

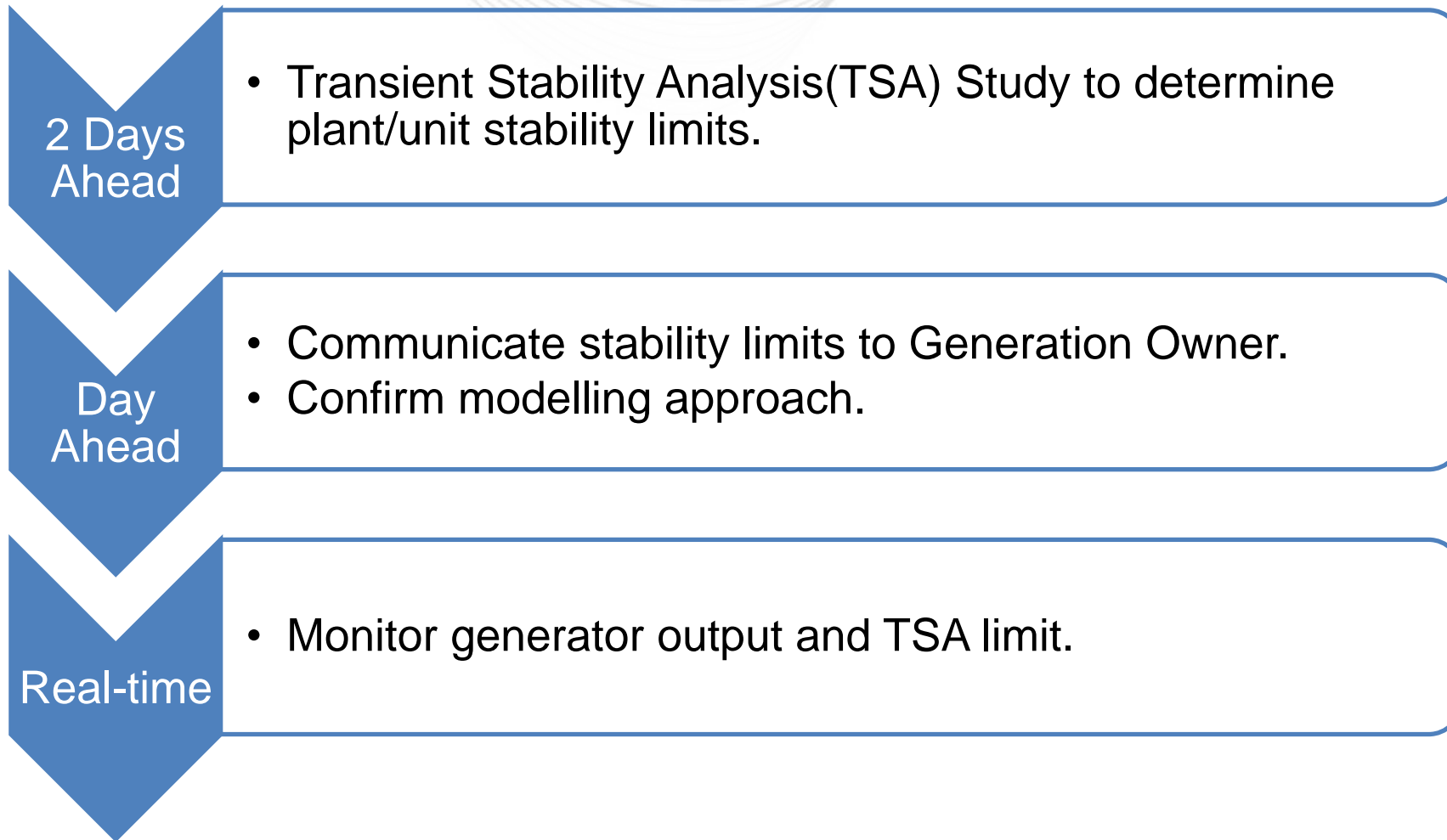
Real-Time Generation Stability Calculation and Market Modelling Process

Manual-03: Section 3.9.1 Process for Handling Generator Stability Limitations

“The Reliability Limited Generation Compensation Task Force established the following procedure on how PJM currently handles Stability Issues on the transmission system. When a stability issue is identified and advanced coordination is not possible, PJM will:

- 1) Confirm/calculate the stability limit and communicate the limit to the generator(s) as quickly as possible and prior to DA market submission when practical.*
- 2) Create an interface that would be used in the Day Ahead and Real Time Market so that LMP will be utilized to reflect the stability constraints.*
 - a) If the generator chooses to reduce their Economic Maximum bid below the stability limit, the constraint would not bind.*
 - b) If the constraint does bind, it would be handled consistent with how PJM handles other transmission constraints on the system. All current market rules regarding Lost Opportunity Cost (LOC) would apply and LOC would be paid as currently defined in the Tariff when a transmission constraint is in effect.”*

