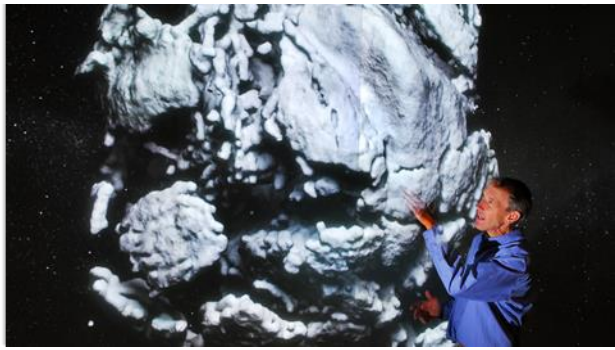
*Exceptional service in the national interest*

Sandia National Laboratories

energy.sandia.gov





# High Penetration PV – A Transmission Perspective on DG Standards


**Abraham Ellis, PhD, PE**

**Photovoltaics and Distributed Systems Integration Department**

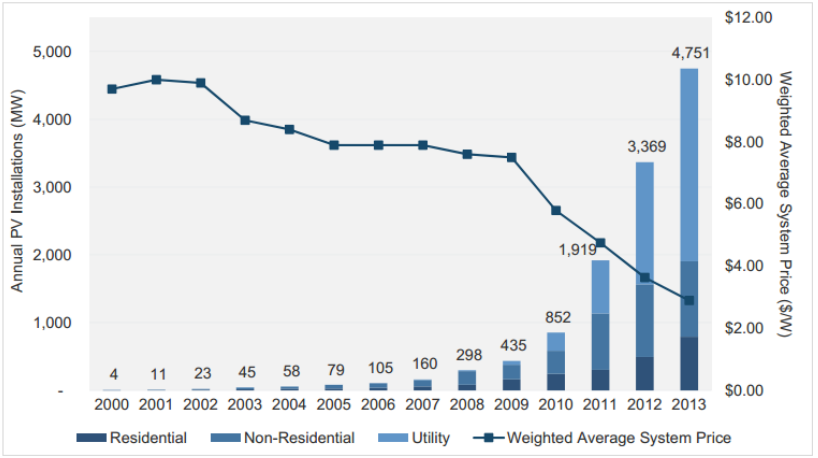

U.S. DEPARTMENT OF ENERGY

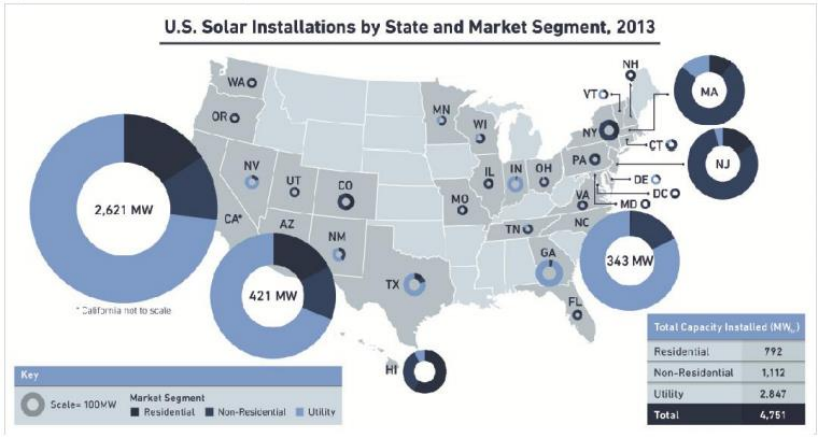
NNSA National Nuclear Security Administration


Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND 2010-5138P.

# PV capacity is growing fast!

- Total installed capacity is 12.1 GW total; 4.7 GW installed in 2013
  - Installed capacity projected to triple in the next 2-3 years
- High-Pen Scenarios developing in several areas
  - California
    - ~2 GW of distribution-connected PV
    - Aiming for 12 GW of DG (PV) by 2020
  - Hawaii
    - Half of distribution circuits are at 100% of daytime minimum load
    - Highest penetration at the balancing area level (island grids)

