ES, Reliability, and Standards:
IEEE 1547-2018 Revision Informing Energy Storage for Grid Reliability

for NELHA ESS 2018 Conference, Second Conference on Energy Storage Trends and Opportunities

Panel Session: Energy Storage & Reliability

Charlie.Vartanian@PNNL.gov

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Disclaimer

- *This presentation on IEEE 1547-2018 are the author's views and are not the formal position, explanation or position of the IEEE or PNNL*

- *The author acknowledges the contribution of the IEEE 1547-2018 Working Group and Officers*

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Presentation Outline

1) DER and BPS Reliability: Big Picture Impacts and Opportunities

2) IEEE 1547-2018 Revision and Grid Support Functions and ES Considerations

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Bulk Power System (BPS) Impacts from High DER Penetration

1. "Generators that use inverters to interface to the grid … can only supply relatively small amounts of short circuit current. Typically, inverter short circuit current is limited to a range of 1.1 to 1.4 per unit. As the penetration levels of these generators increases and displaces conventional synchronous generation, **the available short circuit current on the system will decrease. This may make it more difficult to detect and clear system faults.** "

2. "… as DER displaces synchronous generation, **there may be times when there is insufficient system inertia and primary frequency response to arrest frequency decline** and stabilize the system frequency following a contingency."

(**emphasis** added)

Source, "Potential Bulk System Reliability Impacts of Distributed Resources", NERC, August 2011

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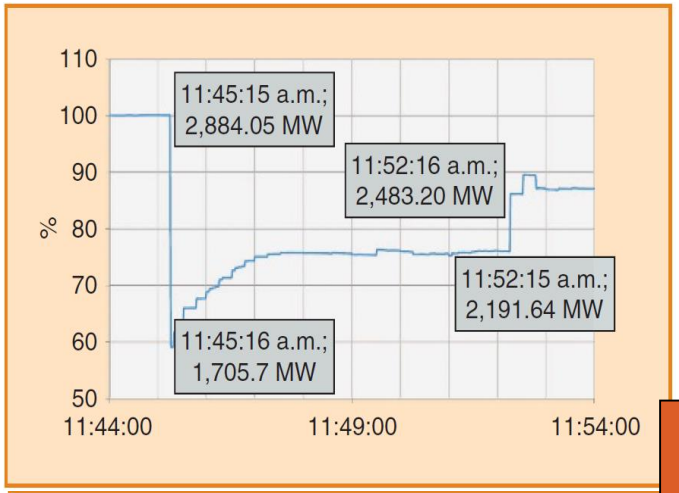
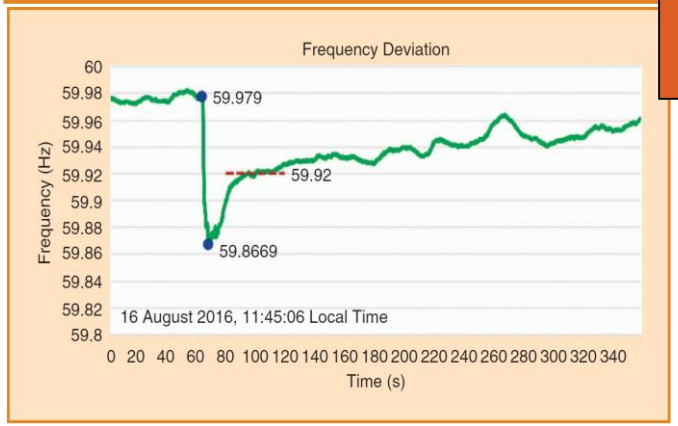
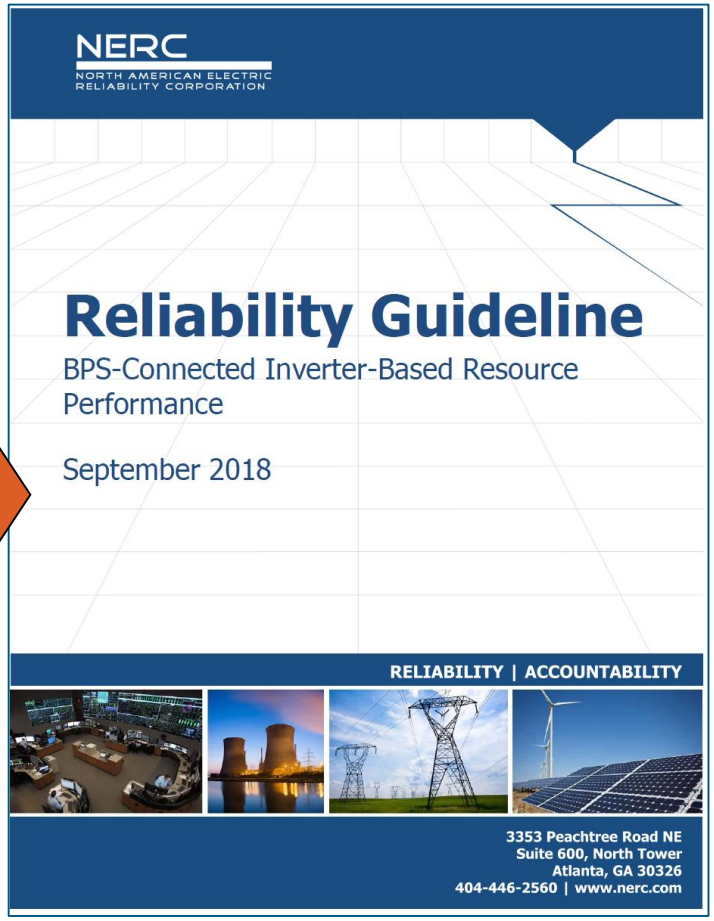
Learning from Actual BPS Frequency Event: The Blue Cut Fire Event to IRPTF Reliability Guide







