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PJM Manual 37
Reliability Coordination

Revision: [132](#)

Effective Date: [September 1, 2015](#)

Prepared by
System Operation Division

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PJM Manual 37

Reliability Coordination

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Approval

Approval Date: [09/01/2015](#)

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Phil D'Antonio, Manager
Reliability Engineering

Current Revision

Revision ~~132~~ ([09/01/2015](#)):

- ~~Section 2.4.2, replaced Change Control Review Board with more detail around PJM's Enterprise Change Management Standard which encompasses the CCRB.~~
- ~~Section 3.1, Removed effective date footnote with respect to COMED IROL.~~
- ~~Section 3.1, Updated SOL definition to note that PJM controls to the most conservative limits and that IROLs are an elevated SOL rather than being distinct from SOLs.~~
- ~~Section 3.1, Removed empty row in IROL table found on page 9.~~
- ~~Section 3.2, Added clarification to SOL and IROLs monitored by PJM.~~
- ~~Section 3.2, Added clarification to SOL limit violation reporting.~~
- ~~Section 5.1, Updated hyperlink for PJM / Duke Energy Progress Joint Operating Agreement (JOA). Updated company name from Progress Energy Carolinas to Duke Energy Progress.~~
- ~~Administrative Change - Updated references from edata to Data Viewer~~
- ~~Periodic Review Complete~~
- Section 3.1, Renamed ComEd Reactive Transfer Interface to CE – East Reactive Transfer Interface
- Section 3.1, added clarification noting specific M-03 sections used to support PJM's SOL methodology
- Section 3.2, added controlling actions to the list of actions implemented by PJM for congestion control
- Attachment A: PJM Reliability Plan updated to note ITC as a new PJM TOP effective June 1, 2016
- Periodic Review Complete

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Introduction

Welcome to the ***PJM Manual for Reliability Coordination***. 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 Reliability Coordination*** focuses on how PJM and the PJM Members are expected to carry out reliability coordination duties in accordance with the PJM Reliability Plan.

The ***PJM Manual for Reliability Coordination*** consists of five sections. The sections are as listed in the table of contents beginning on page ii.

PJM shall annually review and update this manual and provide a copy to neighboring Reliability Coordinators, Transmission Operators, Balancing Authorities, and appropriate Regional Reliability Organizations.

Intended Audience

The Intended Audiences for the PJM Manual for Reliability Coordination are:

- *PJM Reliability Coordinators and system operators*— Declare and implement normal operating procedures and emergency procedures.
- *Transmission Owner/Operator (TO/TOP) and Generation Owner/Operators (GO/GOP)*— Respond to PJM dispatcher requests for emergency procedures.

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- PJM RTO Balancing Authorities and Transmission Operators – coordinate operation of Balancing Authority (BA) and Transmission Operator (TOP) operations with PJM Reliability Coordinator (RC).
-
- PJM Reliability Coordinators and operations staff — Perform system studies.

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References

The references to other documents that provide background or additional detail directly related to the **PJM Manual for Reliability Coordination** are:

- PJM Manual for [Balancing Operations \(M12\)](#)
- PJM Manual for [Transmission Operations \(M03\)](#)
- PJM Manual for [System Restoration \(M36\)](#)
- PJM Manual for [Operations Planning \(M38\)](#)
- PJM Manual for [Emergency Operations \(M13\)](#)
- PJM Manual for [Generator Operational Requirements \(M14dM14D\)](#)
- PJM Manual for [Certification and Training Requirements \(M40\)](#)
- PJM Manual for [Definitions & Acronyms \(M35\)](#)

Using This Manual

We believe that explaining concepts is just as important as presenting 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, 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
- 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 PJM Member actions
- Attachments that include additional supporting documents, forms, or tables in this PJM Manual
- A section at the end detailing all previous revisions of this PJM Manual



Section 1: Roles and Responsibilities

Welcome to the Roles and Responsibilities section of the **PJM Manual for Reliability Coordination**.

- This section of the manual addresses PJM and the PJM Members' responsive actions to obligations as the PJM Reliability Coordinator.

1.1 Policy Statements

PJM is the Reliability Coordinator for PJM members within the PJM Balancing Authority Area. PJM operates in compliance with the PJM Reliability Plan (Attachment A – [PJM Reliability Plan](#)).

PJM's authority is addressed in the following document, which all PJM members must sign:

PJM Operating Agreement (PJM Website link:
<http://pjm.com/media/documents/merged-tariffs/oa.pdf>)

In this document, the PJM members commit to comply with PJM Reliability Coordinator directives unless such actions would violate safety, equipment, or regulatory or statutory requirements (See Attachment B – [Excerpt from PJM Operating Agreement regarding authority of PJM](#)). Under these circumstances, the Transmission Operator, Transmission Owner, Balancing Authority, Generator Operator, Transmission Service Provider, Load-Serving Entity, or Purchasing-Selling Entity shall immediately inform PJM, the Reliability Coordinator, of the inability to perform the directive so that the PJM may implement alternate remedial actions.

PJM has clear decision-making authority to act and to direct actions to be taken by Transmission Operators, Transmission Owners, Balancing Authorities, Generator Operators, Load-Serving Entities, and Purchasing-Selling Entities within its Reliability Coordinator Area to preserve the integrity and reliability of the Bulk Electric System. These actions shall be taken without delay, but no longer than 30 minutes.

PJM shall act in the interest of reliability for the overall Reliability Coordinator Area and the Interconnection before the interests of any of its members or other entity. PJM is committed to supporting its fellow Reliability Coordinators. PJM has developed coordination agreements with cooperation with its neighboring Reliability Coordinators for the purpose of clarifying roles and responsibilities with these entities and for coordinating response when necessary. [NERC Standard IRO-001-~~1.1~~, R1-R3, R7-R-9]

PJM executes the Reliability Coordinator tasks with a group of highly trained and qualified system operators, all of whom maintain current NERC Certification as Reliability Operators.

PJM Actions:

PJM is responsible for the following activities:



- Preparing a PJM Reliability Plan and obtaining approval for the plan from the NERC Operating Committee and appropriate Regional Reliability Organization (RRO) Committees.
- Staffing the Reliability Coordinator activities with trained and certified system operators who maintain the NERC Certification for Reliability Operators.
- Implementing coordination agreements with other Reliability Coordinators.
- Taking actions that it determines are consistent with Good Utility Practice and are necessary to maintain the operational integrity of the PJM RTO and the Eastern Interconnection
- Coordinating emergency procedures and RCIS notifications.
- Directing the operations of any PJM Members as necessary to manage, alleviate, or end an emergency, including but not limited to emergency purchases/sales and load shedding.
- Providing information to and receiving information from PJM Members and other Reliability Coordinators, as appropriate to manage, alleviate, or end an Emergency in the PJM RTO or in another Reliability Coordination Area.
- Monitoring voltages, tie flows, line loading, EMS alarms, interchange schedules, ACE Control, Frequency, NERC IDC and RCIS.

PJM Member Actions:

PJM Members are responsible for performing the following activities:

- Taking any action, as requested or directed by PJM, to manage, alleviate, or end an Emergency or other reliability issue.
- Cooperating with other Transmission and Generation Owners and PJM to carry out requests and instructions received from PJM for the purpose of managing, alleviating, or ending an Emergency or other reliability issue in the PJM Reliability Coordinator area or neighboring Reliability Coordinator area.



Section 2: Facilities

Welcome to the *Facilities* section of the **PJM Manual for Reliability Coordination**. In this section, you will find the following information:

- A description of the communications facilities that are used to perform Reliability Coordination activities in PJM.
- The data requirements and data exchange process for the population of the real time monitoring tools
- A description of the real time monitoring tools that PJM uses to perform Reliability Coordination activities.
- Procedures for the maintenance of the real time analysis tools

2.1 Communications Facilities

The communications facilities that PJM and its members use to carry out its Reliability Coordinator duties are explained in PJM Manual, M-01, Control Center Requirements, Section 3, [NERC Standard IRO-002, R1, R4]

2.2 Data Requirements

The data exchange requirements and facilities that PJM and its members use to carry out its Reliability Coordinator duties are explained in PJM Manual, M-01, Control Center Requirements, Section 3, [NERC Standard IRO-002, R2, R3]

2.3 Real Time Monitoring Tools

The real time monitoring tools that PJM uses to carry out its Reliability Coordinator duties are explained in PJM Manual, M-01, Control Center Requirements, Section 1. [NERC Standard IRO-002, R4-R7; IRO-003, R1-R2]

2.4 Maintenance of Real Time Monitoring Tools

2.4.1 Capabilities of the on-site support staff

PJM maintains a highly qualified and trained staff to provide support to the real time monitoring tools. The EMS and its associated applications are supported by the Model Management Department that is in System Operations. This group has full time people on staff during normal business hours, which maintain the EMS database, the advanced applications, and troubleshoot EMS problems. This group is on-call to the control room staff on off-hours, to address real time problems.

