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Working to Perfect the Flow of Energy

PJM Manual 36:

System Restoration

Revision: ~~14~~15

Effective Date: ~~4/27/2011~~

Prepared by

System Operations Division

PJM Manual 36:

System Restoration

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Approval

Approval Date: 04/27/2011
Effective Date: 04/27/2011

Glen Boyle, Manager,

System Operator Training

Current Revision

Revision 14 15 (04/27/2011)

- Annual Review of entire Manual
- Minor formatting changes
- Update of Attachment F
  - 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

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Introduction

Welcome to the ***PJM Manual for System Restoration***. 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

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*** 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*** consists of 8 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*** are:

- PJM dispatchers — Personnel who work in conjunction with the transmission owners to respond to outages and blackouts to restore the transmission system to service.
- Local Control Center dispatchers — Personnel who respond to PJM dispatcher 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*** are:

- PJM Manual for ***Balancing Operations*** (M-12)
- PJM Manual for ***Emergency Operations*** (M-13)
- PJM Manual for ***Operating Agreement Accounting*** (M-28)
- PJM Manual for ***Definitions and Acronyms*** (M-35)
- PJM Manual 36-A (Confidential references to details – Attachment 1 – EOP-005)
- Restoration Plans of PJM neighboring Reliability Coordinators, Transmission Operators, and Balancing Authorities.

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***. 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 dispatchers 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-004-0, "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 control areas 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) includes 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.)
- 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 Member Actions:

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

- 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.
- 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."

Section 2: Disturbance Conditions

Welcome to the *Disturbance Conditions* section of the ***PJM Manual for System Restoration***. 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 Control Areas. Providing maximum assistance to the other Control Areas 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 Control Area 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 dispatcher 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 dispatcher adjusts generation in appropriate areas to alleviate overloaded internal lines.

PJM Members Actions:

- Transmission / Generation dispatchers implement emergency procedures requested by PJM dispatcher 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.

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.

High-frequency operation may be as damaging as low frequency operation. 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 Control Area 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 Control Area 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)

It is vitally important that automatic load shedding be allowed to function before generator underfrequency relaying causes tripping of generators. 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.

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, the following actions are implemented:

- PJM dispatcher 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.

- 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

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

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 Members Actions:

- The Transmission dispatchers / LSEs manually dump load in the quantity directed by the PJM dispatcher.
- 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.

Section 3: System Restoration

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

- How PJM and the Transmission Owners/Generation Owners/Load Serving Entities 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 PJM dispatcher 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, PJM dispatcher and the Transmission Owners/Generation Owners/Load Serving Entities 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.

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]

The PJM RTO has the capability of being completely restored from a shutdown state within 24 hours. However, the majority of the PJM RTO (80%) is capable of being restored within 16 hours. The Transmission Owners bulk power transmission systems are capable of being restored within 10 hours. Because of the current scheduling strategies, the amount of nuclear units operating, and direct purchases, these restoration times may be difficult to achieve, but are striven for in restoration plans and procedures. Faster restoration times may be possible dependent upon actual system separation boundaries and status of equipment.

To assist in assuring each transmission zone has sufficient critical black start generation to increase the probability of meeting these restoration targets, 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 definition of critical load.

Each Load Serving Entity is responsible for restoring its own customer load with internal generation or through coordinated efforts with other Transmission/Generation Owner and PJM. After a subsystem is stabilized, requests from neighboring entities for cranking power

[2] NUC-001 R9

are a higher priority than restoring additional customer load of the supplying Load Serving Entity/Transmission Owner. Any Load Serving Entity/Transmission Owner that is not operating in parallel with adjacent Load Serving Entities/Transmission Owners is free to restore or shed load in any manner or at any rate it may deem reasonable.

Local Control Centers that share common transmission or generation facilities (345 kV or below) must develop pre-arranged plans for the priority operation of these facilities during restoration. These plans include the maintenance of good communications during the period of the emergency. Any deviations from these pre-approved published plans must be coordinated with PJM.

PJM dispatcher immediately establishes communications with the Transmission Owners and adjacent control areas 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, radio communications, and/or PJM Satellite Phone System).

3.1.1 PJM 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 control areas.
- 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 control areas.
- 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.[4]

[3] NERC EOP-005 Attachment 1-8.
[4] (NERC EOP-005 Attachment 1- 3.)

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

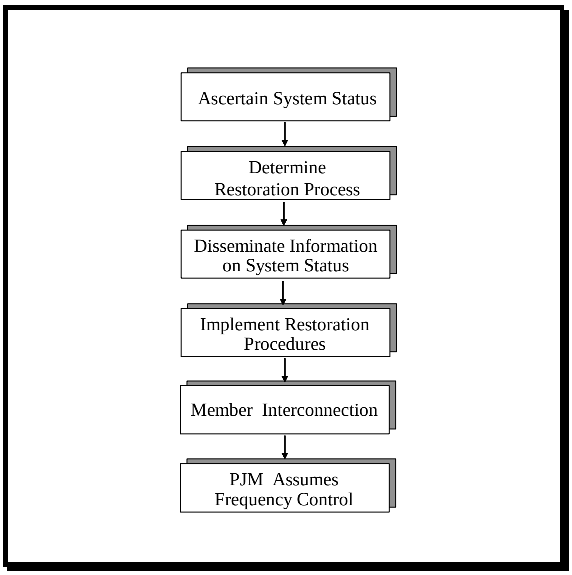

Exhibit 5: Restoration Process

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 dispatcher establishes communications between the Transmission Owners that are experiencing the disturbance and between adjacent Transmission Owners or TOP/ BA areas.
- PJM dispatcher 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 dispatcher collects specific information from each Transmission Owner/Generation Owner and adjacent areas to ascertain the present system conditions.
- PJM dispatcher 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 M36: PJM System Restoration Plan.
- Transmission Owner/Generation Owner dispatchers establish communications immediately with PJM and other Transmission Owners that are involved in the disturbance, adjacent Transmission Owners, and/or other control areas.
- Transmission Owner dispatchers verify the extent of their service interruption.
- Transmission Owners/Generation Owners collect information and notify PJM dispatcher of known system conditions, generation and transmission capabilities, equipment damage, and other pertinent information, including possible cause, if known.
- The Transmission Owner/Generation Owner dispatchers notify key personnel and power plant operators regarding the extent of the outage, as known.
- The Transmission Owner/Generation Owner dispatchers report initial system conditions to PJM, using the Company Initial Restoration Report presented in Attachment B. The Transmission / Generation dispatchers report hourly status updates using the Local Control Center Hourly Report 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.
- As part of the PJM RTO, both the Transmission and Generation Owner 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.

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

PJM Member Actions:

- The Transmission Owner dispatchers identify restoration strategy based on system status.
- The Transmission Owner dispatchers organize steps and/or sequential order of the System Restoration Plan (SRP).
- The Transmission Owner dispatchers assign sections/steps of the SRP to individuals and begin implementation.
- The Transmission Owner dispatcher communicates 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 dispatcher 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 dispatcher notifies Public Relations and other appropriate authorities i.e., FEMA, DOE, NERC, appropriate RROs, Public Utilities Commissions (or equivalent).
- PJM supervising dispatcher 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 dispatcher will coordinate the restoration strategy and system control.

PJM Member Actions:

- The Transmission Owners/Generation Owners dispatchers use established personnel call-out procedures to obtain the necessary staff.
- Transmission Owners/Generation Owners personnel notify appropriate personnel including public relations, and authorities, i.e., DOE, NERC, Public Utilities Commissions (or equivalent).
- Transmission Owner / Generation Owner 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. These reports are completed hourly, on the half-hour.
- The Transmission Owners/Generation Owners dispatchers convey to PJM dispatcher 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 Operators 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 dispatcher acts as coordinator and disseminator of information relating to generation and transmission availability.
- PJM dispatcher 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 Operator shall use professional judgment to modify the System restoration plan.
- PJM dispatcher develops updated run-of-river hydro capability. PJM dispatcher 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, or external power sources. Requests for cranking power have a higher priority than load restoration for the supplying Transmission Owners/Generation Owners.
- Offsite 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.
- 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 Owners/Generation Owners dispatchers maintain communications with PJM dispatcher 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,*** 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.
- Transmission Owners/Generation Owners work to provide offsite power to Nuclear Facilities.
- Transmission Owners and Nuclear Power Plants must effectively communicate to keep Nuclear Power Plant apprised of the anticipated restoration time for offsite power.

