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Energy Storage Integration

Illinois Commerce Commission

Energy Storage Webinar Series

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U.S. DEPARTMENT OF ENERGY BATTELLE

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Outline

1. **Review: What's in an Energy Storage System (ESS)**

2. **Successful ESS Integration Requires Interconnection & Interoperability**

   Referencing Standards – one tool to help avoid unintended barriers to used and useful adoption

3. **Dealing with Rapid Pace of Technical Innovation,**

   ES with smart inverters support multi-use applications

   Bulk Power Impacts from DER Relevant to microgrids too

4. **Conclusion**

ESS Major Sub Systems: BESS Example

Identify:
- **Area EPS (utility)**
- **Local EPS**
- **PoC**
- **PCC (or PoI)**

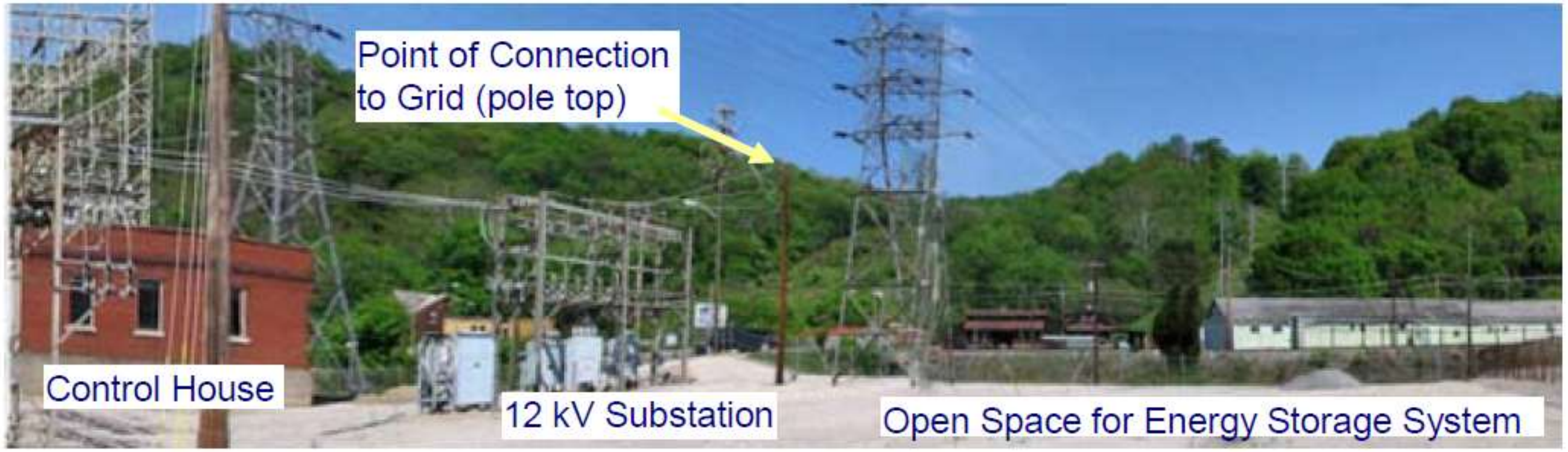
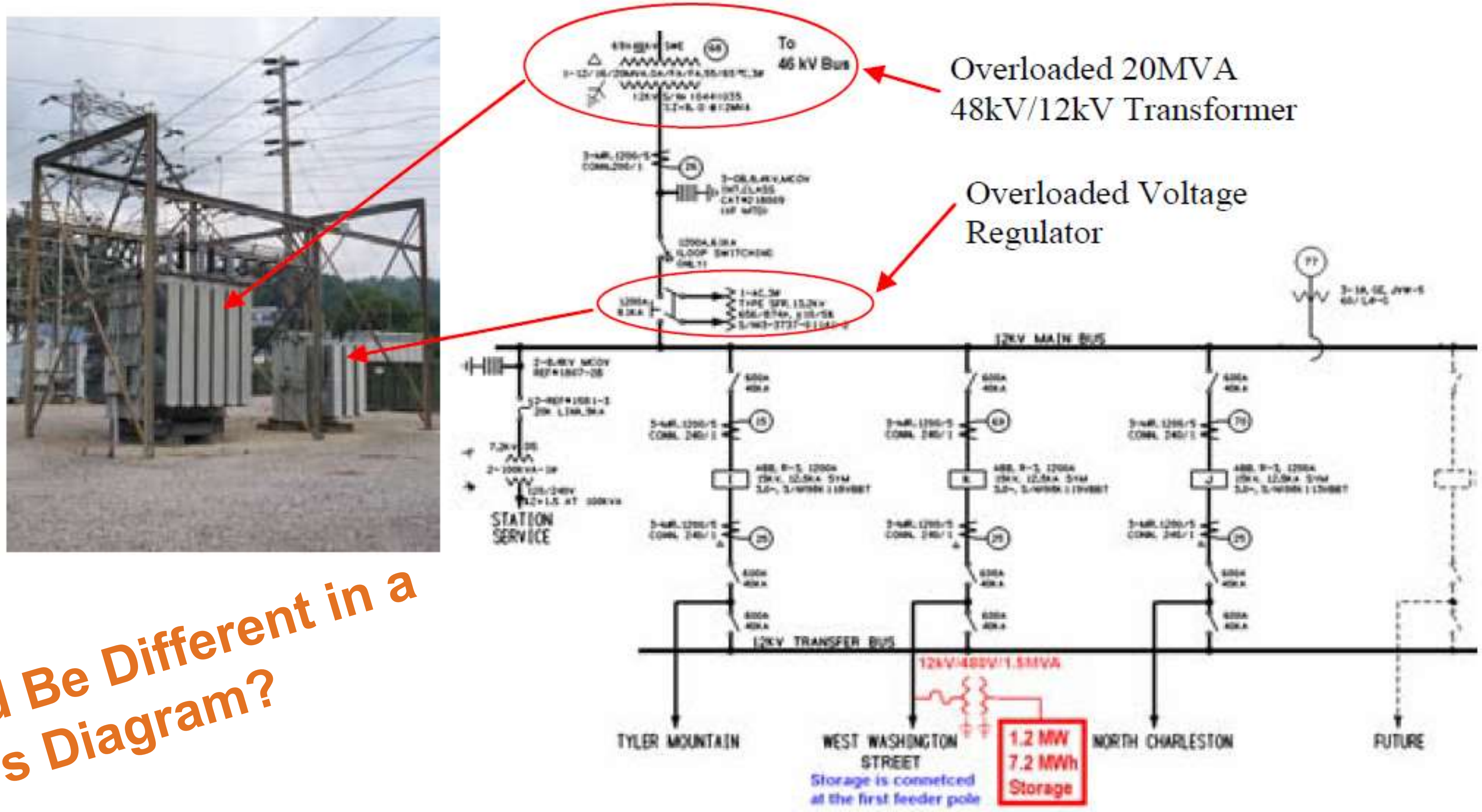


