Telecommunications
Generator Data Requirements

PJM State & Member Training Dept.
Students will be able to:

- Identify the various PJM communication protocols and procedures
- Identify the various PJM communication tools
- Identify the requirements of Member companies to have a plan for loss of Control Center Functionality
- Identifying NERC Requirements for Generating Unit Complete Loss of Communication
Data Exchange

• Data is exchanged between PJM and the MOC, TO, LSC and Marketing Center, other RTOs, and LSEs and Marketers for the following services:
  – Generation Scheduling Services
  – EMS Services
  – Historical EMS Data Services
  – Energy Transaction Services
  – Long-term Planning Services
  – PJM Administration Services
PJMnet

• Primary wide-area private network for secure Control Center data communication to and from PJM

• Will support two communication protocols:
  – **ICCP** (Inter-control Center Communication Protocol)
    • International standard
    • Used to exchange data between control centers, utilities, power pools, regional control centers, etc.
  – **DNP3** (Distributed Network Protocol)
    • Primarily used for communications between a master station and RTUs
Cyclic Data

- Sent from Member Companies to PJM includes data needed for:
  - PJM control programs
  - Monitoring generation
  - Monitoring transmission
  - Monitoring interchange

- Sent from PJM to Member’s EMS/GMS includes:
  - System control data
  - Generation & transmission information required for monitoring & SA programs
  - Area regulation data

EMS/GMS data is exchanged periodically on one of several fixed cycles, as well as on demand, by exception, and interactively.
**Data Exchange**

**Fast Scan Rate**
- Used to develop ACE and regulation values
- Sent every 2 seconds

**Slow Scan Rate**
- Used to develop dispatch control values, security monitoring and data tracking
- Sent every 10 seconds

**Hourly Data**
- Accumulated energy values
Data exchanged by exception, on demand or interactively:

- Breaker
- Disconnect
- Line status changes
- Emergency messages in text format

Data Accuracy

- PJM Members are responsible for the accuracy of the data they send to PJM
  - Max of 2% overall inaccuracy
## Real-Time Telemetry

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Real-Time Telemetry Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generators participating in the PJM market as capacity resources</td>
<td>Real and reactive power</td>
</tr>
<tr>
<td>Generator 10 MW (Maximum Facility Output) or larger</td>
<td>Real and reactive power</td>
</tr>
<tr>
<td>Generators greater than 1 MW (Maximum Facility Output) and connected at 50 kV or greater</td>
<td>Real and reactive power</td>
</tr>
<tr>
<td>Solar parks 3 MW (Maximum Facility Output) or greater</td>
<td>Real and reactive power</td>
</tr>
<tr>
<td>Distributed generators modeled less than 10 MW (Maximum Facility Output)</td>
<td>Real and reactive data at the BES injection point of accuracy within 10% of hourly MWh settlements data</td>
</tr>
</tbody>
</table>
Categories of Data

Real-Time Data

• Instantaneous information
• Data required by PJM that determines:
  - System Security
  - Stability
  - Congestion
  - LMP

Non Real-Time Data

• Revenue information needed by PJM’s applications and systems
• Determine Grid Accounting and Energy Interchange, such as Power Meter
Real-Time Data

• Instantaneous Net (+/-) MW for each unit, measured on the low-side of generator step-up transformer
• Instantaneous Net (+/-) MVAR for each unit, measured on the low-side of generator step-up transformer
• Distributed generators modeled at less than 10 MW must provide Instantaneous Net (+/-) MW and MVAR at aggregation point based on an agreed upon algorithm
• Additional transmitted data may include:
  – Bus voltages
  – CB status
Non Real-Time Data

- Hourly Compensated MWh delivered for each unit
- Hourly Compensated MWh received for each unit
- Hourly Compensated MVARh delivered for each unit*
- Hourly Compensated MVARh received for each unit*

*Note: The MVARh revenue information is not currently required. Data will be considered a requirement in the event that PJM implements a Reactive Power Market.
## Precision Requirements

