Transmission ITP

Data Exchange Requirements

PJM State & Member Training Dept.

Objectives

The student will be able to:

- Recognize and correct any inconsistencies in data reported via EMS

Real-Time Data

- PJM and Member Companies analyze the security of the system using real-time information
- The model and results of PJM and the Member Companies network applications are only as accurate as the input data used in the calculations and modeling
  - Garbage in …. Garbage out
- Per NERC Standard IRO-010-1a, PJM as the Reliability Coordinator, has determined and listed the data required in order to accurately monitor the security of the electric system

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 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 EMS to Member's EMS 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

Data Requirements

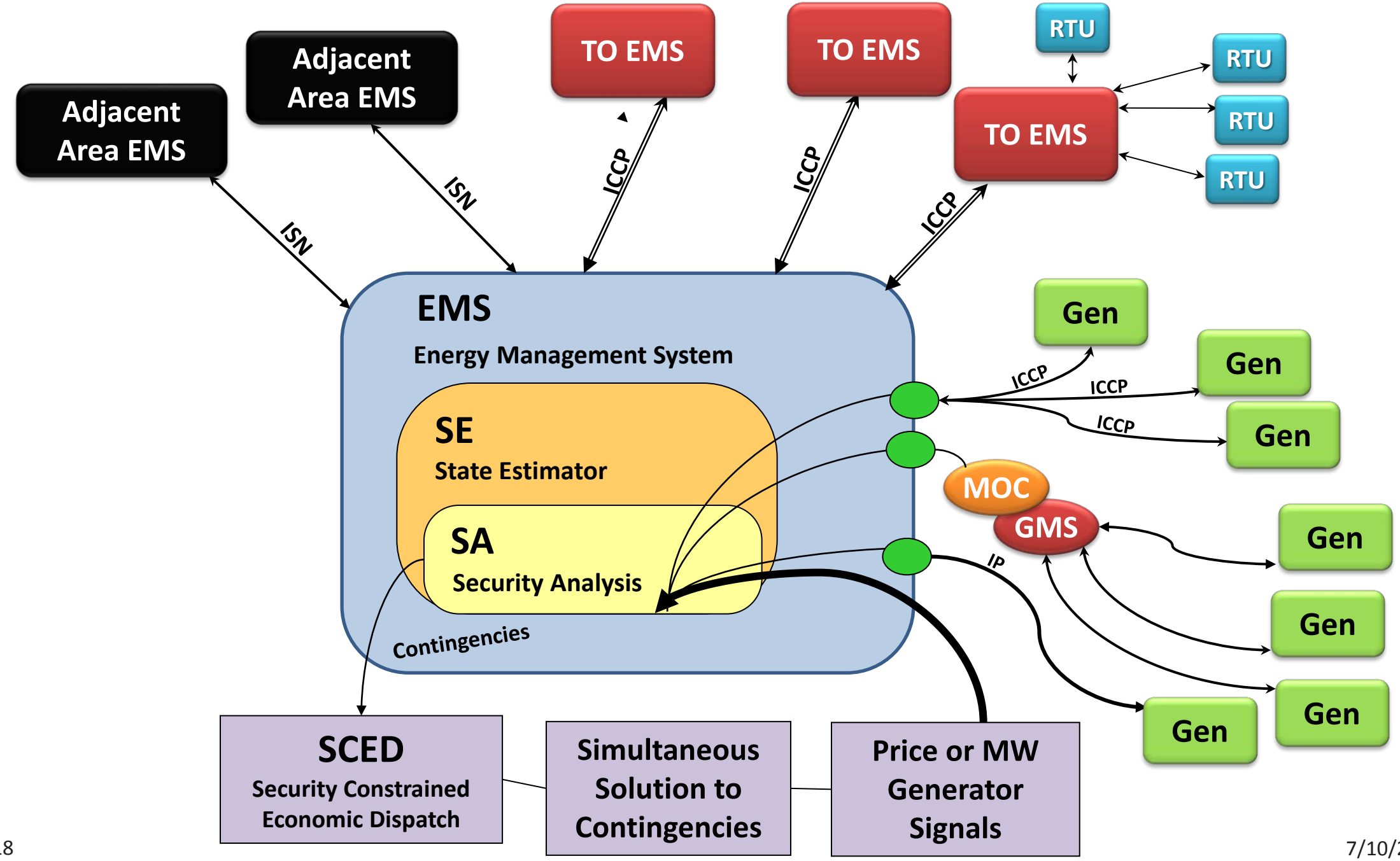
Analog Data measurements required

- Voltages for buses at 34 kV & above
- MW & MVAR values for individual generating units > than 1 MW
- MW & MVAR values for designated transmission facilities at 69 kV & above (for single-phase metering, B-phase is preferred)
- Transformer phase angle regulator (PAR) tap
- Transformer load tap changer (LTC or TCUL) tap
- MVAR values for synchronous condensers
- MW & MVAR injections on buses at 34 kV and above
- Selected station frequencies

Data Requirements

Status Data required

- Breaker and disconnect statuses
- Transformer fixed tap settings (change in no-load tap setting)


Adjacent Area EMS
Adjacent Area EMS
TO EMS
TO EMS
RTU
RTU
RTU
RTU
TO EMS
ISN
ISN
ICCP
ICCP
ICCP
EMS
Energy Management System
SE
State Estimator
SA
Security Analysis
Contingencies
Gen
Gen
Gen
ICCP
ICCP
ICCP
MOC
GMS
IP
Gen
Gen
Gen
Gen
SCED
Security Constrained Economic Dispatch
Simultaneous Solution to Contingencies
Price or MW Generator Signals

Advanced Applications

EMS Advanced Applications

- Single State Estimator solution
  - Basis for the PJM Security Constrained Economic Dispatch (SCED)
  - Network Applications Package
- Interruptions to data / inaccurate data could result in:
  - Non-convergence to the state estimator
  - Inability of PJM and Member TOs to monitor the transmission system
- Avoid unnecessary ICCP link outages / database maintenance, if possible
  - Multiple company ICCP datalink outages could result in:
    - PJM or Member Company EMS Security Analysis issues
    - Potential system reliability issues even during moderate load levels

Advanced Applications

Real-Time Analysis

- TOs must have real-time analysis if:
  - They own BES facilities and serve load greater than 300 MW
    - Or they must have their BES facilities observable within another TO analysis program
- Unknown Operating State
  - Due to a catastrophic failure of the ICCP links or loss of EMS analysis tools
    - Considered an Emergency and operations shall be restored to respect proven reliable power system limits within 30 minutes in accordance with NERC standards

Advanced Applications

Back Up to PJM

- TOs serve as a back-up to PJM, monitoring BES facilities, when the PJM EMS is inoperable
- TOs shall notify PJM dispatch within 15 minutes when their analysis programs are unavailable
- In general, PJM may be in an unknown state when both PJM and TO analysis programs are unavailable

Manually Entered Data

What is it?

