Conservative Operations
Objectives

The Student will be able to:

• Identify the process and requirements for operating during conservative operations
Triggers for Conservative Operations

• Certain events, conditions, or circumstances may put the Bulk Electric System (BES) at an increased level of risk, compared to normal operating conditions

• In these situations, PJM – as the Reliability Coordinator – must implement additional actions to ensure the BES remains reliable in the face of the additional threats
Triggers for Conservative Operations

• Some conditions which may trigger PJM to implement Conservative Operations include;
  
  – Fuel Delivery Issues
    • Ice/snow impacting fuel deliveries
    • Possible curtailments of Natural Gas supplies
  
  – Forest or Brush Fires
    • Smoke from the fires can cause lines above them to short to ground
  
  – Environmental Alerts
    • Emissions limits may affect the output of older units
  
  – Bad Weather
    • Thunderstorms
    • Extreme heat or cold
Triggers for Conservative Operations

• Conditions triggering Conservative Operations (con’t):
  – Geomagnetic Disturbances (GMDs)
  – Terrorist or Sabotage *threats* against the BES
    • Including recent copper theft events
  – *Actual attacks* against physical or cyber assets critical to the operation of the BES
    • Substation equipment
    • Company EMS components
  – PJM entering an “unknown operating state,” as defined by NERC.
We will discuss general actions PJM can take when implementing Conservative Operations, as well as specific actions to address specific triggers.

PJM has a variety of additional actions available, depending on which trigger has initiated the need for Conservative Operations.
General Actions
PJM Actions during Conservative Operations - General

• General Actions:
  – PJM will analyze power flows into, across and through the PJM control area to determine if it is in jeopardy
    • PJM’s most critical limits are the Interconnection Reliability Operating Limits (IROLs), which are determined by flows across the system
      ▪ Transfer Limits can be reduced
      ▪ Contracts may be suspended or cut
      ▪ TLRs may be issued
PJM Actions during Conservative Operations - General

• General Actions (Con’t):
  – PJM may initiate additional off-cost operations to limit or reduce flows across critical interfaces
  – PJM may procure (or load) additional reserves, making more resources available to respond to any unexpected events
PJM Actions during Conservative Operations - General

• General Actions (Con’t):
  – PJM may look at the possibility of losing multiple pieces of equipment simultaneously
    • Normal operation – PJM studies single contingencies
    • May look at selected double contingencies (ex: shared right-of-way)
    • May look at “Maximum Credible Disturbances”
    • If the analysis shows vulnerability, PJM may take additional actions to allow the system to survive these events
      ▪ Cost assignments to load additional reserves
      ▪ System reconfiguration (Reduce power flows on selected facilities)
      ▪ Reduce power transfers by using conservative transfer limits
• General Actions (Con’t):

  – PJM may implement an additional layer of security on communications with and between members
    • May require additional verification with members when issuing instructions or responding to reports
    • May increase the frequency of Satellite Phone checks
  
  – PJM may ask for additional updates on system status
    • More frequent IRCs, SSRs, and/or RRCs
    • More frequent SOS Conference calls
  
  – PJM may ask members to staff their back-up control centers, critical BES Substations, or black start facilities
Member Company Actions during Conservative Operations - General

• As with all emergency conditions, PJM expects that Member companies will comply with and follow the specific requests and direction of PJM during these events
  - Provide additional reporting data
  - Man substations or generating plants
  - Follow PJM operational directives (Transmission) or Dispatch signals (Generation)
Fuel Delivery Emergencies
Conservative Operations – Fuel Delivery Emergencies

• Not only PJM, but RTOs and ISOs throughout North America have been affected by natural gas curtailments during cold weather periods
  
  – When natural gas supply or deliverability issues occur during cold weather:
    
    • Gas companies must give priority to heating over power generation

  – This has led to some generating plants being unavailable to generate during heavy load periods
Conservative Operations – Fuel Delivery Emergencies