Other real time applications are supported by the Operations Support Division. This group is responsible for non-EMS applications that also comprise the set of tools for real time monitoring. They are also full time during normal business hours, with call out support for off-hours requests from the control room.



Backing up the System Operations and Operations Support staff is the Information Technology Operations Center (ITOC). ITOC is staffed on site on a 24 x 7 basis with IT professionals with primary responsibility for the corporate applications, some of which are used indirectly in the real time monitoring role. The ITOC is also the focal point for marshalling support forces in the off-hours to respond to control room concerns.

2.4.2 Change management process

Changes to the Real Time Monitoring Tools are implemented in accordance with the procedures contained in the Enterprise Change Management Standard, OP-IT-3091. The Enterprise Change Management Standard is an internal PJM standard, PJM document #D596201, to ensure that changes to PJM business application systems, programs, data, systems software, hardware, and any other aspect of the information-processing environment at PJM, are authorized and applied in a controlled and consistent manner that does not compromise the stability and security of any component in the Information Technology environment. [NERC Standard IRO-002, R8].



Section 3: SOL and IROL Limits

Welcome to the *Monitoring SOL and IROL Limits* section of the PJM Manual for **Reliability Coordination**. In this section, you will find the following information:

- Process for determining SOL and IROL limits
- How PJM monitors SOL and IROL limits

3.1 SOL and IROL Limit Determination

IROL Determination: An Interconnected Reliability Operating Limit (IROL) is defined in the NERC Glossary of Terms as a System Operating limit that, if violated, could lead to instability, uncontrolled separation, or Cascading ~~Outages-outages~~ that adversely impact the reliability of the Bulk Electric System (**BES**).

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PJM performs an IROL analysis in the Planning and Operating Horizons. Planning studies are performed consistent with the ideology contained within M14 A through E, evaluating credible “double-contingencies” modeling firm transactions, consistent with planning criteria. Operating studies are performed consistent with the ideology contained within the PJM Transmission Operations Manual (M03), evaluating “single-contingencies”.

The Base Case is generally developed using 50/50 (non-diversified) forecasted load levels, net PJM Interchange level determined from the MMWG Series case that is adjusted for firm point-to-point contracts associated with generation for recent NERC ERAG analysis.

PJM typically screens a large set of possible limiting contingencies as identified in the OATF results at forecasted 50/50 (non-diversified) peak loads including PJM EMS and maximum credible disturbance contingencies.

PJM’s Operational methodology to determine IROL facilities simulates transfers across a facility or interface (combination of facilities), comparing thermal and voltage violations associated with a facility.

The transfers are simulated by increasing the load at the Sink (Control Area(s) or subset of Control Area) with the corresponding generation increase at the Source (typically west of the facility/interface being studied) until a voltage violations/collapse is reached.

Thermal Violations that do not result in wide-spread voltage violations / collapse are controlled via load shed procedures documented in PJM Manuals (PJM Transmission Operations Manual M03 -Section 2 and PJM Emergency Procedures Manual M13 - Section 5). These procedures require PJM to take emergency actions, including load ~~dump-shed~~ to return flows below Emergency Ratings within 15 minutes and below Load Dump Ratings within 5 minutes. Transmission Owners are required to provide thermal ratings consistent with the timeline defined above.

PJM classifies a facility as an IROL facility on the PJM system if wide-area voltage violations occur at transfer levels that are near the Load Dump thermal limit. Under conditions where only a thermal violation exists, PJM staff will have sufficient time to



dump-shed load post-contingency to avoid voltage collapse, and therefore, the facility will not be classified as an IROL facility. Exceptions to this criterion are evaluated on a case-by-case basis. Current IROL facilities are defined as follows:

Transfer Limit/Thermal Rating	Reportable IROL Violation
Eastern Reactive Transfer Interface	Flow exceeds Last Convergent Case Limit for 30 minutes (T_v)
Central Reactive Transfer Interface	Flow exceeds Last Convergent Case Limit for 30 minutes (T_v)
5004/5005 Reactive Transfer Interface	Flow exceeds Last Convergent Case Limit for 30 minutes (T_v)
Western Reactive Transfer Interface	Flow exceeds Last Convergent Case Limit for 30 minutes (T_v)
AP South Reactive Transfer Interface	Flow exceeds Last Convergent Case Limit for 30 minutes (T_v)
Bedington – Black Oak Reactive Transfer Interface	Flow exceeds Last Convergent Case Limit for 30 minutes (T_v)
AEP-DOM Reactive Transfer Limit	Flow exceeds Last Convergent Case Limit for 30 Minutes (T_v)
Cleveland (CLVLND) Reactive Transfer Interface	Flow exceeds Last Convergent Case Limit for 30 Minutes (T_v)
<u>ComEd-CE - East</u> Reactive Transfer Interface	Flow exceeds Last Convergent Case Limit for 30 Minutes (T_v)

PJM has developed a SOL Methodology for use in the Operating Horizon to ensure reliable BES performance. Including the dynamically ally limits-calculated limits for the IROL facilities above, the most restrictive applicable limit (thermal / voltage / transient stability / voltage stability) upon all BES facilities and “Reliability and Markets” sub-BES facilities as listed on the PJM Transmission Facilities pages, <http://www.pjm.com/markets-and-operations/ops-analysis/transmission-facilities.aspx>, are considered System Operating Limits (SOL). These SOL shall not exceed the associated ratings for a given facility. For each SOL category, PJM will control on a pre-contingency and post-contingency basis (consistent with FAC-011-2, R 1) as detailed in Operating Guidelines provided in PJM Manual M-03 consistent with established SOL methodology:

- Facility Thermal Ratings:
 - Section 2-
 - Section 5
- Transient, Dynamic, and Voltage Stability Ratings:

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- o ~~Section 3.8 & 3.9~~
- o ~~Section 5 and~~
- ~~Voltage Stability Ratings: Section 5.~~
- ~~System Voltage Limits:~~
 - o ~~Section 3.2.~~
 - o Section 5

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PJM Actions:

- Perform periodic review of facilities and margins as needed after seasonal assessment (OATF Inter regional Winter/Summer) studies are completed.
- Discuss identified IROL with the impacted TO/TOP(s).
- Develop ~~ed~~ Operations Guide for each IROL
- Document Transmission Operator load shedding program
- Develop PI display for each IROL
- Provide IROL training to system operators
- Develop IROL visualization
- Distribute Manual 37 documentation to external systems and provide a response to technical comments within 45 calendar days of receipt to include whether a change will be made to the SOL/IROL Methodology documentation, including reason.

PJM Member Actions

- Participate in periodic review of IROL facilities as part of seasonal assessment (OATF-Inter regional Winter/Summer).
- Discuss identified IROL with PJM staff.
- Understand IROL Operations Guide
- Document load shedding program
- Provide IROL training to system operators

3.2 Monitoring of SOL and IROL Limits

Monitoring of the SOL and IROL limits is accomplished through the use of the tools described in the PJM Transmission Operations Manual, M-03, Sections 2 and 3. [NERC Standard IRO-003, R1, R2]

PJM monitors SOL and IROL limits via the PJM EMS. PJM Dispatch prioritizes constraints based on the impact to System Reliability. IROL facilities are facilities that if exceeded have the potential to result in wide-area voltage collapse. All BES facilities



and “Reliability and Markets” sub-BES facilities as listed on the PJM [Transmission Facilities](#) pages are considered System Operating Limits (SOL), including the subset of SOLs that make up the PJM defined IROLs. Clear guidance and supporting procedures are essential to ensure proper prioritization when attempting to mitigate multiple constraints. This includes guidance when generating units are not following dispatch instructions and the appropriate use of Post-Contingency Local Load Relief Procedures. The following list of actions provides general prioritization guidelines, recommended operator actions, and associated timelines for SOL and IROL limits.

PJM Actions:

- PJM Dispatch shall confirm pre-/post-contingency flows and ratings with PJM TO/TOP or external RC.
- PJM Dispatch shall proactively propagate constraints into SCED in order to prepare for unanticipated system events. Constraints above 95% shall be propagated into SCED, but not necessarily bound.
- PJM Dispatch shall evaluate and prioritize constraints, looking for common controlling actions. In general, constraints shall be prioritized in the following manner. Actual violations may hold a higher priority depending on their magnitude and voltage level.
 - Non-Converged contingencies
 - IROL Violations
 - Reactive Transfers
 - Actual Violations
 - Contingency Violations
- PJM dispatch shall utilize SCED to ensure the proper re-dispatch of the system when unanticipated system events force multiple constraints.
- PJM Dispatch shall implement controlling actions in the following order if time permits:
 - Non-cost measures
 - Curtailing “Not-willing-to-pay” transactions that adversely impact constraint.
 - Cost-Effective re-dispatch:
 - Dispatch sufficient generation to control constraints within the allotted timeframe.
 - Initiate Market-to-Market (M2M) Re-dispatch for reciprocally coordinated flowgates
 - Review regulation assignments and their impact on constrained operations. Localized constraints may require de-committing specific regulating units.
 - Direct generation shift via SCED and phone to ensure generation is following set-points.