Figure 14 – Photographs of AEP's Chemical Substation before & after installation of 1.2 MW DESS in line with a 12kV feeder

Source, AEP
From, SANDIA REPORT, Installation of the First Distributed Energy Storage System (DESS) at American Electric Power (AEP), SAND2007-3580, June 2007

ESS Interconnection: BESS Example



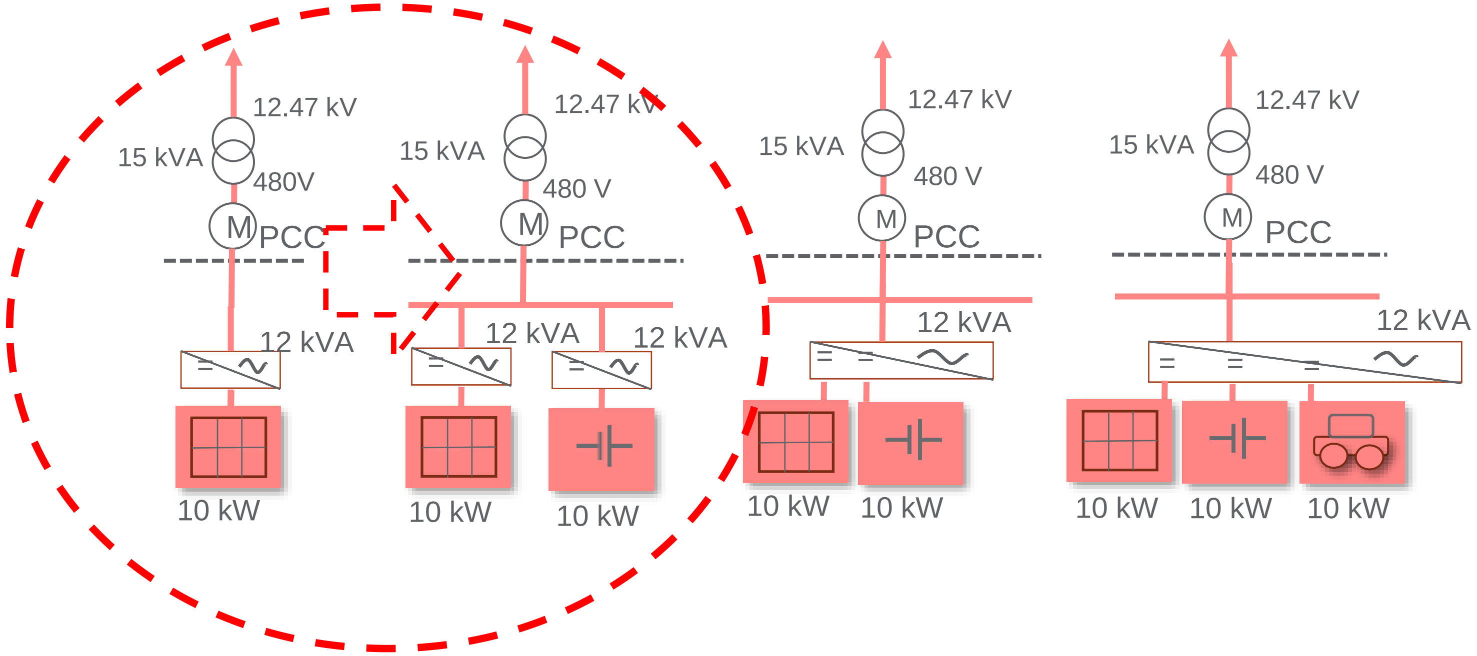
What Would Be Different in a PV Project's Diagram?

Source, AEP

From, SANDIA REPORT, Installation of the First Distributed Energy Storage System (DESS) at American Electric Power (AEP), SAND2007-3580, June 2007

ESS Integration: Integrated System or 'Sum of Parts'?

