

## **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 the Transmission Owners, to designate specific generators whose location and capabilities are required to re-energize the transmission system.

These designated resources, called ~~b~~Black ~~s~~Start ~~u~~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 ~~t~~Transmission ~~e~~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 Black Start Service. If a partial or system-wide blackout occurs, Black Start ~~Service generating u~~Units can assist in the restoration of the PJM balancing area.

### **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 12: Balancing Operations

- Section 4: Black Start Service
- 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 10: Pre-Scheduling Operations

- Section 2: Generation Outage Reporting

#### PJM Manual 1: Control Center and Data Exchange Requirements

- Section 5: Meter Accuracy Standards

#### PJM Manual 14D: Generation Operational Requirements

- Section 10: Black Start Generation Procurement
- Attachment E: PJM Generator and Synchronous Condenser Reactive Capability Testing

#### PJM Manual 27: Open Access Transmission Tariff Accounting

- Section 7: Black Start Service Accounting

#### PJM Manual 36: System Restoration

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

### **4.6.2 Restoration Assumptions**

Transmission ~~e~~Customers must purchase ~~b~~Black ~~s~~tart ~~e~~Capability from PJM. Generation resources providing this service must successfully pass the requirements for Black Start Capability.

PJM, in collaboration with the Transmission Owners, is responsible for identifying the generating units that are critical for PJM balancing area system restoration. During restoration activities, the Transmission Owner manages and deploys the Black Start Capability, as needed, depending on the specific situation.

The Transmission Owners have developed, and shall annually review, the restoration plan. The annual update of the Transmission Owner's restoration plan may highlight the need for changes to the black start requirement. The Transmission Owner will alert PJM of these situations to allow PJM to acquire more black start generation, if needed, through the Black Start Incremental ~~RFP~~request for proposal Process documented in Manual 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 [the 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 the 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**

- Once a Black Start Unit is started, it can be used to facilitate the startup of other units (black start or not) at the same plant.
- Designated critical black start generation is identified as such in each Transmission Owner's restoration plan.
- Redundancy of critical Black Start Units is desirable due to the possibility of a unit's failure to start or the failure of a transmission facility, preventing Black Start Units from serving their intended loads.

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

PJM Manual 36: System Restoration, 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 percent margin) and a minimum of two 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, is responsible for selecting the black start resources for a system restoration plan. PJM would work closely with the Transmission Owners 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 Transmission Owner will adjust its system restoration plan based on the Black Start Units allocated to it from this selection process. The Transmission Owner 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 OATT.

Should there be a disagreement about the location, amount or number of black start resources, or disagreement between the supplying Transmission Owners, receiving Transmission Owner, 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 issues would be referred to the Dispute Resolution Process as detailed in Schedule 5 of the PJM Operating Agreement.
- A general notification of initiation and result of Dispute Resolution process will be given to the Operating Committee.

#### **4.6.8 Product Description**

**Black Start Service** - A generating unit is defined as "black start capable" or as a Black Start Unit 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 PJM and all affected Transmission Owners to be useful to system restoration and will be incorporated into the restoration plans of all affected Transmission Owners.
- The generating unit must have the ability to close the output breaker to a dead bus within 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 three-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 three-hour start time requirement, if needed, on a case-by-case basis.
- A generating unit that is needed for system restoration and participates in ~~b~~Black ~~s~~Start ~~s~~Service tests and system restoration drills may be eligible for compensation under Black Start Service.

#### 4.6.9 Generator Owner's Commitment

For Black Start ~~u~~Units on the base formula rate, ~~t~~The ~~g~~Generation~~e~~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 Generation Owner and the Transmission Owner) with one year's advance 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's~~advance 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 until such termination notice is provided~~.
- ~~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 ~~g~~Generation~~e~~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 the TariffOATT via eDART upload process using the black start forms using the link in Attachment C of this manual.

