (OATT) Schedule 6A" Black Start Service".

#### 4.6.3 Jurisdiction

Following the complete loss of system generation (blackout), it will be necessary to establish initial generation that can supply a source of electric power to other system generation and begin system restoration. These initiating generators are referred to as system black start generators. They must be able to self-start without any source of off-site electric power and maintain adequate voltage and frequency while energizing isolated transmission facilities and auxiliary loads of other generators. Generators that can safely reject load down to their auxiliary load or an isolated island of load are another form of black start generator that can aid system restoration.

#### 4.6.4 Definitions

**Black Start Unit**— A single generator that is able to start without an outside electrical supply or the demonstrated ability of a base load unit to remain operating, at reduced levels, when automatically disconnected from the grid.

**Black Start Plant**— A plant that includes a unit that can black start. A Black Start Plant with black start units at different voltage levels (electrically separated) will be considered multiple Black Start Plants.

#### 4.6.5 Objectives of Determining Black Start Criticality

- Provide sufficient amount and redundancy of black start resources to initiate an orderly restoration of critical transmission system components and provide cranking power to generation facilities within PJM.
- Provide sufficient off-site power to ensure restart for nuclear facilities within PJM within the acceptable time-frame.
- Provide operational flexibility to address alternate system restoration scenarios as required by facility failures and outages.
- Critical black start generation is used to restore generator auxiliary load or other critical load to facilitate the system restoration process.

#### 4.6.6 Assumptions

~~—Enough black start generation will be deemed critical to facilitate the goal of~~

~~restoring the majority of the PJM RTO (80% of load) in 16 hours (recognizing other factors are involved in meeting this restoration time).~~

~~· Once a black start unit is started, it can be used to facilitate startup of other units (black start or not) at the same plant.~~

~~· Designated critical black start generation is identified as such in each Transmission Owners restoration plan.~~

~~· Redundancy of critical black start units is desirable due to possibility of unit failure to start or transmission facility failures preventing black start units from serving their intended loads.~~

#### **4.6.7 Minimum Critical Unit Requirements**

The PJM System Restoration Manual (M-36), Attachment A: Minimum Critical Black Start Requirement defines the minimum critical black start by transmission zone. In general, there must be sufficient critical black start to serve critical load (plus a 10% margin) and at least a minimum of three critical black start units for each transmission zone that has a critical load requirement. Exceptions to this requirement will be heard on a case by case basis and must be approved by PJM and seek endorsement by the PJM System Operation Subcommittee-Transmission.

PJM, in its role as Transmission Operator (TOP), is responsible for selecting the Black Start resources for a system restoration plan. PJM 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

The TO will adjust its system restoration plan based on the Black Start units allocated to it from this selection process. The TO 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).

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
  - o General notification of initiation and result of Dispute Resolution process will be given to the Operating Committee

#### **4.6.8 Critical Unit Restrictions for Eligible Compensation under the PJM Black Start Service**

~~–No more than three black start units at any one black start plant will be considered critical and eligible for compensation under the PJM Black Start Service unless approved as an exception~~  
~~–Critical black start units at a plant shall be chosen to minimize the impact of transmission outages or failures on black start capability.~~

#### **4.6.9 Exceptions**

~~Transmission Owners may request additional black start (more than 3 black start units at a plant) to be considered critical for black start and thus eligible for compensation under the PJM Black Start Service through an exception process.~~

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~~The exceptions must be for justifiable reliability reasons for system conditions or configurations not incorporated into this document.~~

~~Possible exceptions would be due to plant/unit limitations or restrictions, electrical (transmission) characteristics, electrical (auxiliary/balance of plant) characteristics or control characteristics.~~

~~These exceptions will be heard on a case by case basis and must be approved by PJM and the PJM-SOS Transmission.~~

***PJM Actions:***

- ~~- PJM has collected the list of critical black start units by Transmission Zone.~~
- ~~- PJM will analyze the critical black start units to ensure an adequate amount of black start generation exists on the system.~~
- ~~- PJM will analyze any exceptions to the three units per zone rule internally and through the SOS committee.~~

***PJM Member Actions:***

- ~~- PJM Transmission Owners will submit any requested changes to the critical black start list due to system configuration changes or changes to System Restoration plans to PJM Performance Compliance Department as they become known. The remainder of existing commitments to black start generators must be fulfilled unless agreed upon by the Generation Owner.~~

**4.6.10-8 Product Description**

**Black Start Service** - A generating unit is defined as "black start capable" if the following conditions are met:

- The generating unit has the ability of being started and can close an output circuit breaker to a dead bus without energy from other PJM generating units or demonstrated ability to operate at reduced levels upon automatic isolation from the grid in such a way that it meets all requirements stated in the Performance Standards and Testing sections of this document.
- The generating unit owner and PJM have agreed that the unit should be designated as black start capable.
- ~~The generating unit is located where black start capability is determined by the LCC and/or PJM by PJM and all affected TOs to be useful to system restoration and will be incorporated into the restoration plans of all affected TOs.~~
- ~~The generating unit must have the ability to close the output breaker to a dead bus within 90 minutes ~~three hours~~ of the request from the local Transmission Owner or PJM. PJM 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. PJM recognizes that Black Start resources with three hour start times may not be appropriate to meet nuclear power off-site safe-shutdown load restoration requirements. PJM will allow exceptions to this 3 hour start time requirement, if needed, on a case by case basis.~~
- A generating unit that is needed for system restoration and participates in black start service tests and System Restoration Drills may be eligible for compensation under black start service.

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**4.6.11-9 Generator Owner's Commitment**

The generator owner shall be committed to provide black start capability:

- Generators shall commit initially for at least two years to provide black start service from the black start service implementation date, with an annual right to terminate by each party (the generator owner and the transmission owner) with

one year's notice. In the event that neither the Black Start Unit owner nor the Transmission Owner exercises its right to terminate by providing a one year notice of termination, the commitment to provide Black Start Service automatically will be extended for an additional year to maintain a rolling two-year commitment.

- All succeeding annual commitments must be at least an additional year to maintain a rolling two-year commitment. Changes in cost may be made annually, but will become effective in the second year of commitment.

- If due to an event of force majeure a generator owner cannot provide Black Start Service, the commitment requirements stated above shall not be binding.

- In the event that a Black Start Unit fails to fulfill its two year rolling commitment to provide Black Start Service, the Black Start Unit owner shall forfeit the received monthly Black Start Service revenues for the period of its non-performance not to exceed revenues for a maximum of one year.

- A failure by a Black Start Unit to complete its applicable annual black start requalification test or failure of the annual test does not serve as notification of the Black Start Unit owner's intent to terminate Black Start Service nor does it serve as notification to start the Black Start Replacement Process described in **Manual 14D- Generator Operational Requirements**.