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- Review initial dispatch orders to ensure cost-effective constraint control.
- Monitor generation dispatch and contact units that are not performing.
- Manually direct generation as required
 - ~~Market to Market Re-dispatch~~
- Emergency Procedures (as detailed in PJM Manual 13), including “safe operating mode” and TLR (note: TLR for excessive circulation may be declared prior to initiating off-cost). Curtail transactions that source/sink in priority order if there is insufficient time to declare TLR. Adjust internal curtailments per IDC.
- If there are insufficient resources available to control constraints within 60 minutes, dispatch shall have formulated and communicated a load ~~dump shed~~ plan to impacted TO/TOP, issuing a Post-Contingency Local Load Relief Procedure (for facilities 230 kV and below) or Manual Load Dump Warning (for facilities 230 kV and above).
- ~~Manually direct generation as required~~
- Direct manual load shed as required via:
 - Load Shed Directive
 - Manual Load Dump Action
- Report IROL Limit violation exceeding 30 minutes (T_v) or any SOL violations that have become an IROL violation because of changed system conditions to the Regional Reliability Organization (RRO) and NERC within 24 hours.
- Report SOL Limit violations that exceed the following criteria:
 - Thermal Ratings: flow exceeds the time limit associated with the rating (i.e. normal limit = 24 hours, LTE limit = 4 hours, STE limit = 30 minutes - 2 hours, LD – 15 minutes).
 - Transient Stability Ratings and Voltage Stability Ratings: Stability limitation exceedances for 30 minutes or greater based on limits provided in Section 3 & 5 of Manual M-03 or the most current real-time analysis.
 - System Voltage Limits: a valid non-radial, non-converged system contingency (unsolved) observed in real-time Security Analysis for 30 minutes or greater.

PJM Member Actions:

- PJM Dispatch shall confirm pre-/post-contingency flows and ratings with PJM TO/TOP or external RC.
- TO/TOP Dispatch shall monitor facilities and communicate limit violations to PJM Dispatch.
- Generation Owner Dispatch shall follow SCED desired set point.

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- Generation Owner Dispatch shall communicate generator issues that will prohibit units from following SCED desired set points.

A chart that demonstrates the order which PJM Reliability Coordinators prioritize constraints, available actions and associated timelines are included within this manual as Attachment C – Constraint Prioritization.



Section 4: Transmission Loading Relief (TLR)

This is the Transmission Loading Relief section of the *PJM Manual for Reliability Coordination*. In this section you will find the following information:

- How PJM uses TLR and other procedures to implement loading relief on transmission lines.
- How PJM responds to TLRs issued by neighboring RCs

4.1 Initiating the NERC TLR Process

PJM monitors designated transmission facilities within the PJM RTO as well as tie-lines with adjacent interconnected control areas. When PJM determines overload conditions exist on any designated facility, or would exist for the first contingency loss of another facility, PJM will take all reasonable necessary action(s) to restore transmission facilities within operating security limits.

PJM will generally not use TLR to mitigate a transmission overload (actual or simulated) unless it has exhausted all other means available, short of load shedding (reconfiguration, re-dispatch within the PJM market area, market-to-market (M2M) re-dispatch with MISO, etc.).

During periods of excessive circulation, PJM may use TLR and curtail transactions that are not willing to pay congestion on the PJM system. However, under normal system conditions, PJM will re-dispatch internal generation to the extent possible and if more relief is needed, PJM will perform the following actions:

- Invoke the NERC Transmission Loading Relief Procedure, in accordance with NERC Standard IRO-006-1, IRO-006-EAST and NAESB Business Practice WEQ-008
- Curtail external transactions and/or charge external customers for the cost of congestion as specified in the PJM Open Access Transmission Tariff

If all transactions for which transmission customers have elected not to pay through congestion have been curtailed and further relief is still required on the transmission facility, PJM will begin to curtail all transactions (internal and external) for which transmission customers have elected to pay through congestion, in priority order. [NERC Standard IRO-006-EAST, R1-R6]

PJM Actions:

- PJM implements all non-cost measures to control transmission flows.
- PJM curtails transactions with transmission service in PJM that are “not willing to pay through congestion”.
- PJM adjusts output of generators off-cost to alleviate overloads/implements M2M.



- PJM re-dispatches to the fullest extent possible, excluding Maximum Emergency Generation, and initiates the NERC TLR procedure via the IDC. [NERC Standard IRO-006-EAST R1]
 - PJM will re-evaluate the TLR level at least every clock hour and reissue the TLR via the NERC IDC as needed.
 - PJM will monitor the NERC IDC to confirm that all impacted RCs acknowledge the curtailments required in the IDC TLR curtailment report. If curtailments are not acknowledged in a timely manner, PJM will contact the RC to determine if there is a reliability concern and coordinate alternate mitigation options as necessary.
- PJM curtails external transmission customers not willing to pay through congestion and charges other external customers willing to pay for the cost of congestion, as set forth in the PJM Open Access Transmission Tariff.
- PJM curtails transmission customers willing to pay through congestion (and no longer charges those curtailed for congestion) in priority order.

PJM Member Actions:

- External transmission customers may elect, in accordance with section 1.10.6A of the Open Access Transmission Tariff, to pay congestion charges during Transmission Loading Relief in the PJM RTO.
- PJM transmission customers may elect to curtail their own transactions at any time if congestion charges have become too great.

4.2 Responding to the NERC TLR Process

PJM monitors the NERC IDC tool continuously and responds to all RC requests for congestion management actions via the TLR process.

PJM Actions:

- PJM Monitors the NERC IDC tool at all times.
- PJM acknowledges, within 15-minutes, any congestion management actions to be implemented by the external RC initiating the TLR procedure, which may include transaction curtailments, Market Flow curtailment, transmission reconfiguration, Native Load curtailment, etc. provided such actions will not result in a reliability concern. If they would, PJM will contact the issuing RC and develop an alternate plan of action to address both reliability needs.



Section 5: Coordination with Neighboring Reliability Coordinators

Welcome to the Coordination with Neighboring Reliability Coordinators section of the **PJM Manual for Reliability Coordination**. In this section, you will find the following information:

- A summary of coordination agreements between PJM and neighboring Reliability Coordinators.
- How PJM communicates with neighboring Reliability Coordinators.
- How PJM works with neighboring Reliability Coordinators to mitigate operational problems.

5.1 Agreements with Neighboring Reliability Coordinators

PJM has developed coordination agreements with its neighboring Reliability Coordinators, as follows:

Joint Operating Agreement between the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection, L.L.C.

(See PJM Website link:

<http://pjm.com/media/documents/merged-tariffs/miso-joa.pdf>)

Joint Reliability Coordination Agreement among and between PJM Interconnection, L.L.C., and Tennessee Valley Authority

(See PJM Website link:

<http://pjm.com/~media/documents/agreements/joint-reliability-coordination-agreement-miso-pjm-tva.ashx>)

Joint Operating Agreement between New York Independent System Operator, LLC and PJM Interconnection, L.L.C.

(See PJM Website link:

<http://pjm.com/~media/documents/agreements/20090910-vft-facility-protocol.ashx>)

Joint Operating Agreement between VACAR South and PJM Interconnection, L.L.C.

(See PJM Website link:

<http://pjm.com/~media/documents/agreements/executed-pjm-vacar-rc-agreement.ashx>)



Joint Operating Agreement between Duke Energy Progress and PJM Interconnection, L.L.C.

(See PJM Website link:

<http://www.pjm.com/media/documents/merged-tariffs/progress-joa.pdf>

The coordination agreements detail requirements to which both parties are committed to preserve reliability. The agreements address a wide range of topics, including data exchange, ATC calculation, outage coordination, emergency operations, etc. These agreements provide for the ongoing cooperation between the signatories by the establishment of joint operating committees that meet periodically to discuss and resolve operational issues. [NERC Standard IRO-014, R1, R2, R3, R4]

5.2 Communications with Neighboring Reliability Coordinators

5.2.1 Communications Facilities

PJM communicates with its neighboring Reliability Coordinators in a number of ways, governed by the urgency of the issue. The communications vehicles include:

- Regular telecommunications over the public switched telephone network
- Satellite telephones
- E-mail
- Reliability Coordinators Information System (RCIS)
- NERC Hotline

5.2.2 Required Notifications

Certain operational situations are of a magnitude that notification to neighboring Reliability Coordinators is necessary. These situations are explained in PJM Manual M-13, Emergency Operations. They include:

- Capacity Emergencies
- Extreme Weather—e.g. Tornadoes, Hurricanes, Extreme Temperatures, Solar Magnetic Disturbances, etc.
- Sabotage or Terrorism Incidents (if the event is significant to the PJM system and may impact neighboring systems)
- Transmission Security Emergencies—Heavy Load/Low Voltage situations, IROL limit violations (if the emergency could cause an impact on the neighboring Reliability Coordinator's system)
- Other events—Events which are of such a nature or magnitude that they could impact the operations of the neighboring Reliability Coordinator(s), in the judgment of the operator.

