Inverter-based DER Ride Through and IEEE Standard 1547

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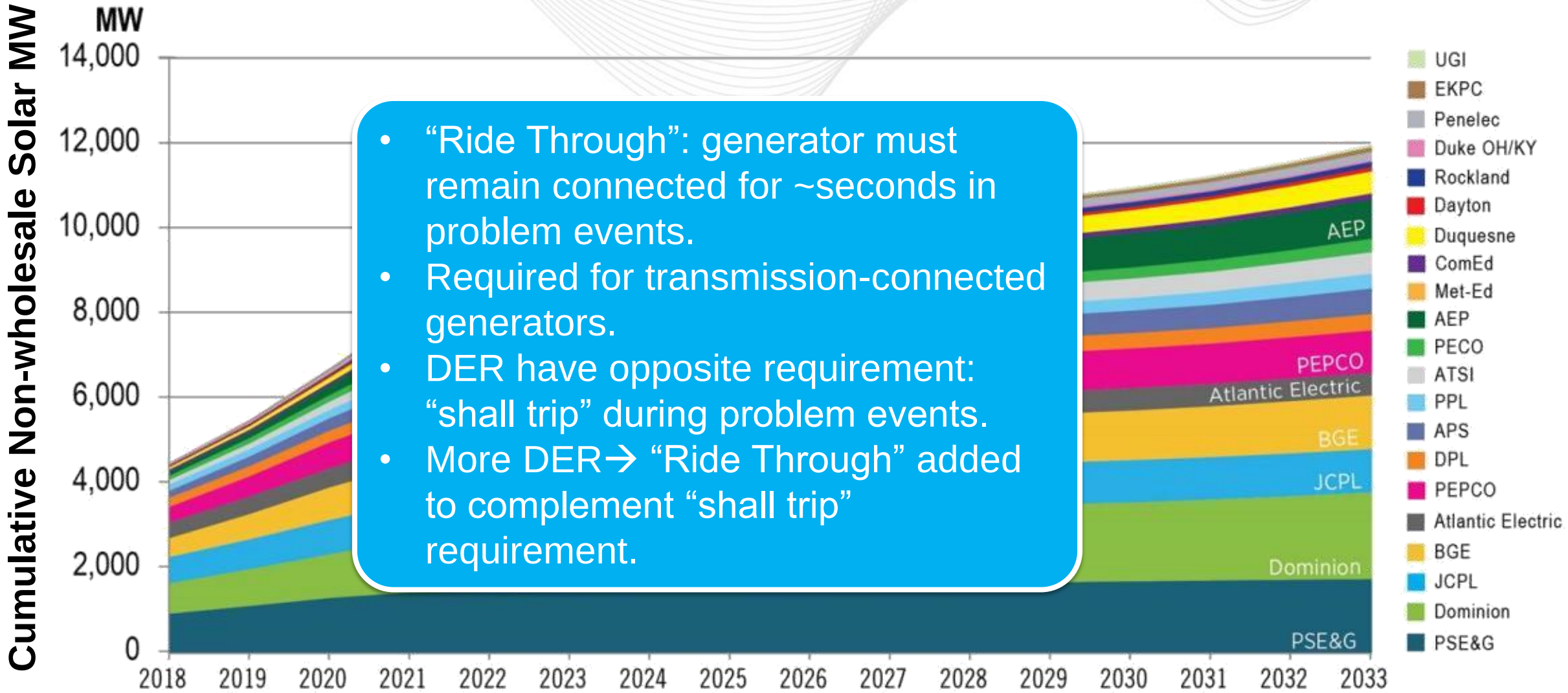
More DER deployment in PJM → Ride Through

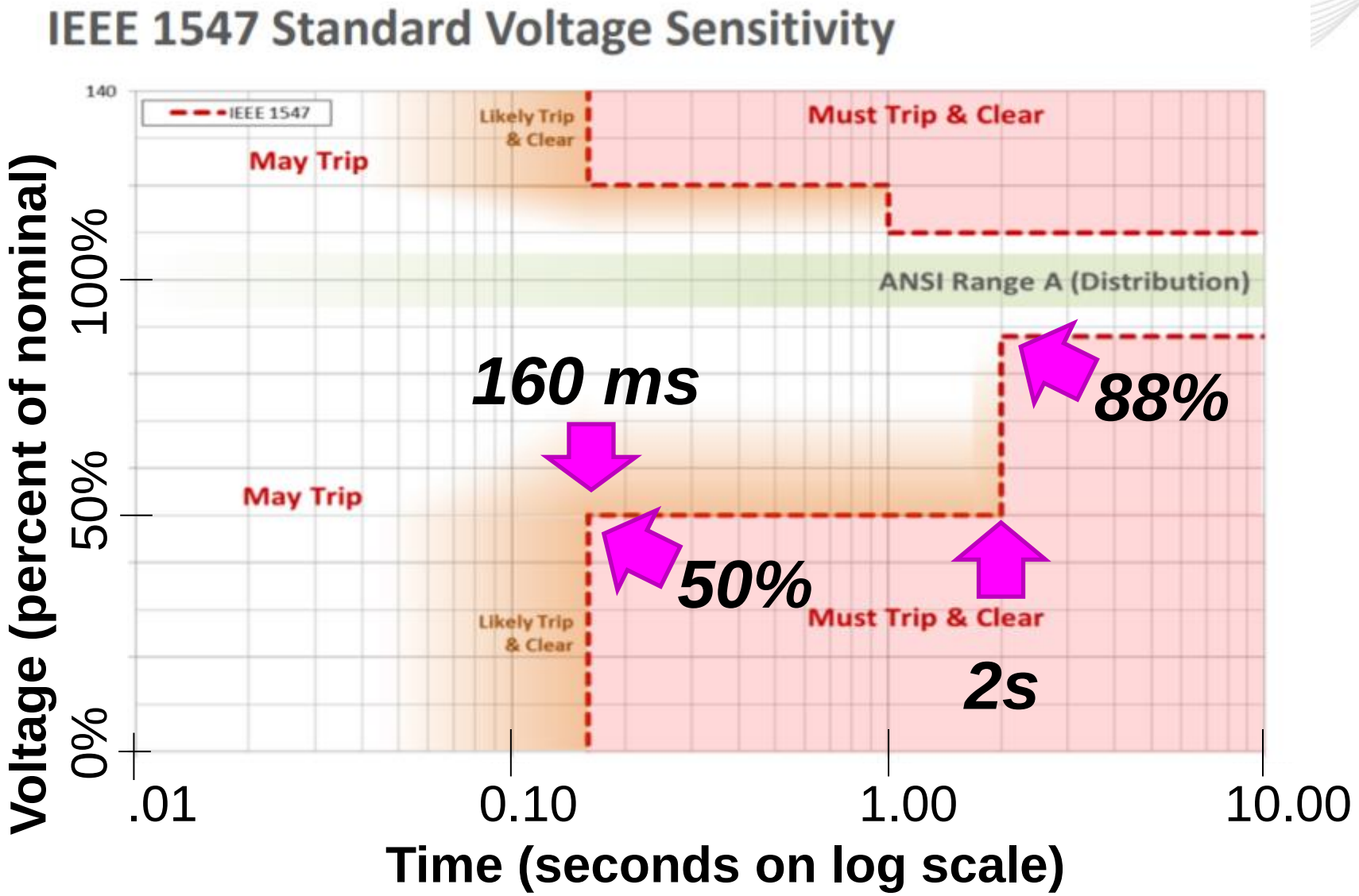


- "Ride Through": generator must remain connected for ~seconds in problem events.
- Required for transmission-connected generators.
- DER have opposite requirement: "shall trip" during problem events.
- More DER→ "Ride Through" added to complement "shall trip" requirement.

