DER Trip Impact Study

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PJM DER Ride Through Task Force

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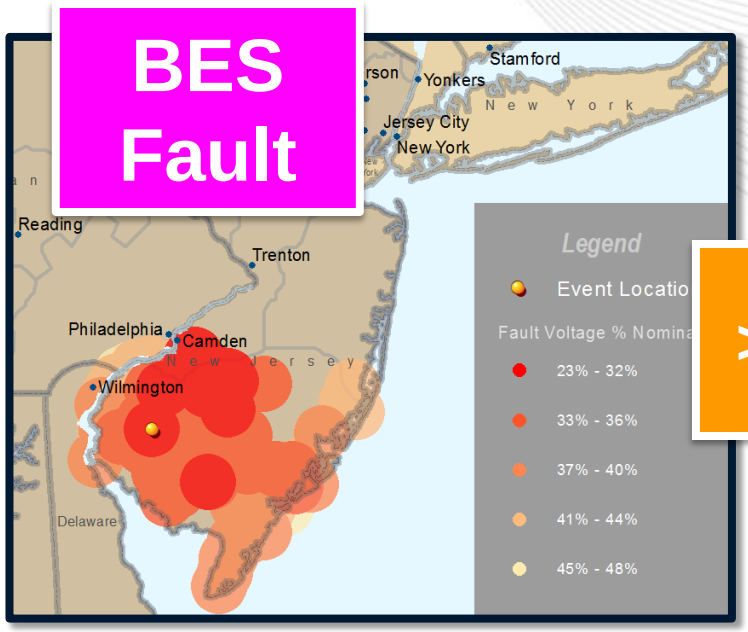
Purpose and Summary of Study

- **Summary**: PSS/E dynamic study of transmission (and equivalized distribution) for response of DER and transmission network to a 3-phase transmission fault.
- **Purpose**:
  - Understand severity and nature of the transmission impact of fast-trip (and lack of ride through) under high DER scenario.
  - Compare the impact under the status quo IEEE 1547-2003 trip settings (and lack of ride through) with the impact given alternative trip settings including ride through and momentary cessation (under IEEE 1547-2018).

Mechanics

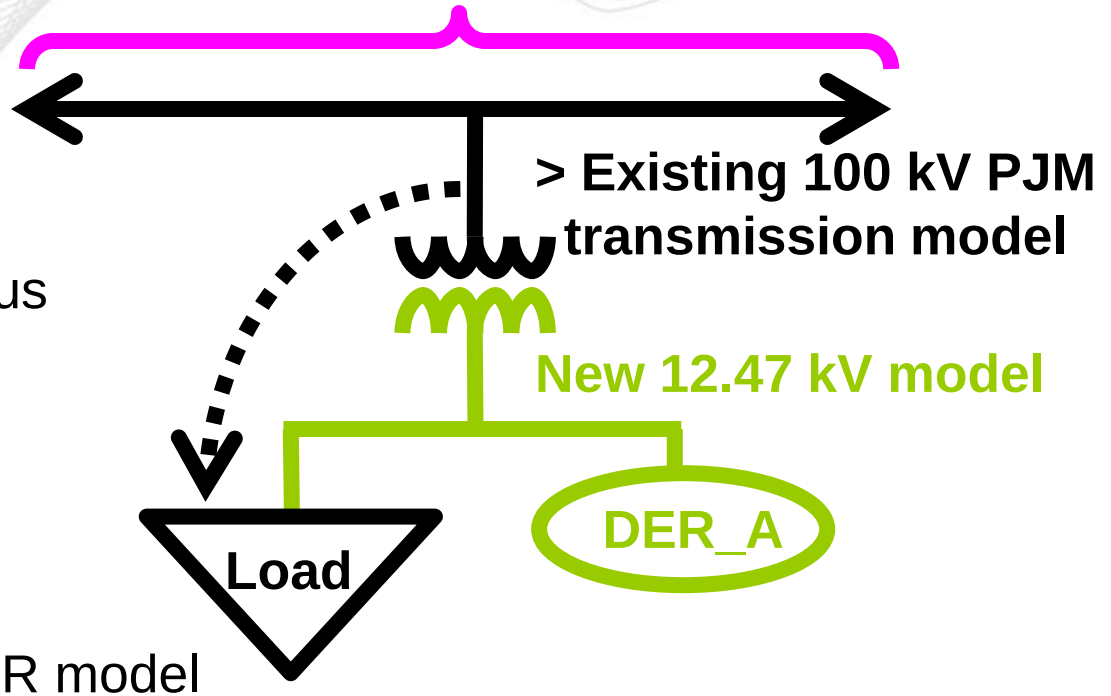
("BES" = "Bulk Electric System" = the transmission system)



