The Changing Resource Mix:

Reliably Integrating Distributed Energy Resources

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ESIG Plenary Session: Thinking About the Value of DER

20 March 2020

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About NERC: Mission

To ensure the reliability of the North American bulk power system

- Develop and enforce reliability standards
- Assess current and future reliability
- Analyze system events and recommend improved practices
- Encourage active participation by all stakeholders
- Accountable as ERO to regulators in the United States (FERC) and Canada (NEB and provincial governments)

- Adequacy — Supply electrical demand and energy requirements at all times
- Operating Reliability — Ability to withstand sudden disturbances – short circuits or unanticipated loss of system elements

Distributed Energy Resources Defined

***Distributed Energy Resource (DER)* is any resource on the distribution system that produces electricity and is not otherwise included in the formal NERC definition of the Bulk Electric System (BES).**

Is it distributed or limited to distribution-connected???

Types of DER :

- Distributed Generation – Sub-transmission and non-BES transmission
- Behind the Meter Generation
- Energy Storage Facility
- DER Aggregation
- Micro-Grids
- Cogeneration
- Emergency, Stand-By or Back-Up Generation

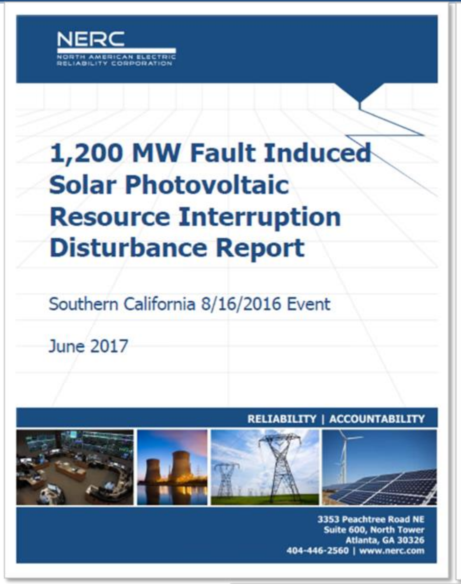
Some Problem Complexities:

- Various technologies, unit sizes, ages, customer types
- Physical or Virtual Aggregation
- Variability of Output
- System Protection coordination (bi-directional and low fault current)
- Distribution feeder flow balancing

Why is NERC Interested in DER?

- Penetration of renewables (mostly DER) growing at incredible rates
- Concern no longer limited to distribution-connected DER
  - Significant solar and wind development on voltages above distribution – sub-transmission (<100 kV) and LV transmission systems (non-BES)
  - Aggregation – DER Management Systems (DERMS) with several types of resources and controllable load components – virtual power plants
- Often not directly visible to or under control of system operators
- Includes several technologies
  - Solar, wind, energy storage, managed loads, and several combinations
  - Micro-grid impacts
  - Mostly connected through inverters (know collectively as IBRs)
- **Lack of data for planning and operating the grid**

Full Analyses of Four IBR-Related Events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1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

Southern California 8/16/2016 Event

June 2017

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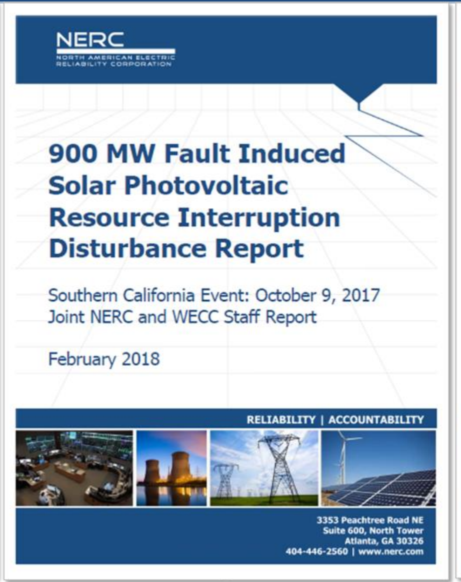
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900 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