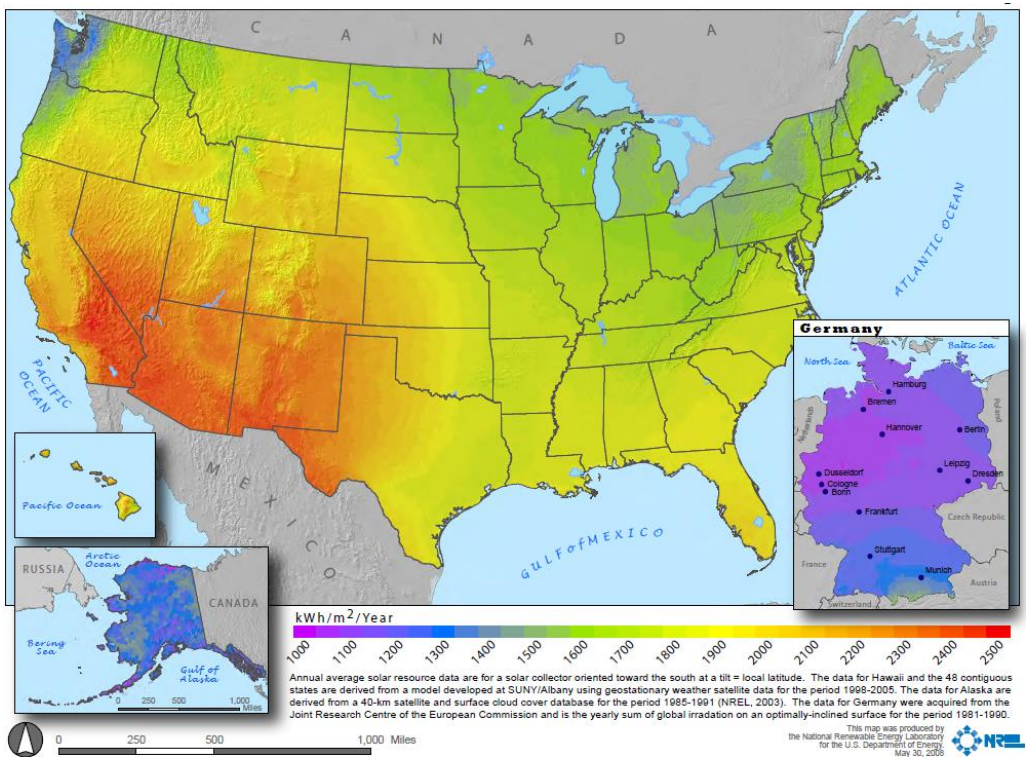


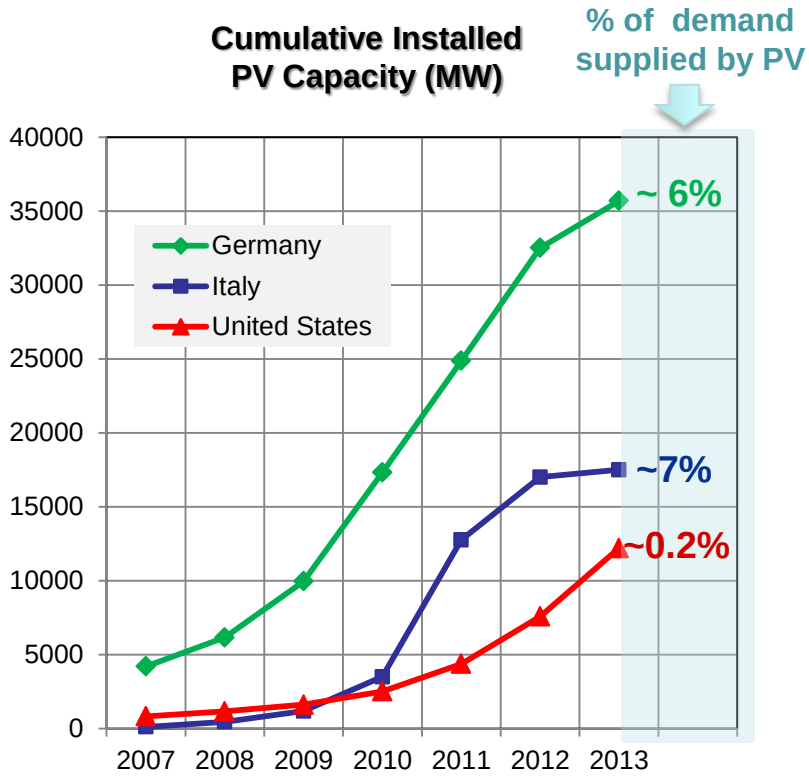




**Source: GTM Research, US Solar Market Insight 2013 Year in Review**

# Huge potential for further growth!

- A slow start, but rate of deployment is accelerating rapidly, and the ultimate deployment potential is very high.