- Black Start Unit Owners shall commit to supplying an update to the Black Start Service cost formula as detailed in Schedule 6A of OATT via eDART upload process using the Black Start Forms in Attachment C.

#### **4.6.12-10 Performance Standards**

Each black start unit shall meet the following performance standards:

- The ability to self-start without any source of electric power from another PJM Capacity Resource within three hours or the time defined in the TO system restoration plan, Transmission LCC, as demonstrated through testing or the demonstrated ability to operate at reduced levels when automatically disconnected from the grid.

- The ability to close into a dead (de-energized) bus. This may be demonstrated by (a) physically closing the generator breaker connected to a dead bus while the unit is running or (b) by a test that simulates closing the generator breaker while only the generator side of the breaker is energized.

- If the unit has the ability to operate at reduced levels when automatically disconnected from the grid, this may be demonstrated by {a} physically removing the unit from the grid while the unit is running or {b} by a test that simulates removing the unit from the grid.

- The capability to maintain frequency under varying load. This may be demonstrated by (a) picking up an isolated block of load, or (b) by appropriate dynamic off-line testing of the governor controls.

- The capability to maintain voltage under varying load. This may be demonstrated by (a) picking up an isolated load, (b) by producing both leading and lagging VARs by varying the voltage setting while the unit is synchronized to the system, or (c) by appropriate dynamic off-line testing of the voltage controls.

- Ability to maintain rated output for a duration as identified by the LCC-TO System-system Restoration restoration Requirements plan. Requirements for supply to gas fueled black start units should be considered in the LCC-TO System-system Restoration restoration Plan plan. Specific gas supply requirements include, but are not limited to, electric feed to gas gate valves, or local gas compressors needed to maintain gas supply during the restoration process.

· In addition to these unit-specific performance standards, each black start generation owner must maintain procedures for the startup of black start generation at each black start generating station. These standards shall remain in effect for the duration of the commitment.

#### **4.6.13-11 PJM Obligations**

Generators that commit to provide Black Start Service shall not have their black start capable designation terminated within the time of their commitment. PJM shall provide at least a two-year notice to the owner or owners of generating units that are providing Black Start Service prior to terminating that unit's designation as black start capable.

Designated black start generating units shall recognize that PJM shall have the authority to ensure a minimum amount of black start capacity when deciding whether to approve generator outages. Critical black start units will have additional planned outage restrictions as defined in the Section 2 of PJM Manual 10: Pre-scheduling Operations.

#### **4.6.14-12 Testing**

Every generating unit that is providing black start capability shall be tested to verify that it can be started and operated without being connected to the PJM power system. Black start generating unit owners/operators shall annually schedule tests of resources providing black start capability to confirm the ability of such resources to meet the applicable standards for performance and control.

Tests may be scheduled at the discretion of the generation owner, however, tests must be prescheduled with PJM prior to the test. Compensation for energy output delivered to the system shall be provided for the unit's minimum run time at the higher of the unit's costcapped offer or real-time LMP, plus start-up and no-load costs for up to two start attempts, if necessary. Any unrecovered costs of Black Start Tests should be submitted in writing to the Manager of Market Settlements.

For units with high operating rates with the ability to remain operating at reduced levels when automatically disconnected from the grid, an opportunity cost will be provided to compensate the unit for lost revenue during the black start testing.

Annual tests shall include:

- Starting and bringing the resource to synchronous speed without assistance from a system electrical feed or demonstrating the ability to remain operating at reduced levels when automatically disconnected from the grid.
- Testing of all communication circuits.
- Simulating switching needed to connect the black start unit to the transmission system following a system blackout.
- Testing the features unique to each facility that relate to Black Start Service.

For New Units:

For a generator that is a new Black Start Unit, revenue requirements must be submitted to PJM and the MMU through the eDART upload process. Next, the unit must successfully pass a Black Start Service test according to their plant's procedures (and restoration plan requirements), and submit the test results to PJM using the PJM Black Start Test Report Form (Attachment C). Upon successful completion of the Black Start Service test, the payment start date is the 1st day of the next month following the receipt of both test and cost data.

For Units Integrating into PJM:

For an existing Black Start Unit which has recently been integrated into the PJM Region, the Black Start Unit owner must send revenue requirements to PJM and

**Comment [GB1]:** Note: No changes are required to BS test forms

the MMU through the eDART upload process at least one month prior to joining PJM. The unit must successfully pass a Black Start Service test within 6 months of integration then submit the test results to PJM using the PJM Black Start Test Report Form (Attachment C). The payment start date is the 1st day of integration.

For Recertifying Units:

After the Black Start Unit has been decertified due to failure to complete testing requirements, the Black Start Unit will be considered a new unit for purposes of testing, and must recertify by conducting a successful Black Start Service test. PJM will reinstate the unit's payment in the next month after the successful test is performed.

#### **4.6.13 Testing and Training Standards and Records**

Each black start generating unit shall be tested to verify it can be started and operated without being connected to the system. The black start generating unit owner/operator shall annually test the start-up and operation of each black start generating unit. Multiple tests may be attempted following the identification and reporting of corrective actions (See the Non-performance Issues section). Testing records shall include:

- Date(s) of test(s)
- Duration of test(s) from start of test until unit is on-line
- Test conditions (ambient temperature, general weather conditions)
- Indication of whether the unit was able to start without being connected to the system or demonstration of the ability to disconnect from the grid automatically and remain operating at reduced levels.

#### **Start time of Black Start unit from beginning of start up until unit connects to dead bus**

- Indication of the ability to close a circuit breaker into a dead bus
- Indication of the ability to remain stable and control voltages while operating isolated from the transmission grid and supplying the source's own auxiliary load for a period of at least 30 minutes.
- Description of the cranking path of the unit.
- Description of startup of auxiliary equipment required for startup and operation of the next non-black start unit.
- Description of communications and control systems that are capable of allowing SCADA/EMS data and voice communications, as defined in the PJM Control Center and Data Exchange Requirements Manual.
- Explanation of failed test and corrective actions taken
- Description of operator training
- Dates of training
- Copies of black start procedures
- If the item is not tested the Generator Owner must submit an explanation on the Black Start testing form explaining why the item was not tested.

Documentation of the test results of the start-up and operation of each black start generating

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unit shall be provided to PJM. PJM shall verify that the number, size, and location of black start capable units are sufficient to meet PJM's restoration plan expectations.

Note 1: If verification is done through simulation, the analytical analysis must be the result of dynamic studies that include the capacitive effects of cranking path circuits, unit reactive capabilities, possible steady-state and transient switching voltages, acceptable frequency, and proper modeling of large auxiliary motors required in startup.