In addition, the PJM Reliability Coordinator is responsible to monitor system frequency and ACE control.



The preferred communications method in the above situations is the telephone with a message also being entered on the RCIS. [NERC Standard IRO-015, R1]

PJM Actions:

- Monitor the transmission system and other media news and weather outlets to identify threats or risks to the reliability of the system.
- If an emergency situation, identified above, is in progress, or imminent, provide notification to the neighboring Reliability Coordinators by phone or conference call. Also, enter a message on the RCIS. If the situation is of a magnitude that coordinated action or assistance may be necessary, organize a conference call on the NERC hotline, or commercial teleconferencing service.
- If the situation is sabotage or terrorism related, notify the appropriate law enforcement authorities.
- Once the situation is concluded, provide a notification as in 2 above that the situation has been concluded and that no further action is required.

PJM Member Actions:

- Monitor system conditions and identify potential or actual emergency situations to PJM as soon as possible to permit PJM to organize assistance from the neighboring Reliability Coordinators, if required.
- Follow directives from PJM that may come from neighboring Reliability Coordinators to implement action to mitigate the emergency situation.

5.3 Mitigating Operational Problems

Rapid, coordinated action is sometimes necessary to mitigate or alleviate an operational problem. Such action may require assistance from a neighboring Reliability Coordinator(s). In these situations, clear, concise communications are necessary to develop a coordinated action plan that can be implemented quickly. When working with other Reliability Coordinators, the key is to gain a mutual understanding of the problem at hand and how the other Reliability Coordinator may be of assistance. When a mutually agreed upon course of action cannot be developed, then implement the most conservative course of action. [NERC Standard IRO-016, R1]

PJM Actions:

- As part of the notification processes described above, or immediately thereafter, contact the neighboring Reliability Coordinator, if there is the potential for assistance. Concisely, yet fully, explain the situation and how the neighboring Reliability Coordinator could be of assistance.
- Be responsive to the needs of the neighboring Reliability Coordinator to require additional information to assess their ability to provide assistance. Provide any necessary information that may be needed to analyze the situation and develop a corrective action. [NERC Standard IRO-015, R3]
- PJM Reliability Coordinator shall document, in PJM SmartLog system, the need to enhance the PJM EMS Bulk Electric System external model based on real-time system conditions. The PJM Reliability Coordinator shall communicate the



need to enhance the PJM EMS Bulk Electric System external model to PJM Engineering Support via e-mail.

- Work to achieve a consensus on the course of action to be followed. In the absence of a consensus, adopt the most conservative course of action. Through the course of the discussions and during the implementation of the course of action, document steps taken and points of disagreement in the operator logs. [NERC Standard IRO-016, R2]

PJM Member Actions:

- Follow directives from PJM that may come from neighboring Reliability Coordinators to implement action to mitigate the emergency situation.



Attachment A: PJM Reliability Plan



Working to Perfect the Flow of Energy

PJM RTO Reliability Plan





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Introduction

The North American Electric Reliability Corporation (NERC) requires every Region, sub-region, or interregional coordinating group to establish a Reliability Coordinator to provide the reliability assessment and emergency operations coordination for the Balancing Authorities and Transmission Operators within the Regions and across the Regional boundaries.

PJM Interconnection, LLC (PJM) serves as the Reliability Coordinator (RC) for its transmission-owning members. PJM is responsible for regional system reliability, which includes responsibility for both the Bulk Electric System, and lower voltage facilities that have been turned over to PJM for operational control. The PJM functions associated with the reliability of the Bulk Electric System include review and approval of planned facility transmission line outages and generation outages based upon current and projected system conditions, monitoring of real time loading information and calculating post-contingency loadings on the transmission system, administering loading relief procedures, re-dispatch of generation, and ordering curtailment of transactions and/or load. PJM operates a single Balancing Authority (BA) in its footprint and is also responsible for system control performance. PJM reliability procedures and policies are consistent with NERC and Regional Reliability Organization (RRO) Standards. PJM operates in multiple NERC RROs and recognizes each RRO's policies and standards.

This plan supersedes the previous PJM RTO Plan. This plan is provided to document the entry of the following systems into the PJM BA ~~as follows~~:

~~East Kentucky Power Cooperative~~

~~(NCR01225) Effective date: June 1, 2013~~

International Transmission Company (ITC)

(NCR11638) Effective date: June 1, 2016

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A. Responsibilities -- Authorization

1. Authority to Act - PJM is responsible for the reliable operation of the Bulk Electric System within its Reliability Coordination Area in accordance with NERC Standards, Regional policies and standards. PJM's authority to act is derived from a set of agreements that all PJM members have executed (See Appendix A). PJM has clear decision-making authority to act and to direct actions to be taken by its members within its Reliability Coordination Area to preserve the integrity and reliability of the Bulk Electric System.
 - 1.1. PJM has a Wide Area view of its Reliability Coordination Area and neighboring areas that have an impact on PJM's area. PJM has the operating tools, processes and procedures, including the authority, to prevent or mitigate emergency operating situations in both next-day analysis and during real-time conditions per the NERC Standards and Regional policies and standards, as well as the governing documents listed in Appendix A of this document.
 - 1.2. PJM has clear decision-making authority to act and to direct actions to be taken by its members within its Reliability Coordination Area to preserve the integrity and reliability of the Bulk Electric System. PJM's responsibilities and authorities, as well as its members' responsibilities, are clearly defined in the governing documents.
 - 1.3. PJM has not delegated any of its Reliability Coordinator responsibilities.
2. Independence - PJM will act in the best interest of insuring reliability for its Reliability Coordination Area and the Eastern Interconnection before that of any other entity. This expectation is clearly identified in the governing documents (see Appendix A).
3. PJM Directives Compliance - Per the governing documents (see Appendix A), the PJM local control centers shall carry out required emergency actions as directed by PJM, including the shedding of firm load if required, unless such actions would violate safety, equipment, regulatory, or statutory requirements.



B. Responsibilities – Delegation of Tasks

1. PJM has not delegated any Reliability Coordination tasks.

C. Common Tasks for Next-Day and Current-Day Operations

This section documents how PJM conducts current-day and next-day reliability analysis for its Reliability Coordination Area.

1. Determination of Interconnection Reliability Operating Limits (IROLs) – PJM determines IROLs based on local, regional and inter-regional studies including seasonal assessments and ad hoc studies. The majority of the PJM IROLs are voltage stability interfaces.

During real time operations, PJM calculates the actual flow for the reactive interface IROLs using Transmission Limit Calculator (TLC). TLC uses a state estimator snapshot, calculates a voltage collapse transfer limit, and establishes an operating limit based on a back off from the calculated collapse point. These limits are calculated approximately every 5 minutes using the current system topology and posted to the PJM website in close to real time.

2. Operation to prevent the likelihood of a SOL or IROL violation in another area of the Interconnection and operation when there is a difference in limits - PJM, through the Joint Operating Agreement with other Reliability Coordinator neighbors, coordinates operations to prevent the likelihood of a SOL or IROL in another area. These agreements include data exchange, Available Transfer Capability coordination, and Outage Coordination and are listed in Appendix B.

Local control centers in the PJM Reliability Coordination Area are required to follow directives provided by PJM and operate to NERC Standards to prevent the likelihood that a disturbance, action, or non-action in its Reliability Coordination Area will result in a SOL or IROL violation in another area of the Interconnection. When there is a difference in derived limits, PJM utilizes the most conservative limit until the difference is resolved.

3. Operation under known and studied conditions and re-position without delay and no longer than 30 minutes – PJM ensures that entities within its Reliability Coordination Area always operate under known and studied conditions and that they return their systems to a secure operating state following contingency events within approved timelines, regardless of the number of contingency events that occur or the status of their monitoring, operating and analysis tools. PJM also ensures its local control centers re-position the system to be within all IROLs following contingencies within 30 minutes.

On a daily basis, PJM conducts next-day security analysis utilizing planned outages, forecasted loads, generation commitment, and expected net interchange. The analyses include contingency analysis and voltage stability analysis on key interfaces. These analyses model peak conditions for the day and are conducted utilizing first contingency (n-1) analysis. Results and mitigation are documented in the Next-Day Security Analysis



Report and distributed to PJM staff and neighboring Reliability Coordinators. The Next-Day Security Analysis Report is also e-mailed to the PJM local control centers and neighbors. Mitigation plans are formed as needed for potential violations determined in the next day security analysis.