Opportunity for Controls-Based Power Rating @ PCC



ITC Relevance Too

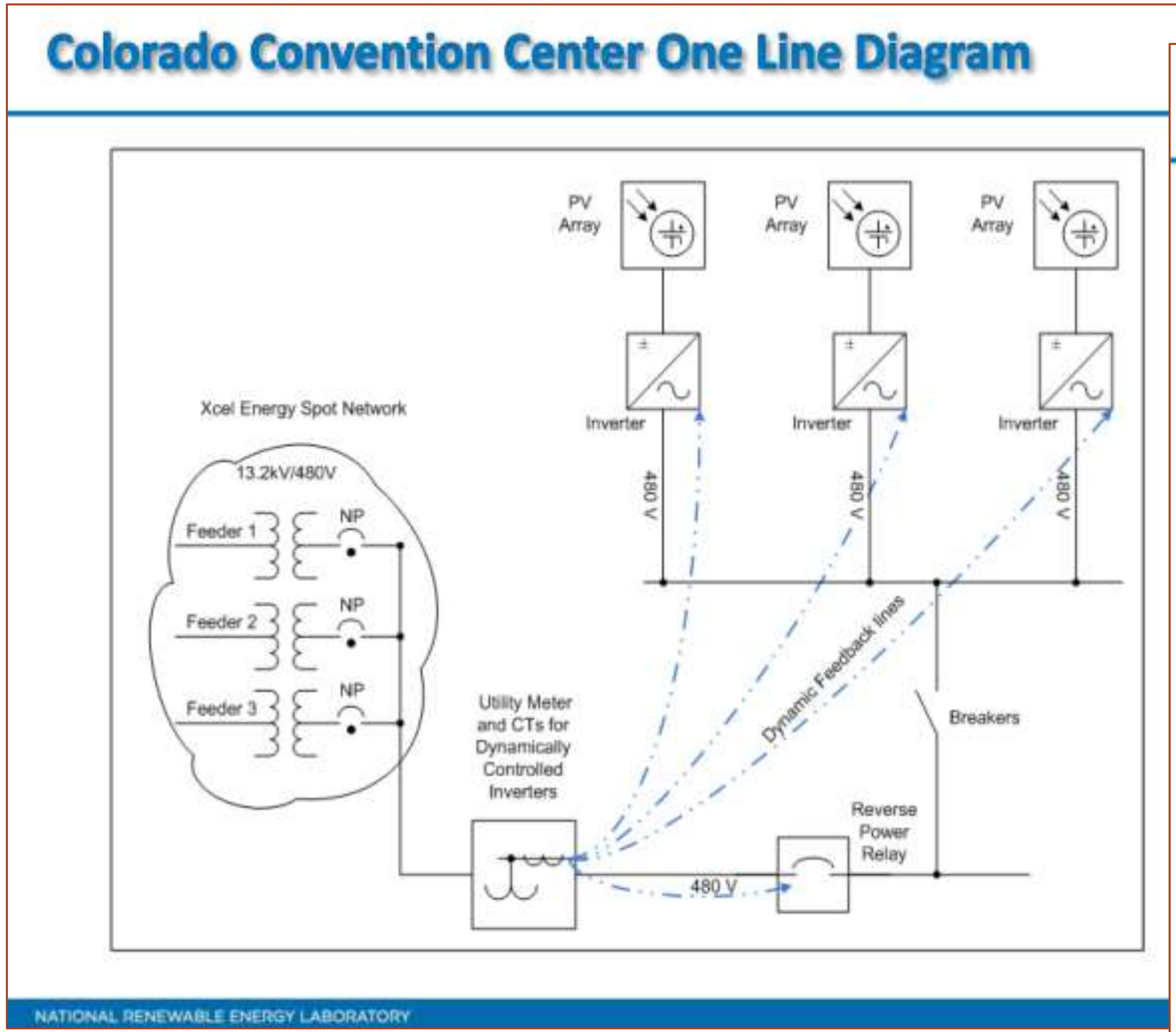
What's the interconnection rating and/or requirement at the PCC?
Who determines? On what basis?

IEEE 1547-2018's recognition of "system" based compliance helps.
Versus depending on listed-equipment based compliance only.
(However, the simple 'nameplate capacity' approach remains a useful 'fast-track' interconnection review screen, for smaller simple ESSs).