#### **4.6.16-14 Non-performance**

To collect monthly black start revenues, a unit must have a successful black start test on record with PJM within the last 13 months. Once a generator is qualified, they have until the end of the 13th month following the last successful black start test date to submit documentation of the next successful annual test to PJM. Units are encouraged to adopt an annual testing cycle allowing the extra month to be reserved for retesting or scheduling conflicts.

If a unit fails a black start test, the unit is given a ten day grace period within which it may retest without financial penalty if within the thirteen month testing period. If the unit does not successfully pass a black start test within the ten day grace period immediately following notification of PJM a failed test, monthly black start revenues will be forfeited from the time of the first day of the month in which the unsuccessful test occurred until the first day of the first month AFTER the unit successfully passes a black start test.

#### ***PJM Actions:***

- PJM Performance Compliance Department will collect and analyze the Black Start Test data as described above from each black start unit to determine each unit's eligibility for Black Start Service payments. PJM will notify the MOC or Unit owner, as applicable, within five business days of test submittal of unit's failure.
- PJM Performance Compliance will notify the TO if a black start unit in their zone fails to complete a successful black start test in the required timeframe. PJM Performance Compliance will also notify the TO when units that failed black start tests are again eligible after completing a successful test.
- PJM Performance Compliance Department will maintain the list of eligible black start units and forward any changes to PJM Market Settlements.
- PJM Market Monitoring Unit will analyze any requested generator black start cost changes on an annual basis and forward all approved revenue requirements to PJM Market Settlements. The approved revenue requirements will be applied by PJM Market Settlements to Black Start Service payments starting with the month following the submission of the black start cost changes.

#### ***PJM Member Actions:***

- Black Start Generation Owners will notify PJM Performance Compliance [Blackstart@pjm.com](mailto:Blackstart@pjm.com), as well as the LCC in whose zone the black start unit operates, of expected black start test date.
- Black Start Generation Owners will notify PJM Operations prior to start of black start test.
- Black Start Generation Owners will report Black Start Test results using the PJM Black Start Test Report Form displayed in Attachment C of this manual. Generation Owners with Auto Load Reject Units will report their testing results using the PJM Auto Load Reject Test Report Form in Attachment C of this manual. Completed forms and other requested data will be submitted to the PJM Performance Compliance Department using the eDART XLS Upload Process.

· Black Start Generation Owners may request changes to their Schedule 6A revenue requirements (formulaic costs) annually by completing the PJM Black Start Formulaic Cost Data Form displayed in Attachment C of this manual. Formulaic cost data requests will be reviewed and approved by the PJM Market Monitoring Unit. Alternatively, Black Start Generation Owners may request changes to their actual costs annually by completing the PJM Black Start Actual Cost Data Form in Attachment C of this manual. Completed cost data forms and other requested data will be submitted with appropriate documentation to the PJM Market Monitoring Unit for analysis using the eDART XLS Upload Process, however actual cost change requests must be filed to with appropriate documentation to the FERC for approval.

#### **4.6.17-15 Termination of Black Start Service**

In the event a Black Start Unit intends to terminate Black Start Service, the Black Start Unit owner shall notify PJM of its intent to terminate Black Start Service using the steps described in the Black Start Replacement Process described in Manual 14D.

In accordance with the provision of Schedule 6A, PJM OATT, the unit owner must give one year's advance notice of intent to terminate Black Start service to allow time for the Black Start Replacement Process.

#### ***PJM Member Actions:***

· Follow actions for the Black Start Replacement Process as described in ***Manual 14D-Generation Operational Requirements.***

- Manual M-27 Open Access Transmission Tariff Accounting

Section 7 – Black Start Service Accounting

**NOTE: THESE CHANGES TO M-27 ARE SUBJECT TO CHANGE BASED ON FINAL OATT CHANGES.**

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## Section 7: Black Start Service Accounting

Welcome to the *Black Start Service Accounting* section of the **PJM Manual for Open Access Transmission Tariff Accounting**. In this section, you will find the following information:

An overview of the black start service accounting process (see “*Black Start Service Accounting Overview*”).

How credits for black start service are calculated (see “*Black Start Service Credits*”).

How charges for black start service are calculated for Network and Point-to-Point Transmission Customers (see “*Black Start Service Charges*”).

### 7.1 Black Start Service Accounting Overview

To ensure the reliable restoration following a shutdown of the PJM Transmission System, black start service is necessary to facilitate the goal of complete system restoration. Black Start Service is the capability of generating units to start without an outside electrical supply or the demonstrated ability of a generating unit with a high operating factor to automatically remain operating at reduced levels when disconnected from the grid. Black Start Service enables the Transmission Provider, ~~in collaboration with~~ and Transmission Owners to designate specific generators (Black Start Units) whose location and capabilities are required to re-energize the transmission system following a system-wide blackout (see the [PJM Manual for Balancing Operations \(M-12\)](#) for more details and eligibility).

Black Start Service is provided by the Transmission Provider, and all Transmission Customers must purchase this service from the Transmission Provider, pursuant to the PJM Open Access Transmission Tariff Schedule 6A. The charges for this service are based on a formula rate that allocates generation owners' black start revenue requirements, ~~Transmission Owner black start revenue requirements~~, and applicable Day-ahead and Balancing Operating Reserve Credits to Network and Point-to-Point Transmission Customers based on their monthly transmission use on a megawatt basis. Customers serving zonal Network and Point-to-point load are allocated a ratio share of the total revenue requirements and applicable Day-ahead and Balancing Operating Reserve Credits in the applicable zone(s). Customers serving non-zone load (including Point-to-Point Transmission Customers not serving PJM load) are allocated a ratio share of the total revenue requirements and applicable Day-ahead and Balancing Operating Reserve Credits for PJM. Effective 2/1/2013, the applicable Day-ahead and Balancing Operating Reserve Credits are those credits associated with the scheduling of units for Black Start service or testing of Black Start units.

### 7.2 Black Start Service Credits

Each generation owner of Black Start Units that meet PJM and NERC criteria receives a monthly Black Start Service credit equal to one-twelfth (1/12) of its annual black start revenue requirement. Revenue requirements for Black Start Service may include the following, where applicable: NERC CIP Capital Costs, fixed black start unit costs, variable black start costs, training expenses, oil storage and an incentive factor. Revenue requirements for units with the ability to disconnect from the grid automatically and remain operating at reduced levels (ALR) may only recover training costs and an incentive factor. ~~Each Transmission Owner that is eligible to recover costs for cross zonal coordination receives a monthly Black Start Service credit equal to one-twelfth (1/12) of its annual black start revenue requirement~~ For more information on Black start unit revenue requirements, please see **Schedule 6A, PJM's Open Access Transmission Tariff (OATT)**.

