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IEEE 1547 and High Penetration PV

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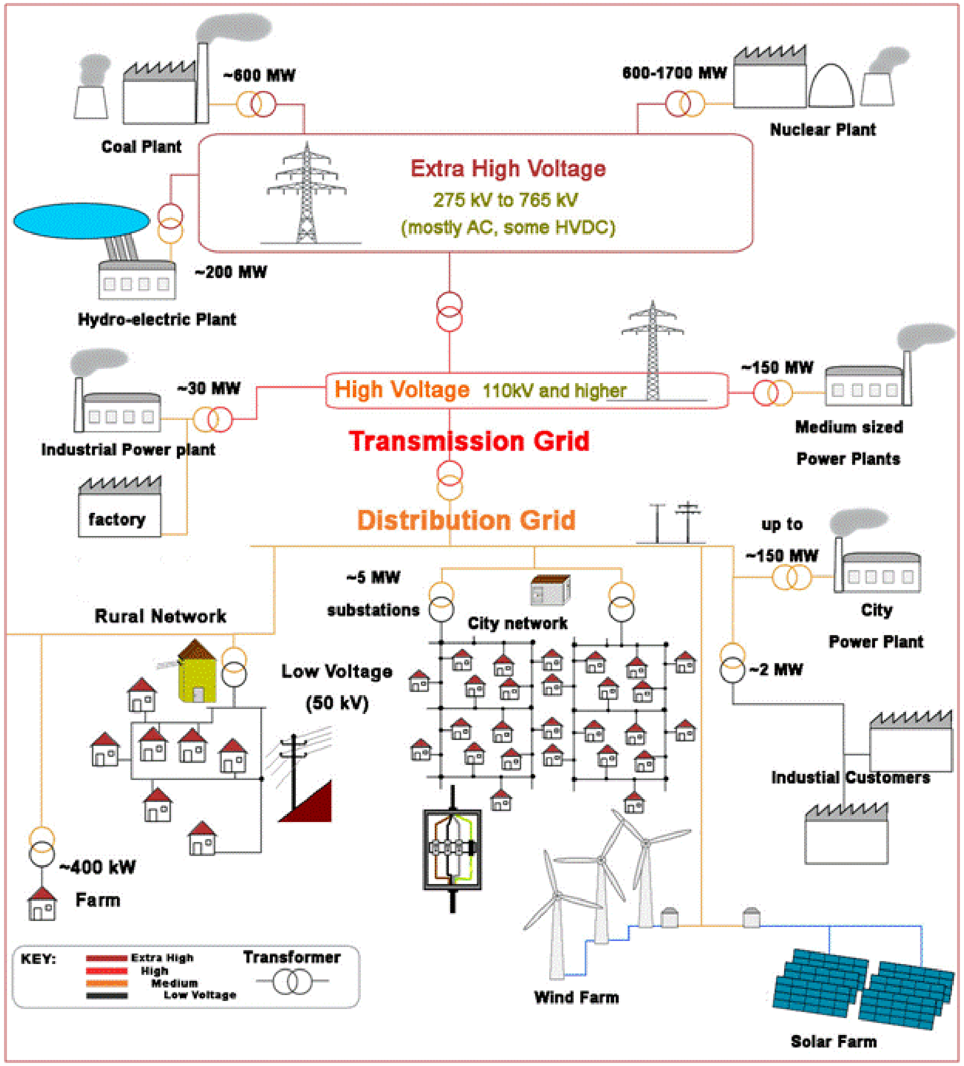
One system, different rules



Bulk System Guidelines
<u>NERC, FERC</u>
ANSI, IEC, NESC

Plenty of technical and jurisdictional overlap, confusion, contradiction…

Distribution System Guidelines
<u>IEEE 1547</u>, PUC/PRC
ANSI, IEC, NEC

IEEE 1547 – Key Provisions

- Voltage and frequency trip thresholds

Voltage Range (% Nominal)	Max. Clearing Time (sec) *
V < 50%	0.16
50% ≤ V < 88%	2.0
110% < V < 120%	1.0
V ≥ 120%	0.16

