

Transmission ITP

Telecommunications

PJM State & Member Training Dept.

Students will be able to:

- Explain the back-up satellite phone testing requirements
- Explain how to coordinate outages of telemetry and communication equipment with PJM (RTUs, datalinks, etc.)
- Identify the requirements of Member Companies to have a plan for loss of Control Center Functionality
- Recognize and correct any inconsistencies in data reported via EMS

Satellite Phones

Satellite Phone Review

- Satellite telephones are used by PJM dispatchers as Alternative Interpersonal Communication capability for voice communications
 - These telephones are used to protect against loss of common carrier services
- Transmission Owners shall have satellite phone capabilities at both their primary and back-up facilities
- Generation Operators shall have satellite phones capabilities when controlling one or more units totaling 500 MW or greater

Satellite Phone Review

- Functional Requirements for Satellite Phones:
 - Compatible with PJM satellite network
 - Ability to receive dedicated all-call
 - Ability to bypass the ground phone (PSTN) network

Satellite Phone Review

- Tests are conducted to verify that all equipment is working correctly and proper communication protocols are being used
- Two tests are conducted including the use of the Push-to-Talk (PTT) and Two-way Point-to-Point systems



Satellite Phone Review

When Does Testing Take Place?

- Test are normally conducted on weekly basis
 - Target test day is Saturday at 12:30 hrs
- Tests may need to take place more frequently depending on current security level
- Satellite phones are also tested during a PJM-sponsored emergency procedures drills

Satellite Phone Review

Who Participates in the Testing?

- All Member Companies with satellite phone systems participate in the tests
 - Generation Operator (GO) Control Centers must have satellite phones when one or more units total 500 MW or greater
 - Transmission Owners must have satellite phones at both their primary and back-up facilities

Satellite Phone Review

What Are the Main Purposes of Testing?

- The testing ensures proper functionality and reliability of the satellite phone system at both PJM & Member Company locations
- Allows the opportunity to test readiness level of Operators
- Operators have the opportunity to become familiar with the satellite phone equipment



Satellite Phone Review

Communication Protocols & Testing

- Testing ensures proper communication protocols are being followed when using the satellite phone system
 - Speak clearly, slowly and be mindful of pronunciations
- Use proper “code words” when communicating
 - “Over” when message/statement complete
 - “Out” when terminating transmissions (Initiator)
- Always identify your company and your name

Coordinating Telemetry and Equipment Outages

Data Outages

Miscellaneous Reportable Outages

- Email coordination notice 24 business hours in advance of regular system changes that could affect ICCP data link communications or the data exchange with PJM
 - Any action affecting ICCP data sent to PJM (EMS/GMS Database updates, server failovers)
 - Significant Software Enhancements
 - Communication line outages
 - Backup center testing
 - Failovers to alternate sites
 - Network and Firewall maintenance
 - RTU outages or changes to RTU data sent to PJM for RTUs connected to EHV (345kv and above) facilities

Data Outages

Miscellaneous Reportable Outages (Cont.)

- The PJM EMS Networking group will coordinate any technical details, or additional support, as needed, with the member company
- Members providing notification should send an email to: outage@pjm.com.
- 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 (610-666-8806) at least 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 or existing ICCP data link outages
 - Deny a request for a member company planned outage if requested time has been previously scheduled
- PJM will notify member companies of PJM initiated outages via an email list at least 24 business hours in advance
- PJM will follow-up significant outages with an All Call message 15 minutes prior to the outage

Data Outages

Scheduling Data Outages

- The following time periods are not allowed for planned outages:
 - During specific resource critical times including PJM quarterly model build days, due to heightened operational and technical complexity and risk
 - During other unique and infrequent major events for PJM, such as major EMS upgrades or major company integrations
 - Over holidays, due to constrained resource availability
 - During multiple company ICCP data link outages (No more than one member company planned outage will be accepted in any given time period)
 - Further restrictions may be enforced when peak load operations are projected in any Control Zone

Data Outages

Scheduling Data Outages (con't)

- Unscheduled system changes or events that could potentially affect data received by or sent by PJM must be immediately communicated
- To the extent possible, emergency changes should occur:
 - Prior to 11:00 EPT during summer operations
 - Between 10:30 – 14:30 EPT during winter operations
 - If emergency work that cannot be delayed or rescheduled requires an outage, the PJM Shift Supervisor will work with the emergency coordinators for approval and scheduling

Data Outages

Unscheduled Data Outages - Considerations/Actions (TO/GO):

- Contact PJM Dispatch to report/discuss problem
- Contact the support staff to resolve the issue
- Provide a contact person and phone number to PJM Dispatch to enhance efficiency of communications avoiding potential reliability issues
- Notify PJM Control Room when system has returned to normal

Data Outages

Unscheduled Data Outages – Additional GO Considerations/Actions:

GO Operator – MOC Operator

- Recognize previous SCED approved base-points are stale while ICCP link problems exist
- Verbally communicate manual dispatch directions to plants if communication problems are not resolved within 10 minutes
- Log manual dispatch direction

Data Outages

Unscheduled Data Outages – Additional TO Considerations/Actions:

TO (Operator)

- Contact PJM Dispatch regarding transmission constraints
- Staff critical substations to support transfer of critical data to PJM

Data Outages

Unscheduled Data Outages – PJM Generation Considerations/Actions:

- Recognize previous SCED approved base-points the member is receiving are stale
- Communicate zonal cost if problems are not resolved within 10 minutes
- Communicate targeted generation dispatch if transmission constraints arise
- Log manual dispatch direction
- Reassign regulation to other MOC units as necessary
- Elevate PJM/MOC communication to Shift Supervisor level if reliability issues arise

Data Outages

Unscheduled Data Outages – PJM Transmission Considerations/Actions:

- Communicate impact on ability to monitor transmission system
- Update EMS with the critical data provided by the Transmission Owner
- Manually redispatch, as necessary, to control transmission constraints based on the Transmission Owner's analysis
- Ensure all actions are logged

Data Outages

- Data Exchange during EMS Datalink Outages
 - Members are responsible for determining data quality indicators for all data transmitted to PJM
 - Failed individual values and any value calculated using a failed point must be flagged
 - State estimated values may suffice for an interim period
 - If PJM encounters any real-time data quality issue that affects Real-time Assessments, PJM will notify the Member via email or phone call to address the issue
 - Members shall send data to PJM during planned and unplanned outages based on the type of outage, the available alternative communication method and the thresholds for reporting

Data Outages

- The following are acceptable alternate methods of communication based on the outage type:
 - RTU/Device Outages (when the ICCP/DNP3 communication is up, but a specific data set is lost due to RTU or telemetry device outage)
 - Member shall manually replace the failed data within their EMS, which is communicated to PJM automatically via the existing EMS data link
 - Member shall call the PJM Control Room to verbally communicate the failed measurement data needed by PJM Control Room
 - Member shall securely transfer measurement data files using a mutually acceptable transfer protocol

Data Outages

- The following are acceptable alternate methods of communication based on the outage type:
 - EMS Link Outages (when the data link is down and all incoming EMS data from the member is telemetry failed):
 - Member shall securely transfer measurement data files using a mutually acceptable transfer protocol
 - Member operator shall call PJM control room to verbally communicate the measurement data

Data Outages

- If using an automated or manual electronic alternate method of communication, the PJM Member shall follow the procedure below:
 - The following measurement data shall be updated at least every 30 minutes via manually entered values or via the secure data file transfer:
 - Tie Line Flows, both internal and external
 - Transmission MW and MVAR flows and bus voltages at ≥ 100 kV
 - Generation MW and MVAR flows at ≥ 25 MW capacity

Data Outages

- If using an automated or manual electronic alternate method of communication, the PJM Member shall follow the procedure below:
 - If the PJM Member is using the secure data file transfer method, the measurement data file shall include the following information:
 - Equipment name
 - Measurement description
 - ICCP Object ID (if applicable)
 - Measured value
 - Timestamp

Data Outages

- In addition, if a significant event as described below occurs, the Member shall verbally notify the PJM Dispatch Office:
 - The loss of any equipment $\geq 100\text{kV}$
 - A change of ≥ 25 MW of any generator MW flow
 - A change of ≥ 100 MW flow at $\geq 500\text{kV}$
 - A change of ≥ 50 MW flow at $< 500\text{kV}$
 - A transformer tap position change occurring at $\geq 230\text{kV}$
 - A breaker status change at $\geq 100\text{kV}$
- If the actual values cannot be given, provide the best data available

Data Outages

- If the Member is unable to send a secure transfer file or manually replace values, then the Member shall follow the procedure below:
 - The Member shall check every 30 minutes for significant system changes compared to the last measurements verbally or electronically communicated to PJM Dispatch
 - If there are, the Member shall call PJM Control Room to verbally communicate these changes
 - If the actual values cannot be given, provide the best data available
 - Significant changes include:
 - The loss of any equipment $\geq 100\text{kV}$
 - A change of ≥ 25 MW of any generator MW flow
 - A change of ≥ 100 MW flow at $\geq 500\text{kV}$
 - A change of ≥ 50 MW flow at $< 500\text{kV}$
 - A transformer tap position change at $\geq 230\text{kV}$
 - A breaker status change at $\geq 100\text{kV}$

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, Section 2 – “Member Control Center Requirements”
- In addition, Manual 01, Section 2.5.6 specifies that each Member TO must have a plan for loss of control center functionality, which includes
 - Procedures and responsibilities for providing annual training
 - Assurance 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