Monthly black start service revenues are forfeited for: units that fail a black start test and do not successfully pass a test within a ten day grace period immediately following a failed test; and, for units without a successful black start test on record with PJM within the last thirteen months.

Revenue requirements for joint-owned black start units are allocated to the owners based on their ownership shares. Zonal revenue requirements equal the total revenue requirements of all black start units nominated as critical by a transmission owner the Transmission Provider in that zone regardless of zonal location and the share of annual revenue requirements for eligible cross zonal coordination costs.

The current zonal revenue requirements are posted on the PJM website under Markets & Operations/Market Settlements (<http://www.pjm.com/markets-and-operations/market-settlements/black-start.aspx>).

### 7.3 Black Start Service Charges

This section describes the process of calculating the Black Start Service charges. Charges for black start service are calculated for zone (Network Customers and customers serving load with Point-to-Point Transmission Service) and for non-zone (Non-Zone Network Customers and Point-to-Point Transmission Customers) load separately. The sum of all customers' monthly charges equal one-twelfth (1/12) of the total annual black start revenue requirements that are credited to generation owners of black start units plus one-twelfth (1/12) of the total annual black start revenue requirements that are credited to Transmission Owners for cross zonal coordination costs plus a share of the applicable Day-ahead and Balancing Operating Reserve Credits that are credited to generation owners of black start units for the month. Effective 2/1/2013, the applicable Day-ahead and Balancing Operating Reserve Credits are those credits associated with the scheduling of units for Black Start service or testing of Black Start units.

Each Transmission Customer's charge is calculated by determining the Transmission Customer's monthly zone and non-zone transmission use on a megawatt basis.

- Monthly zone transmission use is the sum of a Transmission Customer's Network daily peak load contributions to a PJM zone and daily average Point-to-Point energy reservations where the point of delivery is within a PJM zone.
- Monthly non-zone transmission use is the sum of a Transmission Customer's non-zone Network daily peak load contributions and daily average Point-to-Point energy reservations where the point of delivery is the border of PJM.

Transmission Customers with monthly non-zone transmission use are charged a share of the total PJM pool-wide black start revenue requirement and applicable Day-ahead and Balancing Operating Reserve Credits based on their portion of the total PJM monthly transmission use. Transmission Customers with monthly zone transmission use are charged a share of the applicable zonal black start revenue requirements and applicable Day-ahead and Balancing Operating Reserve Credits (less the total share of revenue requirements recovered from non-zone transmission use) based on their portion of monthly transmission use in that zone(s).

#### **PJM Actions:**

- The PJM accounting process collects each generation owner's and transmission owner's annual black start revenue requirement for each zone. Monthly black start revenue requirements equal 1/12 of the annual revenue requirements. Black Start Units that are shared and nominated by multiple zones will have their annual revenues allocated by Transmission Owner designated critical load share percentage. Transmission Owner cross zonal coordination costs for Black Start Units that are shared and nominated by multiple zones will have their annual revenues allocated by Transmission Owner designated critical load share percentage.
- The PJM accounting process collects each generation owner's day-ahead operating reserve credits and balancing operating reserve credits that are associated with the scheduling of units for black start service or black start testing for each zone. Additional details on testing of units for Black Start service can be found in Manual 12. The PJM accounting process retrieves the point-to-point energy reservations for each Transmission Customer.
- The PJM accounting process calculates each Transmission Customer's monthly non-zone transmission use (MW) by summing for all hours in the month all of their point-to-point energy reservations (adjusted for PJM curtailments) and dividing that value by 24.
- The PJM accounting process calculates each Transmission Customer's monthly zone transmission use (MW) by summing for all days in the month all of their daily network integration transmission



service peak load contributions for each zone (see *Network Integration Transmission Service Accounting* section of the **PJM Manual for Open Access Transmission Tariff Accounting**).

- The PJM accounting process calculates charge allocations for each Transmission Customer with monthly non-zone transmission use as follows:

$$\text{Monthly Non - Zone Charge} = \left( \frac{\text{Transmission Customer's Monthly Non - Zone Transmission Use}}{\text{PJM Total Transmission Use}} \right)$$

- $\times$  (PJM Total Generation Owners' and Transmission Owners' Monthly Black Start Revenue Requirements + PJM Total Monthly Day - ahead and Balancing Operating Reserves Credits associated with Black Start)

- The PJM accounting process calculates an Adjustment Factor to be applied to all monthly zone charges as follows:

$$\text{Adjustment Factor} = \frac{\text{Total Monthly Zone Transmission Use for all PJM Zones}}{\text{PJM Total Monthly Transmission Use}}$$

- The PJM accounting process calculates charge allocations for each Transmission Customer with monthly zone transmission use as follows:

$$\text{Monthly Zone Charge} = \left( \frac{\text{Transmission Customer's Monthly Zone Transmission Use}}{\text{Total Monthly Zone Transmission Use in Zone}} \right)$$

- $\times$  (Total Generation Owners' and Transmission Owners' Monthly Black Start Revenue Requirements in Zone + Total Generation Owners' Monthly Day - ahead and Balancing Operating Reserve Credits associated with Black Start in Zone)
- $\times$  Adjustment Factor

- The PJM accounting process calculates each Transmission Customer's total monthly black start service charge by summing its monthly charge allocations for all zone and non-zone transmission use.

- Manual M-36 System Restoration

Section 6.2 – Cranking Power

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## 6.2 Cranking Power

As currently designed, many if not most units located at stations throughout the PJM RTO trip offline as a result of a major event. The shutdown of these units occurs automatically by relay action or manually by plant operator intervention to protect the units.

A few units in the PJM RTO are designed to automatically isolate with enough local load to achieve stable load/generation balance. In the event that a unit does isolate with load and is able to stabilize within acceptable frequency levels, operators should exercise prudence in their efforts to pick-up load or provide assistance to others.

Shutdown generating units that do not have black start capability require start-up cranking power from an offsite source. To deliver the cranking power, a start-up path consisting of transmission and distribution lines and buses must be established. Each Transmission Owner's system restoration plan (SRP) must provide for cranking power to non-black start units including any necessary arrangements with other Transmission Owners or systems as may be necessary to provide start-up assistance not readily available within the company's area.

The following types of Cranking Paths are defined:

Cranking Path – transmission path from a Black Start unit to another generator with the intent to facilitate startup of that generator to aid in the restoration process. ~~If the generator being supplied the cranking power has an 8 hour or less startup time, it is considered as Priority 4 Critical load per Attachment A~~

Critical Restoration Path (Nuclear) – transmission path from a Black Start unit (or other source) that provides offsite power to a nuclear plant's auxiliary equipment to allow the nuclear plant to maintain safe shutdown

Critical Restoration Path (Load) – transmission path from a Black Start unit (or other source) to restore load that is identified as critical load in ~~the System Restoration plan or~~ Attachment A

Non-Critical Restoration Path – transmission path from a Black Start unit (or other source) to restore non-critical loads or facilities as identified in the System Restoration plan

### 6.2.1 Units Requiring Cranking Power

Following a blackout condition, an assessment must be made of the status, condition, and availability of system generating units. This survey identifies all available units requiring cranking power for restart. Even units normally capable of black start operation may require cranking power due to pre-existing constraints or as a result of the event leading to shutdown.

