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PJM Manual 36

System Restoration

Revision: 23~~2~~

Effective Date: June 10, 2016~~June 15, 2015~~

Prepared by:

System Operations Division

©PJM 2015~~6~~

Manual 36:

System Restoration

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Approval

Approval Date: ~~05/28/2015~~ 05/26/2016
Effective Date: ~~06/15/2015~~ 06/10/2016

Glen Boyle, Manager

System Operator Training

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Current Revision

Revision 2~~2~~3 (~~06/15/2015~~06/10/2016):~~)~~

- ***Annual Review per EOP-005-2, R3 and EOP-006-2, R3***
- ***Minor formatting changes throughout***
- ***Consistency in title "Transmission Owner operator" and "Generation Owner/MOC dispatcher" throughout manual***
- ***Section 3.1.2 Clarification of responsibilities for report submittals and communications***
- ***Section 3.1.7 Clarification on load shedding during system restoration***
- ***Section 4.1.1 Additional detail on communication protocols during system restoration***
- ***Section 6.2.1 Clarification on responsibility for tabulation of unit status***
- ***Section 7.2.1 Update Exhibit 10. Added clarifying requirement on establishment of tie schedule between interconnected areas***
- ***Section 8 Minor clarifications and updated references***
- ***Attachment A Noted that critical nuclear safe shutdown power is defined in NPIRs. Updated dates for Black Start RTO wide RFP. Removed transitional process verbiage. Added EOP-005-2, R-15 requirement on notification of change to Black Start unit ability to meet TO restoration plan within 24 hours.***
- ***Attachment B Added SMECO to Exhibits 11 and 13.***
- ***Attachment D Change from System Restoration Coordinators Task Force to Subcommittee.***
- ***Attachment F Updated Figure 1 – TO restoration document references***
- ***Attachment G Clarification of eDART Restoration Plan coordination process. Clarification on completion of Attachment G-2. Added SMECO and ITCI to annual update timeline. Changed EKPC annual update timeline.***
    - ***Added new subsection G-4 Dynamic Study and Restoration Plan Updates***
- ***Attachment H – Updated Under Frequency Load Shed Table***

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- ~~*Annual Review per EOP-005-2, R3 and EOP-006-2, R3*~~
- ~~*Formatting and clarifying changes to Sections 2.3, 3.1.5, 3.1.6, 6.1.4, 7.1.2 and 7.2*~~
- ~~*Sections 3.1.7 and 3.1.8 – Added more detail to when PJM Assumes Control and when PJM Returns to Normal Operation in response to feedback from Spring Restoration Drill*~~
- ~~*Section 7 – Annual Update of Exhibit 10 "PJM Table of Major Synchronization Devices"*~~
- ~~*Section 8.1.9 – Added guidance on completion of Interconnection Checklist*~~
- ~~*Section 8.1.11 – Deleted section on System Control Progress*~~
- ~~*Attachment B – Minor updates to Restoration Forms*~~
- ~~*Attachment F – Figure 1 "TO Restoration Document References" updated based on latest TO restoration plans*~~
- ~~*Attachment H – Under Frequency Load Shed (UFLS) Table updated based on updated load values*~~

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Introduction

Welcome to the ***PJM Manual for System Restoration (M36)***. In this Introduction, you will find the following information:

- What you can expect from the PJM Manuals in general (see "*About PJM Manuals*").
- What you can expect from this PJM Manual (see "*About This Manual*").
- How to use this manual (see "*Using This Manual*").

About PJM Manuals

The PJM Manuals are the instructions, rules, procedures, and guidelines established by PJM for the operation, planning, and accounting requirements of PJM and the PJM Energy Market. The manuals are grouped under the following categories:

- Transmission
- PJM Energy Market
- Generation and transmission interconnection
- Reserve
- Accounting and billing
- PJM administrative services
- Miscellaneous

For a complete list of all PJM Manuals, go to www.pjm.com and select "Manuals" under the "Documents" pull-down menu.

About This Manual

The ***PJM Manual for System Restoration (M36)*** is the PJM Restoration Plan required by NERC EOP standards and is one of a series of manuals dealing with PJM System Operations. This manual focuses on how PJM and the PJM Members are expected to respond to system disturbance conditions or system blackout.

The ***PJM Manual for System Restoration (M36)*** consists of 9 sections and 8 attachments. The sections and attachments are listed in the Table of Contents beginning on page ii.

Intended Audiences

The intended audiences for the PJM Manual for System Restoration (M36) are:

- PJM System Operator — Personnel who work in conjunction with the transmission owners to respond to outages and blackouts to restore the transmission system to service.
- Transmission Owner ~~dispatchers~~ operators — Personnel who respond to PJM System Operator requests for emergency procedures.

- Black start generator operators
- PJM neighboring Reliability Coordinators, Transmission Operators, and Balancing Authorities and appropriate Regional Reliability Organizations.
- PJM operations staff — Personnel who perform system studies.
- Government, regulatory and emergency response personnel.
- All PJM Members.

References

The references to other documents that provide background or additional detail directly related to the ***PJM Manual for System Restoration (M36)*** are:

- PJM Manual for ***Control Center and Data Exchange Requirements*** (M-1)
- PJM Manual for ***Transmission Operations*** (M-3)
- PJM Manual for ***Balancing Operations*** (M-12)
- PJM Manual for ***Emergency Operations*** (M-13)
- PJM Manual for ***Generator Operational Requirements*** (M-14D)
- PJM Manual for ***Operating Agreement Accounting*** (M-28)
- PJM Manual for ***Definitions and Acronyms*** (M-35)
- Restoration Plans of PJM neighboring Reliability Coordinators, Transmission Operators, and Balancing Authorities
- NERC Standard EOP-005-2: Mapping of PJM Member TO Restoration Documents to Applicable Elements

Using This Manual

We believe that explaining concepts is just as important as presenting the procedures. This philosophy is reflected in the way we organize the material in this manual. We start each section with an overview. Then, we present details and procedures or references to procedures found in other PJM Manuals. The following provides an orientation to the manual's structure.

What You Will Find in This Manual

- A table of contents that lists two levels of subheadings within each of the sections and attachments
- An approval page that lists the required approvals and a brief outline of the current revision
- Sections containing the specific guidelines, requirements, or procedures including PJM actions and participant actions
- Attachments that include additional supporting documents, forms or tables
- A section at the end detailing all previous revisions of this PJM Manual.

Section 1: Overview

Welcome to the *Overview* section of the ***PJM Manual for System Restoration (M36)***. In this section, you will find the following information:

- A description of PJM policy statements for system disturbances (see "Policy *Statements*").

1.1 Policy Statements

Power system disturbances are most likely to occur as the result of loss of generating equipment, transmission facilities, or as the result of unexpected load changes. These disturbances may be of, or develop into, a magnitude sufficient to affect the reliable operation of the PJM RTO. The associated conditions under severe system disturbances generally result in critically loaded transmission facilities, critical frequency deviations, or high or low voltage conditions.

The policy of PJM is to maintain, at all times, the integrity of the PJM RTO transmission systems, the Eastern Interconnection, and to prevent any unplanned separation of the Transmission Owner's systems. The purpose of this plan is to establish procedures with a priority of restoring the integrity of the Interconnection. Based on system restoration lessons learned in 2003, the PJM restoration plan should stand alone with no dependencies on neighboring systems to help prevent separation of additional systems.

In the case of the PJM RTOs' inter-area transmission lines, the policy of PJM is to give maximum reasonable assistance to adjacent systems when a disturbance that is remote from the PJM RTO occurs.

Each Transmission / Generation owner has an obligation to protect their own system's equipment and reliability. However, steps taken to do so are coordinated, if at all possible, with the PJM System Operator so as to solve the problem in the best manner, realizing that actions taken may have a far reaching effect.

PJM will provide RFC on an annual basis a copy of the Blackstart Capability Plan and associated list of units designated as blackstart capable for Inclusion in the RFC Blackstart Database per NERC standard EOP-009-0 and RFC standard EOP-007-RFC-01, "System Restoration Plans."

PJM Actions:

In general, PJM is responsible for the following activities:

Taking actions that it determines are consistent with Good Utility Practice and are necessary to maintain the operational integrity of the PJM RTO.

- Coordinating and monitoring restoration of all or parts of the Bulk Electric System (BES) in the PJM RTO, as necessary.
- Providing all reasonable assistance to adjacent Balancing Authorities or systems as necessary to facilitate system restoration to include coordination of restoration plans with neighboring Reliability Coordinators, Transmission Operators, and Balancing Authorities.

- This manual (M36 – the PJM Restoration Plan) and other data sources as noted include:
  - A reliable black-start capability plan including:
    - Fuel resources for black start power for generating units (Black start database)
    - Available cranking and transmission paths (Black start database)
    - Communication adequacy and protocol and power supplies (Black start database)
    - Accounting for the possibility that restoration cannot be completed as expected.
    - Operating instructions and procedures for synchronizing areas of the system that have become separated.
    - Procedures for simulating and, where practical, actually testing and verifying the plan resources and procedures.
  - Documentation in the personnel training records that operating personnel have been trained annually in the implementation of the plan and have participated in restoration exercises (Learning Management System - LMS).
  - The functions to be coordinated with and among Reliability Coordinators and neighboring Transmission Operators. (Including references to coordination of actions among neighboring Transmission Operators and Reliability Coordinators when the plans are implemented.)
  - Notification to be made to other operating entities as the steps of the restoration plan is implemented.
  - Incorporate updates from Transmission owner supporting documentation as described below as it changes.
- Review this manual on a minimum of an annual basis for updates and changes and review with the PJM Systems Operation Subcommittee. Changes could be triggered based on system changes (transmission/generation) or feedback from restoration drills/simulations.
- PJM will distribute the most recent version of this manual to each Transmission Operator and neighboring Reliability Coordinators within 30 days of revision.

PJM Member Actions:

The PJM Members are responsible for developing and maintaining the following:

- Plan and procedures outlining the relationships and responsibilities of the personnel necessary to implement system restoration.
- The provision for a reliable black-start capability plan including available cranking and transmission paths
- The necessary operating instructions and procedures for restoring loads, including identification of critical load requirements.

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- Review the PJM Restoration manual (M36) on a minimum of an annual basis for updates and changes through the PJM Systems Operation Subcommittee.
- Review company supporting restoration documentation on an annual basis.

When a disturbance or blackout occurs, the PJM Members are responsible for performing the following activities:

- Taking other actions, as directed by PJM, to manage, alleviate, or end the disturbance or blackout.
- Using the company restoration plan to restore the system in a bottom-up approach and coordinate with PJM if any deviations from the published plan are required.
- Cooperating with each other and PJM to implement requests and instructions received from PJM for the purpose of managing, alleviating, or ending a disturbance or blackout.
- Providing notification and other information to governmental agencies as appropriate.
- Collecting, storing, and providing data and other information to PJM, as necessary, to facilitate preparation of reports required by governmental or industry agencies as a result of a disturbance or blackout.
- Cooperating and coordinating with PJM and other PJM Members in the restoration of all or parts of the bulk power system in the PJM RTO with a priority of restoring the integrity of the Interconnection.

A PJM Generation owner controlling the output of a Capacity Resource must take or arrange for any or all of the following actions as directed by PJM in order to manage alleviate, or end an Emergency, or such actions as PJM may deem appropriate for these purposes:

- Reporting the operating status and fuel situation.
- Starting, including black start, and loading such generation, as directed.

Note: PJM Emergency Authority: Section 10.4, of the PJM Operating Agreement (OA) provides that PJM has the responsibility to “direct the operations of the Members as necessary to manage, alleviate, or end an Emergency”. Likewise, Section 11.3.1 of the OA states that PJM Members must comply with “all directives of the Office of the Interconnection to take any action for the purpose of managing, alleviating or ending an Emergency.”

1.2 PJM System Restoration Plan Objectives

High Level Strategy (EOP-006-2 R1.1)

The high level strategy of the PJM System Restoration Plan is to restore the integrity of the interconnection as quickly as possible. In general, the following steps are taken by PJM, Transmission Owners and Generation Operators:

- Perform a system assessment to determine extent of outage

- Start Black Start units to form islands
- Build cranking paths to other generating units, nuclear stations and critical gas facilities
- Restore critical load as defined in Attachment A
- Synchronize and interconnect islands to form larger islands
- Connect to outside areas
- Return to normal operations

Minimum Criteria for Meeting Objectives of Reliability Coordinators Restoration Plan (EOP-006-2 R1.1)

- Provide nuclear stations with auxiliary power to maintain safe shutdown. Target time for restoration of this auxiliary power is 4 hours.
- Restore interconnections between all internal TOs
- Restore interconnections to all external Reliability Coordinator Areas

Section 2: Disturbance Conditions

Welcome to the *Disturbance Conditions* section of the ***PJM Manual for System Restoration (M36)***. In this section, you will find the following information:

- A description of disturbance conditions (see "*Overview*").
- How PJM responds to internal problems without separation (see "*Internal without Separation*").
- How PJM responds to internal problems with separation (see "*Internal with Separation*").

2.1 Overview

When a system disturbance occurs, it is important to maintain a parallel operation throughout the PJM RTO and the adjacent interconnected Balancing Authorities. Providing maximum assistance to the other Balancing Authorities that are in trouble may prevent cascading of trouble to other parts of the interconnected system and assist in restoration of normal operation. If sufficient assistance cannot be obtained, the deficient system may need to provide load relief measures or ultimately face the loss of assistance being provided by its neighbors when separation occurs. The PJM RTO provides all possible assistance, including a 5% voltage reduction, provided the adjacent power system requesting assistance has already implemented a 5% Voltage Reduction.

Depending on the level of the disturbance and available resources post-disturbance, PJM may implement a "Top-down", "Bottom-up", or both a "Top-down" and "Bottom-up" restoration strategy simultaneously to restore the system as quickly as possible. The exact restoration strategy will be communicated at a PJM System Operations Subcommittee conference call once a system status is ascertained consistent with Section 3 of this manual.

2.2 Internal without Separation

When an adjacent Balancing Authority or more remote interconnected system tie lines and/or internal PJM RTO transmission facilities are overloaded, it is necessary to implement the following actions:

PJM Actions:

- PJM System Operator issues emergency procedures as needed, up to and including Manual Load Dump, to restore tie lines to within limits.
- Any required load shedding shall be implemented in steps established to minimize the risk of further uncontrolled separation, loss of generation, or system shutdown.
- PJM System Operator adjusts generation in appropriate areas to alleviate overloaded internal lines.

PJM Members Actions:

- Transmission Owner operators / Generation Owner/MOC dispatchers implement emergency procedures requested by PJM System Operator and notify appropriate personnel.

2.3 Internal with Separation

PJM will coordinate automatic load shedding throughout the RC area with underfrequency isolation of generating units, tripping of shunt capacitors, and other automatic actions that will occur under abnormal frequency, voltage, or power flow conditions.

2.3.1 Generator Frequency Trip Settings

PJM procedures require that each Generation owner may take independent actions to protect its generating plant equipment and preserve as much load as possible during separations with the following guidelines for the different control zones:

PJM Mid-Atlantic Control Zone (Based on the former MAAC region requirements)

If frequency is at or below 58.0 Hz for 30 seconds, generation and load connected to the same bus may be sequestered.

If frequency is at or below 57.5 Hz for 5 seconds, generation is disconnected.

If frequency is above 62.0 Hz and shows no sign of immediate recovery, frequency must be adjusted toward 60.25 Hz.

PJM West Control Zone (Based on the former ECAR region requirements)

The following table is provided only as a guide; specific units, or specific individual company practices, may provide for longer periods of operation below these specified frequencies. However, in considering the possible consequences during an area-wide underfrequency operating condition, it is recommended that the following table be used in developing operating practices other than those that apply to specific generating plants or individual units. If a generating unit is removed from the Balancing Authority at a frequency higher than or a time less than that shown in the following table, an amount of load equal to the generation being removed from the Balancing Authority must also be shed simultaneously.

PJM RTO Frequency	Time Delay to trip
60 – 59.5 Hz	Unlimited
59.5 to 58.5 Hz	30.0 minutes to trip
58.5 to 58.2 Hz	7.0 minutes to trip
58.5 to 58.2 Hz	Unit isolation without time delay can be expected

PJM ComEd Control Zone (Based on the former MAIN region requirements)

In those cases where generators must be tripped for their own protection outside the specifications of the table below, additional load shedding must be installed within the immediately adjacent load entity, to compensate for the generators that trip outside the specifications.

PJM RTO Frequency	Time Delay to trip
> 59.5 Hz	Automatic tripping not permitted
59.5 to 59.2 Hz	2700 seconds to trip
59.2 to 58.5 Hz	120 seconds to trip
58.5 to 58.0 Hz	15 seconds to trip
< 58.0 Hz	Owner's discretion

PJM South Zone

There is no standard requirement for the Dominion Transmission Zone, however, a number of generators have underfrequency set point that range between 56.5 Hz - 58.2 Hz. ranging from 0.5 - 120 seconds.

2.3.2 Underfrequency Load Shed Trip Settings

- Underfrequency relays automatically dump load as the frequency decays as follows:

PJM RTO Frequency	PJM Mid-Atlantic Control Zone Load Dump
59.3 Hz	10%
58.9 Hz	10%
58.5 Hz	10%

Exhibit 1: Underfrequency Relay Automatic Load Dump - PJM Mid-Atlantic Control Zone

PJM RTO Frequency	PJM West Control Zone Load Dump
59.5 Hz	5%
59.3 Hz	5%
59.1 Hz	5%
58.9 Hz	5%
58.7 Hz	5%

Exhibit 2: Underfrequency Relay Automatic Load Dump - PJM West Control Zone

PJM RTO Frequency	PJM ComEd Control Zone Load Dump
59.3 Hz	10%
59.0 Hz	10%
58.7 Hz	10%

Exhibit 3: Underfrequency Relay Automatic Load Dump - PJM ComEd Control Zone

PJM RTO Frequency	PJM South Control Zone Load Dump
59.3 Hz	10%
59.0 Hz	10%
58.5 Hz	10%

Exhibit 4: Underfrequency Relay Automatic Load Dump - PJM South Control Zone

PJM Actions:

When a power shortage causes a separation[1] of all or parts of the PJM RTO with the probability of overloaded transmission lines and/or abnormal frequency, PJM System Operator orders a sufficient amount of load to be dumped to:

- return the frequency to 59.75 Hz or higher
- relieve the actual transmission overloads
- return inter-area ties to schedule

In general, dumping 6% load raises the frequency by 1 Hz.

PJM Members Actions:

- The TO ~~dispatchers~~ operators manually dump load in the quantity directed by the PJM System Operator.
- If the frequency declines to 59.75 and is decaying, Generating station operators act independently to increase generation until frequency returns to 59.90 Hz or until Maximum Generation or transmission limitations are reached.
- If the frequency rises to 60.25 Hz and is continuing to increase, generating station operators act independently to decrease generation until the frequency returns to 60.10 Hz.

[1] (NERC EOP-005 Attachment 1- 4.)

Section 3: System Restoration

Welcome to the *System Restoration* section of the ***PJM Manual for System Restoration (M36)***. In this section, you will find the following information:

- How PJM and the Transmission Owners/Generation Owners restore the PJM RTO, including a description of the emergency procedures (see "*Restoration Process*").

3.1 Restoration Process

A system disturbance may occur at any time under normal or emergency conditions. It is expected that the PJM System Operator apply the actions described in Section 2 of this manual during this disturbance conditions to reduce the probability of system separation following a contingency or disturbance. In the event of separation, the PJM System Operator and the Transmission Owners/Generation Owners use the procedures described in this section to return the PJM RTO to its pre-disturbance condition as efficiently as possible. Since the nature of the disturbance and exact separation boundaries cannot be predicted, the procedures outlined in this section are a general guide.

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.

Nuclear units require additional consideration. Restoring customer load will normally need to be accomplished without the help of nuclear units due to their start up requirements. Generally, the following prerequisites are necessary to restart a nuclear unit: (1) A minimum of two independent offsite power sources need to be available; (2) Adequate actual and unit trip contingency voltages must be observed on the transmission system supplying the nuclear unit; and (3) Stable system frequency must be present. Any decisions regarding the satisfying of the prerequisites for startup must be made by the nuclear plant personnel. NRC start-up checklists do not permit hot restarts of nuclear units and their diesels are not permitted to supply auxiliary power to other generating stations. Nuclear units that are taken offline on a controlled shutdown can normally be restored to service between 24 and 48 hours following the controlled shutdown.[2]

To assist in assuring each transmission zone has sufficient critical black start generation, a Minimum Critical Black Start criteria (Attachment A) has been developed, which defines the minimum critical black start requirements based on that transmission zone's critical load.

Each Transmission Owner is responsible for restoring its zonal customer load with internal generation or through coordinated efforts with other Transmission/Generation Owners and PJM. After a subsystem is stabilized, requests

[2] NUC-001 R9

from neighboring entities for cranking power are a higher priority than restoring additional customer load of the supplying area. Any Transmission Owner that is not operating in parallel with adjacent Transmission Owners is free to restore or shed load in any manner or at any rate it may deem reasonable.

Any deviations from these pre-approved published plans must be coordinated with PJM.

PJM System Operator immediately establishes communications with the Transmission Owners and adjacent Balancing Authorities experiencing the disturbance to establish the extent and severity of the separation. If direct communication channels are not functioning, communications are established via whatever means are available (i.e., routing calls through alternate channels, outside phone lines, cellular phones, radio communications, and/or PJM Satellite Phone System).