> 160 ms → TRIP → ~ 10,000 ms

BES Fault → DER Trip → BES Fault Clearing → BES Response → DER recovery

PSS/E Model



- PSS/E v33.12 dynamics
- Model load substation transformer at each load bus
  - Secondary is 12.47 kV
- Single equivalized model object per load bus for:
  - Feeder
  - Load – complex load model
  - DER – DER_A inverter-based residential DER model
- Simulating dynamics for ~ 1,000 – 10,000 ms: through initial fault, voltage disturbance propagation across BES (and sort-of for feeder), DER trip or momentary cessation, transmission fault clearing, ongoing transmission response, and (for momentary cessation) eventual DER return to pre-event output.

How does low-voltage condition reach 160 ms given fast BES relaying?

IEEE 1547-2003 mandates 160 ms trip for V< 50%. (Note 10 “cycles” = 167 ms).

1. Normal 3-phase 230 kV+ transmission relay clearing is faster than 120 ms.
2. Possible DER cumulation on instant recloser action with permanent fault accumulates two fault conditions
   - I.e., 5 cycle clearing time for initial transmission fault, instantaneous recloser tryback followed by second 5 cycle clearing time = 10 cycle accumulated fault time
3. Failed primary relaying (including any redundant relaying) is possible and backup relay clearing times can reach (or exceed) 160 ms.
4. Fault induced delayed voltage recovery on distribution or transmission.

