Smart Inverter Update

Intermittent Resources Subcommittee

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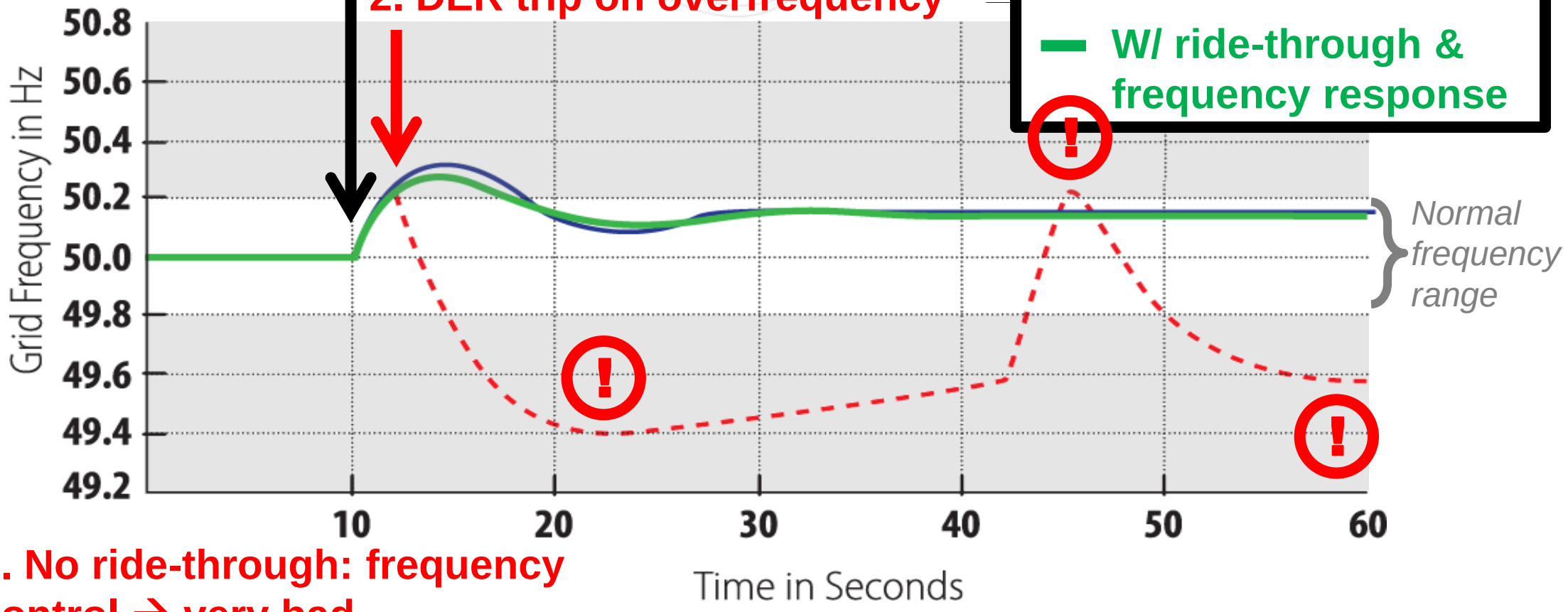
After contingencies: it is bad if generators trip offline. Germany case.

1. Bad fault→lots of load shed→frequency rise

2. DER trip on overfrequency



3. No ride-through: frequency control → very bad.

Germany Solution

Germany

- Retrofitting >300,000 solar PV units due to voltage and frequency issues
- $250 Million

US

- 80% of renewable generation impacts distribution
- Vast majority provides no grid support

WEIL Western Electric Industry Leaders

"There is an immediate need for new solar to be fitted with "smart inverters" to provide necessary voltage support to integrate effectively and prevent costly renovations and reliability impacts"
– Western Electric Industry Leaders, Aug 2013

DER “Smart Inverter” Functions & The Regional Grid

Priority DER requirements for the regional grid:

- Robust frequency ride through and voltage ride through

Other requirements:

- Frequency response

No position:

- Voltage regulation

Timeline of smart inverter rules

Current PJM "Enhanced Inverter" Requirements

- **Applicability**: "non-synchronous" generators that entered the New Service Queue on or after May 1, 2015 (AB1 queue or later) that sign an Interconnection Services Agreement
  - Distribution-connected units that sign "WMPAs" are not subject to PJM's requirements for interconnection.
- **Required functionality**:
  - **Ride through** (mandatory) of abnormal voltage and frequency according to NERC PRC-024
  - **Voltage regulation** (capability) 0.95 leading/lagging measured at high side of facility substation transformers (or measured at the generator's terminals if entered queue prior to Nov 1, 2016 as per FERC Order 827).
  - **Ramp limit** (capability)
  - **Frequency response** (capability) (underfrequency: if available)

1547-2003

- **Applicability**: most non-wholesale DER in the United States today (not CA & HI)
- **Requirements**:
  - Ride through is prohibited.
  - Instead: “shall trip”.
  - Voltage regulation is prohibited:
  - Instead: “unity power factor”.

CA Rule 21 Requirements

- **Applicability:** state-jurisdictional inverter-based generation in California (perhaps other states soon)
- **Required functionality:**
  - **Ride-through** (mandatory) of voltage and frequency
  - **Voltage regulation** (capability): fixed power factor, volt-var
    - "Volt-watt" (optional)
  - **Frequency response** (permitted) (underfrequency: if available)
  - Enter service **ramp limit** (capability)
  - Reconnect by "**soft start**" (mandatory)

- 1547a allows ride through and voltage regulation w/o specific settings.
- CA Rule 21 has detailed settings, but no test procedure for "type testing".
- UL 1741 "SA" has test procedures, links to a "Source Requirements Document".
- Hardware commercially available recently.
- New Rule 21 required starting Sep 8, 2017.

Requirements of 1547 revision

- **Applicability:** future: possibly certain state-jurisdictional and FERC-jurisdictional DER.
- **Requirements**
  - **Ride-through** (mandatory) of voltage & frequency
  - **Voltage regulation** (capability): fixed power factor, volt-var, watt-var, fixed reactive power, volt-watt
  - **Frequency response** (capability) (underfrequency: if available)
  - **Communications interface** (capability): SEP2, DNP3, or SunSpec Modbus
  - Enter service **ramp limit** (mandatory)

- 1547 revision: expected out in 2018.
- Test procedures (revised “1547.1”) published ~2019+. UL1741 after.
- Regulators or utilities together with NERC Reliability Coordinators (e.g., PJM) to specify 1547 categories and adjustments. Some time required.
- Where PJM cites to 1547 today (e.g., manual 14a), PJM may revise language in response to 1547 revision.

PJM Smart Inverter Technical Demonstrations

- Goal: refine recommended settings for PJM “enhanced inverter” requirements and for coordinating possible state-level ride-through requirements.
- Partnerships with several utilities in two states and one state commission.
- One or more smart inverter installations for testing of actual behavior to refine input for large-scale models. Test plan with most of the functions described in the 1547 revision.
- Large scale modeling in PSS/E of regional reliability impact/benefit of significant deployment of DER with vs. without ride through and voltage regulation.
- Documented results expected early next year.