(*) Maximum clearing times for DER ≤ 30 kW; Default clearing times for DER > 30 kW

Frequency Range (Hz)	Max. Clearing Time (sec)
f > 60.5	0.16
f < 57.0 *	0.16
59.8 < f < 57.0 **	Adjustable (0.16 and 300)

(*) 59.3 Hz if DER ≤ 30 kW

(**) For DER > 30 KW

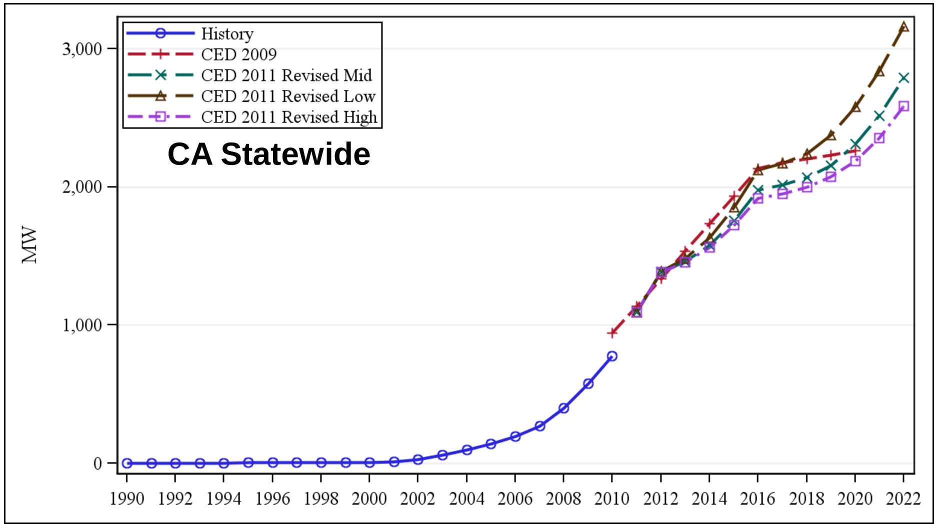
- Additional disconnection requirements
  - Cease to energize for faults on the Area EPS circuit
  - Cease to energize prior to circuit reclosure
  - Detect island condition and cease to energize within 2 seconds of the formation of an island ("anti-islanding")

Opposite Points Of View

- Distribution System – IEEE 1547 Domain
  - Bulk generation and voltage support is "infinite" – who cares!
  - Main concern is protection coordination, power quality, and safety during and after distribution system events
  - **DG must trip** outside specified voltage vs. time and frequency vs. time envelope
- Bulk Power System – NERC Domain
  - Distributed generation capacity is too small – who cares!
  - Main concern is maintaining frequency and local voltage (grid security) during and after transmission system events
  - **Generators must not trip** inside specified voltage vs. time and frequency vs. time envelope

As DG penetration increases, these opposing points of view must be reconciled.