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 above 60.00 Hz before load is picked up. The LSEs 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 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 Local Control Center

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). 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 Owners calculate 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 Member Interconnection

The purpose of this step is to provide guidelines for the Transmission Owners to interconnect 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 dispatcher acts as coordinator and disseminator of information relative to generation and transmission availability.
- PJM dispatcher 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 dispatcher provides the Transmission Owners/Generation Owners with updated run-of-river hydro capability.

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 consult and follow the pre-interconnection checklist presented in Attachment B. The Transmission Owner dispatchers adjust the frequency of the smaller area (subsystem) to match the frequency of the larger area. In addition, the Transmission Owner dispatchers control the voltages of the areas so that they are as close as possible prior to synchronization.
- The Transmission Owner dispatchers 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 assists in coordinating and maintaining scheduled tie-line flows between the other Transmission Owners.
- The objective of Transmission Owners maintaining flat tie line control 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 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 above 60.00 Hz before load is picked up. Transmission Owner/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 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/Generation Owner dispatchers recalculate and reassign regulation and reserve assignments.
- After synchronization occurs, the Transmission Owner dispatchers continue to strengthen and stabilize the interconnected area by the closure of additional Transmission Owner-to-Transmission Owner tie lines.
- The Transmission Owner/Generation Owner dispatchers continue to maintain communications with PJM dispatcher to provide updated status of system conditions, in addition to the hourly report.

3.1.7 PJM Assumes Frequency Control

This occurs when the control of an interconnected area is too burdensome for any one Local Control Center.

PJM Actions:

- PJM dispatcher assimilates information contained in Attachment B.
- PJM dispatcher 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 dispatcher determines the regulation requirement to regulate frequency. Capacity assigned should be two percent (2%) of the interconnected area load. PJM dispatcher assigns regulation on a proportional basis of connected load.
- PJM dispatcher continues to coordinate run-of-river hydro operations.
- PJM dispatcher updates the DMT to reflect unit capability that is reported by the Transmission Owner/Generation Owner dispatchers.

PJM Member Actions:

- The Transmission / Generation Owner 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/Generation Owner dispatchers report their status to PJM dispatcher.
- The Transmission Owner dispatchers maintain scheduled Transmission Owner-to-Transmission Owner tie line flows until the PJM RTO returns to free-flowing tie conditions.
- The Transmission Owner dispatchers 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 / Generation Owner dispatchers respond to emergency procedures when initiated by PJM dispatcher.
- The Transmission Owner dispatchers request PJM dispatcher's approval prior to the closure of any reportable transmission line (see the PJM Manual for Transmission Operations) or a line that establishes an interconnection, either Transmission Owner-to-Transmission Owner or to an external system.
- The Transmission / Generation Owner dispatchers maintain communications with PJM dispatcher 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 dispatcher notifies Transmission Owners/Generation Owners 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 dispatcher 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 dispatcher directs generation and load adjustments, as required, to maintain reliable operations. LSE native generation normally is assigned to native load, except in instances where Transmission Owner-to-Transmission Owner tie line schedules are arranged. PJM dispatcher notifies all Transmission Owners on the interconnected area of schedules that are in effect, or pending.

Transmission Owners are responsible for communicating to PJM dispatcher any potential transmission problems i.e. contingency or actual overloads, voltage problems, etc. PJM dispatcher 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 the 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 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 dispatchers enter their regulating capability into the program, and units may automatically respond to the signal. The Transmission Owner/Generation Owner dispatchers may elect to manually dispatch these units. Regulation is two percent (2%) of the interconnected area load.

PJM dispatcher continues to direct generation and load assignments as required to maintain reliable operation. PJM dispatcher 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 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, 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.

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 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).

The 500 kV / 765 kV kV system is not to be restored unless energy is available from remote sources to be delivered to energy deficient areas, i.e., the Keystone/Conemaugh mine-mouth complex adjacent systems, or excess internal generation.

Allocation of Joint Owned Generation

PJM dispatcher 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 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 dispatcher 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.

3.1.9 PJM Reliability Coordinator Responsibilities during the Restoration Process

- PJM maintains the current coordinated version of the restoration plan of each Transmission Operator in its Reliability Coordinator Area. There are three TOPs in PJM's Reliability Coordinator Area: PJM, AEP, and OVEC. PJM serves as both RC and TOP for the PJM area, with the exception of the Ohio Valley Electric Corporation (OVEC), for which PJM serves only as RC. American Electric Power (AEP) operates the 138kV transmission, though PJM serves as TOP for its other transmission assets.
- 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 control areas
  - 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 control areas
  - 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 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 dispatcher establishes communications between the Transmission Owners that are experiencing the disturbance and between adjacent Transmission Owners or TOP/ BA areas
  - PJM dispatcher 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 dispatcher collects specific information from each Transmission Owner/Generation Owner and adjacent areas to ascertain the present system conditions
  - PJM dispatcher 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 Manual 36. As stated in section 1.1 of Manual 36, "Policy Statements," This manual (M36, the PJM Restoration Plan) includes 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. As stated in Section 3.1.3 (Determine Restoration Process):
  - "PJM dispatcher acts as coordinator and disseminator of information relating to generation and transmission availability. PJM dispatcher 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 control areas:
  - "Contact Neighboring Control Areas — Knowledge of the neighboring Control Areas' 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 Control Areas 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 Local Control Center," provides the procedure for synchronizing subsystems within the area of a local control center 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, "Member Interconnection," describes the guidelines for synchronizing and interconnecting the systems of two or more members within PJM's system. The section assigns the following actions to PJM's operators:
    - PJM dispatcher acts as coordinator and disseminator of information relative to generation and transmission availability.
    - PJM dispatcher 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 dispatcher 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.*** 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 via computer, 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 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 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 (voice and FAX), telex, 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 M01: Control Center and Data Exchange Requirements.

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.
- 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. The military method of the receiver repeating the message back to the sender is valuable insurance against errors, particularly under the stressful conditions of restoration.
- Logging is of critical importance to dispatchers 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.

4.1.2 Notifications and Contacts[5]

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 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 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 control areas.

[5] NERC EOP-005 Attachment 1-9.

- *Contact Neighboring Control Areas* — Knowledge of the neighboring Control Areas' 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 Control Areas 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 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/Load Serving Entities are bombarded with phone calls from employees and customers. From the Transmission Owners/Load Serving Entities 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 for the Transmission Owners/Load Serving Entities. 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
- *Employee Call-ins* — System restoration requires an enormous number of tasks for Transmission Owner/Generation Owner/Load Serving Entity personnel to complete. It is essential for Transmission Owner/Generation Owner/Load Serving Entity 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. Local Control Centers 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 Transmission Owner/Load Serving Entities systems. The system scanner 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.

Section 5: Reserves during Restoration

Welcome to the *Reserves during Restoration* section of the ***PJM Manual for System Restoration.*** 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 by the guidelines.

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, and 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 advisable not 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.

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.

Governor Response	**=**	**5% x 300 MW** **25% x 400 MW** **15% x 100 MW**	**=**	**15 MW** **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 underfrequency steps (i.e. 59.3 Hz, 58.9 Hz, and 58.5 Hz). Consideration may be given to adjusting the calculated Dynamic Reserve for the governor response which is provided by the largest energy contingency.

Section 6: Generation

Welcome to the *Generation* section of the ***PJM Manual for System Restoration.*** 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. Each generator's system 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.

6.1.1 Generating Stations

In the event of a system separation, and/or shut-down, enough equipment and manpower is available at generating stations to assure safe shutdown and to be capable of being restarted as soon as cranking power becomes available. Generating stations are provided with a minimum of two hour stand-alone capability.

The local generating station operator must 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 LCC 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. Black Start unit's operators shall 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.
- *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/Generation Owner 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 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.