• In conjunction with NYISO and ISO-NE, PJM has developed and maintains an RTO Natural Gas Coordination Procedure
  – The 3 RTOs will communicate jointly with Natural Gas Suppliers and the operators of Interstate Gas pipelines to manage potential inadequacy situations
  – Each RTO has developed a database of natural gas infrastructure in its footprint, including;
    • Location of units fueled by natural gas
    • Interstate pipeline supplier or LDC
    • Connection point on gas pipeline system
    • Contract arrangements for gas supply and transmission
    • Complete set of maps of the gas lines serving its system
    • Contact list for suppliers
Conservative Operations – Fuel Delivery Emergencies

• RTO Natural Gas Coordination Procedure (*con’t*):
  
  – The RTOs will work jointly to share all information and work with suppliers to determine the best overall use for limited gas resources
  
  – This larger picture view helps protect the Eastern Interconnection as a whole, ensuring resources are used to best protect the Interconnection, not an individual RTO
Conservative Operations - Fuel Delivery Emergencies

PJM Actions

• Monitor weather conditions and identify forecast conditions which could trigger the need for a Cold Weather Alert

• Analyze and forecast the need for natural gas-fired resources, given forecast weather conditions, and determine the need for invoking this procedure

• Request a conference call with ISO New England and New York ISO to request the invoking of the procedures
Conservative Operations - Fuel Delivery Emergencies

PJM Actions

- The RTOs will jointly communicate with the interstate pipelines to include:
  - Summary of the expected electrical demand and capacity conditions in the RTOs during the forecasted weather event
  - Expected need for the natural gas-fired generation
  - Contact information for the interstate pipelines within each RTO
PJM Actions

• Each RTO will follow up individually with each of its interstate pipeline suppliers in its respective area, requesting:
  – The operational status of the pipeline
  – The presence or anticipation of any Operational Flow Orders (OFOs) or other emergency procedures
  – An assessment of the pipelines ability to serve contracts for gas-fired generation through the expected duration of the weather event
PJM Actions

• After collecting pipeline data, the RTOs will share the information, reconvene, and determine actions to be taken to include:
  – A modification of the generation dispatch day-ahead to account for expected unavailability of gas-fired generation
  – A limitation of the granting of outages to maximize availability of generation resources
  – An adoption of conservative operations actions intended to mitigate risks associated with gas system contingencies or gas-fired generation unavailability
Additional PJM Actions

• Work with NYISO and ISO-NE to determine the need to implement these procedures

• Provide information to the interstate pipelines concerning the need for gas-powered generation:
  – to operate and request information concerning pipeline status, emergency procedures, and/or contract curtailments

• Take the information provided to develop a joint strategy to maximize use of the available resources among the RTOs
Conservative Operations – Fuel Delivery Emergencies

Additional PJM Actions (con’t):

• Limit the granting of Generator Outages during these periods, to maximize availability

• Adopt Conservative Operations
Conservative Operations – Fuel Delivery Emergencies

Additional Member Actions

• Provide facility information on gas-fired generation
  – Gas Supplier
  – Data on physical connections to the Interstate gas supply system

• Inform PJM of any delivery limitations to their gas supply

• Comply with any and all operational instructions issued by PJM
Environmental Alert Emergencies
Purpose and Learning Objectives

This course will provide an overview of Geomagnetic Disturbances (GMD), emphasizing common questions and making a sharp distinction between myths and facts. The course will address:

• Geomagnetically Induced Currents (GIC).
• Transformer half-cycle saturation.
• Wide-area impacts on power system equipment and power system stability.
• NERC GMD TPL-007 standard.
Agenda

1. Space Weather
2. GMD Impacts on Power Systems
3. GMD Standards
4. Conclusion & Final Remarks
Geomagnetic Disturbances

• As part of its normal functioning, the sun puts off a constant stream of ionized particles – known as the solar wind – which streams out in all directions

• A portion of these ionized particles reach the earth, and interact with its magnetic field
  – Depending on the alignment of the charge on the particles, they are either deflected, or channeled to the north and south magnetic poles
    • Some of the particles interact in the atmosphere, causing the Northern (and Southern) Lights
Geomagnetic Disturbances

