Telecommunications

Generator Data Requirements

PJM State & Member Training Dept.

Objectives

Students will be able to:

- Identify the various PJM communication protocols and procedures

- Identify the various PJM communication tools

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

Data Exchange

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

Data Exchange

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

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

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 Exchange

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

Metering Plan

- All generators that participate in the PJM market as a capacity resource must provide instantaneous power and reactive power flow (real-time telemetered) data, regardless of MW size
- Distributed generators modeled at less than 10 MW must provide instantaneous power data at the BES injection point within 10% of hourly MWh revenue accumulated data
- Generators that are not participating as capacity resources must provide instantaneous real power and reactive power flow data only if:
  - They are 10 MW or larger, or
  - They are greater than 1 MW and connected at a bus operating at 24 kV and above

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 is needed by PJM's applications and systems that determine Grid Accounting and Energy Interchange, such as Power Meter

Real-Time Data

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

Data Requirements

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

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

*PJM will accept greater precision if available

**PJM will send smaller signals to certain sites such 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

Manually Entered 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

Initial Data

Initial Data

- 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 (Long. and Lat.) of site or each turbine if available
- Hub height of wind power facility

Initial Data

Initial Data (cont.)

- 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

Parameter	Units	
Wind Speed	Meters/second	*Required*
Wind Direction	Degree from True North	*Required*
Temperature	Fahrenheit	*Required*
Pressure	Hectopascals	*Required*
Humidity	Percent	Preferred

Real Time Data

- 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

Data Outages

Miscellaneous Reportable Outages

- The PJM EMS Networking group will coordinate any technical details, additional support, etc. with the member company
- Members providing notification should send it to the following email address (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
  - Reschedule or cancel a member company scheduled planned outage based on existing ICCP data link outages
  - Deny a request for a member company planned outage if requested time has been previously scheduled

Data Outages

Scheduling Data Outages (cont.)

- During Peak Load Operations, to the extent possible, emergency changes should occur:
  - During Summer operations - prior to 11:00 EPT
  - During Winter operations - between 10:30 – 14:30 EPT
  - Weekly routine maintenance should be canceled or rescheduled to days when emergency procedures are not anticipated

Data Outages

Unscheduled Data Outages

- Considerations / actions:
- **MOC or Generator Owner/Operator**
  - Contact PJM Dispatch to report/discuss problem
  - Recognize prior SCED approved base-point 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

Data Outages

Unscheduled Data Outages

- Considerations / actions:
- **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 (cont.)

- Considerations / actions:
- **PJM Actions**
  - Contact MOC/TO to discuss communication issues
  - Resolve communication issue
  - Recognize prior SCED approved base-point 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