3.1.1 PJM System Operator Responsibilities during the Restoration Process

In addition to the PJM actions listed on the following pages, the PJM System Operator has certain responsibilities regardless of the stage of the system restoration process. Transmission Owners will have primary responsibility of restoring their transmission system based on their pre-approved plans until such time as PJM is returning to normal operation and resumes authority over the transmission system. PJM actions during a system restoration include:

- PJM will coordinate all interchange schedules with external Balancing Authorities.
- PJM will coordinate and direct all restoration of the 500 kV and above transmission systems.
- PJM will develop and calculate ACE as required when appropriate data is available to perform this calculation.
- PJM will coordinate interconnection of internal islands between TOs.
- PJM will coordinate and direct all transmission tie connections to external Balancing Authorities.
- PJM will identify opportunities for interconnection between PJM internal Transmission Owners and/or neighboring Reliability Coordinator, Balancing Authority, and Transmission Operator systems[3].
- PJM will collect system status information and provide status updates to members on system restoration status.
- PJM will conduct periodic System Operations Subcommittee (SOS) conference calls, as appropriate.
- In the event the restoration plan cannot be completed as expected, PJM will develop and coordinate alternate steps to restore the system.

Exhibit 5 presents the general steps that are performed to restore the PJM RTO following separation.

[3] NERC EOP-005 Attachment 1-8.

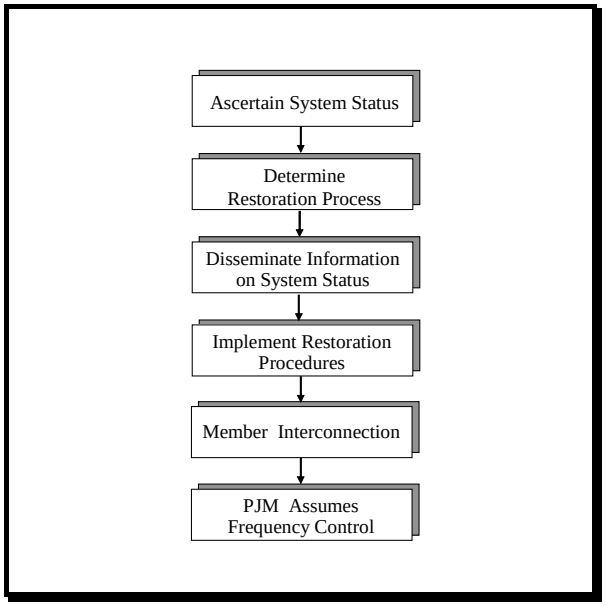

Exhibit 5: Restoration Process

3.1.2 Ascertain System Status

After a system disturbance occurs that results in a significant loss of customer load in a widespread area, it is important to determine transmission and generation loss, equipment damage, and the extent of the service interruption.

PJM Actions:

- PJM System Operator establishes communications between the Transmission Owners that are experiencing the disturbance and between adjacent Transmission Owners or TOP/ BA areas.
- PJM System Operator determines the extent and cause of the service interruption and informs the appropriate personnel as soon as possible of existing generation and transmission capabilities, equipment damage, and other pertinent information.
- PJM System Operator collects specific information from each Transmission Owner/Generation Owner and adjacent areas to ascertain the present system conditions.
- PJM System Operator reports via the ALL-CALL system, the extent and cause, if known, of the outage.

PJM Member Actions:

- Transmission and Generation Owners are responsible for adhering to the PJM Member Actions contained within PJM Manual for System Restoration (M36).

- Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers establish communications immediately with PJM and other Transmission Owners that are involved in the disturbance, adjacent Transmission Owners, and/or other Balancing Authorities.
- Transmission Owner ~~dispatchers~~ operators verify the extent of their service interruption.
- Transmission Owner~~s~~ operators~~/~~ and Generation Owner/MOC~~s~~ dispatchers collect information and notify PJM System Operator of known system conditions, generation and transmission capabilities, equipment damage, and other pertinent information, including possible cause, if known.
- The Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers notify key personnel and power plant operators regarding the extent of the outage, as known.
- The Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers report initial system conditions to PJM, using the Company Initial Restoration Report presented in Attachment B. The Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers report hourly status updates using the Company Hourly Restoration Reports presented in Attachment B. PJM may elect to suspend the Initial Restoration Report and / or the hourly status update reporting requirements depending on the severity of the disturbance and the level and quality of available telemetry. Transmission Owner operators will collect the required status information from the Generation Owner/MOC dispatchers within their zone for the Company Initial Restoration Report and Company Hourly Restoration Reports and submit to PJM.
- As part of the PJM RTO, both the Transmission Owner operators and Generation Owner/MOC dispatchers will assess the extent of the outage. Based on the severity of the outage, PJM and the Transmission Owners will decide if an emergency will be declared and the Standards of Conduct suspended, allowing Transmission and Generation personnel to work closely together. This will provide swift and accurate communications with the intent of providing a timely recovery of the power system.
- Transmission Owners will also be in communication with the PJM RTO, adjacent Transmission Owners, and Generation Owners. PJM RTO will coordinate between neighboring Transmission Operators to include OVEC, Reliability Coordinators and Balancing Authorities. The Transmission Owner will communicate the following to all involved parties:
    - Extent of the service interruption.
    - Known system conditions, including generation and transmission capabilities.
    - Equipment damage and other pertinent information.
    - Extent of outage will be communicated to Power Plant operators and Generation Owner/MOC dispatchers.

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3.1.3 Determine Restoration Process

The purpose of this step is to develop and implement a restoration strategy. This step is performed after the status of the PJM RTO is determined.

PJM Actions:

- PJM System Operator acts as coordinator and disseminator of information relating to generation and transmission availability. PJM System Operator keeps the Transmission Owners/Generation Owners informed of the PJM RTO's status.
- PJM System Operator uses the EMS security program to identify any actual overloads on the system. PJM System Operator may need to use a manual monitoring procedure to estimate distribution factors.

PJM Member Actions:

- The Transmission Owner ~~dispatchers~~ operators identify restoration strategy based on system status.
- The Transmission Owner ~~dispatchers~~ operators organize steps and/or sequential order of the System Restoration Plan (SRP).
- The Transmission Owner ~~dispatchers~~ operators assign sections/steps of the SRP to individuals and begin implementation.
- The Transmission Owner ~~dispatcher~~ operators communicate~~s~~ overall status to PJM and PJM coordinates the SRP for the PJM region.

3.1.4 Disseminate Information

The purpose of this step is to provide updated information of the system status to appropriate personnel. After system restoration plans are established and implemented, all participants must be apprised of system conditions.

PJM Actions:

- PJM System Operator uses established personnel call-out procedures to obtain the necessary staff. PJM supervisor notifies PJM management, and a member of the supervisory group makes support staff calls. PJM management is kept informed of the PJM RTO's status.
- PJM System Operator notifies Public Relations and other appropriate authorities i.e., FEMA, DOE, NERC, appropriate RROs, Public Utilities Commissions (or equivalent).
- PJM Shift Supervisor assigns a person to act as an information coordinator responsible for collecting system status information and disseminating it to all involved participants.
- PJM information coordinator develops reports hourly for distribution to public relations personnel and Transmission Owners.
- Due to PJM's ability to monitor all Transmission Owners/Generation Owners data, PJM System Operator will coordinate the restoration strategy and system control.

PJM Member Actions:

- The Transmission Owner~~s~~ operators~~/~~ and Generation Owner~~s~~/MOC dispatchers use established personnel call-out procedures to obtain the necessary staff.
- Transmission Owner~~s~~ operators~~/~~ and Generation Owner/MOC~~s~~ ~~personnel~~ dispatchers notify appropriate personnel including public relations, and authorities, i.e., DOE, NERC, Public Utilities Commissions (or equivalent).
- Transmission Owner operators~~/~~ and Generation Owner/MOC ~~Dispatchers~~ dispatchers assigns a person to act as an information coordinator, to collect system status information and relay the information contained in the Company Hourly ~~Generation~~ Restoration Report (Attachment B) and the Company Transmission Restoration Report to PJM. Transmission Owner operators will collect the required status information from the Generation Owner/MOC dispatchers within their zone for the Company Hourly Restoration Reports and submit to PJM. The Transmission Owner operators will complete and submit the Company Transmission Restoration Report.
- The Transmission Owner~~s~~ operators/Generation Owner~~s~~/MOC dispatchers convey to PJM System Operator any information deemed essential to facilitate the restoration process, i.e. generation operating, cranking power availability, system voltages, restoration strategy, etc.
- Transmission Owners will provide a status of progression as they proceed with their system restoration plan to PJM System Operator as requested and also at periodic System Operations Subcommittee Conference Calls.

3.1.5 Implement Restoration Procedure

The purpose of this step is to direct the restart of Generation Owners internal generation and load on-line generation in planned steps while maintaining system load, scheduled frequency, voltage control, and reserves. This step is performed when a Transmission Owner/Generation Owner is in a completely isolated or blacked-out condition and must restart their system without outside assistance.

PJM Actions:

- PJM System Operator acts as coordinator and disseminator of information relating to generation and transmission availability.
- PJM System Operator keeps Transmission Owners/Generation Owners apprised of the developing system conditions to assist in the formation and on-going adjustments of a cohesive System Restoration Plan. System Restoration Plans may be adjusted to take advantage of this additional information. In situations where the actual conditions do not match the studied conditions, the PJM System Operator shall use professional judgment to modify the System restoration plan.
- PJM System Operator develops updated run-of-river hydro capability. PJM System Operator communicates with the affected Transmission Owners/Generation Owners to develop the most effective use of this limited resource.

PJM Members Actions:

- Plant operators implement shut-down and start-up procedures immediately, if unable to maintain on-line status.
- Station service is restored to generating plants and critical substations as soon as possible using black start capability, when available (as defined in Attachment A), or external power sources. Requests for cranking power have a higher priority than load restoration for the supplying area.
- Offsite safe shutdown power should be restored as soon as possible to nuclear units, both units that had been operating and those that were already offline prior to the system disturbance, without regard to using these units for restoring customer load. Transmission Owners and Nuclear Power Plants must effectively communicate to keep Nuclear Power Plant apprised of the anticipated restoration time for offsite power.
- Generating units that are able to maintain on-line status have priority of load assignments to provide loading above minimum levels to achieve stable unit operation.
- The Transmission Owner~~s~~ operators~~/~~ and Generation Owner/MOC~~s~~ dispatchers maintain communications with PJM System Operator to provide updated status of system condition, and local SRP in addition to the hourly report.
- Each Transmission Owner/Generation Owner that is isolated may elect to adhere to all or none of the guidelines for system control, as described in the ***PJM Manual for Balancing Operations (M12),*** depending on system conditions. Each affected Transmission Owner shall resynchronize islanded area(s) with neighboring area(s) only when coordinated by PJM and in accordance with the established procedures in this manual.

Frequency Control

The control objective of the frequency regulating unit(s) in the frequency controlling area (or subsystems) is to keep the frequency on schedule. All units not assigned to regulate frequency are re-dispatched to keep each frequency regulating unit's energy at the middle of its regulating range.

The best regulating unit(s) in the area (or subsystems) are used to regulate frequency during restoration. The best regulating unit is determined based on the amount and quality of regulation provided, as well as energy considerations. If the frequency burden becomes too large for one unit, the frequency burden is shared by two or more units, preferably in the same plant control room for better coordination.

The frequency is regulated between 59.75 Hz and 61.0 Hz. If the frequency decays to 59.50 Hz, or below, Synchronous Reserve and/or manual load shedding is initiated to restore the frequency to between 59.75 Hz and 61.00 Hz. Shed approximately six percent (6%) of load to increase frequency 1.0 Hz (General rule for small island).

Frequency is adjusted to slightly above 60.00 Hz before load is picked up. The TOs pick up load in small increments. The regulation requirement to maintain frequency during system restoration is calculated as 2% of the area load.

Voltage Control

During the restoration process, the bulk power system is operated so that reasonable voltage profiles can be maintained (generally 90% to 105% of nominal). Distributed reactive regulation is also established to limit voltage drop for any single contingency.

Transmission shunt capacitor banks are removed from service until sufficient load (approximately 40% of system load) has been re-energized to prevent high voltage. Shunt reactors are placed in service when initially restoring the system to help reduce system voltages. Static VAR Compensators under automatic control are placed in service as soon as practical. Generator automatic voltage regulators are placed in service as soon as practical while continuing to aim low on voltage when energizing circuits to reduce charging currents.

Reserves

There are only two categories of reserves that are essential and therefore need to be tracked during system restoration. These are Dynamic Reserve and Synchronous Reserve. These are described later in more detail in Section 5.

- *Dynamic Reserve* — The amount of Dynamic Reserve in an area (or subsystem) must be sufficient to allow the system to survive a frequency deviation due to the loss of the largest energy contingency (generation or load). Dynamic Reserve may consist of reserves on generators via automatic governor action, as well as system load with underfrequency relay protection enabled.

No more than 50% of the total Dynamic Reserve in an area (or subsystems) can consist of load with underfrequency relay protection enabled.

- *Synchronous Reserve* — Synchronous Reserve is required in order to enable an area or subsystem to return to a pre-contingency state (both tie lines and frequency) as soon as possible after a contingency.

During system restoration each area or subsystem carries enough Synchronous Reserve to cover its largest energy contingency. Synchronous Reserve may be either on-line generation that can be loaded within 10 minutes, or load (including customer load and "pumping load") that can be shed manually within 10 minutes.

Unit Dispatch

No generator is loaded above a level at which there is not enough Dynamic Reserve on remaining units to survive the resultant frequency decay if that unit trips. Generation Owner/Transmission Owner maintains sufficient load on each unit to stabilize its operation. Generating units are loaded as soon as possible to load levels above their normal minimum point to achieve reliable and stable unit operation unless the area (or subsystems) cannot survive the contingency loss of the unit at minimum load.

Synchronization of Areas (Subsystems) Within a Transmission Owner Zone

Prior to synchronizing two areas (or subsystems), the Transmission Owner will communicate with PJM. The transmission owner adjusts the frequency of the

smaller area (or subsystem) to match the frequency of the larger area (or subsystem). In addition, the voltages of the two areas (or subsystems) are as close as possible prior to synchronization.

Upon synchronization, the regulation requirement for frequency control must be recalculated and reassigned. After synchronization, the Transmission Owner calculates reserve requirements for the combined system, and adjust unit dispatch accordingly.

Area (or subsystem) frequency is maintained above 59.75 Hz and below 61.0 Hz. Achieving and maintaining these frequency levels require close coordination between plant operators and Transmission Owners.

3.1.6 Criteria and Conditions for Reestablishing Interconnections

The purpose of this step is to provide conditions and criteria for the Transmission Owners to interconnect with other Transmission Owners within PJM or TOPs or RCs external to PJM and control frequency, tie line, voltage schedules, share reserves, and coordinate emergency procedures. This step is performed after the Transmission Owners have restarted and desire to interconnect and share reserves or Transmission Owners have coordinated plans to restart while interconnected.

PJM Actions:

- PJM System Operator acts as coordinator and disseminator of information relative to generation and transmission availability.
- PJM System Operator keeps the Transmission Owners/Generation Owners apprised of developing system conditions to assist in the formation and on-going adjustments of a cohesive System Restoration Plan. System Restoration Plans may be adjusted to take advantage of this additional information.
- PJM System Operator provides the Transmission Owners/Generation Owners with updated run-of-river hydro capability.
- PJM will coordinate with neighboring RCs and TOPs to establish external interconnections and establish tie schedules with neighbors

PJM Member Actions:

- Prior to synchronizing, each Transmission Owner must ascertain that adequate reserves are available to cover the largest energy contingency within the interconnected area. The Transmission Owner ~~dispatchers~~ operators consult and follow the interconnection checklist presented in Attachment B. The Transmission Owner ~~dispatchers~~ operators adjust the frequency of the smaller area (subsystem) to match the frequency of the larger area. In addition, the Transmission Owner ~~dispatchers~~ operators control the voltages of the areas so that they are as close as possible prior to synchronization.
- The Transmission Owner ~~dispatchers~~ operators may share reserves, i.e., Dynamic Reserve and Synchronous Reserve, and agree on a plan to act in a coordinated manner to respond to area emergencies. This plan includes identification of the coordinating Transmission Owner (the frequency controlling Transmission Owner is the natural coordinator).

- The Transmission Owner that agrees to regulate the interconnected area's frequency (the area with more generation capacity) will adjust generation and load to maintain the area's frequency within the acceptable range (59.75 Hz – 61.0 Hz).
- The objective of Transmission Owners maintaining flat tie line control (the area with lower generation capacity) is to control their "Net Tie Line" flow value to equal their "Net Tie Line" schedules by adjusting load and/or generation and to coordinate with the Transmission Owner controlling the interconnected area frequency.
- Guidelines for frequency regulation and tie line control are in effect as identified in the ***PJM Manual for Balancing Operations (M-12)*** unless all Transmission Owners agree to suspend any portion of the procedure.
- Capacity that is assigned to regulation is approximately two percent of the interconnected area's load. Frequency is regulated between 59.75 Hz and 61.0 Hz.
- Frequency is adjusted to slightly above 60.00 Hz before load is picked up. Transmission Owner operators~~/Generation Owner dispatchers~~ pick up load in small increments.
- When necessary, Synchronous Reserve (including manual load dumping) is used to keep the frequency above 59.50 Hz. Transmission Owner ~~dispatchers~~ operators shed approximately six percent (6%) load to restore frequency 1.0 Hz (general rule for small island).
- Dynamic Reserve is allocated/assigned proportionally to the available Dynamic Reserve in each area.
- As additional areas are added to the interconnected area, the Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers recalculate and reassign regulation and reserve assignments.
- After synchronization occurs, the Transmission Owner ~~dispatchers~~ operators continue to strengthen and stabilize the interconnected area by the closure of additional Transmission Owner-to-Transmission Owner tie lines.
- The Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers continue to maintain communications with PJM System Operator to provide updated status of system conditions, in addition to the hourly report.

3.1.7 PJM Assumes Balancing Authority Role

During a system restoration, interconnected Transmission Owners will balance their own islanded areas. This occurs by the largest area controlling frequency and the smaller areas controlling tie line flow.

The PJM EMS has the capability of calculating and monitoring ACE for up to five internal islanded areas or subsystems connected to the Eastern Interconnection. This assumes that PJM has sufficient monitoring in these subsystems (including frequency monitoring and tie line monitoring). Once PJM verifies accurate data and ACE calculation within a subsystem, PJM will coordinate with the Transmission

Owners within the subsystem and when appropriate resume Balancing Authority functions for this area. PJM will balance the area through manual generation dispatch. There will be no energy market or economic based generation dispatch until the system is more fully restored and PJM's economic dispatch tools are operational.

PJM Actions:

- PJM System Operator assimilates information contained in Attachment B.
- PJM System Operator determines the required Dynamic Reserve and Synchronous Reserve for the area based on largest energy contingency. Reserve assignments are made on a proportional basis
- PJM System Operator determines the regulation requirement to regulate frequency. Capacity assigned should be two percent (2%) of the interconnected area load. PJM System Operator assigns regulation on a proportional basis of connected load.
- PJM System Operator continues to coordinate run-of-river hydro operations.
- PJM System Operator updates the DMT to reflect unit capability that is reported by the Transmission Owner operators~~/~~ or Generation Owner/MOC dispatchers.

PJM Member Actions (in those areas being controlled by PJM as the Balancing Authority):

- The Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers continue to return generating units to on-line status and restore native load in small increments to maintain generation and load balance.
- As units return to service, the Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers report their status to PJM System Operator.
- The Transmission Owner ~~dispatchers~~ operators maintain scheduled Transmission Owner-to-Transmission Owner tie line flows until the PJM RTO returns to free-flowing tie conditions.
- The Transmission Owner ~~dispatchers~~ operators assure that adequate underlying transmission capability is electrically connected at the interconnection point of the 500 kV and above bulk transmission system to provide adequate fault current (relay protection) and VAR absorption capability when the line is energized (overvoltage).
- The Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers respond to emergency procedures when initiated by PJM System Operator.
- The Transmission Owner ~~dispatchers~~ operators request PJM System Operator's approval prior to the closure of any reportable transmission line (see the ***PJM Manual for Transmission Operations (M-3)***) or a line that establishes an interconnection, either Transmission Owner-to-Transmission Owner or to an external system.
- The Transmission Owner operators~~/~~ and Generation Owner/MOC dispatchers maintain communications with PJM System Operator to provide updated status of system conditions, in addition to the hourly report.

System Control

PJM system control may progress through three stages depending on existing system conditions:

- *Manual Control* — Manual control is initiated when sufficient data is not available for any type of automatic control. When this mode of control is initiated, PJM is replacing the frequency controlling Transmission Owner.

PJM System Operator notifies Transmission Owners~~/~~ and Generation Owners/MOC of their share of the regulation requirement by percentage. Regulation energy assignments are dispatched manually using whole numbers, with each Transmission Owner responding with their percentage. These assignments are made via the ALL-CALL system. Frequency is maintained between 59.75 Hz and 61.0 Hz. If the frequency decays below 59.50 Hz, PJM System Operator initiates emergency procedures, which may include load shedding, to maintain stable operations. If load shedding is required, it is assigned on a proportional basis.

The amount of generation adjustments to control frequency may be based on one percent (1%) of system load to adjust frequency by 0.1 Hz. Actual system response may differ based on the changing system characteristic. Real-time adjustments may be required.

PJM System Operator directs generation and load adjustments, as required, to maintain reliable operations. TO zone native generation normally is assigned to native load, except in instances where Transmission Owner-to-Transmission Owner tie line schedules are arranged. PJM System Operator notifies all Transmission Owners on the interconnected area of schedules that are in effect, or pending.

Transmission Owners are responsible for communicating to PJM System Operator any potential transmission problems i.e. contingency or actual overloads, voltage problems, etc. PJM System Operator coordinates corrective action. PJM monitoring system has limited capability for contingency evaluation and on-going monitoring until a majority of the bulk transmission system is intact.

- *Flat Frequency Control* — Flat frequency control is initiated when the capability exists for an ACE signal to be developed by using a frequency value in the interconnected area. If PJM is not electrically connected to the area being controlled (i.e., frequency is different), the frequency of the area being controlled may be ~~entered into~~utilized in the AGC control program. If PJM is electrically connected to the area being controlled, and not on diesel stand-by power, the in-house frequency may be used. The Frequency Bias setting is one percent (1%) of the interconnected areas' load. The bias setting is readjusted as the interconnected area load changes.

