

Operations Planning Transmission Outage Analysis

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Operations

OC Special Session

July 22, 2022

- Ensure scheduled transmission Facility outages do not compromise system reliability
- Identify and resolve scheduling conflicts
- Coordinate outages to keep member's equipment maintenance and projects on schedule



- PJM studies forecast potential SOL and IROL exceedances and determine if they are controllable
- Long-term outage analysis studies are performed using peak load forecasts to find most stressful operating conditions
- An SOL and/or IROL exceedances found in studies can lead to congestion in real-time operations (i.e. unit redispatch)
- PJM study engineers alongside TO engineers work to find non-cost solutions to all identified SOL and IROL exceedances
- An “On-Time” outage without non-cost options but controllable SOL/IROL exceedances using generation redispatch is considered reliable and will be approved

- Seasonal – Operations Assessment task Force (OATF)
- 6-Month Out Analysis
- 1-Month Out Analysis
- 3-Day Out Analysis
- 2-Day Out Analysis
- Day Ahead Analysis
- Pre-switching Real-time Analysis
- Ad-Hoc Analysis

- OATF study scope defined in PJM Manual 38, Attachment A
- Performed under direction of SOS-T
- Study of peak Summer and Winter periods
- Identify thermal overloads and voltage limit exceedances in N-1 analysis as well as switching and/or off-cost requirements
- Potentially develop operating procedures to handle issues discovered during study

Base Case and Contingencies

- MMWG base case
- Data supplied/reviewed by OATF members

Generator Outages

- Average generation metrics
- OATF member input

50-50 Non-diversified Load Forecast

- Peak values are aligned so each zone is at its peak load
- This results in RTO load total being elevated

PJM Interchange

- Consider Scheduled Firm Imports and Exports, including pseudo-ties and dynamic schedules and historical Interchange from last year top 10 peaks

Average Bid Data

Day ahead generator bid data from Markets

Renewable Generation

Average generation profile from top 10 peaks last year

Planned transmission outages

- Currently scheduled in eDart
- Outages scheduled for majority of study period

N-1 contingency analysis

8,000+ contingencies of equipment internal to PJM

Transfer analysis

- Analysis of existing IROL interfaces
- Analysis of any potential new interface

Analysis of transfers into PJM load pockets

Analysis for any constraint or need for operating procedure

External impacts

2500 contingencies of equipment in neighboring RRC zones

Impacts of scheduled outages

Results in operating procedures or coordination of outages

Maximum credible disturbances

1,900 contingencies

Analyze potential issues due to gas pipeline disruptions (Winter)

- About 50 contingencies analyzing credible segment and compressor station losses
- About 20 LDC contingencies

Potentially develop operating procedures to handle issues discovered during study

PJM Manual-03 Section 4.2.1 and CTOA

- Outage submission requirements:

FTR Auction	Status	Outage Duration	For “On-time” status Outage Request to be Submitted
Monthly Auction	1 Month Out Rule	All	Before the 1 st of the month prior to the starting month of the outage
Monthly Auction	6 Month Out Rule	Outage > 5 Calendar Days	Before the 1 st of the month six months prior to the starting month of the outage
Annual Auction	30 Day Rule	Outage > 30 Calendar Days	Before February 1 (for the following Planning Year June 1 – May 31)

- Outage approval criteria:
 - **“On Time”**: outage will be approved if it does not jeopardize system reliability.
 - **“Late”**: outage may be cancelled if it causes congestion.
 - See PJM Manual 03 Section 4.2.9.1 for more information on Direct Billing

- 1-month out example:
 - A 3-day outage submitted on 1/31/2022 for 3/1/2022 will be considered on-time (or submitted for any time in March)
- 6-month out example:
 - A 15-day outage submitted on 5/31/2022 for 12/1/2022 will be considered on-time (or submitted for any time in December)
- Planning year example:
 - A 40-day outage submitted on 11/31/2021 for 6/1/2022 will be considered on-time (or submitted for any time in June)

PJM Manual-03 Section 4.2.9

- Rescheduled outages due to weather or at PJM direction maintain On-Time status
- Revisions to the dates and duration of On-Time outages are allowed as long as the outage is scheduled to occur in the same month
- See PJM Manual-03 for additional examples

Example 1:

A 1-day long outage rescheduled from 1/1/22 to 2/1/22 due to a snow storm will maintain On-Time status because it was rescheduled due to weather

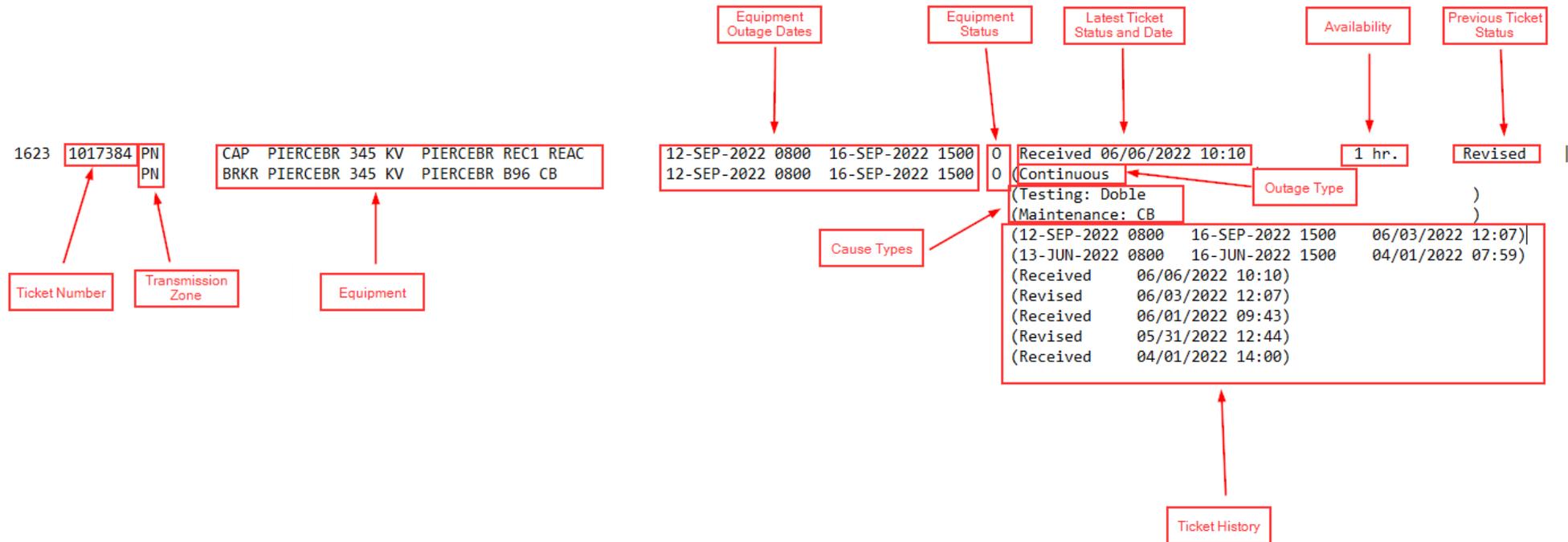
Example 2:

A 1-day long outage moved from 1/1/22 to 1/15/22 will maintain On-Time status because it was rescheduled for the same month

Example 3:

A 1-day long outage for 1/1/22 changed to a 6 day long outage for 1/1/22 – 1/6/22 on 12/1/21 will be considered “Late” since it violated the 6-month out submittal rule

- PJM posts all outages to the Outage Information page on PJM OASIS
 - Exception: market sensitive equipment
 - <https://www.pjm.com/markets-and-operations/etools/oasis/system-information/outage-info>





Selective Coordination before 6 month out

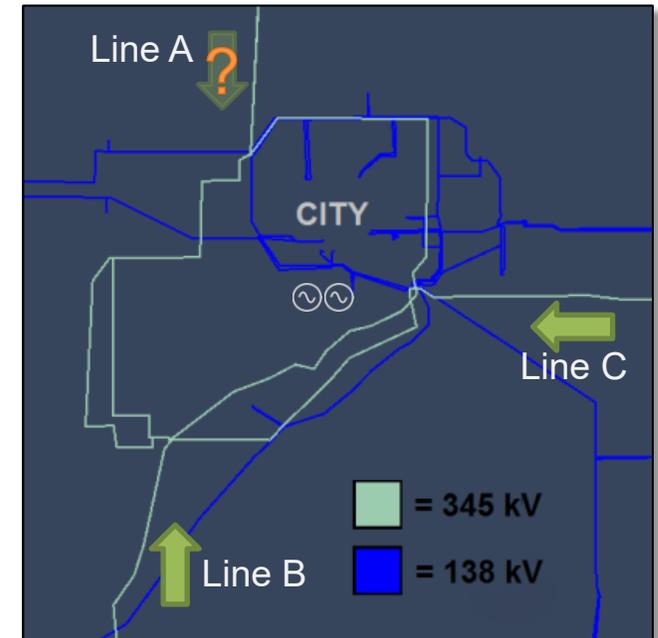
- Discussion of high profile outages in advance
- Transmission Owners can request “Ad Hoc” Studies for future outages

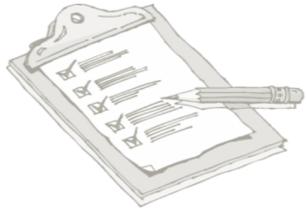
As soon as ticket is submitted, goes through “Conflict Identifier” logic

- Situational awareness tool to alert outage engineers of a potential conflict
- Manually created logic based on previous experiences

All tickets reviewed for correctness upon submission

- Performed Monday through Friday during regular business hours
- Reviewed by PJM Dispatchers for near-term tickets





6-month out study

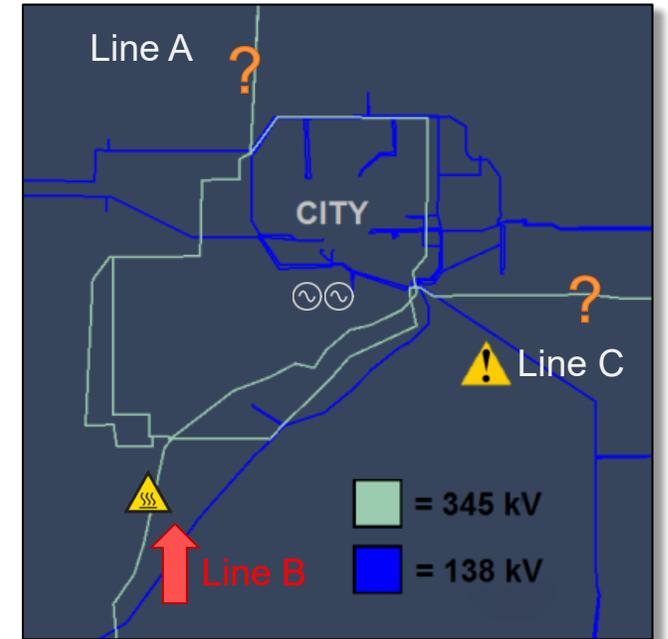


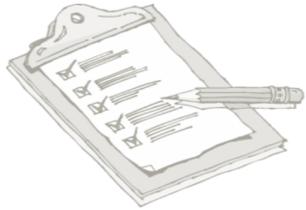
1-month out study



**3-day out
2-day out
Day-Ahead (RE)**

- Outage > 5 Calendar Days
 - For on time status
 - Additional studies for outages > 30 days
- Coordination between generation and transmission outages
- Many variables to consider:
 - Load (Study with High Loads)
 - Other Planned outages
 - Future topology due to system upgrades





6-month out study

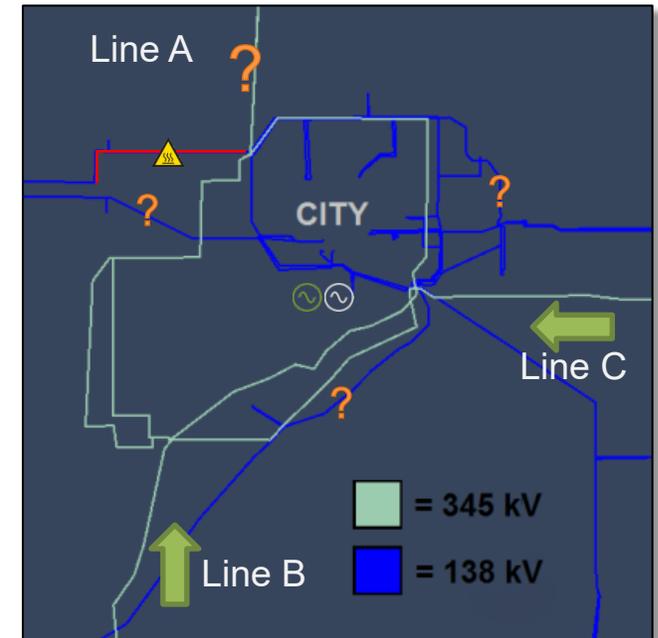


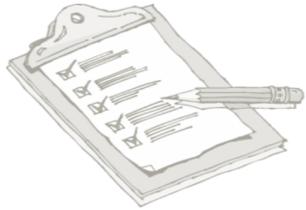
1-month out study



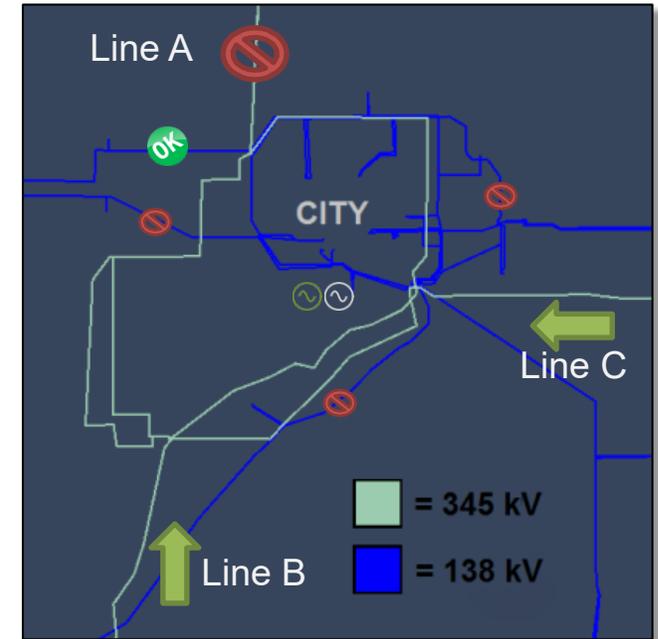
3-day out
2-day out
Day-Ahead (RE)