Southern California Event: October 9, 2017
Joint NERC and WECC Staff Report

February 2018

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April and May 2018 Fault Induced Solar Photovoltaic Resource Interruption Disturbances Report

Southern California Events: April 20, 2018 and May 11, 2018
Joint NERC and WECC Staff Report

January 2019

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Industry Recommendation

Loss of Solar Resources during Transmission Disturbances due to Inverter Settings

Initial Distribution: June 20, 2017

NERC identified a potential characteristic exhibited by some inverter-based resources, particularly utility-scale solar photovoltaic (PV) generation, which reduces power output during fault conditions on the transmission system. An example of this behavior has been observed during recent BPS disturbances, highlighting potential risks to BPS reliability. With the recent and expected increases of utility-scale solar resources, the causes of this reduction in power output from utility-scale power inverters needs to be widely communicated and addressed by the industry. The industry should identify reliability preserving actions in the areas of power system planning and operations to reduce the system reliability impact in the event of widespread loss of solar-resources during faults on the power system.

For more information, see the 1,200 MW Fault Induced Solar Photovoltaic Resource Interruption Disturbance Report

About NERC Alerts >>

Status:	Acknowledgement Required by Midnight Eastern on June 27, 2017 Reporting Required by Midnight Eastern on August 31, 2017

PUBLIC: No Restrictions
More on handling >>

Instructions:	This recommendation provides specific actions NERC registered entities should consider taking to respond to a particular issue. Pursuant to Rule 810 of NERC's Rules of Procedure, NERC registered entities shall 1) acknowledge receipt of this advisory within the NERC Alert System, and 2) report to NERC on the status of their activities in relation to this recommendation as provided below. For U.S. entities, NERC will compile the responses and report the results to the Federal Energy Regulatory Commission.

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Industry Recommendation

Loss of Solar Resources during Transmission Disturbances due to Inverter Settings - II

Initial Distribution: May 1, 2018

NERC has identified adverse characteristics of inverter-based resource performance during grid faults that could present potential risks to reliability of the BPS. As the penetration of inverter-based resources (particularly solar PV resources) continues to increase in North America, these adverse characteristics need to be widely communicated. This Level 2 Industry Recommendation alerts industry to these adverse characteristics observed with BPS-connected solar PV resources, and provides recommended actions to address fault ride-through and timely restoration of current injection by all inverter-based resources connected to the BPS.
(See Background section for more information.)

Although this NERC Alert pertains specifically to BES solar PV resources, the same characteristics may exist for non-BES[1] solar PV resources connected to the BPS regardless of installed generating capacity or interconnection voltage. Owners and operators of those facilities are encouraged to consult their inverter manufacturers, review inverter settings, and implement the recommendations described herein. While this NERC alert focuses on solar PV, we encourage similar activities for other inverter-based resources such as, but not limited to, battery energy storage and wind resources.

For more information, see the October 9, 2017 Canyon 2 Fire Disturbance Report.

About NERC Alerts >>

Status:	Acknowledgement Required[2] by Midnight Eastern on May 8, 2018 Reporting Required by Midnight Eastern on July 31, 2018

PUBLIC: No Restrictions
More on handling >>

[1] These resources do not meet the Bulk Electric System definition, and are generally less than 75 MVA yet connected to transmission-level voltage.
[2] To the extent that Canadian jurisdictions have implemented laws or requirements that vary from Section 810 of the ROP, NERC requests entities in such jurisdictions voluntarily participate in response to this Alert.