Data Exchange Requirements

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-010-2, under Requirement 1, 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

- 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
 - EMS
 - Historical EMS Data
 - Energy Transaction
 - Long-term Planning
 - PJM Administration

Data Exchange

PJMnet Communications System

- Primary wide-area network for communicating Control Center data to and from PJM
- Supports two communication protocols:
 - ICCP data links to Control Centers
 - SCADA links to plants via remote terminal units (RTUs) using Distributed Network Protocol (DNP3)

Data Exchange

JetStream

- Data system to connect remote assets and PJM to satisfy real-time, market and other data transactions
- Small generators, load response assets and other market participants can communicate with the PJM EMS through the Jetstream system
 - The connecting network is the Internet and the data protocol is DNP3
 - High levels of security are provided

Data Exchange

PJM EMS Communication Protocols

- Utilizes two communication protocols:
 - Inter-control Center Communications Protocol (ICCP)
 - Connects with Member Control Centers and qualifying generating plants over PJMnet
 - Distributed Network Protocol (DNP3)
 - Connects with PJM Member substation RTUs over PJMNet for qualifying generators or Jetstream for smaller plants

Data Exchange

EMS Data Exchange

- Sent from Member Companies to PJM includes data needed for:
- Data is exchanged between each Member's and PJM periodically on one of several fixed cycles, as well as on demand, by exception, and interactively
- Data sent cyclically from PJM Members to PJM includes data needed for:
 - PJM control programs
 - Monitoring generation
 - Monitoring transmission
 - Monitoring interchange

Data Exchange

EMS Data Exchange

- Data sent cyclically from PJM to each Member includes:
 - System control data
 - Generation and transmission information required for monitoring and Security Analysis 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, and 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

- Bus voltages 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) taps
- Transformer load tap changer (LTC or TCUL) taps
- MVAR values for synchronous condensers
- MW & MVAR injections on buses at 34 kV and above
- Selected station frequencies