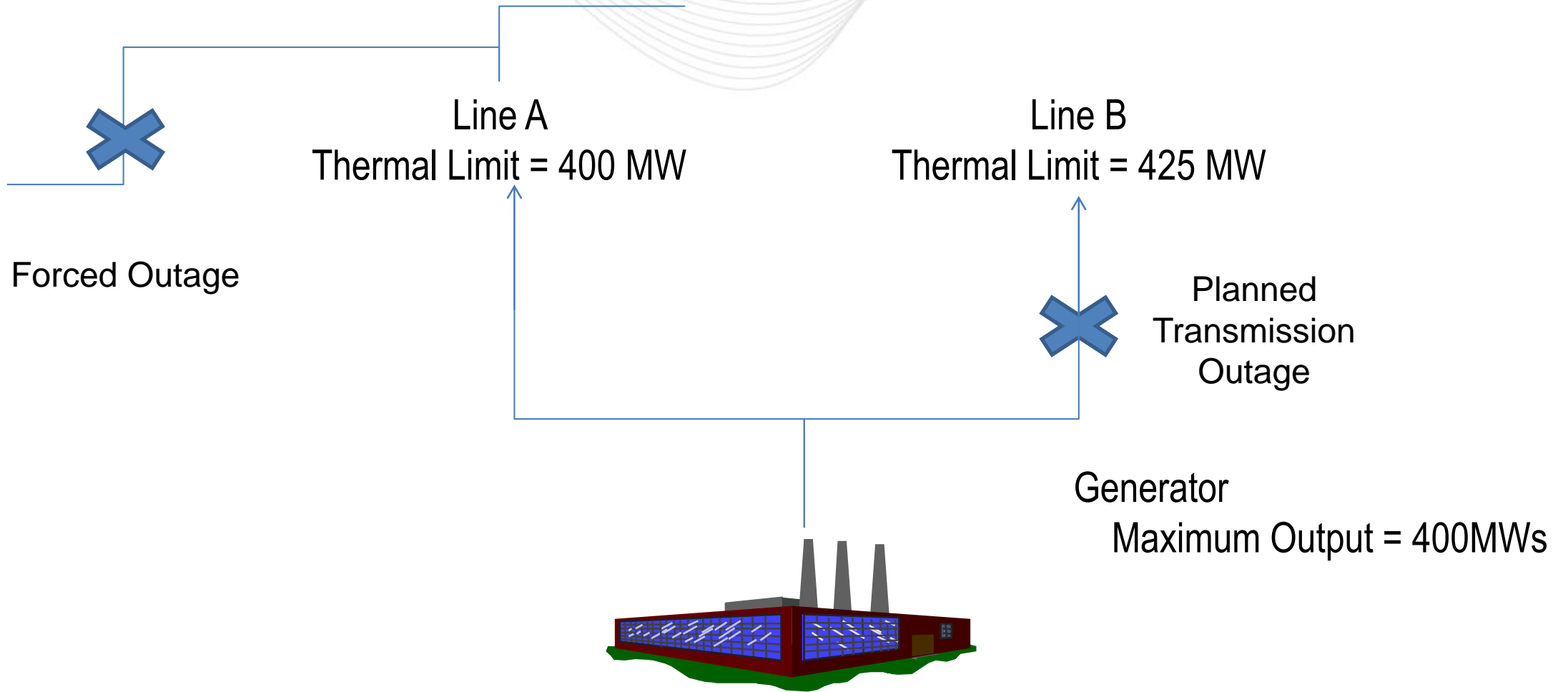
- Definition and Impact
 - Transient: Ability to remain synchronized after being subjected to a disturbance
 - Dynamic: Ability to damp oscillations cause by minor disturbances
 - Unstable units may impact other generators on the system
- NERC Standard
 - FAC-011-3 R2.1: *“all Facilities shall be operating within their Facility Ratings and within their thermal, voltage and **stability limits**; and **Cascading or uncontrolled separation shall not occur.**”*



- PJM utilizes a Transient Stability Assessment (TSA) Tool.
 - Manual-03 Section 3.9 defines the uses of TSA.
 - Manual-03 Section 5 contains plant specific limitations of common stability areas
 - Use in case TSA is not available
 - Provide transparency to GO and Market Participants
- For transmission outages, PJM will:
 - Study and determine plant/unit stability limitations.
 - TSA limitations tend to be less conservative than M-03 procedures.
 - 2 Days Ahead of Operating Day (further ahead for nuclear plants)
 - Limitations can be Maximum MW or/and Minimum MVar.