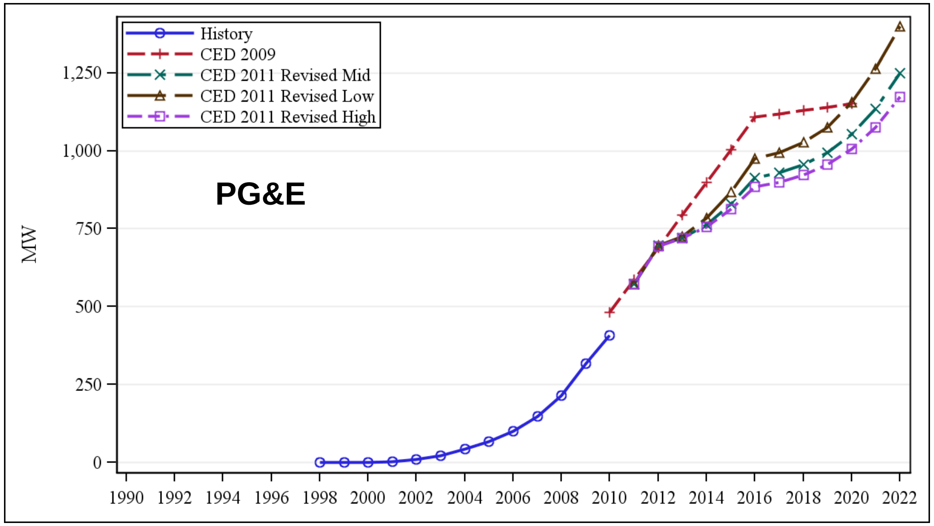
High Pen Distributed PV Scenario Developing!



Data for distributed PV in CA

Message: We are on a steep part of the growth curve

Source: Gautam, California Energy Demand 2012-2020 – Revised Staff Forecast, IEPR Committee Workshop – Feb 2012.



Why is This an Issue… Now?

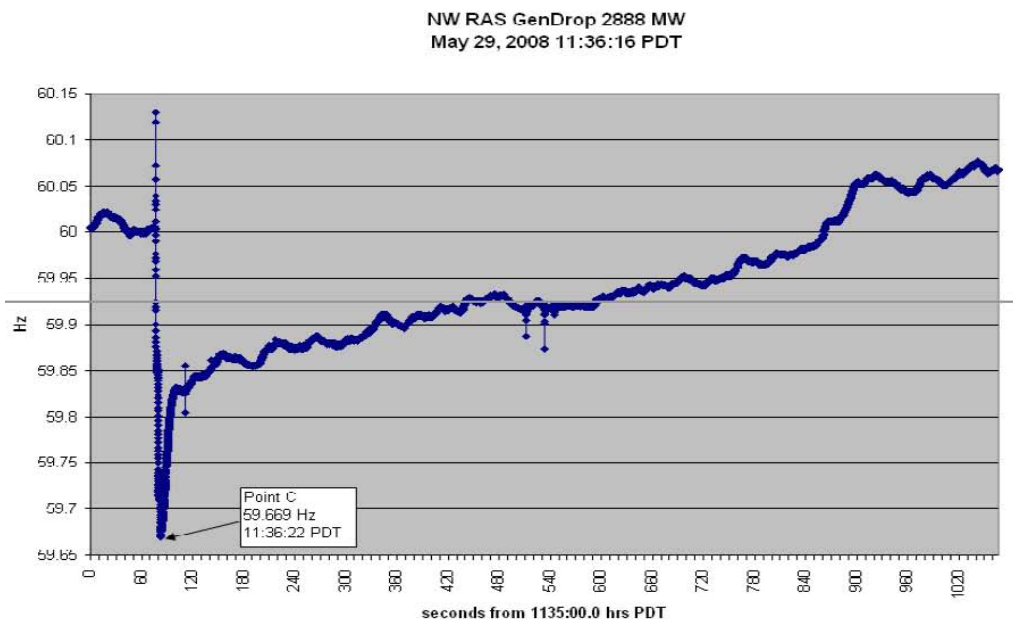
- Address growing exposure to tripping of large amounts of DG due to system disturbances

Two specific drivers:

1. Maintain bulk grid stability (e.g., disturbance tolerance per NERC requirements)
   - Voltage Stability, Frequency Stability
2. Generation supply reliability and cost
   - DG contribution to capacity and other ancillary services
   - Cost of additional spinning reserves