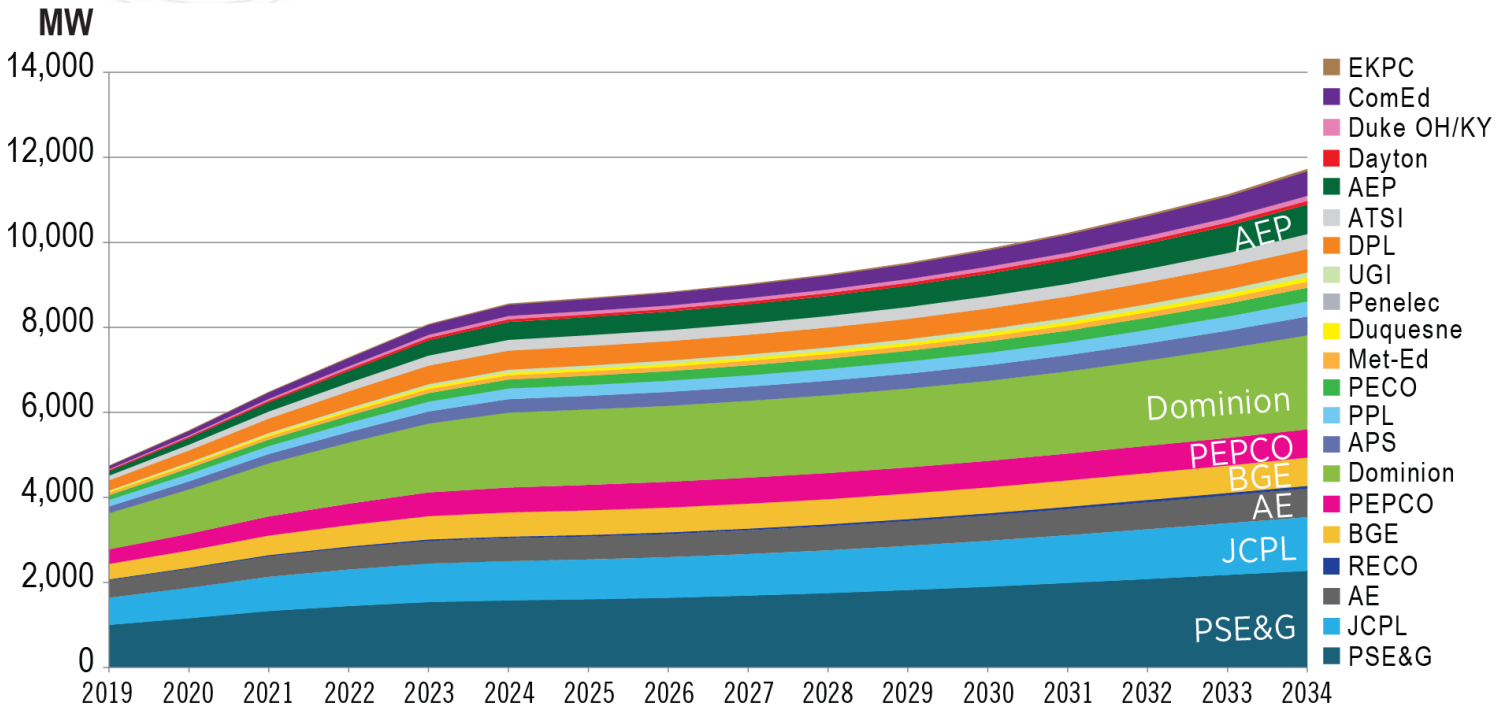
Under NERC requirements, 160 ms is necessary and sufficient ride through for V < 50% of nominal

Does voltage quickly propagate from transmission to distribution?

- Yes, voltage generally quickly propagates from transmission to distribution, despite the fact that there is high impedance between distribution and transmission
  - Distribution feeders that are self-sufficient in real and reactive would be expected to have unique dynamics relative to other feeders.
  - In either case, PSS/E dynamics will adequately simulate the timing of voltage propagation, even across high impedance boundaries and under varying flows of real and reactive power across those boundaries.
- Only dynamic voltage regulating equipment significantly changes voltage propagation timing.
  - STATCOMs, synchronous condensers, and generators providing dynamic voltage regulation. These are largely absent on distribution.
  - DER providing dynamic voltage regulation would be adequately captured with PSS/E dynamics and this is a scenario PJM will study.