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

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

6.2.1 Units Requiring Cranking Power

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

Before decisions can be made on returning generating units to service, certain facts about the specific units must be known beforehand. Having a tabulation of the individual unit characteristics, capabilities, and operating restrictions is beneficial when selecting the order and fit of the units for the restoration sequence. These facts need to be compared to the actual serviceability of these units soon after the disturbance has occurred, with special emphasis placed on defining any changes to ramp rates, re-start times, minimum or maximum load and VAR generation, regulation capability, fuel availability, or damage that occurred which might constrain unit operation.

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

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 is required from another Transmission Owner/Generation Owner or Control Area, arrangements include a determination of whether or not the unit receiving start-up assistance becomes synchronized to the supplying company or system. Implications could include isolation of the receiving unit from its own system or creation of an unintended interconnection between the two areas.

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.*** 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. TheTransmission 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 LCCs. 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 requirements 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
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 Requirements

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

- primary and backup relays in service
- 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:

- Lines
- 500 kV / 765 kV lines and transformers separately
- transformers ideally from low side
- lines from strongest source
- parallel with 500 kV / 765 kV circuit breaker
- Line and Transformers
- clear dead bus sections
- close source 230 kV circuit breaker
- reduce 500 kV / 765 kV voltage via tap changer
- minimize line charging
- Line Terminating to Transformer
- energize line alone
- prevents overvoltage due to stuck or slow closing circuit breaker poles
- Transformer Voltages
- sending end, 475 kV or lower and 230 kV or lower
- receiving end, approximately 500 kV / 765 kV and 230 kV
- receiving end tap equal to, or exceeding, receiving end voltage

- use emergency generator to change transformer tap if no AC station service is available

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

Detailed Analyses 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 should be utilized to confirm aforementioned "rules of thumb".

Description	Reason
***Minimum Generating Capacity* — 30 MW/ mile of500 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

- minimum of three MVAR of electrically close VAR absorption per mile of 500 kV / 765 kV to be connected
- control line voltage to less than 500 kV / 765 kV
- may be:
- generator reactive load (leading)
- shunt reactors
- reactive load
- static VAR compensators
- at least 3 MW of electrically close load per mile of 500 kV / 765 kV to be energized
- provides damping to control overvoltage when energizing transformers

- established on underlying system
- 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 Local Control Center, or between two or more Local Control Centers 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 pickup 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.

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.

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Locations of Synchronization Devices		
Region	**Page/ Reference**	**Document**
AEP	Appendix B p. 37-41	AEP Emergency Operating Plan
AP	p. 147-152	AP System Emergency Operations Manual 1-Manual 5
Atlantic Electric	p. 154-158 Appendix C p. 161-166	Atlantic City Electric System Restoration Guide
BG&E	p. 156 Attachment 23 p. 162-165	BG&E System Restoration Manual
ComEd	Black Start Maps Tab Appendix Sync Guide	ComEd Restoration Manual
Dayton	p. 40-41, 73	Dayton System Restoration Manual
Delmarva	p. 73-75	Delmarva Power Restoration Manual
Dominion	Section 3.1.8- p. 10 Section 3.1.12.2- p. 14	Dominion Restoration Manual
FE	p. 79-84 RCC-EOP-04 Circuit Sheet & Sync Attach (PN) - p.9-25 (ME) - p.33-46 (JC) - p.51-62 (ATSI) – p. 30, 42, 48, 72-73, 78, 90-92	First Energy Restoration Guidelines, Version 4 WCC-EOP-250 FE West ATSI PSR, version 0
Orange and Rockland Utilities	Appendix 1 p. 24	Orange and Rockland System Restoration Plan 01 6-E-16
PECO	Appendix 9 p. 1-3	PECO System Restoration Manual
PEPCO	Section 9 p. 1-3	PEPCO System Restoration Manual
PPL	Supplement C	PPL Restoration Manual
PSE&G	Section 15 p. 23-26	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 Control Area.
- 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 are used by Transmission Owners of the two systems to be tied.

Synchronization

Prior to synchronization, the transmission owner must communicate with PJM (PJM will coordinate with neighbors as required) and get approval for synchronization. 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.*** 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, OVEC, and PJM. It is recognized that individual system restoration plans are based on the concepts:

- Each Load Serving Entity/Transmission is responsible for restoring its own customer load to include identifying critical loads as appropriate[6] 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.
- Transmission Owners that share common transmission or generation facilities (345 kV or below) must have developed pre-arranged plans for the priority operation of these facilities during restoration. These plans include the maintenance of good communications during the period of the emergency.
- 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 must 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.

[6] (NERC EOP-005 Attachment 1- 5.)

- 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:
- 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 Unit Commitment database.
- All telephone and microwave 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 requirements for system restoration can be met by available personnel. Any additional manpower is assumed available through existing manpower procurement procedures.
- Transmission Owners do not establish bilateral transactions.

In general, an SRP 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/Load Serving Entity 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 provide information regarding the extent of the outage known at the time.
- Generation plant reports are used to determine unit availability. The dispatchers notify each power plant about the extent of the outage and system status known at the time.
- Equipment status is tabulated by dispatchers through communications with power plants.

- Cranking Power Availability — Sufficient resources for black start units are available to ensure safe shutdown and be capable of restart as soon as cranking power is available.
- Cranking power is available to restart necessary steam generating units at steam plants or through portions of the internal transmission system.
- Confirm status of plant starting procedures — Each steam plant implements start-up procedures immediately following plant shutdown. Steam plants do not wait to implement start-up procedures until contacted by Transmission Owner/Generation Owner dispatchers. A restoration time for station service of thirty (30) minutes or less is striven for.
- Estimated time of return (on-line time) — Plants provide estimates to Transmission Owner/Generation Owner dispatchers of unit return times.
- Where applicable at steam power plants, station services are restored as soon as possible taking into consideration battery limitations and loss of water/steam in boilers.
- Units that were able to maintain on-line status have priority for additional load to achieve stable operation.

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 / Generation Owner dispatchers 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 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/Load Serving Entity 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.
- *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/Load Serving Entity is assigned to contact Public Relations, and authorities, i.e. D.O.E., NERC, Public Utilities Commissions (or equivalent). Dispatchers 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 control areas.

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 of this manual.

8.1.5 Frequency Control

- See ~~"~~PJM Assumes Frequency Control" in section 3 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"* in section 3 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[7].

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 control areas 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 Exhibits 15 and 16.
- Certain informational items, contained in Exhibits 15 and 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.
- PJM will set up and coordinate any interchange schedules with external control areas.
- 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.

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

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 Local Control Centers.

8.1.11 System Control Progress

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

Attachment A: Minimum Critical Black Start Requirement

A.1 Critical Black Start Criteria

A.1.1 Goal

The PJM System Operations Subcommittee (Transmission) was requested to create a minimum critical black start criterion that can be applied across zones to support system restoration goals defined within the ***PJM Manual for System Restoration (M-36)***. This criterion is intended to be utilized as a measure to evaluate critical black start retirement and ensure adequate replacement. Since there are many factors that impact targeted restoration times contained with M-36, maintaining the minimum critical black start requirement by transmission zone does not necessarily guarantee restoration targets will be realized. Specific black start data[8] to include fuel resources for black start power for generating units, available cranking and transmission paths, and communication adequacy and protocol and power supplies are contained in this manual and in the PJM Black start database.

A.1.2 Minimum Critical Black Start Requirement

This attachment to the ***PJM Manual for System Restoration (M-36)*** defines the Minimum Critical Black Start Requirement on each transmission zone to be the sum of critical steam cranking power load, gas infrastructure critical load and nuclear off-site station light and power load requirements.

The SOS-T established the benchmark of ensuring critical steam is provided cranking power and gas infrastructure critical load is restored within 2 hours. Establishing cranking power within 2 hours allows all critical steam units, which have hot-start capability of 8 hours, to be on-line within 10 hours of the initial blackout. Ensuring that gas infrastructure critical load is restored within 2 hours will provide added insurance that gas fired units will remain on-line during the restoration process. Having critical steam units on-line within 10 hours will assist in ensuring that the first time based restoration goal of restoring the Transmission Owners bulk power transmission systems within 10 hours is achieved.