1,200 MW of inadvertent PV loss on Aug. 16, 2016 impacted Western U.S. system frequency, ***and recovery.***

Source: NERC, IEEE

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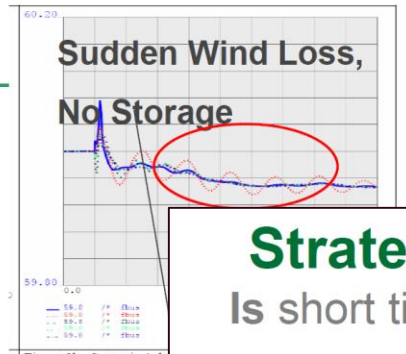
ES for Support of BPS Frequency Response, Conceptual

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

MegaWatt Storage Farms™

- MODELED DYNAMIC RESPONSE
  - 700 MW Wind Out Following 'T-1'
  - 250-750 MW Fast-Acting Storage 5 Cycles After Wind Out
  - SUBSTANTIAL IMPROVEMENT TO SYSTEM FREQUENCY RECOVERY



try, March 2008 FINAL DRAFT FOR REVIEW

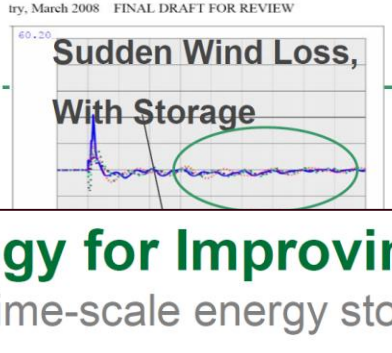


Figure 2b: Scenario 1, b

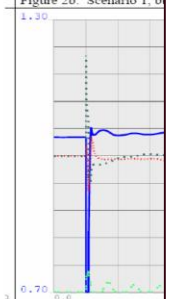
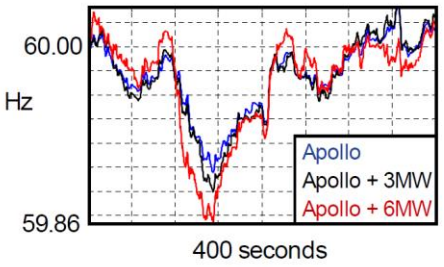