The PJM AGC control program is capable of developing an ACE based on scheduled frequency versus actual frequency. Regulating signals may also be developed via the automatic regulation program. The Generation Owner/MOC dispatchers enter their regulating capability into the program, and units may automatically respond to the signal. The Transmission Owner operators~~/~~ or Generation Owner/MOC dispatchers may elect to manually dispatch these units. Regulation is two percent (2%) of the interconnected area load.

PJM System Operator continues to direct generation and load assignments as required to maintain reliable operation. PJM System Operator regulates area frequency between 59.75 Hz. and 61.0 Hz. When the regulating energy has been loaded to restore frequency to 60.0 Hz., efforts are made to return the units to their mid-point.

The Transmission Owners are notified via the ALL-CALL system to closely monitor transmission parameters, since the PJM monitoring program may not have sufficient data at this point except for actual overloads.

Energy available from external sources is assigned to the Transmission Owners/Generation Owners based on need and transmission capabilities and/or limitations.

- *Tie Line Bias Control* — Tie Line Bias Control is used to develop an ACE signal when Balancing Authority tie lines are in service. When ties to external systems are placed in service, PJM returns to the Tie Line Bias control mode. This mode (normal control mode) develops an ACE by comparing scheduled frequency versus actual frequency and scheduled tie line flow versus actual tie line flow to facilitate interconnected operation. All control functions are normal including ACE and the regulation control program. The regulation continues to be two percent of the area's load.

The frequency bias setting is one percent of the interconnected area's load and is readjusted as the load changes. Generation and load assignments continue to be manually dispatched until the system can respond automatically via the AGC system. PJM may now be capable of monitoring the transmission parameters, but Transmission Owners continue to closely monitor their systems.

Allocations of Load Shedding

Load shedding, if required if required for frequency or ACE control, is allocated based on connected load on a proportional basis. Exhibit 6 presents an example.

Sub-Area	Load	Obligation
1	1000 MW	1/6 Requirement
2	2000 MW	1/3 Requirement
3	3000 MW	1/2 Requirement

Exhibit 6: Load Shedding Example

No re-allocation of load already shed is made as other sub-areas are added to the interconnected island. However, new allocation factors are calculated if additional load shedding is required.

Load shedding for transmission overloads will be based on the most effective location to alleviate the overload.

EHV Restoration

Due to the heavy reactive charging current generated by the 500 kV / 765 kV bulk power transmission system (approximately 1.70 MVAR per mile), sufficient load and generation must be restored to the affected areas. Transmission Owner ~~dispatchers~~ operators assure that adequate underlying transmission capability is electrically connected at the interconnection point of the 500 kV / 765 kV bulk transmission

system to provide adequate fault current (relay protection) and VAR absorption capability when the 500 kV / 765 kV line is energized (overvoltage). See Minimum Source Guidelines in Section 7.1.2.

Allocation of Joint Owned Generation

PJM System Operator directs the increase of the generation/transactions when it is beneficial to the overall system restoration process. Allocations of energy are not based on ownership or joint-owned generation allocations, but on the capabilities and needs of the interconnected area. Allocations, if possible, are on a proportional basis. As additional Transmission Owners/areas interconnect, no attempt is made to re-allocate generation that is already carrying load. However, revised allocation factors are calculated.

3.1.8 PJM Returns to Normal Operation

Re-establish PJM single control center coordination.

This occurs when an ACE can be calculated for the entire single control area~~.~~ ~~-~~and a return to central coordinated operation is desired by PJM and the Transmission Owners.

When conditions permit, PJM System Operator notifies all Transmission Owners/Generation Owners that the PJM RTO is returning to normal operation. Returning to normal operations includes:

- Return to free flowing internal Transmission Owner-to-Transmission Owner ties
- Scheduled external ties to neighboring Balancing Authorities
- ACE calculated using standard Tie Line Bias control
- Full functionality of PJM Network Applications including State Estimator, Security Analysis and Transfer Limit Calculator
- Generation under AGC and economic dispatch (SCED) control
- Return to published regulation and reserve requirements.
- LMP calculation resumes based on actual system conditions

3.1.9 PJM Reliability Coordinator Responsibilities during the Restoration Process and Coordination of Information

- PJM maintains the current coordinated version of the restoration plan of each Transmission Operator in its Reliability Coordinator Area. There are ~~two~~ three TOPs in PJM's Reliability Coordinator Area: PJM, ITCI and AEP. PJM serves as both RC and TOP for the PJM area. American Electric Power (AEP) operates the 138kV transmission, though PJM serves as TOP for its other transmission assets. Additionally ITCI is a TOP in PJM for a 345 kV generating station, Covert and the Covert-Segreto (AEP) 345 kV line in Michigan.
- PJM monitors restoration progress and coordinates any needed assistance in the RC area. PJM actions during a system restoration include:

- PJM will coordinate all interchange schedules with external Balancing Authorities
- PJM will coordinate and direct all restoration of the 500 kV and above transmission systems
- PJM will develop and calculate ACE as required when appropriate data is available to perform this calculation
- PJM will coordinate and direct all transmission tie connections to external Balancing Authorities
- PJM will identify opportunities for interconnection between PJM internal Transmission Owners and/or neighboring Reliability Coordinator, Balancing Authority, and Transmission Operator systems
- PJM will collect system status information and provide status updates to members on system restoration status
- PJM, in its role as Reliability Coordinator, is the primary contact for disseminating information regarding restoration to neighboring Reliability Coordinators and to Transmission Operators and Balancing Authorities within its Reliability Coordinator area.
- PJM will conduct periodic System Operations Subcommittee (SOS) conference calls, as appropriate
- In the event the restoration plan cannot be completed as expected, PJM will develop and coordinate alternate steps to restore the system
- PJM System Operator establishes communications between the Transmission Owners that are experiencing the disturbance and between adjacent Transmission Owners or TOP/ BA areas
- PJM System Operator determines the extent and cause of the service interruption and informs the appropriate personnel as soon as possible of existing generation and transmission capabilities, equipment damage, and other pertinent information
- PJM System Operator collects specific information from each Transmission Owner/Generation Owner and adjacent areas to ascertain the present system conditions
- PJM System Operator reports via the ALL-CALL system, the extent and cause, if known, of the outage
- PJM's Reliability Coordinator Area restoration plan provides coordination between individual Transmission Operator restoration plans and ensures reliability is maintained during system restoration events.
- PJM's Reliability Coordinator Area Restoration Plan is contained in PJM Manual for System Restoration (M36). As stated in section 1.1 of Manual 36, "Policy Statements," This manual (M36, the PJM Restoration Plan and other data sources as noted) include the following:
    - A reliable black-start capability plan including:

- Fuel resources for black start power for generating units (Black start database)
- Available cranking and transmission paths (Black start database)
- Communication adequacy and protocol and power supplies (Black start database)
- Accounting for the possibility that restoration cannot be completed as expected.
- Operating instructions and procedures for synchronizing areas of the system that have become separated
- Procedures for simulating and, where practical, actually testing and verifying the plan resources and procedures

➢ Documentation in the personnel training records that operating personnel have been trained annually in the implementation of the plan and have participated in restoration exercises (training database)

➢ The functions to be coordinated with and among Reliability Coordinators and neighboring Transmission Operators (including references to coordination of actions among neighboring Transmission Operators and Reliability Coordinators when the plans are implemented).

➢ Section 3.1.5 ("Implement Restoration Procedure") and 3.1.6 ("Member Interconnection") of Manual 36 describes broadly the implementation of PJM's RC Area Restoration Plan so as to maintain reliability during system restoration events. Additional procedures for maintaining reliability during system restoration are included in Section 6, "Generation," and Section 7, "Transmission."

- PJM is the primary contact for disseminating information regarding restoration to neighboring Reliability Coordinators and Transmission Operators or Balancing Authorities not immediately involved in restoration (per EOP-006-2 R1.8). As stated in Section 3.1.3 (Determine Restoration Process), the criteria for sharing information regarding restoration with neighboring Reliability Coordinators and with Transmission Operators and Balancing Authorities within its Reliability Coordinator area (in accordance with EOP-006-2, R1.7) is listed below:
  - "PJM System Operator acts as coordinator and disseminator of information relating to generation and transmission availability. PJM System Operator keeps the Transmission Owners/Generation Owners informed of the PJM RTO's status." Section 4.1.2 (Notifications and Contacts) outlines some of the common notifications that must be made during a restoration event, including to neighboring Balancing Authorities:
  - "Contact Neighboring Balancing Authorities — Knowledge of the neighboring Balancing Authorities' status enhances restoration through PJM RTO of restart sources, reserves, and transmission reliability. Utilities must have functional communications to gain timely knowledge of the status.
  - SCADA data links with neighboring Balancing Authorities may aid in limiting the amount of verbal communications. Communications using normal and

emergency systems as well as RCIS should be utilized to maintain communications with PJM neighbors."

- PJM approves, communicates, and coordinates the resynchronizing of major system islands or synchronizing points so as not to cause a Burden on adjacent Transmission Operator, Balancing Authority, or Reliability Coordinator Areas.
    - Section 3.1.5 of this manual, under the heading "Synchronization of Areas (Subsystems) Within a Transmission Owner," provides the procedure for synchronizing subsystems within the area of a Transmission Owner in PJM's system. It states: "Prior to synchronizing two areas (or subsystems), the Transmission Owner will communicate with PJM. PJM will approve the synchronization and coordinate with neighbors as needed before the transmission owner adjusts the frequency of the smaller area (or subsystem) to match the frequency of the larger area (or subsystem)."
    - Section 3.1.6 of this manual, "Criteria and Conditions for Reestablishing Interconnections," describes the guidelines for synchronizing and interconnecting the systems of two or more members within or external to the PJM's system. The section assigns the following actions to PJM's operators:
- PJM System Operator acts as coordinator and disseminator of information relative to generation and transmission availability.
    - PJM System Operator keeps the Transmission Owners/Generation Owners apprised of developing system conditions to assist in the formation and on-going adjustments of a cohesive System Restoration Plan. System Restoration Plans may be adjusted to take advantage of this additional information.
    - Section 7.2 of this manual, "Synchronization," provides detailed procedures for synchronizing and interconnecting between islands and to neighboring areas. It states: "Prior to synchronization, the transmission owner must communicate with PJM (PJM will coordinate with neighbors as required) and get approval for synchronization." Exhibits 14 and 15 in Attachment B: Restoration Forms provide a written form and checklist for communications related to interconnection of two islands or entities. This form is used to facilitate communication between islands to be connected and PJM.
    - PJM's RC Area can be restored from complete system failure without outside assistance, and as such will not cause a burden on any neighboring areas. Section 1.1, "Policy Statements," of this manual, states: "The policy of PJM is to maintain, at all times, the integrity of the PJM RTO transmission systems, the Eastern Interconnection, and to prevent any unplanned separation of the Transmission Owners' systems. The purpose of this plan is to establish procedures with a priority of restoring the integrity of the Interconnection.
    - Based on system restoration lessons learned in 2003, the PJM restoration plan should stand alone with no dependencies on neighboring systems to help prevent separation of additional systems."
    - Section 8.1.9 of this manual, "Guidelines for Area Interconnection and Use of External Power during System Restoration" provides guidelines for reconnecting to the Eastern Interconnection and assisting neighbors by

actions such as providing excess power to deficient areas, taking power from areas with excess, sharing reserves, and providing cranking power to neighboring areas, so as to provide a service rather than a burden to neighbors and assist in the overall restoration of the Eastern Interconnection as needed.

- PJM will take steps to restore normal operations once an operating emergency has been mitigated in accordance with its restoration plan. As stated in Section 3.1.8 (PJM Returns to Normal Operation): "Re-establish PJM single control center coordination. This occurs when an ACE can be calculated for the area to be controlled (entire PJM area or portion) and a return to central coordinated operation is desired by PJM and the Transmission Owners. When conditions permit, PJM System Operator notifies all Transmission Owners/Generation Owners that the PJM RTO is returning to normal operation, i.e., free flowing Transmission Owner-to-Transmission Owner ties, Balancing Authority to Balancing Authority ties, generation under AGC control, and return to published regulation and reserve requirements."

Section 4: Communications

Welcome to the *Communications* section of the ***PJM Manual for System Restoration (M36).*** In this section you will find the following:

- A description of the communications guidelines for use during a restoration.

4.1 Communications

All modes of communication used in power system operations, including voice, print, SCADA, and data exchange, are of great importance to the prompt restoration of the PJM RTO after a major event that results in shutdown or separation. Of the several forms of exchange, voice communication is most critical.

Communications by ~~dispatchers~~ operators involving voice (and printed data) can include exchange with plant operators and field personnel operators within neighboring Reliability Coordinators, Transmission Operators, and Balancing Authorities, Transmission Owner/Generation Owner management, identified federal, state, and local authorities and agencies. ~~Dispatchers~~ Operators also interact with corporate public relations departments or other designated groups that, in turn, issue communiqués to the media that advise the general public of system status and appeals for actions that customers may be asked to take.

The system restoration procedures identified earlier in this section assume normal telecommunications systems are available and functioning properly. These include telephone, internet, microwave, and radio. However, the possibility exists that this assumption may not be supported due to the effects of the event leading to shutdown or separation, or the system's response to the event. ~~As a result, dispatchers and others may have to use their ingenuity to employ any and all means necessary to establish and maintain contact with key locations throughout the system (e.g., critical substations, generating stations, etc.).~~ The possibility that one or more modes of communication may not be readily available requires that system operators and others be familiar with the organization of their telecommunications network including primary, secondary, and alternate pathways to important locations. This possibility is raised due to the critical role that communications play in the restoration process and that problems may arise despite all efforts taken to assure the reliability of the communications systems prior to the event. In addition, these communication systems should be tested by Transmission owners at a minimum annually or during the restoration drills.

Primary and back-up sites must contain sufficient communications and power supplies consistent with ***PJM Manual for Control Center and Data Exchange Requirements (M-1)***.

4.1.1 Voice Communication and Logging Protocols

The following general and specific subjects are among the number of considerations that are addressed when developing and implementing system restoration plans:

- Effective communications during normal and emergency conditions are essential. System Operators must practice 3-part communications consistent with NERC COM-002.

- PJM will communicate with Transmission Owner operators and Generation Owner/MOC dispatchers utilizing the same contacts that they use in normal operations.
- Prior to PJM resuming its Balancing Authority role, Transmission Owner operators may communicate to the Generation Owner/MOC dispatcher or directly to the generating plant operators for generation related communications (i.e. starting units, changing unit output, etc). However, if the Transmission Owner operator is communicating directly with the plant operators, either the Transmission Owner operator or the plant operator must also keep the Generation Owner/MOC dispatcher informed of the operating status of their generators.
- Once PJM resumes the Balancing Authority role (see section 3.1.7), PJM must also be made aware of any changes in unit dispatch or operating status. Changes to unit dispatch may be directed by PJM at this point through their normal Generation Owner/MOC dispatcher contacts.
- Support Staff participating in conference calls must adhere to M36, Attachment C: Conference Call Protocol.
- Voice messages have three parts:
  - Introduction — to get the attention of the receiver and allow them to focus
  - Body — the substance of the message
  - Summary — repeat main points of message
- Receivers must critically assess the content of the message and must get clarification if needed before carrying out any action. Logging is of critical importance to ~~dispatchers~~ operators during restoration of the system and to others after the system has been restored. Therefore, all log entries must be complete, accurate, and readable. To the extent possible, logs include relevant data to support strategic decisions as well as specific actions taken. Data regarding the PJM RTO status is important to note since actions are referenced to conditions as they were known at that time. All entries include the time and identification of the dispatcher making the entry.
- Since logs are likely examined by various groups after-the-fact, all entries are in accordance with Transmission Owner/Generation Owner protocols using correct terms.

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4.1.2 Notifications and Contacts

A person in each Transmission Owner/Generation Owner and PJM is assigned to act as an information coordinator. The Transmission Owner/Generation Owner individual relays disturbance information to PJM as soon as it becomes available. This information is compiled and disseminated to all relevant locations by PJM information coordinator.

- *Notify Plants* — Plants are regularly informed of system status as it impacts each plant. A person at each plant is assigned as a station's communicator who is

continuously available for communication with the ~~dispatchers~~ operators during and after synchronization.

- *Notify Field Locations* — Personnel in field locations are notified that a system shutdown has taken place and that routine work on transmission or distribution facilities is curtailed or completed expeditiously.
- *Notify Management* — Management is kept continuously informed of system status during the restoration process.
- *Notify Public Relations and Authorities* — A person in each Transmission Owner/Generation Owner is assigned to contact public relations, and authorities, i.e. D.O.E., NERC, Public Utilities Commissions (or equivalent). ~~Dispatchers~~ Operators do not perform this function.
- *Report Status to PJM* — Communications are established immediately between the Transmission Owners experiencing the disturbance and PJM and directly between adjacent Transmission Owners or Balancing Authorities.
- *Contact Neighboring Balancing Authorities* — Knowledge of the neighboring Balancing Authorities' status enhances restoration through PJM RTO of restart sources, reserves, and transmission reliability. Utilities must have functional communications to gain timely knowledge of the status. SCADA data links with neighboring Balancing Authorities may aid in limiting the amount of verbal communications. Communications using normal and emergency systems as well as RCIS should be utilized to maintain communications with PJM neighbors.

4.1.3 Evaluate System Status

- *Evaluate Transmission System Status* — A system blackout generally causes initial confusion and creates a large number of SCADA alarms and reports. Before generating units can be restarted, an accurate picture of the transmission and generation system must be developed. The first step of the restoration process is a complete evaluation of the transmission system. Energy Management System (EMS) SCADA indications should be confirmed by dispatching field personnel as required or verifying key indications from other sources. This EMS SCADA data will be used during the restoration process and must be accurate if the process is to be successful. All known and/or suspected transmission damage is identified. Work can then be initiated on damaged transmission facilities that are involved in the black-start process to either isolate or repair the damaged facilities.
- *Evaluate Generation Resources* — Generation resources in any system are constantly changing. This is especially true following a partial or complete system blackout. The units that are on-line during the event are likely to be offline and in an unknown condition. Plant personnel begin an immediate assessment and, as soon as possible, communicate unit status to the Generation Owner. This must be complete before any restoration process is initiated. This information is used to develop a black start process based on actual unit availability.

Communications within generating stations need to be independent of normal AC power sources. Consideration is given to the value of cell phones, walkie-talkies or other personal communications devices to expedite the coordination efforts in plants

during the surveillance, shutdown, and restart processes (as well as the benefits during normal operations).

4.1.4 Telephone Systems

A functional communication system is critical for the assessment of the extent of a blackout and determining the status of generation and transmission facilities. Transmission Owners/Generation Owners must review their communication systems, regardless of whether it is a private carrier (Telcos), or Transmission Owner/Generation Owner-owned, or whether it is hardwire (twisted pair), fiber optic, microwave or radio. The assessment is essentially the same for private carrier or Transmission Owner/Generation Owner owned. The assessment must determine whether there is an adequate power source to the communication equipment in order to handle the duration of the blackout conditions.

- *Ability to Receive and Evaluate Customer Calls* — In the early stages of system restoration, Transmission Owners and Distribution Providers are bombarded with phone calls from employees and customers. From their perspective, continual calls inquiring into status of service provide no useful purpose. In fact, continual customer calls may be a detriment by degrading the public telephone system to a point that it is not functional. Some of the ways of mitigating problems are:
  - automatic dialing system to notify employees on the status
  - immediate notification of customer service representative
  - public appeal to limit phone system use
  - priority call system for utility dispatcher's phone system
  - notifications of restoration status posted on company websites
- *Employee Call-ins* — System restoration requires an enormous number of tasks for Transmission Owner/Generation Owner personnel to complete. It is essential for Transmission Owner/Generation Owner to promptly get their off-duty personnel notified to report to duty. Automatic notification systems can provide system and plant operators with necessary relief of this burden. For effective use of extra personnel, utilities should consider defining responsibilities in advance of the event. Consideration must also be given for rotating personnel in order that system and plant operators maintain effectiveness.

4.1.5 SCADA and Local Metering

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 Transmission Owners/Generation Owners offices. SCADA systems are designed so that alarm processing does not inhibit detection of problems and are capable of continued operation during system disturbances/blackouts.

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

- *Transmission Facilities Unavailable for Service* — in the initial evaluation phase of the system, switch positions as shown on a monitor display cannot be relied on as the indicator regarding facilities being available for service. The dispatcher relies on field verified data to determine if equipment is faulted. Also, equipment with neutral connections, such as reactors, transformers, and capacitors, may be locked-out from the neutral overcurrent conditions during system shutdown. These facilities may be in serviceable condition.
- *RTU Operation without AC Power* — In order to be functional in a blackout, RTUs must not be dependent on normal AC power feeds. RTUs, in general, are designed to be powered by DC from the station battery. The RTU interface equipment with the telephone system, such as amplifiers and equalizers must also be independent of normal AC power feeds. Telephone companies generally try to use normal AC powered equipment throughout their system, but utilities have a special need. Transmission Owners should include periodic monitoring of RTU and other communication equipment to verify independence from standard AC powered equipment feeds as part of their routine inspections.

4.1.6 Computer and Operator Aides

The PJM systems, if available, are used by PJM to monitor and coordinate restoration in the affected areas. The system diagram, 500 kV / 765 kV kV diagram, and generation bar charts provide accurate information and can, therefore, be very useful in determining the extent of the disturbance.

The PJM Thermal Tracking Program detects the actual overloads on the system. The contingency overload feature of PJM's Security Analysis Computer Programs is of little value until most of the transmission network is restored. The contingency overload displays, therefore, are either ignored or used as a rough guide since the contingency loadings, in many cases, are more severe than indicated. A manual monitoring procedure is used as required to check for normal and contingency overloads using best estimates for distribution factors.

4.1.7 Emergency Power for Communications and Related Support Systems

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 when normal AC power sources are not available.