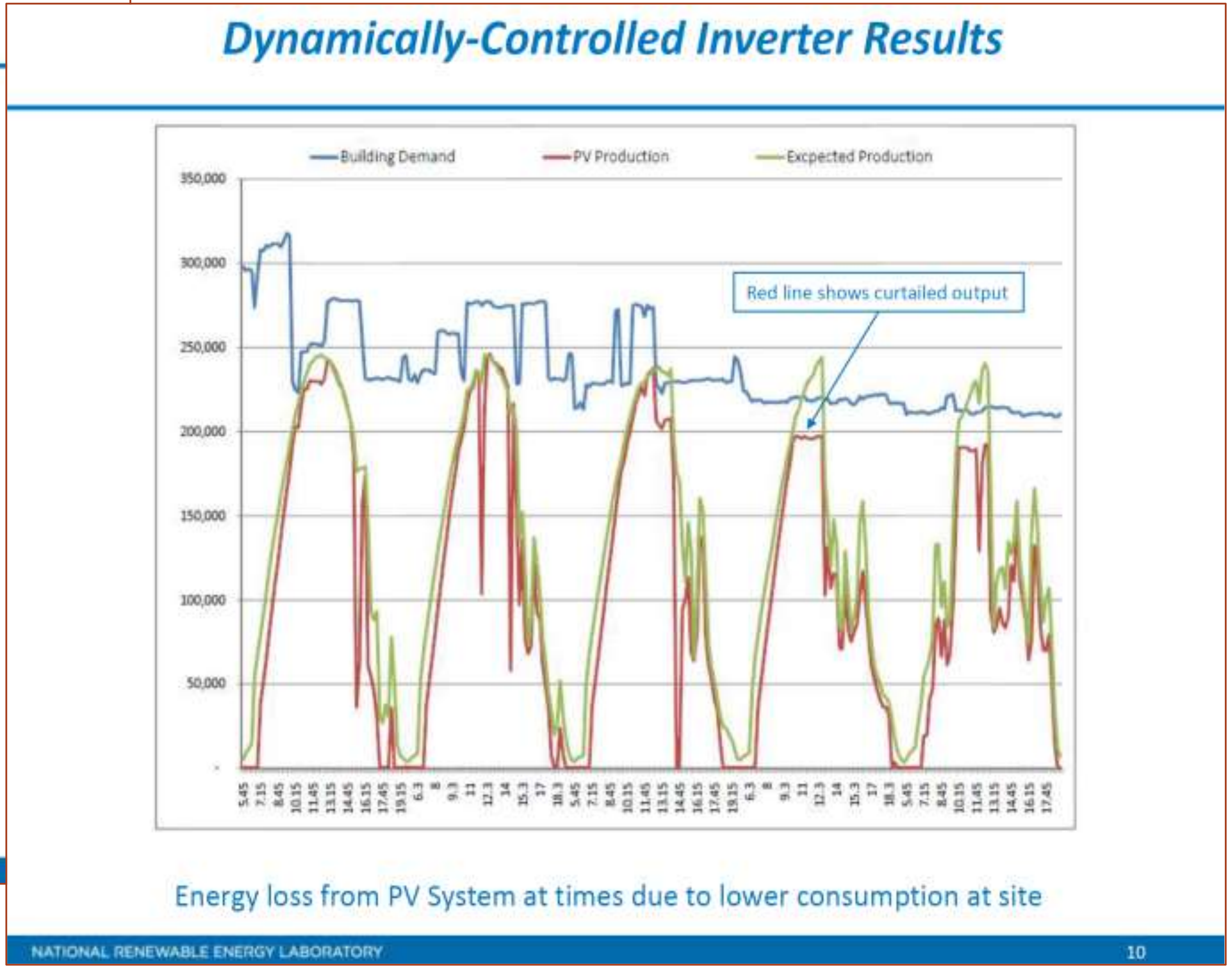
One of several reasons for AHJs' to reference revised IEEE 1547-2018.