<table>
<thead>
<tr>
<th>Data Point</th>
<th>Precision Requirement</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real-Time Instantaneous Data Sent to PJM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>1/1000th of HZ</td>
<td>60.001 Hz</td>
</tr>
<tr>
<td>Voltage</td>
<td>1/10th of kV</td>
<td>69.1 kV</td>
</tr>
<tr>
<td>Real Power MW</td>
<td>1 MW integer required*</td>
<td>52 MW</td>
</tr>
<tr>
<td>Reactive Power MVAR</td>
<td>1 MVAR integer required*</td>
<td>42 MVAR</td>
</tr>
<tr>
<td>Regulation Capability MW</td>
<td>1 MW integer required*</td>
<td>10 MW</td>
</tr>
<tr>
<td><strong>Real-Time Instantaneous Data Sent from PJM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Individual Unit MW Base Point from Security Constrained Economic Dispatch (SCED)</td>
<td>1/10th of MW</td>
<td>323.1 MW</td>
</tr>
<tr>
<td>Regulation Signal (AR)</td>
<td>1 MW integer, +/- **</td>
<td>10 MW</td>
</tr>
<tr>
<td><strong>Revenue Data Sent to PJM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MWh Delivered and Received</td>
<td>1/1000th of MWh</td>
<td>20.001 MWh</td>
</tr>
<tr>
<td>MWARh Delivered and Received</td>
<td>1/1000th of MVARh</td>
<td>15.002 MVARh</td>
</tr>
</tbody>
</table>

* PJM will accept greater precision if available  
** PJM will send smaller signals to certain sites as renewable resources
Manually Entered Data

What is It?

Data that is manually entered and updated by the System Operator

• Steps:
  – Identify suspected data
  – Verify validity of suspected data
    • Use other tools, experience & knowledge, other computer models if available
  – Sanity check - bus summation calculations
  – Determine requirements for updating
    • (30 minutes, Manual 3)
  – Resolve cause of bad data
Keeping on Top of Manually Entered Data

- **Start of Shift:**
  - Identify points that are currently updated manually
    - Shift turnover sheet or pass down from previous shift
    - EMS displays that summarize manually replaced data

- **During Shift:**
  - Monitor system for additional bad data
  - Take necessary action to correct data when found
  - Update values or status of current manually replaced data

- **End of Shift:**
  - Inform your relief of all points currently manually entered
Data Requirements – Intermittent Resources
• General turbine information
• Class of turbine
• Capacity of turbine
• Power generation threshold rates (i.e. min/max wind speed)
• Manufacturer power curves of individual wind turbines
• Geographic location (longitude and latitude) of site or each turbine if available
• Hub height of wind power facility
• Aggregate historic data for existing facilities connected to PJM or bid into PJM market
  – Measured MW output
  – Outage information
  – Wind speed at hub height

• Ambient temp operation limits
  – Information on “cold weather packages” installed
Real Time Data

• Aggregate real time output
  – Low side and high side net generator MW and MVAR

• Real time meteorological data
  – Must have at least one tower
    • Or wind speed and direction from selected turbines
  – Height should be same or close to hub height of turbine
    • Calibrated annually

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed</td>
<td>Meters/second</td>
<td>Required</td>
</tr>
<tr>
<td>Wind Direction</td>
<td>Degree from True North</td>
<td>Required</td>
</tr>
<tr>
<td>Temperature</td>
<td>Fahrenheit</td>
<td>Required</td>
</tr>
<tr>
<td>Pressure</td>
<td>Hectopascals</td>
<td>Required</td>
</tr>
<tr>
<td>Humidity</td>
<td>Percent</td>
<td>Preferred</td>
</tr>
</tbody>
</table>
Real Time Data (Cont.)

- Depending on topology and accuracy of the Wind Power Forecast, PJM may require additional towers at a site.

- All data items, regardless of type, shall be collected and disseminated at a frequency of 10 seconds or less.
Data Interruptions
Data Outages

Miscellaneous Reportable Outages

• Email coordination notice 24 business hours in advance of significant system changes that could affect ICCP data link communications or the data exchange with PJM

  – Data Set Switches
    • This does not include database updates, editing data exchange lists, etc. unless they include an outage
  – Significant Software Enhancements
  – Communication line outages
  – Backup center testing
  – Failovers to alternate sites

  – ICCP server failovers
  – Network and Firewall maintenance
  – RTU outages or changes to RTU data sent to PJM for RTUs connected to EHV (345kv and above) facilities
    • 1 day notice required
Miscellaneous Reportable Outages (Cont.)