Before decisions can be made on returning generating units to service, certain facts about the specific units must be known beforehand. Having a tabulation of the individual unit

characteristics, capabilities, and operating restrictions is beneficial when selecting the order and fit of the units for the restoration sequence. These facts need to be compared to the actual serviceability of these units soon after the disturbance has occurred, with special emphasis placed on defining any changes to ramp rates, re-start times, minimum or maximum load and VAR generation, regulation capability, fuel availability, or damage that occurred which might constrain unit operation.

Priority access to start-up power is given to hot units that can return to service ~~immediately, or within a short timeframe~~ within 4 hours. In addition, as cranking power becomes available, preference is given ~~initially to the best~~ regulating units to assure stable system frequency after they are loaded.

[See Attachment A for Critical Load requirements.](#)

### **6.2.2 Cranking Power Demand**

Assess cranking power requirements from each station for return of individual units. Critical auxiliary loads are picked up in discrete steps, where possible, to minimize the total cold-load pick-up.

### **6.2.3 Cranking Power Source and Black Start Paths**

Contingency plans for re-start of all units are prepared, including examination of steady state and transient voltages resulting from possible system configurations and switching conditions in establishing a black start path.

Transmission or distribution corridors for supplying start-up power are selected, taking extra care to isolate and avoid damaged facilities, while restoring critical AC power to key substation facilities along the black start path. The integrity of air and gas operated circuit breakers and pressurized oil filled cables, as well as relay, control, and communications systems at these key substations depends on the timely restoration of their stations service facilities.

Where possible, field personnel are used to verify the condition of equipment along the black start path and to verify breaker positions.

Transmission Owners must include available cranking power and transmission paths in their individual restoration manuals.

When start-up power or Black Start generation is required from another Transmission Owner/Generation Owner or Control Area, arrangements include a determination of whether or not the unit receiving start-up assistance becomes synchronized to the supplying company or system. Implications could include isolation of the receiving unit from its own system or creation of an unintended interconnection between the two areas. [Cranking paths between TO zones must be documented within each TO system restoration plan.](#)

### **6.2.4 Energize Start-up Loads**

Auxiliary power is restored to the generating sites as soon as possible to improve their availability. Station emergency generators and back-up batteries may provide power for only the most essential safety systems, but cannot be counted on as a source for a unit start-up.

Early restoration of auxiliary power to the non-black start units will help control equipment damage and minimize the time for required unit re-starts.

## SECTION 8.1.1 Ascertain System Status

### 8.1.1 Ascertain System Status

Each Transmission Owner and PJM determine the extent of the service interruption within its boundaries and inform the appropriate personnel as soon as possible of existing generation and transmission capacities, equipment damage, and other appropriate information.

SCADA and local metering is used to provide important information regarding the status of the electric power system. During a system collapse, there are a large number of changes in equipment status and alarms coming into the respective Transmission Owner/Generation Owner energy control centers. SCADA systems are designed so that alarm processing does not inhibit detection of problems and are capable of continued operation during system disturbances/blackouts.

Energy control centers have adequate back-up power to provide a minimum of 24 hour stand-alone capability. However, plans should include provisions to ensure longer stand-alone capability. Future hardware is designed and powered by redundant sources where possible. Telecommunications systems used in conjunction with RTUs, operating computer systems, telemetry, voice, etc. must be powered by battery, UPS, or emergency generators and be capable of operating during a complete system blackout.

Field reports from personnel in substations can be used to enhance information obtained from SCADA systems regarding the status of the electric power system. These personnel can provide meter readings, breaker status, alarms, etc.

PJM reports via the ALL-CALL system provide information regarding the extent of the outage known at the time.

Generation plant reports are used to determine unit availability. The dispatchers notify each power plant about the extent of the outage and system status known at the time.

Equipment status is tabulated by dispatchers through communications with power plants.

Cranking Power Availability — Sufficient resources for black start units are available to ensure safe shutdown and be capable of restart as soon as cranking power is available.

Cranking power is available to restart necessary ~~steam~~-generating units at ~~steam~~-plants or through portions of the internal transmission system.

Confirm status of plant starting procedures — Each steam plant implements start-up procedures immediately following plant shutdown. Steam plants do not wait to implement start-up procedures until contacted by Transmission Owner/Generation Owner dispatchers. ~~A restoration time for station service of thirty (30) minutes or less is striven for.~~

Estimated time of return (on-line time) — Plants provide estimates to Transmission Owner/Generation Owner dispatchers of unit return times.

Where applicable at steam power plants, station services are restored as soon as possible taking into consideration battery limitations and loss of water/steam in boilers.

Units that were able to maintain on-line status have priority for additional load to achieve stable operation.

## NEW SECTION 9: Cross-Zonal Coordination

Welcome to the Cross-Zonal Coordination section of the PJM Manual for System Restoration (M-36). In this section you will find the following information:

How PJM works with the TOs to identify cross-zonal coordination opportunities

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### 9.1 Cross Zonal Coordination of system restoration plans

PJM will work with the TOs to identify areas in the RTO where it would be beneficial to coordinate system restoration plans based. Analysis on the benefit of pursuing this option will be based on the following criteria:

#### 1) Reliability Requirements

- Reliability requirements including:

- Procuring sufficient Black Start resources to meet critical load requirements
- Meeting critical load restoration timing requirements
- Meeting redundancy requirements

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#### 2) Efficiency Opportunities

- Cost Savings

- PJM will work with the TOs on a cost/benefit analysis for decisions on utilizing cross zonal coordination. The cost/benefit analysis will require a savings ratio of 1.2 (benefit to cost) threshold for consideration. Cost benefit ratio will evaluate:

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- Black Start unit cost differences (savings)
- Potential additional TO costs including coordination costs, CIP related costs and other costs the TO might incur (such as increased training, increased analysis of the restoration plan, increased compliance cost, etc)

- Potential for increased efficiency and speed of restoration

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The following considerations will be evaluated when analyzing cross-zonal coordination options:

- Technical feasibility requirements including:

- 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

- 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
  - 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

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These cross zonal opportunities will be evaluated during the 5 year Black Start selection process (as outlined in Manual M-14D) or upon changes to Black Start capability or critical load amounts. TOs may also request PJM to evaluate opportunities.