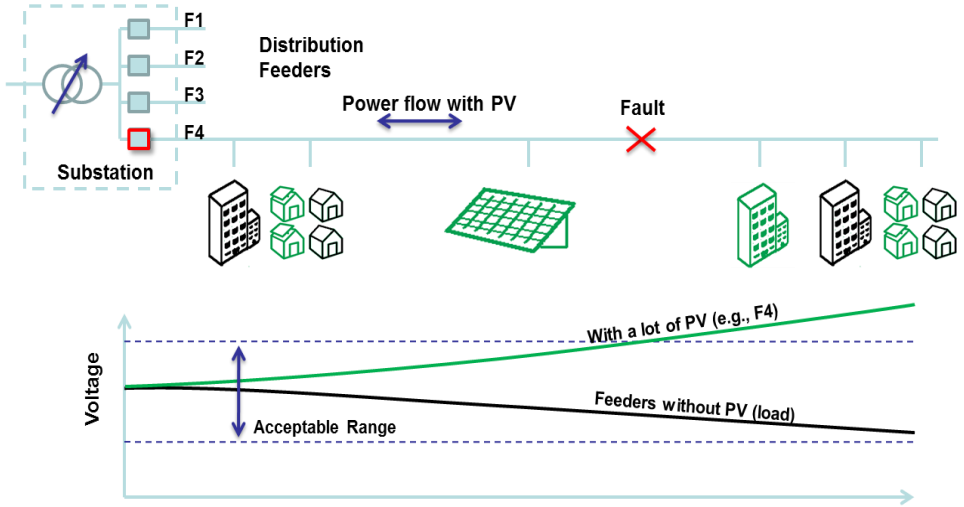
# Interconnection Level

- Distribution-connected
  - Residential, Commercial
- Transmission-connected
  - Numerous 100+ MW PV plants are operating, under construction, or planned

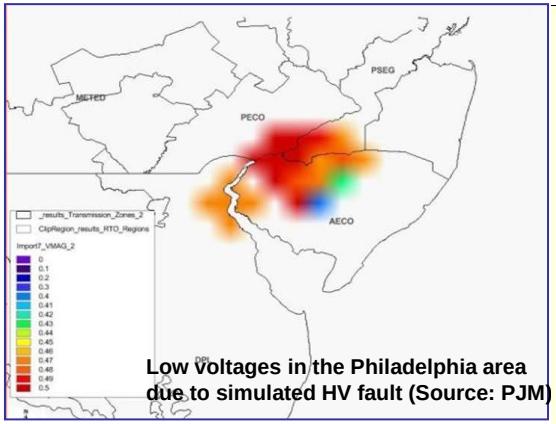
# High Pen PV… What is the Problem?

## Near-term technical issues

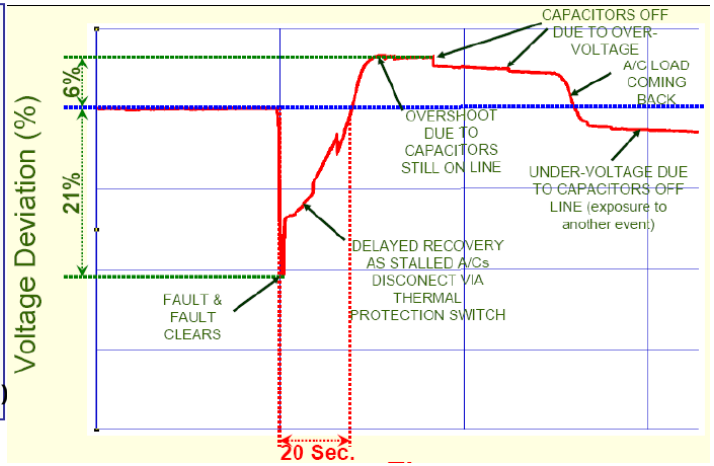
- Distribution-level voltage control and protection

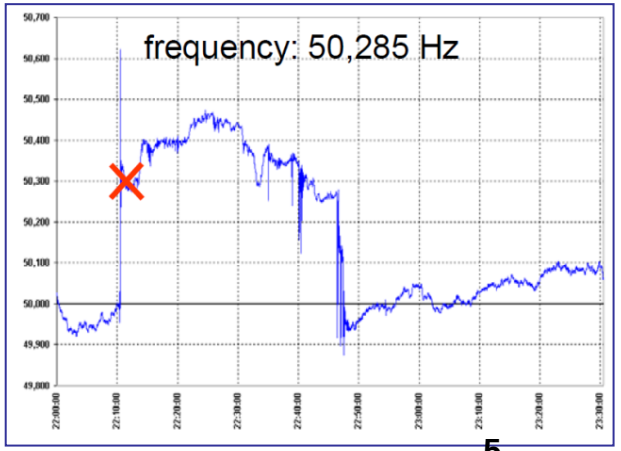



- Bulk system stability
  - Possible loss of DG during disturbances




Low voltages in the Philadelphia area due to simulated HV fault (Source: PJM)