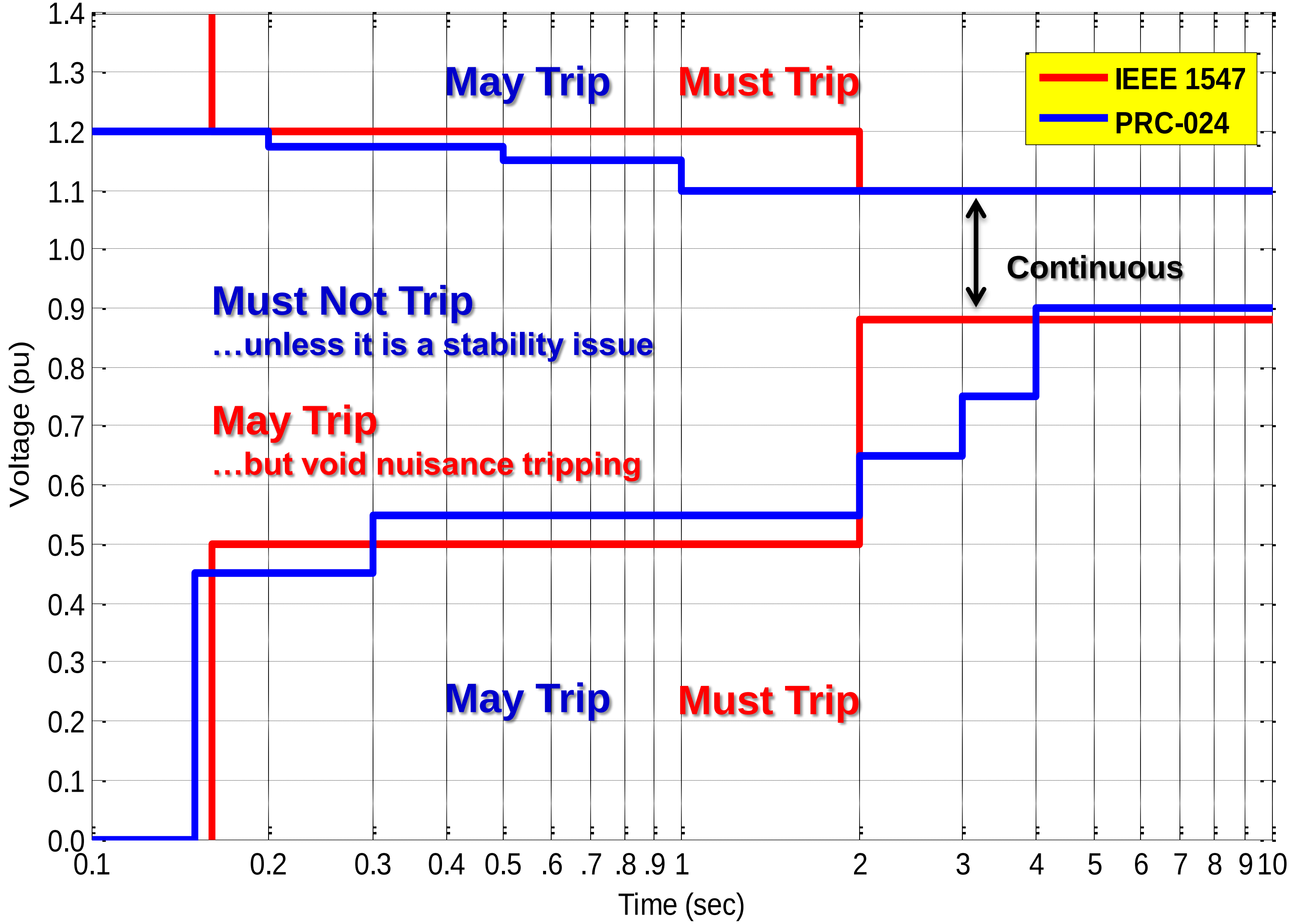
Tolerance to Frequency Events

- Excessive DG tripping during a high or low frequency could affect interconnection frequency performance
  - Could impact spinning reserves
  - High frequency tripping is currently a concern in Germany
    - Recent standard revisions: High-frequency droop, higher trip level