Center for Space Environment Modeling
University of Michigan

T = 00:00:00
Introduction: Geomagnetically Induced Currents

$\frac{\partial B}{\partial t}$

Ionospheric Electrojet

Grounded Transformer | Transmission Line | Grounded Transformer

$E_x(t) = -\frac{1}{\sqrt{\pi \mu_0 \sigma}} \int_{t}^{\infty} \frac{1}{\sqrt{t-u}} \frac{\partial B_y(t)}{\partial t} \, du$

$E_y(t) = -\frac{1}{\sqrt{\pi \mu_0 \sigma}} \int_{t}^{\infty} \frac{1}{\sqrt{t-u}} \frac{\partial B_x(t)}{\partial t} \, du$
Fact: GIC is a DC current (<0.1 Hz).
Introduction: Why Should We Care?

- Hydro-Quebec Blackout 1989:
  - 7 SVCs tripped.
  - Transformer consume more MVARs.
  - Loss of 21,500 MW of generation.
  - 1 confirmed transformer damage: Salem’s GSU

- Halloween Storm 2003:
  - Outages in Sweden.

- Carrington event 1859.

- Large CME 1921.

Myth: EMP Commission Report: 350 transformers are going to fail.
Myth: We only need to be worried during solar maximum.
NOAA: GMD Forecast

• **NOAA alert system:**
  – Watch, Warning, Alert.

• **Monitoring devices:**
  – Satellite Stereo.
  – Satellite ACE.
  – Satellite DISCVR.
  – Ground magnetometers.

_Myth:_ We don’t know when a CME is going to hit earth.
NOAA Forecasting: Coronographs
NOAA: Kp-Index (or G-scale)

- **NOAA Forecast:**
  - **Watch:** long term forecast (1 day ahead).
  - **Warning:** short lead time (hours ahead).
  - **Alert:** real-time activity.
- **PJM is the GMD monitor for Eastern Interconnection until January 31, 2017.**

---

**Fact:** K-index was not designed for power systems.
GMD Severity: V/km

Myth: The GMD has the same severity across the USA.
Geomagnetic Disturbances

• By constructing the Bulk Electric System, we have inadvertently given these currents a much less resistant path to flow along
  – The vast majority of BES Power Transformers are connected in a grounded Wye-Delta configuration
  – The GICs in high ground resistance areas travel up the ground path into the BES Power Transformers, travel along the transmission lines, and return to the ground via a BES transformer ground path in the area of lower induced voltage potential
Geomagnetic Disturbances

BES Power Transformer Ground paths

GIC current path
Geomagnetic Disturbances

- PJM has installed special monitoring to detect these currents at locations known to be prone to GIC activity
  - Meadowbrook (Winchester VA)
  - Missouri Ave (Atlantic City NJ)
  - Limerick, Susquehanna, and Hope Creek Nuclear stations
  - Whitpain
  - Waugh Chapel
Transformer ½ Cycle Saturation

- Geomagnetically Induced Current (GIC):
  - Quasi-DC: <0.1Hz.
Transformer Hot-Spots

• Heating is not instantaneous.
  – Rate-of-rise and final temperature are quite different for different active and structural parts.

• Thermal analysis:
  – Ambient temperature.
  – Loading condition.
  – GIC.
Transformer Testing

Connection between 2 terminals instead of 3 terminals.

Measurement shunt

Rectifier

Position 20

Variac

Temperature logging
Oscilloscope

Position 30
Monitoring

- Thermocouples.
- Vibration.
- Sound.
- Voltages/Currents
Voltages & Currents

Mitsubishi @ GIC=5

SMIT @ GIC=2.85

Voltage [kV]

Currents [Amps]
Temperature Rise

### Structural Parts
- Top Support
- Bottom Support
- Top pressure plate
- Top Pressure Plate
- Tank shield
- Tie rot

### Windings
- 2LW05_30
- 2LW01_30
- 2LW03_30
- 2LW07_30

### Core
- 2CC15_30
- 2CC16_30
- 2CC18_30
- 2CO17_30

Calculated: 0.37 C/min
Measured: 0.035 C/min
Calculated SIEMENS: 0.005 C/min
Noise

- Noise: 20 dB jump.
  - It is pretty loud.
- Vibration:
  - Function of GIC; not a big concern.