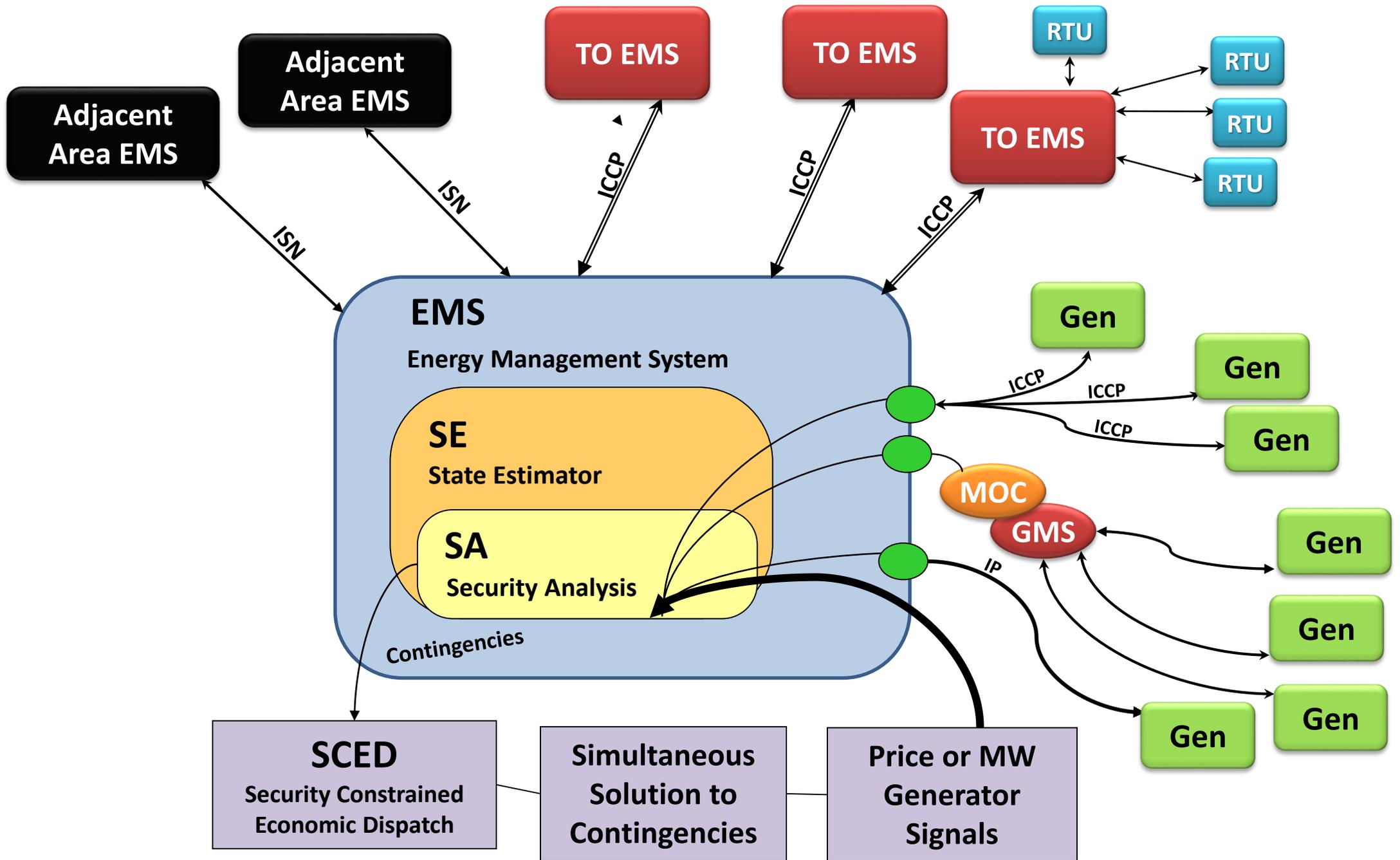
Data Requirements

Status Data required

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

Real-Time Telemetry

Criteria	Real-Time Telemetry Requirements
Generators participating in the PJM market as capacity resources	Real and reactive power
Generators 10 MW (Maximum Facility Output) or larger	Real and reactive power
Generators greater than 1 MW (Maximum Facility Output) and connected at a bus operating at 50 kV or greater	Real and reactive power
Solar parks 3 MW (Maximum Facility Output) or greater	Real and reactive power (see Section 12.2 for additional requirements)
Distributed generators (such as, the treatment of many units dispersed over a wide area as one aggregated unit) modeled less than 10 MW (Maximum Facility Output)	Real and reactive data at the BES injection point of accuracy within 10% of hourly MWh settlements data (revenue meter or accumulator data)
Generators that will also participate as PJM demand response resources when they will reduce load and have PJM-approved interconnection rights to inject power.	Real and reactive data, based on the Generator criteria in this table, at the point of interconnection and real and reactive power for the generators.



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 – Utilize 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

Display View Setup Execution Disp_Indx Summaries Error_Logs Main_Disp PUM Help

REAL TIME STATE ESTIMATOR
TELEMETERED DATA SNAPSHOT: 12/02/08 08.18.50
LAST CONVERGED SE SOLUTION: 12/02/08 08.19.01 FULL YES

SE STATUS: DONE 08.19.22 MODE: FULL PAGE 1

MEASUREMENT				RESIDUAL	MEAS	EST	NUM	TIME	FIRST
STATION	VOLTAGE	NAME	TYPE				DET	DETECTED	
FTMARTIN	500 KV	FTMARTIN-RONCO 516	LINE PM	2	1522	1520	1	08:19	12/02
HATFIELD	500 KV	HATFIELD-YUKON	LINE PM	0	857	857	1	08:19	12/02
HATFIELD	500 KV	HATFIELD-RONCO 538	LINE PM	-1	-1515	-1514	1	08:19	12/02
HATFIELD	500 KV	HATFIELD TRSN 3	XFORMER XFRM PM	536	-508	-1044	1	08:19	12/02
YUKON	500 KV	HATFIELD-YUKON	LINE PM	0	-857	-857	1	08:19	12/02
HUNTERST	500 KV	HUNTERST 1 BANK	XFORMER XFRM PM	0	183	-183	4	08:19	12/02
SANDERSO	138 KV	OBLAPLJT-SANDERSO	LINE PM	-71	-33	38	36	07:36	12/02
CANERUN	138 KV	CANERUN A1	XFORMER XFRM PM	8	-141	-149	36	07:36	12/02
CANERUN	138 KV	CANERUN B2	XFORMER XFRM PM	7	-139	-146	36	07:36	12/02
CANERUN	69 KV	CANERUN B	LOAD P-LD PM	358	-121	-479	36	07:36	12/02

CLEAR BAD DATA FOR NEXT SE RUN - WAIT UNTIL SE IS DONE FIRST

REAL-TIME NA MONITOR SE WILL NOT CONVERGE SE BAD TIES
 SE ABNORMAL DATA SE CORRECT BAD SOLUTION

Cancel Execute DataEntry RepeatEntry Recall SEARCH(1)