- All on-time outages
 - (New Outages \leq 5 calendar days long)
- Each day of the upcoming month is studied individually
- Coordination between generation and transmission outages
- Study with Monthly High Load Forecast (LAS subcommittee)
- Focus on transmission conflict resolution
- Monthly meetings with Transmission Owners
- Coordination with neighboring RTO/ISO



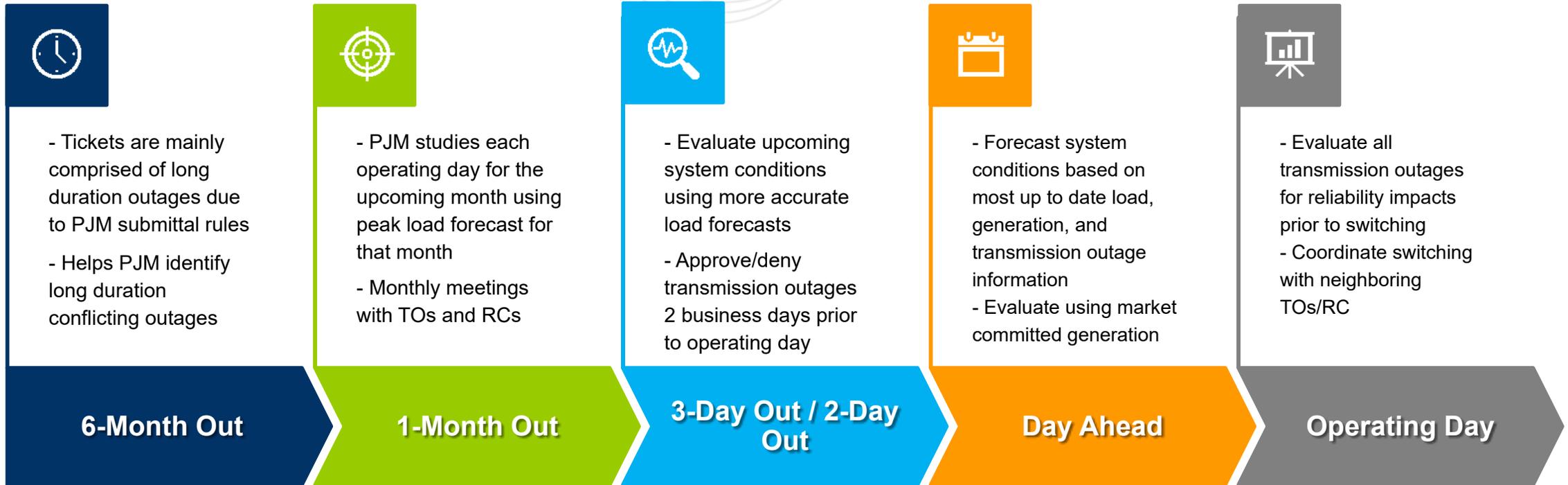


- **3-Day Out Study**
 - Fewer unknown variables as study horizon draws closer to real-time
 - Coordination between PJM Operations and Markets
- **2 Day Out Study**
 - Engineer performs study similar to 3-day study
 - Approval/denial of each outage ticket is made by 2:00 PM
- **Day Ahead/2-Pass (by Reliability Engineer)**
 - Results are submitted to the PJM Markets group by 10:00 AM



- Dispatch reviews upcoming tickets and expected impacts
- Dispatcher reviews individual ticket with Transmission Owner
 - Switching is coordinated
 - Outage is studied prior to switching
 - Results and mitigating actions are reviewed

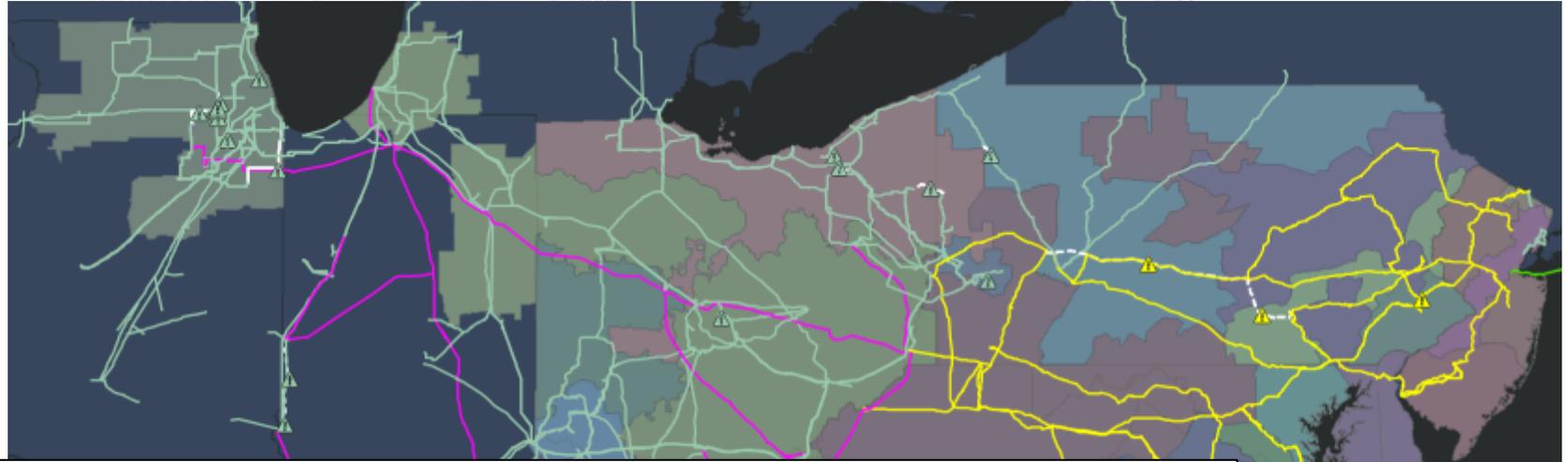




The process above is followed to evaluate and predict system conditions for each Operating Day

Outage Analysis

Base Case

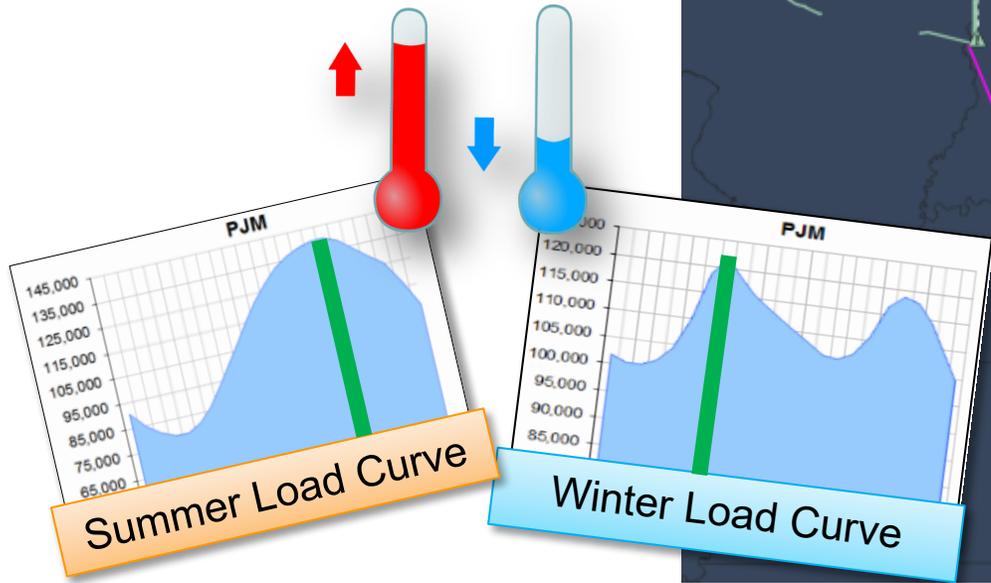
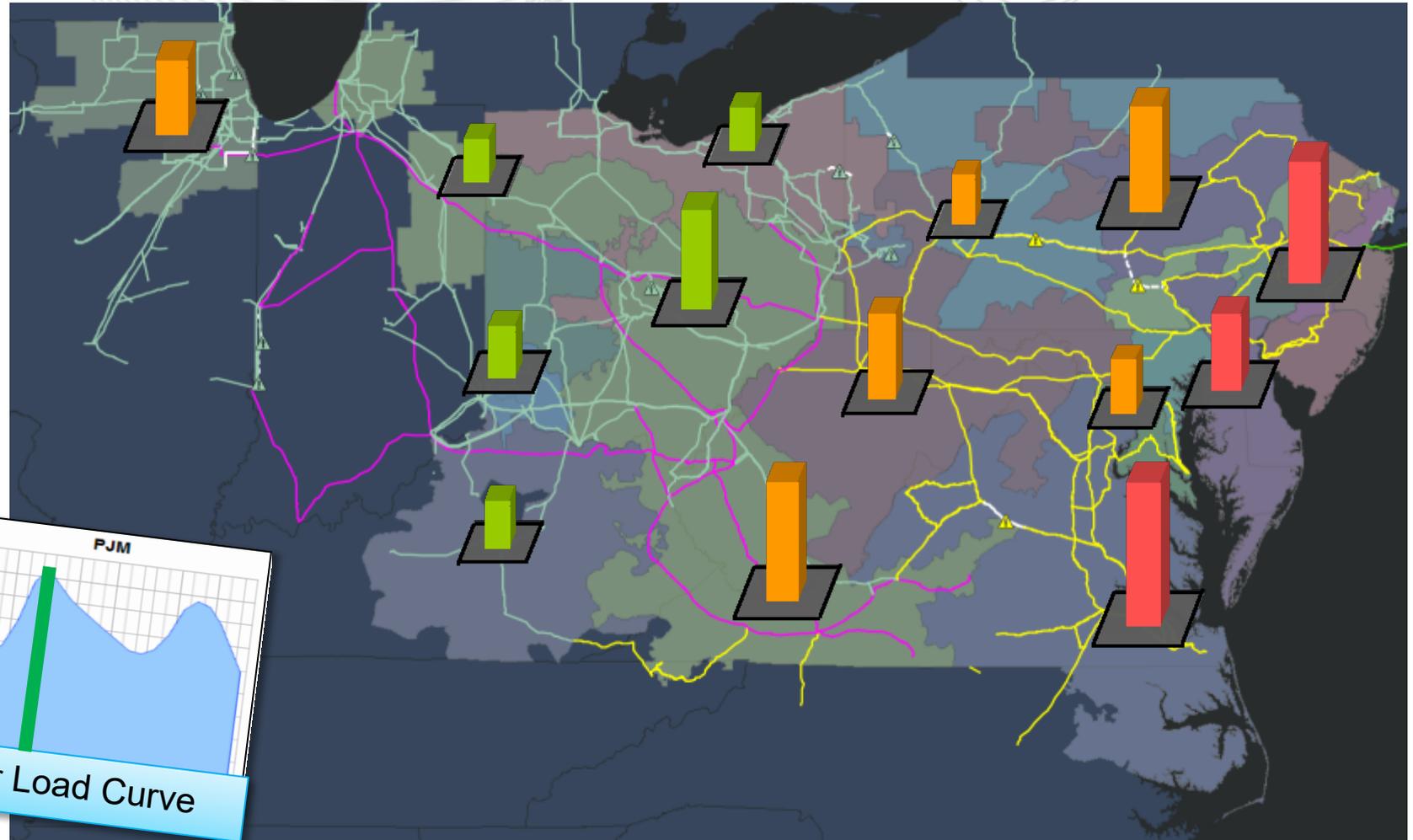
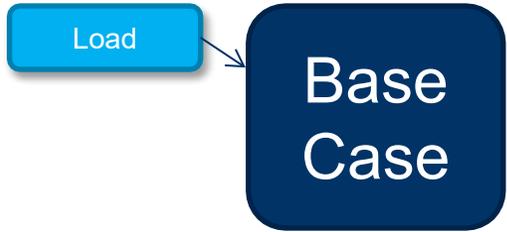