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 Section 5 of the PJM Operating Agreement
  - General notification of initiation and result of Dispute Resolution process will be given to the Operating Committee

There are three possible levels of Cross Zonal Coordination as defined in the following subsections.

#### 9.1.1 Level One Cross Zonal Coordination

Level one cross zonal coordination refers to supplying Black Start generation from outside a TO zone to meet that zones critical load requirements. PJM would pursue this option in order to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).

Restoration plans would remain on a TO basis, but coordinated between TOs. The cross-zonal coordination must be documented in both the receiving TO restoration plan and the supplying TO restoration plan. The supplying TO would document the cranking path from the Black Start unit to an agreed upon border with the receiving TO. The receiving TO would document the cranking path from the agreed upon border with the supplying TO to the critical load that is being supplied.

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Black Start redundancy will be evaluated on a TO zonal basis (2 BS units allocated to each TO zone, though physically may be outside zone)

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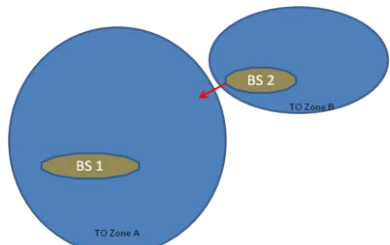


Figure X – Example of level one cross zonal coordination. In this example Black Start units one and two both supply TO Zone A even though Black Start Unit two is located in TO Zone B.

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### 9.1.2 Level Two Cross Zonal Coordination

Level two cross zonal coordination refers to supplying critical load and/or customer load pockets across TO zones. A single Black Start resource may be used to serve critical load in multiple TO zones. PJM, in collaboration with TOs, would pursue this option in order to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).

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Restoration plans would be on a TO basis, but coordinated between TOs. The Level two cross zonal coordination must be documented in both TO Restoration Plans. Redundancy would be on a TO basis (2 BS units allocated to each zone, though physically may be outside zone)

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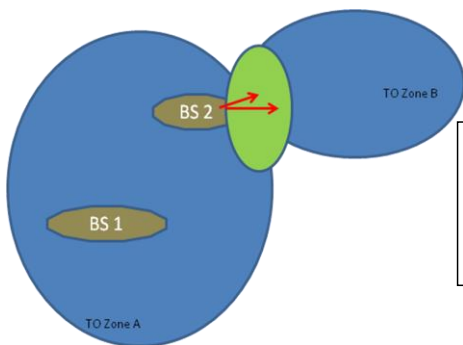


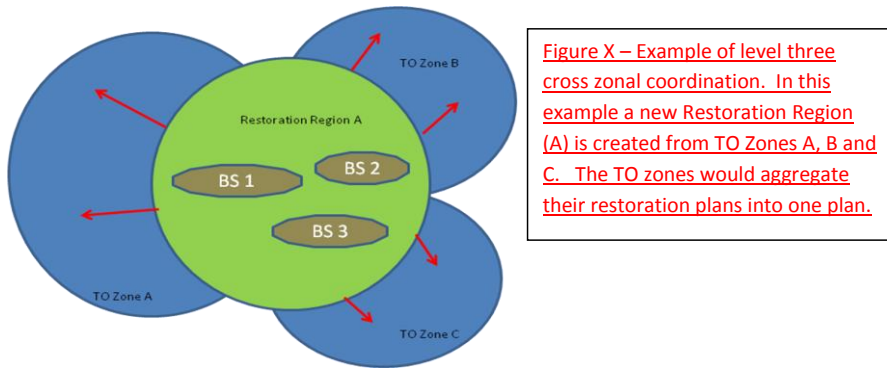
Figure X – Example of level two cross zonal coordination. In this example Black Start unit two is shared between TO Zone A and TO Zone B. Critical load is restored from this unit

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### 9.1.3 Level Three Cross Zonal Coordination

Level three cross zonal coordination refers to fully aggregate TO restoration plans into a combined plan for a newly defined Restoration region. This could be done to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).

Level three cross zonal coordination would involve merging of 2 or more existing TO zones or creating new Restoration Regions (new boundaries). There would be one Restoration plan for the aggregated area(s). Redundancy requirements would be evaluated on a Restoration region basis.



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## Attachment A: Minimum Critical Black Start Requirement

### A.1 Critical Black Start Criteria

#### A.1.1 Goal

The PJM System Operations Subcommittee (Transmission) was requested to create a minimum critical black start criterion that can be applied across zones to support system restoration goals defined within the **PJM Manual for System Restoration (M36)**. System Restoration Strategy Senior Task Force (SRSTF) was charged by the Markets and Reliability Committee (MRC) with the task of examining the current System Restoration planning process to determine its viability and efficiency moving forward in light of pending Black Start retirements. This criterion is intended to be utilized as a measure to evaluate critical black start retirement and ensure adequate replacement. Since there are many factors that impact targeted restoration times contained with M-36, maintaining the minimum critical black start



~~requirement by transmission zone does not necessarily guarantee restoration targets will be realized. The SRSTF developed requirements for the amount and redundancy of Black Start generation based on critical load requirements.~~ Specific black start data<sup>1</sup> to include fuel resources for black start power for generating units, available cranking and transmission paths, and communication adequacy and protocol and power supplies are contained ~~in this manual and~~ in the PJM Black start database.

### A.1.2 Minimum Critical Black Start Requirement

This attachment to the *PJM Manual for System Restoration (M-36)* defines the Minimum Critical Black Start Requirement on each transmission zone ~~(or restoration area if level 3 cross zonal coordination is utilized)~~ to be the sum of critical steam cranking power load, gas infrastructure critical load and nuclear off-site station light and power load requirements, ~~with an allowance for exceptions or additions based on unique circumstances.~~ Critical Load consists of the following components:

- ~~1. Cranking power to all units with a hot start time four hours or less\*~~
- ~~2. Off-site Nuclear Station Light and Power (to maintain safe shutdown)~~
- ~~3. Critical Natural Gas Infrastructure (such as electric compressors)~~
- ~~4. Exceptions or additions to the criteria shown above will be allowed with PJM approval~~
  - ~~a. SOS-T endorsement will be sought for these exceptions and additions.~~
  - ~~b. One such example could be to address coping power needs for steam units that cannot be supplied by resources other than Black Start.~~

~~\*Note: For generating stations with multiple units (0-4 hour start), consider the impact on restoration time if only enough critical load was carried to start one of the units at the station. This unit could then supply the other units at the station with auxiliary power. If doing this would increase restoration time significantly, critical load will be identified for all units at the station. Consideration will also be given to whether plant personnel can start all units at the plant in parallel given physical plant or resource constraints.~~

~~Off-site power should be restored as soon as possible to nuclear units, both units that had been operating and those that were already off-line prior to system disturbance, without regard to using these units for restoring customer load. Nuclear units that are taken off-line on a controlled shutdown can normally be restored to service between 24 and 48 hours following the controlled shutdown~~

~~A list of critical substations that serve Gas Infrastructure critical load will be documented in the Transmission Owner's Restoration Manual~~

~~**Required Black Start = 110% (Critical Load requirement) on a locational basis**~~

<sup>1</sup> NERC EOP-005 Attachment 1-2

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This will account for an average forced outage rate (5%) plus an allowance for additional, unexpected Critical Load (5%). It is recognized that while this requirement is generally specified on a TO zonal basis, that zones may be aggregated, as described in Section 9 (cross zonal coordination) , such that the Black Start resources may physically lie in adjacent zones.