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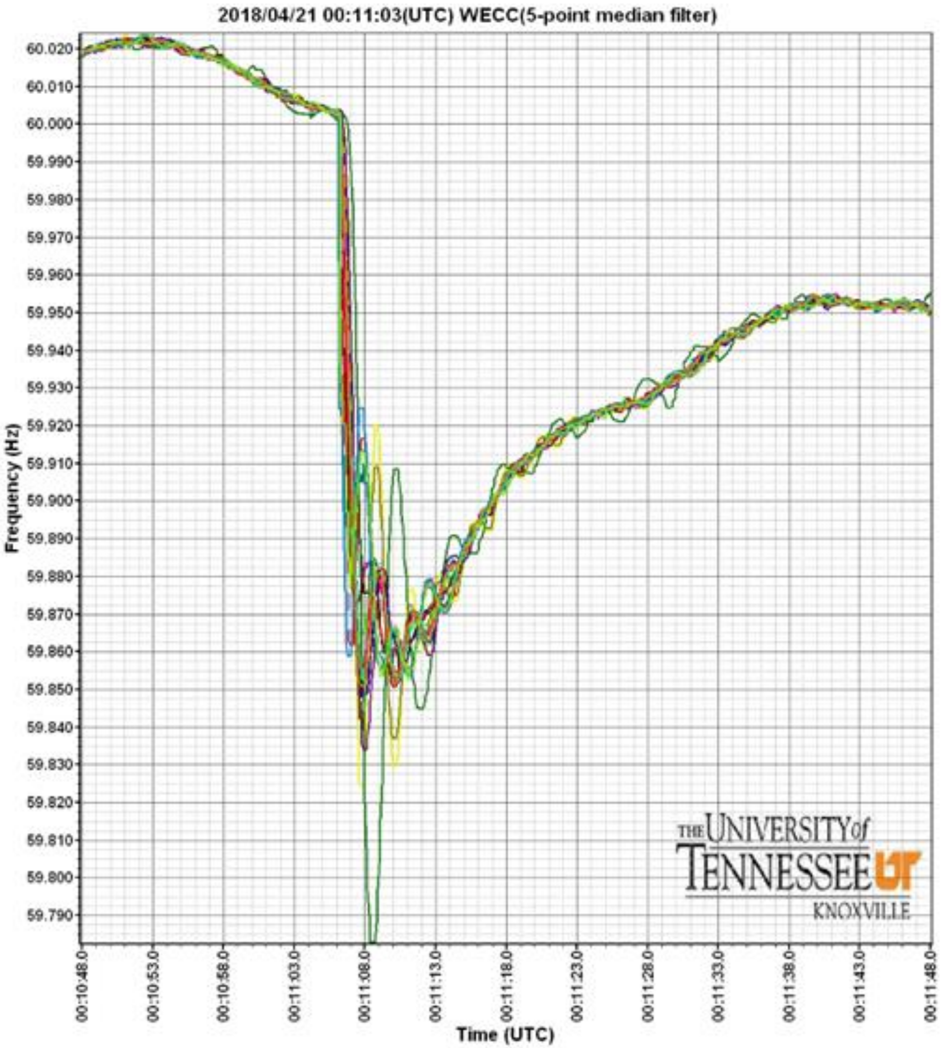