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

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

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

[8] NERC EOP-005 Attachment 1-2

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:

The ***PJM Manual for System Restoration (M-36)*** defines time-based restoration goals as follows: "The PJM RTO has the capability of being completely restored from a shutdown state within 24 hours. However, the majority of the PJM RTO (80%) is capable of being restored within 16 hours. The Transmission Owners bulk power transmission systems are capable of being restored within 10 hours." To assist in meeting the goals defined above, the PJM SOS Transmission applied the following assumptions:

- 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)

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

B. Definition of Critical Load

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

1) Priority 1 – Critical load provided by black start
   - Cranking power to Critical Steam
     - Critical steam is defined as steam units with a hot-start time of 8 hours or less.
   - Off-site Nuclear Station Light and Power
     - Off-site power should be restored as soon as possible to nuclear units, both units that had been operating and those that were already off-line prior to system disturbance, without regard to using these units for restoring customer load. Nuclear units that are taken off-line on a controlled shutdown can normally be restored to service between 24 and 48 hours following the controlled shutdown.
   - Critical Gas Infrastructure

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

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

2) Priority 2 – Critical Load provided by black start or other critical generation
   - Cranking power to combustion turbines
   - Power to electric infrastructure in accordance with timeframe defined in restoration manual.
   - Light and Power to restore critical substations (if applicable).
   - Pumping plants for underground cable systems.
   - Critical Communication Equipment.
   - Critical command and control facilities
   - Underfrequency load shed circuits
   - 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).***

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

Transmission Owners prioritize restoration of load as follows:

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

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

C. 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

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Formatted: Numbered + Level: 1 + Numbering Style: 1, 2, 3, … + Start at: 1 + Alignment: Left + Aligned at: 0.5" + Indent at: 0.75" black start or replacement black start generation would need to be procured if there is insufficient pre-existing black start capability (refer to the ***PJM Manual for Generator Operational Requirements (M-14D),*** Section 9: *Black Start Replacement Process*). In addition, the transmission owners have the ability to list specific exceptions within the Transmission Owners Restoration Manual; these exceptions are not explicitly defined as part of critical load.

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

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

- Critical black start generation should be electrically dispersed within the Transmission zone. The placement of critical black start units should:
  - Support the simultaneous restoration of multiple islands, consistent with concepts documented within the Transmission Owner's Restoration Plan.
  - Provide sufficient redundancy within an electrical area to protect against equipment failures, allowing the execution of the documented restoration plan.
  - Ensure multiple transmission outlets, protecting against equipment damage.
  - Ensure a minimum of 3 critical black start generators per Transmission Zone.

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

- The following factors should be considered in ranking the benefits of replacement Black Start Generation.
  - Located at Plant – It is more beneficial to co-locate Black Start generation at a station with multiple generators. The number of Black Start generators at a common plant should be limited to 3.
  - Electrically close to Critical Steam. Some consideration may be given to location based on fuel diversity of critical steam.
  - Electrically close to Combustion Turbines
  - Sized appropriately (MW and MVAR lead/lag) – Black Start Generation must be sized appropriately to provide sufficient MW to restore critical load and sufficient MVAR capability for voltage control
  - Transmission outlet(s) / sufficient load for voltage control – Units that are not co-located at a station should ensure multiple transmission outlets so that the Black Start generation is not bottled in the event of equipment damage. Additionally, Black Start generation size

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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:																				**PJM**
Company:	**RECO**	**PS**	**PE**	**AE**	**DPL**	**PL**	**JC**	**ME**	**PN**	**BC**	**PEP**	**DOM**	**AP**	**DLCO**	**DAY**	**AEP**	**COM**	**ATSI**	**CPP**	**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:																				**PJM**
Company:	**RECO**	**PS**	**PE**	**AE**	**DPL**	**PL**	**JC**	**ME**	**PN**	**BC**	**PEP**	**DOM**	**AP**	**DLCO**	**DAY**	**AEP**	**COM**	**ASTI**	**CPP**	**Total**
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

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

Date: / /
Time: HRs

Generation Data by transmission Zone

Company Report Time:																				PJM
Company:	RECO	PS	PE	AE	DPL	PL	JC	ME	PN	BC	PEP	DOM	AP	DLCO	DAY	AEP	COM	ATSI	CPP	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:																				PJM
Company:	RECO	PS	PE	AE	DPL	PL	JC	ME	PN	BC	PEP	DOM	AP	DLCO	DAY	AEP	COM	ATSI	CPP	Total
Customer Load Lost MW																				
% of Customer Load Lost																				
# of Customers Lost (000)																				
% of Customers Lost																				
Estimate for 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:

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*

COMPANY TRANSMISSION RESTORATION REPORT					
Date:			**Time:**		
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@pjm.com. All Transmission Owners will use facility listings for their transmission systems which include the following information:**					
EXAMPLE DATA					
ID	**Facility Identification**	**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**	**Date Restored**	**Time Restored**	**Energized since Last Report (?)**	**Expected in Next Hour (?)**

Exhibit 15: Company Transmission Restoration Report

Comment [I1]: Clean up the text section.

INFORMATION TO BE EXCHANGED BETWEEN TWO COMPANIES/AREAS PRIOR TO INTERCONNECTING PAGE 1 OF 2

Date	Time	Company:____________________ Contact:________________ Neighbor Co/Area: Contact:

	Company	Neighbor / Area
A. Are You Presently Interconnected	YES NO	YES NO
If Yes, Company/Area		
Existing Tie - Line Schedules In Effect		
From________ to ________	________MW	________MW
From________ to ________	________MW	________MW
From________ to ________	________MW	________MW
B. Do You Need Cranking Power?	YES NO	YES NO
If Yes, How Much	________MW	________MW
C. Can You Supply Energy?	YES NO	YES NO
If Yes, How Much	________MW	________MW
D. System Load Restoration (MW)	________MW	________MW
And % Of Load Restored	__________%	__________%
*E. Load Restored With Underfrequency Relaying Enabled	59.5 Hz_____MW	59.5 Hz_____MW
	59.3 Hz_____MW	59.3 Hz_____MW
	59.1 Hz_____MW	59.1 Hz_____MW
	59.0 Hz_____MW	59.0 Hz_____MW
	58.9 Hz_____MW	58.9 Hz_____MW
	58.7 Hz_____MW	58.7 Hz____ MW
	58.5 Hz_____MW	58.5 Hz_____MW
*F. Generation On Line: Capacity:	________MW	________MW
Generation On Line: Energy	________MW	________MW
*G. Generator Governor Reserve	________MW	________MW
+ Enabled Underfrequency Relay Reserve	________MW	________MW
= Total Dynamic Reserve	________MW	________MW
H. Synchronous Reserve (Not Including Load Shedding)	________MW	________MW
I. Largest Energy Contingency	________MW	________MW

Exhibit 16: Information Exchange Prior to Interconnecting - Page 1 of 2

INFORMATION TO BE EXCHANGED BETWEEN TWO COMPANIES/AREAS PRIOR TO INTERCONNECTING PAGE 2 OF 2		
*J. Frequency Range Over Last Hour (Min and Max)		
K. Tie To Be Established (Location)		
L. Tie Schedule to be established	________MW	________MW
M. Which Company Will Control Frequency & Coordinate?		
N. Which Company (ies) Will Control Tie - Line Flow		
O. Company That Will Coordinate Synchronization Of Tie Closure		
P. Voltage At Boundary Bus	_________kV	_________kV
Q. When Will The Tie Be Made? (Time) Name Main Contact Phone No.	____________	____________
R. Maximum Amount Of Load Pick - Up Without Notification ?	________MW	________MW
S. Are There Any Conditions That Would Necessitate Opening A Tie Line: ____ ____ ____ ____ ____		
T. Additional Comments: ____ ____ ____ ____ ____ ____		
U. Approval by PJM:____		
_* - Not Required if connecting to Eastern Interconnection		

Exhibit 17: Information Exchange Prior to Interconnecting - Page 2 of 2

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		Minimum Source Requirements:
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 18: 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 spokes person 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 or faxed 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 that will be 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 is the leader’s responsibility to encourage participation by all, while at the same time keeping the meeting on track.
- Silence does not necessarily 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.
- Avoid cell phones, if possible.
- Do not place call on hold.