Myth: Vibrations can destroy a transformer.
A Very Difficult to Test

- Over-heating of connection between two stator shields to ground.
  - 20 MVA, 3 phase generator.

Fact: Factory tests are extremely difficult.
Voltage Stability

Hot-spots  MVARs  Harmonics

\[ Q = V \cdot (k \cdot GIC) \]
Voltage Stability

- Transformer consume extra reactive power:
  - Voltage stability.
  - Potential issues with state estimator.
Harmonics

GIC [Amps/phase]

- h1
- h2
- h3
- h4
- h5

Harmonic Current [Amps RMS]

Magnetizing Current

R1 X_L1 R_C

XL2 R2

N1 : N2

Im

MVARs

Hot-spots
Impact of Harmonics

• Impact of harmonics:
  – Protection system and fuses.
  – Generator negative sequence heating.
  – Control devices.

Fact: Harmonics caused 1989 Hydro-Quebec blackout.
Agenda

1. Space Weather
2. GMD Impacts on Power Systems
3. GMD Standards
4. Conclusion & Final Remarks
1-in-100 Year Benchmark → Hot Spots → MVARs → Harmonics

Instability, Uncontrolled Separation, or Cascading
Corrective Action Plan

**Hardening**
- P&C upgrade.
  - Capacitors.
  - SVC/STATCOM
  - Generators
- Technical specifications.
  - Transformers.
  - Harmonic Filters.
- Blocking devices.

**Situational Awareness**
- NOAA forecast.
- GIC monitors.
- Magnetometers.
- Harmonics.
- Reactive power.
- Thermocouples.
- DGA.

**Operating Procedures**
- Topology.
- Cancel outages.
- Generation dispatch.
- Transformer cooling.
Enhanced Operating Procedures

• Enhanced Operating Procedures:
  – Topology control.
  – Cancel outages.
  – Optimal generation re-dispatch.
  – Preventive transformer cooling.
  – Contingency analysis.
Geomagnetic Disturbance Warning

• If the National Oceanic and Atmospheric Administration (NOAA) issues a warning or an alert for a potential geo-magnetic storm of severity K7 or greater, PJM will provide notification via the All-Call system and Emergency Procedure Posting Application.
Geomagnetic Disturbance Warning

PJM Actions:

• PJM dispatch notifies members (Generation and Transmission) via the PJM All-Call of GMD warnings/alerts issued by the National Oceanic and Atmospheric Administration (NOAA) via the RCIS and/or the NERC Hotline.

• If GIC measurements exceed the associated GIC operating limit, in amperes, at one and only one of the transformers monitored for GIC flow, PJM dispatch confirms that this measurement is a result of a severe geomagnetic storm by contacting the TO or GO in order to verify that the readings are accurate.
Geomagnetic Disturbance Warning

Member Actions:

• Transmission/Generation dispatchers provide confirmation of measurement values as requested by PJM dispatch

• Generation dispatchers provide as much advance notification as possible regarding details of more restrictive plant procedures that may result in plant reductions to protect equipment
Geomagnetic Disturbance Action

- PJM dispatcher may take action as soon as necessary for a GMD disturbance but must take action if conditions persist for 10 minutes.

- If GIC measurements exceed the GIC Operating Limit at two or more transformers monitored for GIC flow, PJM dispatch contacts the TO(s) and GO(s) in order to verify the readings are accurate and determine if excess MVAR exist at area transformers.

