NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Essential Reliability Services

An Introduction to Key Concepts

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RELIABILITY | ACCOUNTABILITY




Background and Overview

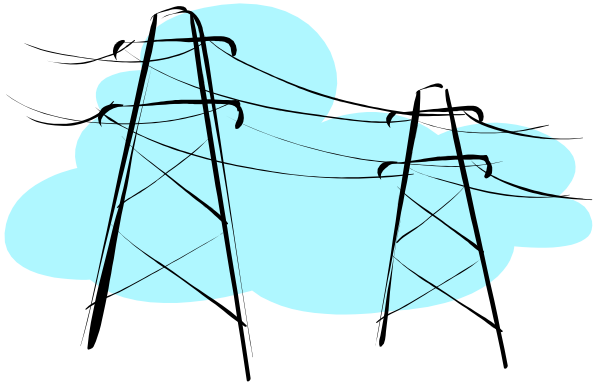
- NERC Background and Overview
  - What is the Bulk Power System (BPS)
  - NERC Mission Statement and Purpose
  - Magnitude of BPS in the USA
  - NERC Regions and Assessment Areas

What is the Bulk Power System (BPS)?

USA – 2005 Energy Policy Act and 2011 Federal Power Act[1] § 215
Canada – 8 Provincial memorandum of understanding agreements
México – 2017 memorandum of understanding agreement

"Bulk Power System (BPS)" means—

- (A) facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof); and
- (B) electric energy from generation facilities needed to maintain transmission system reliability.
- The term does not include facilities used in the local distribution of electric energy.



[1] *16 U.S.C. § 824o (2011)*

NERC : Mission and Purpose

To assure North American bulk power system reliability

Accountable as ERO to regulators in the United States (FERC) And Canada (CA NEB and provincial authorities) to:

- **Develop and enforce NERC Reliability Standards**
  - Over 100 mandatory standards (1,500 requirements) in place
  - Developed and voted on by technical experts
  - Approved and Enforced by NERC and FERC
- **Assess current and future reliability**
  - Develop reports to assess resource adequacy and identify reliability issues
  - Analyze system events and recommend improved practices
  - Manage technical committees and stakeholder groups

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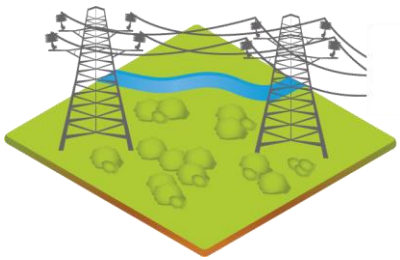
United States Bulk Power System

By the Numbers 2016

Generation

- Power Plants ≈ 7,300
- Total Capacity ≈ 1,245 GW
- Peak Capacity ≈ 1,000 GW
- Operators ≈ 950

NERC Data: GADS



Transmission

- High Voltage Line ≈ 160,000 Miles
- Operators ≈ 320
- Substations ≈ 2,000

NERC Data: TADS

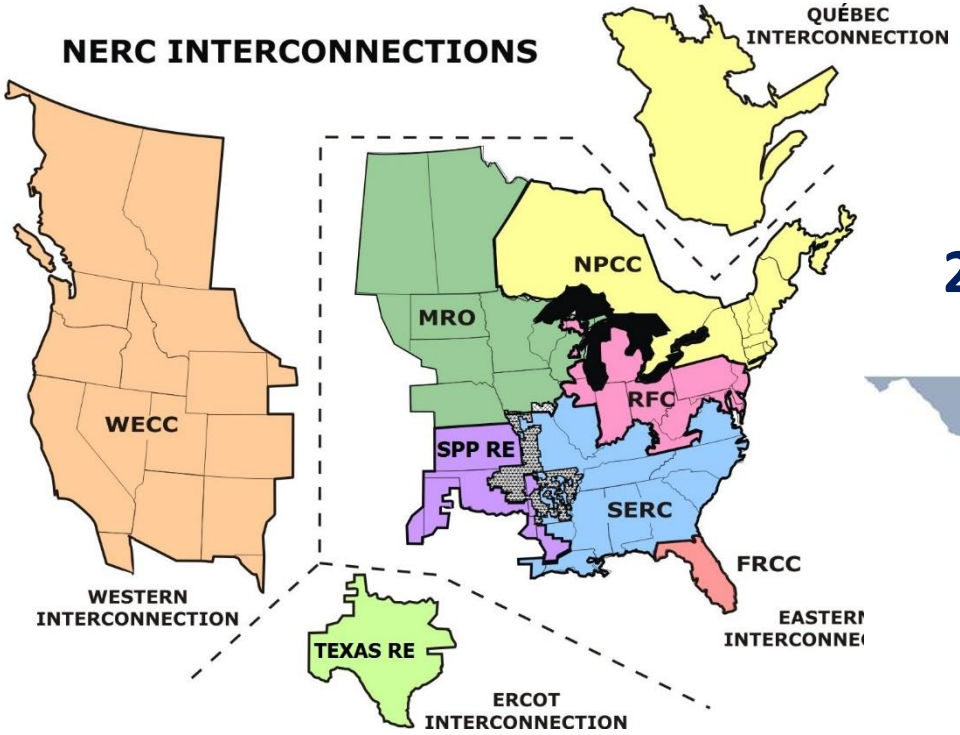
Distribution (Non-BPS)