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[9]. This guide will also be used as to train operating personnel in the implementation of the restoration plan. The training will include at least two annual simulated exercises as required by EOP-005 R6 and R7.

Drill Logistics

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

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 OTS. The PJM operators work side by side with the member operators in this effort. The top-down approach to system restoration is emphasized. A debrief and critique follows each drill. These drills are typically two-day events.

Transmission Owners test telecommunication facilities that are needed to implement their restoration plan as part of the semi-annual PJM Restoration Drill if not done otherwise during the year.

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

Transmission Owner Training Staff retain personnel training records that demonstrate PJM Certified operating personnel have been trained annually in the implementation of restoration concepts and the PJM and Transmission Owner restoration plans[10]. 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.

[9] NERC EOP-005 Attachment 1-6.
[10] NERC EOP-005 Attachment 1-7.

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 Task Force (SRCTF), and approved by the SOS. The following are sample objectives:

Comment [I2]: The System Restoration Coordinator Working Group (SRCWG) has been renamed the System Restoration Coordinator Task Froce (SRCTF).

- Foster a greater understanding between the company and PJM 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 LCC 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.
- Ensure that all nuclear units have been provided with one offsite source 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 operators.

Example Drill Scenarios

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

PJM will have experienced a complete system shutdown. The only surviving islands will be those designed to survive via automatic isolation schemes in the AP zone. 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 Working Group
- Dispatcher Training Task Force
- System Operations Subcommittee
- Nuclear Generation Owner/Operator Users Group

Drill / Plan Checklist

The PJM Drill Coordinator or designee will use the attached checklist to document EOP-005 requirements in individual transmission owner detailed documentation. This document will be used to provide training and familiarization with the detailed plans.

Elements for Consideration in Development of Restoration Plans

The transmission owner documentation must consider the following requirements, as applicable. At a minimum, the restoration plans should identify the specific location if the element applies, and if it is not applicable, there should be a specific explanation included.

In addition, PJM will keep a copy of these attachments identifying the compliant elements as part of the PJM restoration plan.

1. Plan and procedures outlining the relationships and responsibilities of the personnel necessary to implement system restoration.
   - Reference (Section, page number, etc.)____.
2. The provision for a reliable black-start capability plan including available cranking and transmission paths, and communication adequacy and protocol and power supplies.
   - Reference (Section, page number, etc.)____.
3. The necessary operating instructions and procedures for restoring loads, including identification of critical load requirements.

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 as required by EOP-005 R5:

- 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, OVEC), 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, telex, and microwave systems to communicate with crews

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Attachment F: Transmission Owner and Blackstart Supporting Documentation References

Training record documentation required for operating personnel as required by EOP-005 R1 (Attachment 1-EOP-005 #7) is located in both the PJM ~~learning~~ 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 R1 (Attachment 1-EOP-005 #1); R8; R9; R10; R10.1.

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 R1 (Attachment 1-EOP-005 #1, 2, 5).

NERC Standard EOP-005-1, Attachment 1

Mapping of PJM Member TO Restoration Documents to Applicable Elements

Details of the responsibilities can be found in Attachment 5 of this Mitigation Plan.

Members Registered as Transmission Owners

#	Requirements in Attachment	Allegheny Power	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
	Current Revision Number/Date	6/10/2011	9/1/2010 Revision 10	3/6/2011	6/1/2011 Revision 0	06/17/2011 Revision 2.0	1/1/11	4/1/2011	2/25/2011 Revision 4	3/1/2010
1	Plan and procedures outlining the relationships and responsibilities of the personnel necessary to implement system restoration.	Sect A-4 p. 1-5	p. 13, p. 16-33, & Mapping, p. 5	p. 5-15 Mapping, 187-188	p. 2, p. 4, p. 10	Sect V, p. 22-26	p. 11-14	p 12 - 15	p. 6, 11, 23, 30, 33	p. 13-25 Mapping p. 58-59
2	The provision for a reliable black-start capability plan including: fuel resources for black start power for generating units, available cranking and transmission paths, and communication adequacy and protocol and power supplies.	Sect E-1, L (all), G-1, Appendix 8 & PJM Blackstart Database	p. 16-33 & PJM Blackstart Database & Mapping, p. 5	p. 3-4, 41-137 App. B & PJM Blackstart Database Mapping, 179-180	p. 10, p. 25, p. 34, p. 44, p. 50, p. 51, p. 75, p. 80, p. 94, p. 97-98 PJM Blackstart Database	Att 1, p. 38-91, Att 24 p. 182-192 & PJM Blackstart Database	p. 3-10 & PJM Blackstart Database	N/A	p. 7, 12, 15, 20, 22, 28, 34 PJM Blackstart Database	p. 1-5, 13-20, 36-38 & PJM Blackstart Database Mapping p. 57-58
3	The plan must account for the possibility that restoration cannot be completed as expected.	PJM Manual 36, pages 10, 11, 15, 35, 46								
4	The necessary operating instructions and procedures for synchronizing areas of the system that have become separated.	Sect M (All)	p. 23-33 & Mapping, p. 5-6	p. 44-137, App C Mapping, 187-188	p. 7-8	Att 21, p. 173-174 Att 11, p. 136-137 Att 23, p. 178-181	p. 15-16, 20-32	p 17 - 18	p. 8, 42-44	p. 7-9 Mapping p. 57-58
5	The necessary operating instructions and procedures for restoring loads, including identification of critical load requirements.	Sect N (all), Appendix 9	p. 23-33 & Mapping, p. 7	Mapping, 187-188	p. 9, p. 16, p. 17-25, p. 26-34, p. 35-44, p. 45-51, p. 52-75, p. 76-80, p. 81-94	Att 11 p.138-139	SRSP - Sub A: p. 1, Sub B: p. 55, Sub C: p. 105	p 18 - 19	p. 8, 28, 31, 32, 38, 44	p. 7-9 Mapping p. 57-58
6	A set of procedures for simulating and, where practical, actually testing and verifying the plan resources and procedures.	PJM Manual 36, Attachment D								
7	Documentation must be retained in the personnel training records that operating personnel have been trained annually in the implementation of the plan and have participated in restoration exercises.	PJM Seminar and Drill Records								
8	The functions to be coordinated with and among Reliability Coordinators and neighboring Transmission Operators. (The plan should include references to coordination of actions among neighboring Transmission Operators and Reliability Coordinators when the plans are implemented.)	PJM Manual 36, pages 6, 11, 12, 14, 24, 25								
9	Notification shall be made to other operating entities as the steps of the restoration plan are implemented.	PJM Manual 36, pages 24, 25								

#	Dominion	Duquense Power and Light	First Energy	Pennsylvania Power and Light Company	PECO Energy Company	Potomac Electric Power Company	Public Service Electric and Gas	Rockland Electric Company	UGI
	3/31/2011 Revision 3.2	8/13/2010 Revision 2.2	1/25/2011 Revision 11	6/4/2010 R7	12/22/2010	1/27/2010	4/12/2011 Revision 21	8/1/2010	6/29/2011 Revision 1.4
1	Sect 1, p. 1	Sect 2, Art. 4, p. 7	EOP-4, p. 12-13	p. 1, Sect 1	Sect 1, p. 1 p. 4-1 - 4-13	Sect 6, p. 1-3	Sect 9, & 10; p. 16-20	p. 4-9	p. 2-4, 18
2	Ch. 4, 5, 6, 8 & PJM Blackstart Database	Sect 2, p. 4 & PJM Blackstart Database	EOP-4, p. 11, 44 PenElec p. 15-22 Met-Ed p. 26-31 JCP&L p. 35-40 & PJM Blackstart Database	Sect 2, 3, 8 & PJM Blackstart Database	p. 4-9, A12-1 & PJM Blackstart Database	Sect 2, 3 & PJM Blackstart Database	Sect 11,12,19,20; p. 19-21,29-33 & PJM Blackstart Database	N/A p. 4 No black start required	N/A p. 2
3									
4	Ch 3, p. 10-16	p. 3-26	EOP-4, p. 8-10, 28 and Circuit Sheet & Synchronization Tables Attachment	p. 7-8, Sect 24-32	p. 4-1 - 4-13, App 9	Sect 9, 10	Sect 15, p. 22-25	Sect. 5, p. 12-21	p. 6-11
5	Sect. 3	Sect 2, Art. 5, p. 9-10, Sect 13	EOP-4, p. 11	Sect 9, p. 3	p. 4-11 & 4-12, App 1A	Sect 12, p. 2-4	Sect 5, 23; p. 5-7, 34	p. 5-26	p. 11-17
6									
7									
8									
9									