In real time, PJM relies on its telemetry and real-time analysis tools to monitor the real time system conditions to identify potential IROL and SOL problems. PJM's operational philosophy is to operate on a pre-contingency basis; that is, to mitigate a simulated overload condition before it occurs.

4. PJM provides transmission service within the PJM Reliability Coordination area. PJM communicates IROLs within its wide-area view and provides updates as needed via reports, morning conference calls, and the ALL-CALL system and real-time via voice and messaging.
5. PJM process for issuing directives – PJM uses a number of communications tools for issuing/receiving of directives. The primary communications means is the PJM All-Call System (All-Call) which is a dedicated telephone-based system which sends the directive / message to all control centers simultaneously and confirms response. In addition, PJM will issue follow the verbal message with Emergency Procedures messages on its website through a specific application that runs within its Data Viewer tool and as well direct phone contact as necessary.



D. Next Day Operations

This section documents how PJM conducts next-day reliability analysis for its Reliability Coordination Area.

1. Reliability Analysis and System Studies - PJM conducts next-day reliability analyses for its Area to ensure that the Bulk Power System can be operated reliably in normal and post contingency conditions.

On a daily basis, PJM conducts next-day security analysis utilizing known outages, forecasted loads, generation commitment and dispatch, and expected net interchange using the study capability in the PJM EMS. Base case flows on all monitored facilities compared against the normal rating. Post-contingency flows for all monitored facilities are compared against their emergency rating for all contingencies. Voltage stability analysis is conducted on key critical interfaces to determine a flow limit.

Mitigation plans are formed as needed for potential violations determined in the next day security analysis. Mitigation is of the form of additional generation commitment, system reconfiguration, generation redispatch, use of NERC TLR or other local flow mitigation procedures.

2. Information Sharing –Generation Owners and Transmission Owners in the PJM Reliability Coordination Area and neighboring Reliability Coordinator areas provide to PJM all information required for system studies, such as critical facility status, load, generation, Operating Reserve projections, and known interchange transactions.

The entities in the PJM Reliability Coordination Area provide generation and transmission facility statuses to the PJM outage scheduling application (eDART), forecasted loads, operating reserves, and known interchange transactions via e-tags. PJM shares this information via an SDX file every ten minutes. For entities outside PJM, SDX files are downloaded and loaded into appropriate systems.

3. Sharing of Study Results - When conditions warrant or upon request, PJM shares the results of its system studies with the entities within its Reliability Coordination Area and/or with other Reliability Coordinators. Study results for the next day shall be available no later than 15:00 Eastern Prevailing Time, unless circumstances warrant otherwise.

A Next-Day Security Analysis Report is distributed to PJM and member operations staff and neighboring Reliability Coordinators via e-mail. PJM holds daily conference calls with MISO, and others, as necessary, as part of this process.

E. Current-Day Operations

This section documents how PJM conducts current-day reliability analysis for its Reliability Coordination Area.

1. PJM uses a suite of real time network analysis tools to continuously monitor all Bulk Power System facilities, including sub-transmission information as needed, within the PJM Reliability Coordination Area and adjacent areas, as necessary, to ensure that, at any time, PJM is able to determine any potential SOL and IROL violations within its Reliability Coordination Area.

PJM utilizes a state estimator and real-time contingency analysis as the primary tool to monitor facilities. The state estimator model includes all BES as well as facilities, generally 69 kV and above, in the PJM Reliability Coordination Area. The model also has extensive representation of neighboring facilities in order to provide an effective wide-area view. This model is updated quarterly and may be updated on demand for emergencies.

Real Time Contingency Analysis (RTCA) is performed on contingencies utilizing the state estimator model approximately every 1-2 minutes. Contingencies include all PJM Reliability Coordination Area equipment which has been turned over to PJM for operational control, and neighboring contingencies that would impact PJM Reliability Coordination Area facilities.

In order to continuously monitor its reactive interfaces, PJM uses a real time calculation tool named Transmission Limit Calculator (TLC). TLC takes a state estimator snapshot and calculates a voltage collapse equivalent flow for the interface, based on current real time telemetry and topology. A back off flow is established to prevent an actual voltage collapse as the limit, and PJM operates to maintain flows below the limit.

SCADA alarming is utilized to alert PJM of any actual low or high voltages or facilities loaded beyond their normal or emergency limits.

In addition to the above applications, PJM utilizes a dynamically updated transmission overview display to maintain a wide area view. All transmission facilities 500 kV and above are depicted on the overview with flows (MW and MVAR), indication of facilities out of service, high and low voltage warning and alarming. For more detailed monitoring, bus level one-line diagrams are utilized for station level monitoring and information. The one-line diagrams are populated with the real time telemetered information as well as the state estimated solution.

- 1.1. PJM notifies neighboring Reliability Coordinators of operational concerns (e.g. declining voltages, excessive reactive flows, or an IROL violation) that it identifies within the neighboring Reliability Coordination Area via direct phone calls, conference calls, NERC hotline calls, and/or RCIS messages. PJM has joint operating



agreements with neighboring Reliability Coordinators that are listed in Appendix B. PJM directs actions to provide emergency assistance to all Reliability Coordination neighbors, during declared emergencies, which is required to mitigate the operational concern to the extent that the same entities are taking in kind steps and the assistance would be effective.

2. PJM maintains awareness of the status of all current critical facilities whose failure, degradation or disconnection could result in an SOL or IROL violation within its Reliability Coordination Area via State Estimator, RTCA, SCADA alarming, and transmission displays. PJM is aware of the status of any facilities that may be required to assist Reliability Coordination Area restoration objectives via these same displays and tools.
3. PJM is continuously aware of conditions within its Reliability Coordination Area, and includes real time information in its reliability assessments via automatic updates to the state estimator, TLC, and transmission displays. PJM monitors its Reliability Coordination Area parameters, including the following:
 - 3.1. Current status of Bulk Power System elements (transmission or generation including critical auxiliaries) such as Automatic Voltage Regulators, Special Protection Systems, and system loading are monitored by state estimator, RTCA, SCADA Alarming, and transmission displays. PJM members are required to report to PJM when Automatic Voltage Regulators are not in-service or status changes of Special Protection Systems.
 - 3.2. Current pre-contingency element conditions (voltage, thermal, or stability) are monitored by state estimator, SCADA Alarming, TLC, and transmission displays.
 - 3.3. Current post- contingency element conditions (voltage, thermal, or stability) are monitored by RTCA, TLC, and transmission displays.
 - 3.4. System real reserves are monitored versus what is required in EMS. Reactive reserves versus what is required are monitored via monitoring adequacy of calculated post-contingent steady state voltages versus voltage limits, voltage stability interfaces against limits, and reactive reserves versus required for defined zones. Reactive Reserve Checks are made as needed when reactive reserves in real-time indicate that they are lower than expected.
 - 3.5. Capacity and energy adequacy conditions are determined Day Ahead (DA) and monitored real time in accordance with our Market Processes to maintain the required levels of reserves.
 - 3.6. Current ACE and System Frequency are displayed in a trend chart to the PJM Generation Dispatcher as part of the BAAL field test. PJM is participating in the NERC BAAL field test and adheres to this system control requirement.



- 3.7. Current local procedures, such as operating procedures, are monitored and coordinated with local control centers and implementation documented in the PJM logs. TLR procedures in effect are monitored via the NERC Interchange Distribution Calculator, and also documented on the PJM logs.
- 3.8. Generation dispatching is performed for the PJM balancing authority area by the PJM Generation Dispatcher using the Security Constrained Economic Dispatch (SCED) application, which is a single economic constraint controlled dispatch for the entire PJM RTO area.
- 3.9. Planned transmission or generation outages are reported to PJM via the eDART application. The eDart application tickets, once approved and implemented, automatically update the EMS model.
- 3.10. Contingency Events are monitored by state estimator, RTCA, SCADA Alarming, and transmission displays. Local control centers report Contingency Events on non-monitored facilities to PJM.
4. PJM monitors Bulk Power System parameters that may have significant impacts upon its Reliability Coordination Area and neighboring Reliability Coordination areas with respect to:
 - 4.1. PJM maintains awareness of all Interchange Transactions that wheel-through, source, or sink in its Reliability Coordination Area via NERC E-tags and NERC IDC displays. Interchange Transaction information is made available to all Reliability Coordinators via NERC E-tags. PJM monitors internal transactions in its market area via the PJM ExSchedules application.
 - 4.2. PJM evaluates and assesses any additional Interchange Transactions that would violate IROL or SOLs by using the NERC IDC as a look-ahead tool. As flows approach their IROL or SOLs, PJM evaluates the incremental loading next-hour transactions would have on the SOLs or IROLs and determines if action needs to be taken to prevent and SOL or IROL violation. PJM has the authority to direct all actions necessary and may utilize all resources to address a potential or actual IROL violation up to and including load shedding. PJM has EMS displays, including the reactive interface limits screen that is designed so the operators can watch and monitor specific IROL limits.
 - 4.3. PJM monitors Operating Reserves versus each Regional requirement to ensure the required amount of Operating Reserves is provided and available as required to meet NERC Control Standards via EMS and meet the Regional obligation. If necessary, PJM will commit additional reserves including obtaining assistance from neighbors as needed.
 - 4.4. PJM identifies the cause of potential or actual SOL or IROL violations via analysis of state estimator results, RTCA results, SCADA Alarming of outages, TLC results, transmission displays of changes, and Interchange Transaction impacts. PJM will initiate control actions



including transmission reconfiguration, generation redispatch, or emergency procedures to relieve the potential or actual IROL violation without delay, and no longer than 30 minutes. PJM is authorized to direct utilization of all resources, including load shedding, to address a potential or actual IROL violation. PJM will not solely rely on the NERC TLR procedure to mitigate an IROL violation.