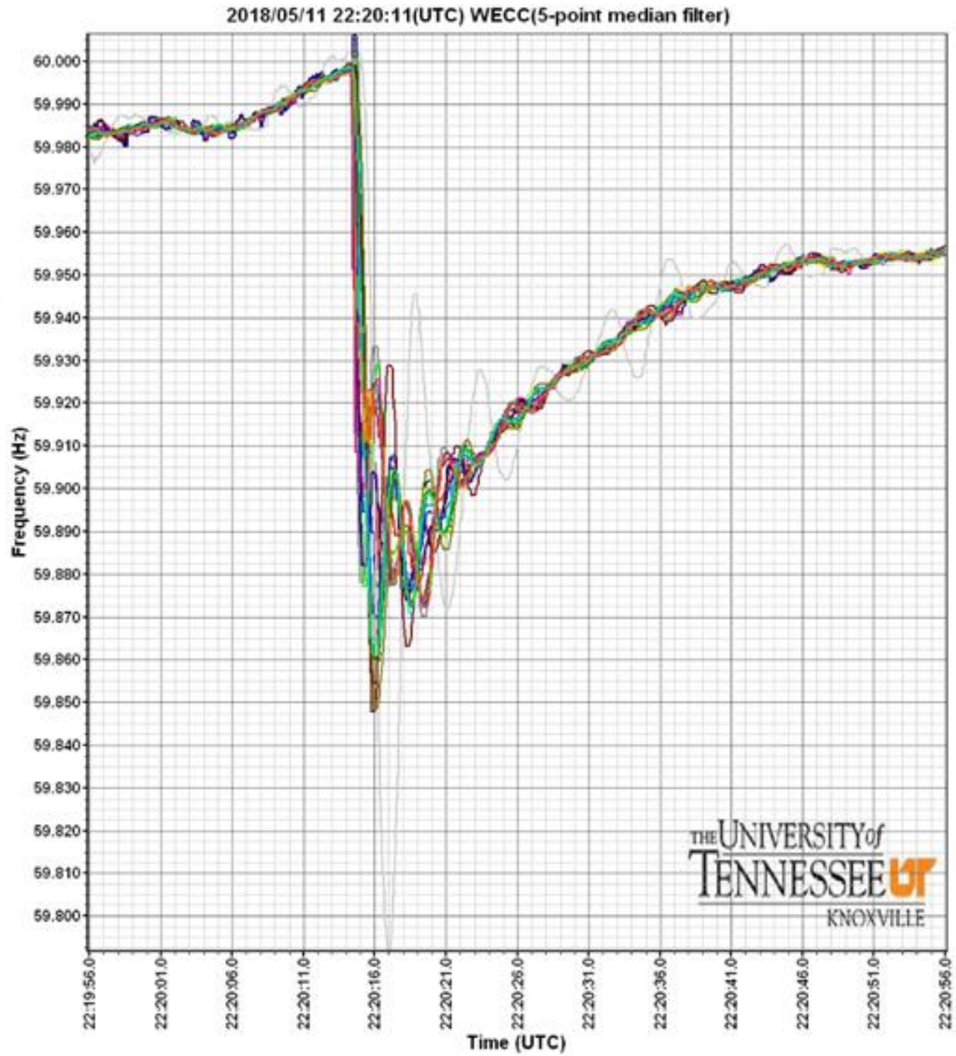
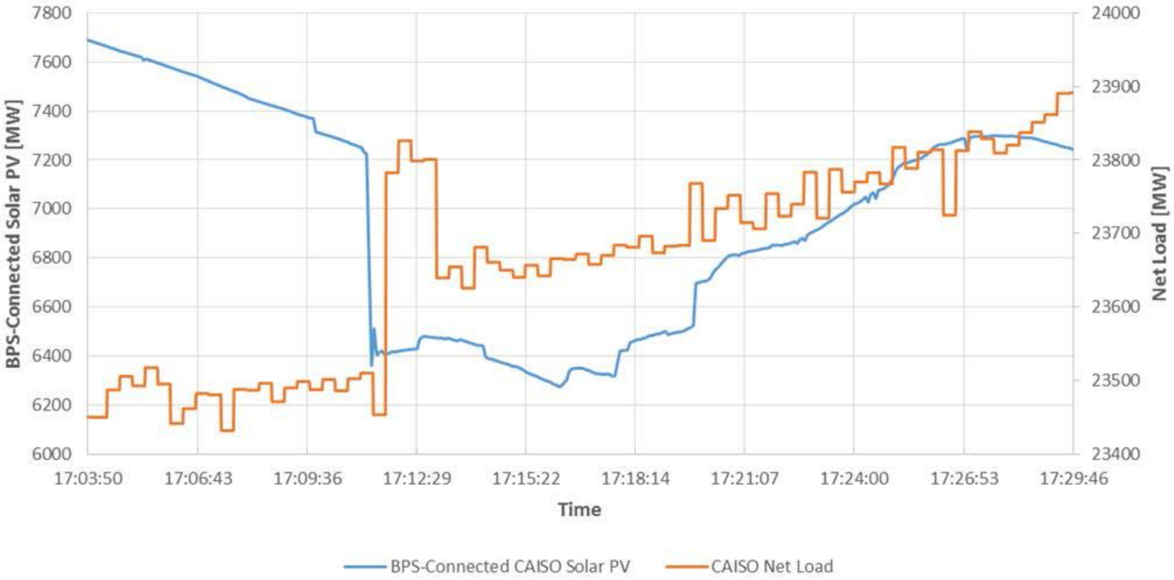