- PJM also checks the NOAA GMD (http://www.swpc.noaa.gov/) to confirm if any storm warnings or alerts have been issued, but this confirmation is not required for implementation of procedures if measurements are indicative of a geomagnetic disturbance.
Upon identification of a geomagnetic disturbance, PJM dispatch declares a Geomagnetic Disturbance Action and operates the system to geomagnetic disturbance (GMD) transfer limits. The geomagnetic disturbance transfer limits are determined from studies modeling various scenarios, including:

- Partial or complete loss of Hydro Quebec Phase 2 DC line to Sandy Pond
- Reduction or complete loss of generation at Artificial Island
- Tripping of certain EHV capacitors
Geomagnetic Disturbance Action

PJM Actions:

• PJM dispatch notifies members (Generation and Transmission) and neighbors via the PJM All-Call, postings on selected PJM web-sties and the NERC RCIS of a Geomagnetic Disturbance Action to mitigate the effects of GMD events on the system

• PJM dispatcher begins to operate the system to the geomagnetic disturbance transfer limits

• To mitigate the effects of GMD events on the system, when the GMD transfer limit is approached or exceeded, generation re-dispatch assignments are made in the most effective areas to control this limit
Geomagnetic Disturbance Action

PJM Actions:

• If insufficient generation is available to control this limit, the emergency procedures contained in Section 2 are implemented.

• If it appears that these emergency procedures are required, an operations engineer is requested to validate the GMD transfer limit and develop a voltage drop curve for the GMD transfer limit contingency.

• Pre-contingency load dumping will not be used to control transfers to the GMD transfer limit.
Geomagnetic Disturbance Action

PJM Actions:

• After GIC measurements at all monitored transformers have fallen below the GIC Operating Limit, PJM dispatch continues to operate the system to the geomagnetic disturbance transfer limits for a period of three hours.

• PJM dispatch must again confirm this measurement by contacting TOs and GOs. If the measurement values are confirmed to remain below the GIC Operating Limit for three hours, members are notified that the Geomagnetic Disturbance Action is cancelled. PJM dispatch restores the appropriate transfer limits for operation of the system.
Member Actions:

• Upon notification of the implementation of this procedure, members that operate facilities with instrumentation installed to record GIC neutral measurements at remote locations dispatch personnel to ensure that measurement equipment working properly.

• Members employing a MVAR summing algorithm method also initiate data collection at this time. It is requested that any data collected during a geomagnetic storm be forwarded to PJM for further analysis.

• The member dispatchers report all actions to PJM dispatch.

Geomagnetic Disturbance Action
Geomagnetic Disturbance Action

Member Actions:

• Transmission Owners are not required to have GMD Operating Plans.

• TOs that do have GMD Operating Plans are required to provide copies of those plans to PJM and are also required to coordinate any actions in their plans with PJM prior to implementation.
Sabotage/Terrorism Emergencies
Conservative Operations – Terrorism and Sabotage

• Responses to any triggers include a multi-faceted plan to safeguard personnel and maintain interconnection reliability, including:
  – Power system operations
  – Communications
  – Cyber security
  – Physical security

• Emphasis is on operations and communications based upon the specific threat and intelligence
  – Actual response can be tailored to the event as needed
Conservative Operations – Terrorism and Sabotage

• Key PJM actions are based upon Threat Levels issued by the Department of Homeland Security (DHS)
  – DHS now uses the National Terrorism Advisory System (NTAS)
  – NTAS has 2 types of alerts;
    1. Elevated Threat Alert: Warns of a credible threat against the U.S.
    2. Imminent Threat Alert: Warns of a credible, specific and impending threat against the U.S.
      ▪ These alerts are issued with a “sunset provision”, which means the alert will expire after a certain time
      ▪ DHS can extend the alert if there is a valid reason to do so based on new or updated information
# Terrorism and Sabotage

<table>
<thead>
<tr>
<th>NTAS Alert Issued</th>
<th>Other Potential Triggers</th>
<th>PJM Actions-Operations</th>
<th>PJM Actions-Communications</th>
</tr>
</thead>
</table>
| None              | • Suspicious activity reported by adjacent systems | • Remind all operators of increased vigilance  
• PJM Operations Management will review and discuss this section of the Emergency Operations manual  
• Increased vigilance and reporting | • PJM passes along credible/actionable intelligence  
• All operations centers should review reporting requirements |
### Terrorism and Sabotage