- Line Miles ≈ 2,200,000
- Providers ≈ 430
- Substations ≈ 7,500
- Over 4,000 Utilities
- 146 Million Customers

Entire Electric System Operation

- Load Serving Entities: 430
- Balancing Authorities: 74
- Peak Load Served ≈ 865 GW
- Customers ≈ 146,000,000

NERC ERO 2016 TOTALS

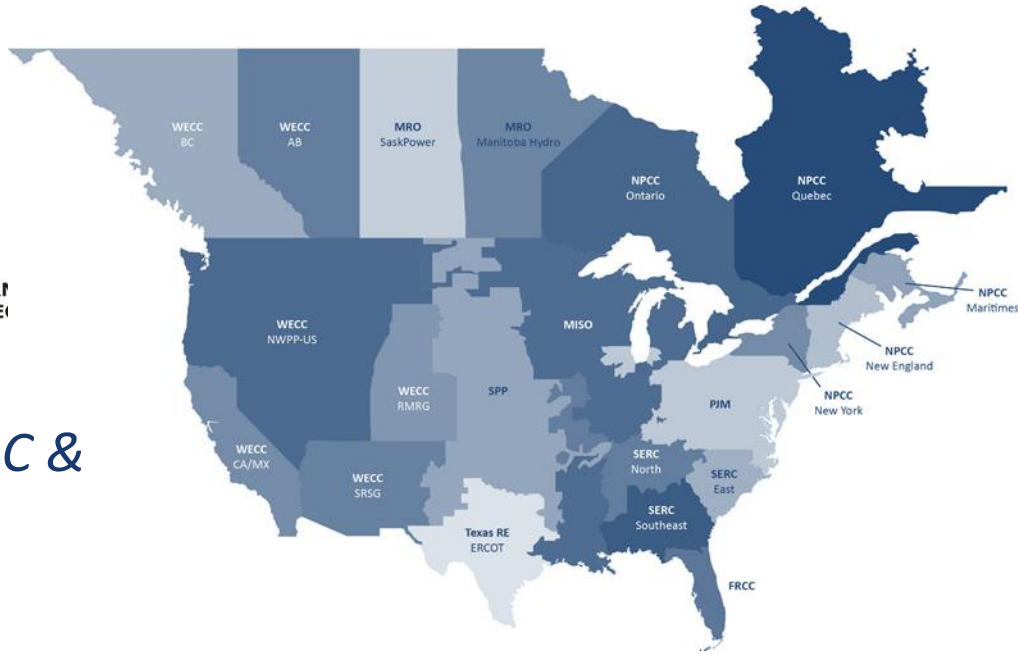


2016 Totals:

4 Interconnections

8 Regions

21 Assessment Areas



Regions: *Develop & Enforce NERC & Regional Reliability Standards*

Assessment Areas:

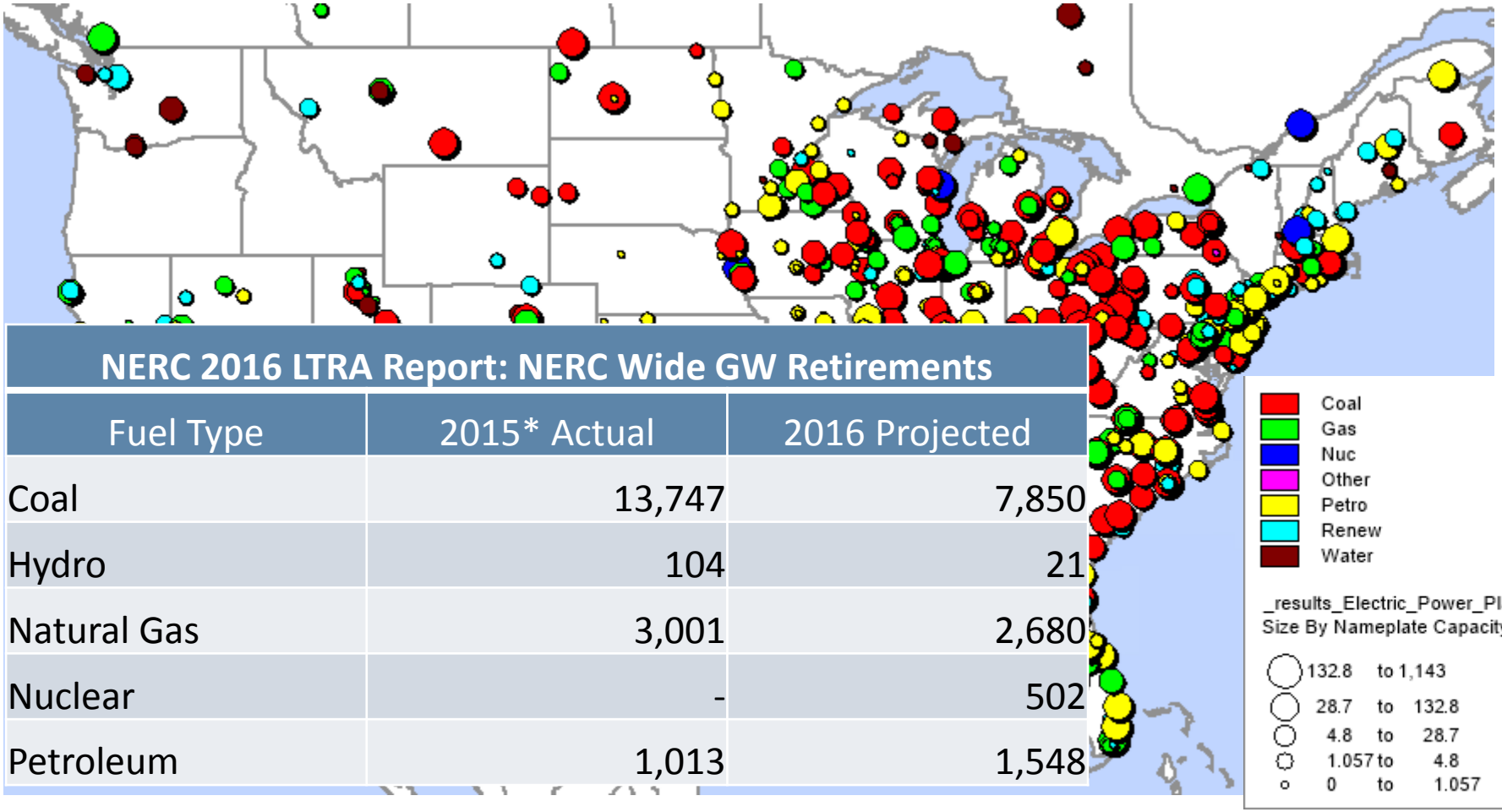
- *Used for Reliability Assessments*
- *Typically Planning Coordinator footprints*

NERC Essential Reliability Services

- Essential Reliability Services (ERS) Measures
  - ERS Building Blocks Fundamentals
  - ERS Introduction to Measures
  - ERS Working Group's Main Deliverables
  - Future Work

United States BPS January 1, 2010 to July 31, 2017 Retirements[4]

[4] *Velocity Suite. (2017). Retrieved July 12, 2017, from ABB Link to Market-intelligence-services-velocity-suite*