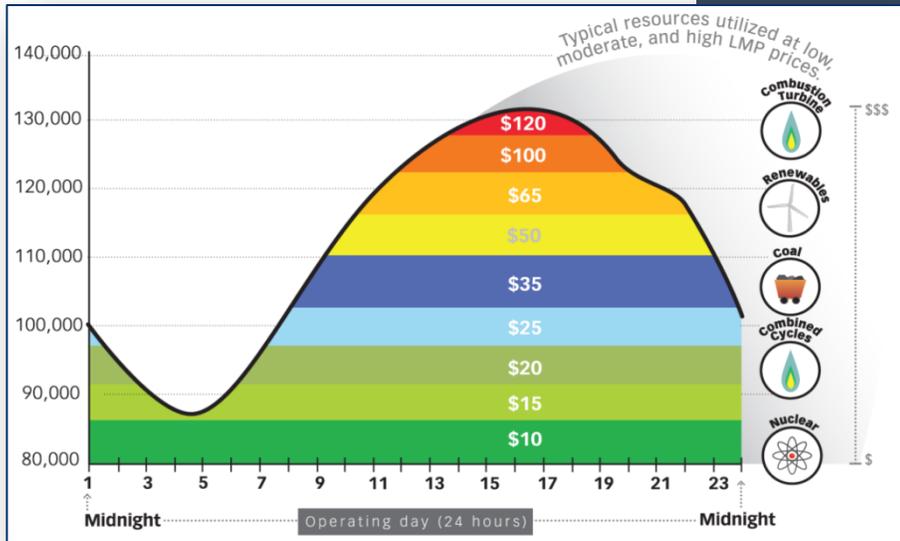
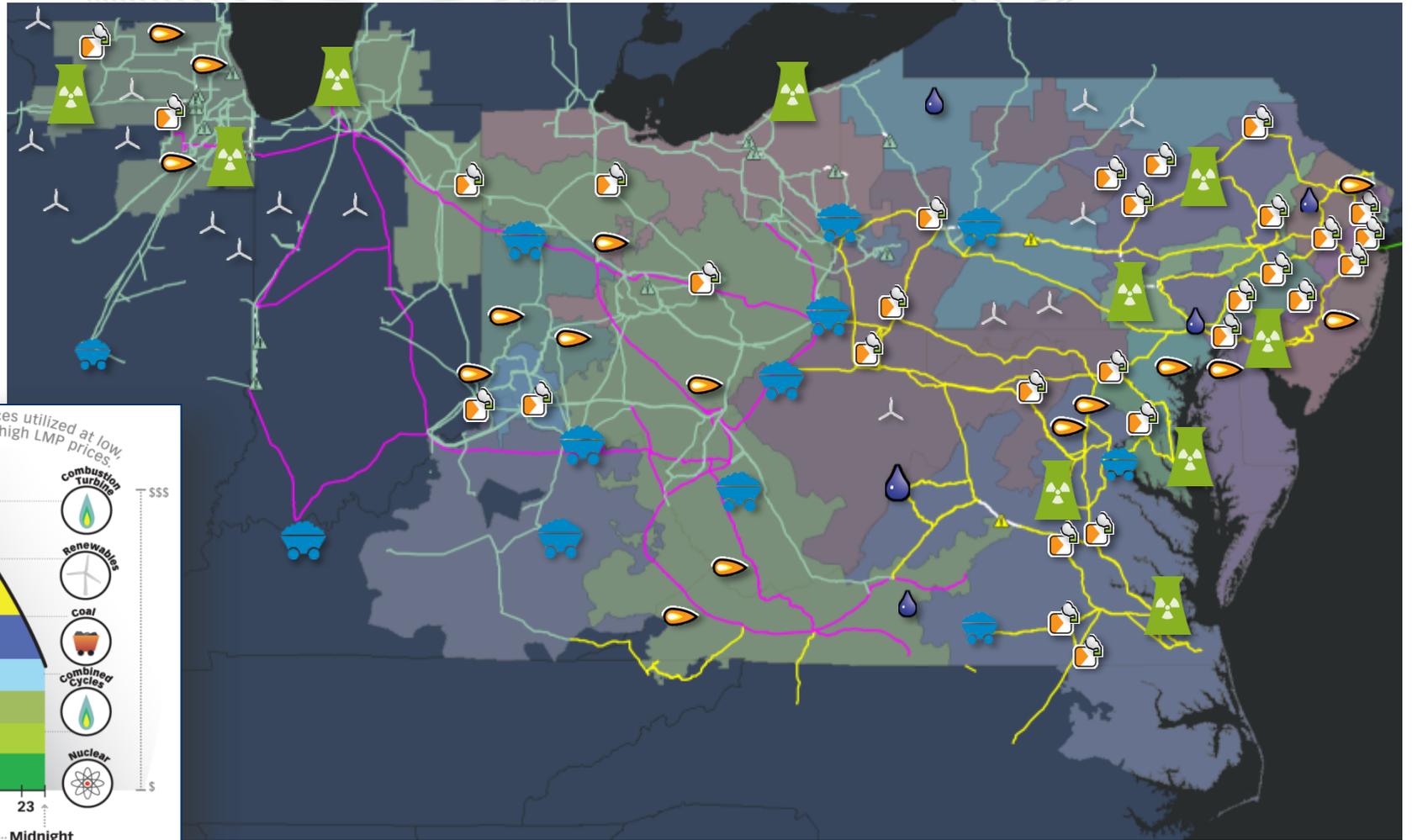
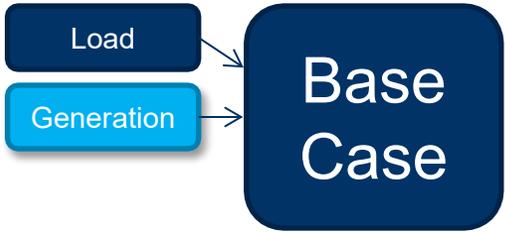
Build a base case for a specific day, and study all outages starting that day

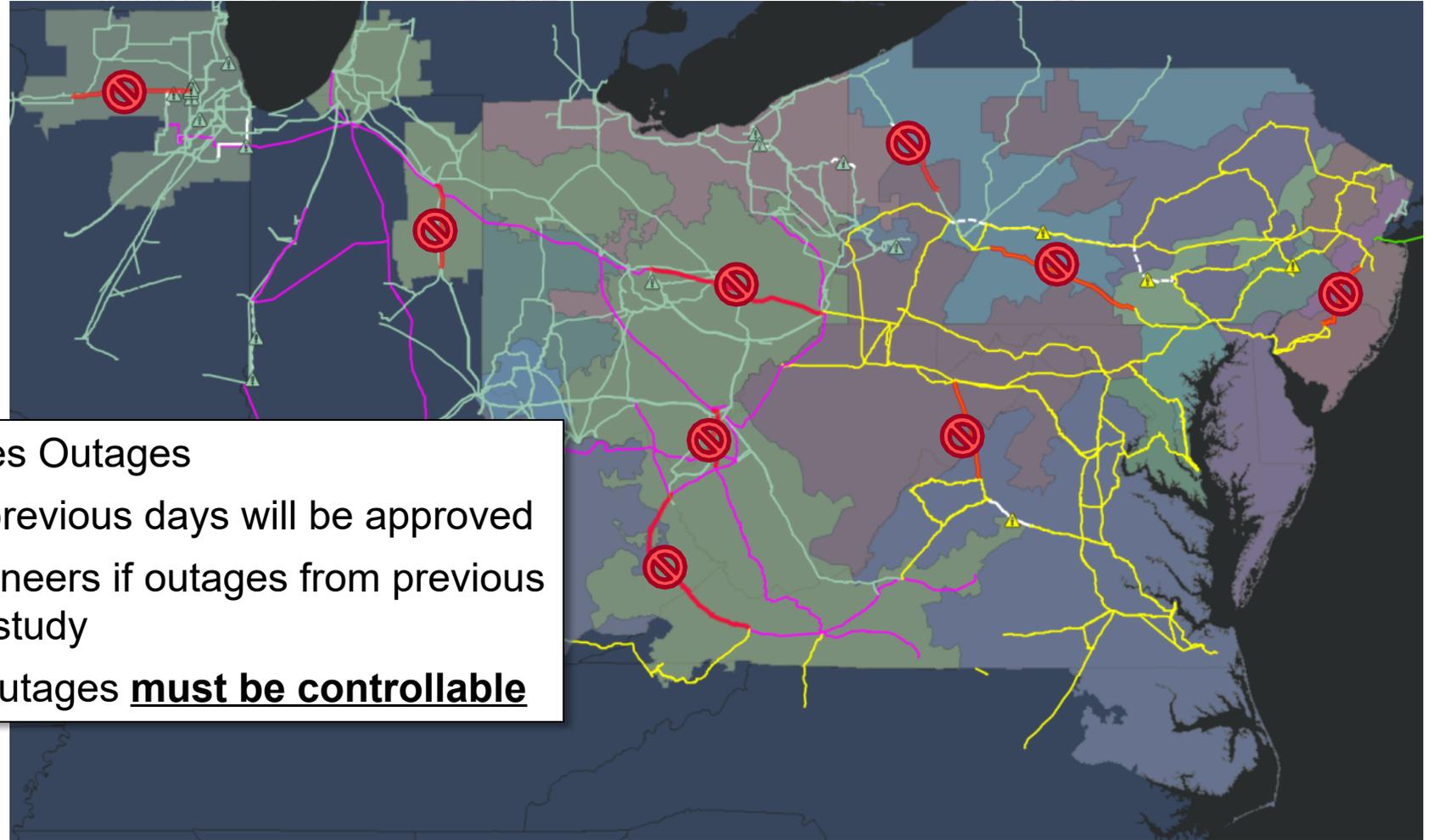
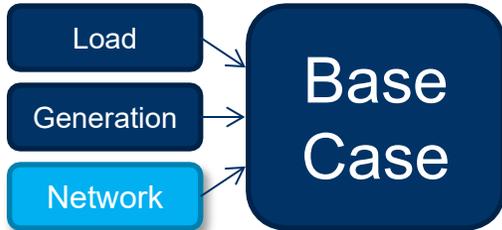
- “Study Mode” of EMS model (replica of dispatch EMS)
- The load at forecasted levels.
- The most economic generation running to match load, losses, and interchange.
- All transmission/generation outages from previous days removed from service.
- Any control actions required to control for previous transmission outages.