- *Control Centers-UPS Systems* — All energy control centers must have adequate back-up power to provide a minimum of 24-hour stand-alone capability. However, plans include provisions to ensure longer stand-alone capability. Future hardware is designed and powered by redundant sources, where possible.
- *Station Service: AC & DC Power* — The station battery is one of the most critical pieces of equipment in the restoration process. Substations on the bulk power system must have adequate battery back-up power to provide a minimum of eight hours stand-alone capability for DC equipment. A common battery standard is enough battery capacity to handle an 8 hour outage of AC power to the battery chargers and be able to serve:
    - all normal DC loads

- the largest creditable substation event at the beginning of the eight hour period
- one full operation of each substation device during the eight hour period

- *Emergency Power for Non-utility Owned Communication Systems* — Transmission Owners/Generation Owners must gain assurance from telephone and other telecommunications companies that their systems continue to operate properly in the absence of normal AC power. This requires them to support their systems with back-up batteries and emergency generators. Such emergency back-up systems must power all critical elements of their system and must be capable of "stand-alone" operation for eight hours or longer.
- *Periodic Maintenance and Testing of Emergency Power Sources* — A schedule of maintenance and testing needs to be implemented for all emergency power systems to assure all such systems will provide reliable service at, or above, specification when needed. Evidence of such maintenance and testing must be provided by companies which lease their systems to the utilities.

The Transmission Owner periodically tests station batteries based on a substation theoretical load profile in a system blackout, not based on design criteria or manufacturer specifications.

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Section 5: Reserves during Restoration

Welcome to the *Reserves during Restoration* section of the ***PJM Manual for System Restoration (M36).*** In this section you will find the following:

- A description of how PJM determines synchronous and dynamic reserves during a restoration.

5.1 Reserves during Restoration

There are only two categories of reserves that are essential and need to be tracked during system restoration.

- The Synchronous Reserve must be modified slightly for system restoration purposes.
- Dynamic Reserve is required to enable the system to be operated safely upon the loss of the "largest energy contingency" on the interconnected system.

Calculation of other reserve categories (i.e., Operating Reserve, etc.), while important, are not required during a system restoration.

5.1.1 Synchronous Reserve

Synchronous Reserve is the reserve capability which is required in order to enable an area to restore its tie-lines or other facilities to pre-contingency state as soon as possible after a contingency that causes an imbalance between load and generation.

During normal operation, these reserves must be provided by increasing energy output on electrically synchronized equipment. But during restoration, customer load may also be classified as Synchronous Reserve.

Each area/subsystem must carry enough Synchronous Reserve to cover its largest energy contingency. This Synchronous Reserve may be either on-line generation that can be loaded within 10 minutes or load that can be shed manually within 10 minutes. Synchronous Reserve is required in order to enable an area/subsystem to restore its system tie-lines to a pre-contingency state within as soon as possible after a contingency. When necessary, Synchronous Reserve (including manual load dumping) is used to keep frequency above 59.5 Hz. (Remember to shed approximately 6% load, in a small island, to restore frequency 1 Hz.)

5.1.2 Dynamic Reserve

Dynamic Reserve is the amount of reserve that is available in order to preserve the system during a frequency disturbance. Therefore, the amount of Dynamic Reserve should be enough to allow the system to survive the loss of the largest energy contingency. Dynamic Reserve consists of two components:

- *Reserve on Generators* — reserve on generators that is available via generator governor action during a frequency disturbance to a level at which generators normally separate from the system (i.e. 57.5 Hz) (Governor response).

The amount of Dynamic Reserve needed can be determined by analysis of generator "load pick-up factors" for units paralleled to the system. These "load pick-

up factors" are the maximum load a generator can pick up as a percentage of generator rating without incurring a decline in frequency below safe operating levels. "Rule of Thumb" load pickup factors are:

- 5% for fossil steam
- 15% for hydro
- 25% for combustion turbines

A generator that trips offline may be considered to have the same effect on a system as picking up load equal to the tripped generator's output on the remaining generators. Therefore, the maximum level of dispatch for a generator in a system should not be allowed to exceed an amount over which the remaining generators in a system could maintain acceptable frequency given a loss of the generator. To determine the maximum level of dispatch for a unit, or in other words, the largest acceptable energy contingency, generator load pick-up factors must be used.

- *Load with Underfrequency Relaying* — System load with underfrequency trip levels above the frequency at which generators will normally separate from the system during a frequency disturbance (i.e. 57.5 Hz).

Generator governor response takes place in seconds and is smooth. Technically, both load with underfrequency relaying enabled and generator governor response act similarly and are automatic and can both be considered as Dynamic Reserve.

Most underfrequency load shedding relays can trip feeders within a matter of cycles; therefore, it is very valuable because it increases the safe levels of dispatch in a system. In fact, every megawatt of load with underfrequency load shedding enabled acts to improve the ability of a system to withstand a sudden increase of load or loss of a generator similar to "generator governor response", except that the effect takes place in cycles and is not as smooth.

During the early stages of restoration, it is not advisable to restore load that has underfrequency relaying enabled. With a small generating base, even small amounts of load pick-up can cause large deviations in system frequency. It is advisable to resist picking up load that has underfrequency relaying enabled until normal load pick-up has been demonstrated to not cause frequency decay below the applicable underfrequency trip level.

Load restored with underfrequency relays enabled too early in the restoration process can result in frequent automatic load shedding. If too much load is shed, there is a risk of running the frequency too high which may result in an overspeed condition.

As the generation base grows, and normal load pick-up does not cause frequency to decay below the underfrequency trip levels, it is advisable to start adding load with underfrequency relays set at the lowest trigger frequency. As the generation base continues to grow, load should be added with increasing underfrequency relays settings.

It is advisable to limit the amount of Dynamic Reserve that consists of load with underfrequency enabled. This is desirable because frequent tripping of load with underfrequency enabled occurs unless we also rely on "generator governor response" to restore frequency after a frequency decay. If too much load has been

restored with underfrequency relays enabled and an incident occurs that results in all underfrequency relays operating, there is a risk of having high frequency which may cause an overspeed condition. As a guide, no more than 50% of Dynamic Reserve in a system consists of load with underfrequency enabled.

The ultimate goal is to rely totally on generator governor response to restore frequency should any credible contingency which causes frequency decay occur. This occurs naturally as system restoration proceeds since many generators are paralleled to the system. Eventually, system restoration reaches a point where all systems agree to suspend calculation of Dynamic Reserve since more than enough Dynamic Reserve exists to enable the system to survive any credible contingency. Before this point is reached, however, Dynamic Reserve must be calculated. Calculation of Dynamic Reserve for an area connected to the Eastern Interconnection is not required.

5.1.3 Sample Dynamic Reserve Calculations

- *Example #1* — A system has 300 MW of steam capacity, 400 MW of combustion turbine capacity, and 100 MW of hydroelectric capacity with load pick-up factors of 5%, 25%, and 15% respectively. Fifty (50) MW of load with underfrequency load shedding enabled has been restored.

		5% x 300 MW		**15 MW**
Governor Response	**=**	**25% x 400 MW**	**=**	**100 MW**
		15% x 100 MW		**15 MW**
Total			**=**	**130 MW**
UF Load			**=**	**50 MW**
Dynamic Reserve			**=**	**180 MW**

- *Example #2* — Same data as Example #1, except 150 MW of load with underfrequency load shedding enabled has been restored.

Governor Response	**=**	**130 MW**
UF Load	**=**	**150 MW**

No more than 50% of Dynamic Reserve can consist of load with underfrequency load shedding enabled. Therefore, the maximum contribution from this source of Dynamic Reserve is 130 MW.

Dynamic Response	**=**	**130 + 130**	**=**	**260 MW**

- *Example #3* — A system has 300 MW of steam capacity. Two hundred (200) MW of this capacity is blocked governor response due to a unit problem. The remaining 100 MW of steam capacity has a 5% load pick-up factor. There is 400

MW of combustion turbine capacity available at a 25% load pick-up factor. There is 100 MW of hydroelectric capacity on-line with a 15% load pick-up factor and this capacity is fully loaded to take advantage of a spilling condition. Fifty (50) MW of load with underfrequency load shedding enabled has been restored.

No governor response will be available from the steam units which have blocked governors or from the hydroelectric units at full output.

Governor Response	**=**	**5% x (300-200) MW** **25% x 400 MW**	**=**	**5 MW** **100 MW**
Total			**=**	**105 MW**
UF Load			**=**	**50 MW**
Dynamic Reserve	**=**	**105 MW + 50 MW**	**=**	**155 MW**

Note: The calculation of Dynamic Reserve indicates that the total contribution of underfrequency load shedding should only approximate fifty percent (50%) of the Dynamic Reserve in the interconnected area(s). [However, if a contingency occurs that reduces the area(s) frequency to a level of the underfrequency relay settings, all of the relays would operate and may cause over-frequency problems.] During the restoration process, it is advisable to restore load with underfrequency trip enabled by alternating the restored load among the three or five underfrequency steps. Consideration may be given to adjusting the calculated Dynamic Reserve for the governor response that is provided by the largest energy contingency.

Section 6: Generation

Welcome to the *Generation* section of the ***PJM Manual for System Restoration (M36).*** In this section, you will find the following information:

- How the generating stations in the PJM RTO respond during restoration (see "Generating Stations").
- A description of cranking power during restoration (see "Cranking Power").

6.1 Generating Stations

During restoration, generation dispatch should maintain sufficient load on each unit to stabilize its operation. Generating units are loaded as soon as possible to load levels above their normal minimum point to achieve reliable and stable unit operation unless the system cannot survive the contingency loss of the unit at minimum load.

Once a generator has achieved its minimum load level, the generation dispatch during system restoration is the sole responsibility of each PJM Member. No generation is loaded above a level at which there is not enough Dynamic Reserve in the interconnected areas to survive the resultant frequency decay should that unit trip.

Each generator's dispatch cannot impede the full governor response of the generator should a frequency decay occur. Otherwise, adjustments must be made to Dynamic Reserve. If a generating unit is loaded to maximum output, for instance, no governor response is available on that unit. In addition, units which have different operating ranges as a result of boiler configuration (i.e., placement of burners, etc.) are not loaded to a point where the unit's operating limit impedes full governor response, if frequency decay occurs.

Many generators in the PJM RTO are equipped with control systems primarily to increase efficiency. These systems may improve a generator's regulation capability in some cases; however, in a majority of cases, the response to frequency decay is degraded. The inherent characteristic of these control systems which contributes to degraded frequency decay response is the fact that turbine valve movement is restricted by the boiler control to avoid large pressure swings in the boiler. These control systems negatively affect both the quality of regulation on our system as well as the expected governor response of our system to large frequency deviations. During system restoration, these governors must not be blocked and plant operators must operate the generator in a mode which allows the governors to respond to frequency deviations.

In a restoration scenario, it is ~~assumed~~ expected that gas availability will not be a concern due to the loss of residential gas load, line packing and placing priority on restoration of gas compressor load.

6.1.1 Generating Stations

In the event of a system separation, and/or shut-down, enough equipment and ~~manpower~~ staffing is available at generating stations to assure safe shutdown and to be capable of being restarted as soon as cranking power becomes available. The

local generating station operator should have sufficient control over frequency and terminal voltage so that he/she can parallel any generating unit with an external source at any time it becomes available.

6.1.2 Plant Shutdown

Generating plant operators take necessary actions to perform a safe plant shutdown and prepare equipment for restart as soon as possible.

6.1.3 Generating Plant Communications

Generating plant reports are used to determine status, the condition, and the availability of the system generating units. Plants also provide estimates of unit return times. Equipment status is then tabulated by dispatchers. Communications must be available to local TO ~~dispatchers~~operators, Generation Owner/MOC dispatchers as well as PJM during a restoration event.

6.1.4 Cranking Power Availability

- *Black Start* — sufficient resources for Black Start units are available to ensure safe shutdown and be capable of restart as soon as possible.
- *Other* — Cranking power is available to restart generating units at stations or through portions of internal transmission systems.

6.1.5 Plant Starting Procedure

Each steam plant implements start-up procedures immediately following a plant shutdown, unless instructed otherwise by the dispatcher.

6.1.6 Notify Plants

The Transmission Owner operators/Generation Owner/MOC dispatchers notify each power plant about the extent of the outage and the system status known at the time.

Plants are regularly informed of system status as it impacts each plant. A person at each plant is assigned as a station communicator who is continuously available for communication with the ~~dispatchers~~ operators during and after unit synchronization.

6.1.7 Blocking Governors

During system restoration, governors must not be blocked and plant operators must operate the generator in a mode which allows the governors to respond to frequency deviations if this mode of control is available. Generating units which cannot meet this criteria do not contribute to Dynamic Reserves.

6.1.8 Plant Frequency Control

It is important that every effort be made to maintain frequency between 59.75 and 61.0 Hz. Plant operators must take actions on their own to restore frequency if it falls below 59.5 Hz or rises above 61.0 Hz.

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.

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 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.
- 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 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. This tabulation is typically performed by the Generation Owner/MOC dispatcher for their fleet and communicated to the Transmission Owner operator.

Priority access to start-up power is given to hot units that can return to service within 4 hours. In addition, as cranking power becomes available, preference is given to 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 Balancing Authority, 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 7: Transmission

Welcome to the *Transmission* section of the ***PJM Manual for System Restoration (M36).*** In this section, you will find the following information:

- How PJM provides voltage regulation and control during the restoration process (see "Voltage Regulation and Control").
- A description of the synchronizing process phases (see "Synchronizing").

7.1 Voltage Regulation and Control

During the restoration process, the bulk power system is operated so that reasonable voltage profiles can be maintained (generally 90% to 105% of nominal). Each Transmission Owner and PJM monitors the line voltages on all transmission circuits, particularly those that provide inter-area ties. If the voltage on any bus deviates from the approved bandwidth (90% to 105% of nominal) corrective action must be taken.

7.1.1 Reactive Regulation

The general strategy is to utilize static devices to absorb or provide VARs to maintain voltages within acceptable bandwidth. To the extent possible reactive reserves are maintained on generating units. Adequate distributed reactive regulation under automatic voltage regulation control is maintained throughout the system.

Transmission shunt capacitor banks are removed from service to prevent high voltage until sufficient load ~~(approximately 40% of system load)~~ is restored. Shunt reactors are placed in service to help reduce voltages. Shunt reactors may be removed from service, as required, to maintain system voltages above the minimum desired voltage and within approved bandwidth. Static VAR Compensators are in service and on automatic control.

The Transmission Owners coordinate energizing transmission lines taking into consideration available reactive reserve so that voltages can be maintained within limits. The Transmission Owners attempt to balance reactive requirements using line charging, shunt capacitors, reactors, unit MVAR capabilities, and static VAR compensators, if available.

PJM is responsible for coordinating the restoration of the BES with the TOs. When sufficient load and generation is restored to the affected areas to safely absorb the heavy reactive charging current generated, lines may be restored when Minimum Source Guidelines (as defined in Section 7.1.2) are met. Typical transmission line charging quantities are presented in exhibit 7.

Nominal Voltage	Charging MVAR/Mile
69 kV Line	0.025
115/138 kV Line	0.100
230 kV Line	0.300
345 kV Line	0.800
500 kV Line	1.700
115/138 kV Cable	2.0-7.0
230 kV Cable	5.0-15.0

Nominal Voltage	Charging MVAR/Mile
345 kV Cable	15.0-30.0

Exhibit 7: Transmission Line Charging

Energization Guidelines

- *Lines* —500 kV / 765 kV lines and transformers are energized separately, not in combination. Ideally, both sending and receiving end 500/230 kV transformers are energized from the low side; the 500 kV / 765 kV line is energized from the strongest source; and a parallel made with a 500 kV / 765 kV breaker.

Load the newly energized path appropriately before energizing additional 500 kV / 765 kV lines. There should be a minimum of 20 MW of connected load per mile of 500 kV / 765 kV line that is energized.

Energize only transmission lines that carry significant load. Energizing extra lines generates unwanted VARS.

- *Line and Transformer* — When energizing a 500 kV / 765 kV bus section with a 500/230 kV transformer, if not already open, open all 500 kV / 765 kV line breakers (clear bus section). Close the source end transformer's 230 kV breaker. Before energizing a line, reduce the 500 kV / 765 kV voltage by adjusting the tap on the sending end 500 kV / 765 kV TCUL transformer. This minimizes VARS generated by line charging, reducing VAR absorption requirements on the underlying system and helps control the voltage to less than 500 kV / 765 kV at the receiving end.
- *Transformer Voltages* — Adjust the sending end line voltage to 475 kV or below. The 230 kV voltage should not exceed 230 kV, preferably as low as reasonable.

Adjust the receiving end line voltage to around 500 kV / 765 kV and 230 kV (+/- 5%).

The receiving end transformer tap matches or exceeds the receiving end voltage. This may be difficult if there is no AC station service power at the receiving end substation. TCUL transformers require AC power for operation which could be supplied by an emergency generator, or since the transformer is de-energized, the TCUL could be operated manually. To minimize overheating due to excitation, before energizing, the high side transformer tap position must be above neutral (receiving end line voltage is typically higher than 500 kV / 765 kV due to charging).

Energize the receiving end transformer only after all the above conditions are met. A circuit switcher or air switch is a good device for energizing a transformer because it energizes at a favorable point of wave (voltage crest).

7.1.2 Minimum Source Guidelines

These guidelines are used to determine the ability to safely energize the 500 kV and 765 kV systems with respect to voltage profiles and fault current availability. These guidelines are conservative and can be used in the absence of more detailed study results. Specific situations may dictate energizing EHV without all of these guidelines being met.

The 500 kV / 765 kV pre-engineering guidelines are:

- ~~primary~~ Primary and backup relays in service
- ~~shunt~~ Shunt capacitors out-of-service
- Generation
  - 600 MW of electrically close generation connected 230 kV or higher
  - Electrically close is defined as less than 50 230 kV miles
  - provides adequate short circuit current for fault clearing
  - minimum of 30 MW of generation per mile of energized 500 kV / 765 kV line
- Load
  - minimum of 20 MW of load per mile of energized 500 kV / 765 kV line
  - Energized Line = Already Energized + The Line Being Energized

The energizing guidelines are:

- Clear dead bus sections
- Energize 500 kV / 765 kV lines and transformers separately
- Energize transformers ideally from low side
- Reduce 500 kV / 765 kV voltage via tap changer
- Reduce sending end voltage to 475 kV or lower and 230 kV or lower
- Energize lines from strongest sourceParallel with 500 kV / 765 kV circuit breaker

The rules of thumb for voltage control are based on available analysis:

- Detailed ~~Analyses~~ analyses ~~Unavailable~~unavailable
- generation electrically close to energizing point
- minimum generating capacity, 30 MW/mile of 500 kV / 765 kV to be connected
- load electrically close to energizing point
- minimum load, 20 MW/mile of 500 kV / 765 kV to be connected
- provides approximately 1.8 MVAR load to prevent machines from excessive loading operation
- When detailed information about the system is lacking, the following guidelines provide a 2:1 safety factor. Generation must be electrically close to the point where the EHV system is to be energized.
- If available, real-time analysis tools or off-line studies should be utilized to confirm aforementioned “rules of thumb”.
-

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Description	Reason
Minimum Generating Capacity — 30 MW/ mile of 500 kV / 765 kV to be connected	Provides approximately two MVAR/mile VAR absorbing capability at full load
Minimum Load — 20 MW/mile of 500 kV / 765 kV line to be connected	Provides approximately 1.8 MVAR/mile VAR load to prevent machine from excessive loading operation. This will help balance the capacitive voltage rise.

Exhibit 8: EHV Energization Guidelines - Information Unavailable

- Detailed Analyses Available
  - When detailed information about the system is known, the following guidelines can be used. Generation must be electrically close to the point where the EHV system is to be energized.

Description	Reason
VAR Absorption — A minimum of 3.0 MVAR of electrically close VAR absorption per mile of 500 kV / 765 kV line connected must be available. May be generator reactive (leading), reactive load, shunt reactors, etc. Static VAR compensator may assist in accomplishing this if available.	This will control line voltage less than 500 kV / 765 kV.
At least 3 MW of load per mile control of 500 kV / 765 kV line to be energized must be established on the underlying system.	To provide damping to dynamic over- voltage when energizing transformers.

Exhibit 9: EHV Energization Guidelines - Information Available

7.2 Synchronization

Restoration of an interconnected system involves re-establishing electrical ties between generators in two or more areas (or subsystems) within a single Transmission Owner, or between two or more Transmission Owners or systems, by synchronizing the two areas to a common speed or frequency. The increased inertia of the resultant enlarged area tends to dampen fluctuations in frequency and increases the capability of the area to pick up larger blocks of load and establishes or maintains Dynamic and Synchronous Reserves. These increased capabilities promote more stable operation, thus facilitating further restoration efforts. However, the benefits of tying two or more areas together must be balanced with the risk of the synchronizing process and the ability to control the enlarged area to maintain generation-load balance within acceptable frequency and voltage bandwidths.

Synchronization is only required when connecting two areas or islands that have running generation sources. Simply using generation in one zone to pick up load in an adjacent zone does not require synchronization.

On a related note, implications of synchronization need to be evaluated in cases where cranking power for unit restart is provided by another Transmission Owner or system.

7.2.1 Synchronizing Process Phases

Pre-tie Preparations

- Mobilize field personnel and alert generating station personnel within both areas to be joined.
- Identify line to "tie" areas together. The tie line must be of sufficient capacity to carry the anticipated flow between the two areas.
- Identify the substation for "tie-in". This substation must be equipped with a synchroscope that can be used for synchronizing the two areas. Also, it must have reliable communication with the system operator who will direct the tie-in. In no case should synchronization between two areas be attempted without either a synchroscope or synchro-check relay due to the high probability of equipment damage and possible shutdown of one or both areas.
- For 2 Transmission Owners synchronizing together, a MW tie schedule must be established between the TOs based on expected flows between areas and agreed upon support that one area will be providing the other. This schedule may be zero or an amount equal to cranking power provided from one area to the other. If one TO has excess generation available, they may increase this schedule to their neighbor as appropriate to assist the neighboring area in restoring their load.