<table>
<thead>
<tr>
<th>NTAS Alert Issued</th>
<th>Other Potential Triggers</th>
<th>PJM Actions-Operations</th>
<th>PJM Actions-Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Elevated Threat Level</td>
<td>• Suspicious activity reported by adjacent systems</td>
<td>• Maintenance outages are analyzed; equipment return times are verified</td>
<td>• Communicate threat through ALL-CALL</td>
</tr>
<tr>
<td></td>
<td>• DHS/FBI issued a Threat Advisory</td>
<td>• Maximum Credible contingencies analyzed by PJM Reliability Engineer</td>
<td>• Satellite Phone checks (daily/weekly)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increased vigilance and reporting</td>
<td>• Enhance voice communications security</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Analyze hydro schedules to increase Black Start capability</td>
<td>• Enhance cyber security scanning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Initiate Black Start Assessment- to determine fuel limitations (SSR)</td>
<td>• Additional SOS conference calls (no market information)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• PJM staffs an Incident Response Team</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• If an attack occurs, notify members (ALL-CALL)</td>
</tr>
<tr>
<td>NTAS Alert Issued</td>
<td>Other Potential Triggers</td>
<td>PJM Actions-Operations</td>
<td>PJM Actions-Communications</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------</td>
<td>------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>• Imminent Threat Level</td>
<td>• Cyber event has shut down control center EMS capability, or physical attack at multiple sites</td>
<td>• Adopt more conservative modeling measures (double contingencies, maximum credible disturbances, or lower reactive transfer limits)</td>
<td>• Communicate threat over ALL CALL</td>
</tr>
<tr>
<td></td>
<td>• Intelligence of an impending attack on a PJM facility</td>
<td>• Increase Available Operating Reserve</td>
<td>• Institute Daily Conference Calls</td>
</tr>
<tr>
<td></td>
<td>• Cyber event has shut down control center EMS capability, or physical attack at multiple sites</td>
<td>• Cancel selected Maintenance Outages –restore outaged equipment (No touch maintenance policy)</td>
<td>• If cyber attack is occurring consider limiting internet accessibility</td>
</tr>
<tr>
<td></td>
<td>• Significant terrorist activity beyond the East Coast</td>
<td>• Consider staffing selected substations, critical CT sites, and black start units</td>
<td>• PJM maintains 24 hour Operations Management presence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increase Synchronized Reserves</td>
<td>• Provide instructions to units to operate within a given set of parameters if communications is lost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Obtain emergency energy bids</td>
<td>• Staff Back-Up Control Centers (as necessary)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Enhance physical security at critical substations</td>
<td>• Reassess the allowed level of communications between generators and transmission operators in order to facilitate necessary communications</td>
</tr>
</tbody>
</table>
Communicating Threats

• Electric Sector-Information Sharing and Analysis Center (NERC operated) receives and reviews information from:
  – U.S. or Canadian Federal Agencies
  – Reliability Coordinator
  – Electric Sector Entities (Region, Control Area, Purchasing-Selling Entity)
  – Other Sector ISACs (Oil and gas, chemical, nuclear, aviation, defense, financial services, etc.)
    ▪ If the information is specific and has credibility, the ES-ISAC will contact the involved entity directly
Terrorism and Sabotage

- ES-ISAC will notify other Electricity Sector Entities as appropriate, including:
  - EEI Security Committee (Edison Electric Institute)
  - APPA (American Public Power Association)
  - EPSA (Electric Power Supply Association)
  - NEI (Nuclear Energy Institute)
  - NRECA (National Rural Electric Cooperative Association)
  - CEA (Consumer Electronics Association)
Terrorism and Sabotage

PJM Actions:

- Communicating Threats
  - Timely and clear communications between PJM and its Members, in both directions is KEY in the successful managing of any suspected or actual crisis
  - PJM will monitor the Reliability Coordinator Information System (RCIS) for the presence of sabotage or terror events, and will alert other RC’s of events on the PJM system via the RCIS
  - If information is urgent or time-sensitive, a Reliability Coordinator Conference call will be convened
Terrorism and Sabotage