- The PJM EMS Networking group will coordinate any technical details, additional support, etc. with the member company.
- Members providing notification should send an email to: outage@pjm.com.
- In an emergency, call the PJM Support Center at 610-666-8886 or the Dispatch Supervisor at 610-666-8806.
  - The notification should include:
    - The action being taken by the member company
    - Planned length and expected time of the outage
    - Potential impact to PJM
    - Member contact information
- Member Company System Operator should coordinate final outage with the PJM Dispatch Supervisor 15 minutes prior to the event.
Data Outages

Scheduling Data Outages

• PJM staff has the authority to:
  – Reschedule or cancel a member company-scheduled planned outage:
    • Based on system conditions
    • Due to existing ICCP data link outages
  – Deny a request for a member company-planned outage:
    • If requested outage time had been previously scheduled
Scheduling Data Outages (Cont.)

• During Peak Load Operations, emergency changes should occur (to the extent possible):
  – During Summer operations, prior to 11:00 EPT
  – During Winter operation, between 10:30 – 14:30 EPT
  – Weekly routine maintenance should be canceled and rescheduled for dates when emergency procedures are not anticipated
Data Outages

Unscheduled Data Outages - Considerations/Actions:

• **MOC or Generator Owner/Operator**
  – Contact PJM Dispatch to report or discuss problem
  – Recognize prior SCED approved basepoint is stale while ICCP problems exist
  – Resolve communications issue (support staff)
  – Manually dispatch directions to plants verbally if problem is not resolved within 10 minutes
  – Log manual dispatch directions
  – Provide a contact person to PJM Dispatch to enhance operations during reliability issues
Unscheduled Data Outages - Considerations/Actions: (Cont.)

• **TO or Merchant Transmission**
  – Contact PJM Dispatch to report/discuss problem
  – Resolve communications issue (support staff)
  – Contact PJM Dispatch regarding transmission constraints
  – Verbally communicate critical data to PJM Dispatch as needed
  – Provide a contact person to PJM Dispatch to enhance operations during reliability issues
Data Outages

Unscheduled Data Outages - Considerations/Actions: (Cont.)

- **PJM Actions**
  - Contact MOC/TO to discuss communication issues
  - Resolve communication issue
  - Recognize prior SCED approved basepoint as stale while ICCP link is down
  - Communicate zonal cost if communication issues are not resolved within 10 minutes
  - Communicate targeted generation dispatch if transmission constraints arise
  - Log manual dispatch/reassign regulation as necessary
  - Communicate impact on ability to monitor transmission system
  - Elevate communication to Shift Supervisor if reliability issues arise
• All outages that affect PJM’s ability to receive telemetered data must be reported:
  – In the case of RTU’s for 345 kV and above, personnel at the station will have to relay critical data to the TO and PJM
  – Data to be kept manually updated includes:
    • MW line flows for 345 kV and higher line and all tie lines
    • Bus voltages for all 345 kV and higher stations
  – Affected data must be updated:
    • After loss of major generator or transmission line
    • When value has a change of 100 MW or more for 500 kV and above, 50 MW for 345 kV and below
    • At least every 30 minutes
Impacts of Bad Data - Examples
Nagel Ties
Impacts of Bad Data Examples

PJM began experiencing problems:

- Nagel-Phipps
- Nagel-Sullivan
- Nagel-Cane River
- Tie line values gradually drifted from actual values
- No sudden step changes that would have alerted operators
Impacts of Bad Data Examples

- The inaccurate tie values resulted in PJM over-generating between 10/3/2006 15:00 to 10/4/2006 09:00
  - Contributed to high frequency for an 18 hour period
Impacts of Bad Data Examples

- At approximately 8:20 a.m. on Oct 3, 2006, both the CPLW Cane River and TVA Nagel-Phipps Bend tie-line meters began reporting what appear to be incorrect values
  - The Nagel-Phipps Bend line appeared to have returned to a correct value at 15:22 p.m. on Oct 3, 2006
  - The Cane River tie appeared to have returned to a correct value at 8:20 a.m. on Oct 4th, 2006
Impacts of Bad Data Examples

Nagel - Cane River 230 kV

Nagel - Phipps Bend 500 kV
Impacts of Bad Data Examples

• In addition to this error, the Nagel Sullivan tie also began reading a bad value during the same time period
• While changing the RTU configuration at Nagel Station, technicians inadvertently disconnected three cables affecting tie-line metering
  – Tie line measurements drifted slowly after cables were disconnected
    • Characteristic of the RTU when the MW input is left “open ended”
  – The AEP and PJM EMS relies on significant spikes (100 MW) in readings to generate a rate of change alarm
• AEP and PJM did not detect bad SE data for numerous hours

