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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Bulk Power System Reliability with Increasing Inverter Technology

NERC Inverter-Based Resource Performance Working Group Update

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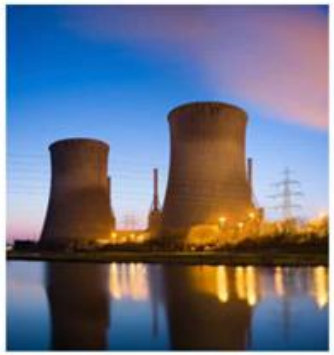
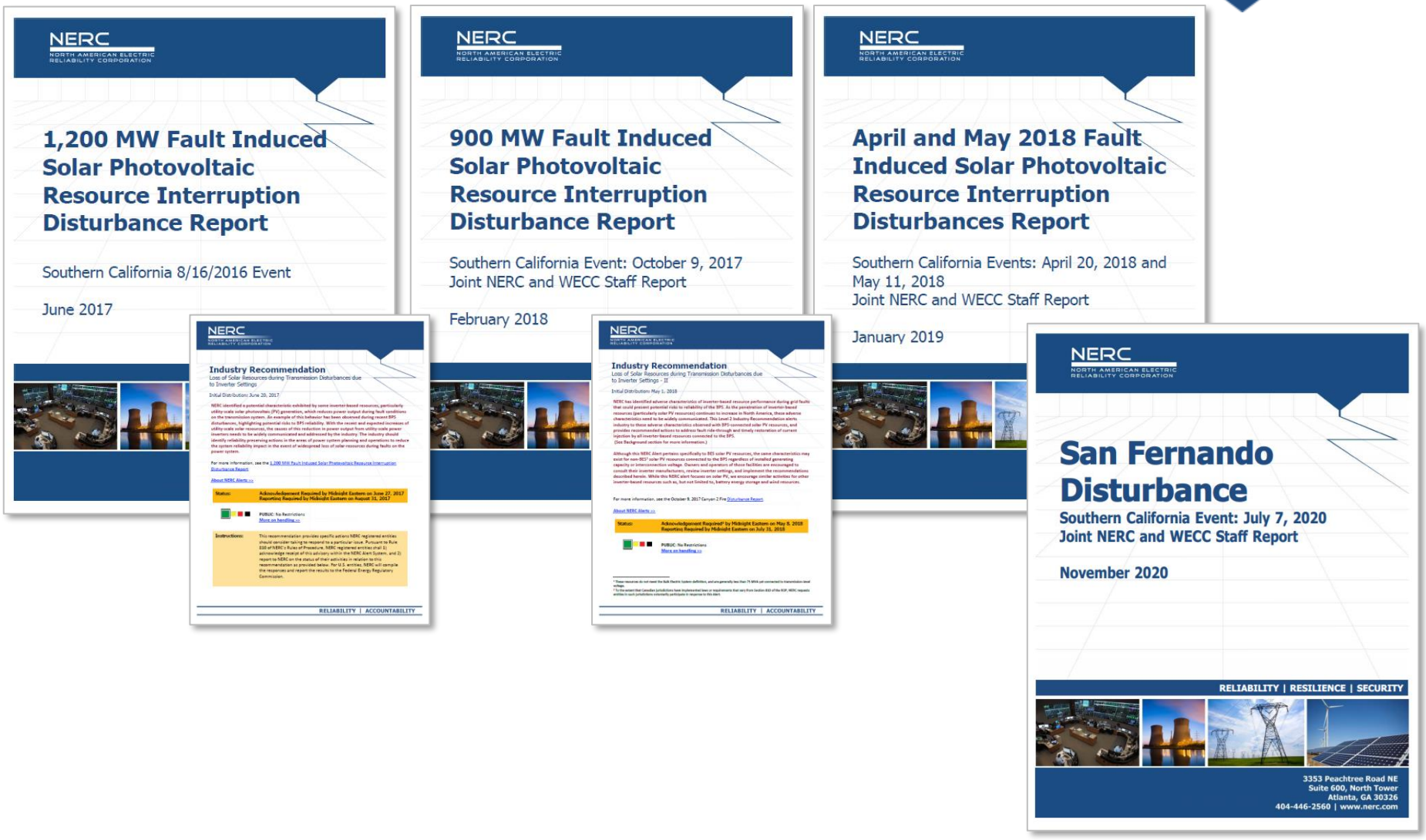
ESIG Spring Technical Workshop 2021