#	Requirements in Attachment	Members Registered as Transmission Owners: Allegheny Power	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	Duquense Power and Light	First Energy	Pennsylvania Power and Light Company	PECO Energy Company	Potomac Electric Power Company	Public Service Electric and Gas	Rockland Electric Company	UGI
	Current Revision Number/Date	40188	9/1/2010 Revision 9.2	4/10/2010	6/1/2011 Revision 0	06/18/2010 Revision 1.8	1/1/10	4/1/2011	2/4/2010	3/1/2010	7/31/2010 Revision 3	8/13/2010 Revision 2.2	3/31/2010 Revision 10	6/4/2010 R7	12/22/2010	2/27/2010	4/12/2011	4/1/2010	5/21/2010
1	Plan and procedures outlining the relationships and responsibilities of the personnel necessary to implement system restoration.	Sect A-4 p. 1-5	p. 13, p. 16-33, & Mapping, p. 5	p. 5-15 Mapping, 187-188	p. 2, p. 4, p. 10	Sect A, p. 13-19	p. 11-14	p 12 - 15	p. 4, 5, 12,13, 24,28,30,37	p. 13-26 Mapping p. 58-59	Sect 1, p. 1	Sect 2, Art. 4, p. 7	EOP-4, p. 12-14	p. 1, Sect 1	Sect 1, p. 1 p. 4-1 - 4-13	Sect 6, p. 1-3	Sect 9, & 10; p. 16-20	p. 4-9, 11	p. 2-4, 16
2	The provision for a reliable black-start capability plan including: fuel resources for black start power for generating units, available cranking and transmission paths, and communication adequacy and protocol and power supplies.	Sect E-1, L (all), G-1, Appendix 8 & PJM Blackstart Database	p. 16-33 & PJM Blackstart Database & Mapping, p. 5	p. 3-4, 41-137 App. B & PJM Blackstart Database Mapping, 179-180	p. 10, p. 25, p. 34, p. 44, p. 50, p. 51, p. 75, p. 80, p. 94, p. 97-98 PJM Blackstart Database	Att 1, p. 44-47 & PJM Blackstart Database	p. 3-10 & PJM Blackstart Database	N/A	p. 13, 20,22,23,32 PJM Blackstart Database	p. 1-5, 13-20, 36-38 & PJM Blackstart Database Mapping p. 57-58	Ch. 4, 5, 6, 8 & PJM Blackstart Database	Sect 2, p. 4 & PJM Blackstart Database	EOP-4, p. 11, 48, 80 PenElec p. 15-22 Met-Ed p. 26-34 JCP&L p. 38-44 & PJM Blackstart Database	Sect 2, 3, 8 & PJM Blackstart Database	p. 4-9 & PJM Blackstart Database	Sect 2, 3 & PJM Blackstart Database	Sect 11,12,19,20; p. 19-21,30-33 & PJM Blackstart Database	N/A No black start required.	N/A (rely on PPL, p. 10)
3	The plan must account for the possibility that restoration cannot be completed as expected.	PJM Manual 36, pages 10, 11, 15, 35, 46																	
4	The necessary operating instructions and procedures for synchronizing areas of the system that have become separated.	Sect M (All)	p. 23-33 & Mapping, p. 5-6	p. 44-137, App C Mapping, 187-188	p. 7-8	Sect I, p 35-40 Sect J, p. 41-42 p. 121-122	p. 15-16, 20-32	p 16 - 17	p. 40,41,50,76,77	p. 7-9 Mapping p. 57-58	Ch 3, p. 10-15	p. 3-26	EOP-4, p. 8-10, 28 and Circuit Sheet & Synchronization Tables Attachment	p. 7-8, Sect 24-32	p. 4-1 - 4-13, App 9	Sect 9, 10	Sect 15, p. 23-26	Sect. 5, p. 12-21	p. 5-9
5	The necessary operating instructions and procedures for restoring loads, including identification of critical load requirements.	Sect N (all), Appendix 9	p. 23-33 & Mapping, p. 7	Mapping, 187-188	p. 9, p. 16, p. 17-25, p. 26-34, p. 35-44, p. 45-51, p. 52-75, p. 76-80, p. 81-94	Att 19	SRSP - Sub A: p. 1, Sub B: p. 55, Sub C: p. 105	p 17 - 18	p. 24-29, 37-47	p. 7-9 Mapping p. 57-58	Sect. 3	Sect 2, Art. 5, p. 9-10, Sect 13	EOP-4, p. 11	Sect 9, p. 3	p. 4-11 & 4-12, App 1A	Sect 12, p. 2-4	Sect 5, 23; p. 5-7, 35	p. 5-26	p. 11-14
6	A set of procedures for simulating and, where practical, actually testing and verifying the plan resources and procedures.	PJM Manual 36, Attachment D																	
7	Documentation must be retained in the personnel training records that operating personnel have been trained annually in the implementation of the plan and have participated in restoration exercises.	PJM Seminar and Drill Records																	
8	The functions to be coordinated with and among Reliability Coordinators and neighboring Transmission Operators. (The plan should include references to coordination of actions among neighboring Transmission Operators and Reliability Coordinators when the plans are implemented.)	PJM Manual 36, pages 6, 11, 12, 14, 24, 25																	
9	Notification shall be made to other operating entities as the steps of the restoration plan are implemented.	PJM Manual 36, pages 24, 25																	

Figure 1 - TO restoration Document References – PJM DOCS # 470991v7

Neptune RTS Emergency Restoration

Comment [I3]: Added Neptune information.

- 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, 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. 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.

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 (Element 9)
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 (~~OVEC,~~ AEP) 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 Balancing Authorities (BA) within its footprint and as well with its neighboring Reliability Coordinators (RC), BAs, and Transmission Operators (TOP) as required by NERC EOP-005.

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

1. **Restoration Plan Coordination Checklist** - This coordination checklist will facilitate an active discussion on the pertinent EOP-005 Attachment 1 elements with the respective parties.
2. **Annual Coordination Timeline** – this timeline will generate the required updates and coordination at a minimum on an annual basis, but (system conditions permitting two restoration drills a year) should provide coordination twice a year.
3. **PJM Transmission Owner Checklist Change Overview** – This overview will facilitate PJM Operators' and impacted parties' (neighbors and internal RE's) review of those plans/sections of plans which may require a more detailed review.

RESTORATION PLAN COORDINATION CHECKLIST

PURPOSE: As per Requirement 4, of EOP-005 this checklist is intended to ensure coordination with our neighboring BA / RC / TOP and the appropriate internal PJM registered entities by providing detailed references to any changes and enhancements to our restoration plans.