Locations of Synchronization Devices

Region	Page/Reference	Document
AEP	Attachment B, p. 67-69	AEP East/PJM System Restoration Black Start, Rev.15.2
Atlantic Electric	Appendix D, p. 183-186	Atlantic City Electric System Restoration Plan Revised December 11, 2015
BG&E	Attachment 22, p. 157-161	System Restoration Manual, Rev. 6.1
ComEd	System Restoration Initial Substation & Cranking Path maps, p. 46-49	2016 ComEd System Restoration, Revision 1
CPP	p. 2-10	Cleveland Public Power NERC Reliability Standards Compliance Policy, EOP-005-2-5, Rev. 5.0
Dayton	p. 40-41	DPL Standard Operating Procedure SOP 601 (Operations Planning) System Restoration, Rev. 11
Delmarva	Appendix D, p.65-66	Delmarva Power System Restoration Plan, Rev. 29
Dominion	Chapter 5, Section 5.10, p. 21-24	Dominion System Restoration Plan, Version 8.1
Duquesne	Attachment 13, p. 86	Duquesne Light System Restoration Plan, Rev. 6.0
DUKE	Appendix IX, p. 82-83	Duke Energy Ohio/Kentucky (DEOK) System Restoration Plan, Rev. 2015 2

EKPC	Appendix E, p. 51-52	EKPC System Restoration Plan, Rev. 22
FE-East	Attachment A, p. 26 Attachment B, p. 65 Attachment C, p. 99	FE-EAST-EOP-005 Power System Restoration Plan, Rev. 7
FE-South	Attachment A, p. 32 Attachment B, p. 54 Attachment C, p. 69	FE-SOUTH-EOP-005 Power System Restoration Plan, Rev. 7
FE-West	Attachment A, p. 54 Attachment B, p. 99	FE-WEST-EOP-005 Power System Restoration Plan, Rev. 4
ITCI	Appendix E-12	ITCI System Restoration Procedures, June 1, 2016
Orange and Rockland Utilities	Appendix 1, p. 30	Orange & Rockland OI 6-E-24 System Restoration Plan Rev. 19
PECO	Appendix 9, p. 140-144	PECO Energy System Restoration Plan, Rev. 2.0
PEPCO	p. 80-82	PEPCO System Restoration Plan, Rev.
PPL	Attachment C, p. 38-47	PPL Electric Utilities Black Start System Restoration Manual, Rev. 20
PSE&G	Section 14, p. 21-24	PSE&G System Restoration Procedure and Philosophy, Rev. 44
Rochelle	p. 9	Rochelle Municipal Utilities Restoration Plan, Rev. 2.0
UGI	Section 10.3, p. 24-26	UGI System Restoration, Rev. 5.0

~~***Locations of Synchronization Devices***~~

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~~**Region**~~	~~**Page/ Reference**~~	~~**Document**~~
~~AEP~~	~~Attachment B p. 60-62~~	~~AEP East System Restoration Manual Rev. 14.2~~
~~Atlantic Electric~~	~~Appendix D, p. 179-183~~	~~Atlantic City Electric System Restoration Plan 2015 1-30-15~~
~~BG&E~~	~~Attachment 22 p. 159-162~~	~~BG&E System Restoration Manual Rev 5.0~~
~~ComEd~~	~~System Restoration Initial Substation & Cranking Path maps p. 48-52~~	~~2015 ComEd Restoration Manual R01~~
~~Dayton~~	~~p. 40-41~~	~~Dayton System Restoration Manual Rev. 11~~
~~Delmarva~~	~~Appendix D, p. 55-57~~	~~Delmarva Power System Restoration Plan 2015 Rev. 24~~
~~Dominion~~	~~Section 5.10- p. 21-24~~	~~Dominion System Restoration Plan Version #: 7.0~~
~~Duquesne~~	~~Attachment 13~~	~~Duquesne Restoration Plan Rev 5.1~~
~~DUKE~~	~~Appendix IX p. 76-77~~	~~DEOK System Restoration Plan Rev 2015_0~~
~~EKPC~~	~~Appendix E p. 49-5055-56~~	~~EKPC System Restoration Plan Rev 21~~
~~FE-East~~	~~Attachment A , Section 5, p.16~~ ~~Attachment B, Section 5, p.20~~ ~~Attachment C, Section 5, p.17~~	~~FE-East-EOP-005 Power System Restoration Plan Rev. 5, and Attachments A, B, & C~~

~~FE South~~	~~Attachment A, Section 5, p. 21~~ ~~Attachment B, Section 5, p.15~~ ~~Attachment C, Section 5, p.14~~	~~FE South-EOP-005 Power System Restoration Plan Rev. 6 and Attachments A, B, & C~~
~~FE West~~	~~Attachment A, Section 5, p.43~~ ~~Attachment B, Section 5, p.31~~	~~FE West-EOP-005 Power System Restoration Plan Rev. 3, and Attachments A & B~~
~~Orange and Rockland Utilities~~	~~Appendix 1 p. 29~~	~~Orange and Rockland System Restoration Plan 6-E-23~~
~~PECO~~	~~Appendix 9 p. 1-4~~	~~PECO System Restoration Manual 2014~~
~~PEPCO~~	~~Section 1 p. 27-28, 74~~	~~PEPCO System Restoration Manual~~
~~PPL~~	~~Attachment C p. 37-4657 - 63~~	~~PPL Restoration Manual Rev 18~~
~~PSE&G~~	~~p. 25~~	~~PSE&G Restoration Procedure~~

Exhibit 10: PJM Table of Major Synchronization Devices

Preparation plans must also consider additional lines to close once joined, to strengthen ties to protect against contingencies. Also, the additional line(s) may be needed as alternates if synchronization is not successful on the identified line for tie in.

- Evaluate the capabilities of two areas to be joined and exchange data between Transmission Owners when not within a single Balancing Authority.
- Each of the two areas to be joined must demonstrate sufficient capability of maintaining frequency and voltage control in order to permit synchronization. Additionally, each one must be strong enough to withstand the "tie-in" and have the capability to share in the control of the enlarged system.

~~Data Exchange Sheets~~Interconnection Checklists (Exhibit 16) are ~~used~~ completed by Transmission Owners of the two systems to be tied.

Synchronization

Prior to synchronization, the ~~transmission~~ Transmission ~~owner~~ Owner must communicate with PJM (PJM will coordinate with neighbors as required) and get approval for synchronization if connecting 2 Transmission Owners (internal or external). Before synchronizing, the frequency of the two areas must be matched. Adjustments are made by the area most able to do so (preferably the smaller area). The aim of the other area is to maintain its frequency at a stable point. Voltage of the two areas are as close as possible. Ideally, the smaller area adjusts frequency and voltage to that of the larger area. When using a synchroscope, frequencies are such that the scope is moving slowly in the fast direction, or with three lights, all lights are out. Failure to match frequency and voltage between the two areas can result in significant equipment damage and possible shut-down of one or both areas.

Post-tie Follow-up

- Coordinated operation, as agreed to, is carried out within the enlarged area (subsystem) maintaining frequency control and tie line schedule(s). Dynamic and Synchronous Reserve requirement are recalculated and re-allocated.

- Communications are maintained on a regular basis between interconnected areas or systems.
- Additional ties are established according to plan to strengthen and stabilize the interconnection between the two areas when appropriate.

Section 8: System Restoration Plan Guidelines

Welcome to the *System Restoration Plan Guidelines* section of the ***PJM Manual for System Restoration (M36).*** In this section, you will find the following information:

- How PJM determines a standard content guideline

8.1 System Restoration Plan Guidelines

The system restoration guidelines provide a basis for a common framework for system restoration plans of the Transmission Owners, AEP, ITCI and PJM. It is recognized that individual system restoration plans are based on the concepts:

- Each Transmission Owner is responsible for restoring its own customer load to include identifying critical loads as appropriate[4] with internal generation or through coordinated efforts with other Transmission Owners. After a subsystem is stabilized, requests from neighboring Transmission Owners for cranking power are a higher priority than restoring additional customer load of the supplying company. Any Transmission Owner that is not operating in parallel with adjacent Transmission Owners is free to restore or shed load in any manner or at any rate it may deem practical.
- The system restoration plans must be reviewed by the Transmission Owners at least annually or more frequently as needed to account for changes in the system configuration. For such changes, the Transmission Owner in conjunction with PJM may amend the restoration plan and determine black start requirements, if either determines that additional black start resources are needed.

During system restoration, it is critical that AC power be restored to key substations as soon as possible to maintain the integrity of air and gas operated circuit breakers. Assure that communication equipment be independent of local AC power supply during abnormal operation.

The local generating station operator should have sufficient control over frequency and terminal voltage so that he or she can parallel any generating unit with an external source at any time it becomes available. Enough equipment and staff are available at generating stations to assure safe shutdown and to be capable of being restarted as soon as cranking power becomes available.

- It is desirable that restoration plans have redundancy built into them such as, when developing each subsystem, at least two sources of cranking power and black start ~~steam units~~ are included.
- When a Transmission Owner can provide a demonstrable plan to restore adequate service from an offsite source to an energy control center, a substation, or a generating station within less time than required in the following guidelines, that plan is then to be considered in compliance with PJM black start standards. PJM black start standards are:

[4] (NERC EOP-005 Attachment 1- 5)

- Energy control centers are provided with adequate on-site facilities to provide a minimum of 24 hour stand-alone capability.
- Substations on the bulk power system are provided with adequate back-up power supplies to provide a minimum of eight (8) hour stand-alone capability.
- Generating stations are provided with a minimum of two hour stand-alone capability.

Base case conditions exist which include both a system configuration following a disturbance and the operational status of equipment on the system. It is recognized that some equipment failures can and will occur during a system shutdown and subsequent restoration. These failures are addressed on an individual basis as they are found and adjustments are made to system restoration procedures, where necessary. For these guidelines, the assumptions are as follows:

- Black start unit is a unit that is capable from going to a shutdown condition to an operating condition and start delivering power without assistance from the system.
- All steam generators on-line at the time of the disturbance trip offline, without damage. Emergency diesels/batteries, where available, can be used to rotate turbines on turning gear. Emergency start-up power is accomplished without incident.
- Steam units are available to synchronize or energize the bus and subsequently load at times as found in the PJM Markets database.
- All ~~telephone and microwave~~voice and data communication systems required for system operations are functional.
- Emergency energy supply systems are operational.
- Fuel inventories at all peaking units and emergency generators are adequate.
- Transmission Owner restoration plans are coordinated with the adequacy of the substation battery capability.
- All circuit breakers remain operational without station service being available.
- ~~Manpower~~ Staffing requirements for system restoration can be met by available personnel. Any additional ~~manpower~~ staffing is assumed available through existing ~~manpower~~ procurement procedures.
- Transmission Owners do not establish bilateral transactions.

In general, a System Restoration Plan includes the following sections:

- Ascertaining System Status
- Determining Restoration Process
- Disseminating System Status Information
- Implementing Restoration Process
- Frequency Control
- Verify Switching Equipment Constraints

- Transmission Owners Interconnect
- Continue Verifications of Switching Equipment Constraints
- Guidelines for Area Interconnection and Use of External Power during System Restoration
- PJM Returns to Normal Operation
- System Control Progress

8.1.1 Ascertaining 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 Generation Owner/MOC dispatchers notify each power plant about the extent of the outage and system status known at the time.
- Equipment status is tabulated by Generation Owner/MOC 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 generating units at 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 operators~~/~~ or Generation Owner/MOC dispatchers.

- Estimated time of return (on-line time) — Plants provide estimates to Transmission Owner operators~~/~~ and Generation Owner/MOC 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.

8.1.2 Determining Restoration Process

Immediately after a severe system disturbance within the PJM RTO, PJM is not able to effectively coordinate the operation of the individual sequestered or blacked-out areas. During this period, PJM acts as a coordinator in the information and damage assessment center and assist the Transmission / Generation Owners as required. The Transmission ~~/~~ Owner ~~dispatchers~~ operators immediately implement restoration procedures as outlined in the restoration plan. System restoration plans are written to address the restoration of a totally blacked-out system without any available cranking power from neighboring companies.

- *Identify restoration strategy based on system status* — Since electric power systems can collapse into blacked-out areas surrounding one or more islands of generation and load, it is necessary to identify an overall restoration strategy based on the current system status. Sequestered generation can be utilized to provide cranking power, restore transmission, station service to substations, or to restore customer load.
- *Organize steps and/or sequential order of System Restoration Plan (SRP)* — Once an overall restoration strategy is identified, all or portions of the SRP are selected as being appropriate for use based on the current system status. In addition, the order of the restoration steps to be used may require changes due to the prevailing conditions.
- *Assign sections/steps of the SRP to individuals and begin implementation* — Once the steps to be used have been identified, they are assigned to ~~dispatchers~~ operators or appropriate personnel who begin implementation of the restoration process.
- Power system disturbances are most likely to occur as the result of the loss of generating equipment, transmission facilities, or as the result of unexpected load changes. These disturbances may be of, or develop into, a magnitude sufficient to affect the reliable operation of the PJM RTO. The associated conditions under severe system disturbances generally result in critically loaded transmission facilities, critical frequency deviations or high or low voltage conditions. Such disturbances can result in equipment damage and a system blackout. Due to the unknown impact of the system blackout on generator and transmission equipment, both PJM and the Transmission Owner must be able to adjust restoration strategies based on actual system conditions.

8.1.3 Disseminating System Status Information

Each Transmission Owner continues to determine the extent of the service interruption within its boundaries and keep the appropriate personnel informed of the existing generation and transmission capabilities and other appropriate information. It is important to have personnel available to provide information on current and future system conditions.

- *Call in Personnel by Established Procedures* — ~~Establish a priority call-out sequence. Transmission Owner/Generation Owner and PJM management are notified by the dispatcher. Support staff calls are made by a supervisor. This allows the dispatcher to restore the system. The dispatcher also calls in additional personnel as needed.~~Additional operating staff should be called in accordance to pre-existing procedures.
- *Notify Plants* — Plants are regularly informed of system status as it impacts each plant. A person at each plant is assigned as a station communicator, who is continuously available for communication with the system operators during and after unit synchronization.
- *Notify Field Locations* — Personnel in field locations are notified that a system shutdown has taken place and that routine work on transmission or distribution facilities should be curtailed or completed expeditiously.
- *Notify Management* — Management is kept continuously informed of system status during the restoration process.
- *Notify Public Relations and Authorities* — A person in each Transmission Owner/Generation Owner is assigned to contact Public Relations, and authorities, i.e. D.O.E., NERC, Public Utilities Commissions (or equivalent). ~~Dispatchers~~ Operators are not to be used for this function.
- *Report Status to PJM* — Communications are established immediately between the Transmission Owners experiencing the disturbance and PJM and directly between adjacent Transmission Owners or Balancing Authorities.

A person in each Transmission Owner and PJM are assigned to act as an information coordinator. He or she relays disturbance information to PJM as soon as it becomes available.

PJM is informed of the restoration of bulk power transmission lines within an Island or between neighboring PJM companies so that PJM can keep abreast of Transmission Owner restoration progress. PJM is also informed of generation lost at each station, generation still operating, load lost and location, and critical voltages throughout the system.

8.1.4 Implementing Restoration Process

- See *"Implement Restoration Procedure"* in section 3.1.5 of this manual.

8.1.5 Frequency Control

- See "PJM Assumes ~~Frequency Control~~Balancing Authority Role" in section 3.1.7 of this manual.

8.1.6 Verify Switching Equipment Constraints

SRPs include information on the limitations of switching equipment which prevail during the restoration process. The limitations are based on pre-studied examination of steady-state voltages and selected switching surge studies. Load flow solutions are used to examine steady state voltage levels which may exist during the restoration process, including those of open-ended lines. If necessary, pre-studied switching surge studies are used to identify transient problems for questionable switching conditions.

- Substations on the bulk power system have adequate battery back-up power to provide a minimum of eight hour stand-alone capability for DC equipment. However, equipment such as SF_6 circuit breakers or oil-filled cables which require AC power may be unable to maintain pressure and/or temperature, based on ambient conditions, beyond one hour, in which case diesel or other AC auxiliary power supplies should be provided.
- SF_6 equipment has limited temperature and pressure operating ranges. Without available AC power, temperature or pressure may fall below the normal operating ranges and SF_6 equipment will become inoperable (normally 1-6 hours).
- Battery voltage decays after loss of AC power to the charger. DC equipment (e.g. circuit breaker controls, protective relays, RTUs, etc.) may become inoperative when voltages reach 80% of nominal or less.
- Air blast equipment has limited pressure operating ranges. Verify normal air pressure prior to energizing.
- Air pressure in pneumatically operated circuit breakers decays after loss of AC power. If the air pressure falls below the operating range, this type of circuit breaker cannot be closed.
- Cable oil pressure decays after loss of AC power. Verify positive oil pressure prior to re-energizing oil filled cables.

8.1.7 Transmission Owners Interconnect

- See *"~~Member Interconnection~~Criteria and Conditions for Reestablishing Interconnections"* in section 3.1.6 of this manual.

8.1.8 Continue Verifications of Switching Equipment Constraints

SRPs include information on the limitations of switching equipment which prevails during the restoration process.

Based on locations at which synchronization can take place:

- Substations that have the capability of synchronizing two systems that are isolated from each other are identified and included in SRPs. Normally, a synchroscope or synchronizing lamps are used to synchronize two subsystems that are isolated from each other[5].

Based on pre-studied examination of steady state voltages and selected switching surge studies:

- Loadflow solutions are used to examine steady state voltage levels that may exist during the restoration process, including those of open-end lines. If necessary, switching surge studies are used to identify transient problems for questionable switching conditions

8.1.9 Guidelines for Area Interconnection and Use of External Power during System Restoration

- Any opportunity to connect to the Eastern Interconnection should be explored as soon as possible.
- Any available energy from neighboring companies or Balancing Authorities should be utilized by a deficient company regardless of the "firmness" of the energy.
- Cranking power to neighboring companies is to be supplied as a priority to restoring internal customer load.
- A company connected to the Eastern Interconnection should supply any available excess energy for load to deficient company. Stability is normally not a concern in this situation.
- There is no need to employ or monitor Dynamic Reserves for companies connected to the Eastern Interconnection.
- Two or more isolated islands under different Transmission Owners that are interconnecting must adhere to the guidelines set up in the Interconnection Checklist found in Attachment B, Exhibit 16.
- Two isolated islands within the same Transmission Owner that are interconnecting are also encouraged to consider the guidelines in the Interconnection Checklist found in Attachment B, -Exhibit 16.
- Certain informational items, contained in the Interconnection Checklist in Attachment B, Exhibit 16, are not required for an island tying to the Eastern Interconnection or tying to a PJM company already connected to the Eastern Interconnection. These items deal with dynamic reserve and frequency stability.
    - When tying to the Eastern Interconnection, only items 1-5 and 15-25 of the Interconnection Checklist in Attachment B, Exhibit 16 are required.
- If only supplying load to an adjacent TO (i.e. no synchronization required), only items 1-5 and 15-25 of the Interconnection Checklist in Attachment B, Exhibit 16 are required.

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[5] NERC EOP-005-1 R11.5.1 - to resynchronize the surrounding area(s) voltage, frequency, and phase angle permit.

- PJM will set up and coordinate any interchange schedules with external Balancing Authorities.
- When a company connects to the Eastern Interconnection, it must have adequate Synchronous reserve by way of available unloaded capability on synchronized generation and/or load shedding to cover their largest energy contingency. It may be possible to make agreements with the external area to share in covering of some of these reserves.

8.1.10 PJM Returns to Normal Operation

Re-establish PJM single control center coordination. This occurs when an ACE can be calculated for the area to be controlled (entire PJM area or portion) and a return to central coordinated operation is desired by PJM and the Transmission Owners.

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

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. 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
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:
       - 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

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

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.

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)

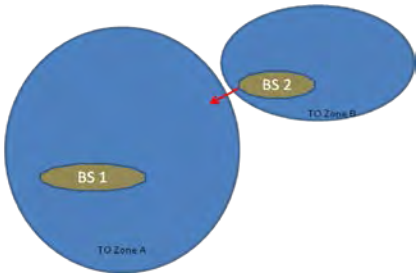

Figure 1 – Example of level one cross zonal coordination. In this example Black Start units one and two both supply TO Zone A even though Black Start Unit two is located in TO Zone B.

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).

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)

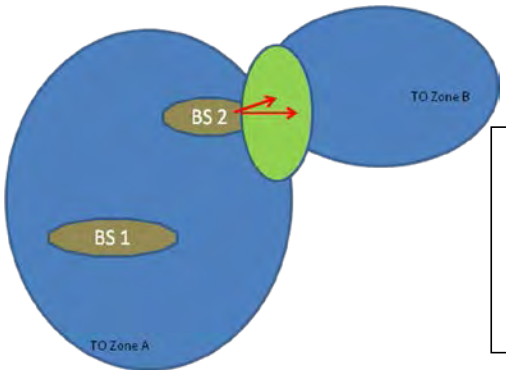

Figure 2 – Example of level two cross zonal coordination. In this example Black Start unit two is shared between TO Zone A and TO Zone B. Critical load is restored from this unit in both zones.

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.

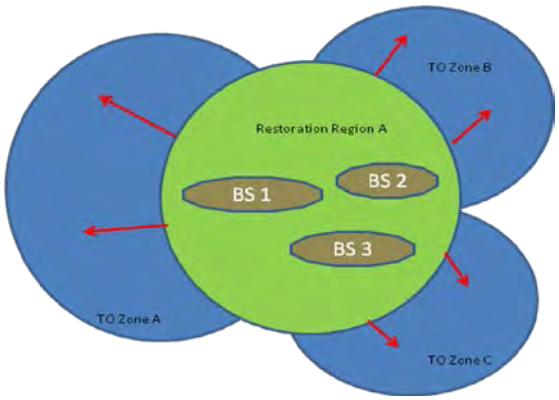

Figure 3 – Example of level three cross zonal coordination. In this example a new Restoration Region (A) is created from TO Zones A, B and C. The TO zones would aggregate their restoration plans into one plan.