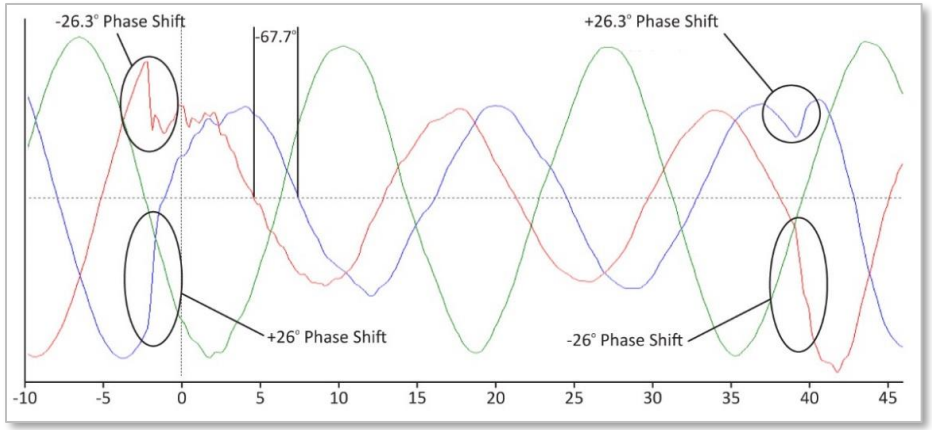
RELIABILITY | RESILIENCE | SECURITY

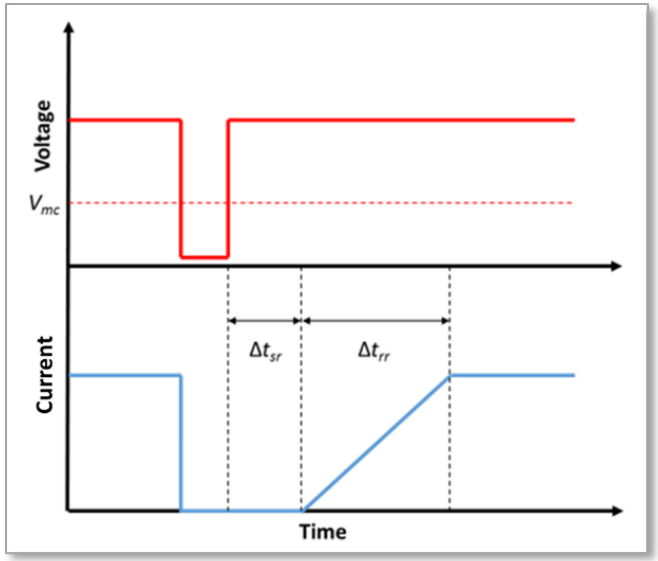



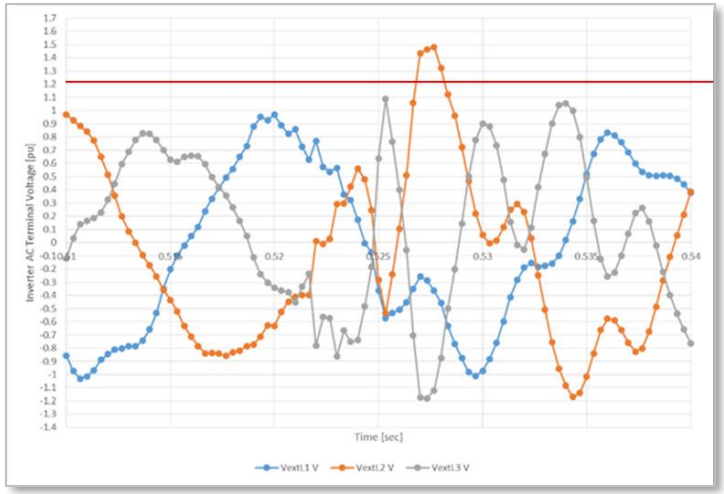
NERC Disturbance Reports and Alerts

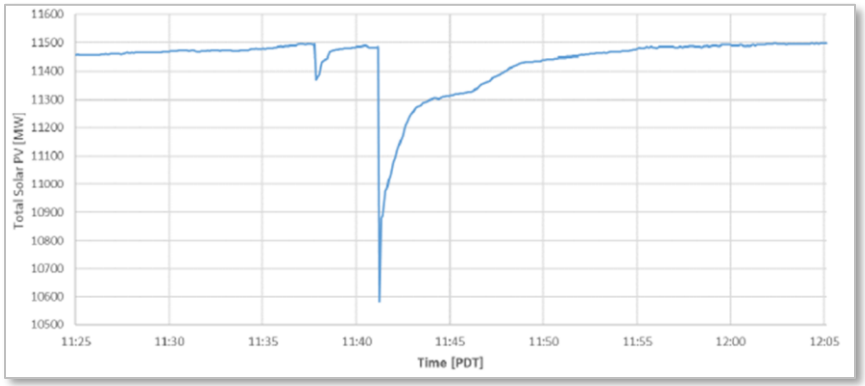


Understanding Abnormal Inverter Performance on the BPS

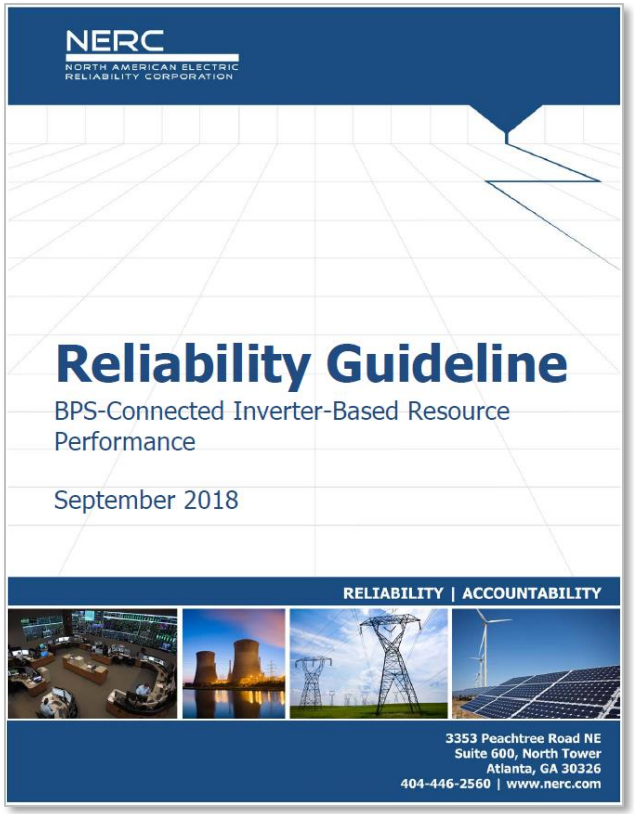