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

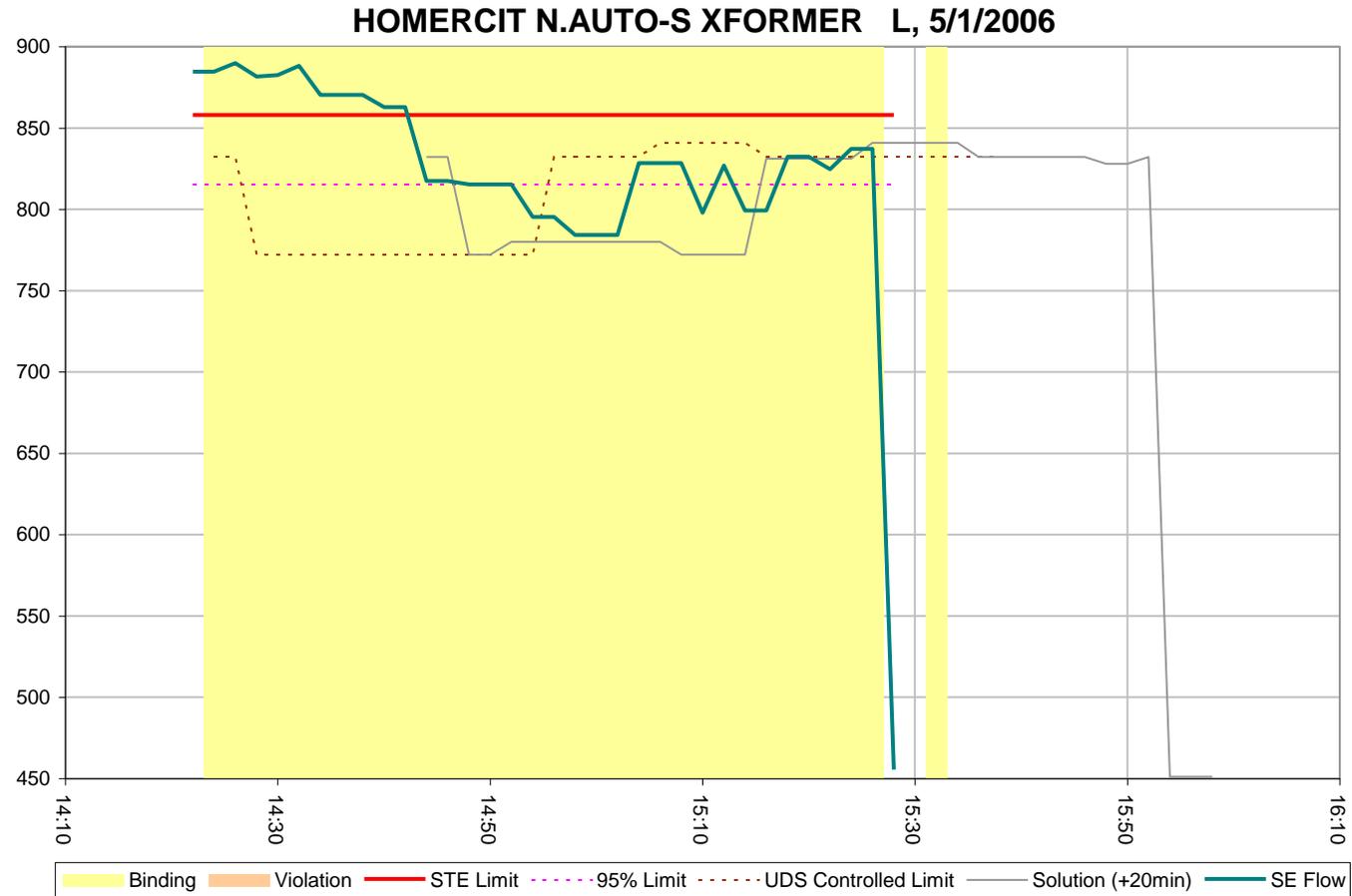
Homer City South 345/230 Auto Transformer CB

- 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 until the problem was corrected on 5/1/2006 @1700