Attachment A: Minimum Critical Black Start Requirement

A.1 Critical Black Start Criteria

A.1.1 Goal

The PJM System Restoration 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 unit retirements. The SRSTF developed requirements for the amount and redundancy of Black Start generation based on critical load requirements. Specific black start data[6] 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 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 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) as defined in each plant's Nuclear Plant Interface Requirements (NPIR) document
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.
   c. Exceptions to critical cranking power are made for intermittent generation (i.e. wind, solar)
   d. Exceptions to critical cranking power will be considered on a case by case basis for:
      i. Complex cranking paths for minimum ICAP gain

ii. Non-dispatchable units or units with very high minimum limits

*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.

Note: PJM will utilize the above definitions for critical load in the 5 Year Black Start Selection Process scheduled for late ~~2013~~2018/early ~~2014~~2019 for implementation in 2020. Following the selection of Black Start units that would best meet these critical load requirements, cranking paths will be updated in TO system restoration plans and the PJM Black Start database. ~~Prior to transitioning to these new cranking paths, TO restoration plans may reflect the previous definition of cranking power (offsite power to steam units with 8 hour or less start time).~~

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

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.

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:

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.

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

Also, per NERC Standard EOP-005-2, R15, each Generator Operator with a Blackstart Resource shall notify its Transmission Operator of any known changes to the capabilities of that Blackstart Resource affecting the ability to meet the Transmission Operator's restoration plan within 24 hours following such change.

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:

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

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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

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

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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)
- 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. 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.
- Other high priority load which should be considered early in the restoration process include:
  - Cranking power to generation with greater than 4 hour start time.
  - Power to electric infrastructure in accordance with timeframe defined in Section 4.1.7.
  - 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
- 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 Transmission Owner's Restoration Plan will identify the importance of restoring these loads, although the Transmission Owner may choose not to explicitly quantify; ensuring these loads are restored as the restoration process progresses.

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 10: *Black Start Generation Procurement*).

Variables for Critical Black Start Replacement—Determining the amount of critical black start generation by transmission zone depends upon the physical characteristics of the 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:
  - 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 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. Electrically close to Critical Load. Some consideration may be given to location based on fuel diversity of critical steam.
  - Start time of the Black Start unit
  - 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.

Attachment B: Restoration Forms

PJM COMPOSITE INITIAL RESTORATION REPORT

Date: / /

Time: HRs

Generation Data by transmission Zone

Company Report Time:								FE-E	FE-E	FE-E														
Company:	RECO	PS	PE	AE	DPL	PL	UGI	JC	ME	PN	BC	PEP	SMECO	DOM	FE-S	DLCO	DAY	AEP	COM	Rochelle	FE-W	CPP	DUKE	EKPC
Generation Lost (Capacity) MW																								
Generation still Operating Capacity (MW)																								
Generation still Operating Energy (MW)																								
# of Generators on Line																								
# of Subsystems																								

Load Data by Transmission Zone

Company Report Time:								FE-E	FE-E	FE-E														
Company:	RECO	PS	PE	AE	DPL	PL	UGI	JC	ME	PN	BC	PEP	SMECO	DOM	FE-S	DLCO	DAY	AEP	COM	Rochelle	FE-W	CPP	DUKE	EKPC
Customer Load Lost MW																								
% of Customer Load Lost																								
# of Customers Lost (000)																								
% of Customers Lost																								
Estimate for Total Restoration (Date/Time)																								

Exhibit 11: PJM Composite Initial Restoration Report

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COMPANY INITIAL RESTORATION REPORT

Reporting Company:	**Date:**
Reporting Contact:	**Time:**

Generation Lost (Capacity)	**MW**
Generation Still Operating (Capacity)	**MW**
Generation Still Operating (Energy)	**MW**
# of Generators on Line	
# of Subsystems (Islands)	
Customers Load Lost	**MW**
% of Customer Load Lost	**%**
# of Customers Lost in (000)	**THS.**
% of Customers Lost	**%**
Total Restoration Expected to be Completed by, Date/Time	

Equipment Damage: _____

Comments (Any outside ties with systems external to PJM that may have survived, etc.): _____

Capacity – Rated Load Carrying Capability
Energy - MW Loading on a Machine

Exhibit 12: Company Initial Restoration Report

PJM COMPOSITE HOURLY RESTORATION REPORT

Operator:		Date		
		Time		HRs

Generation Data by transmission Zone

Company Report Time:								FE-E	FE-E	FE-E															PJM
Company:	RECO	PS	PE	AE	DPL	PL	UGI	JC	ME	PN	BC	PEP	SMECO	DOM	FE-S	DLCO	DAY	AEP	Rochelle	COM	FE-W	CPP	DEOK	EKPC	Total
Generation Lost Capacity (MW)																									
Generation still Operating Capacity (MW)																									
Generation still Operating Energy (MW)																									
# of Generators on Line																									
# of Subsystems																									

Load Data by Transmission Zone

Company Report Time:								FE-E	FE-E	FE-E															PJM
Company:	RECO	PS	PE	AE	DPL	PL	UGI	JC	ME	PN	BC	PEP	SMECO	DOM	FE-S	DLCO	DAY	AEP	Rochelle	COM	FE-W	CPP	DEOK	EKPC	Total
Customer Restored MW																									
% of Customer Restored																									
# of Customer Restored																									
% of BES Restored																									
Estimate fot Total Restoration (Date/Time)																									

PJM Damage Summary Since Last Report:

Comments:

Exhibit 13: PJM Composite Hourly Restoration Report

COMPANY HOURLY *~~GENERATION~~ RESTORATION REPORT	
Date:	Time:
Reporting Company:	
Transmission Zone:	
Company Contact:	Estimated Time to Complete Total Restoration: Date: Time:

- If no changes since last report submitted, report is not required

GENERATION REPORT:	MW	LOAD RESTORATION REPORT:	MW
Generation: Capacity on Line		Total Customer Load Restored	
Generation: Energy on Line		# Of Customers Restored (000)	
# Of Generators on Line		% Customers Restored	
# Of Subsystems (Islands)		% Customers Restored Last Hour	
CAPACITY DUE IN:			
Generation in One Hour (1)			
Generation in Three Hours (3)			
Generation in six Hours (6)			

UNITS ON LINE SINCE LAST REPORT					
Station	Unit	MW	Station	Unit	MW

UNITS EXPECTED DURING NEXT HOUR					
Station	Unit	MW	Station	Unit	MW

Damage detected since last report / comments: _____

CRANKING POWER					
From Company to Station	kV	Time	From Company to Station	kV	Time

Exhibit 14: Company Hourly ~~Generation~~ Restoration Report
**may be required more often. Information to be compiled by TO operators for units within their zone and submitted to PJM*

COMPANY TRANSMISSION RESTORATION REPORT

Date: **Time:**

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Reporting Company:

Company Contact:

****This report should be submitted every 10 lines restored or 30 minutes. During drills, reports may be e-mailed to ~~RestorationDrill~~RestorationForms@pjm.com. If no changes since the last report, no report is required.**

EXAMPLE DATA

ID	Facility Identification	Voltage Level	Date Restored	Time Restored	Energized since Last Report (?)	Expected in Next Hour (?)
5003	Keystone – Conemaugh		01/01/00	0800	X	
5004	Keystone – Juniata					X

ID	Facility Identification	Voltage Level	Date Restored	Time Restored	Energized since Last Report (?)	Expected in Next Hour (?)

Exhibit 15: Company Transmission Restoration Report

INTERCONNECTION CHECKLIST				
DATE:		DATE:		
ISLAND "A":		ISLAND "B":		
CONTACT:		CONTACT:		
INFORMATION EXCHANGE				
			ISLAND "A"	ISLAND "B"
1	Are you currently interconnected?		YES /NO	YES /NO
2	If YES, which company (ies):			
3	Existing Tie-line Schedules:			
	FROM:	To:	MW	MW
	FROM:	To:	MW	MW
	FROM:	To:	MW	MW
4	Do you need start-up power?		YES /NO	YES /NO
	4a	If YES, how much?	MW	MW
5	Can you supply energy?		YES /NO	YES /NO
	5a	If YES, how much?	MW	MW
LOAD INFORMATION (* Not required if connecting to Eastern Interconnection)				
6	Load Restored:		MW	MW
	6a	% of Load Restored	%	%
7	Load Restored With Underfrequency Relaying Enabled		MW	MW
			%	%
			___Hz ___MW	___Hz ___MW
			___Hz ___MW	___Hz ___MW
			___Hz ___MW	___Hz ___MW
			___Hz ___MW	___Hz ___MW
	7a	Total Load Restored w/ Underfrequency Relaying In-Service:	MW	MW
CAPACITY/ENERGY INFORMATION (* Not required if connecting to Eastern Interconnection)				
8	Largest Energy Contingency		MW	MW
9	Generation On-Line: Total Capacity		MW	MW
10	Generation On-Line: Energy		MW	MW
11	Synchronous (Spinning) Reserve (Not Including Load Shedding):		MW	MW
12	Governor Reserve:		MW	MW
13	Total Dynamic Reserve: (Governor Reserve + Total Restored Underfrequency Relaying) (Row 7a + 12) (**N/A** if company is tied to the Eastern Interconnection)		MW	MW
14	Frequency Range over the Last Hour: (**N/A** if company is tied to the Eastern Interconnection)		/ Hz	/ Hz
TIE-LINE LOCATION AND SCHEDULING INFORMATION				
15	Tie-line to be established:			
16	Tie-line schedule to be established:			MW
17	Which company will coordinate synchronization?			
18	Which breaker / substation will be used for synchronization?			
19	Which company will control frequency?			
20	Which company will control tie-line flow?			
21	Voltage At Boundary Buses:		KV	KV
22	Realy or SPS concerns @ sync locations?			
SYNCHRONIZATION				
23	What time will synchronization occur?			
	23a	Contact name:		
	23b	Phone #:		
24	What is the maximum amount of load pick-up without notification?		MW	MW
25	Conditions that would cause the opening of the tie-line:			
ADDITIONAL COMMENTS:				

Exhibit 16: Interconnection Checklist

PJM ASSUMES CONTROL

Date:	**Time:**
Reporting Company:	
Regulation MW	Synchronous Reserve MW
Frequency Controlled by:	Frequency Maintained From to HZ

DYNAMIC RESERVES:

Underfrequency Relays:

Percent at 59.5 HZ_____% Percent at 59.3 HZ_____% Percent at 59.1 HZ_____%
Percent at 59.0 HZ_____% Percent at 58.9 HZ_____% Percent at 58.7 HZ_____%
Percent at 58.5 HZ

Governor Response:

Steam MW CT's MW Hydro MW

Load Pick - up Factors: Steam Units **5%** CT's **25%** Hydro Units **15%**

Total Load with Underfrequency Relaying _____MW
Total Governor Response: _____MW
Total Dynamic Reserves: MW

INTERCHANGE SCHEDULES (Company To Company, Company To Outside)

From Co.	To Co.	MW	From Co.	To Co.	MW

Connected Load	
765 kV MW of Connected Load	MW
500 kV MW of Connected Load	MW
345 kV MW of Connected Load	MW
230 kV MW of Connected Load	MW

Comments:
_____
_____
_____
_____
_____
_____

Exhibit 17: PJM Assumes Control

Attachment C: Conference Call Protocol

- Conference calls should be as brief as possible with only issues requiring immediate attention being discussed.
- Each committee should designate an official leader for all conference calls, typically the chairman of the committee.
- Conference calls should be conducted from a quiet location. Side conversations should be prohibited to prevent distractions during calls. Conference call participants should utilize phone muting capabilities, avoid the use of cell phones whenever possible, and avoid placing the conference call on hold.
- When conference calls are conducted as joint calls between committees, there should be a clear understanding of who the spokesperson is for each company.
- The leader should communicate an Agenda to the members prior to the call if time permits. Otherwise, at the start of the meeting, the leader should announce the Agenda and ask for additional Agenda items. It should be made clear that once the Agenda is finalized, only items on the Agenda will be discussed.
- Status information, spreadsheets, or other text to be discussed during the conference call should be e-mailed to participants prior to the call with sufficient lead time to allow for delivery and review.
- Issues not relating to the group as a whole should be handled by a separate communication between the involved parties.
- Committee members should make every attempt to enter the conference call by or prior to the specified time of the call. The start of the call should not be delayed waiting for participants to join.
- At the start of the call, the leader will initiate a roll call. At this time, it is the responsibility of the individual committee members to announce and introduce any guests on the call.
- Guests should channel all comments through the committee members unless asked to address a certain issue.
- All speakers should identify themselves when speaking.
- It's the leader's responsibility to encourage participation by all, while also keeping the meeting on track.
- Silence does not indicate agreement. When voting on issues, the leader should poll each committee member. It should be predetermined how much agreement is needed on an issue for its approval.
- The meeting should be summarized by the leader highlighting all decisions, action items and priorities. The next conference, if needed, should be set up at this time.
- In crisis situations, action items resulting from the conference call should be sent to all committee members as soon as possible following the end of the call. In routine situations, minutes should be sent out by the end of the following day.
- ~~Use muting capability when not speaking. Do not place call on hold. Avoid cell phones, if possible.~~

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[7]. 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-006-2 R10.

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 or two day events.

PJM will work with the System Restoration Coordinators ~~Task Force~~Subcommittee 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 or PJM System Operators travel to the TO DTS. The PJM System Operators work side by side with the member ~~dispatchers~~ operators 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.

In accordance with NERC standard EOP-006-2 R10 and R10.1:

- PJM expects participation in the Fall and Spring drills by all Transmission Owners with a load serving obligation.
- PJM invites Generation Owners that are integral to the restoration plan to participate in the Fall Restoration drills. This includes the Black Start unit owners, nuclear generation owners and owners of units that receive cranking power from the Black Start units. Other Generation Owners may be invited as requested. Generation Owners participate from their respective control rooms though in some cases may be onsite at PJM or the member TO training rooms. The Generation Owner will communicate with the TO and PJM operators during the drill regarding issues of cranking power, unit startup and unit loading.
- PJM encourages Generation Owner participation in the Spring RTO-wide drill, but does not require it.

[7] NERC EOP-005-2 R6.

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[8]. 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.

[8] NERC EOP-005-2 R10.

Drill Objectives

A set of objectives for each restoration drill is set for that specific drill. These objectives are proposed by the System Restoration Coordinator Subcommittee (SRCS), and approved by the SOS. The following are the typical drill objectives:

- Foster a greater understanding between the company and PJM System Operators as to the responsibilities and functions of each group during a restoration.
- Utilize both the top-down and bottom-up approach during the drill, understanding that initial actions will have to be bottom-up for companies that are blacked-out and isolated (all of PJM).
- PJM will take a proactive approach in identifying opportunities to assist TO in the restoration process. PJM will coordinate restoration opportunities at the Shift Supervisor level.
- Direct the restoration of all available 765 kV and 500 kV transmission facilities.
- Target restoration of at least one offsite source for safe shutdown to all nuclear units within 4 hours.
- PJM to facilitate all interactions and schedules with outside pools.
- Coordinate the restoration process with fuel-limited or unavailable generation and possibly damaged transmission equipment.
- To facilitate training and familiarization of transmission owner restoration plans for PJM System Operators.

Example Drill Scenarios

Each drill has a specific scenario developed by the SRCS, and approved by the SOS. *The following is an example of a spring scenario:*

PJM will have experienced a complete system shutdown. The disturbance will have occurred as follows:

0658 hours—A major ice storm moved into the PJM territory during the early morning hours, and steadily intensified. West to East transfers were high. Several transmission lines were lost simultaneously, resulting in the separation of PJM from the Eastern Interconnection. It was not initially known which transmission facility was the initiating event. The cascading outages caused stability problems at several generating stations. Several major units were lost over the next two minutes.

0700 hours—Due to low frequency, the PJM island collapses. The status of PJM's neighbors is unclear.

Generation / Transmission / Details

The drill will utilize the generation and transmission outages that exist on the day of the drill. Any facilities unavailable on that date will also be unavailable for the drill.

Interchange Details

Initially, no outside assistance will be available. This will require all companies to begin the drill utilizing a bottom-up approach only. Should outside assistance become available

as the drill progresses, those opportunities will be presented to the affected companies on a case by case basis.

In a fall scenario, the drilling transmission zone would have separated from the RTO. The disturbance will extend into neighboring zones to varying degrees, based upon specific drill objectives.

Drill Summary / Synopsis

The PJM Drill Coordinator or designee will document drill results for the System-wide drill and provide a debrief at the following committees:

- System Restoration Coordinators Subcommittee
- Dispatcher Training Subcommittee
- System Operations Subcommittee
- Nuclear Generation Owner/Operator Users Group

Attachment E: Communications, Protocols and Testing

PJM will periodically test its telecommunication facilities needed to implement the restoration plan. This testing will include the following:

- Participation in weekly updates of PJM satellite communications equipment as required in Manual 01 and outlined in the PJM satellite phone test procedures.
- PJM EMS Communications failover tests as outlined in the PJM operating memos.
- PJM Transmission Owners, Transmission Operators (AEP and ITCI), and Black start Generation Operators shall periodically test their telecommunications facilities which are critical to implementing the black start plan. The following types of communications should be considered in annual testing or during the annual restoration drills:
    - systems to communicate with PJM and black start units
    - telecommunications systems such as radio, fax, and microwave systems to communicate with crews

Attachment F: Transmission Owner and Black ~~start~~ Start Supporting Documentation References

Training record documentation required for operating personnel as required by EOP-005-2 R10 and EOP-006-2 R9 is located in both the PJM Learning Management System records as well as the training records of the individual transmission owners.

PJM maintains a database (Black Start Database) of black start units which includes the details for Black start units as required by EOP-005-2 R1.4.

Figure 1 includes specific references provided by the transmission owner documentation to supplement the details required for the PJM restoration plan as required by EOP-005-2 R1. This table will be updated concurrent with M-36 updates. However, the most up to date version can be found on the PJM Dispatch Sharepoint site and website.

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NERC Standard EOP-005-2

Mapping of PJM Member TO Restoration Documents to Applicable Elements

	Requirements in Attachment	American Electric Power	Atlantic City Electric	ATSI	Baltimore Gas and Electric	Commonwealth Edison	Cleveland Public Power	Dayton Power and Light	Delmarva Power and Light Company	Dominion	DUKE OH/KY	EKPC	Duquense Power and Light	First Energy - Fairmont	First Energy - East	Pennsylvania Power and Light Company	PECO Energy Company	Potomac Electric Power Company	Public Service Electric and Gas	Rockland Electric Company	UGI
1	When was the Restoration Plan last updated:	3/1/2015	1/30/2015	8/1/2014	6/1/2014	12/1/2014	2/17/2015	2/1/2015	3/1/2015	7/1/2014	3/1/2015	2/1/2015	6/1/2014	8/1/2014	2/1/2015	2/1/2015	12/1/2014	11/17/2014	3/19/2015	7/1/2014	7/10/2014
2	Reason for this update:	BES modification	Planned BES modification	Other	Unplanned permenant BES modification	Annual Review	Annual Review	Annual Review	Other	Annual Review	Annual Review	Other	Annual Review	Planned BES modification	Planned BES modification	Other	Annual Review	Other	Planned BES Modification	Annual Review	Annual Review
3	Were there any significant changes to the plan's identified responsibilities and relationships, since the last update:	No	No	No	No	No	No	No	No	No	No	Yes	No	No	No	Yes	No	Yes	No	No	No
4	R1.1 Strategies for system restoration that are coordinated with the Reliability Coordinator's high level strategy for restoring the Interconnection.	p. 5	p. 42-44	p. 3-8	p. 15-16	p. 4,5	p. 21, para 1: p. 22-24, items 7,15,16,19	p. 5, 27-29	p. 1-4	p. 7-8	p. 3-10	p. 9, 16	Sect. 2.B, p. 8	p. 2-3	p. 2, 25	p. 7	Sect. 4, p. 71	P. 11	Sect 2, p. 2 Sect 16, p. 24	p. 5	p. 1
	R1.2 A description of how all Agreements or mutually agreed upon procedures or protocols for off-site power requirements of nuclear power plants, including priority of restoration, will be fulfilled during System restoration.	p. 3, 5	p. 44, 49-51	p. 5, 6, 9, 16	p. 22	p. 6,7	N/A	N/A (No nuclear units)	p. 2.7, 31-32	p. 30	N/A (No nuclear power plants)	p. 12	Sect. 4.A, p. 10-11 Sect. 6.C, p. 27	p. 7-8	p. 2	p. 14, 16, 21,65	Sect. 4, p. 74	P. 18	Sect. 6, p. 7	p. 5	p. 1
	R1.3 Procedures for restoring interconnections with other Transmission(Owners)/Operators under the direction of Reliability Coordinator.	M-36 Sect. 3.1.6 & 7.2	p. 49-51, 159-166	p. 8-9	p. 26-105	p. 7	p. 23, Item 15	p. 40-43	p. 8-9, 72-74	p. 143	p. 11-16	M-36 Sect. 3.1.6	Sect 4.H, p. 22-25	p. 7-20	p. 7-8	p. 22-24	Sect. 4, p. 82	p. 22	Sect. 14, p. 20	p. 5	p. 1
	R1.4 Identification of each Blackstart Resource and its characteristics including but not limited to the following: the name, location, MW and MVAR capactiy and type of unit.	p. 12	p. 47-156	p. 8-64	p. 49-49, 50-89, 99, 107, 122	p. 8	p. 21, Sect. A	p. 20-24	p. 52	p. 20-21	p. 28-41	p. 17-19	Sect. 6A, p. 26	p. 7-25	p. 7-25	p. 15	Sect. 3, p. 20	p. 29	Sect. 18, pg. 27	N/A	N/A
	R1.5 Indentification of Cranking Paths and initial switching requirements between each Blackstart Resource and the unit(s) to be started.	p. 14	p. 46, 168	p. 8-64	p. 46-90	p. 5	p. 21, Sect. A	p. 24-26	p. 10-11, 27-49, 75-83	p. 30-137	p. 11-27	p. 17-19	Sect. 7, p. 28 Att. 1.2,3A,3B,4A, & 4B	p. 9-12, att. D	p. 7	p. 19	Sect. 3, p. 35 App. 10, p. 153	p. 30-69	Sect. 19, p. 27	N/A	N/A
	R1.6 Indentification of acceptable operating voltage and frequency limits during restoration.	p. 16-17	p. 206-207	p. 4	p. 130-133	p. 16	p. 22-23, Items 6,17	p. 38-40	p. 5	p. 16	p. 39	p. 32-33	Sect. 4.G.3, p. 20 Sect. 4.G.4, p. 20 Sect. 4.A.4, p. 11	p. 3	p. 3	p. 21-25	Sect. 1, p. 12	p. 70	Sect. 4, p. 4	p. 7,8	p. 12
	R1.7 Operating Processes to reestablish connections within the Transmission(Owner) Operator's System for areas that have been restored and are prepared for reconnection.	M-36 Sect. 7.2	p. 159-166	p. 5-6	p. 100-104	p. 34-36	M-36 Sect. 7.2	p. 38-43	p. 1-3, 8-9, 72-74	p. 143	p. 37-46	p. 33	Sect. 4.H, p. 22 Att. 11	p. 7-20	p. 7-8	p. 23-24	Sect. 4, p. 82	p. 72	Sect. 14, p. 20	p. 20-33	p. 13-18
	R1.8 Operating Processes to restore Loads required to restore the System, such as station service for substations, units to be restarted or stabilized, the Load needed to stabilize generation and frequency, and provide voltage control.	M-36 Sect. 3.1.5, 7.1	M-36 Sect. 3.1.5, 7.1	p. 8-64	p. 32, 46-47, 50-89, 96-100, 113-115, 126-142, 152-153	p. 6-7	M-36 Sect. 3.1.5, 7.1	p. 38-41, 44-45	M-36 Sect. 3.1.5, 7.1	p. 143	p. 37-46	p. 32-36	Sect. 4.G.6, p. 21-22 Att. 9	p. 7-20	p. 25	M-36 Sect. 3.1.5, 7.1	Sect. 4, p. 71	p. 75-78	Sect. 1, p.2 Sect. 4, p. 4 Sect. 5, p. 5	Att. 3, 12	p. 10
	R1.9 Operating Processes for transferring authority back to the Balancing Authority in accordance with the Reliability Coordinator's criteria.	M-36 Sect. 3.1.7	p. 159-160	p. 3-6	p. 101, 103	p. 34-35	M-36 Sect. 3.1.7	p. 41-43	p. 8, 9	p. 146-150	p. 42-46	p. 35-38	Sect. 4.I, p. 25-26 Sect. 5, p. 26	p. 7-20	p. 25	M-36 Sect. 3.1.7	App. 6 p. 140-141	p. 89	Sect. 2, p. 3	M-36 Sect. 3.1.7	M-36 Sect. 3.1.7
5	R2 Have all entities identified in the restoration plan been provided with a description of any changes to their roles and specific tasks prior to the implementation date of the plan:	Yes	No	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes
6	R5 Are copies of this plan available within your primary and backup control rooms prior to the effective date of this plan:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