DER and “Shall Trip”

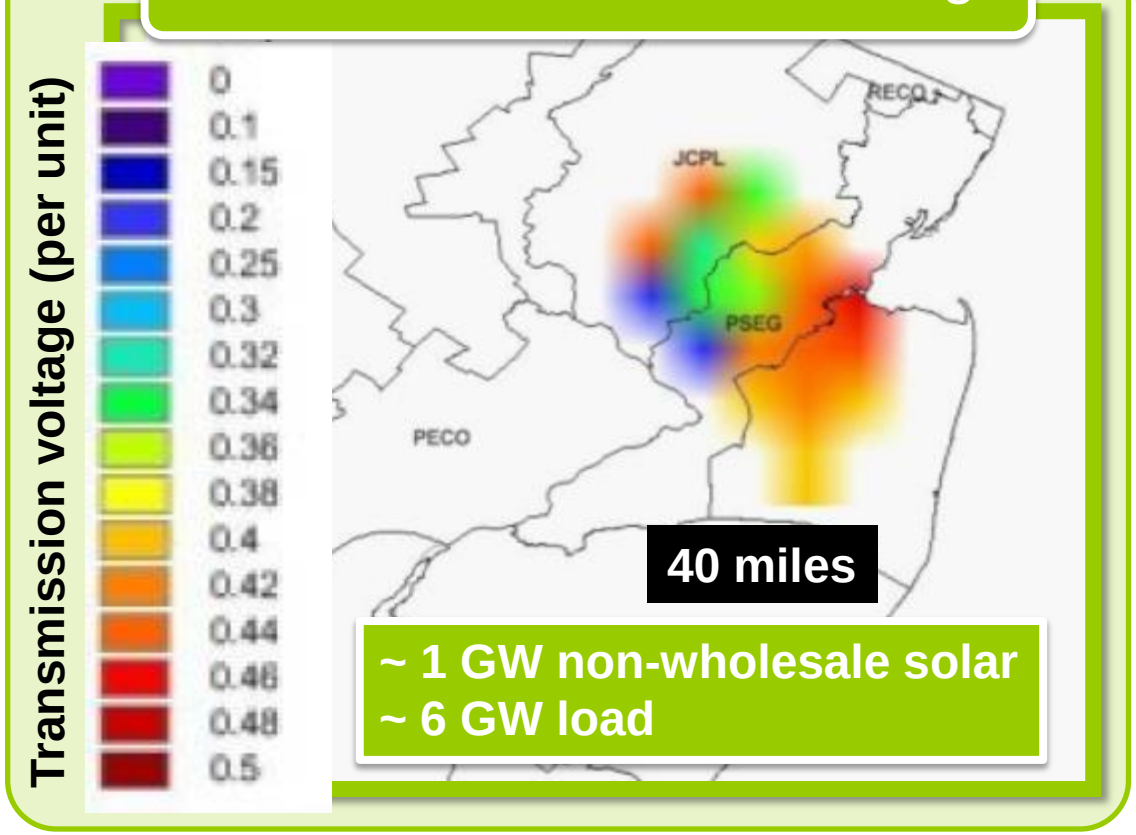
- Distributed Energy Resources are connected to radial distribution
- To preserve existing utility protection schemes, safety of hot-work lineman, and avoid “islanding” conditions that could damage customer and utility equipment…
- DER are configured to trip fairly quickly under adverse conditions: under/overvoltage and under/overfrequency.
- E.g., within 160 milliseconds at 50% per unit voltage.

DER and “Shall Trip”



Could Wide Area Undervoltage in PJM Persist to 160 ms or 2s trip point?

Multiphase transmission faults→wide area undervoltage



~ 1 GW non-wholesale solar
~ 6 GW load

Fault-Induced Delayed Voltage Recovery > 2 s

Voltages on some transmission substation busses decayed to 50% or less of pre-fault conditions. Normal voltage restoration required an extended period of time, estimated to be between 5 and 15 seconds.

15s FIDVR 1992 PECO line-line-ground fault*

Delayed transmission fault clearing 200 – 1,000 ms

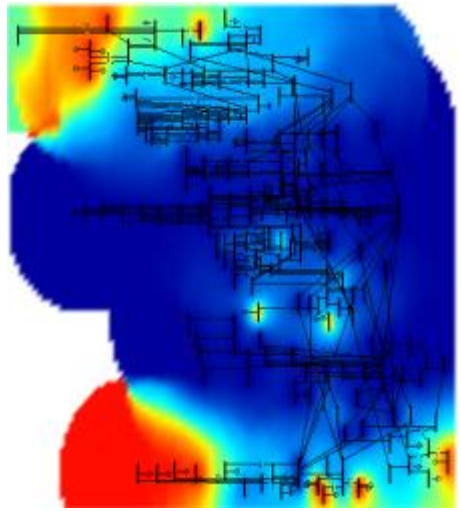
Reclosing and trip timing accumulation

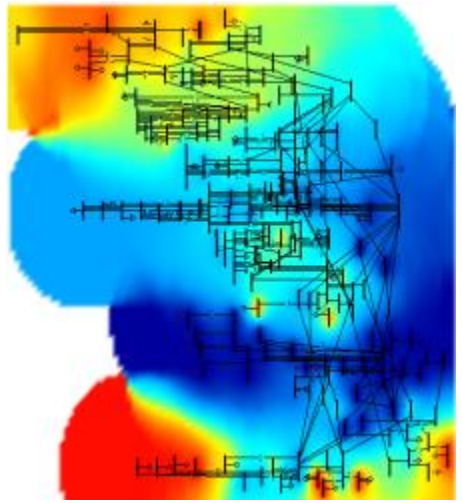
**** EPRI/NERC FORUM ON VOLTAGE STABILITY** at 2/15-24 (Breckenridge, Colo., Sept. 1992) (EPRI TR-102222).*

