Load Deliverability Study And CETL Calculation

PJM Transmission Planning

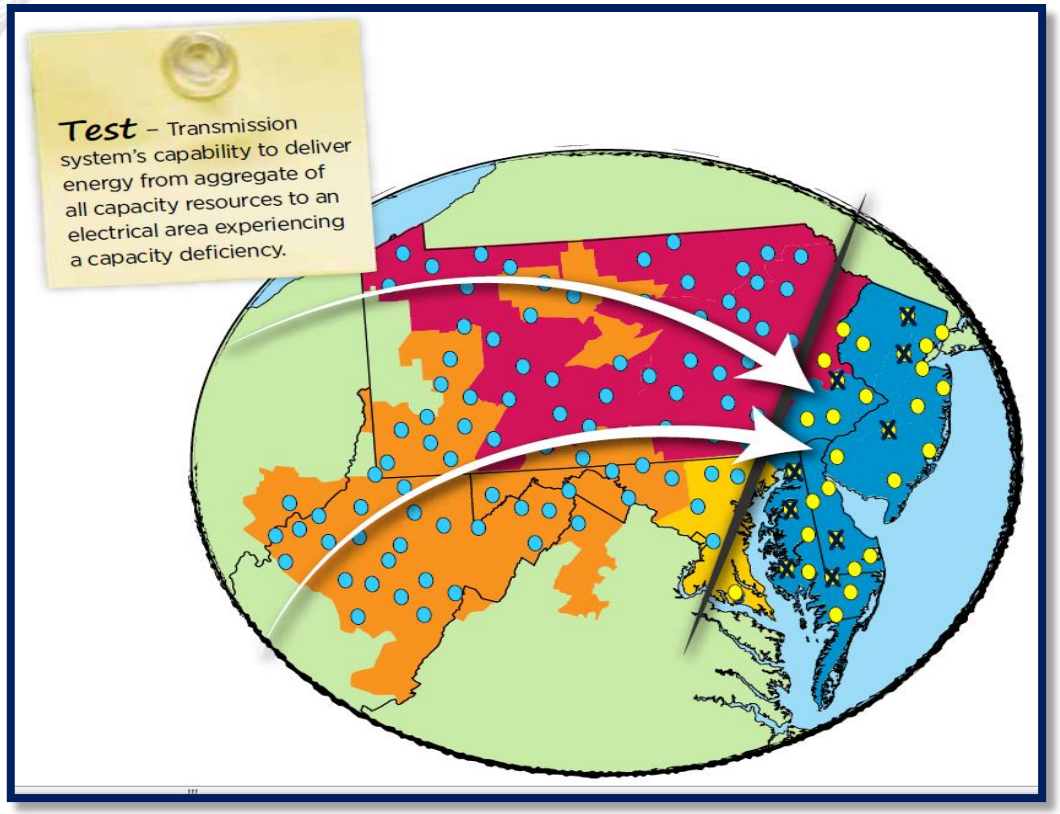
December 16, 2024

Deliverability Background

- Two types of risk must be considered when measuring the reliability of the power system
  - Generation risk
  - Transmission risk
- PJM's Reserve Requirement Study ensures that generation risk across PJM involves no more than one event in ten years where the generation supply is less than the demand on the system
- The concept of deliverability was introduced in order to ensure the transmission risk does not appreciably increase the overall generation risk
  - Load deliverability
  - Generation deliverability