RTU Outages

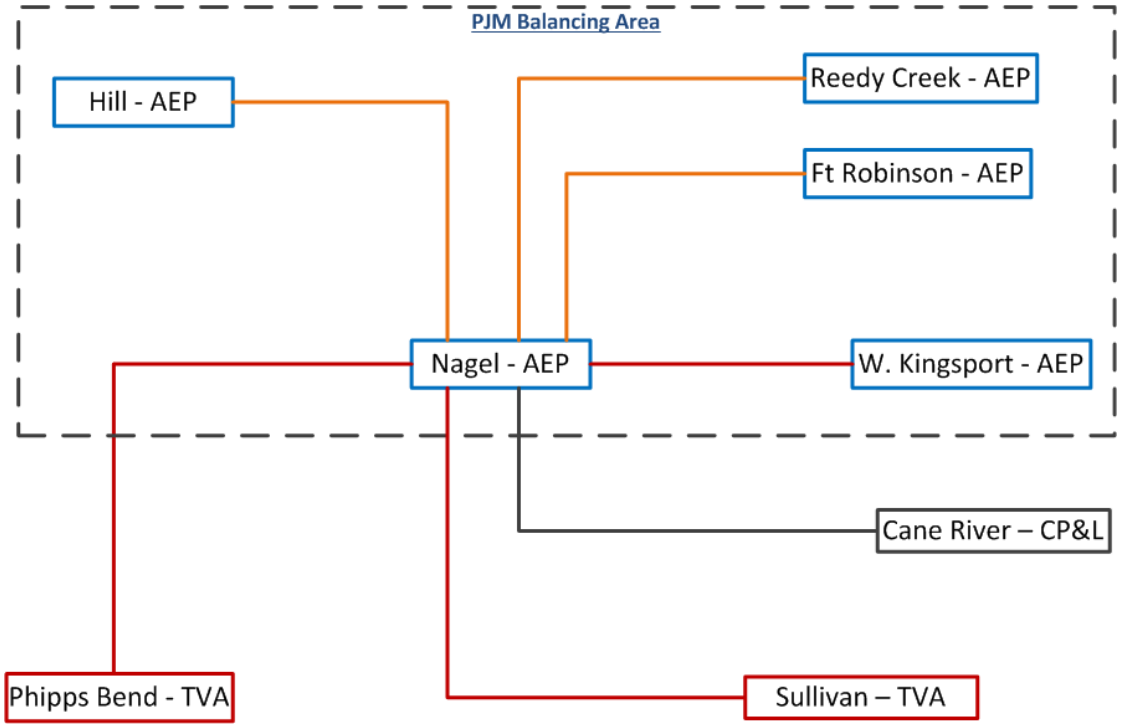
RTU Outages

- 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 500 kV and higher line and all tie lines
    - Bus voltages for all 500 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

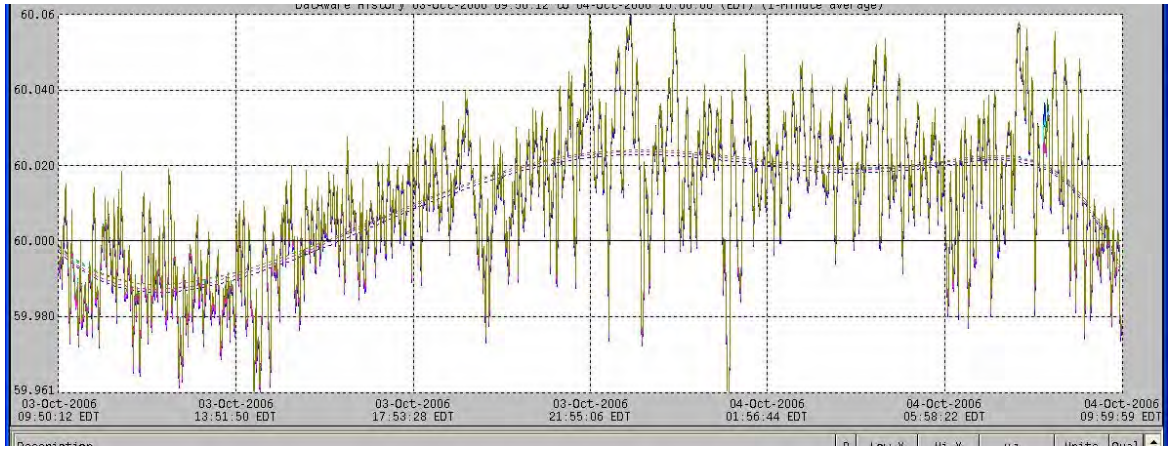


PJM began experiencing problems on the:

- 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

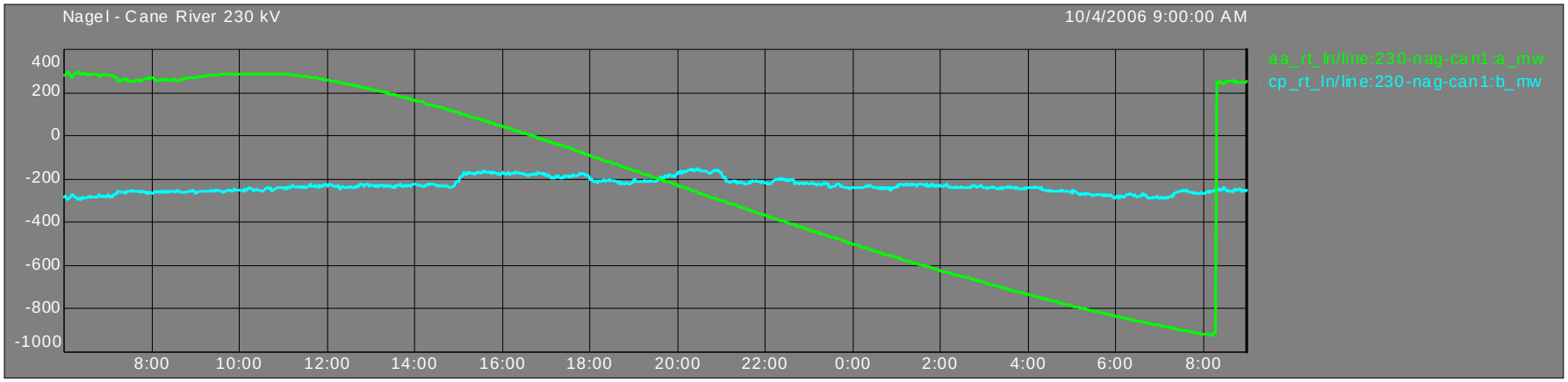
- The inaccurate tie values resulted in PJM over generating between 10/3/2006 15:00-10/4/2006 09:00, contributing to high frequency for an 18 hour period