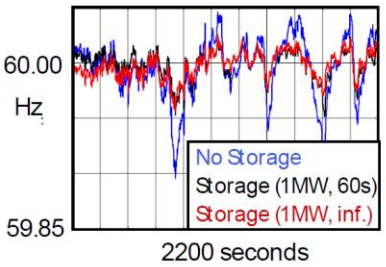
Figure 2d: Scenario 1, st

Strategy for Improving Grid Stability

Is short time-scale energy storage **a viable option?**

- Considering the same May 23rd historical window
- Expand the Apollo wind farm by 3MW, then 6MW
- Short time-scale energy storage showed substantial reduction in frequency sag.





Hawaii Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawaii at Manoa

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Sources: HNEI, Surles
SCE, Vartanian, MWSF Cazalet

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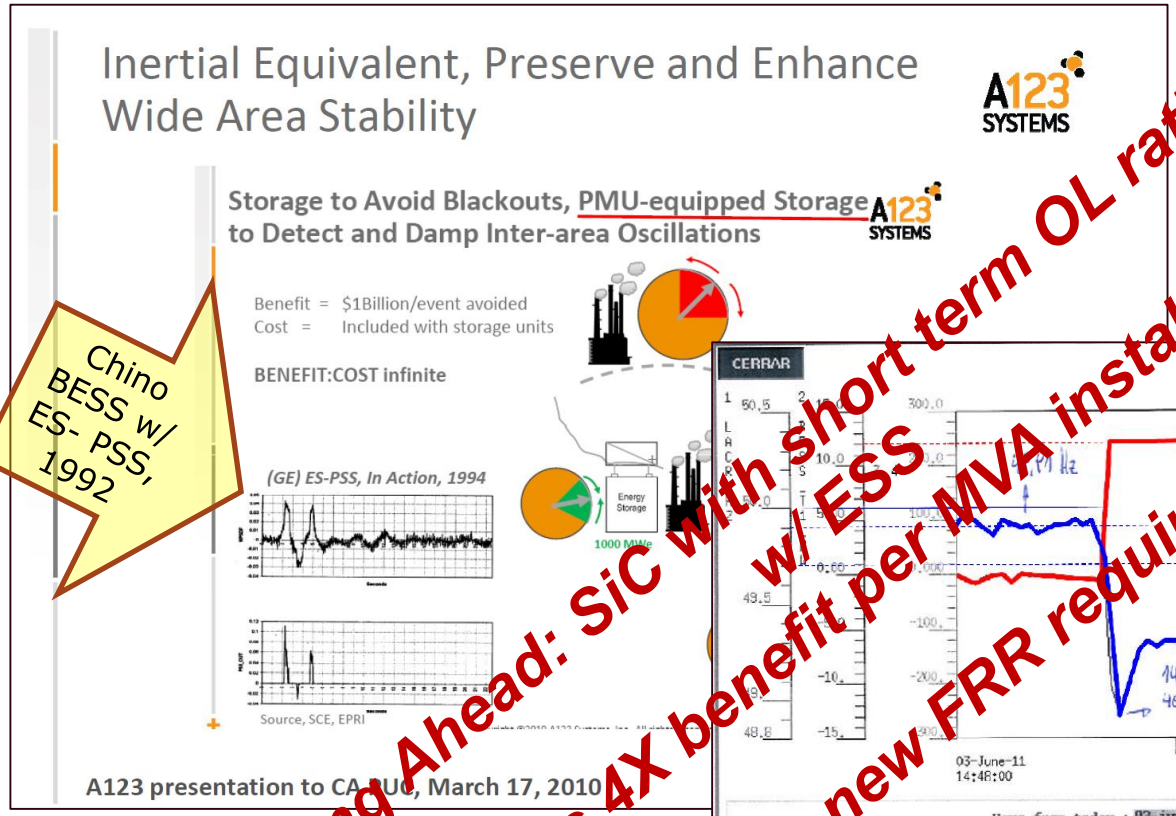
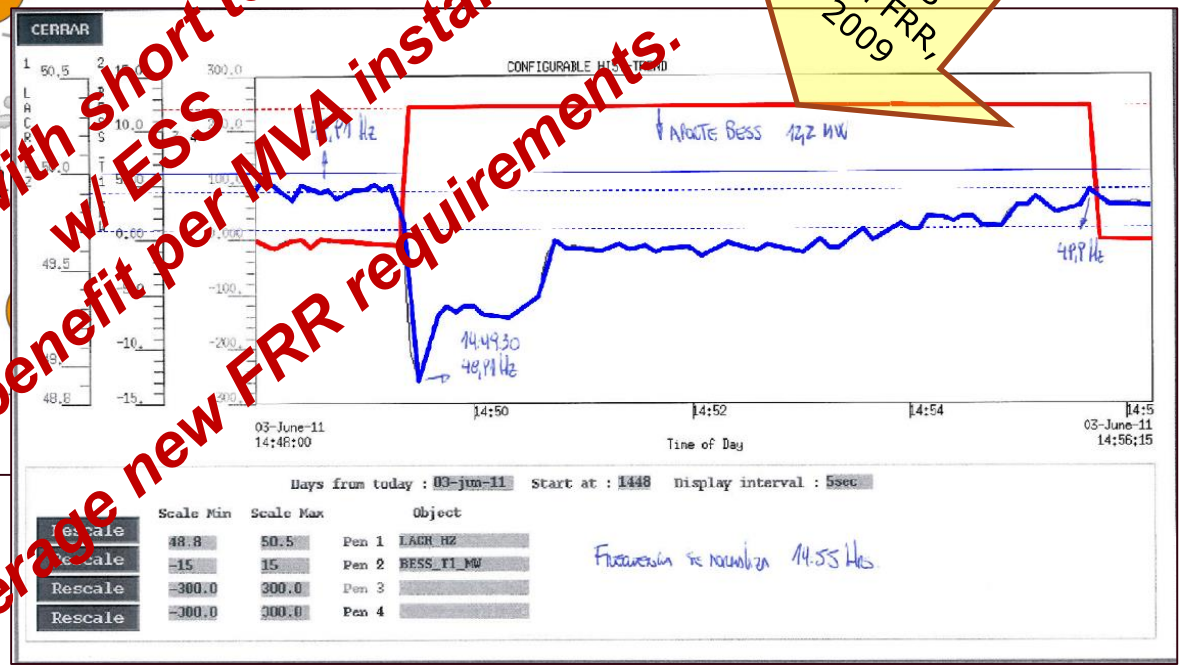
ES for Support of BPS Frequency Response, Actual





Looking Ahead: SiC with short term OL rating used w/ ESS has 4X benefit per MVA installed. Leverage new FRR requirements.

Source: A123 Systems

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2) IEEE 1547-2018 Revision Grid Support Functions and ES Considerations