Data that is manually entered and updated by the System Operator

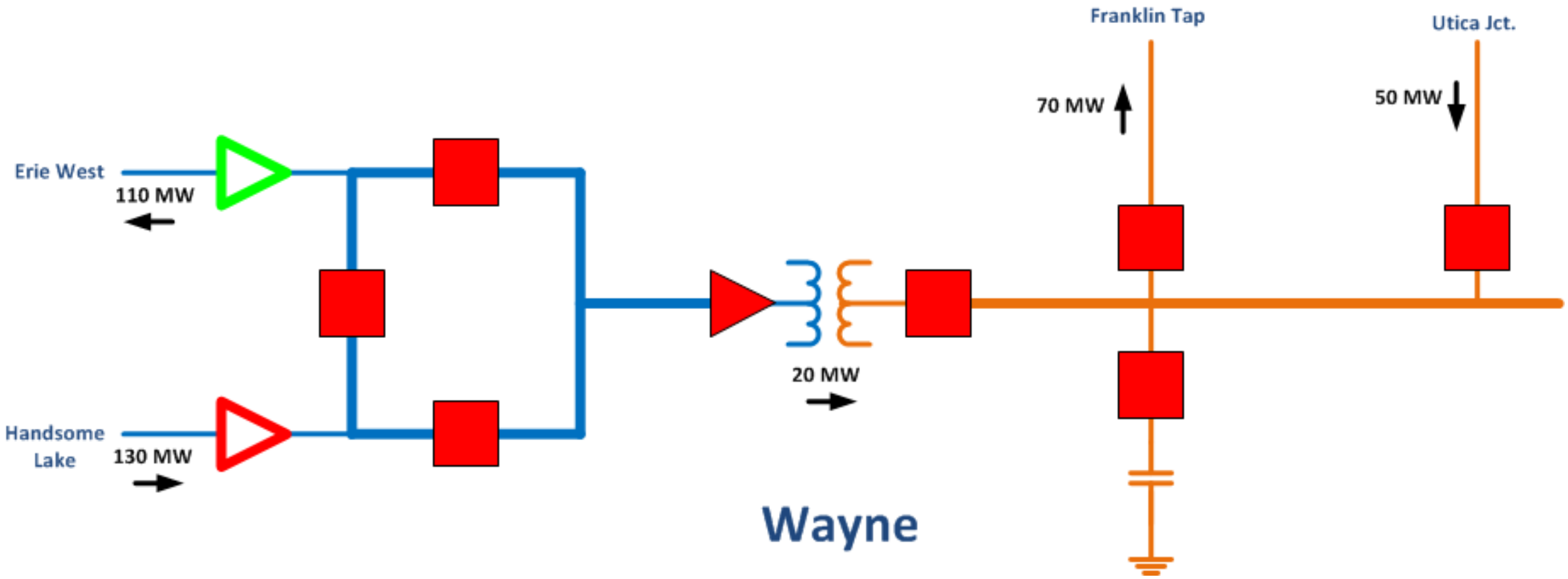
- Steps:
  - Identify suspected data
  - Verify validity of suspected data
    - Use other tools, experience & knowledge, other computer models if available
  - Sanity check - bus summation calculations
  - Determine requirements for updating
    - (For 345kV & higher RTU or tie lines, 30 minutes, Manual 3)
  - Resolve cause of bad data

Manually Entered Data

Keeping on top of Manually Entered Data

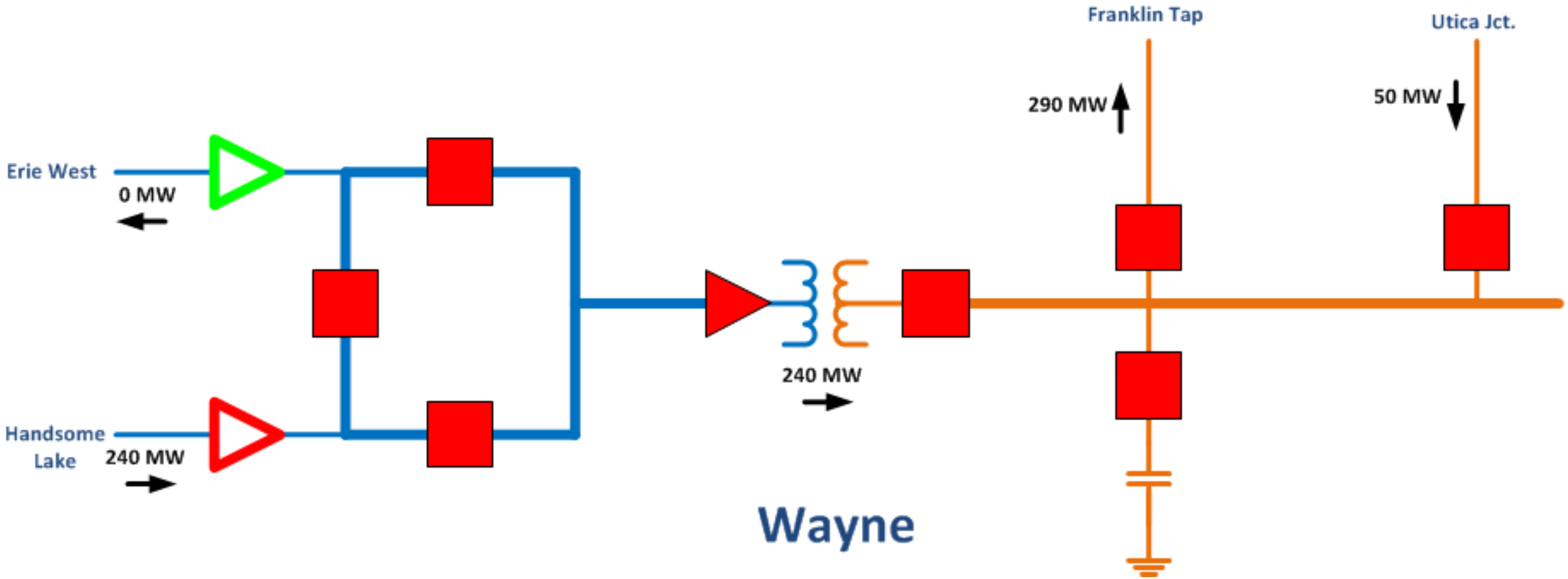
- Start of Shift:
  - Identify points that are currently updated manually
    - Shift turnover sheet or pass down from previous shift
    - EMS displays that summarize manually replaced data
- During Shift:
  - Monitor system for additional bad data
  - Take necessary action to correct data when found
  - Update values or status of current manually replaced data
- End of Shift:
  - Inform your relief of all points currently manually entered