# Minimum V/FRT for DER

Sandia National Laboratories

- Why do we need it?
  - Prevent grid security impacts of high pen. DER
  - Provide more clarity and uniformity to equipment design
  - Avoid potentially overly-onerous requirements
  - Clarify certification requirements
  - Other: Prevent “limits”, retrofits and high integration cost to future DG; enhance DER value to system reliability
- Why incorporate minimum requirements in IEEE Std. 1547?
  - IEEE Std. 1547 is the most widely adopted interconnection standard in North America – codified in State Interconnection Rules, FERC SGIP
  - Compatibility with other interconnection requirements can be intrinsically addressed

# Where are we?

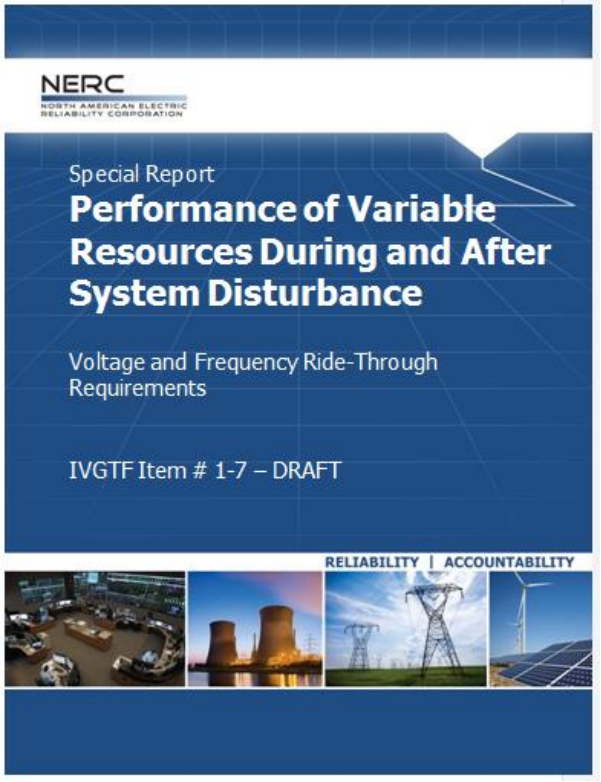
- IEEE Std. 1547a does not go far enough

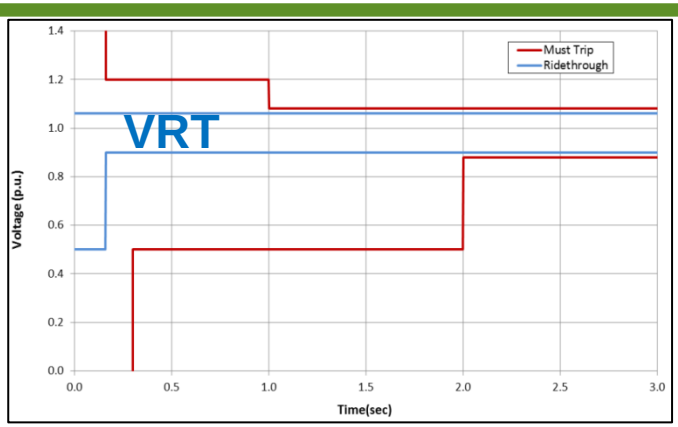
| IEEE 1547-2008 | IEEE 1547a (2013) |
|---|---|
| Shall not regulate voltage [no volt/var allowed] | May participate in voltage regulation [no specification] |
| Shall not regulate frequency [no freq/watt allowed] | May participate in frequency regulation [no specification] |
| Restrictive voltage and frequency must-trip range [opposite of V/FRT] | More widely adjustable voltage and frequency must-trip range [No V/FRT requirement] |