PJM Actions:

• Communicating Threats
  – No information shared by Reliability Coordinators will be passed on without approval
  – No information shared is to be delivered to the public media
Terrorism and Sabotage

Member Actions:

Communicating Threats

- If a PJM Member has been contacted by the ES-ISAC, concerning a threat to their facilities, or has received or observed a sabotage event, contact the PJM Shift Supervisor
  - PJM will then communicate the information to other Reliability Coordinators, via the RCIS
  - PJM will rapidly assess and pass the information to its members via the ALL-CALL for urgent/time sensitive material, or
    - via the SOS or email for general/non-actionable material
Severe Weather Events
Severe Weather Events

Cold Weather Alert:

• Purpose: Prepare personnel and facilities for expected extreme cold weather conditions

• Trigger:
  – When the forecasted weather conditions approach minimum or actual temperatures for a Control Zone fall near or below 10 degrees Fahrenheit
  AND/OR
  – At higher temperatures if increased winds are anticipated
  AND/OR
  – Expected spot market gas curtailments during load pick-up periods
Severe Weather Events

Cold Weather Alert:

PJM utilizes the following weather locations and approximate unavailability rates to declare Cold Weather Alerts on a PJM Control Area or Control Zone basis.
Severe Weather Events

PJM Actions:

• Notify PJM management, PJM public information personnel, and members

• Issue Cold Weather Alert, including;
  – Control Zone(s)
  – Forecasted low temperature
  – Forecasted duration of the condition
  – Amount of estimated operating reserve and requirement
  – Whether fuel limited resources are required to be placed into the Maximum Emergency category

• Assume an unavailability factor of 25% to 75% for scheduled interchange
Severe Weather Events

PJM Actions (con’t):

• Notify respective generation owners if combustion turbines in excess of 2,000 MW are needed

• If the predicted minimum temperature is -5 degrees F or less, or if there is a significant increase in unit unavailability, increase the level of unavailability of CT Generation, and commit additional reserves to cover

• Confer with generation owners;
  – Instruct them to call in or schedule personnel within sufficient time to ensure that all generators are started and available for loading for the morning pick-up
  – Poll large combined-cycle units regarding projected availability during the reserve adequacy run
PJM Actions (con’t):

- Report significant changes in the estimated operating reserve capacity
- Recall/cancel non-critical Generation & Transmission maintenance outages
- Cancel the alert when appropriate
Severe Weather Events

PJM Member Actions:

• Review plans to determine if any maintenance or testing, scheduled or being performed, on any monitoring, control, transmission, or generating equipment can be deferred or cancelled

• Call in or schedules personnel in sufficient time to ensure that all CT and diesel generators that are expected to operate will be started and be available for loading when needed for the morning pick-up
  – Includes operations, maintenance, and technical personnel
  – Units may be run at engine idle or loaded as necessary

• CTs may be started to provide additional Synchronized Reserves
  – Fuel reserves and deliveries will be monitored closely
Severe Weather Events

PJM Member Actions (con’t):

• Attempt to start the most troublesome or unreliable units first

• Review combustion turbine capacities, specifically units using #2 fuel oil that do not have sufficient additive to protect them for low temperatures

• Review fuel supplies/delivery schedules

• Monitor and report projected fuel limitations to PJM

• Contact PJM if it is anticipated that spot market gas is unavailable, resulting in unit unavailability

• Contact PJM if there are gas-fired CTs placed in Maximum Emergency Generation due to daily gas limitations of less than 8 hours
Severe Weather Events

Hot Weather Alert

• Purpose: Prepare personnel and facilities for extreme hot and/or humid weather conditions
  – May cause capacity requirements and unit unavailability to be higher than forecast for an extended period of time

• Trigger: When the forecasted maximum or actual temperature for a Transmission zone is at or above 90 degrees* Fahrenheit, with high humidity, for multiple days

(*Temperature trigger is 93 degrees for EKPC and Dominion Zones)
Severe Weather Events

Hot Weather Alert

PJM utilizes the following weather locations and approximate unavailability rates to declare Hot Weather Alerts on a PJM Control Area or Control Zone basis.