Load Deliverability Test

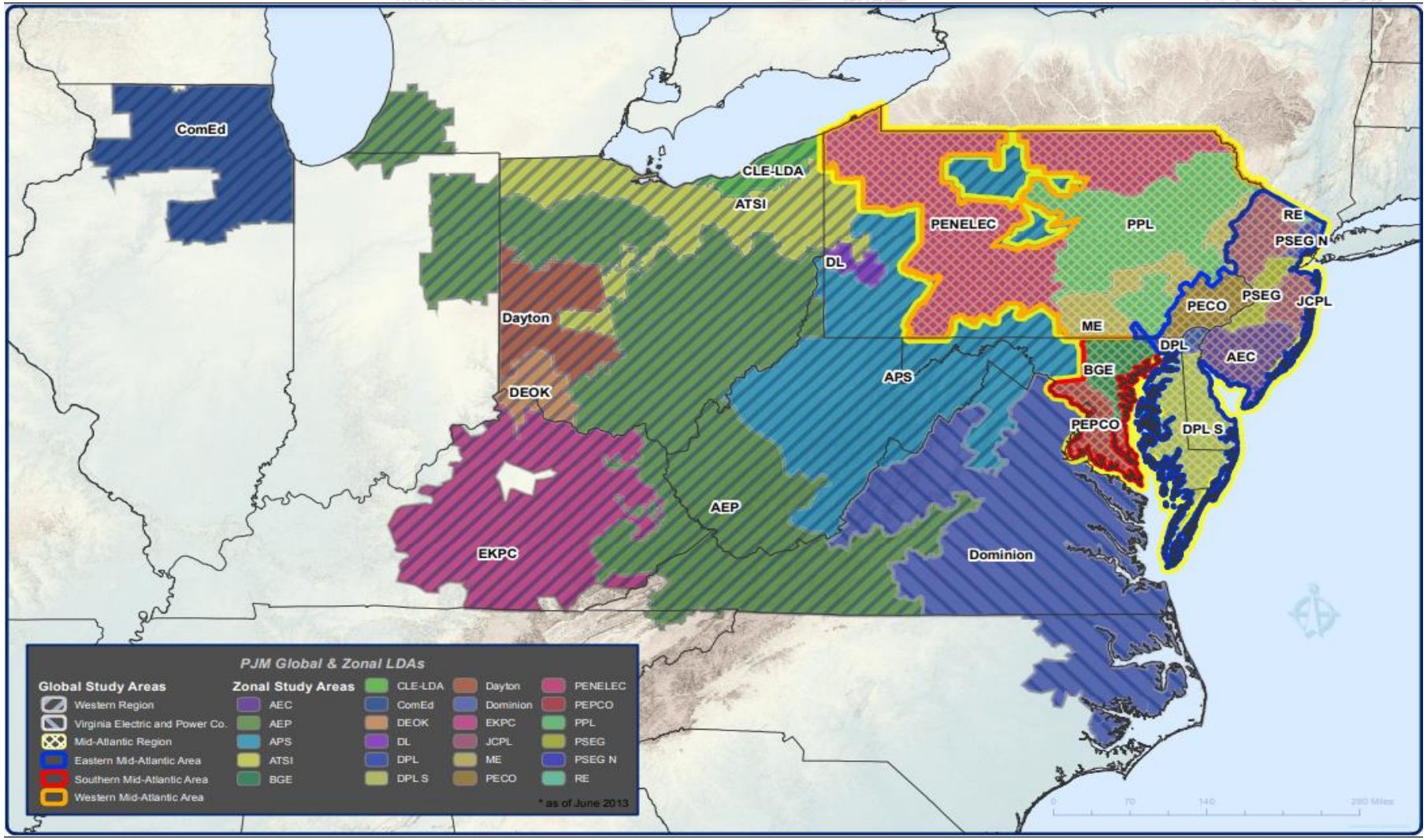
- The concept of load deliverability was first introduced at PJM about 50 years ago to ensure there was minimal transmission risk serving each Locational (load) Deliverability Area (LDA) in PJM
- The load deliverability test ensures sufficient transmission capability exists on the PJM system to supply emergency power from the aggregate of PJM generation to LDAs experiencing capacity emergency and high load conditions



Locational Deliverability Areas

- PJM currently has 27 LDAs comprised of 19 zonal LDAs, 3 sub-zonal LDAs and 5 global LDAs
  - Zonal LDAs correspond to traditional Transmission Owner electrical boundaries
  - Sub-zonal LDAs correspond to portions of zonal LDAs that have been carved out because of historical transmission import concerns
  - Global LDAs are comprised of combinations of zonal LDAs and may contain common EHV facilities that serve the zonal LDAs

Locational Deliverability Areas



Applications of Load Deliverability Test

- Annually as part of the RTEP (summer and winter)
- Annually prior the RPM Base Residual Auction
- As needed for Interconnection Requests
- As needed for Incremental Capacity Transfer Rights (ICTRs)

Core Load Deliverability Concepts

- Capacity Emergency Transfer Objective (CETO): The amount of imports into an LDA that an LDA requires to meet the LDA's resource adequacy criteria
- Capacity Emergency Transfer Limit (CETL): The amount of power that an LDA can import
  - CETL < CETO conditions require transmission reinforcements
- Each LDA within PJM is assumed to be experiencing a generation deficiency independently
- No imports beyond firm from outside PJM