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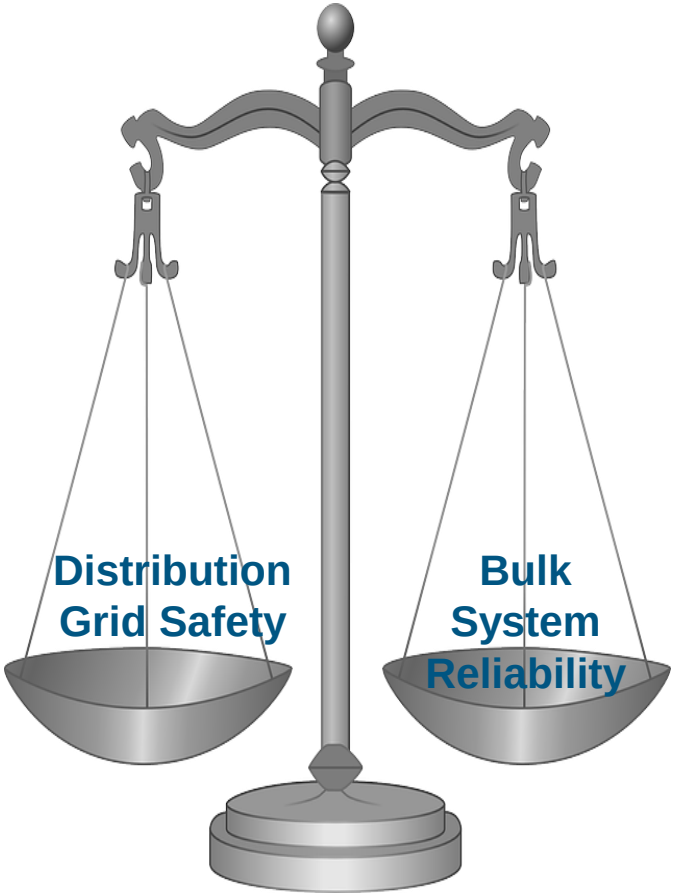
Revising 1547-2003: Striking a New Balance

- IEEE 1547-2018 mandates BOTH:
  - Tripping requirements, and
  - Ride-through requirements
- Ride-through is not a "setting", it is a minimum *capability* of the DER
  - *"shall ride through <u>for at least</u> … seconds"*
  - I.e., it is the minimum required DER robustness to withstand voltage and frequency disturbances
  - May or may not be fully utilized, or it may be exceeded
- Trip thresholds and clearing times are maximum operational *settings*
  - *"shall trip <u>at latest by</u> … seconds"*
  - May differ from *default settings* and are adjustable over a 'range of allowable settings'
  - Specified ranges do not allow DER tripping to seriously compromise bulk power system reliability
  - Tripping points specified by the distribution utility may account for utility-specific practices but may also be constrained by the ***regional reliability coordinator***



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IEEE 1547 Evolution of Grid Support Functions

IEEE 1547-2003

- Shall NOT actively regulate voltage
- Shall trip on abnormal voltage/frequency

IEEE 1547a-2014 (Amendment 1)

- **May** actively regulate voltage
- **May** ride through abnormal voltage/frequency
- **May** provide frequency response[1] (frequency-droop)

IEEE 1547-2018

- **Shall be capable of** actively regulating voltage
- **Shall** ride through abnormal voltage/frequency
- **Shall be capable of** frequency response[2]
- **May** provide inertial response[3]

ESS/Disp. Vs Variable?

2 vs 1 Quadrant Power?

[1]**Frequency response is capability to modulate power output as a function of frequency**

[2]Mandatory capability for Categories II and III under high frequency conditions, Mandatory for Categories II and III under low frequency conditions, optional for Category 1

[3]**Inertial response is capability for DER to modulate active power in proportion to the rate of change of frequency**

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Evolving Standards Support Accessing DER's Value Stack
ES Applications – from CA AB2514

Category	Storage "End Use"
ISO/Market	• Frequency regulation • Spin/non-spin/replacement reserves • Ramp • Black start • Real time energy balancing • Energy price arbitrage • Resource adequacy
VER Generation	• Intermittent resource integration: wind (ramp/voltage support) • Intermittent resource integration: photovoltaic (time shift, voltage sag, rapid demand support) • Supply firming
Transmission/ Distribution	• Peak shaving: off-to-on peak energy shifting (operational) • Transmission peak capacity support (upgrade deferral) • Transmission operation (short duration performance, inertia, system reliability) • Transmission congestion relief • Distribution peak capacity support (upgrade deferral) • Distribution operation (Voltage Support/VAR Support) • Outage mitigation: micro-grid
Customer	• Time-of-use /demand charge bill management (load shift) • Power quality • Peak shaving (demand response), Back-up power