- 4.5. PJM complies with the start and end times for time error corrections as communicated by the Time Monitor. PJM communicates Geo-Magnetic Disturbance forecast information to local control centers and Generation Operators via the All-Call System and the Emergency Procedures webpage. PJM will assist in development of any required response plan and may move to conservative operating mode to mitigate impacts as needed.
- 4.6. PJM participates in NERC Hotline discussions, assists in the assessment of reliability of the Regions and the overall interconnected system, and coordinates actions in anticipated or actual emergency situations. PJM will disseminate this information via the All-Call system or individual phone calls.
- 4.7. PJM monitors system frequency and ACE via trend graph. Since PJM is participating in the NERC Balancing Standard Field Test, if the BAAL is outside of the acceptable range, then the PJM Regulation will be manually adjusted, if necessary, to utilize the support resources for frequency mitigation. PJM will utilize all resources, including firm load shedding, to relieve the emergent condition.
- 4.8. PJM coordinates with other Reliability Coordinators and its Generation Operators and local control centers, as needed, on the development and implementation of action plans to mitigate potential or actual SOL, IROL, BAAL or DCS violations. PJM coordinates pending generation and transmission maintenance outages with other Reliability Coordinators and its Generation Operators and local control centers, as needed and within code of conduct requirements, real time via telephone and next-day, per the PJM outage scheduling process.
- 4.9. PJM will assist or request assistance as the Balancing Authority Operator for the RTO from neighboring Reliability Coordinators via the Energy Emergency Alert (EEA) notification process and will conference parties together as appropriate.
- 4.10. PJM monitors its ACE to identify the sources of problems contributing to frequency, time error, or inadvertent interchange and directs corrective actions per 4.7 above.
- 4.11. The local control centers within PJM's Reliability Area inform PJM of all changes in status of Special Protection Systems (SPS) including any degradation or potential failure to operate as expected by the local control center. PJM factors these SPS changes into its reliability analyses and updates its' contingency definitions as appropriate.



5. PJM issues alerts, as appropriate, to local control centers via the All-Call system, individual phone calls, when it foresees a transmission problem (such as an SOL or IROL violation, loss of reactive reserves, etc.) within its Reliability Area that requires notification. PJM issues alerts, as appropriate, to all Reliability Coordinators via the Reliability Coordinator Information System when it foresees a transmission problem (such as an SOL or IROL violation, loss of reactive reserves, etc.) within its Reliability Area that requires notification.
6. PJM confirms reliability assessment results via analyzing results of state estimator/RTCA, and discussions with local control centers and neighboring Reliability Coordinators. PJM identifies options to mitigate potential or actual SOL or IROL violations via examining existing operating procedures, system knowledge, and power flow analysis to identify and implement only those actions as necessary as to always act in the best interests of the interconnection.



F. Emergency Operations

1. PJM utilizes PJM Manual M-13, Emergency Operations, to direct its Members to return the transmission system to within IROL or SOL limits as soon as possible, but no longer than 30 minutes. This procedure includes the actions (e.g. reconfiguration, re-dispatch or load shedding) that PJM will direct until relief requested by the TLR process is achieved.
2. PJM utilizes PJM Manual M-13, Emergency Operations, when it determines that IROL violations are imminent. PJM Emergency Operations documents the processes and procedures that PJM follows when directing the re-dispatch of generation, reconfiguring transmission, managing Interchange Transactions, or reducing system demand to mitigate the IROL violation to return the system to a reliable state. PJM coordinates its alert and emergency procedures with other Reliability Coordinators via joint operating agreements listed in Section H.
3. PJM directs actions in the event the loading of transmission facilities progresses to or is projected to progress to a SOL or IROL violation.
 - 3.1 PJM directs reconfiguration and re-dispatch within its market area as needed to prevent or relieve SOL or IROL violations. PJM will not rely on or wait for NERC TLR to relieve IROL violations. PJM will implement NERC TLR if doing so will provide additional relief. PJM will adhere to the NERC TLR congestion report instructions including curtailing transactions and re-dispatching for market flow.
 - 3.2 PJM utilizes market-to-market re-dispatch for its market area for reciprocally coordinated flowgates with MISO per the Congestion Management Process (see Appendix B). PJM also coordinates flowgate limits and monitors flows on facilities within TVA, Duke, Progress Energy and other RC areas in order to maintain reliable operation.
 - 3.3 PJM uses market re-dispatch, in conjunction with NERC TLR per the NERC IDC congestion relief report.
 - 3.4 PJM complies with the provisions of the NERC TLR by curtailing Interchange Transactions and re-dispatching for market flow per the NERC IDC congestion relief report.
 - 3.5 PJM will direct reconfiguration, re-dispatch for market areas, and NERC TLR reductions to relieve facilities as necessary. PJM will not rely on NERC TLR as an emergency action.
4. PJM monitors its ACE, and directs action to assist in maintaining system frequency to return within L10 or BAAL limits as appropriate.
5. PJM utilizes PJM Manual M-13, Emergency Operations, to mitigate an energy emergency within its Reliability Coordination Area. PJM will provide



assistance to other Reliability Coordinators per its respective joint operating agreement listed in Appendix B.

6. PJM utilizes PJM Manual M-13, Emergency Operations, when it, or a Reserve-Sharing Group, or a Load-Serving Entity within its Reliability Coordination Area is experiencing a potential or actual Energy Emergency. PJM Emergency Operations document the processes and procedures that PJM uses to mitigate the emergency condition, including a request for emergency assistance if required.
7. PJM also drills at least annually with its members on Emergency procedures.



G. System Restoration

1. Knowledge of PJM Transmission Owner Restoration Plans - PJM is aware of each transmission owner Restoration Plan and has a written copy of each plan. During system restoration, PJM monitors restoration progress and acts to coordinate any needed assistance. PJM may direct the restoration activities, depending on system conditions.
2. PJM Restoration Plan – The PJM Restoration Procedures are contained in PJM Manual M-36, System Restoration. PJM takes action to restore normal operations once an operating emergency has been mitigated in accordance with its Restoration Plan. This Restoration Plan is drilled at least annually.
3. Dissemination of Information - PJM serves as the primary contact for disseminating information regarding restoration to neighboring Reliability Coordinators and members not immediately involved in restoration.

PJM approves, communicates and coordinates the re-synchronizing of major system islands or synchronizing points so as not to cause a burden on member or adjacent Reliability Coordination Areas.



H. Coordination Agreements and Data Sharing

1. Coordination Agreements:
See Appendix B
2. Data Sharing - PJM determines the data requirements to support its reliability coordination tasks and requests such data from members or adjacent Reliability Coordinators. PJM provides for data exchange with local control centers and adjacent Reliability Coordinators via a secure network. PJM members provide data to PJM via ICCP. PJM provides data to entities outside PJM via direct links and ISN.



I. Facility

PJM performs the Reliability Coordinator function at the PJM Headquarters in Valley Forge, PA along with the PJM Milford control center in Milford Township, PA. The Valley Forge and Milford offices have the necessary voice and data communication links to appropriate entities within PJM to perform their responsibilities. These communication facilities are staffed and available to act in addressing a real-time emergency condition.