Load Deliverability Analysis Assumptions And CETL Calculation Methodology

CETO/CETL Case Development

- Start with the applicable RTEP base case and set PJM load to coincident peak levels
- Each LDA studied independently at higher of 90/10 load level minus demand response or 50/50 load
  - 90/10 load adder modeled at 80% Power Factor
- Two separate power flow cases created for each LDA at CETO level. Rest of PJM is assumed to be operating normally and generation is scaled up uniformly to supply the LDA's CETO
  - Mean Dispatch Case: models the average value of each generator's output for the LDA under study from over 10,000 unique dispatches at the CETO
  - Discrete Outage Case: models the most likely discrete generator outage pattern within the LDA at the CETO

Mean Dispatch Case Creation

- Take 10,000 generation outage scenarios by using a Monte Carlo simulation
  - A random number between 1 and 0 is assigned to each generator
  - If the random value > the EFORd, then that generator is turned on at its full capability. If the value < the EFORd, then that generator is turned off.
  - For each outage scenario, the amount of generation selected should be within +/- 2% of the target generation amount to model the import objective.
- Determine the average MW output of each generator by using its dispatched values in the 10,000 generator outage scenarios.
- The reactive capability of each unit is reduced by the ratio of each unit's average MW output to the unit's maximum MW output.

Discrete Dispatch Case Creation

- Use discrete generator outage
  - Derate all generators in the LDA zone by their EFORd.
  - Rank generators by EFORd^(1/PMAX).
  - Select generators in rank order until the next selected generator would exceed 105% of the target generator outage value.
  - For a station with multiple generators the outage shouldn’t exceed 60% of the total generation.

CETL Thermal Analysis

- CETL is the maximum amount of imports into the LDA where no relevant single contingency thermal, voltage magnitude or voltage drop issues exist
- The first step to determine the CETL is to find the thermal import limit into the LDA. This is done for separately for both the mean and discrete outage dispatch cases, i.e. start with the CETO and see how much additional power can be imported into the LDA
- PJM uses the TARA program to transfer power into the LDA while simultaneously performing a security constrained redispatch of PJM generation outside the LDA
- Generation inside the LDA is decreased uniformly (MW and MVAR capability) until the import limit(s) is identified

CETL Voltage Analysis

- After the CETL thermal import limit has been identified for both the mean and discrete outage dispatch cases, the TARA program is used to create the thermal CETL power flow cases
- Next, a single contingency screening is performed for each LDA at the thermal import limit to determine whether there are any relevant voltage magnitude or drop import limits
  - If there are no voltage issues at the thermal import limit, then the lower of the thermal import limits identified using the mean and discrete outage dispatch cases defines the CETL
  - If there are voltage issues at the thermal import limit, then PV analysis is used to determine the voltage import limit and it defines the CETL
- Final CETL is determined by the most limiting value of the thermal or voltage CETLs

Load Deliverability Test Assumptions

- PJM monitors all internal transmission facilities for its load deliverability test and screens criteria violations for facilities that pass an outage transfer distribution factor (OTDF) cutoff test and are on PJM's monitored facility list (lists of PJM monitored lines and substations are available at http://www.pjm.com/markets-and-operations/ops-analysis/transmission-facilities.aspx.)
- N-1 Single Contingency (NERC Transmission Planning Criteria P0 and P1)
- The resulting list of facilities constitutes the PJM Load Deliverability Facility List and may vary from study to study because changes in system topology may change the OTDF

Load Deliverability Test Assumptions

- In all cases, the study area CETL analysis should reflect actual PJM emergency operations procedures designed to make as much power available to the deficient study area as possible under the prevailing system conditions. This should include but is not limited to
  - The operation and redispatch of any available PJM generation external to the LDA regardless of system economics. Redispatch of Capacity Resources are allowed internal to the study area as well to relieve an overload provided that the CETO is increased by the amount of generation reduction required to eliminate the internal overload.
  - The activation of any PJM Load Management (LM) schemes within the LDA that may serve to unload limiting facilities to the extent that doing so does not reduce the load in the area under test below the expected 50/50 load.
  - The adjustment of any Phase Angle Regulators (PARs) which PJM or PJM member companies control within existing agreements for emergency operation. The PJM/NYISO PAR flows will be set according to Attachment B Section (B.3)(VII)(P).
  - The activation of any approved PJM or PJM member company operating procedure.
  - Operating procedures are described in PJM Manual M03 -Transmission Operations.