Manually Entered Data



Real-time Data

Manually Entered Data



State Estimator Data

Manually Entered Data

Impacts of Bad Data

What are the impacts?

- Safety of personnel
  - Energized vs. De-energized
- Reliability
  - Uninterrupted Operation
    - Overloaded lines lead to outages
    - State estimator and Security analysis results incorrect.
    - Violation of limits (Actual, LTE, STE or Load Dump)
- Economy
  - Operating the system at the least cost
    - Bad SE / SA results could lead to unnecessary out-of-merit operation

Impacts of Bad Data

What are the impacts?

- Localized
  - MWH readings for large customers
  - Single value in substation or entire substation
- Company Wide
  - Communication links down with control centers
- System Wide
  - Economic dispatch not followed (ACE not on zero)
- Interconnection Wide
  - Inaccurate net tie flows

Examples

Homer City

Impacts of Bad Data Examples

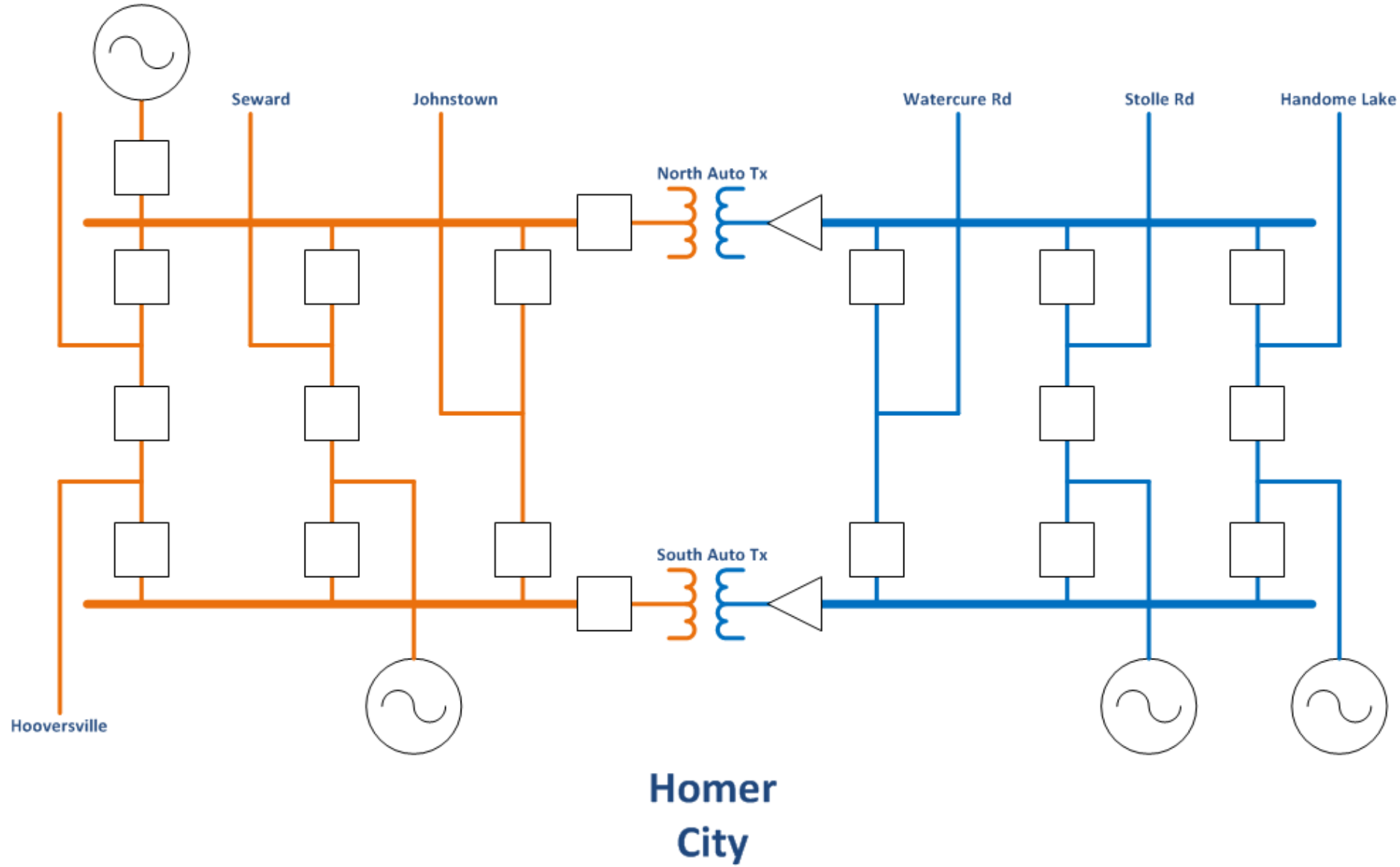
Homer City South 345/230 Auto Transformer CB