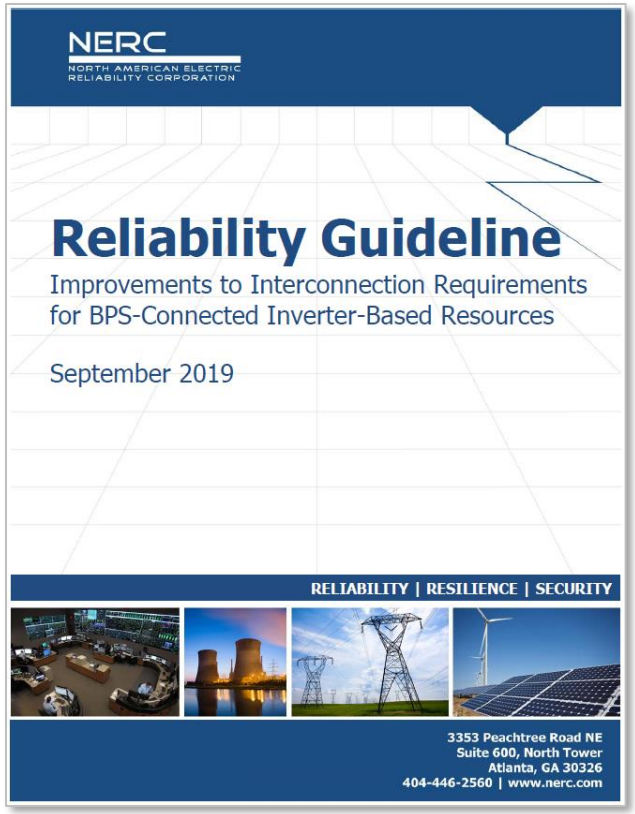




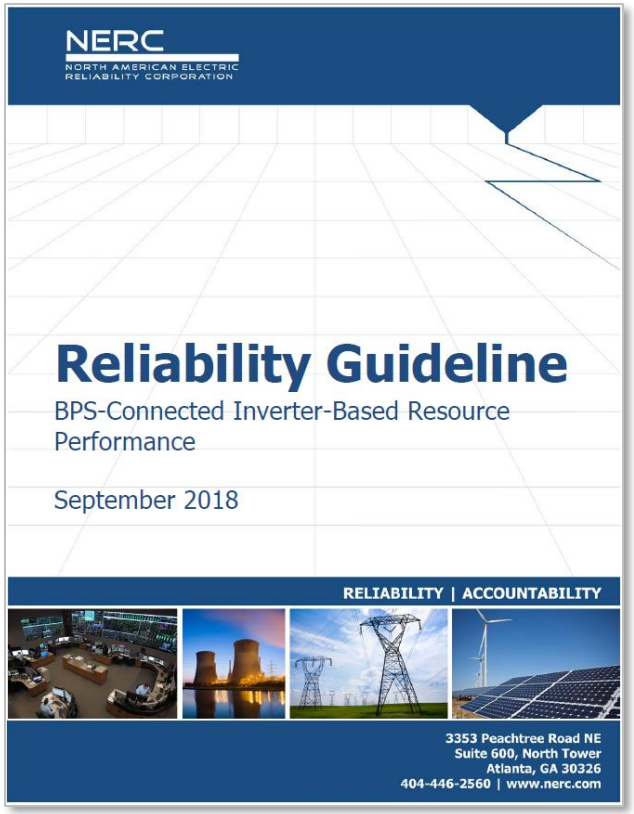


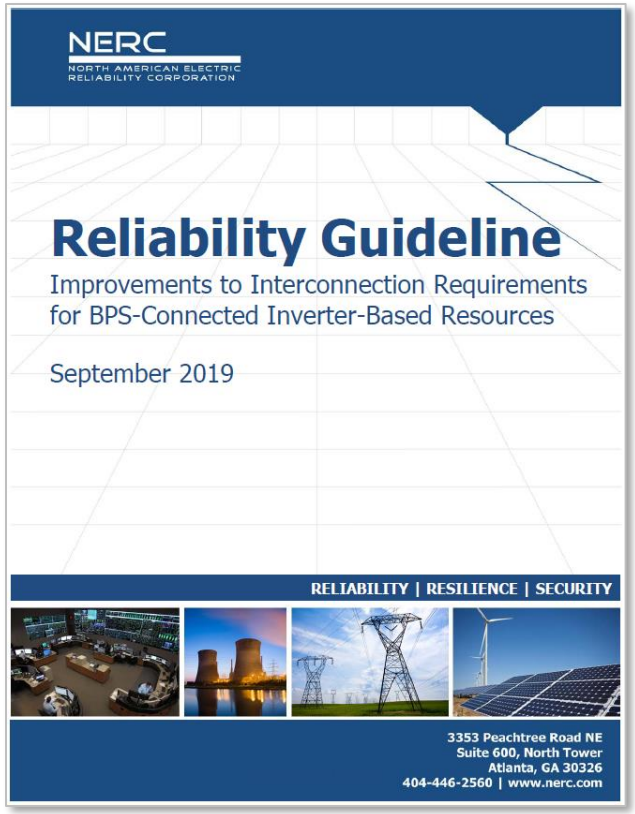
NERC Reliability Guidelines





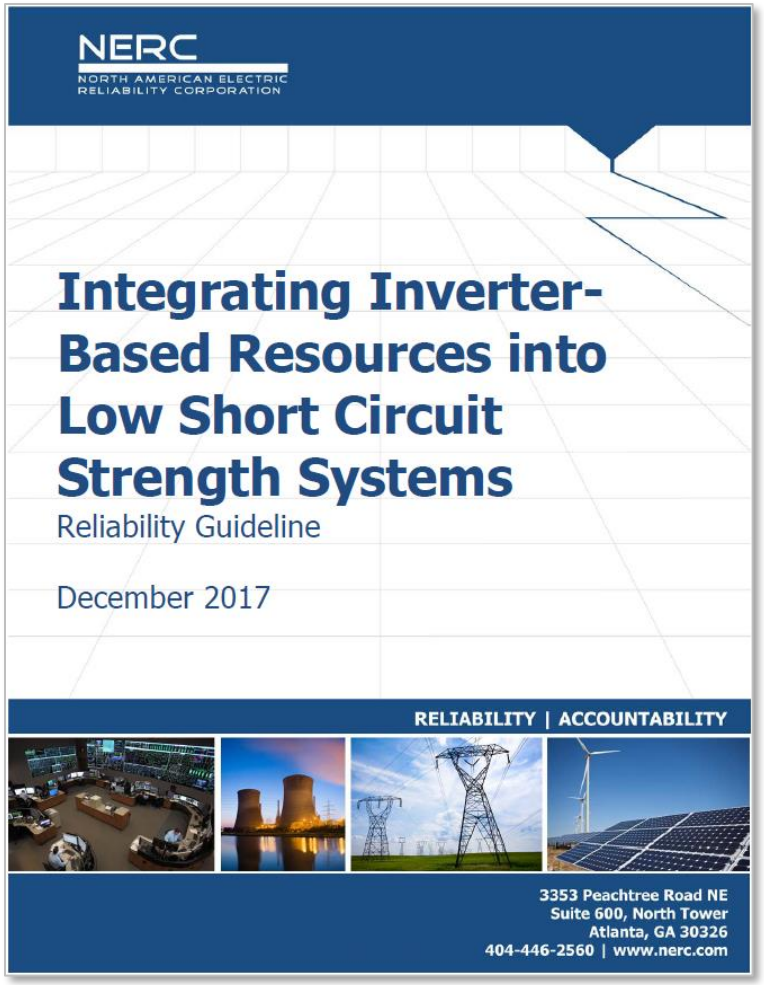
Progression of Guidelines to Industry Standards





P2800 - Standard for Interconnection and Interoperability of Inverter-Based Resources (IBR) Interconnecting with Associated Transmission Electric Power Systems

Guidelines and Reports on Inverter-Based Resource Performance



Guidelines and Reports on Inverter-Based Resource Performance

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Key Takeaways

Inverter Manufacturer and Relay Manufacturer Coordination Meeting
April 2019

NERC facilitated an in-depth technical discussion between inverter manufacturers, protective relay manufacturers, and industry experts related to current injection of bulk power system (BPS)-connected inverters during fault conditions and potential impacts and solutions for BPS protection schemes.[1] The following key takeaways, recommendations, and next steps were an outcome of this discussion.