NERC Standard EOP-005-2

Mapping of PJM Member TO Restoration Documents to Applicable Elements

	Requirements in Attachment	American Electric Power	Atlantic City Electric	Baltimore Gas and Electric	Commonwealth Edison	Cleveland Cliffs Power	Dayton Power and Light	Delmarva Power and Light Company	Dominion	DUKE ENERGY	EKPC	Duquesne Power and Light	ATSI	First Energy - South	First Energy - East	Pennsylvania Power and Light Company	PECO Energy Company	Potomac Electric Power Company	Public Service Electric and Gas	Rockland Electric Company	UGI	ITC	MAECO
	When was the Restoration Plan last updated:	8/12/2015	12/11/2015	4/9/2015	11/30/2015	1/4/2016	4/1/2016	11/26/2015	6/1/2015	5/22/2015	11/1/2015	6/1/2015	5/31/2015	5/31/2015	5/31/2015	6/15/2015	12/1/2015	8/1/2015	8/26/2015	7/1/2015	7/1/2015	1/25/2016	7/1/2016
	Reason for this update:	Planned BES modification	Other	Unplanned permanent BES modification	Planned BES modification	Annual Review	Annual Review	Other	Planned BES modification	Annual Review	Annual Review	Other	Planned BES modification	Planned BES modification	Other	Other	Annual Review	Other	Annual Review	Annual Review	Annual Review	Other	Annual Review
	Were there any significant changes to the plan's identified responsibilities and relationships, since the last update:	Yes	No	No	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No
	R1.1 Strategies for system restoration that are coordinated with the Reliability Coordinator's high level strategy for restoring the Interconnection.	p. 14	p. 198-206	p. 15, 22, 27, 33, 36, 41-42, 44, 47-51, 54, 97, 104, 106, 109, 130-134, 151-155	PSR Rev_0_16_final p. 4,5	p. 2	Sect. 1.1 - p.4 Sect. 4 - p. 27-29	p. 5-7	p. 7-9,11-13	p. 4,47	p. 10-11	Section 2.B, High Level Strategy, Page 8	p. 1-2	p. 1.2	Sect.1 - p. 1.2	Section 5	Sect. 1 Pg 1-1 pdf page 6	P. 11-17	Sect 2, p. 2 Sect 16, p. 25	p. 5	p. 1	Chapter 1 pg 2; Chapter 2 pg 4; Chapter 4 pg 1; Appendix E1 pg 2; Appendix E12 Appendix E13	Section 1.6
	R1.2 A description of how all Agreements or mutually agreed upon procedures or protocols for off-site power requirements of nuclear power plants, including priority of restoration, will be fulfilled during System restoration.	p. 10	p. 44, 107	p. 34, 97, 125-128	PSR Rev_0_15_final p. 6,7	N/A	N/A (No nuclear units)	p. 6,11	p. 30-45	p. 42	p. 13	Section 4.A BVPS Considerations, Pages 11-12 and Section 6.B. Level One Cross Zonal Coordination, Page 29-30	p. 5	Step 2.6 p. 5	Step 2.6 - p. 5	Section 11	Sect. 4 Pg 4-4 pdf page 64	P. 18-23	Sect. 6, p. 7	p. 5	p. 1	Chapter 1 pg 2, 4; Chapter 2 pg 1; Chapter 6 pg 1; Appendix E8 pg 1	Attachment B
	R1.3 Procedures for restoring interconnections with other Transmission(Owners)/Operators under the direction of Reliability Coordinator.	p.14	p. 105-111, 163-169	p. 22, 29-30, 41-42, 44, 97, 101-102, 108, 109	PSR Rev_0_16_final p. 7	p. 2	Sect. 4.7 - p. 39-40	p. 12-13 & 65-67	p. 22-24	p. 47	M-36 Sect. 3.1.6 p. 37, 55	Section 4.H Synchronization of Areas, Pages 24-27	p. 1-2	p. 1.2	Sect.1 - p. 1.2	Sections 17	Sect. 4 Pg 4-12 pdf page 72	p. 24-30	Sect. 14, p. 21	p. 5	p. 1	Chapter 1 pg 2; Chapter 2 pg 2; Chapter 4 pg 1; Appendix E12 pg 1; Appendix E13	Attachment A
	R1.4 Identification of each Blackstart Resource and its characteristics including but not limited to the following: the name, location, MW and MVAR capacity and type of unit.	p. 20	p. 179-181	p. 52-54 55-94, 101-102, 100	PSR Rev_0_16_final p. 8	N/A	Sect. 3.1b - p.18-19	p. 63	p. 30	p. 5	p. 19	Section 6.A Brunot Island Black Start Unit Data, Page 29 and Section 6.B Level One Cross Zonal Coordination, Page 29-30	Att. A - Sect. 2 Att. B - Sect. 2 1st page of each Sect. 2	Attachment A - Section 2, Attachment B - Section 2, Attachment C - Section 2, 1st page of each section 2	Attachment A - Section 2, Attachment B - Section 2, Attachment C - Section 2, 1st page of each	Section 10	Appendix 12 Pg A12-4 pdf Pg 200	p. 31	Sect. 18, p. 28	N/A	N/A	Appendix E8 pg 2	N/A
	R1.5 Identification of Cranking Paths and initial switching requirements between each Blackstart Resource and the unit(s) to be started.	p. 40	p. 47, 51-60, 65-68, 72-82, 171-172	p. 55-94	PSR Rev_0_16_final p. 5	N/A	Sect. 3.3 - p. 24-26	p. 15, 31-61 & 69-72	p. 46-148	Sect. 1, p. 4 Sect. 3, p. 14 Sect. 4, p. 21 Sect 5, p. 32 App. 1, p. 55	p. 17-19	Section 7 Cranking Paths for Blackstart Unit, Page 31; Attachments 1, 1A, 1B, 1C Blackstart Procedure Checklist; Attachments 2A, 2B, Restoration Cranking Paths; Attachments 3A, 3B, BVPS Off-Site Power Paths (Springdale & Brunot Island); Attachments 4A, 4B BVPS Units 1 & 2 Station Service	Procedure Section 1 (step 1.11.1, page 3), and Attachments A and B (starting on page 1, and where applicable within Section 1 of each	Procedure Section 1 (step 1.11.1, page 3) and Attachments A, B and C (starting on page 1, and where applicable within section 1 of each attachment)	Procedure Section 1 (step 1.11.1, page 3) and Attachments A, B, and C ((starting on page 1 and continuing where applicable in each attachment)	Section 12	Appendix 10 pdf Pg 145	p. 32-77	Sect. 19, p. 29	N/A	N/A	Appendix E6 pg 1; Appendix E8 pages 2-3 contain the switching plan details outlining the control open strategy for ITC Interconnection.	N/A
	R1.6 Identification of acceptable operating voltage and frequency limits during restoration.	p. 24	p. 202-203	p. 133-134, 139-140	PSR Rev_0_16_final p. 16	p. 3	Sect. 4.6c - p. 37	p. 9	p. 16-17	p. 42	p. 33-34	Section 4.G.3 Implement Restoration Procedures, Frequency, Page 22; Section 4.G.4 Implement Restoration Procedures, Voltage Control, Page 22; and Section 4.A.4 BVPS Considerations, Voltage Limits, Page 12	p. 4	p.4	Sect.2 - p. 4	Section 21	Sect. 1 Pg 1-8 pdf Pg 13	p. 78-79	Sect. 4, p. 4	p. 7,8	p. 13	Chapter 1 pg 4-5; Chapter 2 pg 2; Appendix E15 pg 1, 2	Section 1.11.2
	R1.7 Operating Processes to reestablish connections within the Transmission(Owner) Operator's System for areas that have been restored and are prepared for reconnection.	M-36 Sect. 7.2	M-36 Sect. 7.2	p. 45, 91-92, 94, 167-170	PSR Rev_0_16_final p. 34-36	p. 3	Sect. 4.7 - p. 41	p. 5-7 & 65-67	p. 21-24	p. 47	p. 35	Section 4.H Synchronization of Areas, Pages 24-27; Attachment 13 Guidelines for Synchronizing Islanded Areas (contains list of substations with sync. scopes)	Procedure Section 2 beginning on page 2, and Section 1 of Attachments A and B beginning on page 2 in each attachment.	Procedure Section 1 beginning on page 2, and Section 1 of each Attachment (A,B and C) beginning on page 2 in each	Procedure Section 1 beginning on page 2, and Section 1 of Attachments A, B, and C beginning on page 2 in each	Section 17	Sect. 4-12 pdf Pg 72	p. 80-82	Sect. 14, p. 21	p. 23-30	p. 14-19	Chapter 1 pg 2; Appendix E1; Appendix E8 pg 2-3; Appendix E12 pg 1; Appendix E13	Attachment 1
	R1.8 Operating Processes to restore Loads required to restore the System, such as station service for substations, units to be restarted or stabilized, the Load needed to stabilize generation and frequency, and provide voltage control.	M-36 Sect. 3.1.5, 7.1	M-36 Sect. 3.1.5, 7.1	p. 32, 47-51, 55-65, 100-101, 115-131, 142-146	SRSP_R0_16_Final & PSR Rev_0_16_final p. 6-7	p. 4	Sect. 4.6 - p. 36 Sect. 4.8 - p.41-43	M-36 Sect. 3.1.5, 7.1.	p. 149-150	p. 42	p. 33	Section 4.G.6 DLC Minimum Critical Black Start Requirements, Pages 23-24; Attachment 11, Minimum Black Start and Critical Infrastructure Priority List	Procedure Sections 1 and 2 beginning on pages 2 and 4, and Section 1 of Attachments A and B beginning on page 2 in each.	Procedure Sections 1 and 2 beginning on pages 2 and 4, and Section 1 of each Attachment (A, B and C) beginning on page 2 in each.	Procedure Sections 1 and 2 beginning on pages 2 and 4, and Section 1 of Attachments A, B, and C beginning on page 2 in each.	Section 12	Sect. 4 Pg 4-14 pdf Pg 74	p. 83-96	Sect. 1, p.2 Sect. 4, p. 4 Sect. 5, p. 5	p. 9 and Appendix 3	p. 11	Appendix E8 pg 2.	Attachment 1
	R1.9 Operating Processes for transferring authority back to the Balancing Authority in accordance with the Reliability Coordinator's criteria.	M-36 Sect. 3.1.7	M-36 Sect. 3.1.7	p.104	PSR Rev_0_16_final p. 34-35	p. 4	Sect. 4.7 - p. 40	p. 13	p. 8	p. 47	N/A	Section 4.I PJM Assumes Balancing Authority Role, Pages 27-28; Section 5, Back to Normal Conditions, Page 29	p. 2	Sect.1 - p. 2	p. 2	Section 17 & 21	Appendix 6 pdf Pg 126	p. 97	Sect. 2, p. 3	M-36 Sect. 3.1.7	M-36 Sect. 3.1.7	Appendix E2 Pg1	M-36 Sect. 3.1.7
5	R2 Have all entities identified in the restoration plan been provided with a description of any changes to their roles and specific tasks prior to the implementation date of the plan:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
6	R5 Are copies of this plan available within your primary and backup control rooms prior to the effective date of this plan:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Figure 1 - TO restoration Document References – PJM DOCS # 470991v22

Neptune RTS Emergency Restoration

- Neptune RTS operates as a "single system". All in-service Neptune components from the Raritan River Substation to the Newbridge Road Substation work together and the loss of a major element within the system will force the plant to shutdown.
- Alternately, the Neptune RTS system cannot operate without the three phase interconnecting AC systems (Raritan River Sub and Newbridge Road) being in service.
  - In the case of LIPA, there is some minimum level of system integrity (combination of transmission and generation) that must be in service before restarting Neptune
- When Neptune RTS is out of service, either due to internal or external factors, Neptune RTS operations utilizes the standard return to service operating steps (found within the COI) to prepare Neptune for operation.
  - Neptune will notify PJM of the plants availability and await dispatch orders.

Linden VFT Emergency Restoration

- Linden VFT operates as a "single system". All in-service Linden components from the VFT ST Substation to the Linden Cogen work together and the loss of a major element within the system will force the plant to shutdown.
- Alternately, the Linden VFT system cannot operate without the three phase interconnecting AC systems (VFT ST Sub and Linden Cogen) being in service.
  - In the case of ConEd, there is some minimum level of system integrity (combination of transmission and generation) that must be in service before restarting Linden.
- When Linden VFT is out of service, either due to internal or external factors, Linden VFT operations utilizes the standard return to service operating steps (found within the COI) to prepare Linden for operation.
  - Linden will notify PJM of the plants availability and await dispatch orders.

Attachment G: Coordination of Restoration Plan with PJM Internal and External Neighboring Entities PJM Approval Process for TO Restoration Plans

G-1 Overview of Coordination Process

PJM, as well as its neighboring entities have a primary function/obligation to maintain the integrity of the Eastern Interconnection and to prevent any unplanned separation of this system. However, once a large scale event does occur, these respective entities must be prepared to react and adapt to the dynamic environment of restoration operations.

Fundamental to re-establishing system integrity between neighboring entities is effective communications/coordination that allows each party to better understand the nature of the problem as well as how one party's activities may impact another neighbors. These communications must be a continuous and evolving process tailored to the demands of the event. Regardless of the situation, PJM will coordinate with its neighboring entities the following minimum functions:

PRE-EVENT COORDINATION

1. Complete annual reviews and updates to restoration plans. Changes should be uploaded using eDART. PJM and its Member TO's will utilize its coordination checklist to highlight manual changes during the process of coordinating these updates.
2. PJM will ~~centralize updated data for items shared by PJM's TO's within Manual 36 and send a return report to the TO if requested and the~~approve submitted TO restoration plans through eDART and allow TOs access to other TO restoration plans if the TO has completed the CEII request form and Non-Disclosure Agreement in accordance with CEII procedure.

POST EVENT COORDINATION

1. Initial Assessment
   a. Extent and Condition of Isolated Area
   b. Damage to Equipment that might impact later coordination
2. Initial Strategy –
   a. Discuss possible points of synchronization and steps needed to be ready for same.
   b. Updates to the strategy as steps of the restoration plan are implemented
3. Coordination of Interchange Schedules with neighboring BA's
4. Ability to Provide and or receive assistance
5. Confirmation of Coordination Protocols (i.e., identification of Liaisons and their numbers)
6. Synchronization Methods/Locations/Assistance

To avoid confusion associated with PJM directly contacting a neighboring entity, PJM will predominately use the RCIS to communicate these details to its neighboring RC's with the expectation that unless direct coordination is required with a neighboring TOP, our neighboring RC's will disseminate this information.

In addition, PJM will incorporate the restoration plans of internal Transmission Operators (AEP and ITCI) and monitor and coordinate their plans with other PJM internal and external areas.

PURPOSE: PJM updates and coordinates its restoration plan with the Generation Owners (GO) and Distribution Providers within its footprint and as well with its neighboring Reliability Coordinators (RC), and Transmission Operators (TOP) as required by NERC EOP-006 R2.

This process ensures PJM's effective coordination of its Restoration Plan both internally and externally to its neighboring entities. This process has two key elements:

1. **Restoration Plan Coordination Checklist (Section G-2)** - This coordination checklist will facilitate an active discussion and PJM approval on the pertinent EOP-005-2 Requirement 1 elements with the respective parties.
2. **Annual Coordination Timeline (Section G-3)** – this timeline will generate the required updates and coordination at a minimum on an annual basis.

G-2 RESTORATION PLAN COORDINATION/APPROVAL CHECKLIST

PURPOSE: As per Requirement 2 of EOP-005-2 and Requirement 2 of EOP-006-2, this checklist is intended to ensure coordination with our neighboring RC / TOP and the appropriate internal PJM registered entities by providing detailed references to any changes and enhancements to our restoration plans. It also provides a mechanism for PJM in its role as RC to approve TO System Restoration Plans.

PROCESS: PJM and the PJM TO will distribute this checklist at least annually or when there are changes to the restoration plan based on unplanned permanent System modifications (within 90 calendar days) or prior to implementing a planned BES modification, that would change the implementation of its restoration plan. PJM will flag all "cut-in" eDART tickets for review by the TO to determine if the change requires update to the TO restoration plan. If the cut-in impacts the implementation of the restoration plan, the TO will upload a revised restoration plan and this checklist through eDART for PJM approval prior to the BES modification. If the cut-in does not impact the implementation of the restoration plan, the TO will select "No Update Required" in eDART. PJM will distribute via e-mail exploder to neighboring entity contacts; RFC Reliability Committee; PJM Operating Committee; and PJM System Operations Sub-Committee.