- Communicate the limit to the Generation Owner (GO) prior to Day-Ahead Market (DAM) closure
- Scenario 1: GO opts to reduce maximum output to communicated stability limit
 - GO should submit eDART generator outage ticket
 - Guidelines in place to avoid EFORd impacts
 - Capacity verified as part of Gen Checkout process
 - Surrogate/interface would not be needed
 - Alleviates negative impacts to LMPs at associated busses due to stability
 - Unit(s) committed and dispatched economically up to new Economic Max
 - Other bid in parameters unaffected for Price, Cost, and PLS schedules
 - PJM preferred method

- Communicate the limit to the Generation Owner (GO) prior to Day-Ahead Market (DAM) closure
- Scenario 2: GO opts NOT to reduce maximum output
 - PJM creates thermal surrogate/interface to reflect stability limitation
 - Constraint will bind in DA and/or Real-time when limits are exceeded
 - Impacts LMPs at affected busses up to Marginal Value Limit as defined by Tariff
 - Unexpected price fluctuations from positive to negative when constraint binds/unbinds
 - LMP distortions may cause downstream settlement impacts outside of DA/RT energy market
 - Units electing to must-run in DA above stability limit could create congestion



- Generator:
 - Generator can provide up to 400 MW of energy
- Transmission Lines:
 - After Line A was removed from service for a planned transmission outage, another nearby transmission facility experienced a forced outage

- Situation:
 - With the new system configuration, the plant has a stability limitation
- What are the courses of action:
 - Scenario 1:
 - PJM determined the stability limit to be 350 MW total maximum for plant.
 - Restriction communicated to the Gen Owner prior to the closing of the Day-Ahead Market.
 - Gen Owner decided to submit an eDART ticket and lower maximum limits to 350 MWs.
 - Unit receives basepoint based on updated limits.
 - No thermal surrogate/interface required in Real-time.

- Scenario 2:
 - PJM determined the stability limit to be 350 MW total maximum for plant.
 - Restriction communicated to the Gen Owner prior to the closing of the Day-Ahead Market.
 - Gen Owner opted not to submit an eDART ticket and not lower maximum limits below the stability limit.
 - Thermal surrogate/interface required in Real-time for stability concern.
 - Surrogate created and controlled as a thermal limit to the stability limitation.
 - » Control percentage may vary as ambient temperatures and stability conditions change

- Scenario 1:
 - Reserve calculations will respect the updated max of 350 MW.
 - » If unit is picked up for reserves, the deployment should not create a stability violation.
- Scenario 2:
 - Reserve calculations will utilize the full output of the plant.
 - » If unit is picked up for reserves, the deployment could violate the stability limitation.
 - » Leads to overestimation for reserves on the unit.

- Scenario 1:
 - No surrogate is used with no resulting pricing impacts from the surrogate in RT.
- Scenario 2:
 - Surrogate is created to best represent the stability limitation.
 - » Depending on the electrical modelling of the unit, an ideal surrogate is not always available.
 - » Based on existing Market rules, surrogate transmission facility must be classified as a Reliability and Markets facility. This eliminates plant side equipment as most are not classified as Reliability and Markets.
 - » May need to use the radial line, which can reveal the marginal unit on the constraint.

- Scenario 1:
 - With no surrogate binding, unit would be dispatched economically between eco limits.
- Scenario 2:
 - When surrogate binds in RT, it could lead to significant LMP difference between intervals.
 - » Depending on the severity of the violation, the surrogate could bind all the way up to the marginal value limit.
 - » An associated ramp-limited basepoint would be sent out. If a unit is unable to follow the basepoint, it maybe deemed to be deviating and logged accordingly.

- Scenario 1:
 - Plant reduces maximum limits and submits associated data in eDART/eGADS.
 - Any outage or derate event for transmission issues are required to be reported to both eDART and eGADS. If, and only if, the events are **scheduled in advance** in eDART as maintenance outages or derates will they be allowed to remain maintenance outage or derates in eGADS.
 - Should not impact EFORd calculations.
 - » Guidelines in proposed Manual 3 language around ticket submission.
- Scenario 2:
 - If outage or derates are not scheduled in advance in eDART, they must be forced outages or derates in eGADS and then they will impact a unit's EFORd.

- Reliability Limited Generation Compensation Task Force (RLGCTF) formed in 2012 to examine generator stability restrictions.
- Task force evaluated multiple design components including communications, method for using interfaces, and compensation.
- Package Summary: After the interface is created and modeled the GO has the option to bid in ECO MAX and bind the constraint in DA or they can place the ECO Max below the Stability Limit and provide eDART Ticket (OMC) and be paid system price.
- With exception of definition of Lost Opportunity cost, status quo was maintained.
- Endorsed by MIC at December 12, 2012 meeting.