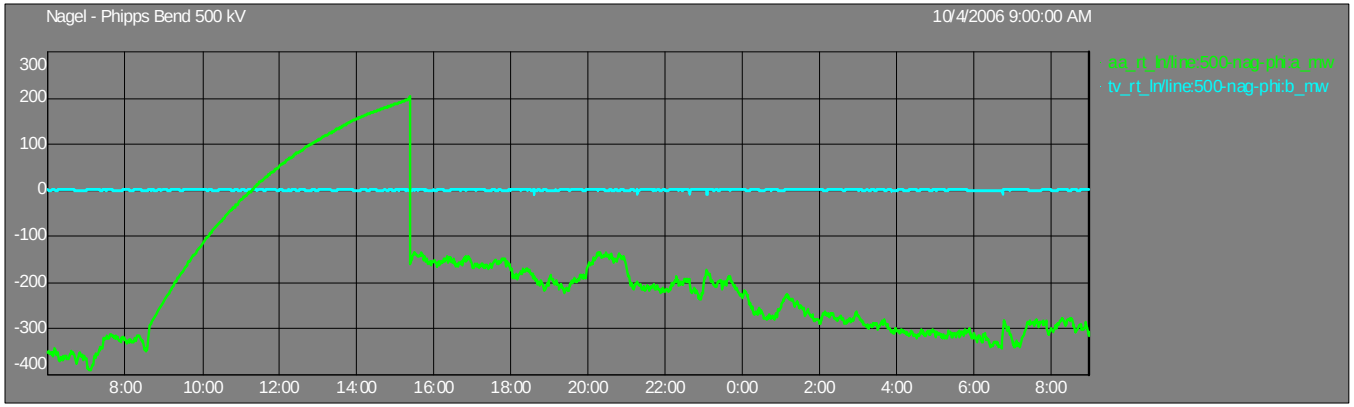


Impacts of Bad Data Examples

- At approximately 8:20 am 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 on Oct 3, 2006
- The Cane River tie appeared to have returned to a correct value at 8:20am on Oct 4th, 2006