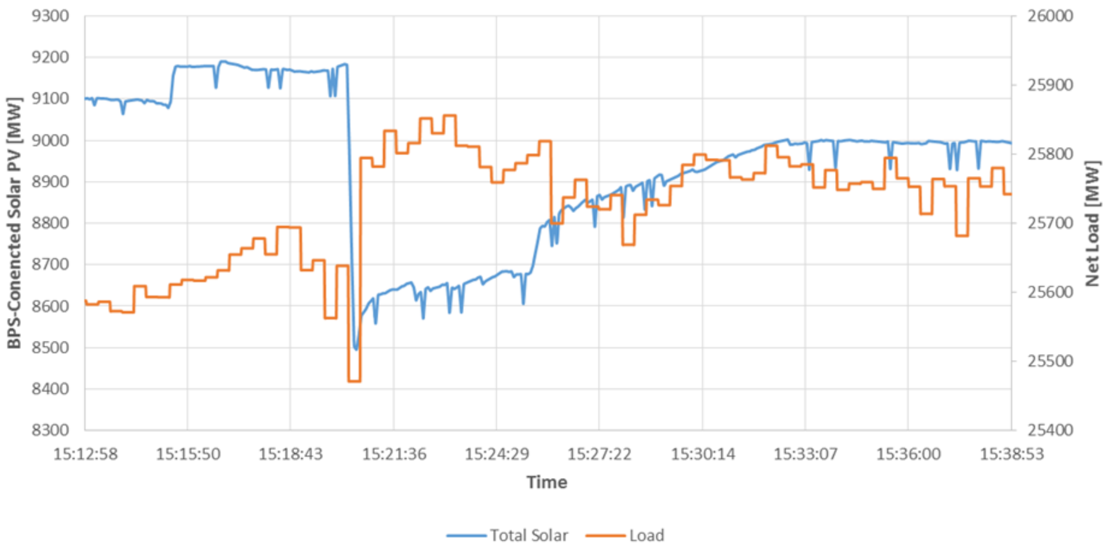
System Frequency during IBR-Related Disturbances