PROCESS: PJM and the PJM TO will distribute this checklist at least annually (NLT December 15th of each year) or when there are changes in the power system network and /or of significant import to neighboring entity operations / restoration plans. PJM will include this checklist in Manual 36 and 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)
Date:	
Point of Contact:	
	(Position/Title and Department)
Phone Number:	
E-mail:	
Signature:	
	(Point of contact signs that their plan has been reviewed and updated with the noted changes/updates)

	Coordination Item	Reference Page #
1.	When was the Restoration Plan last updated: (Date)	
2.	**CHANGE OVERVIEW:** Were there any significant changes to the plan since the last update? If ~~"~~No" – Skip to the last question – *Lessons Learned*. If ~~"~~Yes" summarize changes below:	
	Change 1:	
	Change 2:	
	Change 3:	
	Change 4:	
3.	**Relationships and Responsibilities:** Were there any significant changes to the plan's identified responsibilities and relationships, since the last update? If ~~"~~No" – Skip to the next question. If ~~"~~Yes" summarize changes below:	
	Change 1:	
	Change 2:	

	Coordination Item	Reference Page #
4.	**Black-start Capability:** Were there any significant changes to the plan's Blackstart Generation capability (units, fuel resources, available cranking and transmission paths and communication adequacy), since the last update? If “No” – Skip to the next question. If “Yes” summarize changes below:	
	Change 1:	
	Change 2:	
5.	**Synchronization Procedures:** Were there any significant changes to the plan's synchronization procedures, since the last update? If “No” – Skip to the next question. If “Yes” summarize changes below:	
	Change 1:	
	Change 2:	
6.	**Operating Instructions – Restoring Loads:** Were there any significant changes to the plan's operating instructions and procedures for restoring loads, including critical loads? Are there any changes to the list of critical loads? If “No” to both questions – Skip to the next question. If “Yes” to either question summarize changes below:	
	Change 1:	
	Change 2:	
7.	**Testing and Simulating Procedures:** Were there any significant changes to the plan's processes for simulating/testing and verifying the plan's resources and procedures, since the last update? If “No” – Skip to the next question. If “Yes” summarize changes below:	
	Change 1:	
	Change 2:	
8.	**Functions to be Coordinated:** List any desired changes to how this RE should coordinate with its neighboring RC's and TOP's? These items are a “wish list” of Were coordination could be enhanced before the next simulation/drill. If there are no desired changes skip to the next question. If there are such desired changes summarize these below and specify which neighbor/entity this coordination should occur with.	
	Change 1:	
	Change 2:	
9.	**Notification Steps:** Were there any significant changes to the plan's notification protocols to other operating entities as the steps of the restoration plan are implemented? If “No” – Skip to the next question. If “Yes” summarize changes below:	
	Change 1:	
	Change 2:	

	Coordination Item	Reference Page #
10.	**LESSONS LEARNED:** In our last restoration drill and or simulation ___________(date) the following important lessons were learned, these lessons have not have changed our particular plans but merit highlighting for further understanding of our restoration plan:	
	Lesson 1:	
	Lesson 2:	
	Lesson 3:	
	Lesson 4:	

ANNUAL COORDINATION TIMELINE

DATE	PJM ACTION	OTHERS ACTION
SPRING UPDATE NOTE: The Spring Update is the minimum annual review of these plans		
Winter	At the Winter Systems Operations Subcommittee (SOS) Meeting PJM reminds TO's of their need to review and update their plans and complete the Restoration Coordination Checklist (~~Appendix 1~~Attachment G)	
March	PJM Restoration Drill – The restoration drill through its comprehensive simulations and execution of processes validates the strength of its current plan with its latest changes.	PJM TO's actively participate in this restoration drill
March 31		PJM's TO submit their updated and signed Coordination Checklist to PJM
April	PJM holds its April SOS Meeting	At the April SOS meeting, PJM TO's review their respective Coordination Checklists with one another and explain each change to their restoration plans.
NOTE: 1. PJM validates Blackstart Units by the units that are compensated via PJM OATT Schedule 6A and the units are confirmed by the requesting TO with PJM. 2. PJM validates Cranking Paths, Operating Instructions for restoring loads, Synchronization Points/Procedures by reviewing system topology changes and through the simulations of the restoration drills.		
April - May	PJM rolls up changes to restoration plans (identified in the coordination checklists) and updates its plan accordingly.	

	PJM also updates Attachment ~~1~~ F to Manual 36 to highlight changes to each TO's plans to other TO's and neighbors.	
June	PJM holds its next SOS meeting, and highlights Lessons Learned from its Spring Restoration Drill.	
Late June	If required by the Lessons Learned or the changes made by its TO's, PJM sends its updated public restoration plan and Coordination Checklist to its internal GO's and BA's as well as neighboring BA's, TOP's, & RC's. Note: Even if there are no updates PJM will provide the Coordination Checklist to our neighboring TOP's and RC's highlighting that there are no changes.	
Late June	If required by the Lessons Learned or the changes made by its TO's, PJM presents its changes to the RFC & SERC Reliability/Operating Committees	

WINTER UPDATE		
Summer	At the Summer Systems Operations Subcommittee (SOS) Meeting PJM discuss with the TO's their need to completely review and update their plans and complete the Restoration Coordination Checklist (Appendix 1) prior to their Fall restoration drills.	
Sep-Nov	PJM rolls up changes to restoration plans (identified in the coordination checklists) and updates its plan accordingly after the Fall PJM Restoration Drills – The Fall series of restoration drills provide a more focused level of coordination between each TO and PJM.	PJM TO's actively participate in their respective PJM restoration drills.
December	PJM holds its next SOS meeting, and highlights Lessons Learned from its series of Fall Restoration Drills.	
Late December	If required by the Lessons Learned or the changes made by its TO's, PJM sends its updated public restoration plan and Coordination Checklist to its internal GO's and BA's as well as neighboring BA's, TOP's, & RC's	
Late December	If required by the Lessons Learned or the changes made by its TO's, PJM presents its changes to the RFC & SERC Reliability/Operating Committees	

NERC Reliability Standard EOP-005 requires the coordination of actions by a TOP and BA with neighboring TOPs and BAs when restoration plans are implemented (in the restoration plan). As such, PJM Manual 36 has been revised to incorporate the requirement for such notifications to be made. PJM will electronically provide updates of PJM Manuals 13 and 36 related to system restoration plans with requested acknowledgment of receipts by neighboring BAs, TOPs, and RCs. 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.
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.
3. The receipts will also be used to track acknowledgement for follow-up of contact information for neighboring systems.

PJM Transmission Owner Checklist Change Overview

GENERAL: This overview provides the reviewer (PJM / TO) an opportunity to review all of the TO respective coordination checklist submissions and determine which checklists / plans require review. The rows in this overview correspond to the Restoration Plan Coordination Checklist items. An –**X**" in this table indicates a TO has made a change to their restoration plans. An –**R**" indicates PJM's recommendation that all applicable TO entities should review the particular comments/changes highlighted in the particular TO's Coordination Checklist.

Table 1 - TO Coordination Checklist Overview

		AEP	AP	ATSI	Com Ed	CPP	DOM	DP&L	DUQ	FE	O&R	PE	AE	DPL	PEP	PL	PS
1	Change Overview																
2	Relationships & Responsibilities																
3	Black-start Capability																
4	Synchronization Procedures																
5	Operating Instructions – Restoring Loads																
6	Testing and Simulating Procedures																
7	Functions to be Coordinated																
8	Notification Steps																
9	Lessons Learned																

LAST UPDATE: __________________
PJM Representative's Signature ______________________

APPENDIX 4: PJM Neighboring TOP and RC Checklist Change Overview

GENERAL: This overview provides the reviewer an opportunity to quickly review all of the neighboring RC / BA / TOP respective coordination checklist submissions and determine which checklists require review. The rows in this overview correspond to the Restoration Plan Coordination Checklist items. An –**X**" in this table indicates an entity has made a change to their restoration plans. An –**R**" indicates that PJM and (applicable) TO should review the particular comments/changes highlighted in the entity checklist.