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In addition, PJM recognizes the need for some redundancy in Black Start generation. Redundancy allows for system restoration even if some Black Start resources are unavailable, potential system damage precludes use of certain Black Start resources and also allows for variance between Critical Load calculations and actual needs. To achieve this redundancy:

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**PJM will ensure a minimum of two Black Start resources are “allocated” to each transmission zone with a Critical Load requirement.** Note that the Black Start resources are not required to be physically located within the zone to which they are allocated. However, each zone must be able to identify within their system restoration plan the two resources allocated to them during a system restoration. Exceptions to this “two resource rule” will be allowed with PJM and System Operation Subcommittee-Transmission (SOS-T) endorsement.

Generation Owners must notify PJM and Transmission Owners if a critical blackstart fuel resource at maximum stated output falls below 10 hours.

Additionally, off-site power should be provided to Nuclear Generation consistent with the timelines identified in the Transmission Owner's Restoration Plan or NPIR agreements.

PJM, 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. PJM 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.

PJM, in its role as Transmission Operator (TOP), is responsible for selecting the Black Start resources for a system restoration plan. PJM would work closely with the TOs to identify these units based on:

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- Critical Load requirements
- Available Black Start resources
- Minimum number of Black Start resources allocated to a zone
- Possible cross zonal coordination opportunities

PJM will 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. PJM 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. PJM 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.

The TO will adjust its system restoration plan based on the Black Start units allocated to it from this selection process. The TO 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).

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

~~Additional critical black start, above the minimum critical black start requirement, can be maintained to restore critical priority 2 load, specifically cranking power to combustion turbines, light and power to critical substation, pumping plants for underground cable systems, critical communication equipment, and critical command and control facilities, which should enhance the ability to meet the time dependant targets identified in the **PJM Manual for System Restoration (M36)**.~~

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.

### **A.1.3 Background**

#### **A. Restoration Targets / Assumptions:**

A system assessment following a blackout is a critical first step in identifying an overall system restoration time. While PJM and its Members work to restore the integrity to the interconnection as quickly and safely as possible, there are a wide variety of factors that can influence a system restoration. Following a system assessment, estimates of restoration times of the Bulk Electric System (BES) transmission and customer load restoration estimates can more accurately be made.

The following assumptions are applied to planning for a System Restoration:

- Total system blackout (no assistance from external systems)
- Normal weather pattern (not a result of a natural disaster or extreme weather)
- Intermediate to peak load level (marginal steam units hot)
- Minimal equipment damage (transmission/generation).
- Normal working hours (sufficient personnel located in field or on-call)

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~~Because of the Variables such as the~~ current scheduling strategies, the amount of nuclear units operating, ~~load levels, weather conditions, equipment damage and the amount of~~ direct purchases ~~may impact restoration times, these restoration times may be difficult to achieve, but are striven for in restoration plans and procedures.~~ Longer restoration times may result from disturbances during off-peak hours or disturbances resulting from extreme weather patterns. Faster restoration times may be possible dependent upon actual system separation boundaries, the ability to import generation and status of equipment.

#### ~~B. Definition of Critical Load~~

~~1) In order to prioritize the restoration process in an attempt to accelerate system restoration timelines, the PJM System Operations Subcommittee defined critical load, load which hold a higher priority during the restoration process. Critical loads were divided into 2 priorities. Priority 1 Critical load provided by black start~~

##### ~~Cranking power to Critical Steam~~

- ~~○ Critical steam is defined as steam units with a hot start time of 8 hours or less.~~

##### ~~Off-site Nuclear Station Light and Power~~

- ~~○ Off-site power should be restored as soon as possible to nuclear units, both units that had been operating and those that were already off-line prior to system disturbance, without regard to using these units for restoring customer load. Nuclear units that are taken off-line on a controlled shutdown can normally be restored to service between 24 and 48 hours following the controlled shutdown.~~

##### ~~Critical Gas Infrastructure~~

- ~~○ The operations of the Gas Infrastructure is key in quickly restoring Critical Steam units. A list of critical substations that serve Gas Infrastructure critical load will be documented in the Transmission Owner's Restoration Manual.~~

**Note:** Cold Start is excluded from priority 1 critical load due to assumption of intermediate to peak load conditions. The only exclusion would be seldom run generation, which may still be considered as priority 2 critical load if the Transmission Owner considers the unit a critical component of the restoration plan.

~~Priority 2 Critical Other high priority load provided by black start or other critical generation which should be considered early in the restoration process~~

##### ~~Cranking power to combustion turbines~~

- Power to electric infrastructure in accordance with timeframe defined in restoration manual.
- Light and Power to restore critical substations (if applicable).
- Pumping plants for underground cable systems. \_\_\_\_
- Critical Communication Equipment.
- Critical command and control facilities
- Underfrequency load shed circuits

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- Underfrequency load should be restored consistent with the guidelines contained in Sections 2, 3, and 5 of the *PJM Manual for System Restoration (M-36)*.

~~Black Start generation will not be specifically procured to meet these loads. Sufficient generation should be available in the early stages of system restoration to restore these loads.~~

~~The PJM System Operations Subcommittee agreed to focus on ensuring sufficient black start generation to address Priority 1 Critical Load. Priority 1 Critical Load will be quantified and incorporated into the Transmission Owner's Restoration Plan.~~ The Transmission Owner's Restoration Plan will identify the importance of restoring Priority 2 Critical ~~these~~ loads, although the Transmission Owner may choose not to explicitly quantify; ensuring priority 2 ~~these~~ loads ~~are~~ restored as the restoration process progresses.