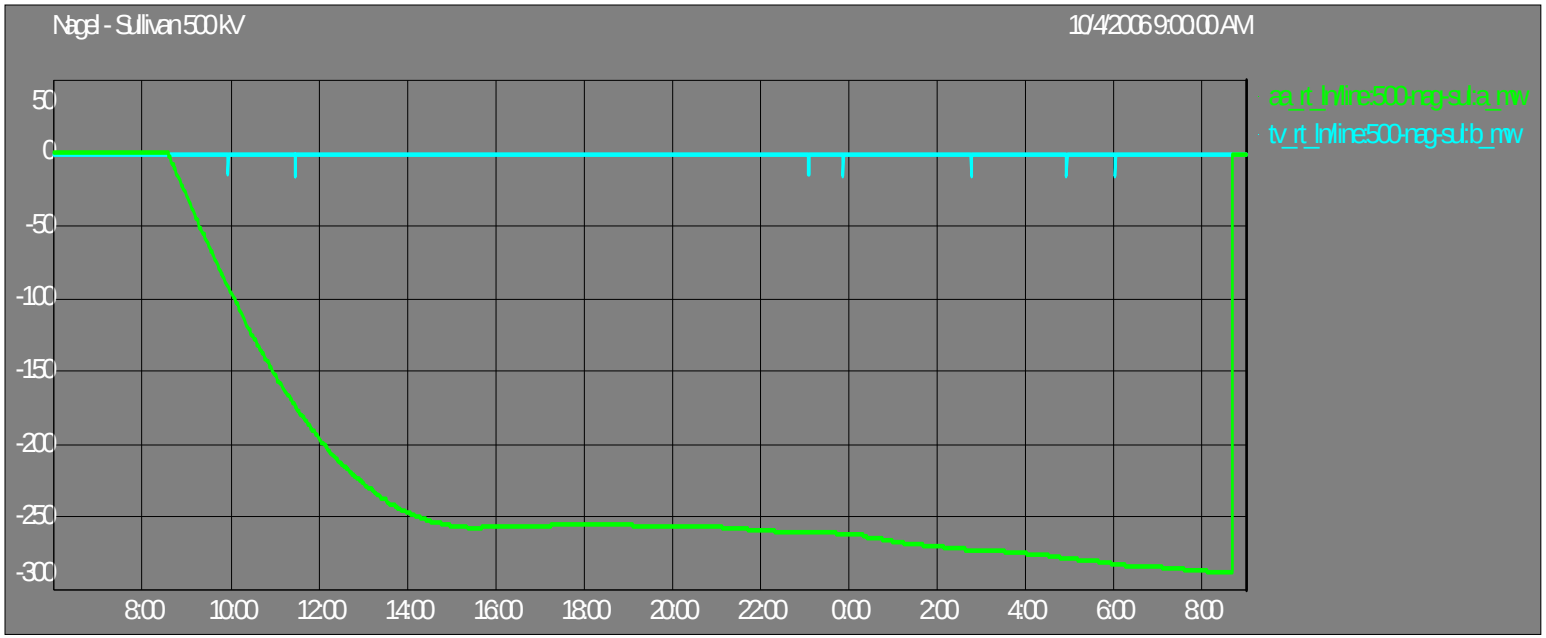
Impacts of Bad Data Examples





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



Impacts of Bad Data Examples

- 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, this is a 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

Impacts of Bad Data Examples

- 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 did follow 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 the meter error values increased significantly over a period of several hours
- AEP contacted maintenance personnel to look into the problem

NEPA Interface

Impacts of Bad Data Examples

Northeast PA (NEPA) Transfer Limit

- A transfer limit to ensure transient stability in Northeastern Pennsylvania (NEPA). It consists of a set of transmission lines whose total MW flow is monitored and controlled to provide an accurate indication of the synchronous stability power export limit

Impacts of Bad Data Examples

Northeast PA (NEPA) Transfer Limit

- Transmission lines in the NEPA transfer interface are:
- Susquehanna-Wescosville 500 kV line
- Siegfried-Harwood 230 kV line
- Harwood-East Palmerton 230 kV line
  - (Originally Susquehanna – East Palmerton 230 kV Line)
- Siegfried-Frackville 230 kV line
- Juniata-Sunbury 500 kV line
- Lackawanna-Peckville 230 kV line
- Lackawanna-Oxbow 230 kV line
- Montour-Elimsport 230 kV line
- Montour-Clinton 230 kV line
- Sunbury-Elimsport 230 kV line

Impacts of Bad Data Examples

- PJM RTO maintains the stability transfer limit and monitors and controls the transfer limit flows

- When flows across the NEPA transfer interface are exceeding its limit, PJM RTO determines where and the amount of generation that must be reduced within this interface to reduce the flow