1. Adequate Communication Links - PJM maintains satellite phones, cellular phones, and redundant, diversely routed telecommunications circuits. There is also a video link between the Valley Forge and Milford Control Rooms.
2. Multi-directional Capabilities – PJM has multi-directional communications capabilities with its members, and with neighboring Reliability Coordinators, for both voice and data exchange to meet reliability needs of the Interconnection.
3. Real-time Monitoring - PJM has detailed real-time monitoring capability of its Reliability Coordination Area and all first tier companies surrounding the PJM Reliability Coordination Area to ensure that potential or actual System Operating Limit of Interconnection Reliability Operating Limit violations are identified.
 - 3.1 PJM monitors BES elements (generators, transmission lines, buses, transformers, breakers, etc.) that could result in SOL or IROL violations within its Reliability Coordination Area. PJM monitors both real and reactive power system flows, and operating reserves, and the status of the Bulk Power System elements that are, or could be, critical to SOLs and IROLs and system restoration requirements within its Reliability Coordination Area.
4. Study and Analysis Tools
 - 4.1 PJM has adequate analysis tools, including state estimation, pre-and post-contingency analysis capabilities (thermal, stability, and voltage), and wide-area overview displays. PJM has detailed monitoring capability of the PJM Reliability Area and sufficient monitoring capability of the surrounding Reliability Areas to ensure potential reliability violations are identified. PJM continuously monitors key transmission facilities in its area in conjunction with the Members monitoring of local facilities and issues.

PJM ensures that SOL and IROL monitoring and derivations continue if the main monitoring system is unavailable. PJM has backup facilities that shall be exercised if the main monitoring system is unavailable.

The systems utilized by PJM include:

- State Estimator and Contingency Analysis
- Status and Analog Alarming



- Overview Displays of PJM Transmission System via Wallboard
- One line diagrams for entire PJM Transmission System
- Transmission Limit Calculator
- Voltage Stability Analysis (VSA)
- Transient Stability Analysis (TSA)
- ExSchedules
- Security Constrained Economic Dispatch (SCED)
- Dispatcher Management Tool (DMT)

PJM utilizes these tools, which provide information that is easily understood and interpreted by the PJM operating personnel. The alarm management is designed to classify alarms in priority for heightened awareness of critical alarms.

- 4.2 PJM controls its Reliability Coordinator analysis tools, including approvals for planned maintenance. PJM has procedures in place to mitigate the effects of analysis tool outages.



J. Staffing

1. Staff Adequately Trained and NERC Certified – The 24 x 7 PJM shift operations team is composed as follows:

- 1 Shift supervisor*
- 2 Generation dispatchers*
- 3 to 4 Transmission dispatchers*
- 1 or 2 Master Coordinators

In addition, one or more Reliability Engineers* are on shift from 5:00 AM to 12:00 midnight, 7 days per week.

*All people in these positions possess the NERC Reliability Coordinator certification¹.

- Positions that have the primary responsibility, either directly or through communications with others, for the real-time operation of the interconnected Bulk Electric System.
- Positions directly responsible for complying with NERC and RRO Standards.

Each week, one of the shift teams is assigned to training. The training program consists of a set curriculum which includes tests that each person must successfully complete. At a minimum, each person must complete a minimum of 32 hours per year of training and drills using realistic simulations of system emergencies, in addition to other training required to maintain qualified operation personnel.

2. Comprehensive Understanding - PJM operating personnel have an extensive understanding of the transmission system within the PJM Reliability Coordination Area, including the operating staff, operating practices and procedures, restoration priorities and objectives, outage plans, equipment capabilities, and operational restrictions.

PJM operating personnel place particular attention on SOLs and IROLs and inter-tie facility limits. PJM ensures that protocols are in place to allow PJM operating personnel to have the best available information at all times.

PJM's System Operators are trained to perform their duties, both at entry level and in continuous training status. Successful completion of both written and simulator tests are required for each progression step in the control room job family. A Learning Management System is used to track the status of each operator's progress. In addition to the above training, PJM conducts other training sessions that PJM System Operators are expected to complete.

3. Standards of Conduct - PJM is independent of the merchant function. PJM does not pass transmission information or data to any wholesale merchant function or retail merchant function that is not made available simultaneously to all such wholesale merchant functions. An officer of PJM has signed the



NERC Reliability Coordinators Standards of Conduct. Every PJM employee, not just the operating staff, has completed training on PJM's Standards of Conduct. Refresher training on PJM's Standards of Conduct is conducted every year. Training records are maintained.



APPENDIX A – PJM Governing Documents

PJM Operating Agreement

PJM Website link: <http://pjm.com/media/documents/merged-tariffs/oa.pdf>

PJM Transmission Tariff

PJM Website link:

<http://pjm.com/media/documents/merged-tariffs/oatt.pdf>

APPENDIX B – Agreements with External Entities

Joint Operating Agreement between the Midwest Independent Transmission System Operator, Inc. and PJM Interconnection, L.L.C.

See PJM Website link: <http://pjm.com/media/documents/merged-tariffs/miso-joa.pdf>

Joint Reliability Coordination Agreement among and between PJM Interconnection, L.L.C., and Tennessee Valley Authority

(See PJM Website link:

<http://www.pjm.com/~media/documents/agreements/joint-reliability-coordination-agreement-miso-pjm-tva.ashx>)

Midwest Independent Transmission System Operator, Inc., PJM Interconnection, L.L.C., and Tennessee Valley Authority

Congestion Management Process

See PJM Website link:

<http://www.pjm.com/documents/agreements/~media/documents/agreements/20080502-miso-pjm-tva-baseline-cmp.ashx>

Joint Operating Agreement between New York Independent System Operator, LLC and PJM Interconnection, L.L.C.

See PJM Website link:

<http://pjm.com/~media/documents/agreements/nyiso-joa.ashx>

Joint Operating Agreement between VACAR South and PJM Interconnection, L.L.C.

See PJM Website link:



<http://www.pjm.com/~media/documents/agreements/executed-pjm-vacar-rc-agree>

APPENDIX C: PJM Reliability Area Map





Attachment B: Excerpt from PJM Operating Agreement

Excerpt from PJM Operating Agreement, Section 10.4, as it pertains to the authority of PJM [addressing NERC Standard IRO-001-2, R2]. PJM shall:

- iv) Comply with NERC, and Applicable Regional Reliability Organization (RRO) operation and planning standards, principles and guidelines;
- v) Maintain an appropriately trained workforce, and such equipment and facilities, including computer hardware and software and backup power supplies, as necessary or appropriate to implement or administer this Agreement;
- vi) Direct the operation and coordinate the maintenance of the facilities of the PJM Region used for both load and reactive supply, so as to maintain reliability of service and obtain the benefits of pooling and interchange consistent with this Agreement, and the Reliability Assurance Agreement;
- vii) Direct the operation and coordinate the maintenance of the bulk power supply facilities of the PJM Region with such facilities and systems of others not party to this Agreement in accordance with agreements between the LLC and such other systems to secure reliability and continuity of service and other advantages of pooling on a regional basis;



Attachment C: Constraint Prioritization

THERMAL CONSTRAINT PRIORITY

Priority	Highest				Lowest	
	Non Converged Contingency ←	IROL Facility	Reactive Interfaces	Actual Violations ←→	Contingency Violations	Limit
Highest	15 Minutes Shed load only if necessary to avoid post-contingency cascading. Communicate Load Dump Plan (PCLLRW) prior to 30 minutes if generation response is insufficient to control within 30 minute timeframe	15 Minutes Shed load only if necessary to avoid post-contingency cascading. Communicate Manual Load Dump Plan prior to 30 minutes if generation response is insufficient to control within 30 minute timeframe (Tv) IROL Violations must be controlled within 30 minutes (Tv).	15 Minutes Shed load only if necessary to avoid post-contingency cascading. Communicate Manual Load Dump Plan prior to 30 minutes if generation response is insufficient to control within 30 minute timeframe	5 Minutes Load All available generation. Shed load within 5 minutes to return flows within Emergency Ratings.	30 Minutes Shed load only if necessary to avoid post-contingency cascading. Communicate Load Dump Plan (PCLLRW) prior to 60 minutes if generation response is insufficient to control within 60 minute timeframe	Thermal Load Dump Rating / Reactive Last Convergent Point
	Not Applicable. Refer to Note 1 (below).	Use all effective actions. Communicate Load Dump Action within	Use all effective actions and emergency procedures except load shed.	15 Minutes Load All available generation. Shed load within 15 minutes to return flows within Emergency Ratings.	Use all effective actions and emergency procedures except load shed. Communicate	Thermal Emergency Rating / Reactive Recommended Limit



Priority	Highest				Lowest	
	Non Converged Contingency ←	IROL Facility	Reactive Interfaces	Actual Violations ←	Contingency Violations	Limit
		30 minute timeframe.	Communicate Manual Load Dump Plan prior to 30 minutes if generation response is insufficient to control within 30 minute timeframe		Load Dump Plan (PCLLRW) prior to 60 minutes if generation response is insufficient to control within 60 minute timeframe	
Lowest	Not Applicable. Refer to Note 1 (below).	Trend – continue to monitor. Take non-cost actions to prevent contingency from exceeding emergency limit.	Trend – continue to monitor. Take non-cost actions to prevent contingency from exceeding emergency limit.	15 Minutes Use all effective actions and emergency procedures except load dump. Coordinate load dump plan as overload duration approached LTE/STE rating definition (i.e. 4 hour, 2 hour, 1 hour or 30 minute rating).	Trend – continue to monitor. Take non-cost actions to prevent contingency from exceeding emergency limit.	Thermal Normal Rating / Reactive Operating Point Limit

NOTE 1: ‘Non-Converged Contingencies’ are considered a ‘sliding’ priority, i.e. it can move up or down the priority list based on modeling accuracy or voltage level.