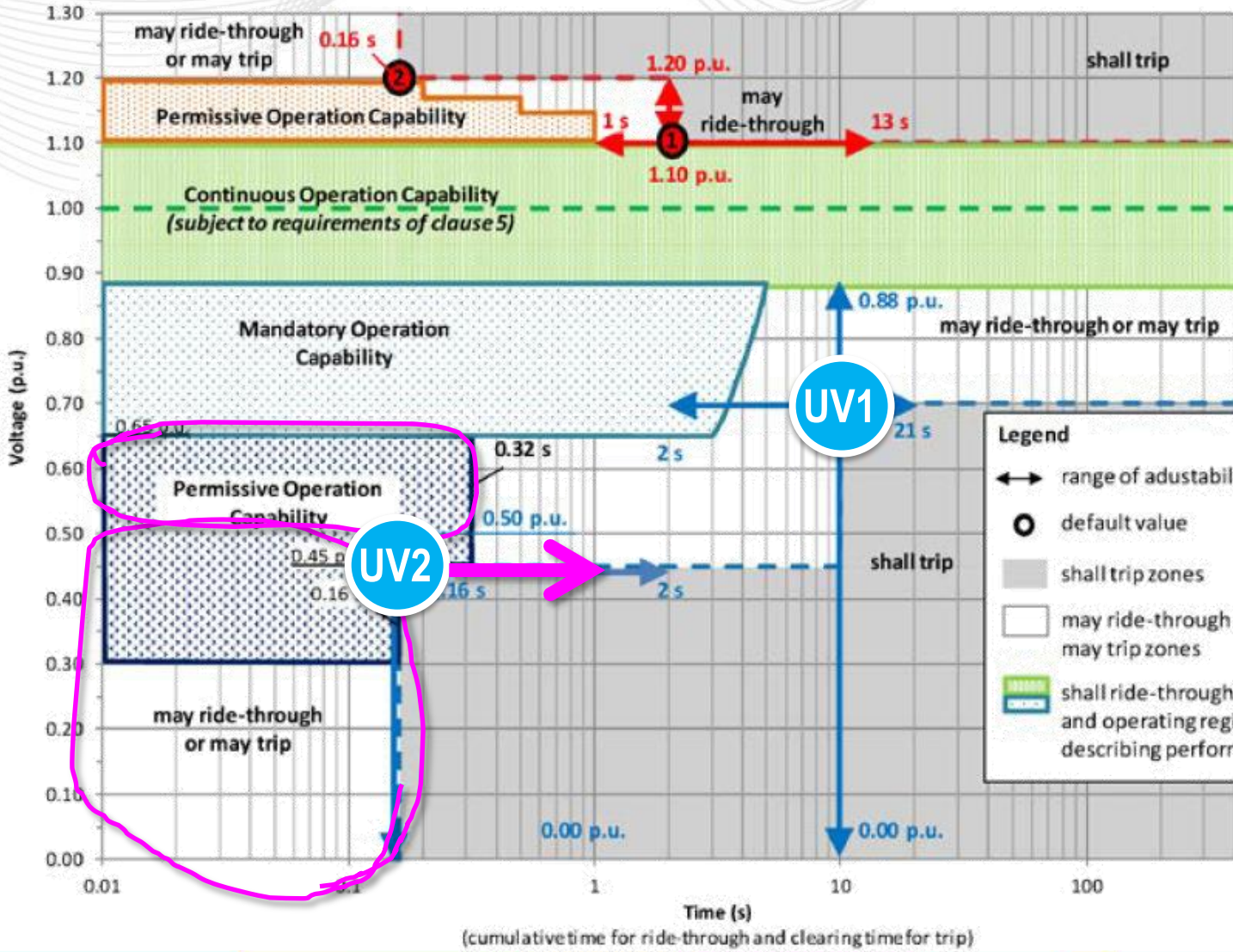
Draft Study DER Deployment Scenarios

- Three cases for DER deployment in 2031 (nameplate solar DER MW):
  - **High**. Current PJM deployment forecast of ~4 GW (< 10% of annual NJ load from solar DER).
  - **Higher**. Range up to 10 GW (< 20% of annual NJ load from solar DER).
  - **Highest.** Range up to 20 GW (< 40% of annual NJ load from solar DER).