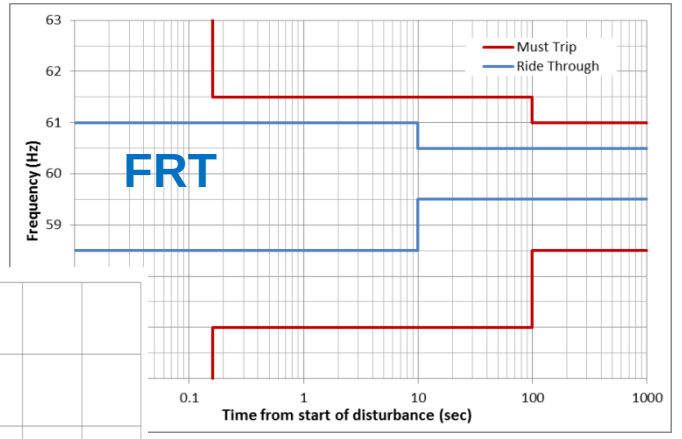
- Does not fully address the problem, and will likely lead to lack of harmonization and over-specification
- Sets stage for future standards harmonization problems
  - CPUC Rule 21, PJM, others starting to develop own standards addressing advanced functions

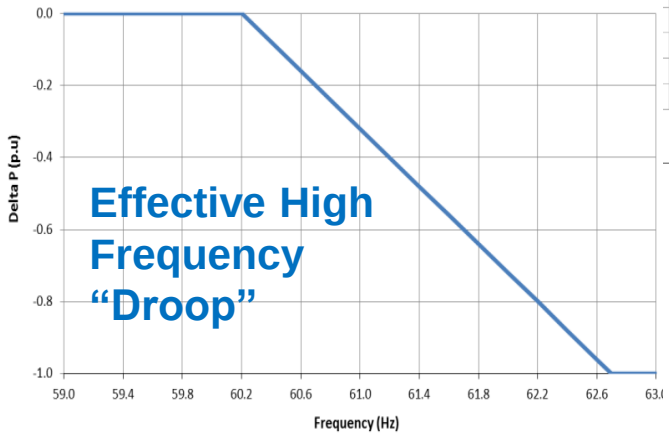
# NERC IVGTF1-7 Recommendations

- Add explicit <u>minimum</u> VRT/FRT requirements
- Add high frequency droop requirement



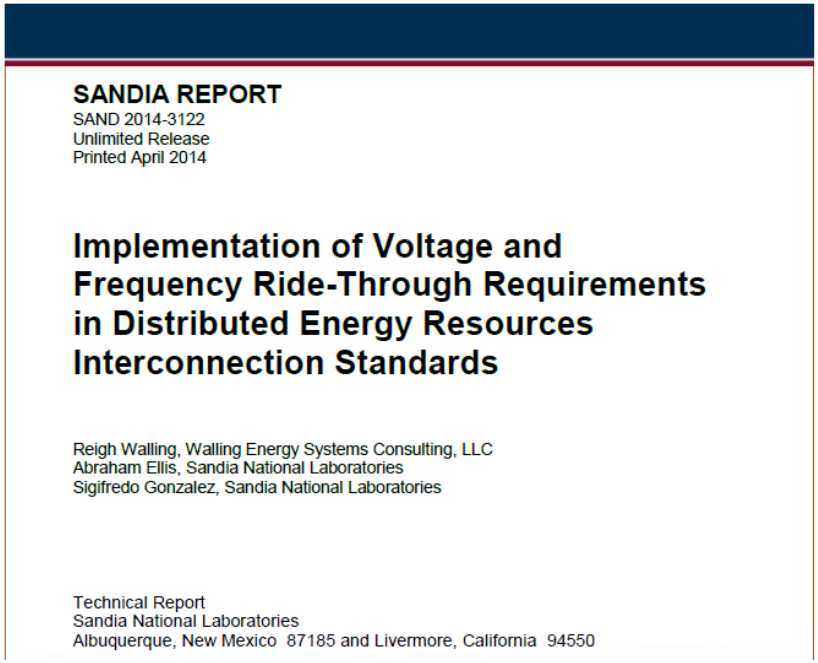



# V/FRT Implementation Challenges

**There are challenges…**

- Equipment Limitations
- Fault Detection
- Islanding Detection
- Reclosing Coordination
- {Technology neutrality?}



SANDIA REPORT
SAND 2014-3122
Unlimited Release
Printed April 2014

**Implementation of Voltage and Frequency Ride-Through Requirements in Distributed Energy Resources Interconnection Standards**

Reigh Walling, Walling Energy Systems Consulting, LLC
Abraham Ellis, Sandia National Laboratories
Sigifredo Gonzalez, Sandia National Laboratories

Technical Report
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

**…they can be overcome**

- Potential grid compatibility "conflicts" can be minimized by ensuring that minimum V/FRT are reasonable
- Technology innovation and creativity
- Recent Sandia Report offers ideas for consideration

# Discussion

Contact:

aellis@sandia.gov