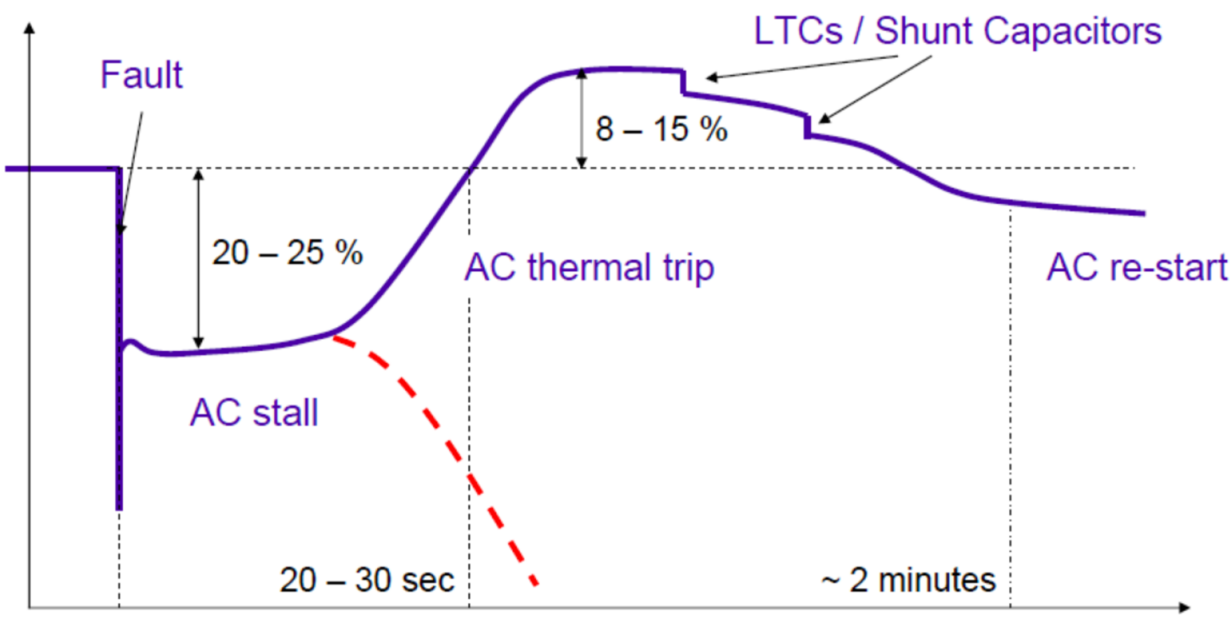
Example of generator trip event and low frequency in WECC (2008)