For New Black Start Units entering ~~the~~Black Start ~~s~~Service ~~under thata~~ Capital Cost Recovery Rate or incurring additional capital costs to continue Black Start Service:

- A Black Start Unit owner that entered Black Start Service after or incurring additional capital costs to continue Black Start Service [effective date of CRF] has a commitment to provide Black Start Service for a minimum of a 20 year period after entering Black Start Service or after incurring additional capital costs and may terminate the provision of

Black Start Service with one year's advance notice and consent of the Transmission Provider (or its commitment period may be involuntarily terminated) provided the Black Start Units demonstrates to the satisfaction of the Transmission Provider at least one of the following reasons for such termination apply:

- Black Start Unit retirement or deactivation;
  - Expiration of a state, federal, or other governmental agency permit(s) required for Black Start Service without the potential for renewal absent major capital additions; or
  - Capital additions are required by the Black Start Unit owner to maintain Black Start Service capability (in which case, the Black Start Unit is required to submit those costs into a Black Start Service Request for Proposal if issued by the Transmission Provider in accordance with the procedures set forth in Manual 14-D and only continue to provide Black Start Service if selected for Black Start Service by the Transmission Provider).
- New Black Start Unit owners recovering capital cost under either Capital Cost Recovery Rate in the OATT Tariff Schedule 6A shall provide PJM an estimated annual revenue requirement based on the most current cost data at the time the unit enters Black Start Service.
- New Black Start Unit owners will submit capital cost documentation to PJM and the IMM within three months after entering Black Start Service. Acceptable documentation may consist of:
  - Third-party invoices supporting costs for contractor services and materials
  - Time sheets or other project tracking documentation for internal labor costs (components of labor rates) including rate sheets and applicable overheads
  - When applications and certificates for payment are used to confirm completion of any portion of a project, they must be signed and notarized. The signature and notarization must be visible on any copies provided.
  - When internal costs are charged to the project, they must include documentation supporting all costs which will be included and a breakdown of how the costs were developed.
- New Black Start Unit owners will submit annual revenue costs including variable black start and fuel storage costs (if applicable) to PJM and the IMM within three months after entering Black Start Service.
  - The annual black start revenue requirement may include annualized capital costs, black start operating and maintenance costs, existing unit level annual VOM cost, and NERC standard compliance costs, all of which must include complete supporting documentation.
  - If the Black Start Unit can be fired on oil, additional required documentation includes support for the claimed minimum tank suction level(s), size of tanks and fuel burn rates. If the tank is shared with other resources, a complete explanation with all supporting data of how tank use is shared and the allocation factor(s) used.

#### **4.6.10 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 Transmission Owner's system restoration plan, 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 or to a live bus.
- 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) 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 the duration identified by the Transmission Owner's system restoration plan. Requirements for supply to gas fueled Black Start Units should be considered in the Transmission Owner's system restoration 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.

#### **4.6.11 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 a at least a two-one year's advance 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 unless the non-performance criteria of Section 4.6.14 apply.

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 Section 2 of PJM Manual 10: Pre-Scheduling Operations.

#### **4.6.12 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 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 cost-capped 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 and 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 IMM 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 first 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 that has recently been integrated into the PJM Region, the ~~b~~Black ~~s~~Start ~~t~~Unit owner must send revenue requirements to PJM and the IMM through the eDART upload process at least one month prior to joining PJM. The unit must successfully pass a Black Start Service test within six 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 first 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 that 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 Section 4.6.14, Non-Performance). Testing records shall include:

- Date(s) of test(s)
- Duration of test(s) from start of test until unit is online
- 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 startup until the unit connects to the 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 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:**

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.

#### 4.6.14 Non-performance

To collect monthly black start revenues, a unit compensated under Black Start Service must have a successful black start test on record with PJM within the last 13 months. Black Start Units providing Black Start Service under Schedule 6A or under a service agreement with the Transmission Owner are required to 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 10 day grace period within which it may re-test without financial penalty if within the 13 month testing period. If the unit does not successfully pass a black start test within the ten 10 day grace period immediately following notification to PJM of 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. If the Black Start Unit owner does not make the necessary repairs to enable the Black Start Unit to pass the annual test within a 90 day period, the Black Start Unit will immediately cease to qualify as a Black Start Unit unless the 90 day period is extended up to one year with PJM approval. If the 90 day period is extended, the Black Start Unit owner will continue to forfeit all black start revenues starting from 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**