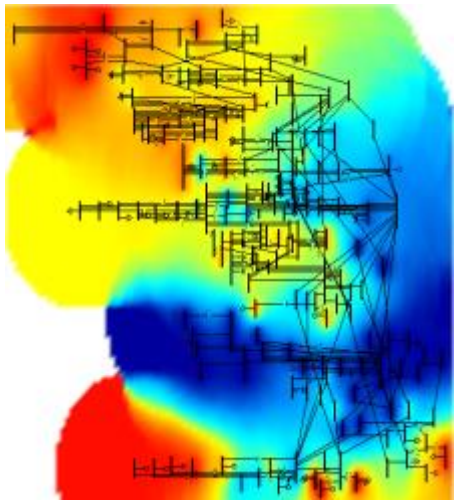
PJM Simulation of Benefit From Ride Through

	Many DER Ride Through: OFF	No DER	Many DER Ride Through: ON
LOAD AT RISK FROM GRID EVENT	***2,600 MW***	***1,600 MW***	***750 MW***

Grid event worsened ← → *Grid event improved*



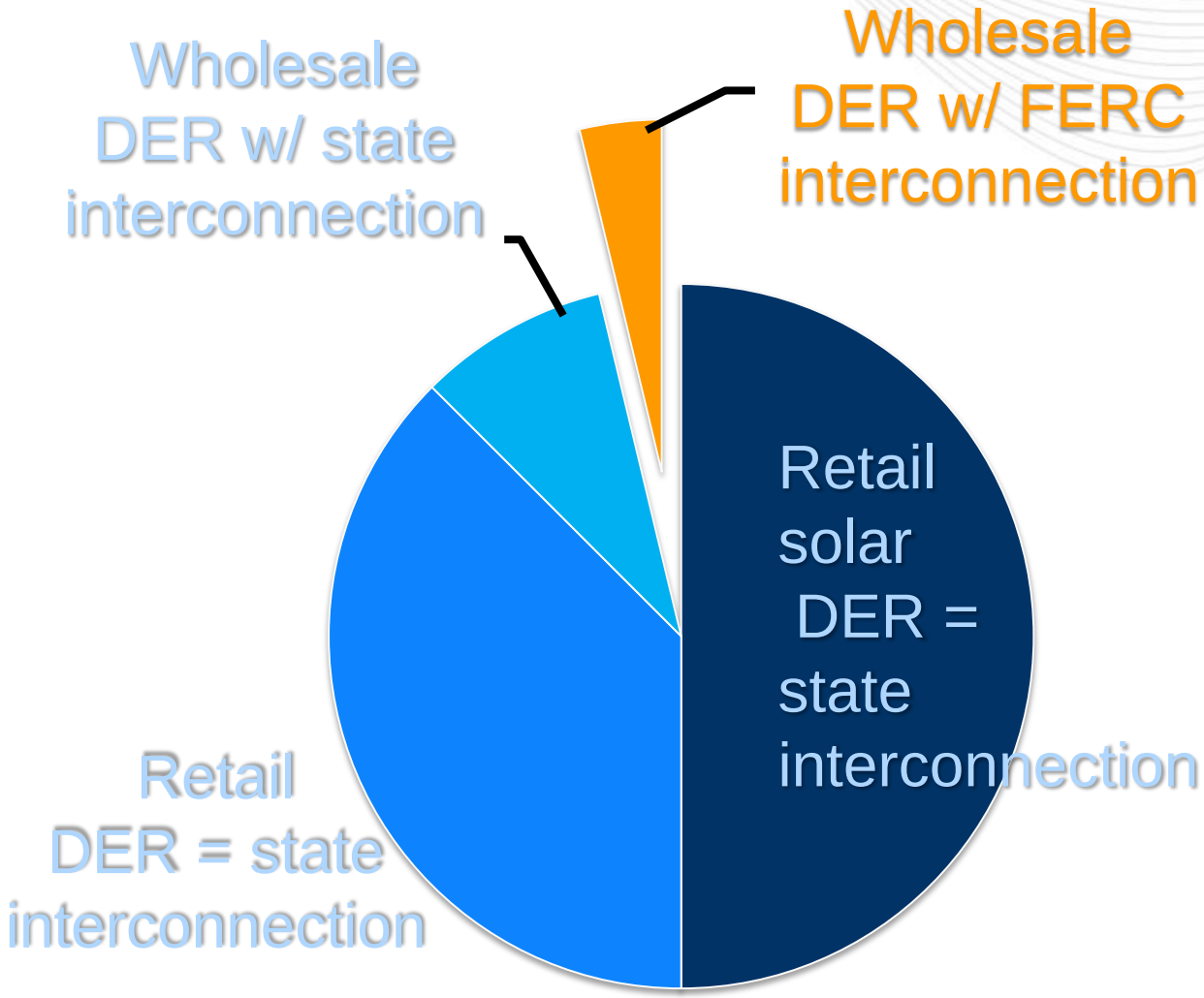




Blue, teal, and green are abnormally low voltage, which puts load at risk (quantified as load exposed to < 85% nominal voltage)