Voltage: IEEE 1547 Vs. NERC PRC-024



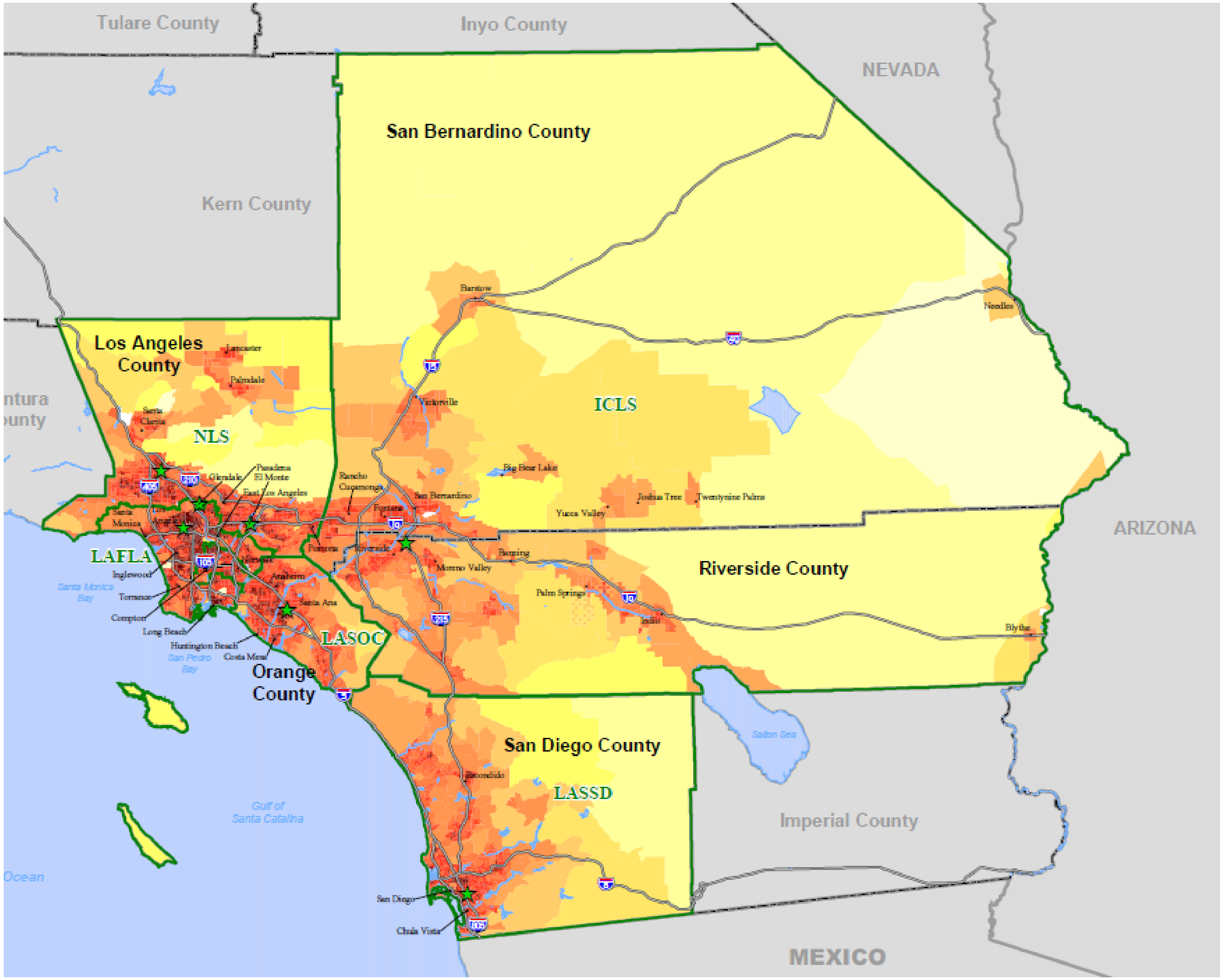
VRT and Voltage Stability

- Excessive DG tripping due to lack of fault tolerance could cause or exacerbate voltage instability
  - Net active/reactive load post-fault would be larger than pre-fault
  - Could exacerbate fault-induced delayed voltage recovery (FIDVR)



FIDVR event in Southern California Following a 230-kV Transmission Fault

How widespread can a LV event be?