CAISO BPS-Connected Solar and Net Load





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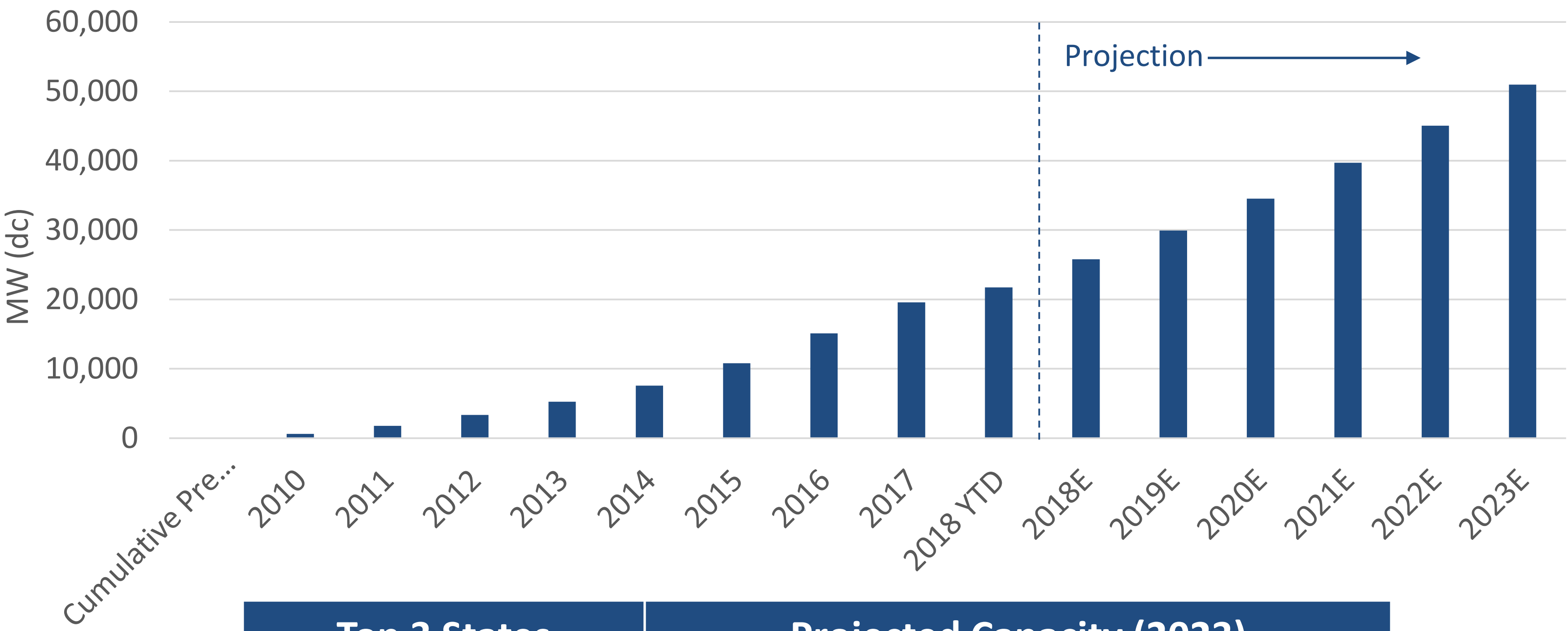
Long-Term Reliability Assessment Key Finding:
Over 30 GW of new distributed solar photovoltaic (PV) expected by end of 2023



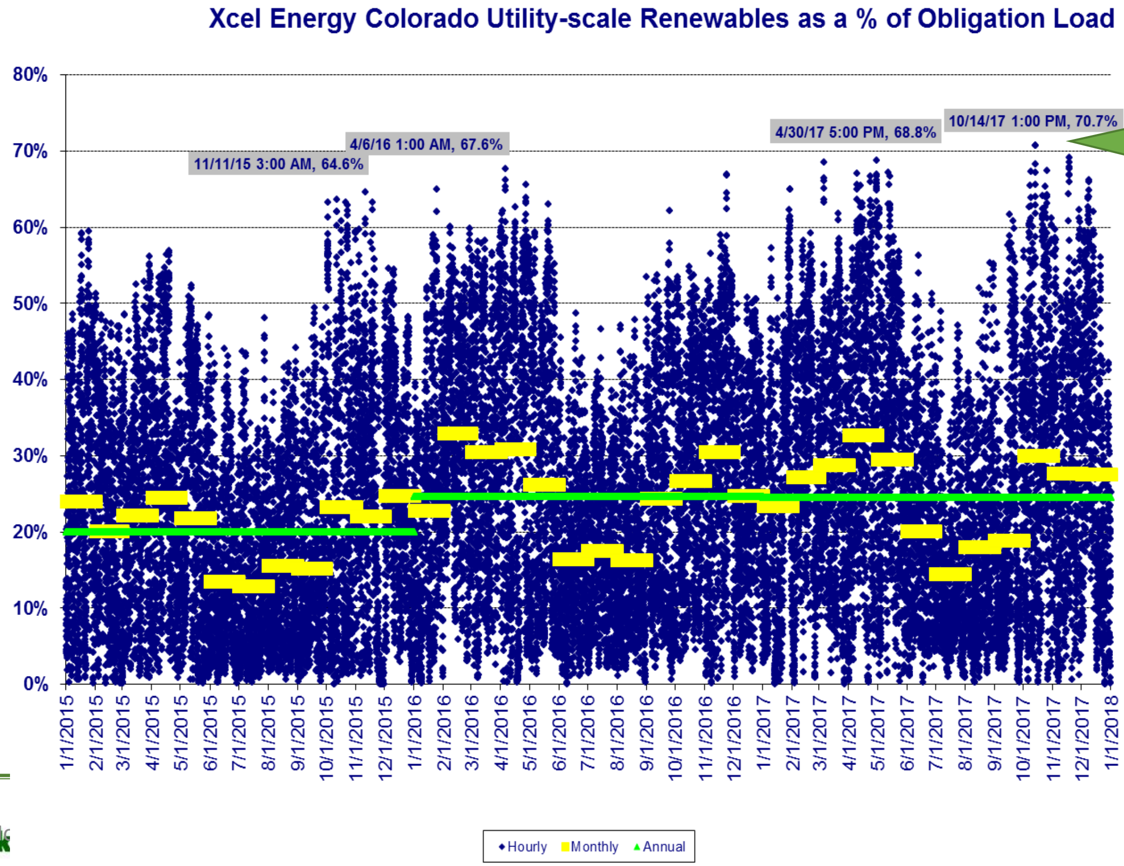
Top 3 States	Projected Capacity (2023)
California	18,000 MW
New Jersey	4,000 MW
Massachusetts	4,000 MW