• PJM operators are responsible for reviewing bad data as part of shift turnover
  – Operator followed proper shift turnover procedures but did not detect the problem

• AEP support staff, not real time operators, review SE bad data during normal working hours

• The AEP Transmission Services Coordinator became aware of the problem when:
  – Meter error values increased significantly over a period of several hours

• AEP contacted maintenance personnel to look into the problem
• Think of a possible scenario where you could impact reliability with bad data

• What potential impacts could bad data have on your operations?
Loss of Control Center

Functionality Requirements
Member Back-Up Control Center Requirements

• PJM Members are required to construct and man Control Centers
  – Subject to the criteria outlined in Manual 01 – “Member Control Center Requirements”

• In addition, Manual 01 specifies that each Member TO must have a plan for loss of control center functionality, which includes
  – Procedures and responsibilities for providing annual training

  • Ensure that operating personnel are able to implement the plans
Member Back-Up Control Center Requirements

• All PJM Members shall develop a backup recovery plan to cover various contingencies,
  – Including maintaining an off-site storage location for updated copies of all software and data files necessary to restore control center functions

• The backup recovery plan is subject to review by PJM
NERC Reliability Guideline

Generating Unit Complete Loss of Communication
NERC Reliability Guideline Intentions

- Incorporation of guideline practices are strictly voluntary, but reviewing, revising, or developing a program using these practices is highly encouraged
  - to promote and achieve the highest levels of reliability for the BES
- Not applicable to generation connected to asynchronous loads or systems not normally part of one of the Interconnections
- Not to be used to provide binding norms or create parameters by which compliance to standards is monitored or enforced
- Not intended to take precedence over any regional procedure
NERC Reliability Guideline Intentions

• Not meant to prevent generating unit operators from taking actions necessary to protect the equipment under their supervision from damage to include if necessary to be taken off line in a safe manner

• Protective equipment should not be bypassed or rendered inoperable in order to follow this guideline
  – Safety of personnel and prevention of damage to system equipment are the first responsibilities of electric system operators at all levels
Assumptions

- **Loss of Communications** – all data and voice communications are lost between the on-site generating unit operator and the System Operator for the Balancing Area, Transmission Operator and Reliability Coordinator.

- **Generating Unit Status** – some generating capacity remains in service or can be brought into service locally at the plant operator’s discretion, to serve the load over the period of lost communications.

- **Instrumentation** – Generating unit are equipped with frequency metering devices capable of displaying system frequency on both narrow (roughly 59.95 Hz to 60.05 Hz) and wide (roughly 58.0 Hz to 62.0 Hz) ranges. Alternatively, nomograms or other job aids that convert generator speed to frequency can be used.

- **Situation Awareness** – The on-site generating unit operators recognize that frequency is abnormal and a unique situation is occurring.
• With no other communication possible, frequency will be the only means that a generator operator will have to control the system.

• Green Zone—no response necessary
  – 59.90Hz to 60.10Hz

• Yellow Zone – selective response
  – 59.80Hz to 59.89 or 60.11 to 60.20Hz
  – Gradually maneuver generation to correct the frequency
  – Generation Ramp Rate = 1% of unit rating per minute
  – Sustained frequency in this range indicates a disturbance has occurred
Frequency Response

• Red Zone—Full Response
  – Frequency <59.80Hz or >60.20Hz
  – All units capable of responding should rapidly maneuver to balance load with generation
  – Reduce the Ramp rate of the units when frequency falls back into the yellow zone

• Emergency Response
  – If the frequency continues to deteriorate, emergency measures will be required
Emergency Response

• High frequency
  – Take all generation to its lowest stable output when frequency increases to 60.30Hz
  – Start tripping units offline when frequency increases to 60.50
    • Smaller units with minimal impacts to transmission should be taken offline first
    • Plants with multiple units should trip generation offline
    • Subsequent generation may be taken offline as needed

• Low Frequency
  – All hydro generation should be loaded when frequency declines to 59.70 Hz
  – All quick-start generation resources should be committed when frequency drops below 59.60 Hz
  – Underfrequency Load Shed-- relays start to operate automatically when frequency declines to 59.50 Hz
Questions?

**PJM Client Management & Services**

**Telephone:** (610) 666-8980  
**Toll Free Telephone:** (866) 400-8980  
**Website:** [www.pjm.com](http://www.pjm.com)

The Member Community is PJM’s self-service portal for members to search for answers to their questions or to track and/or open cases with Client Management & Services.
Resources and References