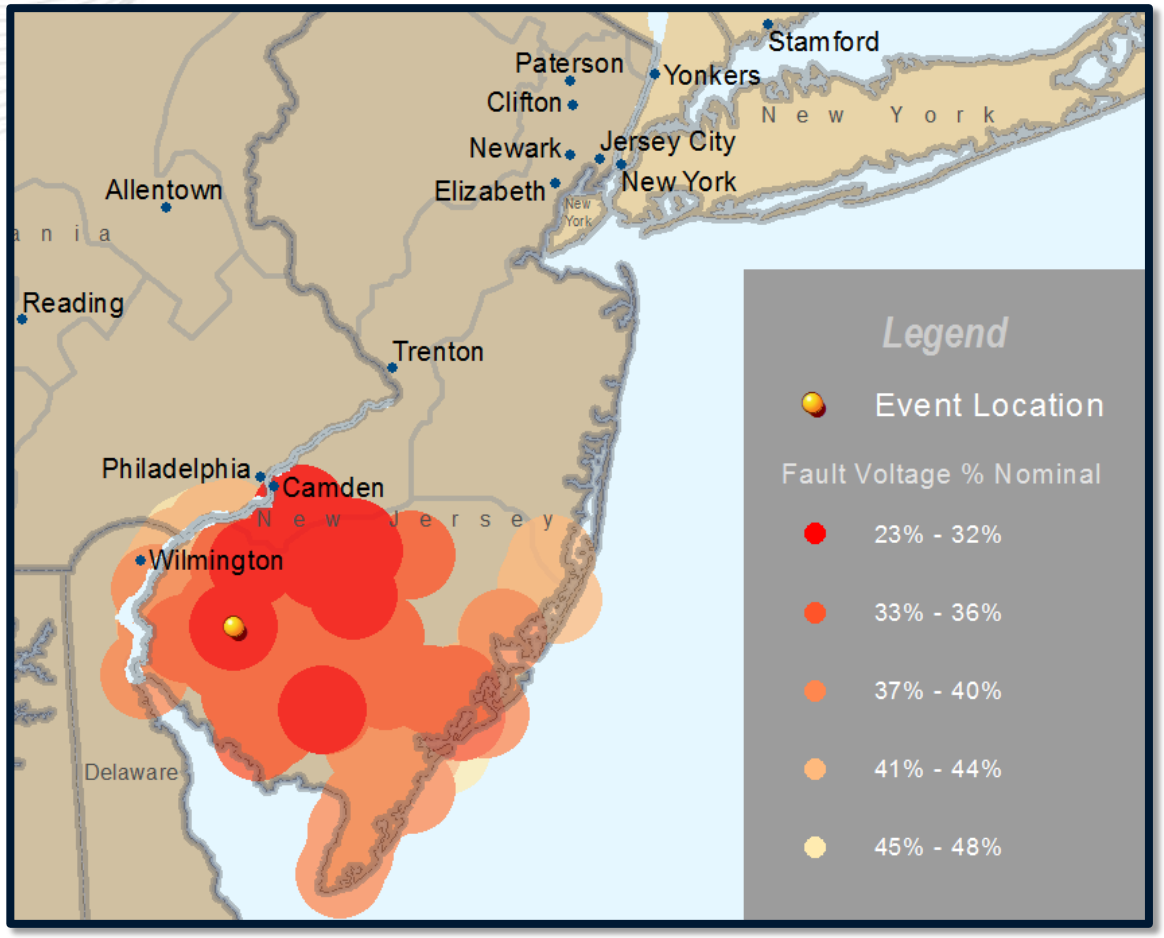
Draft DER Dynamic Behavior Cases

- Transmission relay dynamics: clear the 3-phase fault in ~100 ms. Possible delayed clearing scenario.
- DER dynamics (focus on UV2 behavior < 50% of nominal voltage):
  - Trip before normal transmission fault clearing (< 100ms)
  - 400 ms of momentary cessation after 83 ms <50% nom. voltage
  - 400 ms of momentary cessation after 83 ms <30% nom. voltage
  - Full ride through for 160 ms without momentary cessation
  - With & w/o voltage regulation



Fault Location and Time Scenario(s)

- One or more 3-phase faults (focus on southern NJ).
- One or more times of year (noon in cold December day plus possibly others).
  - Higher gas prices during colder day = some NJ gas generation would not be online
  - Solar output at noon in December not much lower than noon in July
  - Noon loads in December lower than summer peak loads



Requesting Feedback and Input from Distribution Engineers et al

- Scenarios
- Distribution feeder and step-down transformer equivalent impedance and other characteristics
- Feeder models for tuning *v_frac* parameter on the DER_A object in PSS/E
- Load characteristics (residential vs. commercial vs. industrial) for tuning load model