1547-2003 vs. new CA 21 & 1547Revision

Source(table): CPUC Staff, AB2514 workshop, 3/25/2013

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1547-2018 Guidance on Perf. Cat. For ES

Table B.1—Example abnormal performance category assignment grid[137]

	DER type	DER application purpose						
		Retail self generation	Combined heat and power	Waste fuel recovery	Renewable energy	Merchant generation[a]	Critical backup[b]	Peak shaving
		A	B	C	D	E	F	G
1	Engine or turbine driven synchronous generator	Category I	Category I	Category I	Category I	Category I	Category I	Category I
2	Wind turbines (all types)	Category II	N/A	N/A	Category II	Category II	N/A	N/A
3	Inverters sourced by solar PV	Category II[c]	N/A	N/A	Category II[c]	Category II[c]	N/A	N/A
4	Inverters sourced by fuel cells	Category I	Category I	Category I	Category I	Category II	Category I	N/A
5	Synchronous hydrogenerators	Category I	N/A	N/A	Category I	Category I	Category I	N/A
6	Other inverter applications	Category II	Category II	Category II	Category II	Category II	Category II	N/A
7	Inverters sourced by energy storage	Category II	N/A	N/A	N/A	Category II	Category II	Category II
8	Other synchronous generators	Category I	Category I	Category I	Category I	Category I	Category I	N/A
9	Other induction generators	Category II	Category II	Category II	Category II	Category II	Category II	Category II

[a]Merchant generation in this table is intended to characterize DER facilities installed for the express purpose of exporting power, and is not intended to imply only FERC-jurisdictional generation or other regulatory definitions.
[b]Only applies to critical backup generation interconnected to the Area EPS for the purposes of periodic testing. If backup generation is also used for merchant generation or other purposes, the performance requirements of those purposes apply.
[c]Category III should be required where DER penetration on a distribution feeder exceeds [% VALUE TO BE SPECIFIED BY AGIR], or on the distribution system supplied from a given distribution substation bus exceeds [% VALUE TO BE SPECIFIED BY AGIR].

And some thoughts on customer side/implemented reliability

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1547-2018: When can an I.I. leave the grid?

- When conditions are met that are mutually agreed-to by the Area EPS and DER operators;
- If any of the abnormal voltage or frequency trip conditions is met; or
- If an unintentional island is detected.

For these latter two cases, one may substitute entry into intentional island mode for tripping.

I.I. = Intentional Island

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P1547.9, an Outcome of 1547 Revision

ES Interconnection Standard Gap Identified, and Action Taken

1.1 Project Number: P1547.9
1.2 Type of Document: Guide
1.3 Life Cycle: Full Use

2.1 Title: IEEE 1547.9 Guide for Interconnection of Energy Storage Distributed Energy Resources with Power Systems

5.2 Scope: This Guide provides information on and examples of how to apply the IEEE Std 1547, for the interconnection of Energy Storage Distributed Energy Resources (DER ES). Scope includes DER ES connected to area Electric Power Systems (local EPSs) that are capable of bidirectional real and reactive power flow, and are capable of exporting real power to the EPS. Guidance is also provided for non-exporting DER ES, such as UPS type systems that support onsite loads, or EV chargers, with charging attributes that could have power system impacts, e.g. modulating rate of charge proportionally to system frequency.

The first P1547.9 Working Group will be held at NERC, in February 2019. Please contact Charlie Vartanian to be placed on the Interest e-List.

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Thanks!

Questions?

Charlie Vartanian, PE

Charlie.vartanian@pnnl.gov
(626) 818-5230

http://grouper.ieee.org/groups/scc21/1547/1547_index.html
https://standards.ieee.org/findstds/standard/1547-2018.html

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