Integration Challenges

- Several mandates for higher penetration of renewables
- What is higher penetration?
- Displacement of fossil resources – synchronous generators
  - Lower operating reserves possible
  - Not relying on idling gas turbines to provide primary frequency response
- Presents challenges to system operators due to variability
  - Extremely high ramp rates
  - Output is often weather dependent
- How can we take advantage of the wonderful capabilities of Inverter-Based Resources
  - Incredible fast frequency response with zero carbon footprint

What is Penetration?

Moderate annual averages can mean high instantaneous penetrations



25% annual energy means 71% instantaneous penetration in Colorado

Sources: Drake Bartlett, Xcel/PSCO 2018; Debbie Lew

When Does Penetration Become a Problem?

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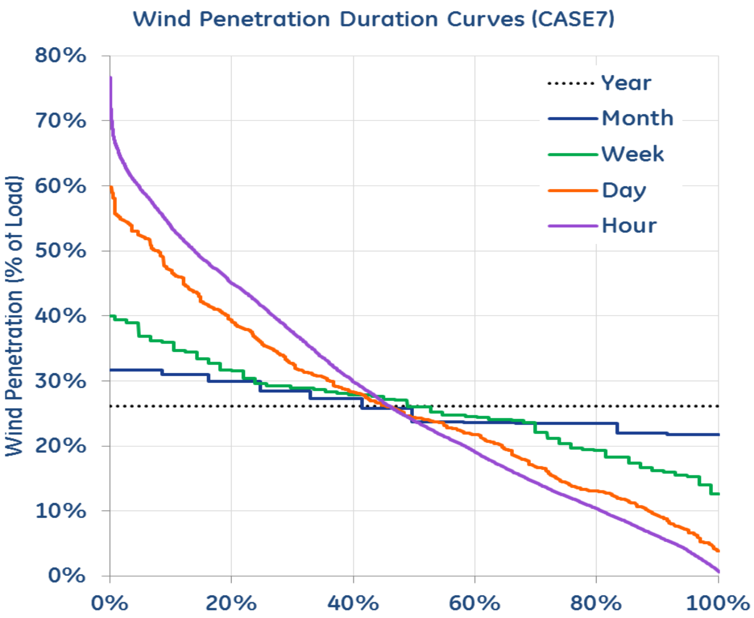
Only instantaneous penetration counts for operability/stability

- 100% Inverter-based resources (IBR) at any moment
- High IBR at any moment
- Pocket of the system with high IBR
- Outage/event conditions
- Weak grids or far from synchronous generators