ESS Integration: Interconnection Topic

Controls-Based Power Rating @ PCC, Colorado Convention Center



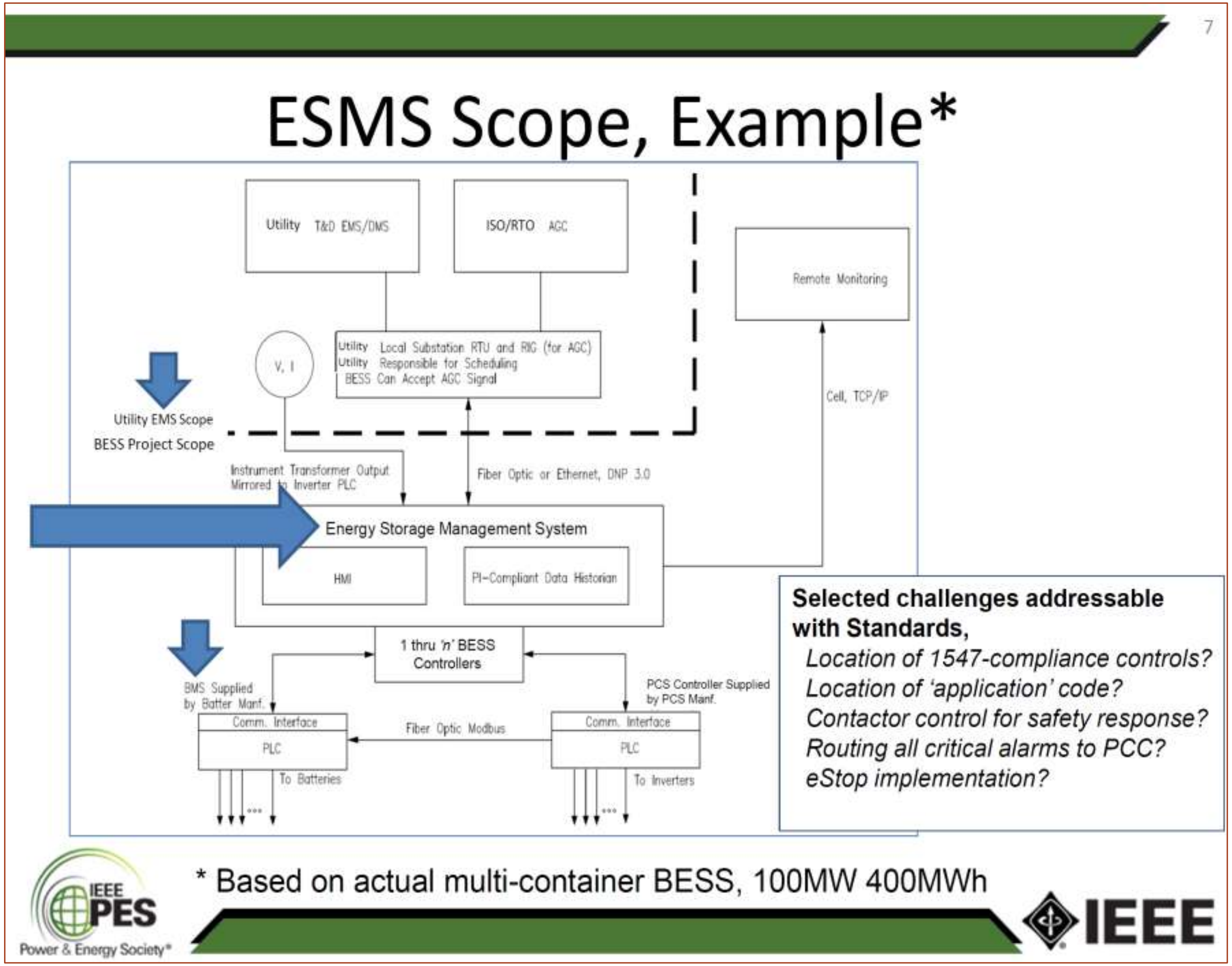
Source, NREL



Source, NREL

This controls approach opens up potential for multi-use ESS applications on networked distribution. Including using ESS to allow PV on networked distribution (renewables integration application).

ESS Integration: Interoperability Topic,
What languages does your ESS speak? Modbus?, SEP2? DNP3?



Source, IEEE P2688 Working Group

ESS Integration: Interoperability Topic,
These languages(protocols) are required by 1547-2018

Protocol	Transport	Physical Layer
IEEE Std 2030.5™ (SEP2)	TCP/IP	Ethernet
IEEE Std 1815™ (DNP3)	TCP/IP	Ethernet
SunSpec Modbus	TCP/IP	Ethernet
	N/A	RS-485

One of several reasons for AHJs' to reference revised IEEE 1547-2018.

Technical/Policy Overlap & Multi-Use Applications, CA AB2514 Example

Without Updated Standards Plus Adoption by AHJ's, Some Services from ES & PV+ES Won't Be Deliverable

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 7	• 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 (original table): CA PUC Staff, AB2514 workshop, 3/25/2013

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IEEE

DNV-KEMA's CA AB2514 Report has guidance on 1) evaluating ESS using util. 'avoided cost' type analysis 2) quantifying ESS project stacked value streams.