General Takeaways

- Industry needs to collectively speak in terms of phase unbalance rather than sequence components, to better understand the underlying issues regarding current injection during faults. Sequence components are a tool for analyzing unbalanced three-phase power systems, and are derived from phase quantities.
- Protection engineers setting protective relay settings do not generally use electromagnetic transient (EMT) simulation programs. Short-circuit programs typically used by protection engineers do not accurately represent the dynamic response of inverter-based resources during the first few cycles after fault inception as the phase and sequen
- The injection of negative sequence current (I events is beneficial for existing protection possible, and in the future, should maintain t phases and faulted phases both in voltage an between sequence voltages and currents, and is consistent with conventional power system
- Inverter-based resources respond to faults b Controlled inverter response generally does (measurement and processing time delay) fro cycles of a severe[3] fault, the response from ir necessary sequence currents for protective r setting primary protection in a heavily inverte
- The concept of critical clearing time may nee inverter-based resources continue to displace

[1] This was a follow-up to the work related to the *IEEE Technical Report and Short-Circuit Performance*. Available: http://resourcecenter.ieee-p
[2] Negative sequence current supports reliable BPS operation. For exam unfaulted phases (avoiding overvoltage).
[3] Typically either a very low terminal voltage, severe voltage distortion
[4] The inverter response is highly dependent on factors including fault t

IEEE Power & Energy Society
July 2018

TECHNICAL REPORT
PES-TR68

IEEE PES Power & Energy Society
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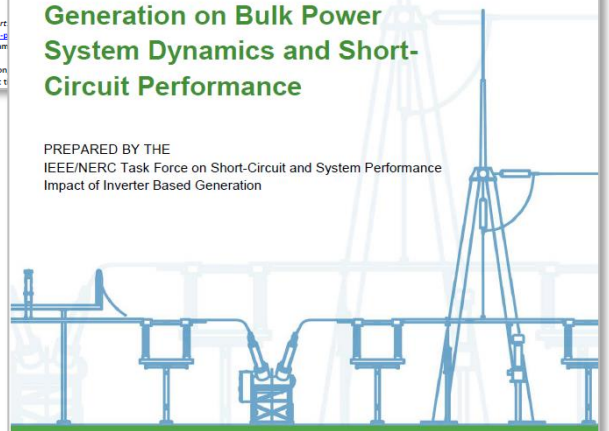
Impact of Inverter Based Generation on Bulk Power System Dynamics and Short-Circuit Performance

PREPARED BY THE
IEEE/NERC Task Force on Short-Circuit and System Performance
Impact of Inverter Based Generation



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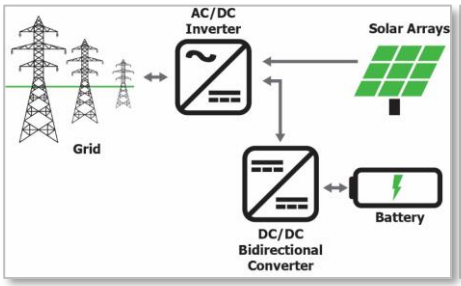
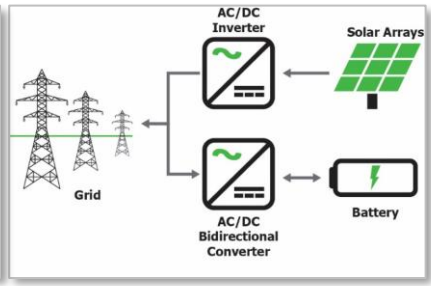
Reliability Guideline

Performance, Modeling, and Simulations of BPS-Connected Battery Energy Storage System and Hybrid Power Plants