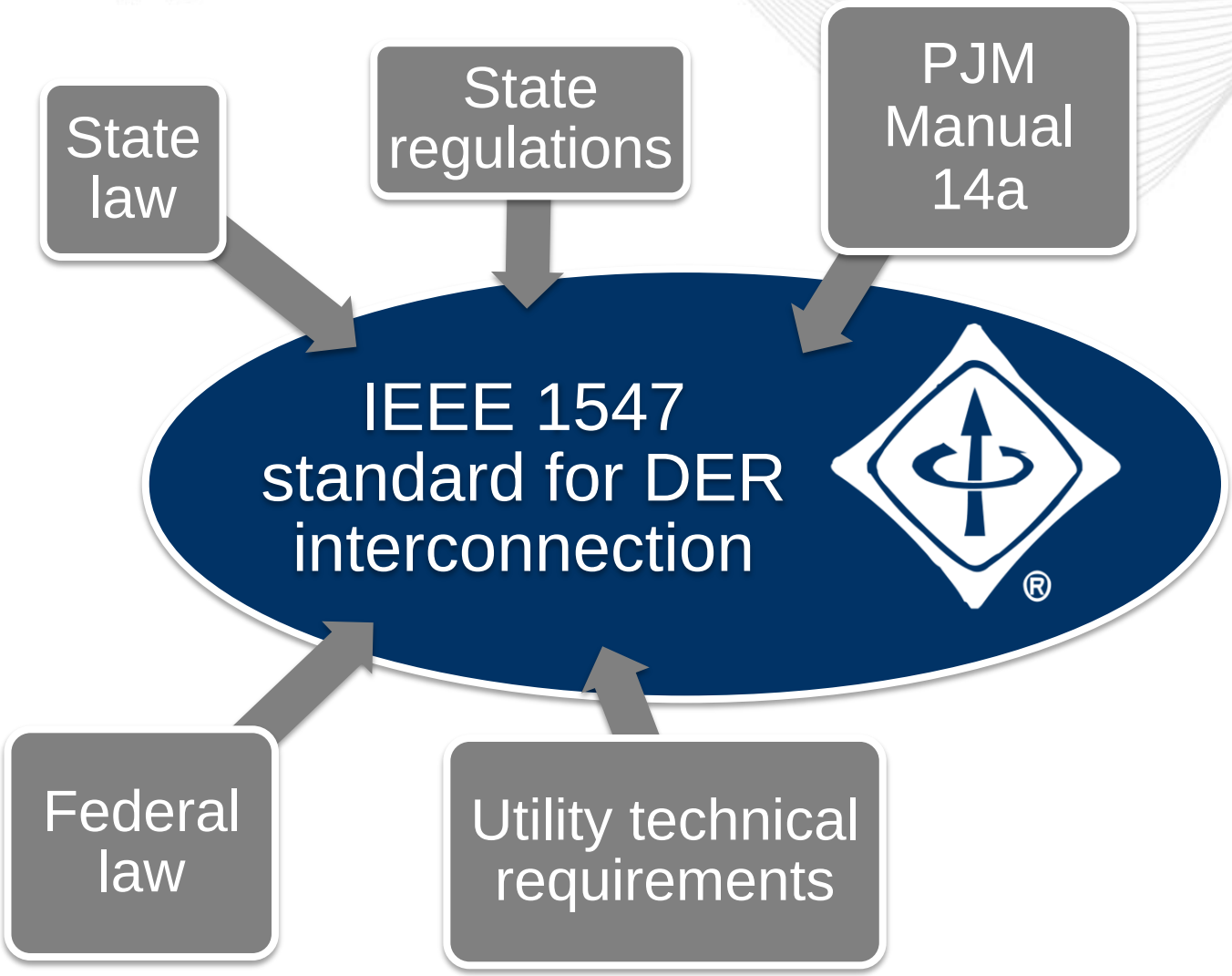
WHAT'S THE POLICY SOLUTION?

Few Wholesale DER Have FERC Interconnection



- Most DER = local jurisdiction, PJM has no interconnection authority.
- Minority of wholesale DER = FERC jurisdiction.
- In all cases: distribution utility is primary technical/utility stakeholder.
- Safety of lineworkers, others is priority.

The Role of IEEE 1547-2018 and "Ride Through"



NEW! 3 GREAT FLAVORS!

*1547-**2018** ed.:*
Ride through requirements

Trip requirements

Harmonics
Voltage: Unity Power Factor
Frequency
Anti-islanding etc…

PJM Stakeholder Effort for DER Ride Through

Feb 28: Preliminary trial workshop w/ 4 utilities (T and D)

Aug 9: 1st read of problem statement PJM Planning Committee

Oct 1-2: Stakeholder Technical Workshop

2018-2019: Task Force discussions

2019: Manual Language and final documentation of Ride Through and Trip parameters

PJM Rules

Distribution Utility Discussions under Local Regulation

OBJECTIVE:

- PJM-wide consensus across T+D on a preferred 1547-2018 profile (e.g., Category II with specified trip adjustments and addition of momentary cessation)
- If necessary: 2 preferred profiles: e.g., a Category II and a Category III
- Two deliverables for technical profile: a policy guide for state/local regulators, and PJM manual language changes.

SCOPE

Ride through capability and trip parameters only.

- Not voltage regulation or communications, etc

For generators:

- Inverter-based
- Connected to radial distribution
- Not connected to BPS or meshed subtransmission.