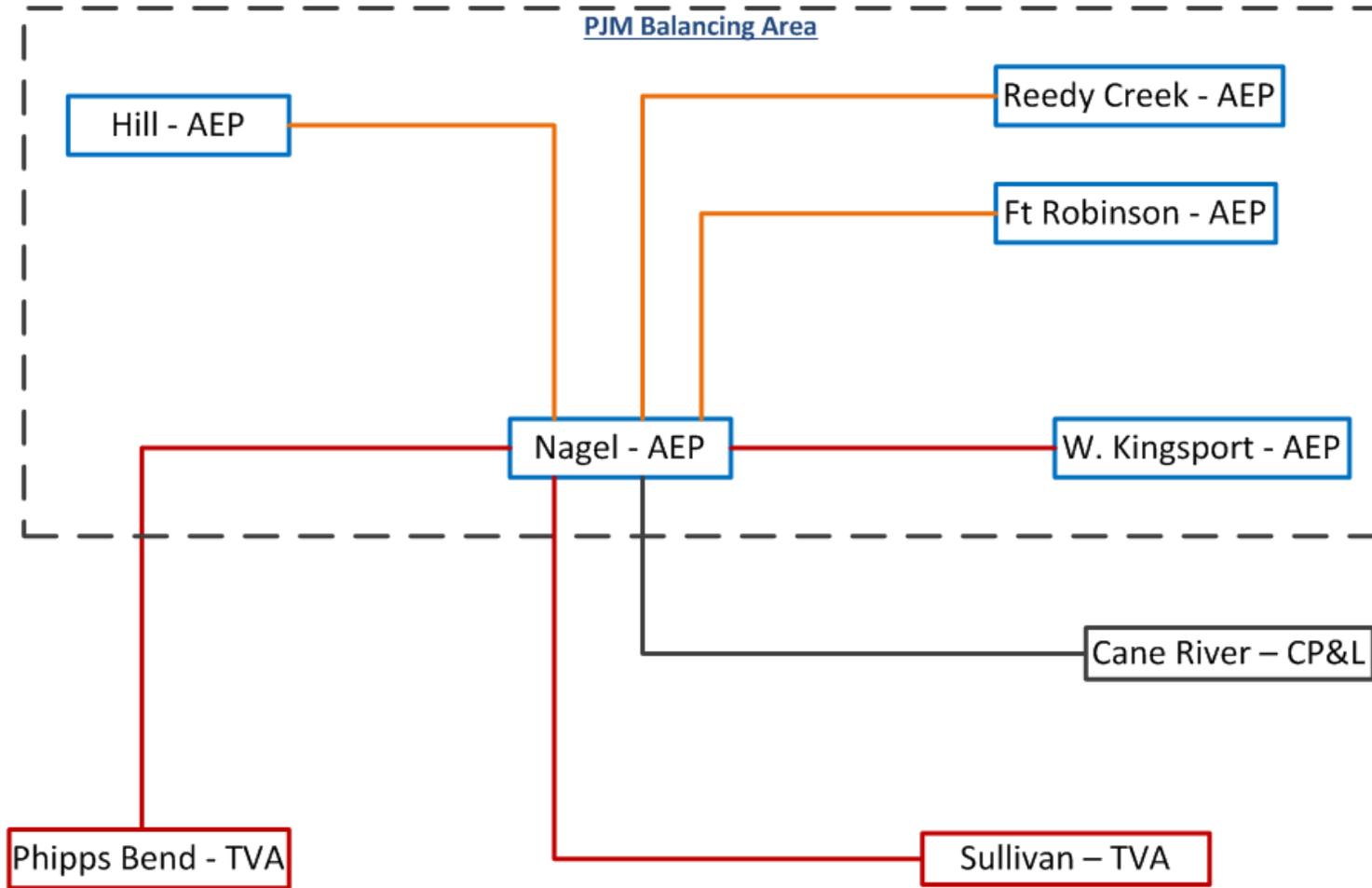
Impacts of Bad Data Examples



Nagel Ties



Impacts of Bad Data Examples

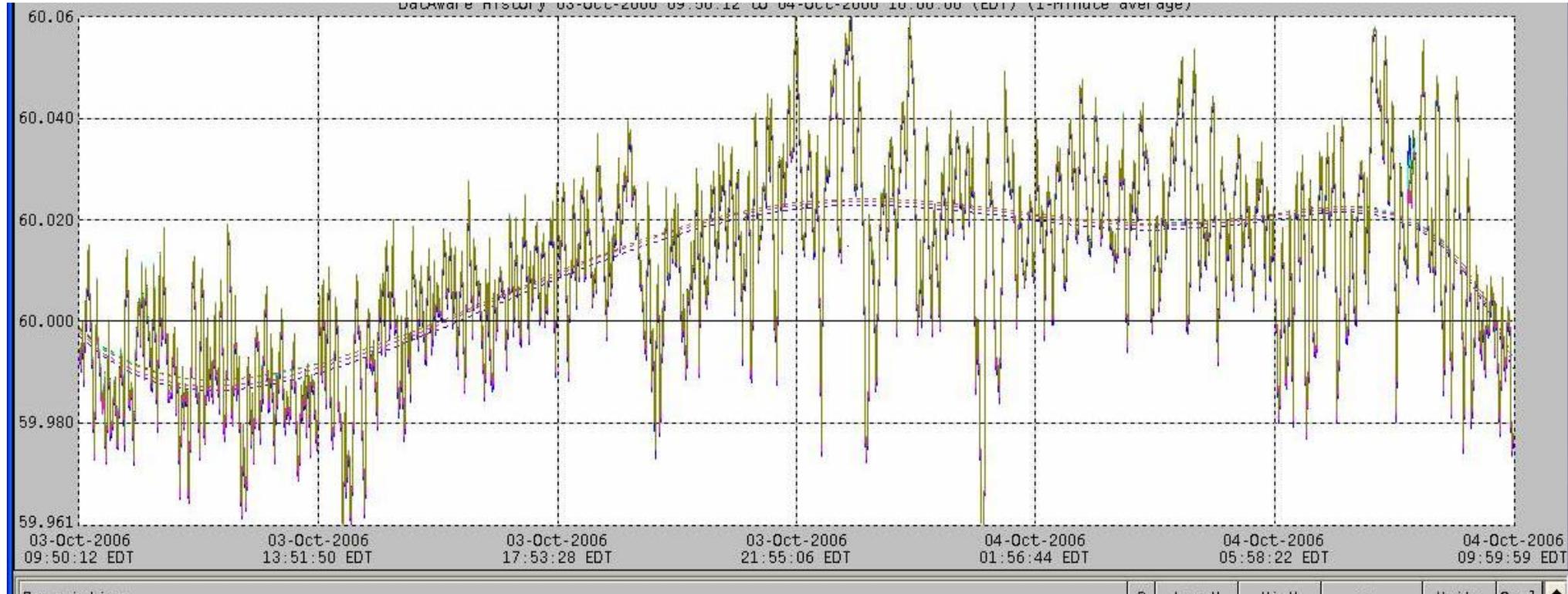


PJM began experiencing problems on the:

- 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