- MW/MVAR reading for South Auto Transformer was identified as being incorrect
  - Problem started 3/31/2006 @ 13:30
- While awaiting repair by field personnel, TO manually replaced the points and updated them on a periodic basis
- During one update the low side CB was inadvertently manually replaced in the closed position
  - Location of MW value in relation to CB was very close

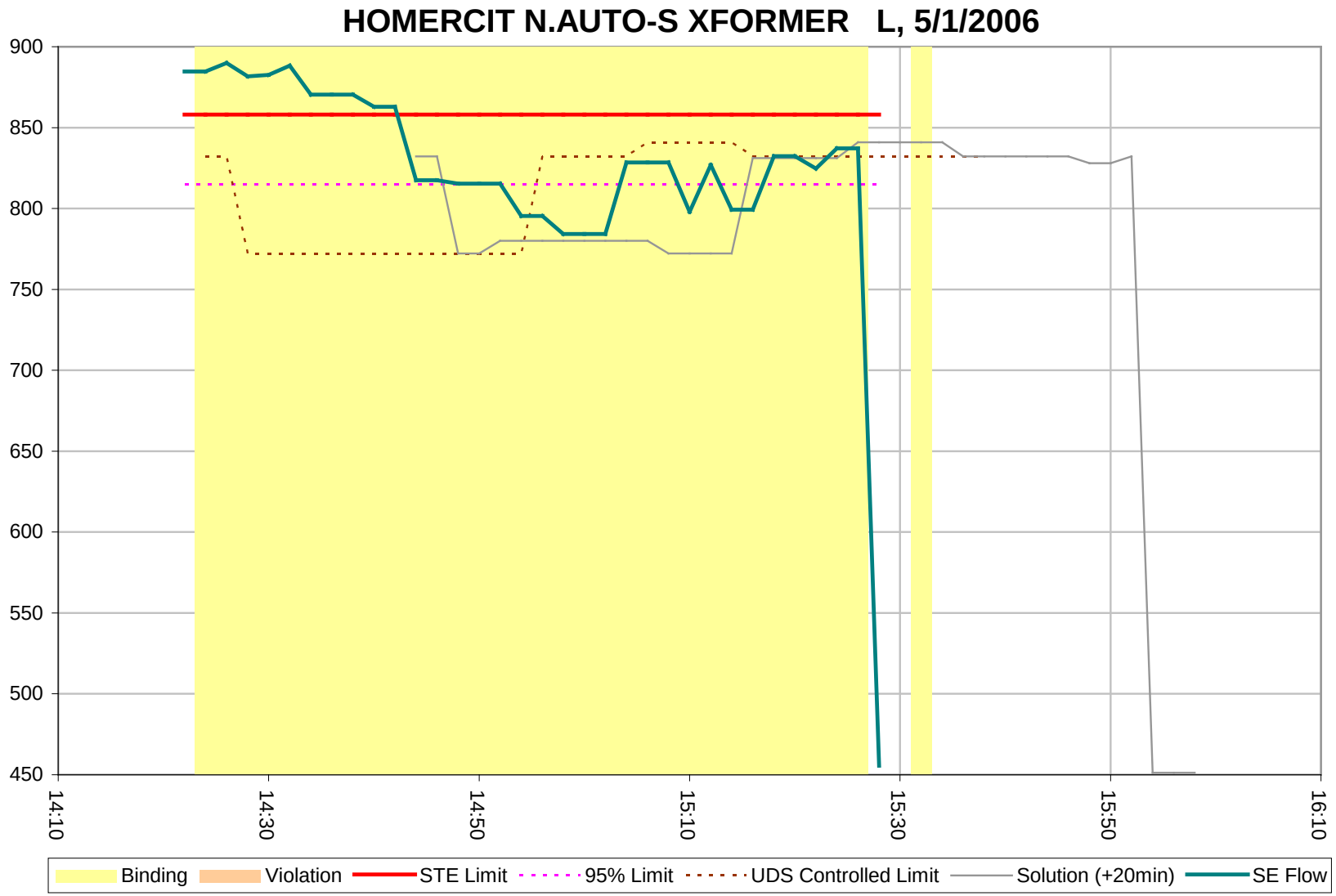
Impacts of Bad Data Examples

- South Auto Transformer 230 kV CB tripped open on 4/29/2006 @ 22:36
  - No indication to TO due to status and MW/MVAR points being manually replaced
- As a result, contingency analysis results for Homer City North Auto Transformer were inaccurate