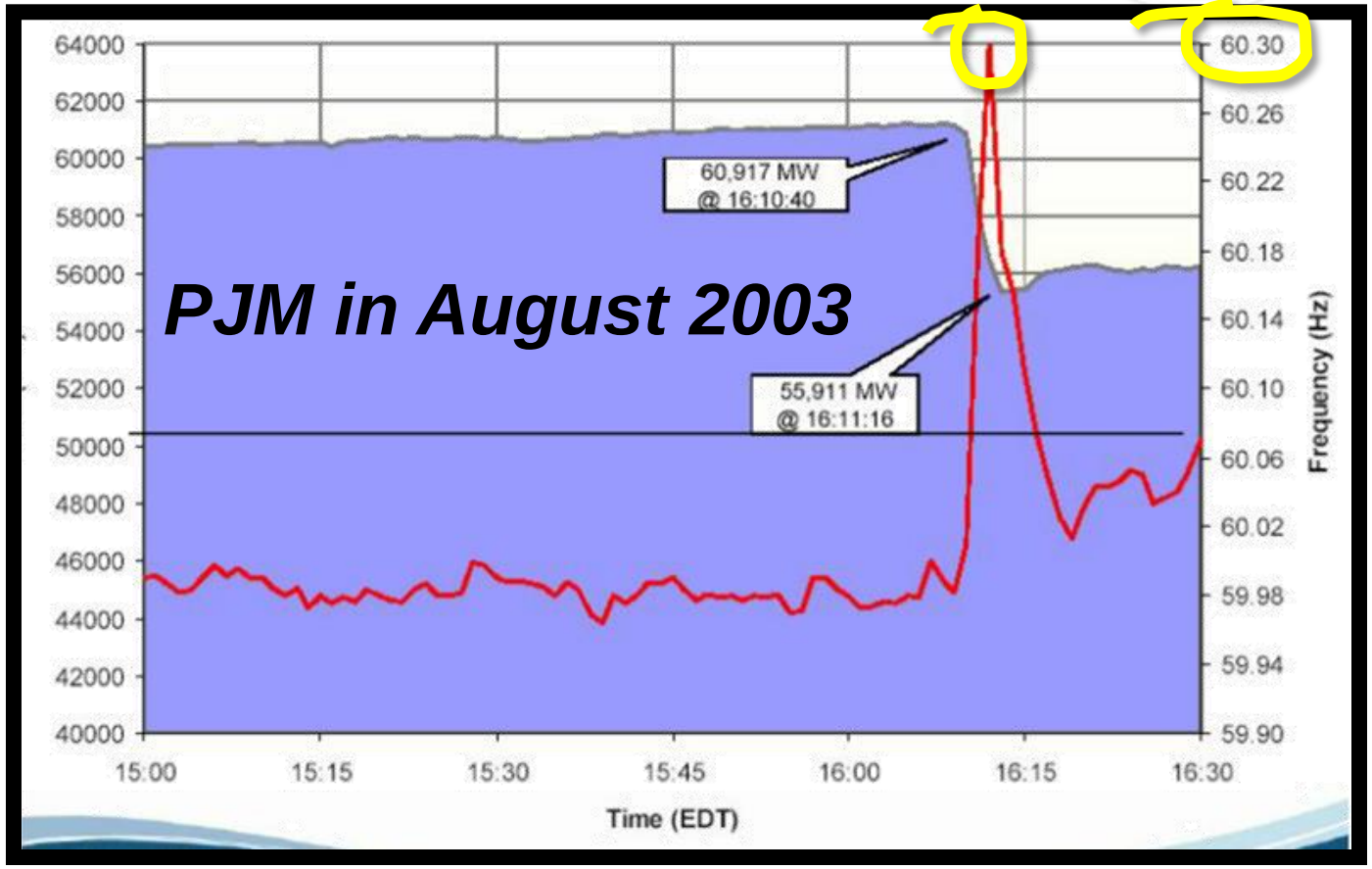
TECHNICAL APPENDIX

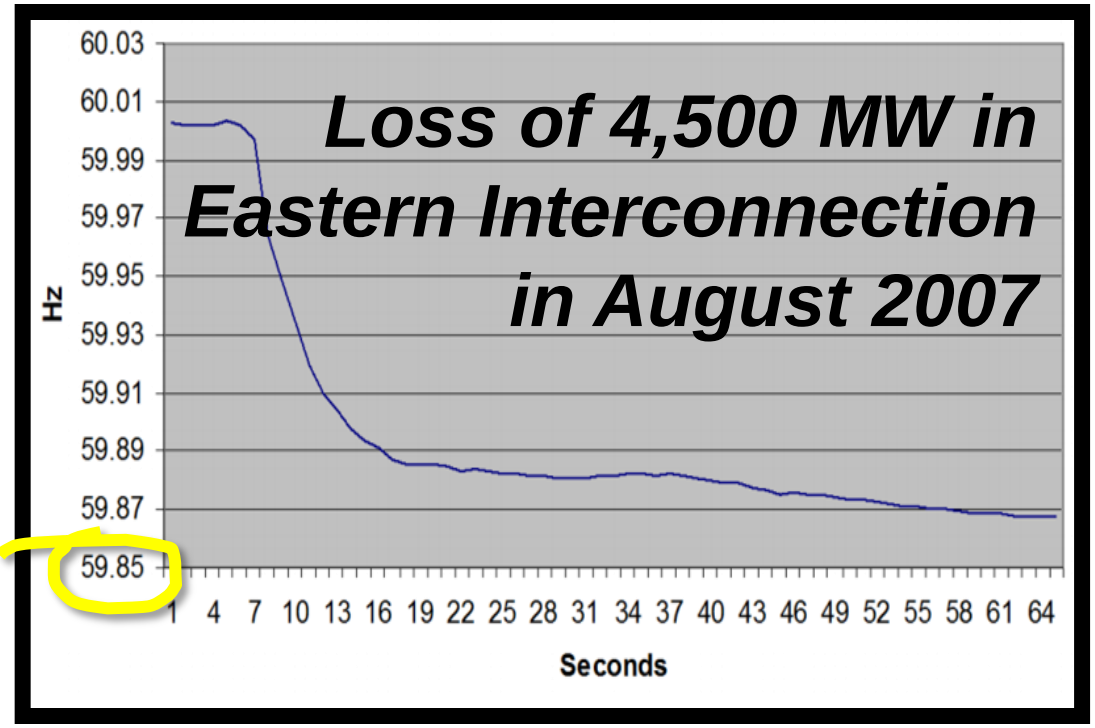
Could 60.5 or 59.8 Hz frequency trip of DER impact PJM?

Catastrophic islanding of interconnection

Black start

Really Really Big Gen Loss





Changes to “Straw Proposal” for DER Voltage Ride Through

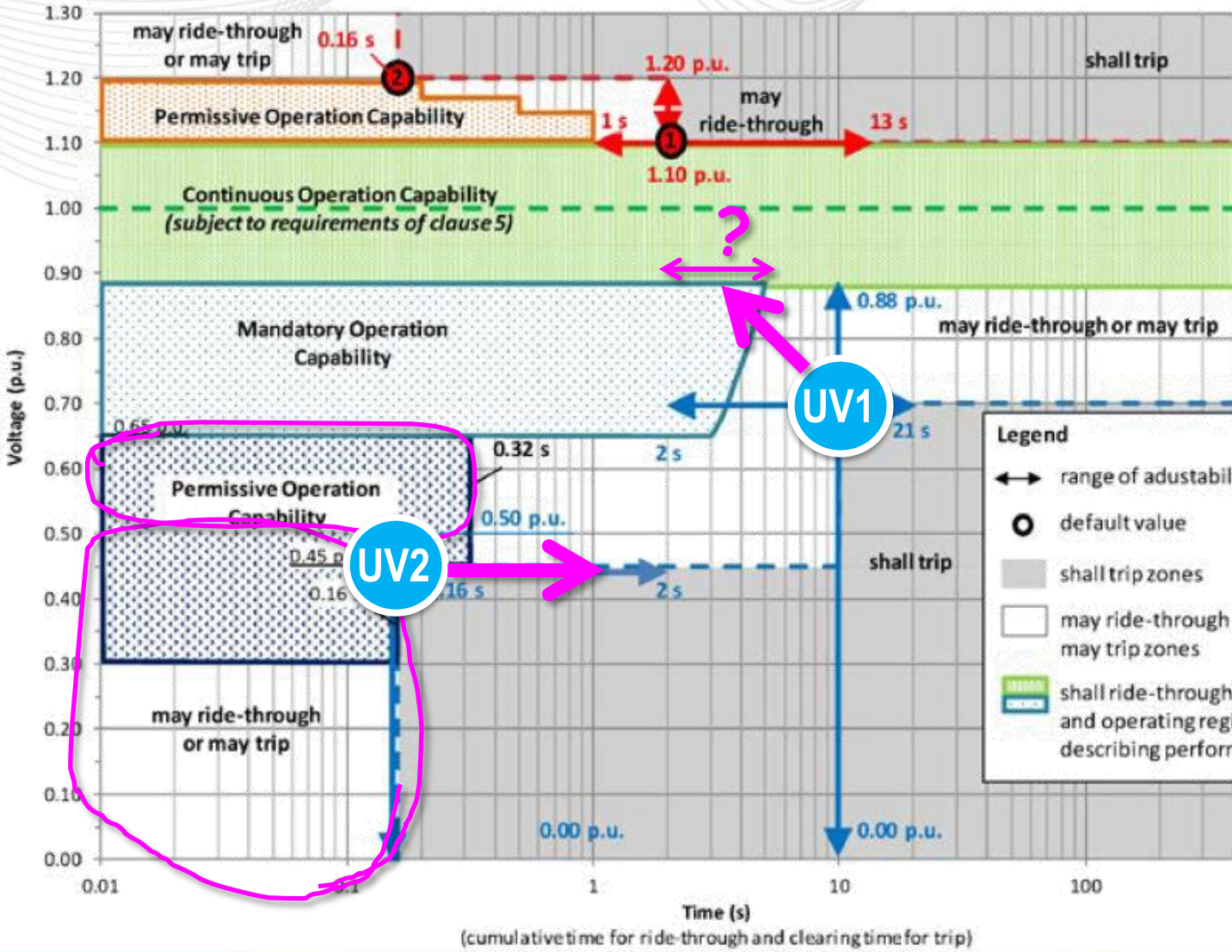
Pre-workshop: IEEE 1547-2018 “Category II” with default settings