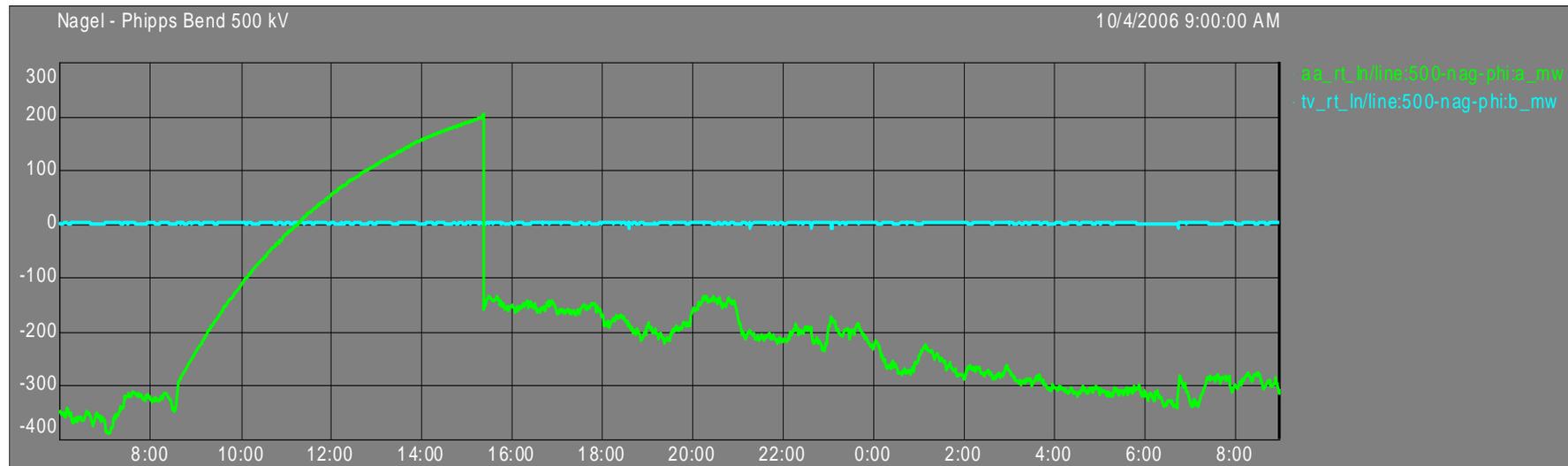
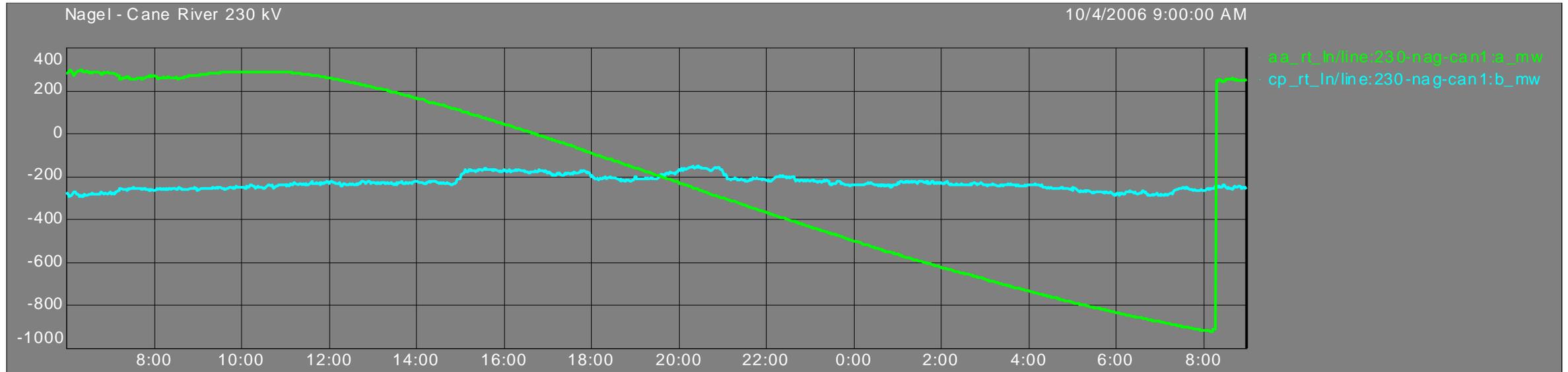
- The inaccurate tie values resulted in PJM over-generating between 10/3/2006 15:00-10/4/2006 09:00, contributing to high frequency for an 18 hour period