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Cost Recovery Discussion Point: ESS T, D, (and)or G? See FERC Order 784.

ELECTRIC PLANT IN SERVICE (Account 101, 102, 103 and 106) (Continued)			
Line No.	Accounts (a)	Balance Beginning of Year (b)	Additions (c)
48	**3. TRANSMISSION PLANT**		
49	(350) Land and Land Rights		
50	(351) Energy Storage Equipment - Transmission		
51	(352) Structures and Improvements		
52	(353) Station Equipment		
53	(354) Towers and Fixtures		
54	(355) Poles and Fixtures		
55	(356) Overhead Conductors and Devices		
56	(357) Underground Conduit		
57	(358) Underground Conductors and Devices		
58	(359) Roads and Trails		
59	(359.1) Asset Retirement Costs for Transmission Plant		
60	TOTAL Transmission Plant (Enter Total of lines 49 thru 59)		
61	**4. DISTRIBUTION PLANT**		
62	(360) Land and Land Rights		
63	(361) Structures and Improvements		
64	(362) Station Equipment		
65	(363) Energy Storage Equipment – Distribution		

Source, FERC

Policy that allow flexibility in investment recovery support full range of ESS multi-applications to be monetized, and thus used.

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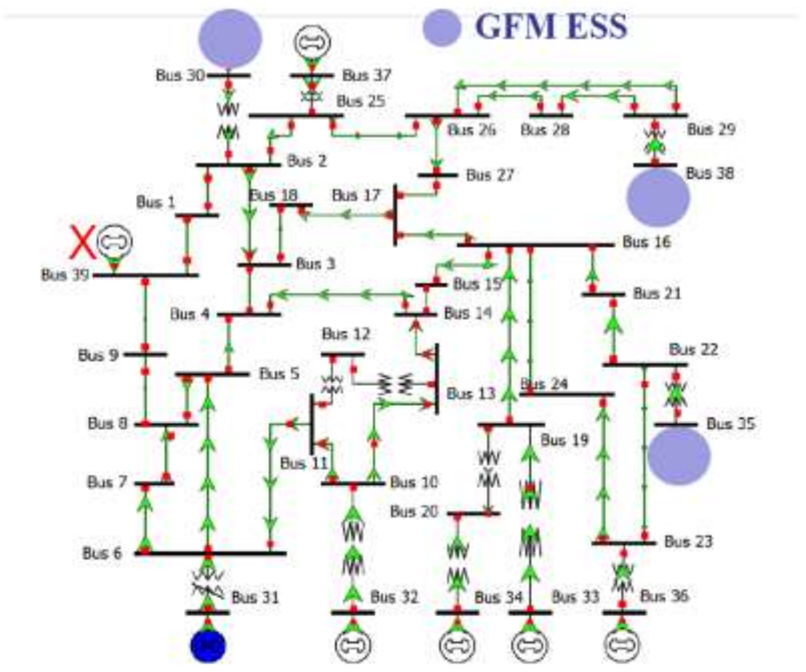
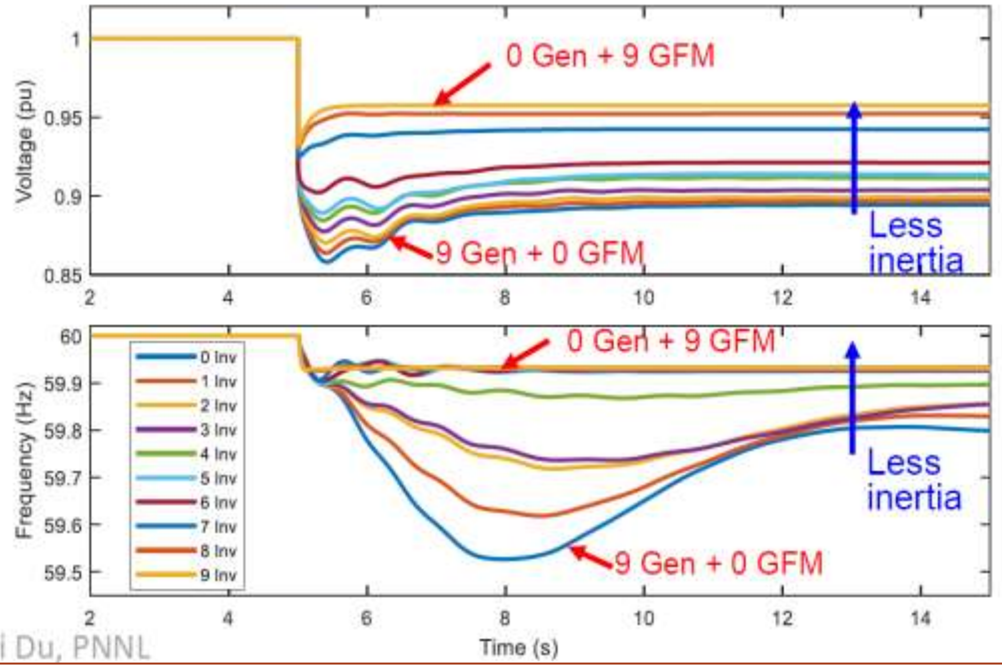
Power of Smart Power Electronics