Impacts of Bad Data Examples

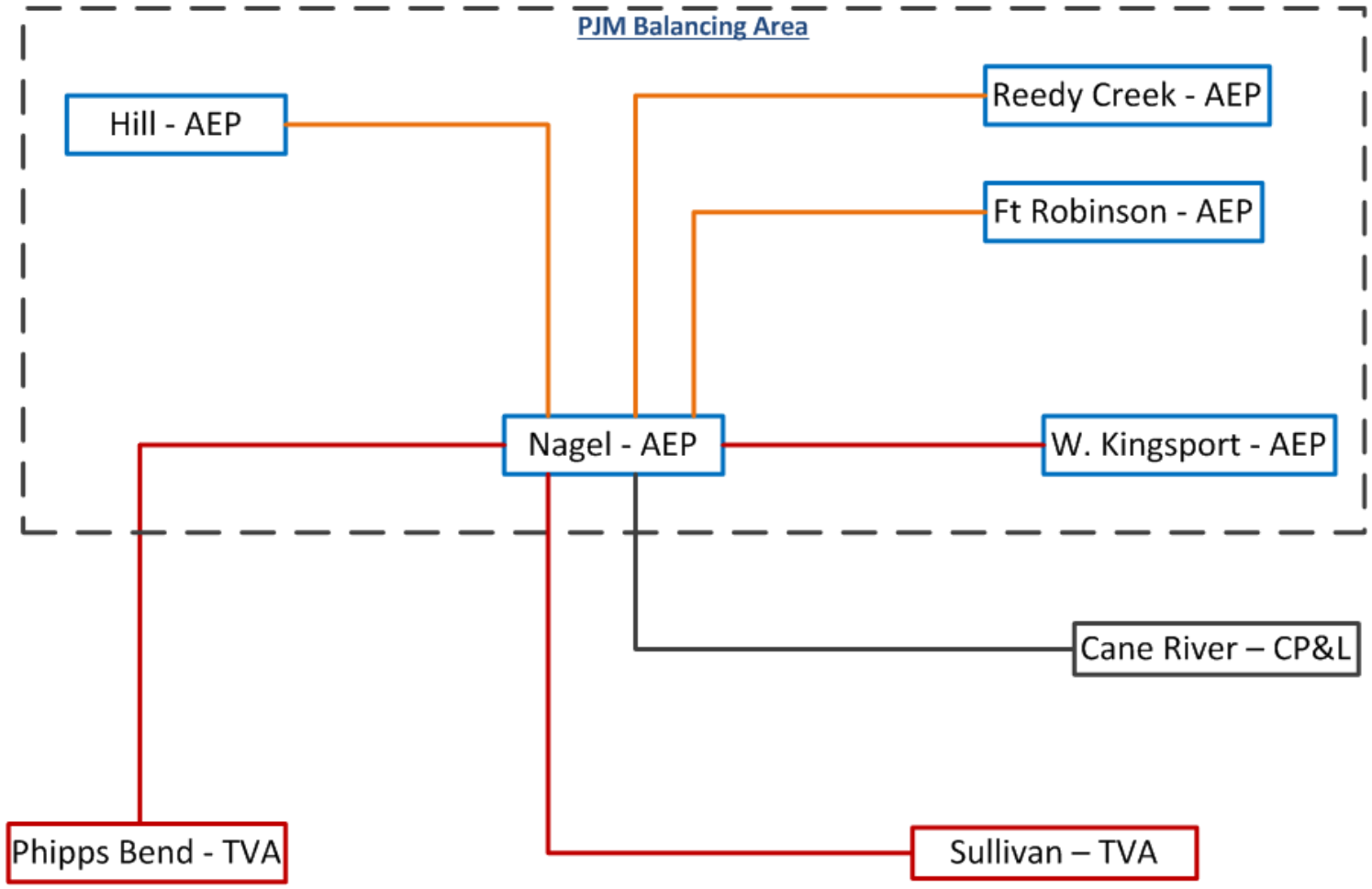


Impacts of Bad Data Examples



Nagel Ties

Impacts of Bad Data Examples

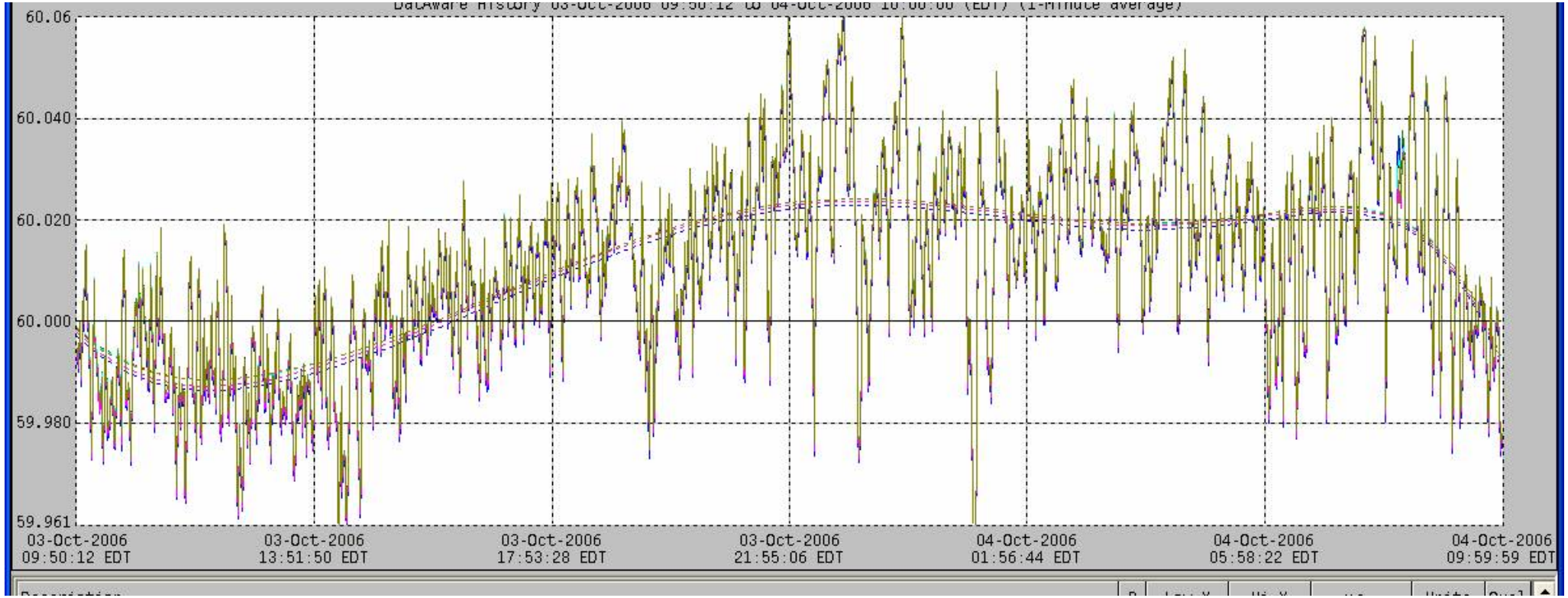


PJM began experiencing problems on the:

- 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

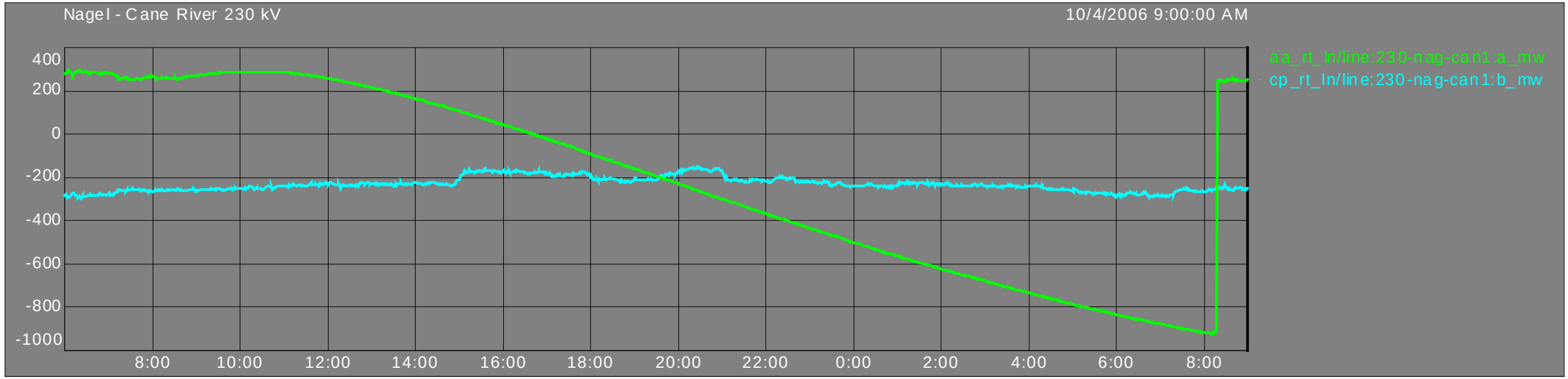
- The inaccurate tie values resulted in PJM over-generating between 10/3/2006 15:00-10/4/2006 09:00, contributing to high frequency for an 18 hour period