Impacts of Bad Data Examples

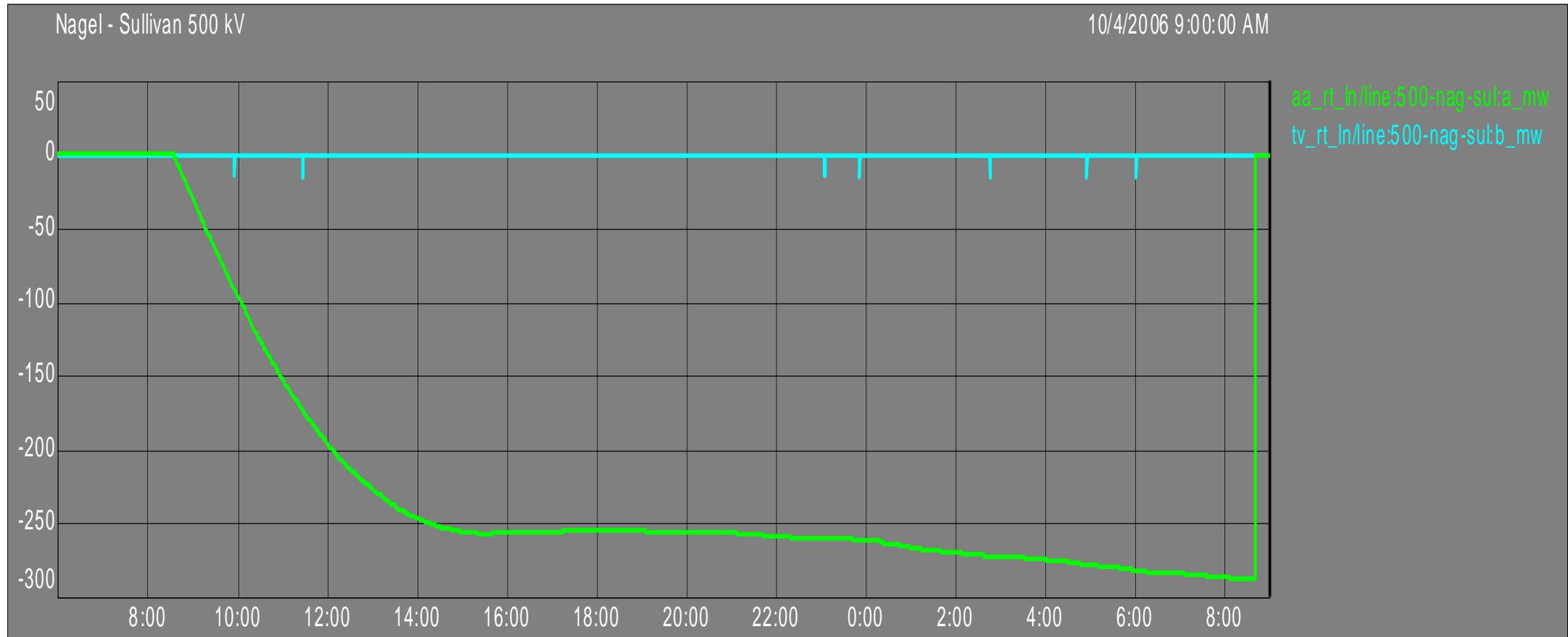
- At approximately 8:20 am on Oct 3, 2006 both the CPLW CANE RIVER and TVA NAGEL-PHIPPS Bend tie-line meters began reporting what appear to be incorrect values
- The Nagel-Phipps Bend line appeared to have returned to a correct value at 15:22 on Oct 3, 2006
- The Cane River tie appeared to have returned 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

Questions?

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 & References



NERC Standards:

- COM-002
- IRO-010-1a
- TOP-003-3
- TOP-010-1(i)

PJM. (2019). *PJM Manual 1: Control Center & Data Exchange Requirements (rev. 40)*. Retrieved from <https://www.pjm.com/-/media/documents/manuals/m01.ashx>