Power electronics inverter control for system frequency and voltage performance

- Low-inertia grid can be a better grid – more responsive!
- Key is on control – grid forming inverters!





Credit: Wei Du, PNNL

Source, PNNL, HH, WD

ES + 'smart' grid forming (GFM) inverters: a pathway to 90%+ renewables contribution.
Use SiC switches in the smart inverters and solve the other NERC-identified DER impact to BPS.

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High DER Penetration Impacts to BPS

The following potential bulk system reliability impacts of high levels of DER have been identified:

- Non-dispatchable ramping/variability of certain DER
- Response to faults: lack of low voltage ride through, lack of frequency ride-through and coordination with the IEEE 1547 interconnection standards for distributed generation
- Potential system protection considerations
- Under Frequency Load Shedding (UFLS) and Under Voltage Load Shedding (UVLS) disconnecting generation and further reducing frequency and voltage support
- Visibility/controllability of DER
- Coordination of system restoration
- Scheduling/forecasting impacts on base load/cycling generation mix
- Reactive power and voltage control
- Impacts on forecast of apparent load seen by the transmission system

Source, NERC

These are also relevant to microgrid planning and operations

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Conclusion

Don't re-invent the wheel for integrating ESS, *just improve the wheel*

- Existing tools and processes used for generation interconnection, e.g. IEEE 1547 std's for DER/distribution through FERC SGIP/LGIP process for wholesale interconnection, *are applicable to ESS with manageable considerations & some enhancements*

- Be as consistent as possible when setting technical criteria across T&D. *The lines between T&D are blurring in terms of resource location, relative aggregate capacity, and Bulk Power System (BPS) performance impact*

- Simulation based interconnection tools & processes work for 'T', *now apply them to 'D'. What if online automated 'hosting capacity' tools could also do automated Feasibility Studies? What if an ESS project increases utility's PV hosting capacity?*

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References

- IEEE 1547-2018 DER Interconnection Standard, https://standards.ieee.org/standard/1547-2018.html
- IEEE P1547.9 Draft ES-DER Interconnection Guide, https://standards.ieee.org/project/1547_9.html
- IEEE P2688 Draft ESMS Recommended Practice, https://standards.ieee.org/project/2688.html
- IEEE P2686 Draft BMS Recommended Practice, https://standards.ieee.org/project/2686.html
- Energy Storage Cost-effectiveness Methodology and Preliminary Results (Draft), https://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=3116
- Third-Party Provision of Ancillary Services; Accounting and Financial Reporting for New Electric Storage Technologies, https://www.ferc.gov/sites/default/files/2020-06/OrderNo.784.pdf
- Potential Bulk System Reliability Impacts of Distributed Resources, NERC, August 2011

Acknowledgement

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Energy Storage Reliability Codes &Standards Project's collaborative industry partners include:

- ***IEEE Standards Association***
- ***MESA Alliance***
- ***EPRI Energy Storage Integration Council (ESIC)***