Impacts of Bad Data Examples

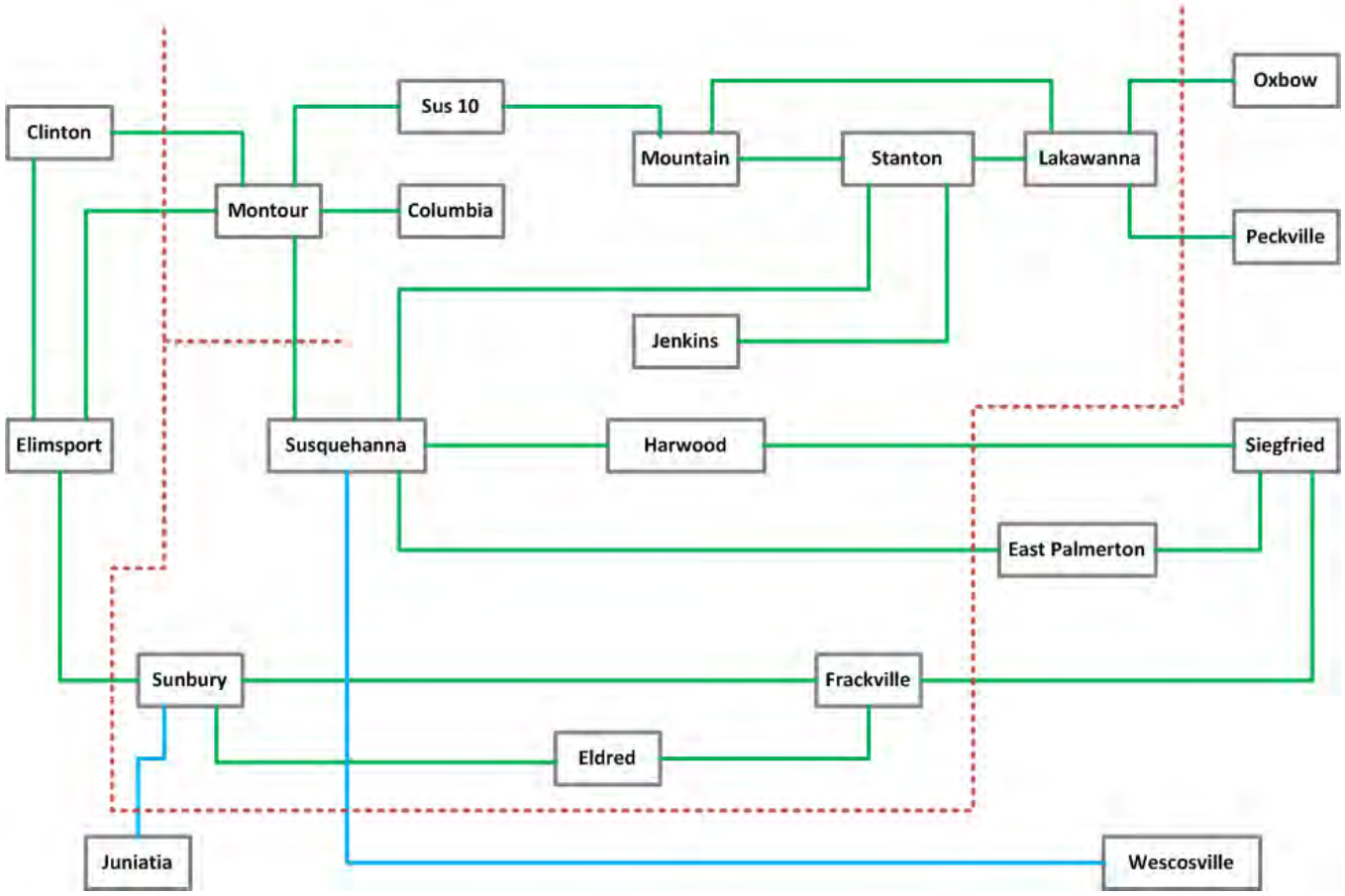
- Normal operations:
  - NEPA transfer export limit is adjusted based on out of service generation and transmission facilities
    - With all facilities in service, the base stability limit is 3900 MW
    - Subtractors associated with specific facility outages are then applied to determine the actual transfer export limit

Impacts of Bad Data Examples

- Events on April 28, 2008:
  - Circuit Breaker outage @ 2140 removed a facility from service and caused PJM to see a violation on the transfer limit
  - PJM had a difference with PL of ~ 400 MW in flow on the interface
  - PJM used more conservative values and issued Local Min Gen Event in area to return flows under the interface limit
  - This included 200 MW reduction on nuclear units in the area
  - Facility was returned to service and Local Min Gen Event cancelled at 0012 on 4/29/08
  - Operators on shift investigated and found cause for differences in values between PJM and PL
  - PJM model did not include changes to 230 kV system causing the calculations to be incorrect