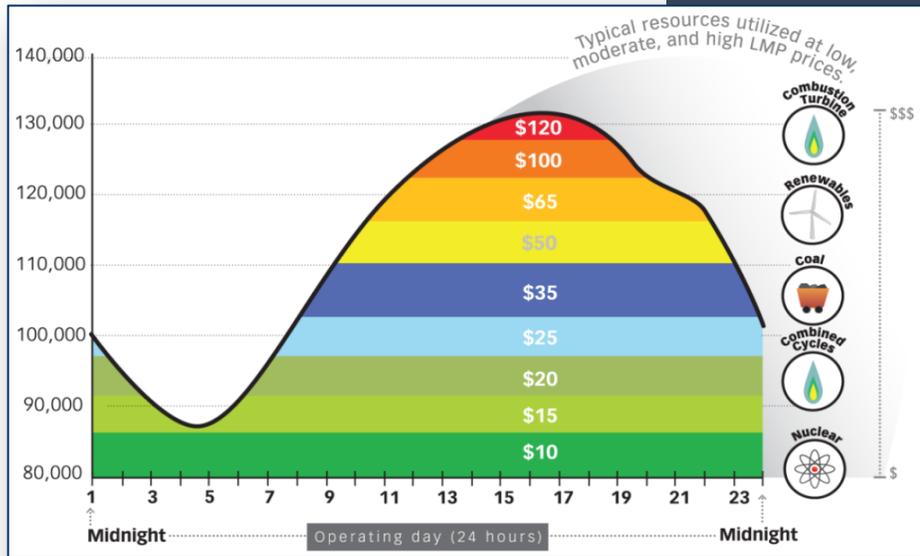
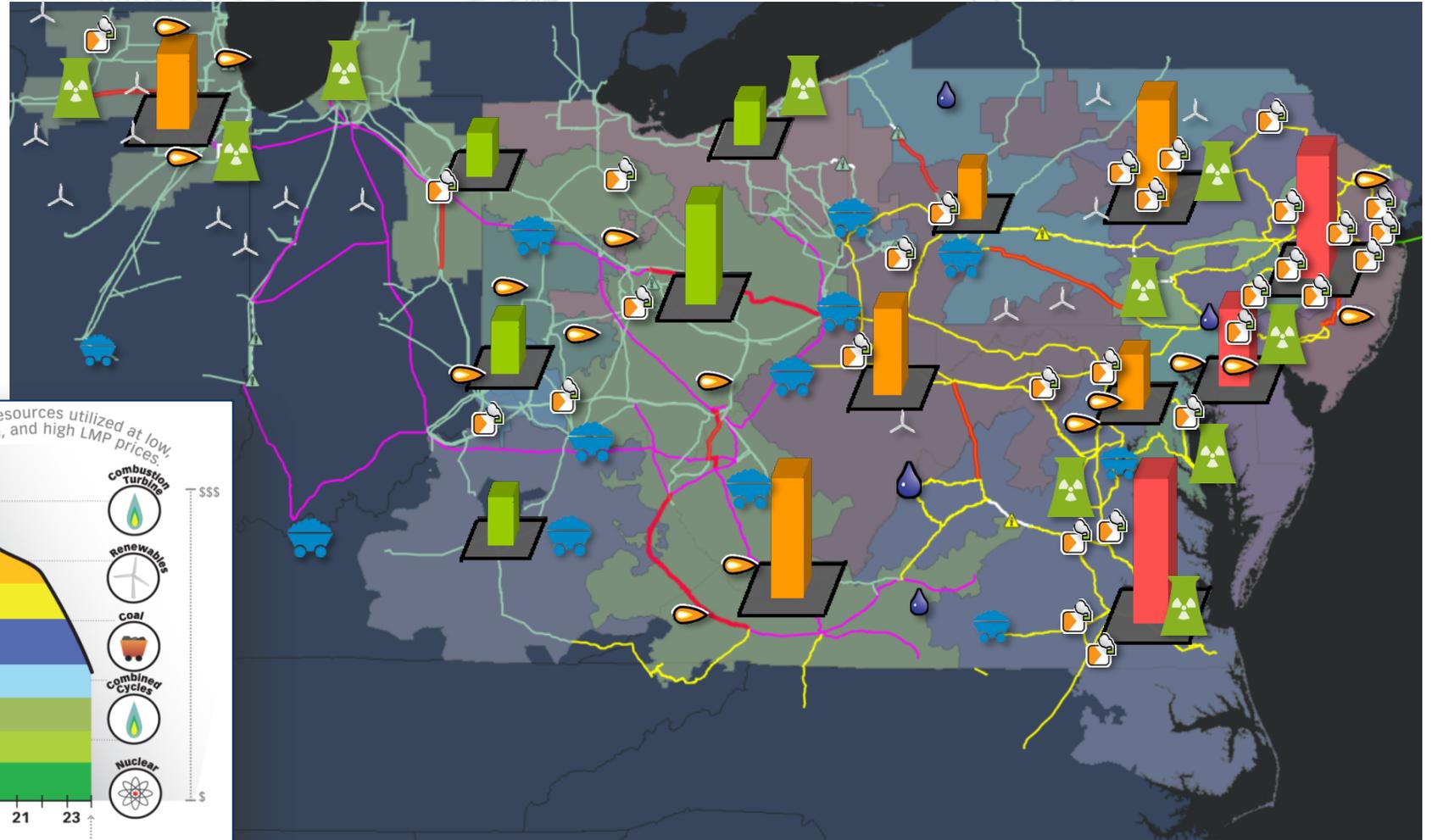
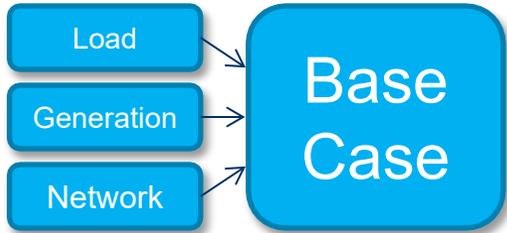
How much power is required and where is it going?

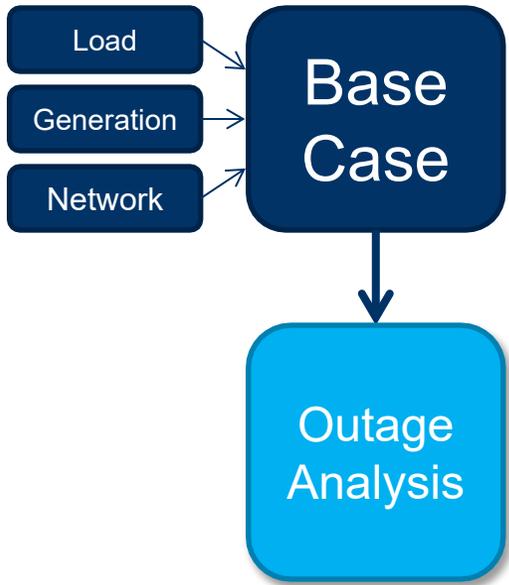


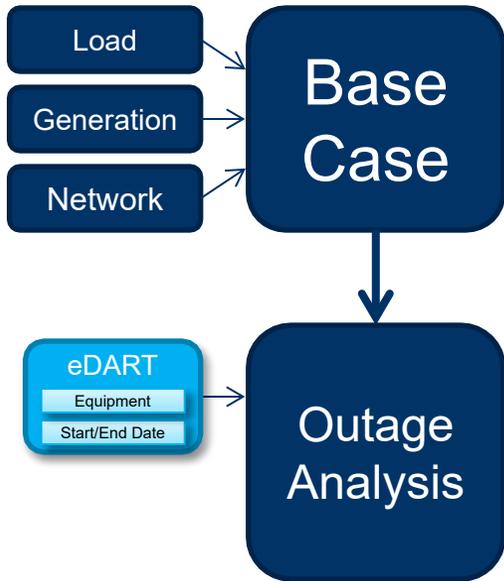




- Ongoing Transmission Facilities Outages
- Assume all outages from the previous days will be approved
- Will work with other study engineers if outages from previous days cause congestion in our study
- All congestion from previous outages **must be controllable**







**Ticket Number
Status
Dates**

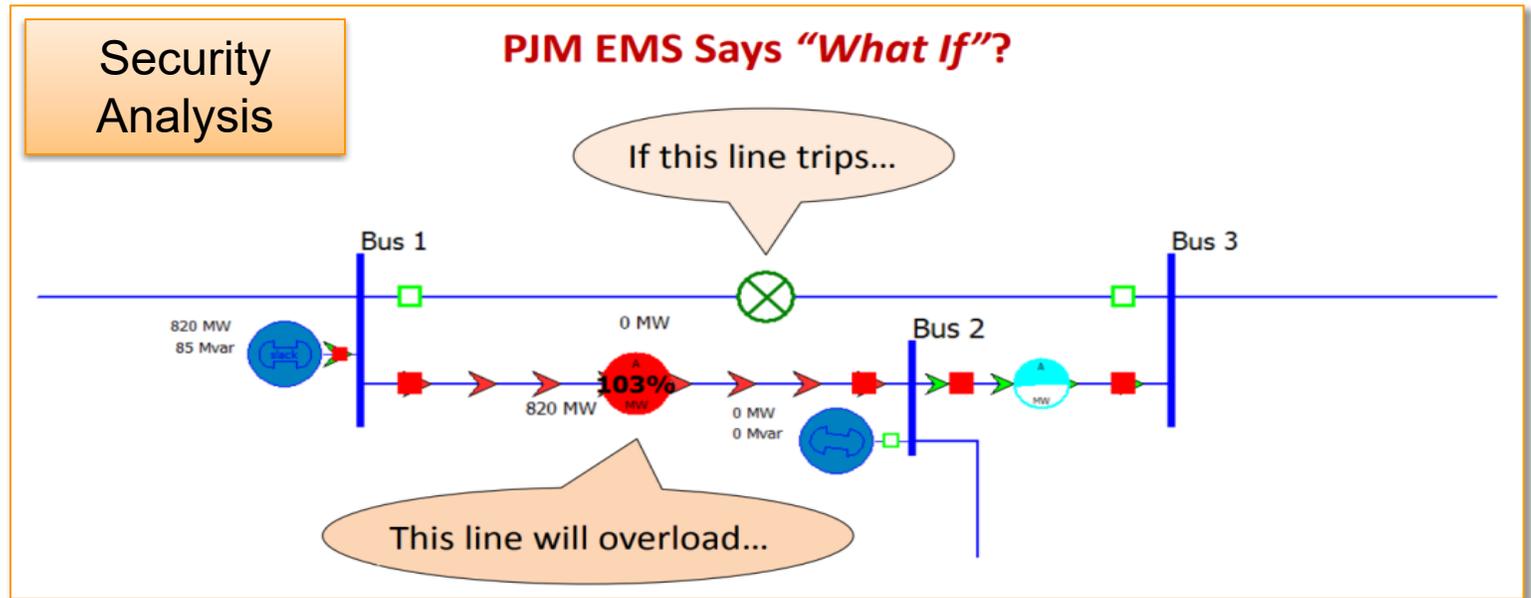
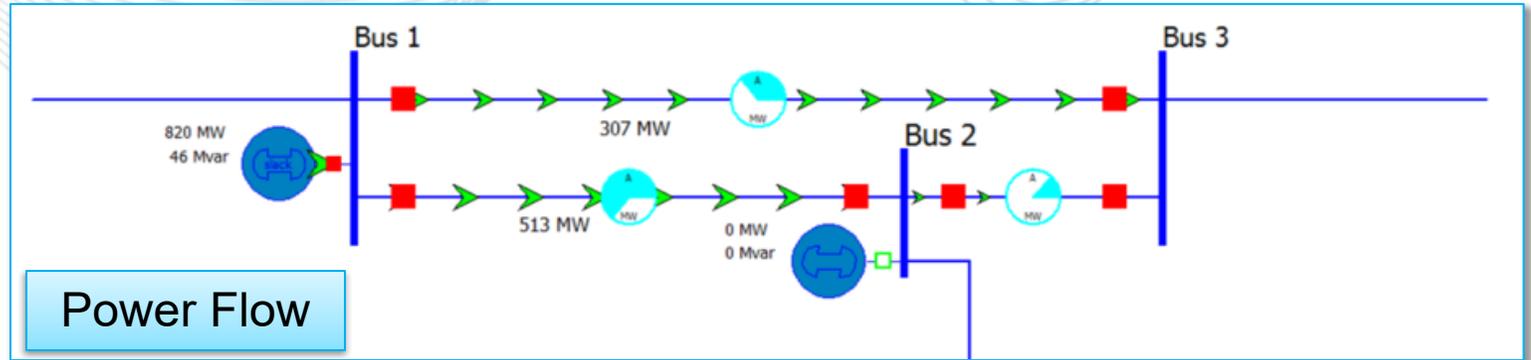
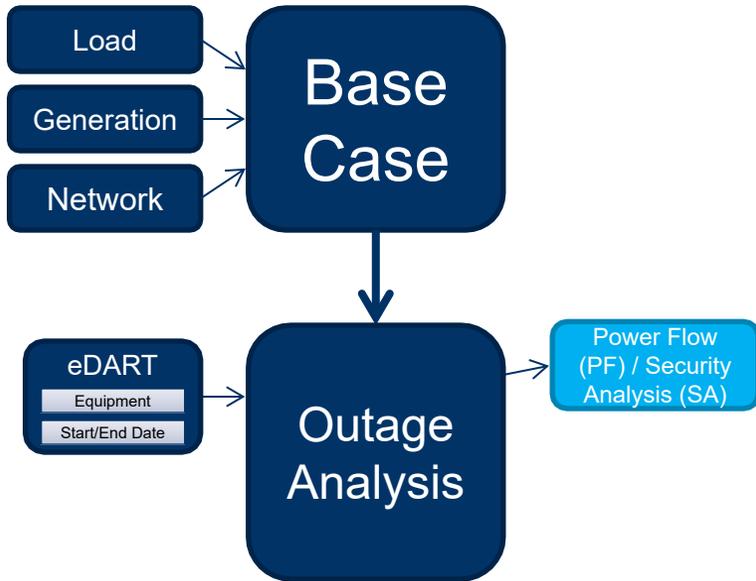
Date Log