Post-workshop modifications:

a) UV2 increased→1.1 seconds for delayed transmission fault clearing.

b) UV1 time decreased→2 – 5 seconds and volts increased→88% for arc-flash and recloser concerns.

c) “Permissive Operation” range and severe low voltage “may trip” range is specified to “Mandatory Operation” for V > 0.50 and “Momentary Cessation” for V < 0.50.



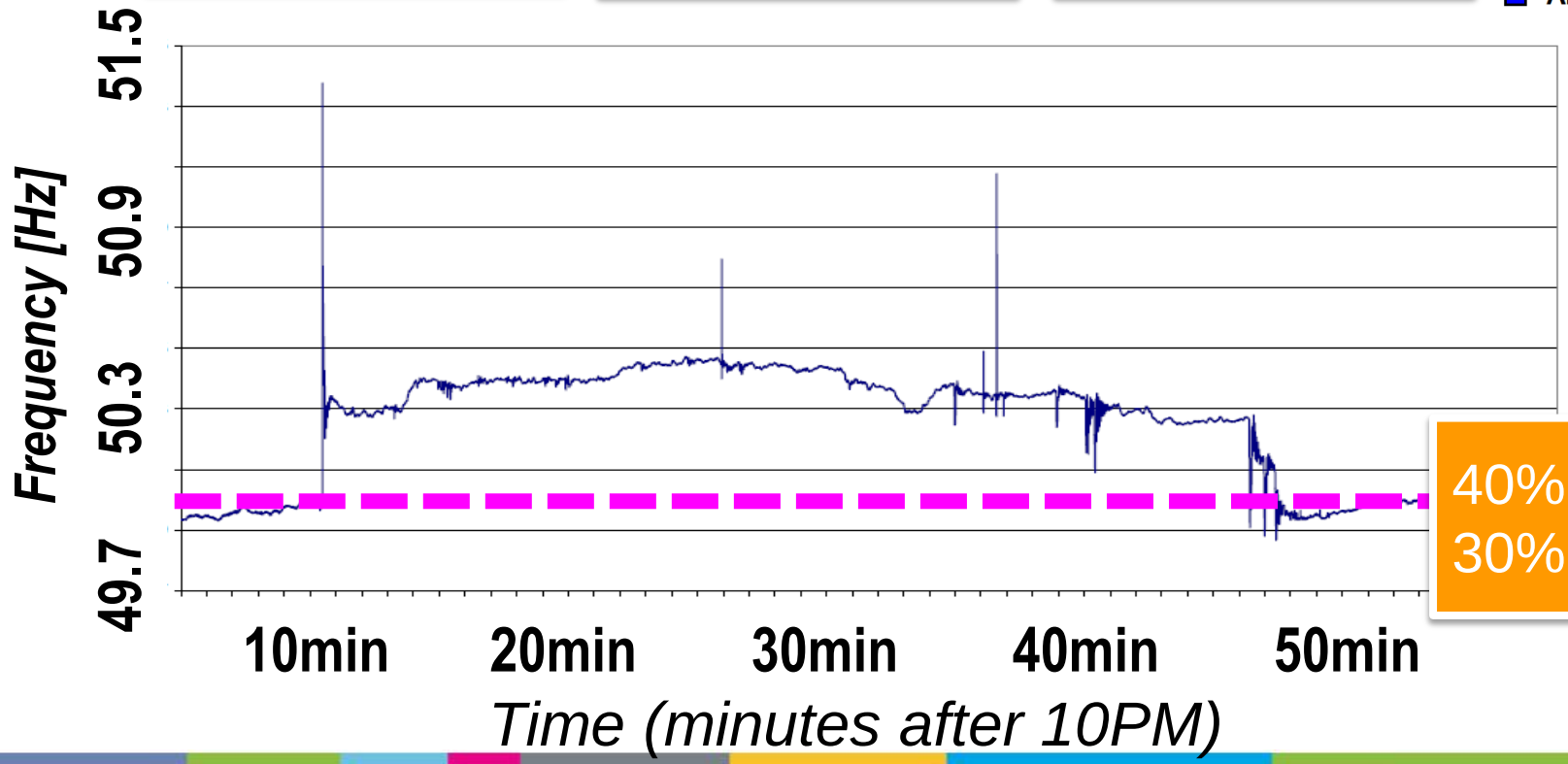
DYNAMIC BEHAVIOR OF INVERTER-BASED GENERATORS MATTERS

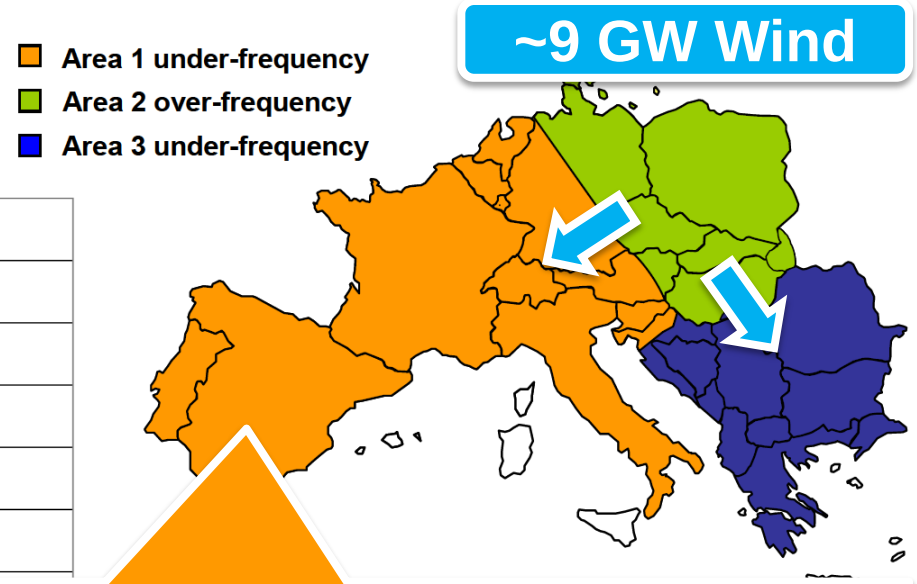
Europe 2006

Ride-Through (Frequency)