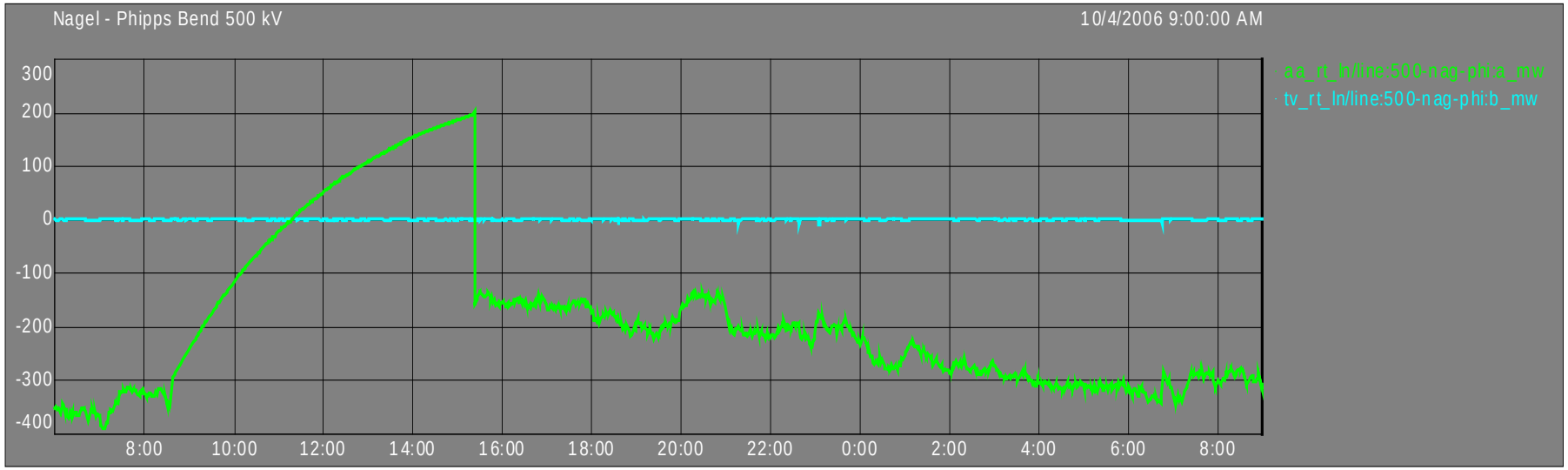


Impacts of Bad Data Examples

- 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

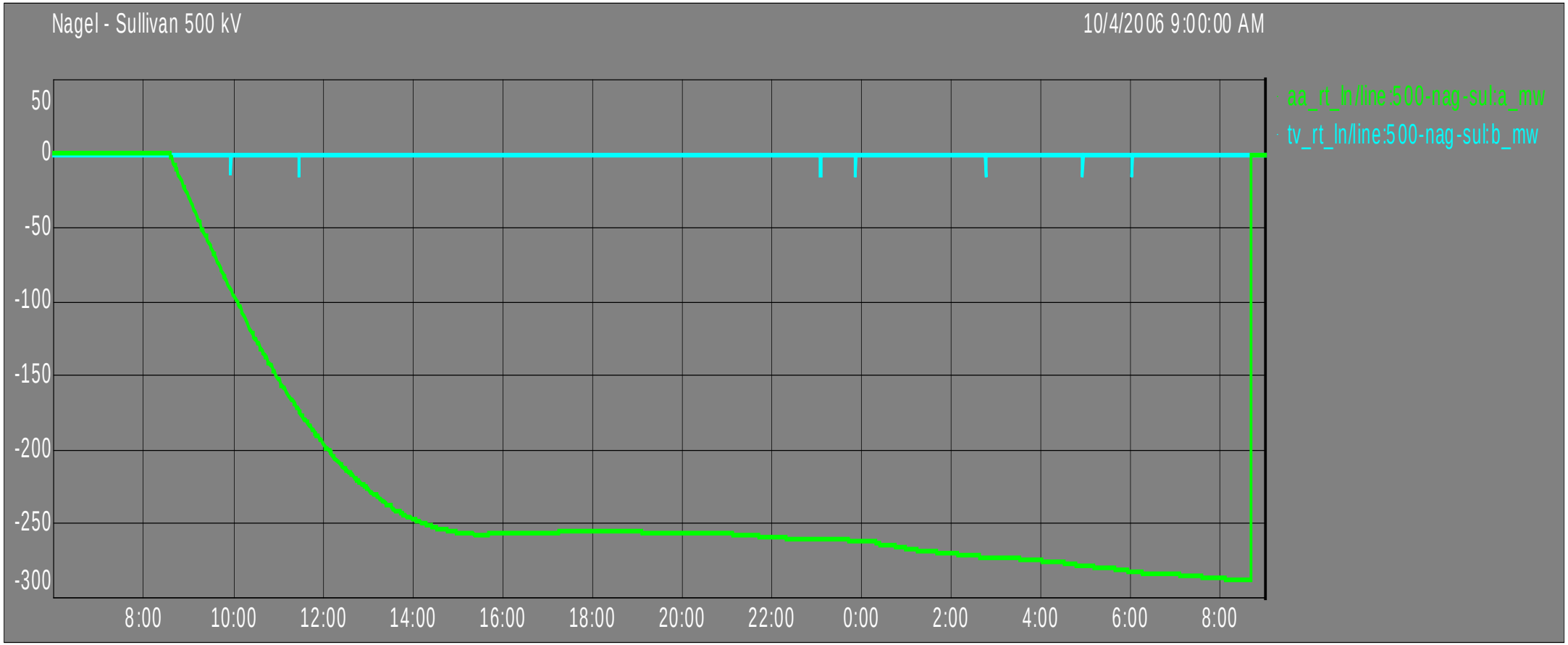
Impacts of Bad Data Examples





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

EMS Cutover

Impacts of Bad Data Examples

FE RTU Cutovers

- Planned cutover from Siemens EMS to AREVA EMS to occur over a 2 day period (1st day was PJM holiday)
  - Numerous ICCP uploads were performed to update the source of analog data being sent to PJM
  - As cutovers progressed, the sign on several analog data items became mismatched between the PJM EMS and the PJM GMS

Impacts of Bad Data Examples

FE RTU Cutovers

- Thirteen data items going to the PJM GMS system needed an invert record to make them match the correct values going to the PJM EMS
- Some of the effects of the error were passed on to member companies through the EMS ICCP links
  - Affected the network applications of PL and PE

Impacts of Bad Data Examples

FE RTU Cutovers

- Numerous cable/RTU moves were performed over 1st and 2nd day
- Once FE had confirmed the integrity of the data on AREVA EMS they would perform an ICCP dB upload get the data to PJM
- PJM engineer would then verify the data and make note of any problems requiring corrective action

Impacts of Bad Data Examples

FE RTU Cutovers

- PJM personnel found mismatch on some data points in PenElec and informed FE of issues at end of 2nd day – 34 hours after start of cutovers
- PJM and FE engineers worked together to indentify 13 points that had incorrect sign being passed to PJM GMS
- Performed database upload to invert sign on values and correct issues

Impacts of Bad Data Examples

FE RTU Cutovers

- This was first of 3 planned EMS cutovers planned
- No formal procedures that outlined data verification process
- During future cutovers, points that needed invert applied were identified prior to start of data migration
- Additional checks to be made to ensure data quality is correct

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
    - Provides 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

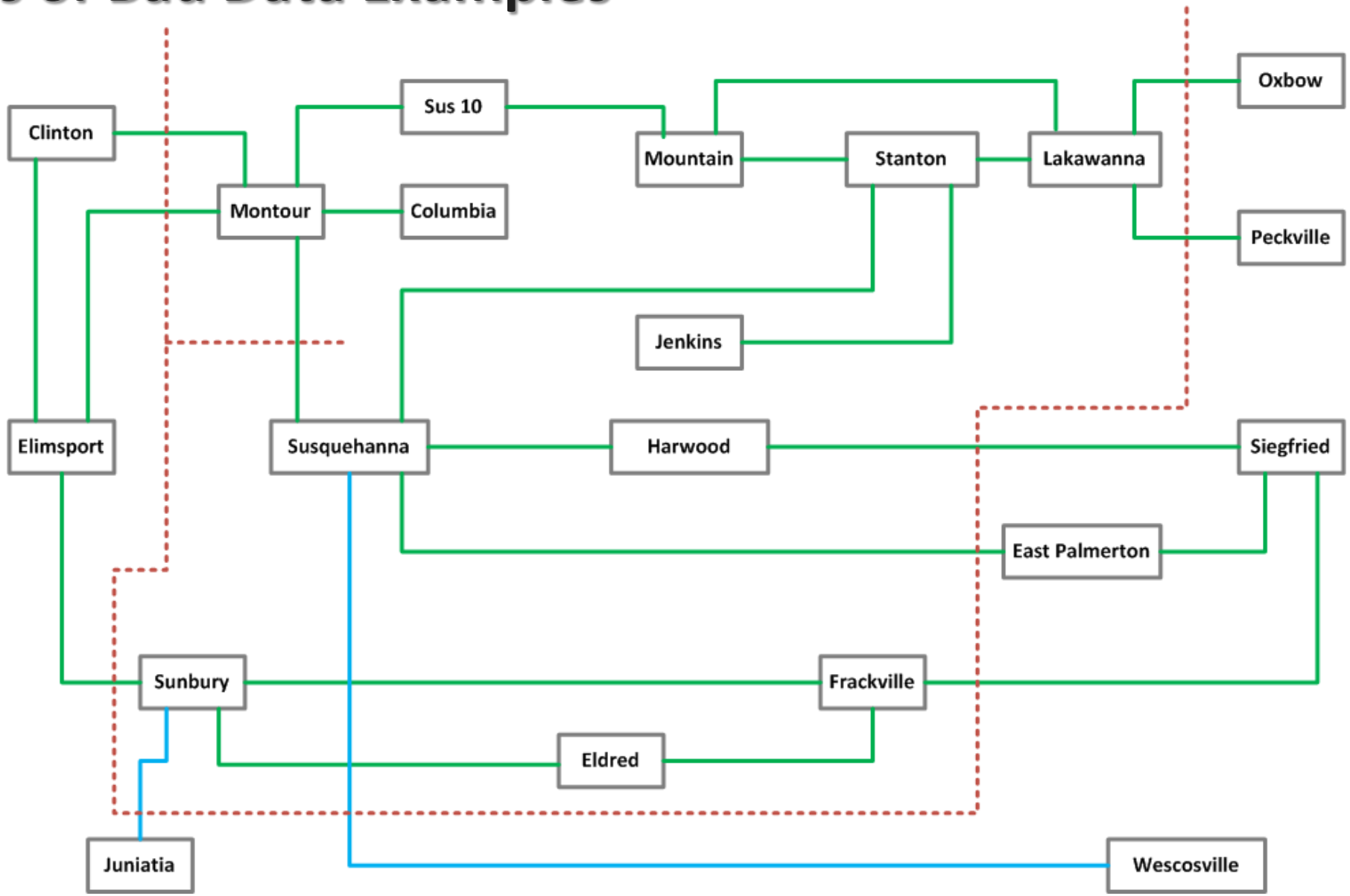
- Normal operations:
  - NEPA transfer export limit is adjusted based on out of service generation and transmission facilities
    - With all facilities in service, the base stability limit is 3900 MW
    - Subtractors associated with specific facility outages are then applied to determine the actual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