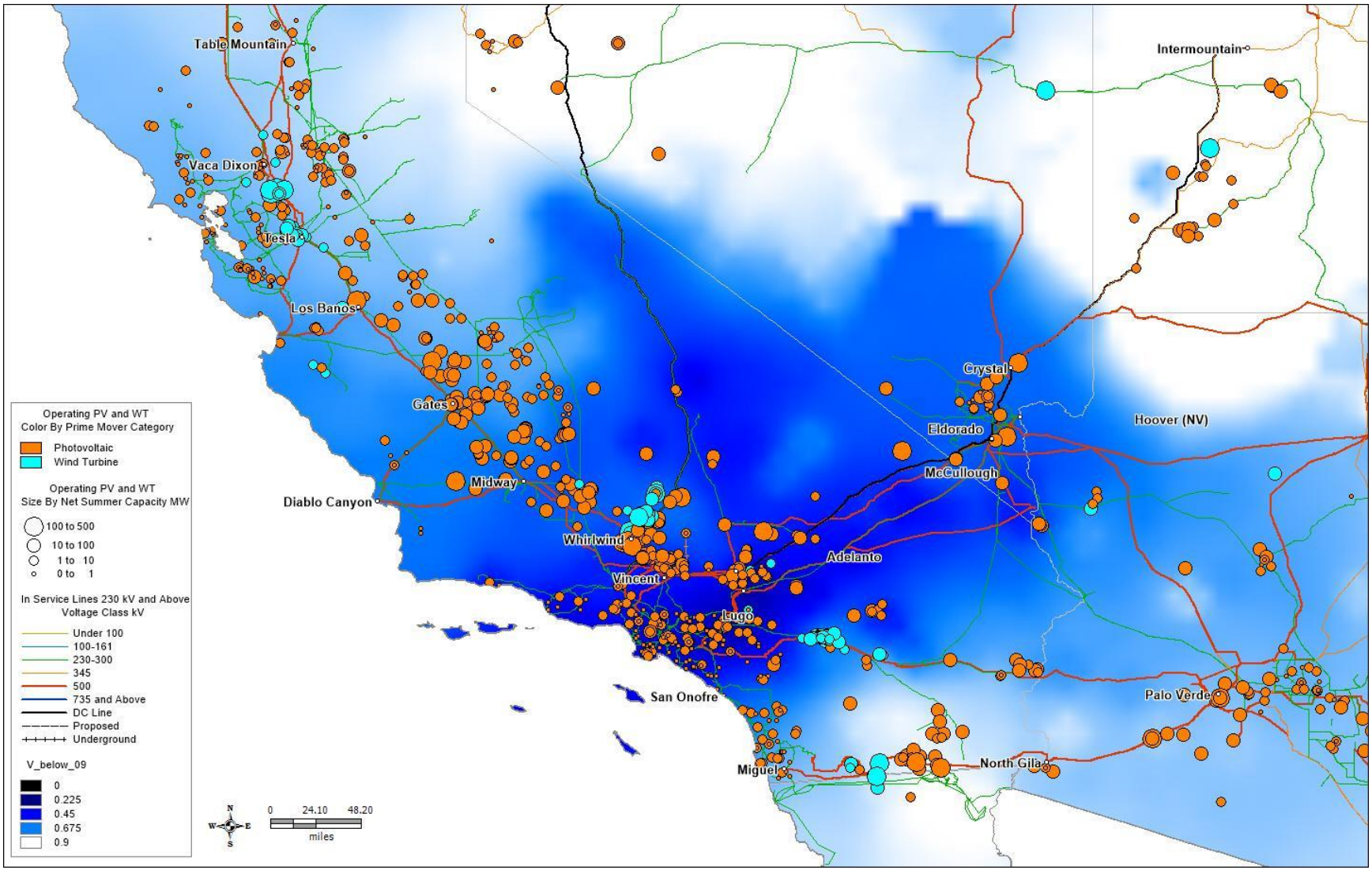
March 2020

DRAFT





Momentary Cessation – NERC Alert I



Modeling Inverter-Based Resources

The Balancing Act

New Equipment and Capabilities

Maturing Equipment Standards

Evolving Inverter Technology

Tax Credits and Incentives

Climate Change Policies

Rising Cybersecurity Concerns

Wildfires and Extreme Weather

Fuel Source Interdependencies

Multi-Sector Electrification

Microgrids and Demand-Side Changes

The Evolving Landscape

Interconnection Study Complexity

Challenges with Data Collection

Systemic Modeling Issues

Limited Data Availability

Lack of Qualified Personnel

Disparate Requirements and Studies

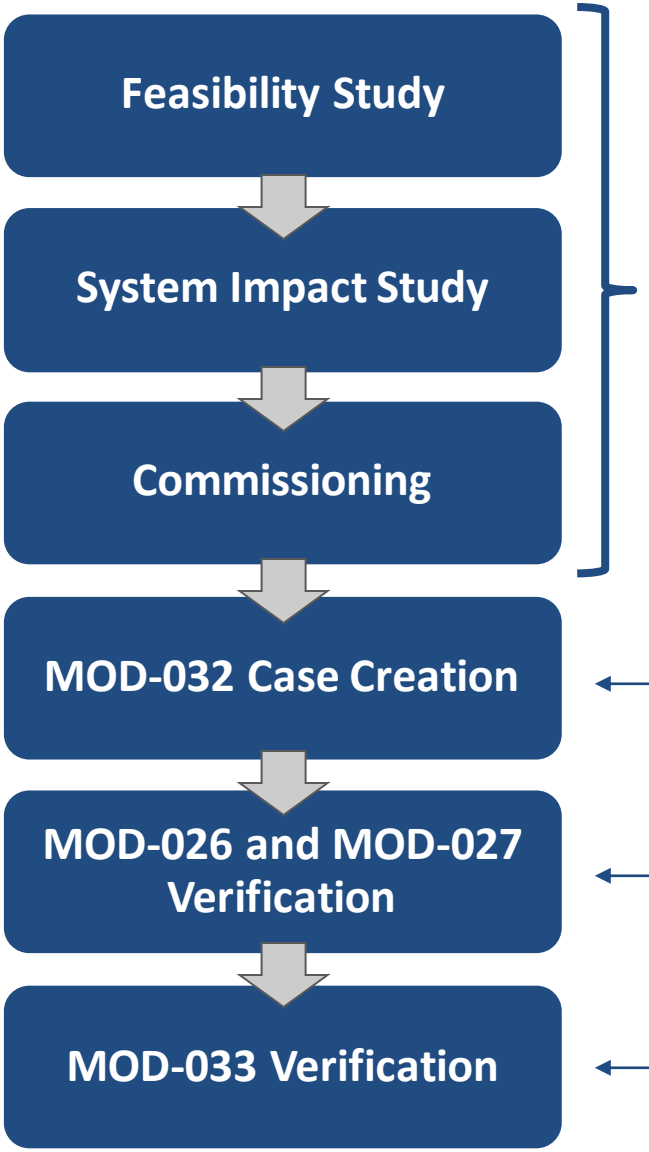
Need for Certainty in World of Variability

Growing Unknown Unknowns

Need for Energy Assurance and Resilience

Focus on Compliance Rather Than Reliability

Improvements Needed to Interconnection Process



- Expedited with inverter-based resources
- Pressures to get resources interconnected quickly
- Multiple inverter changes throughout
- Model revisions not accompanying changes
- Commissioning not resulting in verified model
- Need for EMT studies apparent, but limited in timing

- Known modeling errors exist in interconnection-wide base cases for wind and solar PV resources

- Needs Improvement (IRPTF SAR and NERC SDT being formed)

- Lack high-speed data to make notable impact on model improvements

Our Biggest Obstacles?

Adapting to Change and Mobilizing Quickly Enough to Keep Up…

- Sufficient and comprehensive data collection
- Accurate and verified models
- Streamlined interconnection process
- Suitable and adequate studies prior to interconnection
- Ability to accurately identify future reliability issues
- Sufficient time to develop solutions
- Holistic solutions that create resilience
- Ensuring mitigation of boundary-spanning risks

Hard Questions We Should Be Asking Ourselves

- Are we designing an energy system that has *assurance* of its energy supply? Particularly under extreme circumstances?
- Are we planning and designing a future grid that is as *resilient* as possible?
- Are we *confident* in our resource mix to handle extreme weather and other extreme events?
- Do we *fully* understand the new technologies being presented on the market?
- Are we *configured organizationally* to even study the right things anymore?
- Are the ways in which decisions are made *relevant* in a world of variability, uncertainty, and extremes?
- Do we truly believe that our *security posture* is sufficient to handle the growing risk of cyber threats to our critical infrastructure?

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Questions and Answers

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