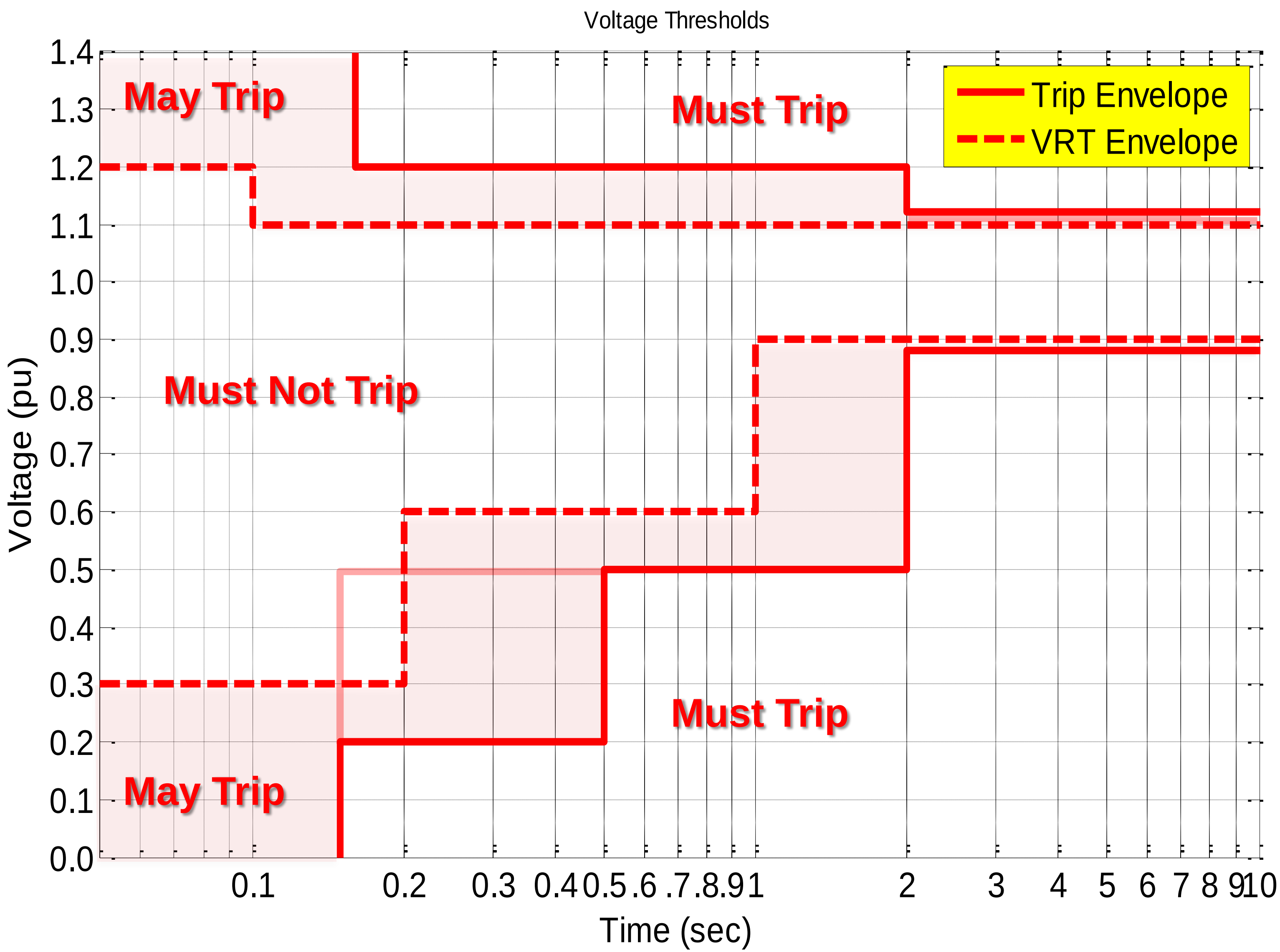


http://en.wikipedia.org/wiki/File:LACountyPopDensity.png

Some IVGTF 1.7 Ideas (unofficial)

- Some VRT capability is needed
  - No need for ZVRT considering DG density
  - VRT can co-exist with anti-islanding and volt/var capability (requirements involve different time frames)
- May need to keep a Must Trip curve as well
  - Must Trip voltage/freq. thresholds used in anti-islanding
  - Could be existing IEEE 1547, with some adjustments
    - Consider relaxing low voltage threshold (for fault tolerance)
    - Consider relaxing continuous high voltage threshold (address inverter nuisance tripping)
- Need a reasonable "buffer" between VRT and Must Trip envelopes (both time and voltage dimensions)

Some IVGTF 1.7 Ideas (unofficial)



Thank You!

More information:
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