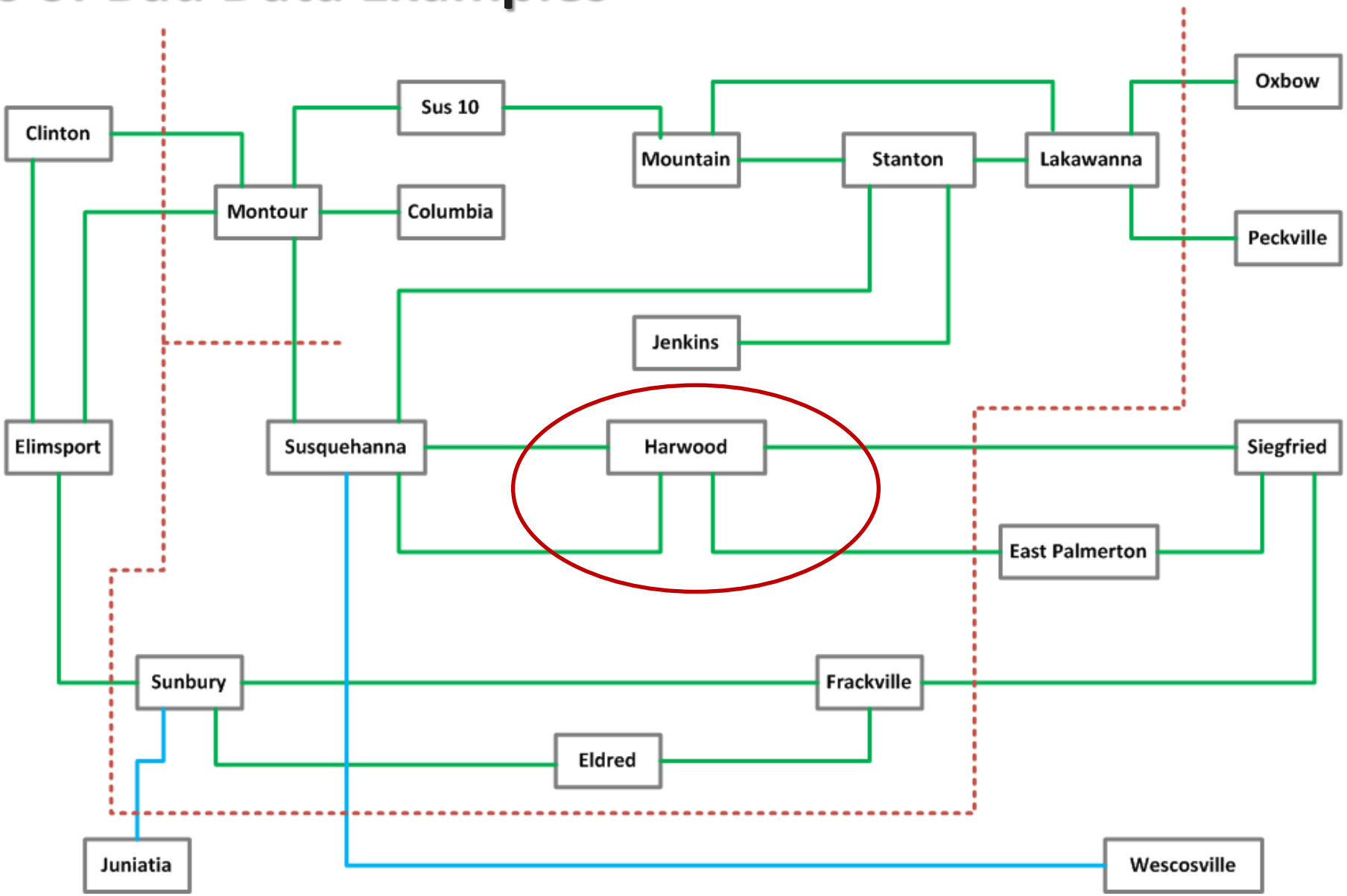
Impacts of Bad Data Examples

PJM Model



Impacts of Bad Data Examples

PL Model



Summary

- PJM requires accurate data for the reliable operation of the bulk electric system
- Errors in data can lead to unreliable and uneconomic operation of the electric system
- System operators are responsible for recognizing and correcting bad data

Contact Information

PJM Client Management & Services

Telephone: (610) 666-8980

Toll Free Telephone: (866) 400-8980

Website: 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

- PJM. (2017). *PJM Manual 1: Control Center & Data Exchange Requirements (rev 35).* Retrieved from http://www.pjm.com/~/media/documents/manuals/m01.ashx
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