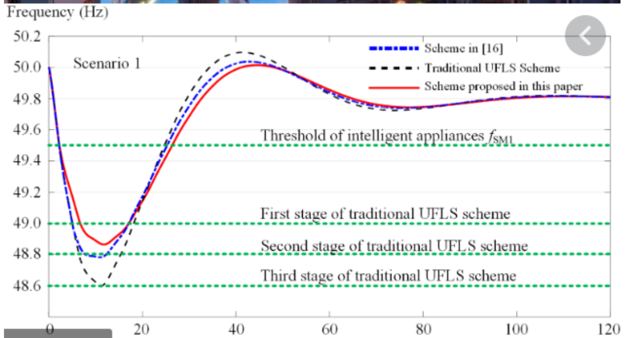


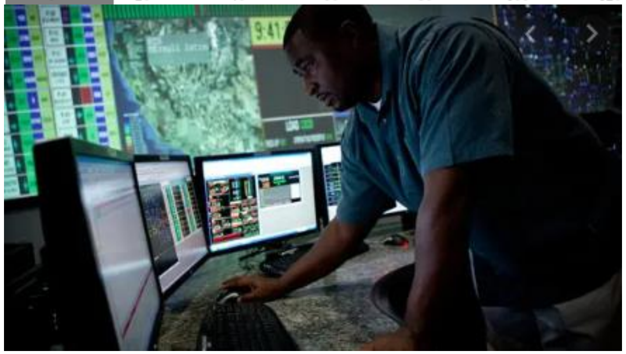
HickoryLedge

Source: Miller et al; NSPI Renewable Integration Study
http://www.nspower.ca/site-nsp/media/nspower/CA%20DR-14%20SUPPLEMENTAL%20REIS%20Final%20Report%20REDACTED.pdf

BPS Operational Impacts

- Generation Commitment and Dispatch
  - Variability of resources
  - Excess Energy (Lowest Reliability Operating Limit)
  - Increased resource ramping to match net demand
  - Lower system inertia and fault current
  - Balancing Control Performance (frequency control and response)
- Generator Impacts
  - O&M Cost from higher ramping rates
  - Increased cycling
- Under-Frequency Load Shedding (UFLS)
- Real-Time Modeling and Tools
  - State Estimation
  - Contingency Analysis





BPS Planning Considerations

- Transmission
  - Models
  - Power Flow and Contingency Analysis
  - Frequency Disturbance Planning
- Protection and Control
  - Models
  - UFLS
  - Short Circuit Assessment
- System Adequacy
  - Models
  - Energy and Capacity Planning
  - Interregional Transmission Planning

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How Should NERC Account for DER?

As the resource paradigm shifts the following questions arise:

- **Are there any immediate risks to BPS reliability?**
- **How can we better model DER**
  - What level of modeling detail is needed
  - Where should DER be modeled – distribution, transmission, or both?
- **How should DER be included in planning & operations for reliability?**
  - What level of visibility and control of DER do system operators need for reliable operations?
  - How to integrate DERMS into distribution and transmission planning and operation?
- **What are the future potential impacts to the reliability of the BPS?**
  - What updates to NERC reliability standards or guidance may be needed?
  - What other industry standards and guidelines are needed?

NERC & Industry Collaborations

NERC & the Industry are collaborating to:

- Determine how DER characteristics contribute to and/or impact BPS reliability
- Quantify the DER characteristics & effects to steady state & dynamic analysis
- Investigate DER modeling, develop guidelines, revise and/or create standards
- Create a forum/platform to address reliability needs across T&D systems

Distribution

- Collaborated with development of IEEE Standard 1547-2018

Sub-Transmission and LV Transmission (non BES)

- Participating in IEEE P2800 standard development – for IBRs connected above distribution voltage
- Participating in IEEE DER Management System (DERMS) Guideline development

Bulk Electric System Standards & Guidelines

- Reliability Guideline and Interconnection guidance for BPS-connected IBRs
- Modification of NERC Standard PRC-024 – Frequency and Voltage Settings

Questions and Answers