<table>
<thead>
<tr>
<th>Control Zone</th>
<th>Region</th>
<th>Weather</th>
<th>Unavailability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid Atlantic</td>
<td>Mid-Atlantic</td>
<td>Philadelphia</td>
<td>2000 – 2500 MW</td>
</tr>
<tr>
<td>FE-South/Duq</td>
<td>Western</td>
<td>Pittsburgh</td>
<td>300 – 500 MW</td>
</tr>
<tr>
<td>AEP</td>
<td>Western</td>
<td>Columbus</td>
<td>500 – 1000 MW</td>
</tr>
<tr>
<td>Dayton</td>
<td>Western</td>
<td>Dayton</td>
<td>300 – 500 MW</td>
</tr>
<tr>
<td>ComEd</td>
<td>Western</td>
<td>Chicago</td>
<td>1000 – 1500 MW</td>
</tr>
<tr>
<td>Dominion</td>
<td>Southern</td>
<td>Richmond</td>
<td>500 – 1000 MW</td>
</tr>
<tr>
<td>FE-West</td>
<td>Western</td>
<td>Cleveland</td>
<td>300 – 500 MW</td>
</tr>
<tr>
<td>DEOK</td>
<td>Western</td>
<td>Cincinnati</td>
<td>100 – 200 MW</td>
</tr>
<tr>
<td>EKPC</td>
<td>Western</td>
<td>Winchester</td>
<td>100 – 200 MW</td>
</tr>
</tbody>
</table>
Severe Weather Events

PJM Actions:

• Notify PJM management and member dispatchers
  – Issue Hot Weather Alert, including;
  – Control Zone(s)
  – Forecasted high temperature
  – Forecasted duration of the condition
  – Amount of estimated operating reserve and requirement
  – Reminder that certain fuel limited resources are required to be placed into the Maximum Emergency category

• Report significant changes in operating reserve capacity

• PJM Dispatch recalls/cancels non-critical Generation & Transmission maintenance outages

• Cancel the alert when appropriate
Severe Weather Events

PJM Member Actions:

• Notify management

• Advise all generating stations and key personnel

• Determine if any maintenance or testing can be deferred or cancelled

• Report to PJM all fuel/environmental limited facilities as they occur, and update as needed

• Contact PJM to inform them of any gas-fired generation placed in Maximum Emergency Generation due to daily gas limitations of less than 8 hours
Questions?
What actions might PJM take when adopting Conservative Operations?

A. Reduce transfer limits  
B. Schedule additional reserves  
C. Suspend market operations  
D. Require additional identity confirmation when submitting energy bids

1. A & B  
2. B & C  
3. C & D  
4. A & D

Response Counter

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>25%</td>
<td>2.</td>
<td>25%</td>
</tr>
<tr>
<td>3.</td>
<td>25%</td>
<td>4.</td>
<td>25%</td>
</tr>
</tbody>
</table>

10/16/2018 PJM©2018
Which entity (along with PJM) participates in the RTO Natural Gas Coordination procedure?

A. NERC
B. MISO
C. ISO-NE
D. ERCOT

Response Counter

C. ISO-NE
During a Geomagnetic Disturbance (GMD) which piece of equipment can see high flows of DC current?

A. Circuit breakers
B. Transformers
C. Reactors
D. CCVTs

Response Counter

A. 25%  B. 25%  C. 25%  D. 25%
The NTAS alert levels now have a ....

A. Color level assigned
B. Mandatory response requirement
C. Specific target mentioned
D. Sunset provision

Correct: C. Specific target mentioned
What is the temperature trigger for a Hot Weather Alert?

A. 80 degrees
B. 85 degrees
C. 90 degrees
D. 95 degrees

Response Counter

A. 25%  B. 25%  C. 25%  D. 25%