- The PJM Performance Compliance department will work directly with the Black Start Unit owner to determine a schedule to complete repairs in order to return Black Start Capability and successfully black start test. Upon PJM acceptance, repair work to include, as necessary, documented equipment procurement, scheduled outage periods dedicated to repairs, and a monthly review with the Black Start Unit owner until the work is complete and successful black start testing. PJM will provide progress information to the IMM once received from the Black Start Unit owner.
- The PJM's 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 endeavor to notify the MOC or unit owner, as applicable, within five business days of test submittal of unit's failure. PJM will provide black start test information to the IMM once received by from the Black Start Unit owner.
- The PJM's Performance Compliance Department will notify the LCC if a Black Start Unit in their zone fails to complete a successful black start test in the required timeframe. The PJM's Performance Compliance Department will also notify the LCC when units that failed black start tests are again eligible after completing a successful test.
- The PJM's Performance Compliance Department will maintain the list of eligible Black Start Units and forward any changes to PJM Market Settlements.
- The PJM IMM 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 the PJM Performance Compliance department via Blackstart@pjm.com, as well as the LCC in whose zone the Black Start Unit operates, of the expected black start test date. Proposed testing dates and times should be communicated via eDART to PJM Dispatch and the Transmission Owner no later than 3 business days prior to the test.
- Black Start Generation Owners will notify PJM Operations Dispatch prior to start of the black start test.
- Black Start Generation Owners will report black start test results using the PJM Black Start Test Report Form displayed (link in Attachment C of this manual). Test results should be submitted within 14 days following the black start test or no later than the 25th of each month. Units submitting successful tests after the 25th of the month may have their revenues deferred to the following month. Generation Owners with auto load reject units will report their testing results using the PJM Auto Load Reject Test Report Form (link in Attachment C of this manual)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 (link in Attachment C of this manual)displayed in Attachment C of this manual. Formulaic cost data requests will be reviewed and approved by the PJM IMM. Alternatively, Black Start Generation Owners may request changes to their actual costs annually by completing the PJM Black Start Actual Cost Data Form (link in Attachment C of this manual)in Attachment C of this manual. Completed cost data forms and other

requested data will be submitted with appropriate documentation to the PJM IMM for analysis using the eDART XLS Upload Process; however, actual cost change requests must be filed with appropriate documentation to FERC for approval.

#### **4.6.15 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 PJM [TariffOATT](#) Schedule 6A, 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](#).

#### **4.6.16 Black Start Service Unit Substitution.**

A generating unit capable of providing Black Start Service, that is at the same Black Start Plant, is on the same voltage level and cranking path, similar age unit (within 5 years), and provides equivalent Black Start Unit Capacity may be substituted for an existing Black Start Unit. PJM will provide the IMM with documentation supporting any substitutions for a Black Start Unit. The black start annual revenue requirement for a substituted unit(s) will be reviewed by the PJM IMM and approved by PJM. A new annual revenue requirement to be completed prior to substitution, and will not include any additional capital expenditures or increase in capital recovery commitment period. All substitutions must have PJM and Transmission Owners approval before a substitution is made.

- A Black Start Unit used as a substitute must have had a valid annual test within the previous 13 months. Black Start testing for substitute units are to follow the testing guidelines and submittals as documented in this manual.
- Black Start Unit substitutions may be permitted for other technical reasons provided by the Generation Owner.
- Black Start Unit substitutions can only be made once every 12 months.

#### **PJM Actions:**

- Review non-critical black start test submittals and update the testing status with the impacted Transmission Owner(s).
- Review requests for Black Start Unit substitution to determine Black Start Capability and receive concurrence with the impacted Transmission Owner(s).
- Review annual revenue requirement with PJM IMM and approve by PJM.

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

- Add Black Start Unit Capability to the impacted Transmission Owner(s) System Restoration Plan(s).

#### **PJM GO Members:**

- Substitution requests are to be submitted with 40 days advance notice.
- Request Black Start Unit substitution to PJM using via [Blackstart@pjm.com](mailto:Blackstart@pjm.com) email.
- Submit substituted unit formulaic cost data to PJM and PJM IMM using the PJM Black Start Formulaic Cost Data Form (link in Attachment C of this manual).