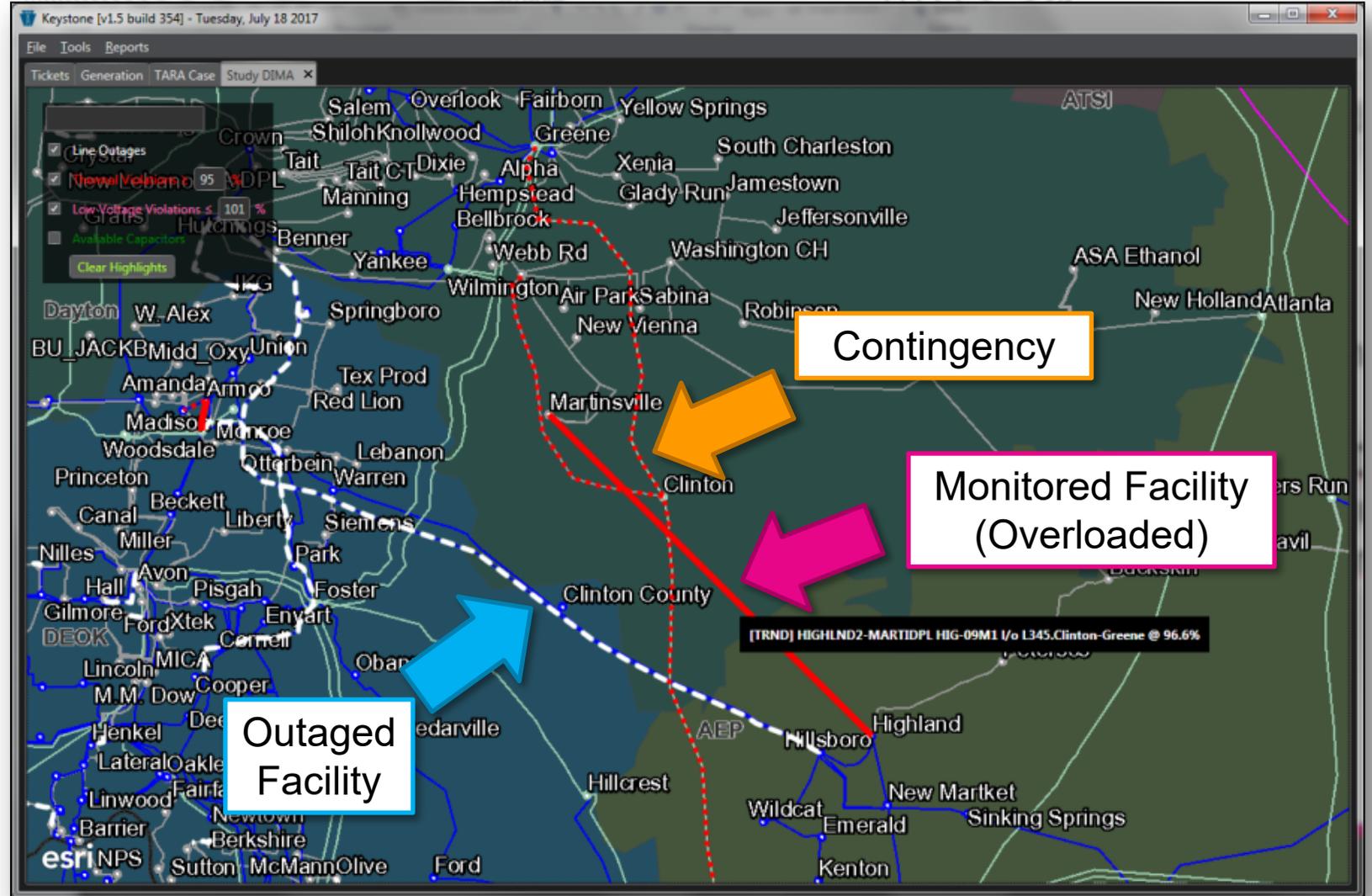
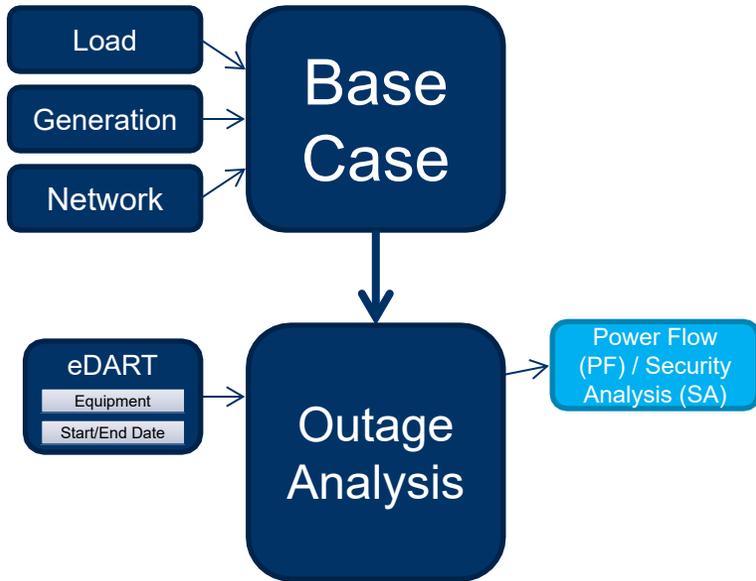
**Transmission Owner Description of Work
PJM Comments**

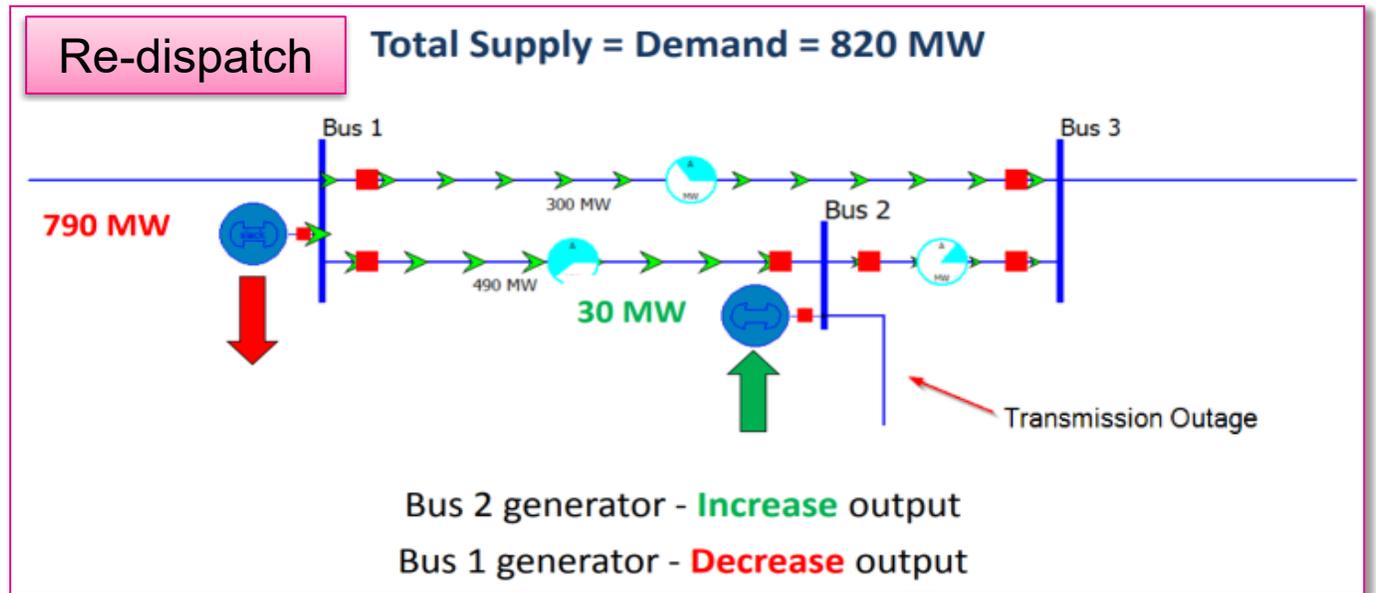
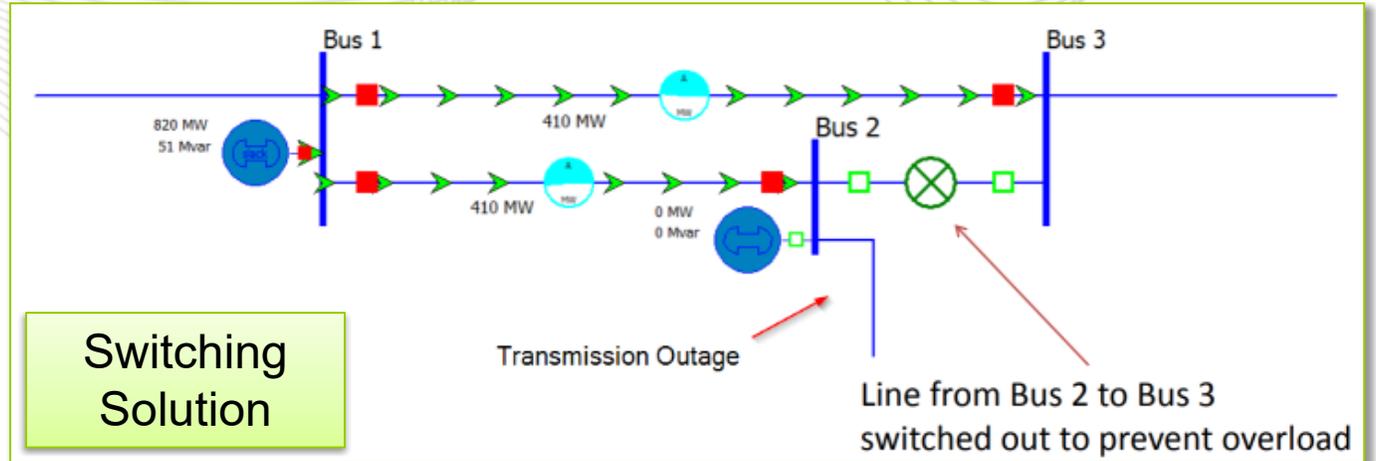
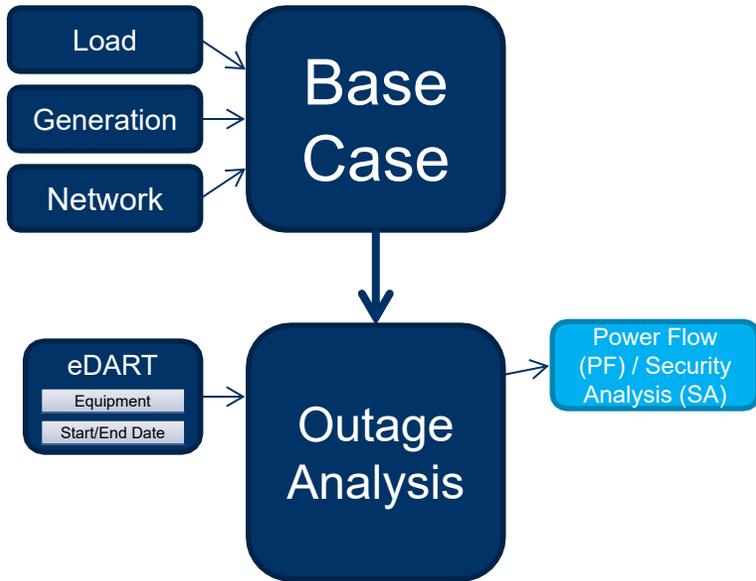
Supporting information

List of equipment that will be de-energized

ID	Status	Type	Station	Voltage	Equipment Name	Start Date	End Date	Prime	Study
1	Open	SR		500		03/20/2017 07:00	03/21/2017 16:00	<input checked="" type="checkbox"/>	B
2	Open	SR		500		03/20/2017 07:00	03/21/2017 16:00	<input type="checkbox"/>	B
3	Open	SR		500		03/20/2017 07:00	03/21/2017 16:00	<input type="checkbox"/>	B
4	Open	LINE		500		03/20/2017 07:00	03/21/2017 16:00	<input type="checkbox"/>	B