Reconnection (Uncontrolled)

50.2 Hz





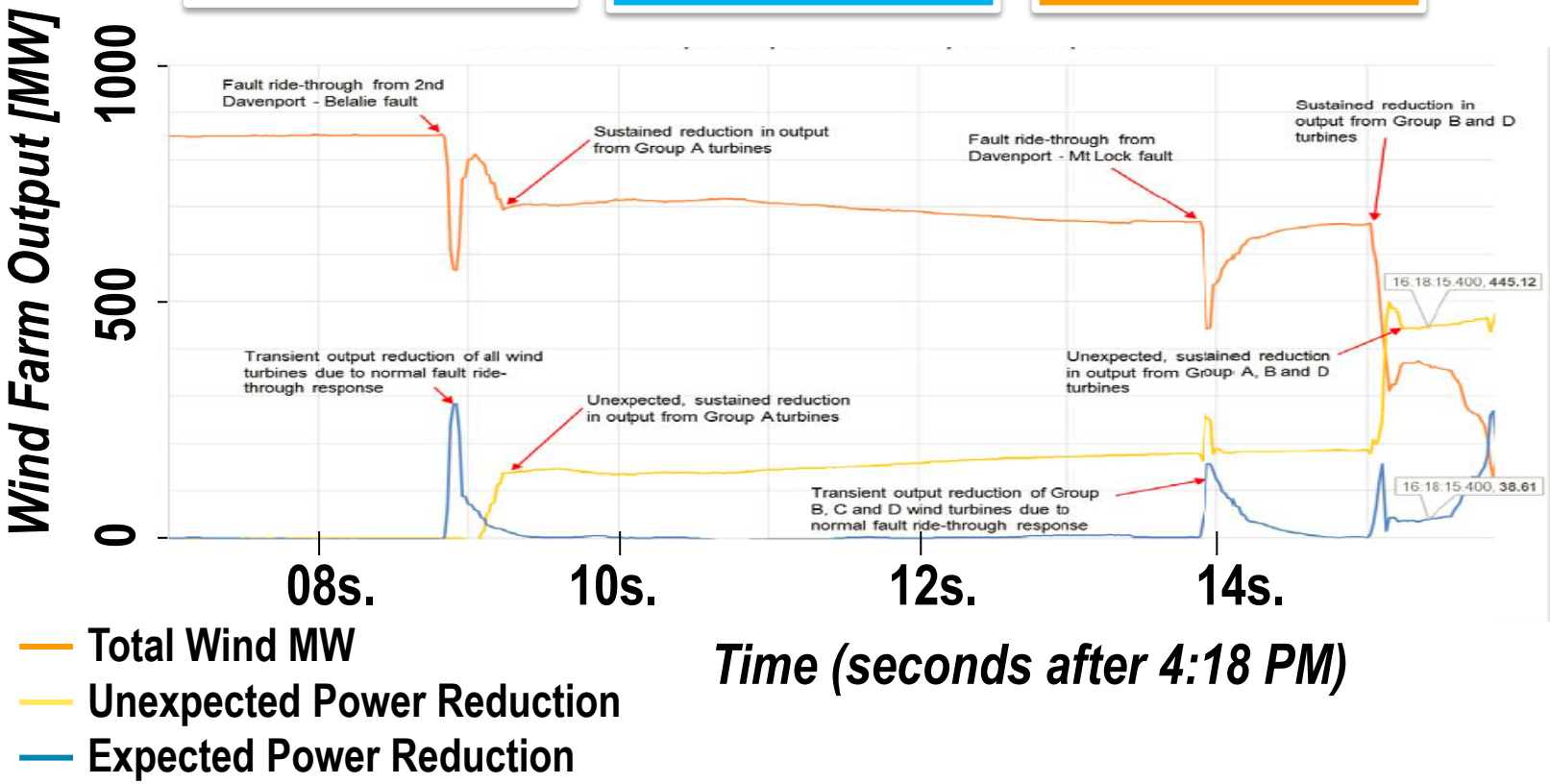
40% Generation Loss – Wind
30% DER Combined Heat & Power

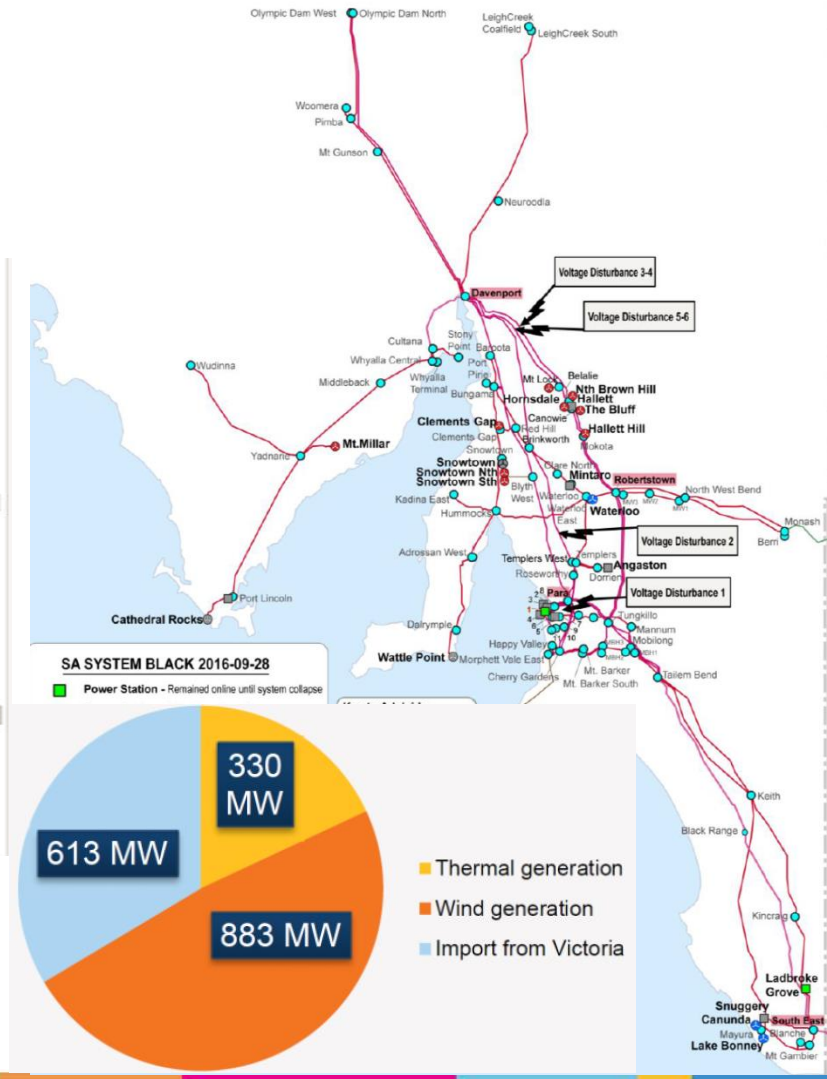
South Australia 2016

Ride-Through (# Attempts)