Registered Entity	
	(Name of Company and Functional Model Responsibility)
Point of Contact:	
	(Name, Position/Title and Department)
Phone Number:	
e-Mail:	
	(TO Plan Contact)
Effective Date of Restoration Plan	
Date submitted to PJM for approval (must be 30 days prior to Effective Date for the Annual Update)	
~~Date approved by PJM (must be prior to Effective Date):~~	PJM approval indicates that the plan has been reviewed and accepted and is compatible with the RC restoration plan and other TO Restoration Plans as per EOP-006, R5.1. Any required changes are communicated to plan owner. The PJM approval will be provided via the eDART tool.
	~~(Completed by PJM)~~
~~PJM Approval~~	
	~~(Name, Position/Title and Department) (Completed by PJM)~~
~~Phone Number:~~	
~~e-Mail:~~	
	~~PJM approval indicates that the plan has been reviewed and accepted and is compatible with the RC restoration plan and other TO Restoration Plans as per EOP-006, R5.1. Any required changes are communicated to plan owner~~

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	Coordination Item	Reference Page #
1.	When was the Restoration Plan last updated: (Date)	
2.	**Reason for this update:** ☐ Annual Review (Complete all questions) ☐ Planned BES modification (Complete items 1-3 and 5-6 only) Restoration Plan must be updated ***prior to*** equipment being energized if it impacts the implementation of the restoration plan ☐ Unplanned permanent BES modification (Complete items 1-3 and 5-6 only) Date of unplanned permanent BES modification _____ (Restoration Plan must be updated within 90 days of this date) ☐ Other	
	Comments:	
3.	**Relationships and Responsibilities:** Were there any significant changes to the plan's identified responsibilities and relationships, since the last update? ☐ No ☐ Yes	
	Comments:	
4.	**Restoration Plan Components:** Verify that the Restoration Plan includes the following components (per R1 of EOP-005-2) and list the page number where it can be found or an explanation as to why the component was not included. This item is only required for the Annual Review.	
	R1.1 Strategies for system restoration that are coordinated with the Reliability Coordinator's high level strategy for restoring the Interconnection	**Reference Page #**
	☐ Included ☐ Not Included	
	Reason for not including:	
	R1.2 A description of how all Agreements or mutually agreed upon procedures or protocols for off-site power requirements of nuclear power plants, including priority of restoration, will be fulfilled during System restoration.	**Reference Page #**
	☐ Included ☐ Not Included	
	Reason for not including:	
	R1.3 Procedures for restoring interconnections with other Transmission (Owners)/Operators under the direction of	**Reference Page #**

	the Reliability Coordinator. *Documented in M-36, Section 3.1.6 and 7.2 (Optional for TO plan)*	
	☐ Included ☐ Not Included	
	Reason for not including:	
	R1.4 Identification of each Blackstart Resource and its characteristics including but not limited to the following: the name of the Blackstart Resource, location, megawatt and m~~ega~~var capacity and type of unit.	**Reference Page #**
	☐ Included ☐ Not Included	
	Reason for not including:	
	R1.5 Identification of Cranking Paths and initial switching requirements between each Blackstart Resource and the unit(s) to be started.	**Reference Page #**
	☐ Included ☐ Not Included	
	Reason for not including:	
	R1.6 Identification of acceptable operating voltage and frequency limits during restoration.	**Reference Page #**
	☐ Included ☐ Not Included	
	Reason for not including:	
	R1.7 Operating Processes to reestablish connections within the Transmission (Owner) Operator's System for areas that have been restored and are prepared for reconnection. *Documented in M-36, Section 7.2 (Optional for TO plans)*	**Reference Page #**
	☐ Included ☐ Not Included	
	Reason for not including:	
	R1.8 Operating Processes to restore Loads required to restore the System, such as station service for	**Reference Page #**

	substations, units to be restarted or stabilized, the Load needed to stabilize generation and frequency, and provide voltage control. *Documented in M-36, Section 3.1.5 and 7.1 (Optional for TO plans)*	
	☐ Included ☐ Not Included	
	Reason for not including:	
	R1.9 Operating Processes for transferring authority back to the Balancing Authority in accordance with the Reliability Coordinator's criteria. *Documented in M-36, Section 3.1.7 (Optional for TO plans)*	**Reference Page #**
	☐ Included ☐ Not Included	
	Reason for not including:	
5	**R2 - Restoration Plan coordination:** Have all entities identified in the restoration plan been provided with a description of any changes to their roles and specific tasks prior to the implementation date of the plan?	**Reference Page #**
	☐ Yes ☐ No	
	Comments:	
6	**R5 – Restoration Plan availability:** Are copies of this plan available within your primary and backup control rooms prior to the effective date of this plan? ☐ Yes ☐ No	
	Comments:	

G-3 ANNUAL COORDINATION TIMELINE

Transmission Owners will submit their System Restoration plans to PJM for review and approval based on the criteria below:

- Annual Updates based on schedule in Table 1 below
- Planned BES modifications affecting restoration plan (System Restoration Plan must be updated and approved prior to implementation of planned modification)
- Unplanned permanent System modification affecting restoration plan (System Restoration Plan must be updated and approved within 90 calendar days of identification of unplanned modification)
- Modifications required based on Lessons Learned by Spring or Fall System Restoration Drills

Restoration Plans will be submitted through eDART based on the schedule in Table 1 or within 2 weeks of required deadlines to allow PJM adequate time to review and approve the plan.

Table 1 – Annual Restoration Plan Review Deadlines

Company	TO submits plan to PJM for approval (T-30 days)	PJM reviews plan, comments and approves (T-15 days)	TO publishes approved plan (T-15 days)	TO Restoration Plan effective date
PJM	Committee approval April/May	N/A	June 1	June 15
RECO	June 1	June 15	June 15-30	July 1
PS	December 1	December 15	December 15-31	January 1
PECO	December 1	December 15	December 15-31	January 1
AE	December 1	December 15	December 15-31	January 1
DPL	February 1	February 15	February 15-28	March 1
PPL	May 31	June 15	June 15-30	June 30
UGI	June 10	June 25	June 25 – July 10	July 10
FE - East	May 1	May 15	May 15-31	May 31
BGE	May 15	June 1	June 1-14	June 15
PEPCO	June 1	June 15	June 15-30	July 1
SMECO	June 1	June 15	June 15-30	July 1
DOM	June 1	June 15	June 15-30	July 1
FE-South	May 1	May 15	May 15-31	May 31
DLCO	May 1	May 15	May 15-31	June 1
DAY	March 1	March 15	March 15-31	April 1
AEP	July 1	July 15	July 15-31	August 1
COMED	December 1	December 15	December 15-31	January 1
Rochelle	December 1	December 15	December 15-31	January 1
FE-West	May 1	May 15	May 15-31	May 31
CPP	June 1	June 15	June 15-30	July 1
DEOK	October 1	October 15	October 15-30	November 1
EKPC	~~December~~ October 1	~~December~~ October 15	~~December~~ October 15-31	~~January~~ November 1
Rock Springs	June 1	June 15	June 15-30	July 1
ITCI	May 1	May 15	May 15-31	June 1

PJM will electronically provide updates of PJM Manuals 13 and 36 related to system restoration plans with requested acknowledgment of receipts by neighboring TOPs, and RCs within 30 calendar days of revision per EOP-006-2 R2. The receipts will be tracked and used to:

1. Follow-up with neighboring systems to coordinate receipt and understanding of document changes;
2. Serve as evidence of compliance that EOP plans and updates were appropriately provided to neighboring systems; and
3. Establish contacts for inclusion in training and drills.

Procedure:

1. Changes to PJM's emergency operations plans (including but not limited to Manuals 13 and 36) shall be sent electronically to all neighboring RCs and TOPs (and BAs as appropriate) with an electronic receipt request within 30 calendar days of revision per EOP-006-2 R2.
2. The transmittal will include PJM contact information for any questions by our neighbors and for any corresponding changes that may result to our neighbors' emergency operations or restoration plans.

   The receipts will also be used to track acknowledgement for follow-up of contact information for neighboring systems.

External RC Restoration Plan Review

In support of EOP-006-2 R4, PJM will review their neighboring Reliability Coordinator's restoration plans and identify any conflicts with the PJM restoration plan. PJM will work with the neighboring RC to resolve any conflicts within 30 calendar days.

G-4 DYNAMIC STUDY AND RESTORATION PLAN UPDATES

In addition to the annual update process described in Attachment G-3, other system events will require updates to System Restoration plans in accordance with EOP-005-2, R 4 and dynamics studies in accordance with EOP-005-2, R6.

Table 2 below summarizes these situations and provides guidance on which events require update to System Restoration plans and dynamic studies as well as expected timeframes for when these activities should take place.

Table 2 – PJM Black Start Study and Restoration Plan Update Guidelines

PJM Black Start Study and Restoration Plan Update Guidelines			
Event #	**Event Description**	**Dynamic Study Required**	**Restoration Plan Update Required**
1	*New Black Start Unit - Incremental RFP - 5 Year RTO wide RFP - Interim Cross zonal solution*	Yes - develop cranking paths and complete studies (prior to Black Start unit or cross zonal solution going into service)	Yes - prior to Black Start unit or cross zonal solution going into service
2	*Replacement Black Start Unit (Same Site)*	If needed due to different unit characteristics or connection bus (prior to BS unit going into service)	Yes - prior to replacement black start unit into service
3	*Black Start Unit Retirement or Termination*	Only if there is no other studied path to critical load (prior to retirement or termination)	Yes - prior to unit retirement or terminated
4	*New Critical Load Unit*	Yes - include in Restoration Plan Annual Update - develop cranking paths with TOs and complete studies	Yes - during Annual Update (1 month prior)
5	*Criticial Load Unit Retirement*	Only if critical load unit is used to feed other critical load a.k.a. "daisychaining" (prior to unit retirement)	Yes - prior to unit retirement
6	*Unplanned Permanent Change impacting Restoration Plan*	Only if it impact a cranking path (No later than 90 days after unplanned permanent change occurs)	Yes - updates need to be made within 90 days of unplanned permanent change

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7	*Planned BES Transmission Change*	Yes - annual Restoration Plan Update or as-needed	Yes - if implementation of a planned BES modification changes the implementation of a restoration plan. To be complete prior to in-service. (Cut-in process)
8	*Unplanned/Planned Temporary Change(i.e. maintenance outage)*	No	No

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Attachment H: Under Frequency Load Shed (UFLS) Tables

Comment [GDB3]: Being updated by Rob Dropkin

PJM Under Frequency Load Shedding (Hz)																	
TO	59.5 Hz	59.3 Hz	59.1 Hz	59.0 Hz	58.9 Hz	58.7 Hz	58.5 Hz	Total	2015 Peak Forecast	59.5 Hz	59.3 Hz	59.1 Hz	59.0 Hz	58.9 Hz	58.7 Hz	58.5 Hz	
AE *		325			290		290	905	2515		12.92%			11.53%		11.53%	35.99%
Vineland *		20			17		17	54	149		13.40%			11.39%		11.39%	36.17%
BGE *		734			752		715	2201	7127		10.30%			10.55%		10.03%	30.88%
DPL *		327			355		357	1039	3035		10.77%			11.70%		11.76%	34.23%
ODEC - DPL *		76			72		78	226	686		11.08%			10.49%		11.37%	32.94%
DEMEC *		29			30		25	84	243		11.94%			12.35%		10.29%	34.58%
Easton *		8			7		8	23	63		12.62%			11.04%		12.62%	36.28%
Dover *		15			17		25	57	149		10.24%			11.10%		16.68%	38.02%
FE East - JC *		698			699		673	2070	6269		11.13%			11.15%		10.74%	33.02%
FE East - ME *		327			326		340	993	2954		11.07%			11.04%		11.51%	33.62%
FE East - PN *		333			358		360	1051	2914		11.43%			12.29%		12.35%	36.07%
PECO *		882			892		890	2664	8645		10.20%			10.32%		10.29%	30.82%
PEPCO *		673			681		591	1945	5830		11.54%			11.68%		10.14%	33.36%
SMECO *		82			84		87	253	810		10.15%			10.36%		10.72%	31.23%
PPL *		827			836		831	2494	7162		11.55%			11.67%		11.60%	34.82%
UGI *		22			20		20	62	197		11.17%			10.15%		10.15%	31.47%
Public Service *		1038			1067		1085	3190	10306		10.07%			10.35%		10.53%	30.95%
RECO *		48			47		49	144	424		11.34%			11.13%		11.58%	34.06%
Neptune*		66			66		66	198	660		10.00%			10.00%		10.00%	30.00%
Hudson Transmission Partners*		66			66		66	198	660		10.00%			10.00%		10.00%	30.00%
Com Ed *		2418		2434		2453		7305	22914		10.55%		10.62%		10.71%		31.88%
Dominion *		1908		2071			1929	5908	17704		10.78%		11.70%			10.90%	33.37%
NOVEC *		107		107			111	325	952		11.24%		11.24%			11.66%	34.15%
ODEC - DVP *		129		115			126	370	1059		12.18%		10.86%			11.90%	34.95%
NCEMC - DVP *		32		32			33	96	285		11.23%		11.16%			11.44%	33.84%
FE South **	444	427	467		470	465		2273	8096	5.48%	5.27%	5.77%		5.81%	5.74%		28.08%
ODEC - AP **	48	61	63		37	60		269	638	7.52%	9.55%	9.87%		5.79%	9.40%		42.13%
AEP **	1344	1271	1187		1593	1582		6977	23511	5.72%	5.41%	5.05%		6.78%	6.73%		29.68%
Dayton **	185	191	188		179	178		921	3497	5.29%	5.46%	5.38%		5.12%	5.09%		26.34%
Duquesne **	157	159	179		187	159		841	2997	5.24%	5.31%	5.97%		6.24%	5.31%		28.06%
FE West **	629	658	623		644	711		3265	12,187	5.16%	5.40%	5.11%		5.28%	5.83%		26.79%
DUKE **	584	535	639		501	557	562	3378	5511	10.60%	9.71%	11.59%		9.09%	10.11%	10.20%	61.30%
CPP **	18	22	25		21	18		104	315	5.81%	6.86%	7.81%		6.79%	5.81%		33.08%
EKPC	115	75	78		98	135	93	594	1,983	5.80%	3.78%	3.93%		4.94%	6.81%	4.69%	29.95%

Please include MW based on the 2015 Summer Peak Load LAS Normal Forecast shown to the right. Items in grey do not apply to transmission zone.

* Must have at least 10% per UFLS setting
** Must have at least 5% per UFLS setting
EKPC is currently working to update its UFLS program to achieve 30% UFLS capability.

Attachment I: Compliance with EOP-005-2 and EOP-006-2

This attachment serves as a guide for mapping the requirements of EOP-005-2 and EOP-006-2 to the appropriate sections of this manual for compliance tracking purposes.

Standard	Requirement	Sub-Requirement	Manual M-36 Section	Comments
EOP-005-2	R1	R1.1	Section 8	Indicates what should be included in TO Restoration Plans to allow for consistency
EOP-005-2	R1	R1.2	Section 1.2, Attachment A	Information on nuclear power restoration can also be found in NPIR agreements
EOP-005-2	R1	R1.3	Sections 3.1.6 and 7.2	
EOP-005-2	R1	R1.4	N/A	Due to the sensitive nature of this information, PJM does not publish it in this Manual, but it can be found in the PJM Blackstart database
EOP-005-2	R1	R1.5	N/A	Cranking paths can be found in the individual TO Restoration Plans and the PJM Blackstart database
EOP-005-2	R1	R1.6	Section 3.1.7, 2.3, 7.1	Frequency limits in Section 2.3

				Voltage limits in Section 7.1
EOP-005-2	R1	R1.7	Section 7.2	
EOP-005-2	R1	R1.8	Section 3.1.5, Section 7.1, Attachment A	
EOP-005-2	R1	R1.9	Section 3.1.7	
EOP-005-2	R2		Attachment G	Coordination process in Attachment G
EOP-005-2	R3	R3.1	Attachment G	Coordination process in Attachment G
EOP-005-2	R4	R4.1	Attachment G	Coordination process in Attachment G
EOP-006-2	R1	R1.1	Section 1.2	
EOP-006-2	R1	R1.2	Section 3	
EOP-006-2	R1	R1.3	Section 8, Attachment G	
EOP-006-2	R1	R1.4	Attachment G	
EOP-006-2	R1	R1.5	Section 7.2, 3.1.6, Attachment B	Information to be Exchanged Prior to Interconnection
EOP-	R1	R1.6	Attachment	Reporting forms for

006-2			B	restoration information
EOP-006-2	R1	R1.7	Section 3.1.9	
EOP-006-2	R1	R1.8	Section 3.1.9	
EOP-006-2	R1	R1.9	Section 3.1.7, Section 3.1.8	
EOP-006-2	R2		Attachment G	
EOP-006-2	R4		Attachment G	
EOP-006-2	R5		Attachment G	

Revision History

- ***Revision 22 (06/15/2015):***
- ***Annual Review per EOP-005-2, R3 and EOP-006-2, R3***
- ***Formatting and clarifying changes to Sections 2.3, 3.1.5, 3.1.6, 6.1.4, 7.1.2 and 7.2***
- ***Sections 3.1.7 and 3.1.8 – Added more detail to when PJM Assumes Control and when PJM Returns to Normal Operation in response to feedback from Spring Restoration Drill***
- ***Section 7 – Annual Update of Exhibit 10 "PJM Table of Major Synchronization Devices"***
- ***Section 8.1.9 – Added guidance on completion of Interconnection Checklist***
- ***Section 8.1.11 – Deleted section on System Control Progress***
- ***Attachment B – Minor updates to Restoration Forms***
- ***Attachment F – Figure 1 "TO Restoration Document References" updated based on latest TO restoration plans***
- ***Attachment H – Under Frequency Load Shed (UFLS) Table updated based on updated load values***

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Revision 21 (12/05/2014):

- Removed Section A.1.3 Reliability Backstop Options from Attachment A

Revision 20 (06/16/2014):

- Annual Review per EOP-005-2, R3 and EOP-006-2, R3
- Changed Control Area to Balancing Authority throughout document
- Section 7.1.2 – Renaming of Minimum Source Requirements to Minimum Source Guidelines and clarification on their use
- Section 7 – Annual Update of Exhibit 10 "PJM Table of Major Synchronization Devices"
- Attachment A – Documented exceptions to the calculation of critical load as approved by System Restoration Strategy Task Force
- Attachment D – Added expectations of Generation Owners and Transmission Owners for participation in PJM sponsored Restoration Drills
- Attachment F – Figure 1 "TO Restoration Document References" updated based on latest TO restoration plans
- Attachment G – Table 1 updated to reflect adjustments to First Energy Restoration Plan annual update and addition of Rock Springs
- Attachment H – Under Frequency Load Shed (UFLS) Table updated based on updated load values

Revision 19 (06/20/2013):

- Annual Review
- Minor grammatical adjustments throughout manual
- Rewrite of Attachment G to conform with EOP-005-2
- Update to Exhibits 16 (Interconnection Checklist) to make consistent across Eastern Interconnection
- Updated Attachment H – Underfrequency load shed tables

Revision 18 (04/01/2013):

Incorporated changes related to system restoration strategy revisions developed by the System Restoration Strategy Senior Task Force. These include:

- Minor updates to section 6.2, cranking power
- Minor updates to section 8.1.1 Ascertaining System Status
- Created new section 9 on Cross Zonal Coordination
- Major edits to Attachment A to reflect changes in critical load definition, Black Start requirements and the reliability backstop process.
- Minor changes to Attachment D – Drill Guide

Revision 17 (12/20/2012):

- Updated to reflect EKPC integration:
- Section 7, Exhibit 10: Locations of Synchronization Devices
- Exhibits 11 and 13
- Figure 1 in Attachment F
- Table 1 in Attachment G
- Appendix 4 in Attachment G
- Attachment H: Under Frequency Load Shed Tables
- Removal of references to System Restoration target times in Section 3.1 and Attachment A

Revision 16 (08/14/2012):

- Annual Review of Manual
- Replaced Local Control Center with Transmission Owner
- Removed references to Load Serving Entities
- Updated Figure 1 in Attachment F
- Updated Attachment H: Under Frequency Load Shed Tables
- Removed references to OVEC as PJM is no longer the Reliability Coordinator for OVEC
- Added UGI to Exhibits 11 and 13
- Expanded on definitions of Cranking Paths in Section 6.2

- Minor grammatical and formatting changes throughout

Revision 15 (08/17/2011):

- Annual Review of entire Manual
- Minor formatting changes
- Update of Attachment F and added DEOK
- Updated Attachment B - Initial and Hourly Restoration Reports (added DEOK)
- Updated Attachment G – TO Coordination Checklist (Table 1) (added DEOK)
- Updated Table 1- PJM Table of Major Synchronization Devices(added DEOK)

Revision 14 (04/27/2011):

- Updated Attachment B – Initial and Hourly Restoration Reports
- Updated Attachment F – Figure 1 TO Restoration Document References
- Updated Attachment G – TO Coordination Checklist (Table 1)
- Updated Attachment H – UFLS Table
- Updated Table 1 – PJM Table of Major Synchronization Devices

Revision 13 (11/01/2010):

- Add Reliability Coordinator language to section 3.1.9
- Added Attachment H – UFLS Table
- Updated Attachment F
- Updated Table 1- PJM Table of Major Synchronization Devices

Revision 12 (01/01/2010):

- Section 6.1.4 - added - Black Start unit operators should not permit their fuel inventory for Critical Black start CTs to fall below 10 hours - if it falls below this level, unit operators shall notify PJM and place the unit in Max Emergency.
- Clarified language in Sections 3.1.5 and 7.2.1 that PJM must both approve and coordinate synchronization

Revision 11 (10/05/2009):

- Additional language on annual communications system testing
- Additional language on coordination with Internal TOPs
- Additional clarifying language on TO/TOP responsibilities

Revision 10 (June 30, 2009):

- This update is part of the annual review and update and includes updated references to transmission owner restoration documentation which has been updated for changes in the transmission system as well as changes found during the annual drills
- The manual has been updated with paragraph numbering for easier reference

- References to the table at Attachment F – transmission owner restoration documentation.

Revision 9 (June 30, 2008):

- Corrections made to the table at attachment F and to Table 1 – table of major synchronization devices

Revision 8 (June 20, 2008):

- Updates to overview section to describe relationship between PJM restoration plan and transmission owner / TO detailed documentation
- Updates to attachments to revise transmission owner documentation references
- Updates to attachments to reference black start database
- Added synchronization table

Revision 7 (1/11/2008):

- Updated language to align existing restoration procedures with NERC EOP language.
- Added language to reference confidential portions (non-posted) of PJM Restoration Plan
- Added EOP checklist as an attachment

Revision 6 (5/25/2007)

- Clarifying statements added with respect to PJM and Member Company Actions based on NERC EOP-005.

Revision 5 (05/16/2007)

- PJM will provide RFC on an annual basis a copy of the Blackstart Capability Plan and associated list of units designated as blackstart capable for Inclusion in the RFC Blackstart Database per NERC standard EOP-009-0 and RFC standard EOP-004-0, "System Restoration Plans."
- Control area to control area replaced with Balancing Authority
- Spinning replaced with synchronous
- Section 2 Disturbance Conditions
- Internal with Separation
- PJM procedures require that each Generation owner may take independent actions to protect its generating plant equipment and preserve as much load as possible during separations with the following guidelines for the different control zones
- List of zones

Revision 4 (02/27/2007)

- Section 8: System Restoration Plan Guidelines—Revised to clarify existing PJM system restoration procedures for better alignment with RFC standards.
- Attachment D: Restoration Drill Guide—Minor revision to clarify existing PJM restoration drill procedures for better alignment with RFC standards.

- Introduction trimmed to eliminate redundant information.
- List of PJM Manuals exhibit removed, with directions given to PJM Web site where all the manuals can be found. All other exhibits renumbered.
- Revision History permanently moved to the end of the manual.

Revision 3 (5/17/2006)

- Incorporated concept of "Minimum Critical Black Start Criteria" as Attachment A. Removed former Attachment A and Attachment B (located in PJM Emergency Procedures Manual (M-13) and relettered all subsequent attachments.

Revision 2 (11/01/05)

- Reorganized document by subject matter, creating new sections. Included Restoration Drill Document as attachment. Revised Restoration Forms. Deleted forms contained in Manual 13.

Revision 1 (5/01/05)

- Miscellaneous editorial corrections and removal of Appendix 7 and Attachment E, which are already contained in Manual M-13.

Revision 0 (10/01/04)

- Initial version of the manual, composed of Sections 6 and 8 of Manual M-13, Rev 18.