Table 2 - Neighboring Entity Checklist

		NY ISO	PEC / CPL	Duke	MISO	OVEC	TVA	
1	Change Overview							
2	Relationships & Responsibilities							
3	Black-start Capability							
4	Synchronization Procedures							
5	Operating Instructions – Restoring Loads							
6	Testing and Simulating Procedures							
7	Functions to be Coordinated							
8	Notification Steps							
9	Lessons Learned							

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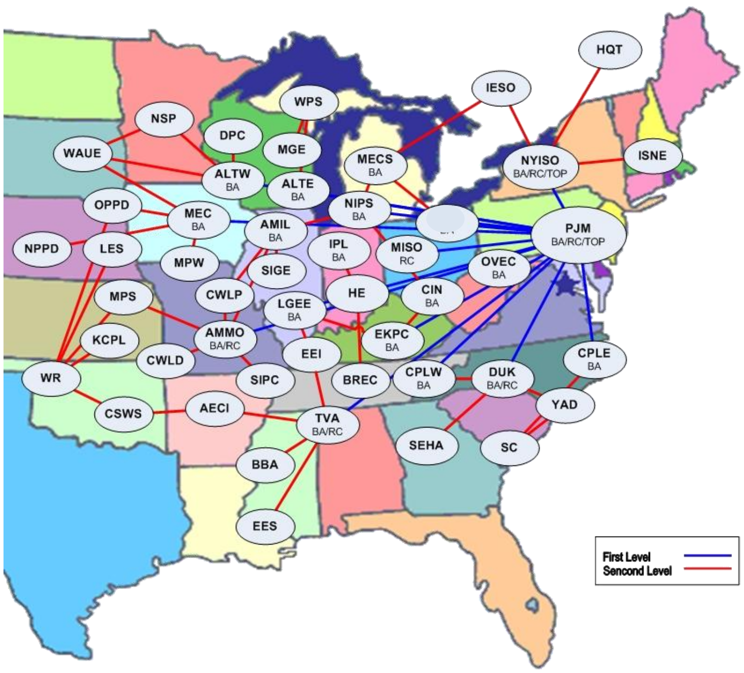
PJM Representative's Signature ______________________

Note: Refer to the attached map illustrating the neighboring entities that will be included in this matrix.


HQT
IESO
WPS
NSP
DPC
MGE
WAUE
ALTW BA
ALTE BA
MECS BA
NYISO BA/RC/TOP
ISNE
OPPD
MEC BA
NIPS BA
PJM BA/RC/TOP
AMIL BA
IPL BA
MISO RC
NPPD
LES
MPW
SIGE
OVEC BA
MPS
CWLP
LGEE BA
HE
CIN BA
AMMO BA/RC
EKPC BA
KCPL
CWLD
EEI
CPLE BA
WR
SIPC
BREC
CPLW BA
DUK BA/RC
YAD
CSWS
AECI
TVA BA/RC
SEHA
SC
BBA
EES
First Level
Sencond Level

Attachment H: Under Frequency Load Shed (UFLS) Tables

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	2011 Peak Forecast	59.5 Hz	59.3 Hz	59.1 Hz	59.0 Hz	58.9 Hz	58.7 Hz	58.5 Hz	Total
AE-Conectiv *		276			280		285	841	2507		11.01%			11.17%		11.37%	33.54%
Vineland *		17			19		21	57	157		10.85%			12.12%		13.40%	36.37%
BGE *		760			764		753	2277	7388		10.29%			10.34%		10.19%	30.82%
DPL-Conectiv *		514			490		433	1437	2906		17.69%			16.86%		14.90%	49.45%
ODEC - DPL *		77			83		87	247	750		10.26%			11.06%		11.60%	32.93%
DEMEC *		29			28		27	84	253		11.46%			11.07%		10.67%	33.20%
Easton *		7			8		8	23	64		10.91%			12.47%		12.47%	35.86%
Dover *		24			21		21	66	174		13.76%			12.04%		12.04%	37.84%
JC *		691			681		682	2054	6396		10.80%			10.65%		10.66%	32.11%
ME *		296			301		297	894	2956		10.01%			10.18%		10.05%	30.24%
PN *		326			328		318	972	2889		11.28%			11.35%		11.01%	33.64%
PECO *		1011			958		933	2902	8696		11.63%			11.02%		10.73%	33.37%
PEPCO *		721			710		647	2078	6133		11.76%			11.58%		10.55%	33.88%
SMECO *		92			96		91	279	853		10.78%			11.25%		10.66%	32.69%
PPL *		811			894		884	2589	7263		11.17%			12.31%		12.17%	35.65%
UGI *		25			22		23	70	195		12.82%			11.28%		11.79%	35.90%
Public Service *		1106			1092		1113	3311	10810		10.23%			10.10%		10.30%	30.63%
RECO *		48			48		46	142	430		11.16%			11.16%		10.70%	33.02%
Com Ed *		2671		2555		2668		7894	22689		11.77%		11.26%		11.76%		34.79%
Dominion *		1868		1783			1949	5600	17366		10.76%		10.27%			11.22%	32.25%
NOVEC *		95		100			99	294	879		10.81%		11.38%			11.27%	33.46%
ODEC - DVP *		111		120			122	353	1102		10.08%		10.89%			11.07%	32.04%
NCEMC - DVP *		35		35			35	105	314		11.13%		11.13%			11.13%	33.40%
AP **	483	456	475		443	516		2373	8655	5.58%	5.27%	5.49%		5.12%	5.96%		27.42%
AEP **	1538	1474	1492		1726	1324		7554	23673	6.50%	6.23%	6.30%		7.29%	5.59%		31.91%
Dayton **	172	172	172		172	172		860	3433	5.01%	5.01%	5.01%		5.01%	5.01%		25.05%
Duquesne **	170	148	172		159	167		816	2944	5.77%	5.03%	5.84%		5.40%	5.67%		27.72%
ATSI **	647	632	619		638	639		3175	13364	4.84%	4.73%	4.63%		4.77%	4.78%		23.76%
DUKE **	418	380	418		506	494		2216	5669	7.37%	6.70%	7.37%		8.93%	8.71%		39.09%
CPP **								0	315	0.00%	0.00%	0.00%		0.00%	0.00%		0.00%

Please include MW based on the 2011 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

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	2010 Peak Forecast	59.5 Hz	59.3 Hz	59.1 Hz	59.0 Hz	58.9 Hz	58.7 Hz	58.5 Hz	Total
AE-Conectiv		268			281		263	812	2589		10.34%			10.85%		10.16%	31.35%
Vineland		19			18		24	60	162		11.57%			10.90%		14.65%	37.12%
BGE		772			802		808	2382	7456		10.36%			10.75%		10.83%	31.94%
DPL-Conectiv		516			471		430	1417	3317		15.56%			14.20%		12.96%	42.72%
ODEC - DPL		82			87		87	256	605		13.55%			14.38%		14.38%	42.31%
DEMEC		29			28		28	85	221		13.26%			12.70%		12.60%	38.55%
Easton		8			10		7	25	68		11.76%			14.26%		10.59%	36.62%
Dover		17			17		21	55	168		10.09%			10.09%		12.46%	32.65%
JC		682			698		696	2076	6440		10.59%			10.84%		10.81%	32.24%
ME		299			305		299	903	2920		10.24%			10.45%		10.24%	30.92%
PN		287			313		299	899	2843		10.09%			11.00%		10.52%	31.61%
PECO		999			953		1001	2953	8528		11.71%			11.18%		11.74%	34.63%
PEPCO		713			717		648	2077	6191		11.52%			11.58%		10.46%	33.55%
SMECO		91			92		91	274	874		10.40%			10.53%		10.38%	31.30%
PPL		839			883		866	2588	7161		11.71%			12.33%		12.10%	36.14%
UGI		23			21		21	64	190		12.00%			10.89%		11.00%	33.89%
Public Service		1096			1098		1098	3292	10921		10.04%			10.05%		10.05%	30.14%
RECO		48			48		46	142	454		10.64%			10.48%		10.04%	31.17%
Com Ed		2313		2412		2285		7010	22536		10.26%		10.70%		10.14%		31.11%
Dominion		1947		1890			1810	5647	17718		10.99%		10.67%			10.22%	31.87%
NOVEC		83		80			83	246	790		10.51%		10.13%			10.51%	31.14%
ODEC - DVP		122		102			132	356	982		12.42%		10.39%			13.44%	36.25%
NCEMC - DVP		34		34			34	102	309		11.00%		11.00%			11.00%	33.01%
AP	445	456	490		456	531		2378	8661	5.14%	5.26%	5.66%		5.26%	6.13%		27.46%
AEP	1551	1460	1486		1765	1286		7548	23287	6.66%	6.27%	6.38%		7.58%	5.52%		32.41%
Dayton	169	171	168		168	169		846	3368	5.02%	5.09%	5.00%		5.00%	5.02%		25.13%
Duquesne	166	160	159		150	144		778	2883	5.74%	5.56%	5.50%		5.19%	5.00%		27.00%
ATSI	687	715	724		700	757		3583	13364 *	5.14%	5.35%	5.42%		5.24%	5.66%		26.81%

*2011 Forecasted Peak**

Revision History

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

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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 / LCC 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.