Power Reduction

Inertia (Island)



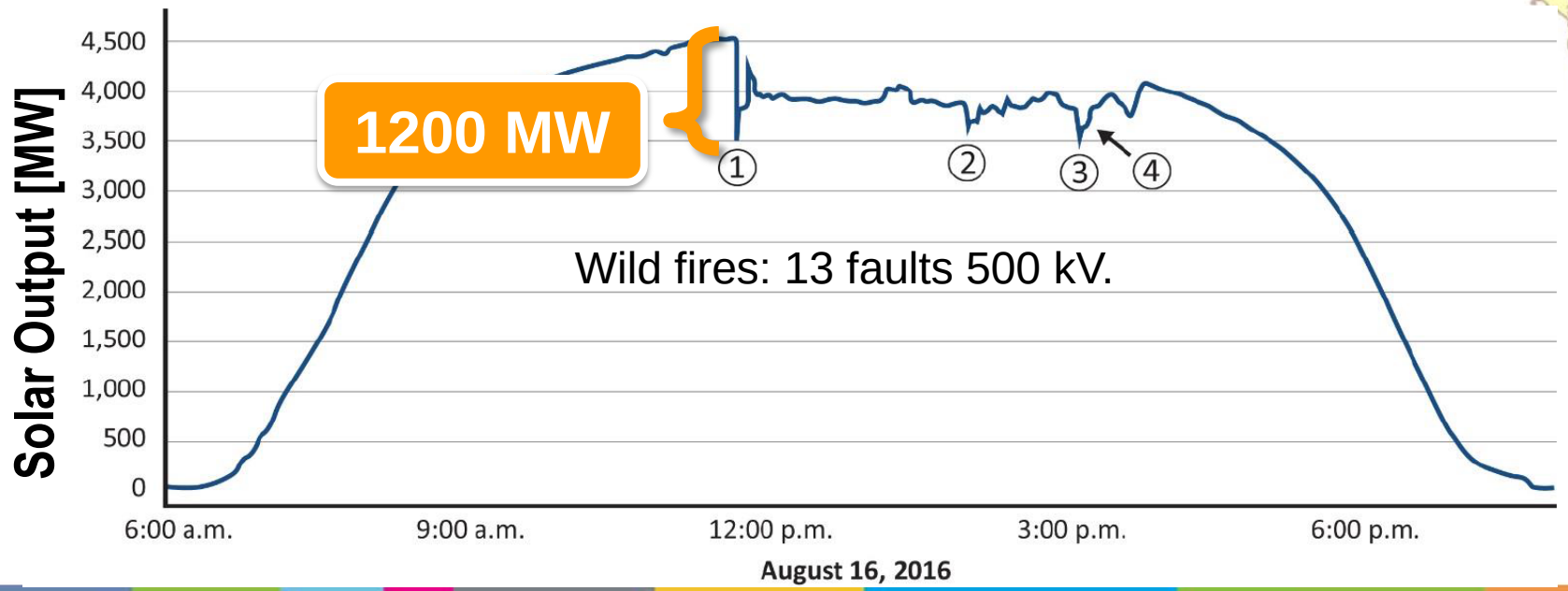


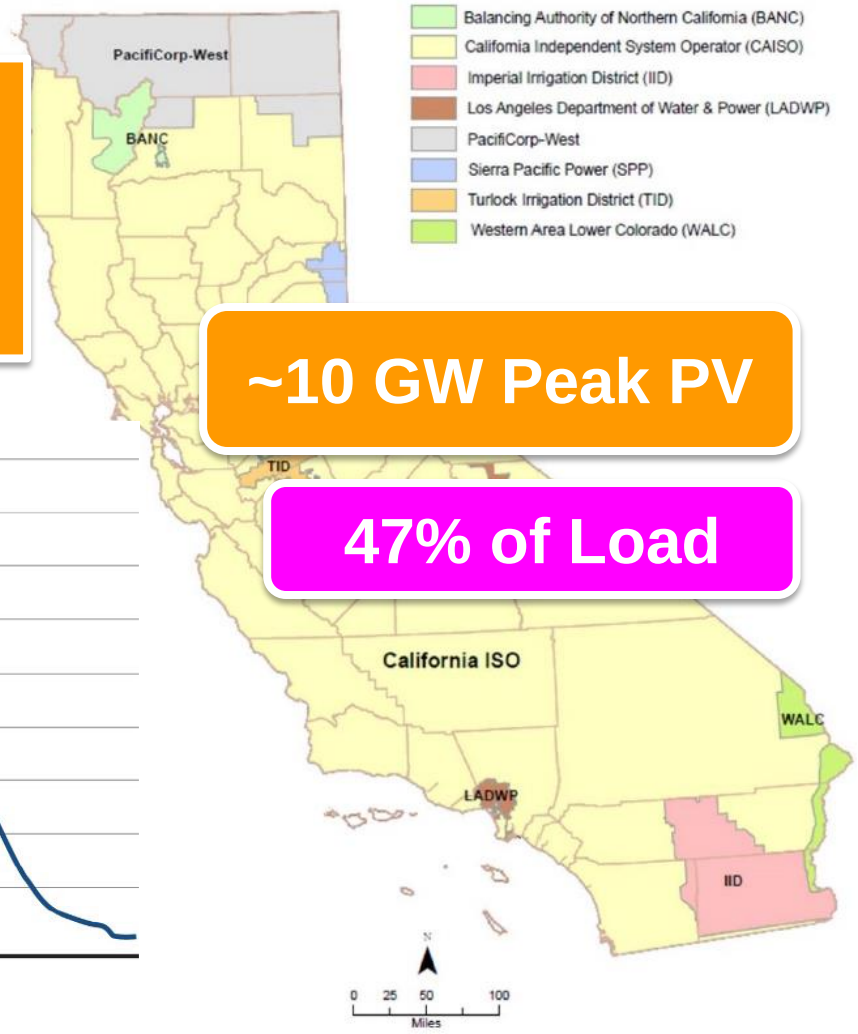
California 2016

57 Hz Trip (phase jump)

Improper Momentary Cessation (Voltage 0.9-1.1)

Ramping (2 min vs 5 sec)





~10 GW Peak PV

47% of Load