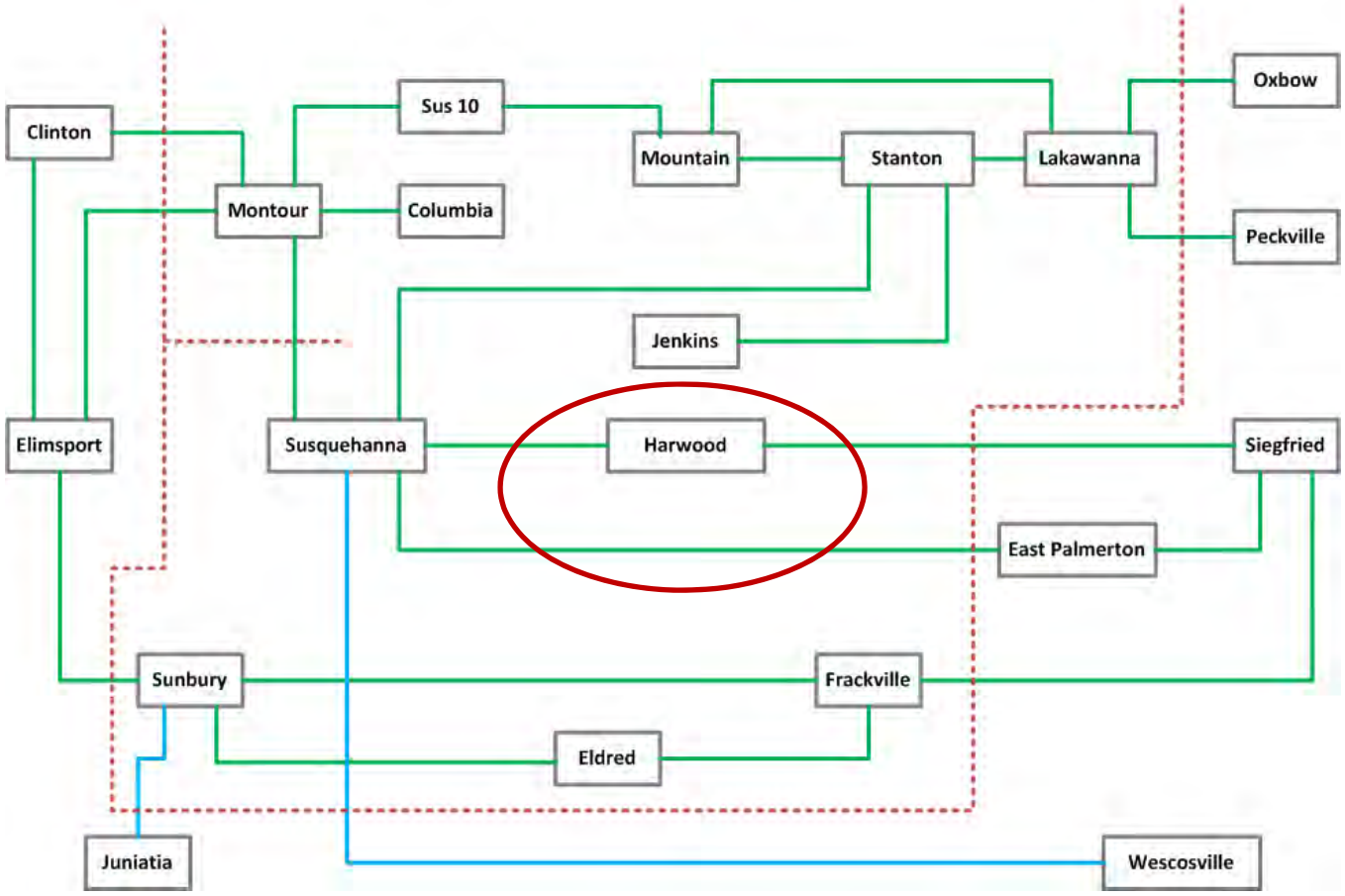
Impacts of Bad Data Examples

PJM Model



Impacts of Bad Data Examples

PJM Model



Discussion Topic

- Think of a possible scenario where you could impact reliability with bad data

- What potential impacts could bad data have on your operations?

Questions?

Resources and References

- PJM. (2014). *PJM Manual 14D: Generator Operational Requirements (rev. 28).* Retrieved from http://www.pjm.com/~/media/documents/manuals/M14D.ashx