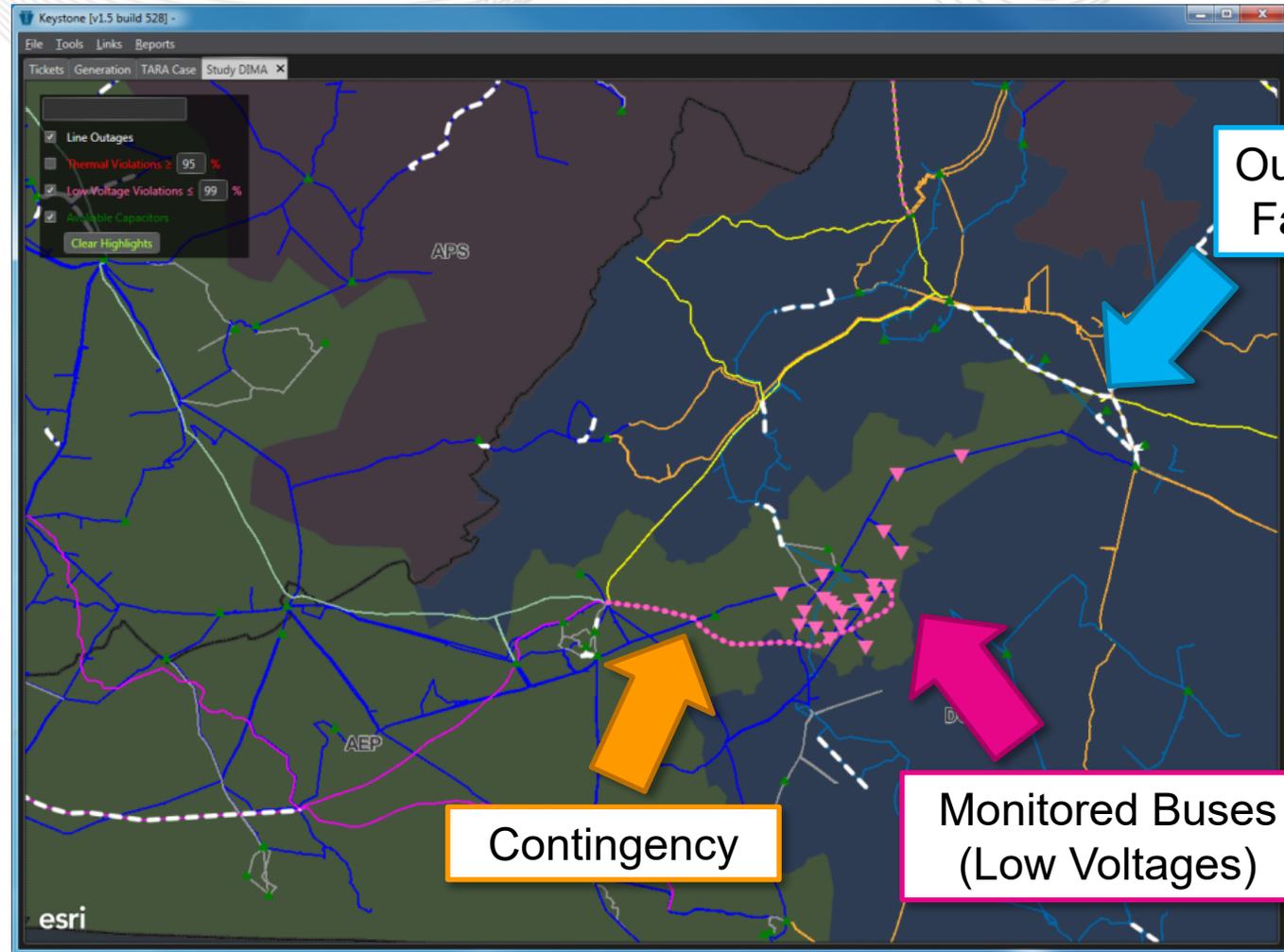
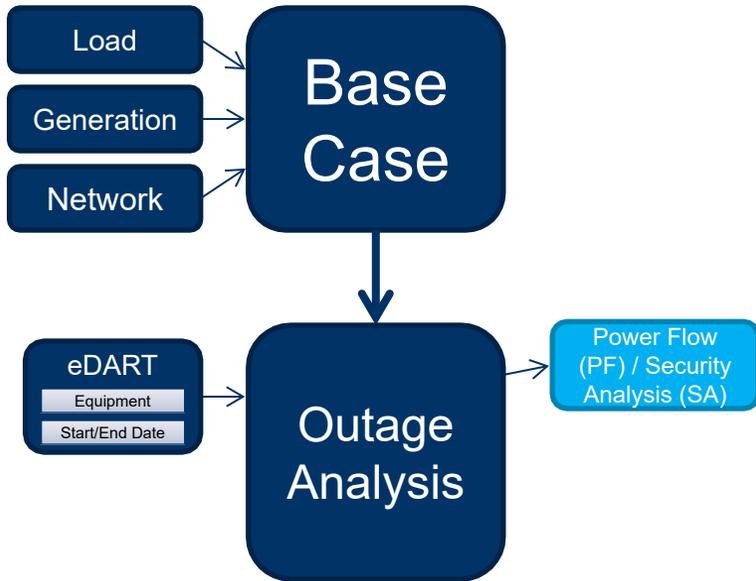


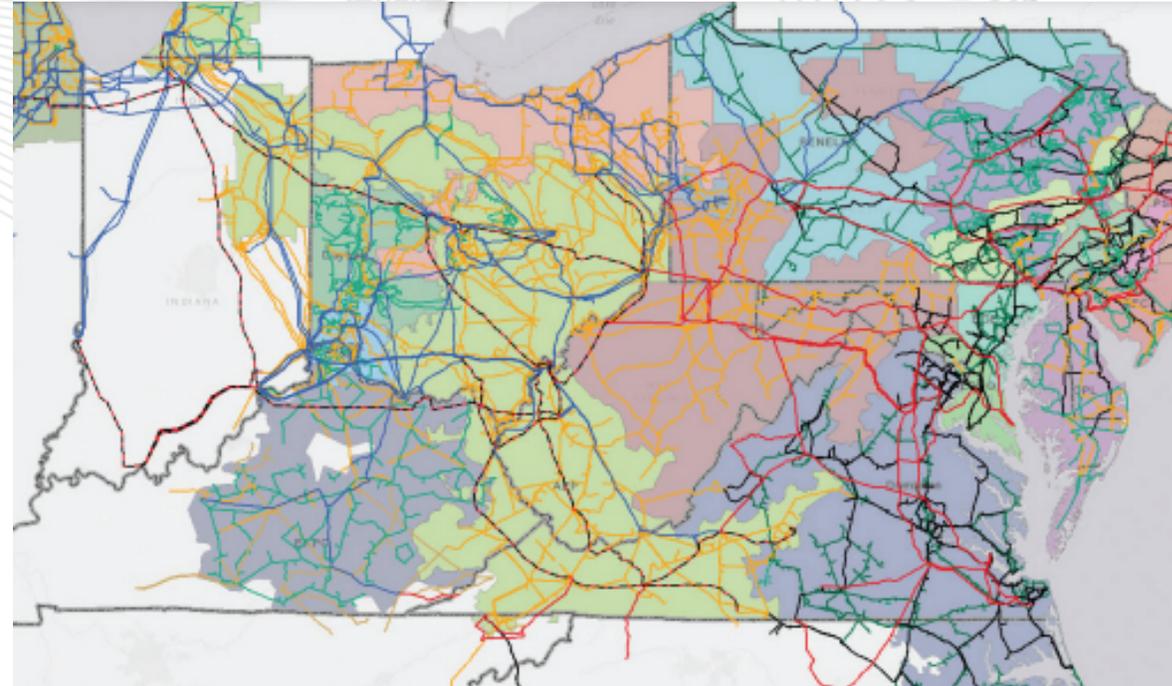
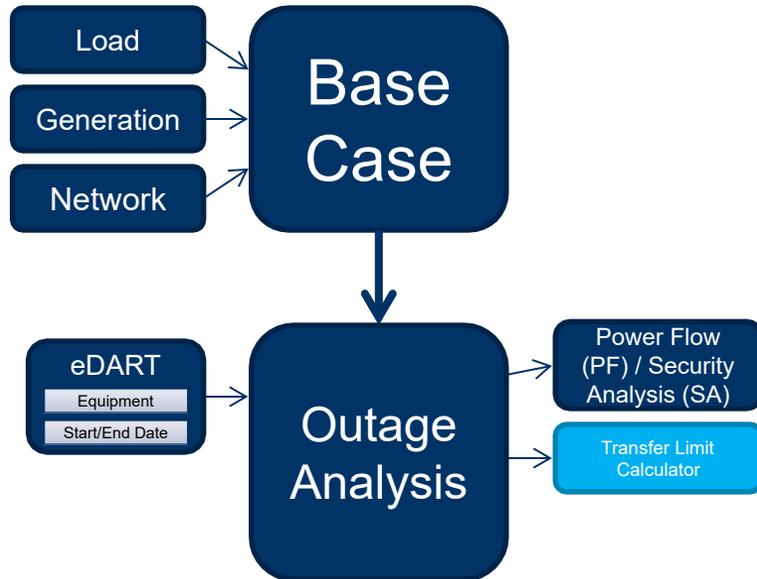
- PJM has multiple ways of identifying switching solutions
 - Switching Solutions on PJM OASIS
 - <https://www.pjm.com/markets-and-operations/etools/oasis/system-information/switching-solutions.aspx>
 - Topology Control application
 - Switching solution provided by the TO
 - PJM EMS Study package
 - Active or upcoming switching solutions are posted to the Outage Information page on PJM OASIS
 - <https://www.pjm.com/markets-and-operations/etools/oasis/system-information/outage-info>

1820	1035240	DOM-N	BRKR	BLMNTDOM	230	KV	BLMNTDOM	227T2180	CB	15-SEP-2022	0930	05-OCT-2022	1600	0	Received	07/11/2022	11:15	Duration	Submitted
		DOM-N	BRKR	BLMNTDOM	230	KV	BLMNTDOM	217812	CB	15-SEP-2022	0930	05-OCT-2022	1600	0	(Continuous)			
															(Operational: Pre-contingency Switching)			
										(15-SEP-2022	0930	05-OCT-2022	1600		07/08/2022	08:46)			
										(Received		07/11/2022	11:15)						

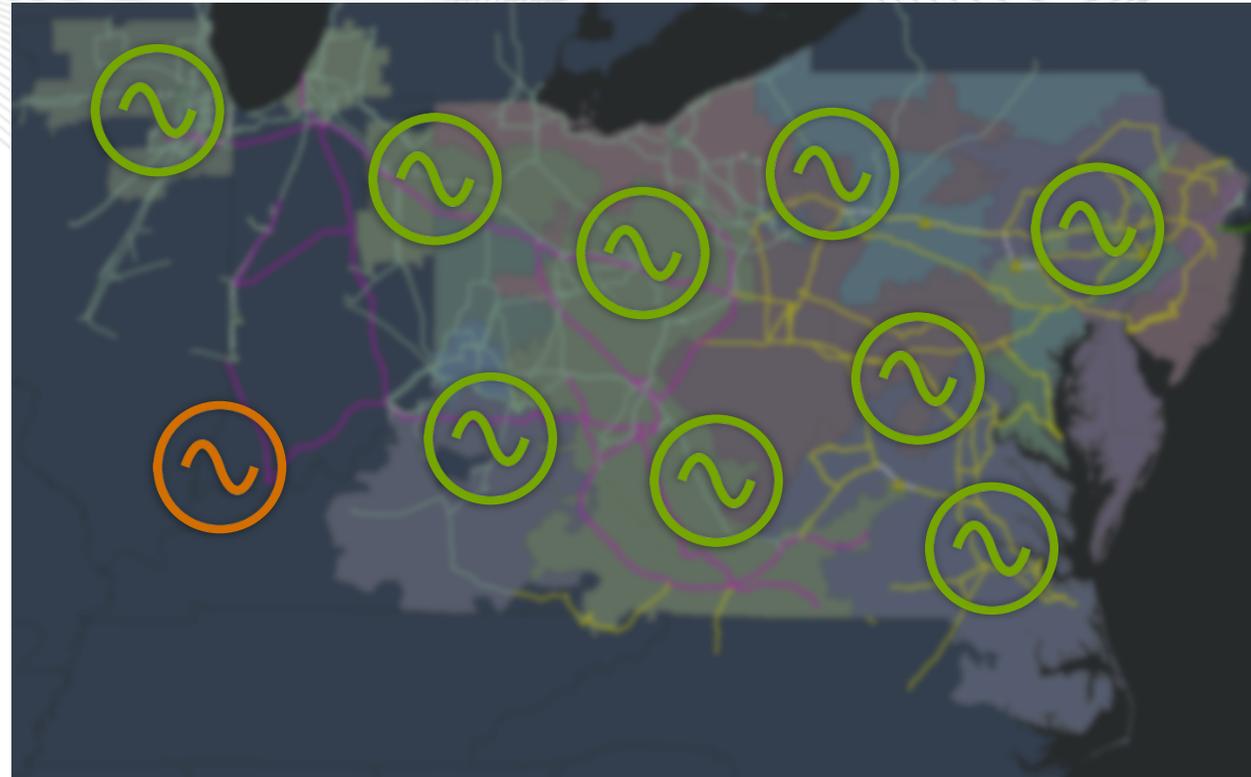
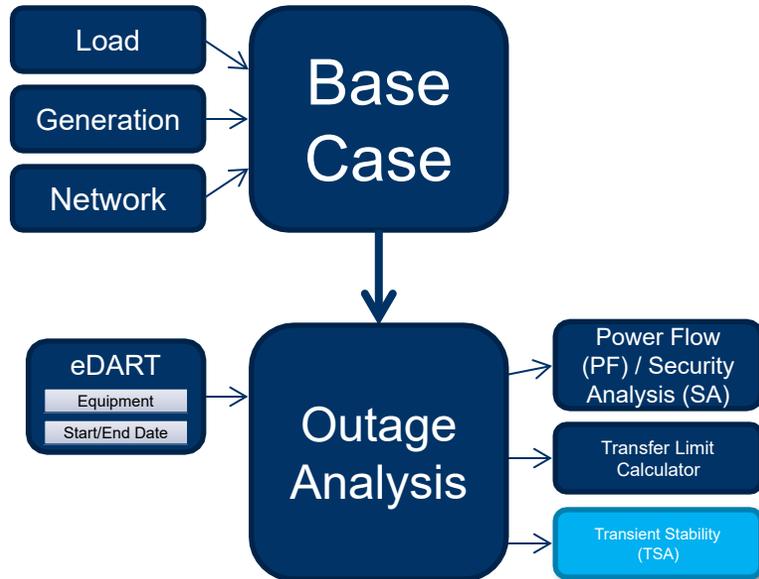
Other non-cost options include:

- Phase Angle Regulator (PAR) moves
- Placing series devices in or out of service
- Placing shunt reactive devices in or out of service
- Adjusting unit or SVC reactive output
- Adjusting transformer taps