NOTE 2: ‘Actual Violations’ are considered a ‘sliding’ priority, i.e. it can move up or down the priority list based on the specific situation.



CONSTRAINT CONTROL ACTIONS

Priority	Associated Actions
<p>Green</p>	<p>Use all non-cost / cost-effective actions:</p> <ul style="list-style-type: none"> Non-cost measures, including approved switching. Curtailing "Not-willing-to-pay" transactions that adversely impact constraint. Cost-Effective redispatch Dispatch sufficient generation to control constraints within the allotted timeframe. This includes manual redispatch, if necessary. Initiate M2M as appropriate Review regulation assignments and their impact on constrained operations. Localized constraints may require de-committing specific regulating units. Direct generation shift via SCED and phone to ensure generation is following set-points. Review initial dispatch orders to ensure cost-effective constraint control. Monitor generation dispatch and contact units that are not performing. TLR Level 3(note: TLR for excessive circulation may be declared prior to initiating off-cost). Curtail transactions that source/sink in priority order if there is insufficient time to declare TLR. Adjust internal curtailments per IDC.
<p>Yellow</p>	<p>Use all non-cost / cost-effective (Green) and effective actions and Emergency Procedures:</p> <p>Emergency Procedures:</p> <ul style="list-style-type: none"> Loading of Quickstart Generation (regardless of cost) 100% Spinning Reserves (appropriate locations) PJM/MISO Safe Operating Mode, if effective TLR 5 (note: TLR for excessive circulation may be declared prior to initiating off-cost). Curtail transactions that source/sink in priority order if there is insufficient time to



Priority	Associated Actions
	<p>declare TLR. Adjust internal curtailments per IDC.</p> <p>Loading of Maximum Emergency Generation</p> <p>Post-Contingency Local Load Relief Warning</p> <p>If there are insufficient resources available to control constraints within 60 minutes, dispatch shall have formulated and communicated a load dump plan to impacted TO/TOPs, issuing a Post-Contingency Local Load Relief Procedure. Include post-contingency switching / generation trip options as part of Emergency Procedures Posting message.</p>
Red	<p>All of the above plus, shed load if violation still exceeds load dump limit after 5 minutes, Emergency Rating for 15 minutes or to avoid post-contingency cascading situation.</p> <p>Emergency Procedures:</p> <ul style="list-style-type: none">Voltage ReductionManual Load Dump

NOTE: In general, procedures shall be implemented in the following order, however, operating conditions or advance lead time may warrant procedures to be implemented in a different order.



VOLTAGE /REACTIVE PRIORITIES

Voltage Limit Exceeded	Actual Voltage Limits Violated	Post-Contingency Limits Violated
High Voltage	Immediate Use all effective non-cost and off-cost actions.	30 Minutes Use all effective non-cost and off-cost actions.
Normal Low	15 Minutes Use all effective non-cost actions, off-cost actions, and emergency procedures except load dump.	Not Applicable Use all effective non-cost actions.
Emergency Low	5 Minutes All of the above plus, shed load if voltages are decaying.	15 Minutes Use all effective non-cost actions, off-cost actions, and emergency procedures except load shed.
Load Dump Low	Immediate All of the above plus, shed load if analysis indicates the potential for a voltage collapse.	5 Minutes All of the above plus, shed load if analysis indicates the potential for a voltage collapse.
Transfer Limit Warning Point (95%)	Not Applicable Use all effective non-cost actions. Prepare for off-cost actions.	Not Applicable Use all effective non-cost actions. Prepare for off-cost actions.
Transfer Limit	15 Minutes or less All effective non-cost and off-cost actions plus, shed load if analysis indicates the potential for a voltage collapse.	15 Minutes or less All effective non-cost and off-cost actions plus, shed load if analysis indicates the potential for a voltage collapse.



Revision History

Revision 12 (09/01/2015):

- [Section 2.4.2, replaced Change Control Review Board with more detail around PJM's Enterprise Change Management Standard which encompasses the CCRB.](#)
- [Section 3.1, Removed effective date footnote with respect to COMED IROL.](#)
- [Section 3.1, Updated SOL definition to note that PJM controls to the most conservative limits and that IROLs are an elevated SOL rather than being distinct from SOLs.](#)
- [Section 3.1, Removed empty row in IROL table found on page 9.](#)
- [Section 3.2, Added clarification to SOL and IROLs monitored by PJM.](#)
- [Section 3.2, Added clarification to SOL limit violation reporting.](#)
- [Section 5.1, Updated hyperlink for PJM / Duke Energy Progress Joint Operating Agreement \(JOA\). Updated company name from Progress Energy Carolinas to Duke Energy Progress.](#)
- [Administrative Change – Updated references from edata to Data Viewer](#)
- [Periodic Review Complete](#)

Revision 11(08/04/2014):

- Updated references for EES to the new ExSchedules application.
- Removed diversified load reference for the OATF studies in Section 3.1. Also updated contingencies modelled in seasonal OATF studies.
- Removed Kammer 765/500Kv transformer and Belmont 765/500Kv transformer IROLs from the IROL table in Section 3.1.
- Updated SOL definition in Section 3.1 to align with the NERC Standard.
- Updated SOL violation to align with the NERC Standard.
- Changed Attachment D reference to Attachment C at the end of Section 3.2 on page 12.

Revision 10 (04/01/2013):

- Updated the PJM Reliability Plan in Attachment A for EKPC integration effective 6/1/2013.
- Removed Attachment C: Change Control Review Board description. This was an old procedure and was out of date. This PJM Change Management procedure is maintained internally in PJM DOCs #596201.
- Added the ComEd Reactive Transfer Interface within table in Section 3.1 SOL and IROL Limit Determination.



- Relabeled Attachment D to Attachment C.

Revision 09 (02/01/2013):

- **Revised several department names in Section 2.4.1 based on changes from a company realignment**
- **Updated the seasonal assessment study names in Section 3.1**
- **Based upon the FERC Performance Audit Recommendation #23, added a clarifying note to Section 3.1 regarding the time to control thermal IROL exceedances.**

Revision 08 (09/01/2012):

- Annual Review
- Adjusted IROL Load Dump plan to indicate Manual Load Dump, not PCLLRW
- Replaced all UDS references with SCED
- Revised the SOL definition to include all 100kV and select sub-100kV equipment.
- Deleted CWIN reference.

Revision 07 (06/01/2011):

- Annual Review
- Removed OVEC from PJM RC footprint.
- Added the CLVLND Reactive Transfer Interface within table in *Section 3.1 SOL and IROL Limit Determination*.
- Updated Attachment A: PJM RTO Reliability Plan.
- Updated the IROL definition in section 3.1 to match the *NERC Glossary of Terms*
- July 11, 2011 – Updated hyperlink for PJM – VACAR South Reliability Agreement

Revision 06 (01/01/2010):

- Updated SOL definition to include all facilities 230kV and above, removing reference to MP-1.
- Added reference to NAESB Business Practice WEQ-008 and other editorial changes in Section 4

Revision 05 (10/01/2009):

- Updated SOL definition and violation criteria.
- Updated links to Joint Operating Agreements.
- Updated Attachment C: Change Control Review Board

Revision 04 (06/26/2009):



- Annual Review
- Reformatted to assist in compliance tracking.

Revision 03 (02/01/2009)

Added T_v indicator to 30 minute response timeframe to IROL facilities, as appropriate, consistent with NERC standards.

Introduction: added annual review and manual distribution requirement.

Section 3: Added requirement to respond to external systems comments on SOL/IROL methodology within 45 calendar days.

Attachment D: Modified Attachment to change 15 minute threshold to 30 minutes. Changed PCLLRW issuance from 30 minute to 60 minutes. Timing changes based on controlling non-IROL constraints to 100% LTE.

Revision 02 (06/01/2008)

Section 3: Made additional updates to IROL facilities specifically the Kammer 765/500 kV transformer and the Belmont #5 765/500kV transformer Thermal Ratings.

Revision 01 (06/01/2008)

Updated all sections to include Bulk Electric System (BES)

Section 3: Updated IROL facilities

Section 5: Updated Links to Joint Operating Agreements with neighboring Reliability Coordinators.

Attachment A: Updated PJM RTO Reliability Plan

Attachment B: Updated Excerpt from PJM Operating Agreement (bullet vi)

Attachment C: Updated Change Control Review Board to latest version of document

Revision 0 (05/15/2007)

New manual