~~Transmission Owners prioritize restoration of load as follows:~~

~~Restoration of Priority 1 critical load which includes cranking power to critical steam, off-site Nuclear station light and power, and Critical Gas Infrastructure.~~

~~Restoration of Priority 2 critical load which includes cranking power to combustion turbines, power to electric infrastructure, critical communications equipment, critical command and control facilities, and underfrequency load shed circuits (consistent with *PJM Manual for System Restoration (M36)*, Sections 2, 3, and 5).~~

#### ~~C.B.~~ **Selection of Critical Black Start Replacement**

Minimum Critical Black Start Criterion—The minimum critical black start criterion is measured against a transmission owner's definition of critical load. If a transmission zone level of critical black start falls below that transmission zones definition of critical load, additional existing black start generation would need to be declared/compensated as critical black start or replacement black start generation would need to be procured if there is insufficient pre-existing black start capability (refer to the *PJM Manual for Generator Operational Requirements (M-14D)*, Section 9: *Black Start Replacement Process*). ~~In addition, the transmission owners have the ability to list specific exceptions within the Transmission Owners Restoration Manual; these exceptions are not explicitly defined as part of critical load.~~

Variables for Critical Black Start Replacement—Determining the amount of critical black start generation by transmission zone depends upon the physical characteristics of the ~~critical steam~~ units, transmission system, and proximity of the critical black start generation to the critical load, as well as the installed capacity and reactive capability of the critical black start generator.

The following variables should be considered when selecting the size and location of critical black start replacement:

Critical black start generation should be electrically dispersed within the Transmission zone. The placement of critical black start units should:

- ~~o Support the simultaneous restoration of multiple islands, consistent with concepts documented within the Transmission Owner's Restoration Plan.~~
- o Provide sufficient redundancy within an electrical area to protect against equipment failures, allowing the execution of the documented restoration plan.

- Ensure multiple transmission outlets, protecting against equipment damage.
- Ensure a minimum of ~~3~~2 critical black start generators per Transmission Zone.

**Note:** Replacement black start outside the boundaries of the Transmission Zone should be considered.

The following factors should be considered in ranking the benefits of replacement Black Start Generation.

- Located at Plant – It is more beneficial to co-locate Black Start generation at a station with multiple generators. ~~The number of Black Start generators at a common plant should be limited to 3.~~
- Electrically close to Critical Steam Load. Some consideration may be given to location based on fuel diversity of critical steam.
- Start time of Black Start unit
- ~~Electrically close to Combustion Turbines.~~
- Sized appropriately (MW and MVAR lead/lag) – Black Start Generation must be sized appropriately to provide sufficient MW to restore critical load and sufficient MVAR capability for voltage control.
- Transmission outlet(s) / sufficient load for voltage control – Units that are not co-located at a station should ensure multiple transmission outlets so that the Black Start generation is not bottled in the event of equipment damage. Additionally, Black Start generation size requirements may increase depending upon the electrical closeness to critical steam in order to restore sufficient load to maintain voltage control.
- Hydro limitations (fuel diversity concerns) – Restoration Plans should not rely too heavily on potential fuel limited resources and should consider fuel diversity.

### A.1.3 Reliability Backstop Option

PJM will trigger a Reliability Backstop option given the following conditions:

- 2 failed incremental RFPs – no technical solution available even after consideration of cross zonal coordination options
- Technically feasible solution available, but not economically feasible (not in accordance with OATT rate or FERC rate is rejected)
- Reliability criteria not met in 5 year Selection Process in one or more areas

If the Reliability Backstop process is triggered, exceptions to the reliability criteria would be allowed for the following situations:

- Black Start capacity is less than Critical Load Requirement

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- Less than 2 Black Start resources per zone (or Restoration Region if zones are aggregated)
- Critical Gas Infrastructure load restoration is longer than 4 hours
- Nuclear safe shutdown load restoration is longer than 4 hours

These exceptions would request (but not require) SOS-T endorsement.

If the Reliability Backstop process is triggered and one or more of the following situations exist, other options for remediation will be pursued:

- NPIR requirement violated
- No Black Start generation allocated to a zone that has a Critical Load requirement

These other options that will be pursued may include:

- RTEP Transmission only solution such as new transmission line for cranking path; reactor/SVC for voltage control; etc
- PJM will work with generators in Interconnection Queue to install new Black Start capability
- PJM will work with TO to contract for Black Start capability

If all of these methods fail:

- Deficient zone will receive cranking power as it becomes available from neighboring zones.
  - This cranking power will NOT be from a Black Start unit and will likely not be available until after an extended period of time
  - Based on M-36, Section 8.1.9, cranking power must be supplied to neighboring areas as a priority to restoring internal load

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## Attachment D: Restoration Drill Guide

### Purpose of Guide

To document procedures for simulating and, where practical, testing and verifying the plan resources and procedures as well as PJM's annual system restoration requirements and goals<sup>2</sup>. This guide will also be used as to train operating personnel in the implementation of the restoration plan. The training will include at least two annual simulated exercises as required by EOP-005 R6 and R7.

### Drill Logistics

PJM holds an RTO-wide restoration drill each spring. The drills are conducted utilizing the Dispatcher Training Simulator (DTS). A team of PJM System Operators coordinate the restoration efforts of all member companies, who operate from their offices, utilizing their DTS, if available. The member companies coordinate with their field personnel. The bottom-up approach to system restoration is emphasized during the drills on the DTS, such that it is clearly demonstrated that critical black start units within each zone's system restoration plan can perform their intended function. System Operations Subcommittee (SOS) conference calls are held periodically throughout the drill. A debrief and critique follows each drill. These drills are one-day events.

[PJM will work with the System Restoration Coordinators Task Force to focus training and drills on a variety of potential scenarios that could result from a system blackout and restoration.](#)

In the fall of each year, PJM hosts "individual" transmission zone drills at the PJM Milford facility. For these drills, each Transmission Owner sends a team to PJM to drill on restoring its system using PJM's DTS. The PJM System Operators work side by side with the member dispatchers in this effort. The top-down approach to system restoration is emphasized. A debrief and critique follows each drill. Transmission Owners test telecommunication facilities that are needed to implement their restoration plan as part of the semi-annual PJM Restoration Drill if not done otherwise during the year.

Transmission Owner restoration plans are tested on at least a semi-annual basis, consistent with the PJM Restoration Drill schedule. As part of the drill post-assessment, PJM and Transmission Owners verify the plan resources and procedures. Additional Transmission Owner simulations or tabletop exercises are conducted to ensure Transmission Owner personnel are familiar with PJM and Transmission Owner restoration plans.

Transmission Owner Training Staff retain personnel training records that demonstrate PJM Certified operating personnel have been trained annually in the implementation of restoration concepts and the PJM and Transmission Owner restoration plans<sup>3</sup>. Training records are provided to PJM on an annual basis or as requested.

PJM and Transmission Owners verify the restoration procedure during the semi-annual PJM System Restoration Drill and internal drills. Transmission Owners review and update their restoration plans at least annually and whenever it makes changes in the power system network, and shall correct deficiencies found during the simulated restoration exercises.

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<sup>2</sup> NERC EOP-005 Attachment 1-6.

<sup>3</sup> NERC EOP-005 Attachment 1-7.