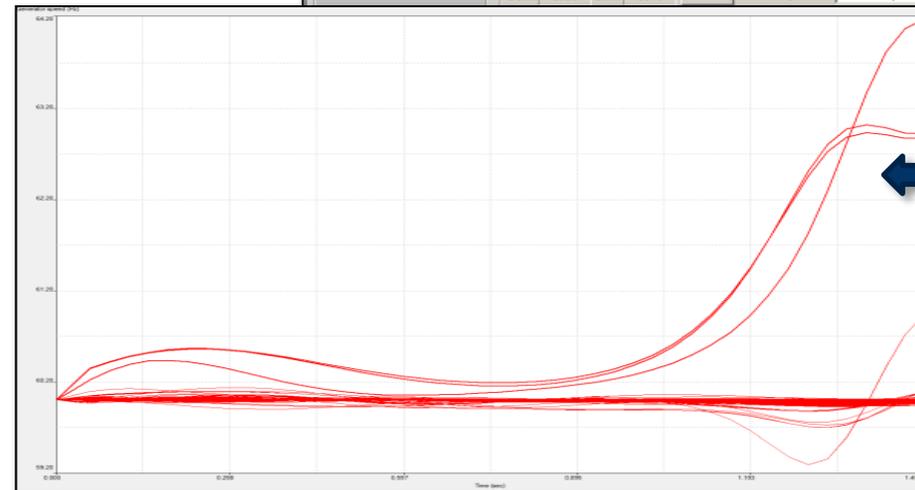
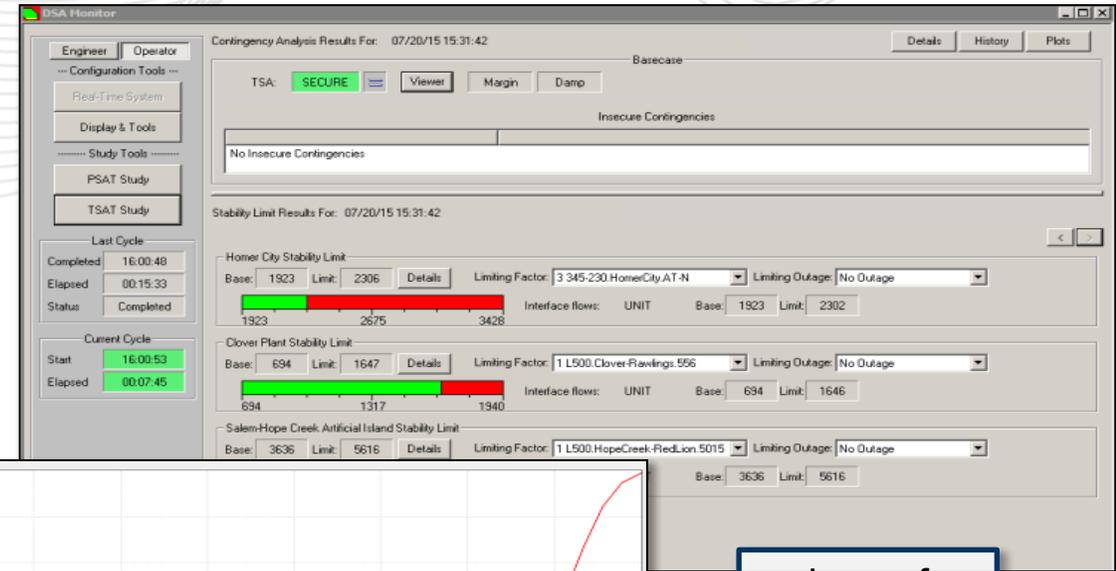
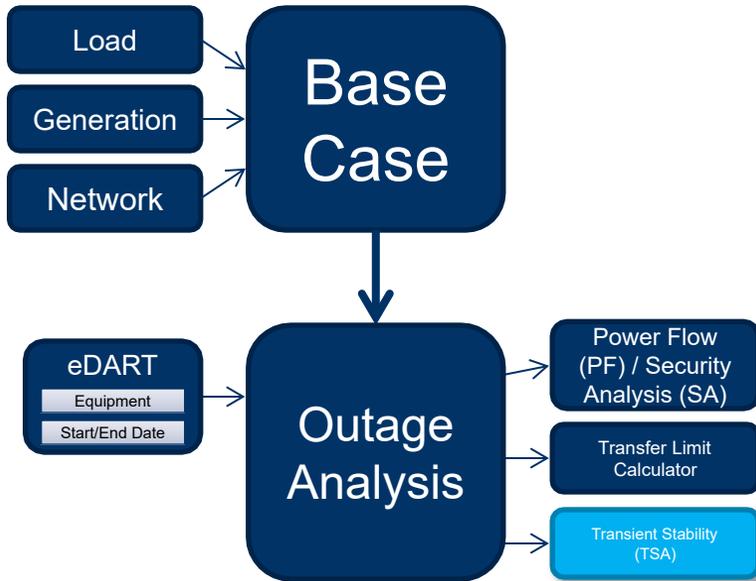




- Helps PJM operators and engineers identify potential wide-area voltage issues
- Used to dynamically calculate pre-identified PJM IROLs
- Calculates the amount of available transfer capability from source to sink across a cut set of lines
- Transmission line outages, especially EHV outages, can decrease the amount of available transfer capability

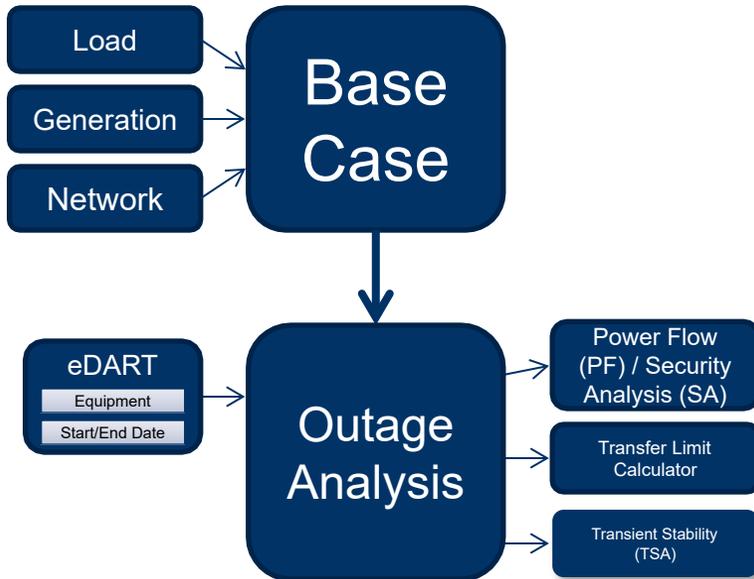


- Transient Stability ensures PJM is not risking any generator damage during transient conditions
- A fault occurs, as system reacts, generators may lose synchronism
- Transmission facility outages increase the likelihood of transient instability



Loss of Synchronism identified

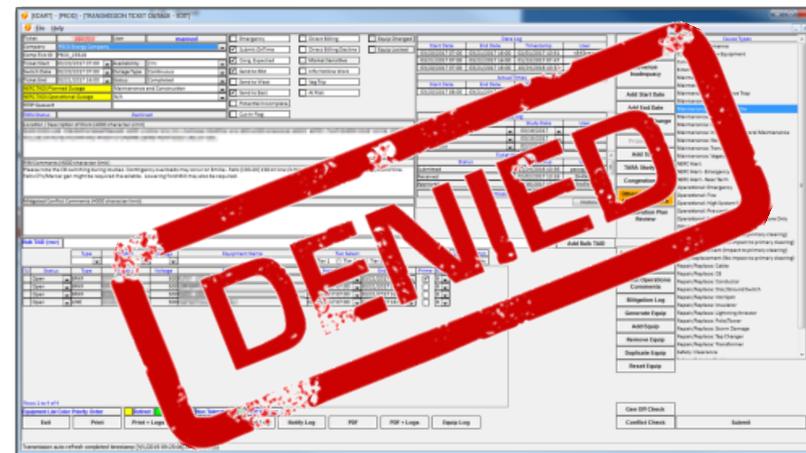
Preventative Controlling Actions:
Increase MVAR Output
 -OR-
Reduce MW Output

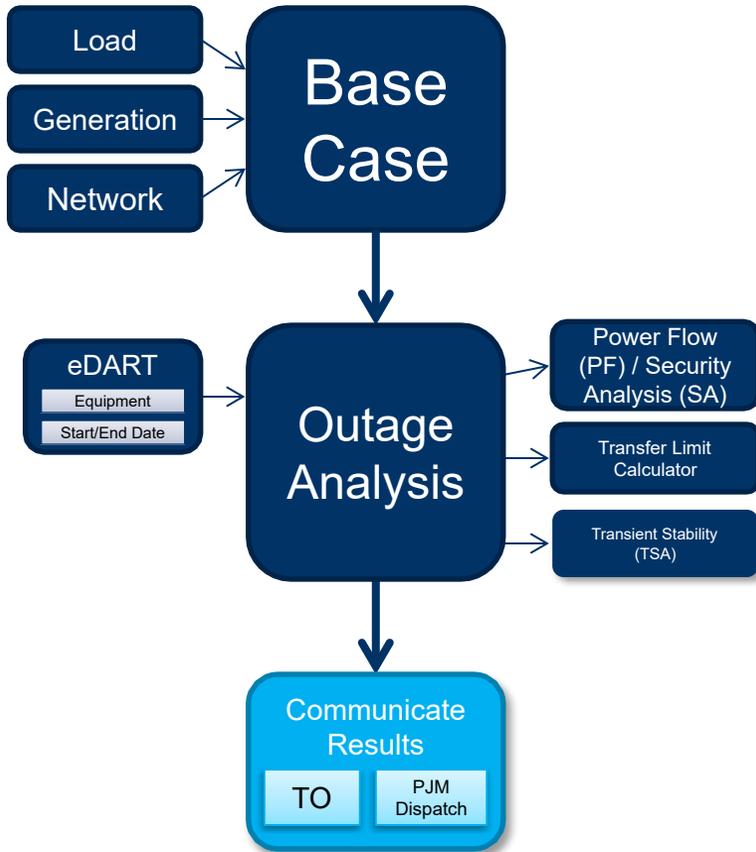


Reasons to deny a transmission outage request:

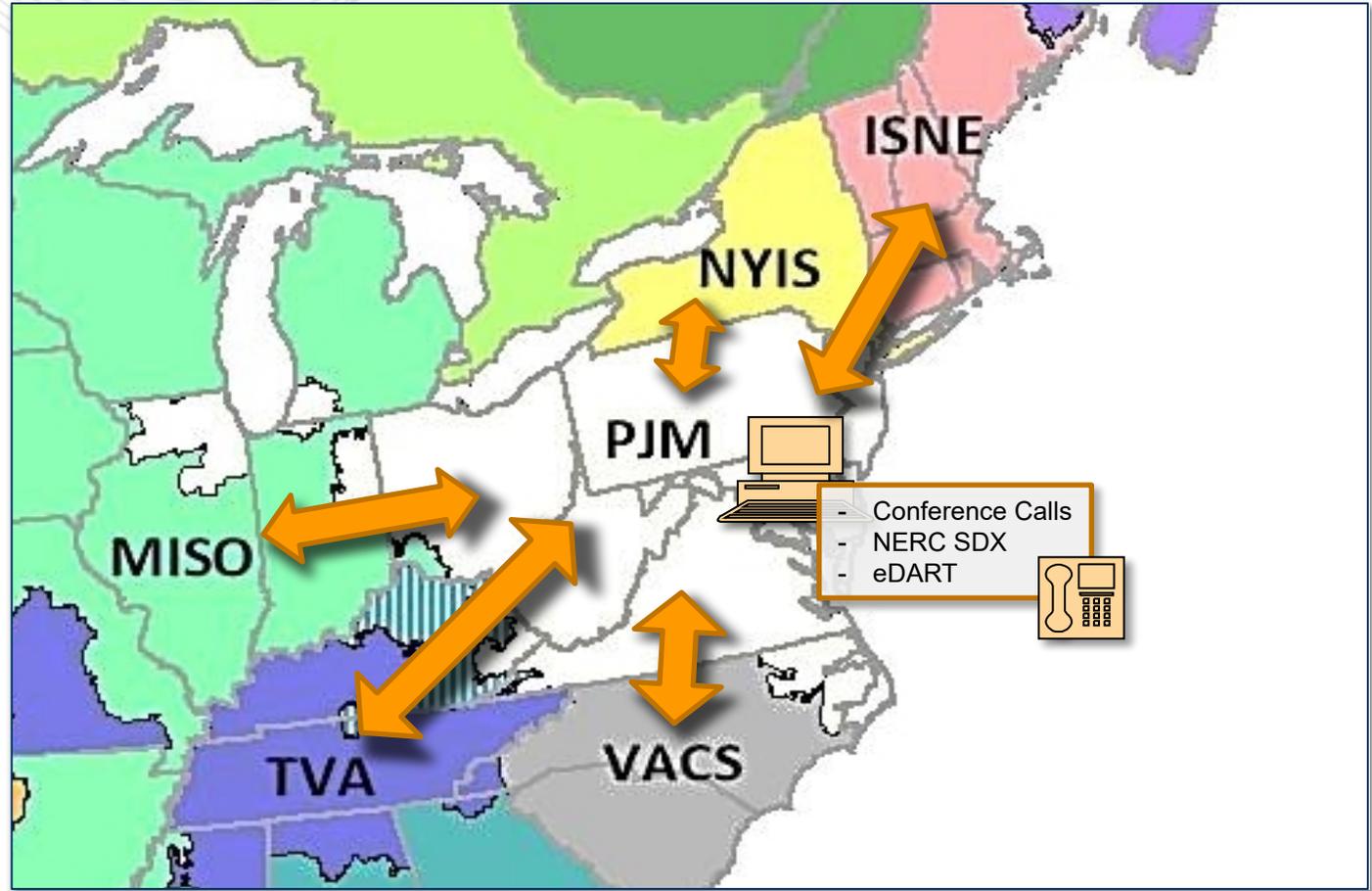
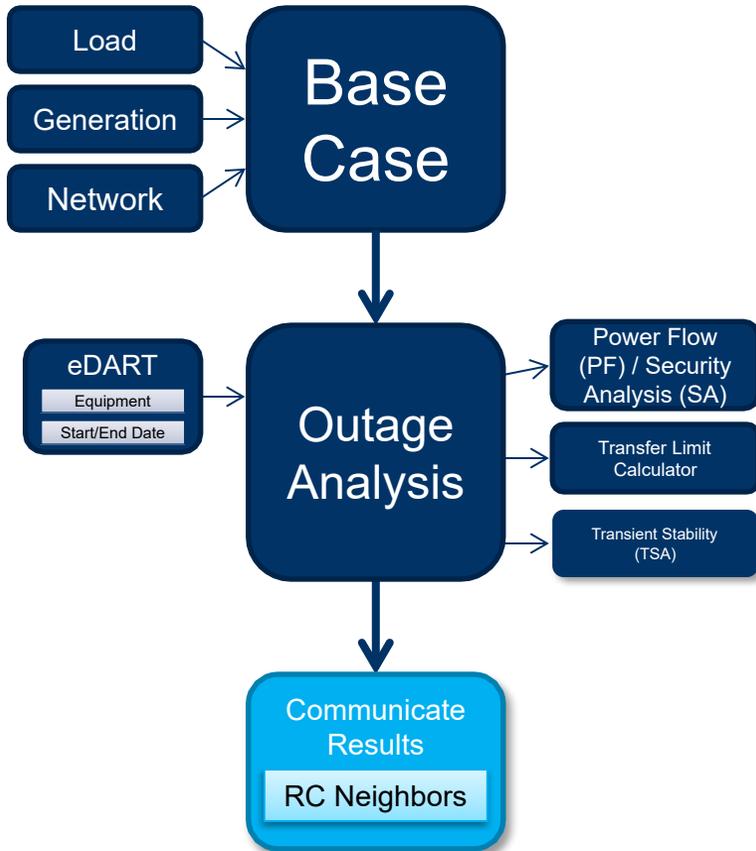
- Uncontrollable reliability (SOL/IROL) exceedances
- Uncontrollable reliability issues due to a conflict
- Does not meet Peak Period Outage Scheduling criteria (PJM Manual 03 Section 4.2.6)
- Outage was “Late” and causes reliability issues or has potential to result in system congestion
- Outage submitted after Day Ahead Market run has begun

A denied “On-Time” outage will maintain its on time status when rescheduled

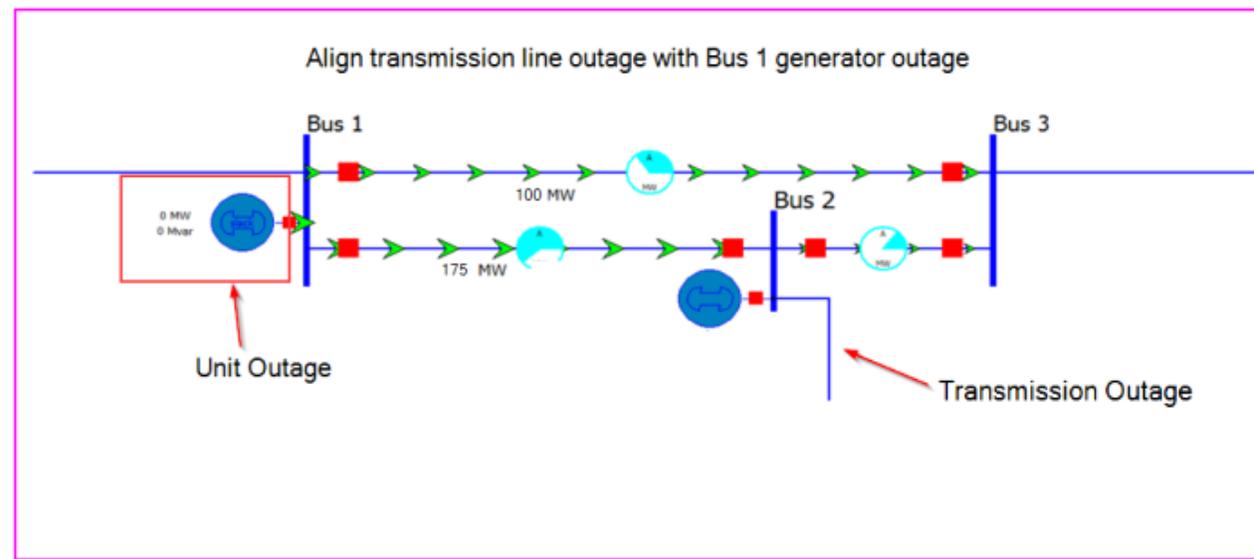
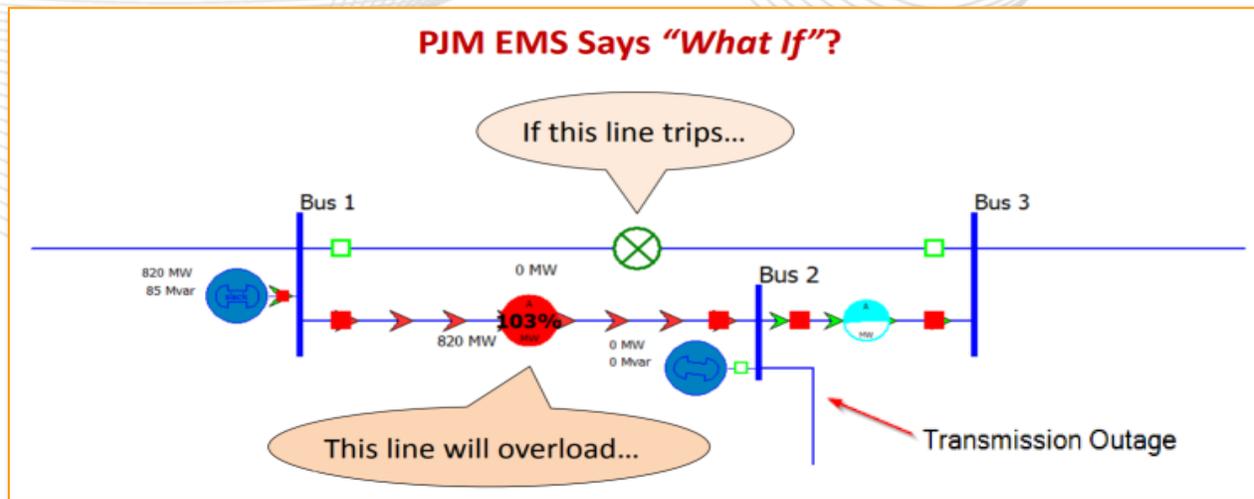




The map shows the PJM region divided into transmission owner territories: ComEd, ATSI, PENELEC, DL, DEOK, AEP, APS, SGE, PEPCO, DPL, AEC, RE, JCPL, PSEG, and Dominion. Colored arrows radiate from the PJM logo, indicating communication links to each territory. An inset image shows a control room with operators at computer workstations. Another inset shows a software interface with a red box highlighting a specific data entry field.



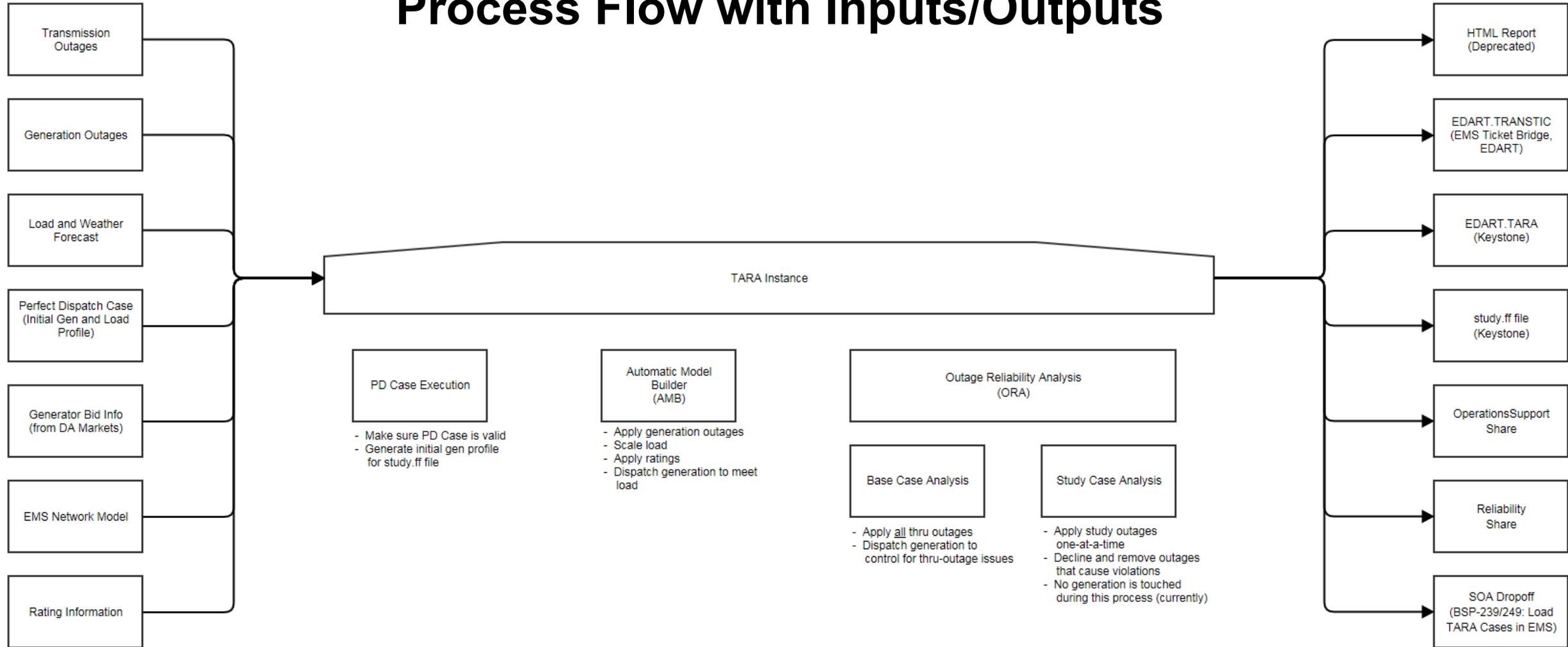
- PJM Manual 3 Section 4.2.13
- TO is responsible for coordinating transmission outages that will force an area generator offline
- Planned generator outage requests are given priority over planned transmission outage requests
- PJM resolves conflicts based on system reliability:
 - Coordinate major outages to minimize anticipated constrained operations
 - Recommend adjustment to outage schedules to coincide with generator outages
 - **Communicate with submitting PJM Members to assist in attempting to minimize the forecast PJM RTO production cost based on anticipated market-based prices**





Outage Automation

Process Flow with Inputs/Outputs



Peak Load

- Single case
- Daily peak

Hourly

- 24 discrete hourly cases
- Hourly peak

Ticket Horizon

- Lifetime of ticket
- Daily peak

Ad Hoc

- User selected date range
- Custom load profile



Case Building:

- Completing a Base Case only gets us to a starting point for studying outages
- If historical cases do not align with the projected load for a given study day 1 to 5 hours can be spent just getting to where they can begin their study.

5 hours
later...

Study Engineer without TARA	Study Engineer with TARA
1 study period per engineer	Analyzes multiple periods per engineer
8 to 12 hrs of base case clean-up for long-term study	Average less than 1 hour of basecase clean-up for long-term outages
Analyze every ticket for a given day	Focus on outages with pre-identified issues
Ad-Hoc studies requires more time	Quick turn around on Ad-Hoc studies
	Industry Leader of outage study automation

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Operations Planning Transmission Outage Analysis



Member Hotline

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(866) 400 – 8980

custsvc@pjm.com

**PROTECT THE
POWER GRID
THINK BEFORE
YOU CLICK!**



Be alert to
malicious
phishing emails.

Report suspicious email activity to PJM.
(610) 666-2244 / it_ops_ctr_shift@pjm.com