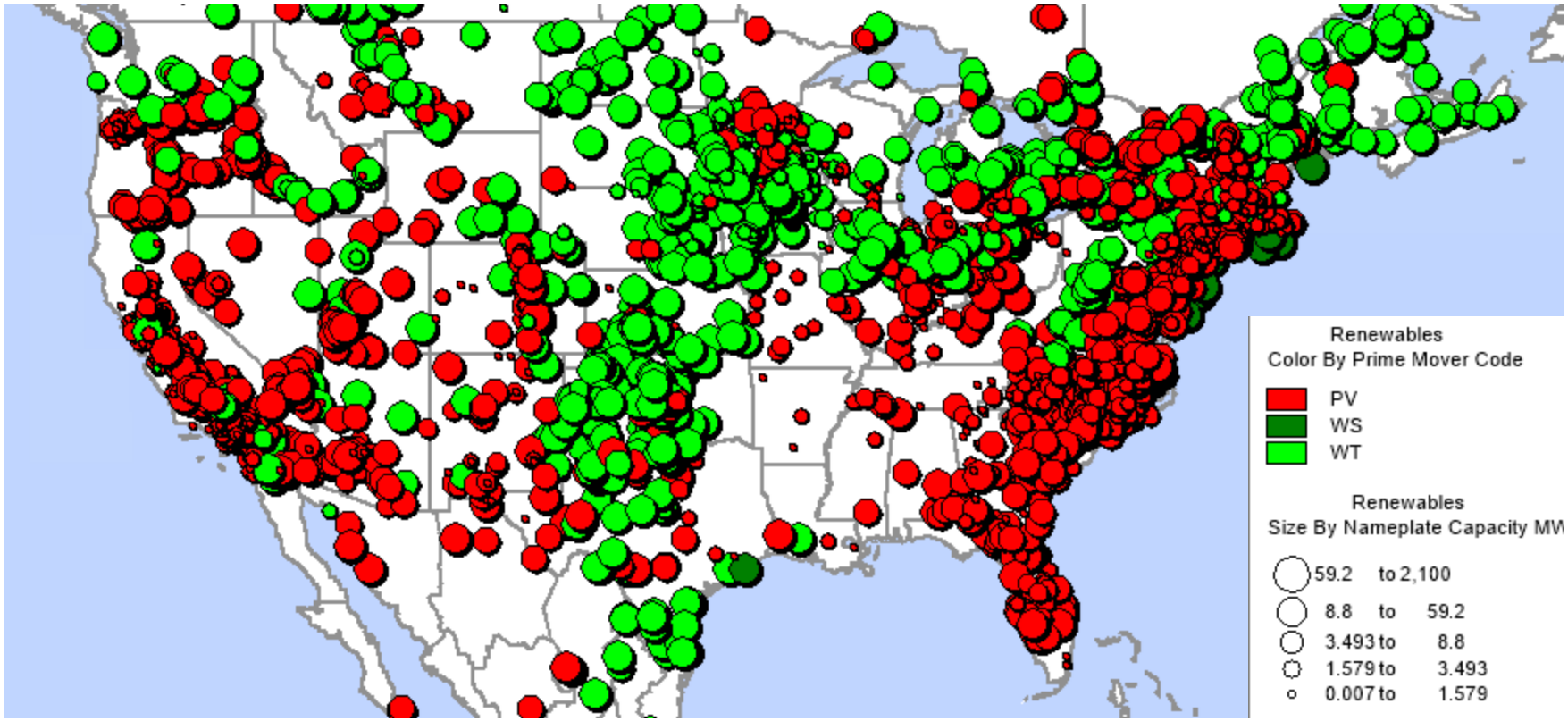


NERC 2016 LTRA Report: NERC Wide GW Retirements		
Fuel Type	2015* Actual	2016 Projected
Coal	13,747	7,850
Hydro	104	21
Natural Gas	3,001	2,680
Nuclear	-	502
Petroleum	1,013	1,548

Predominant Retirements are Large Synchronous Generators (Gens)

United States BPS Variable Energy Resource (VER) Additions[5]

[5] *Velocity Suite. (2017). Retrieved July 12, 2017, from ABB Link to Market-intelligence-services-velocity-suite*



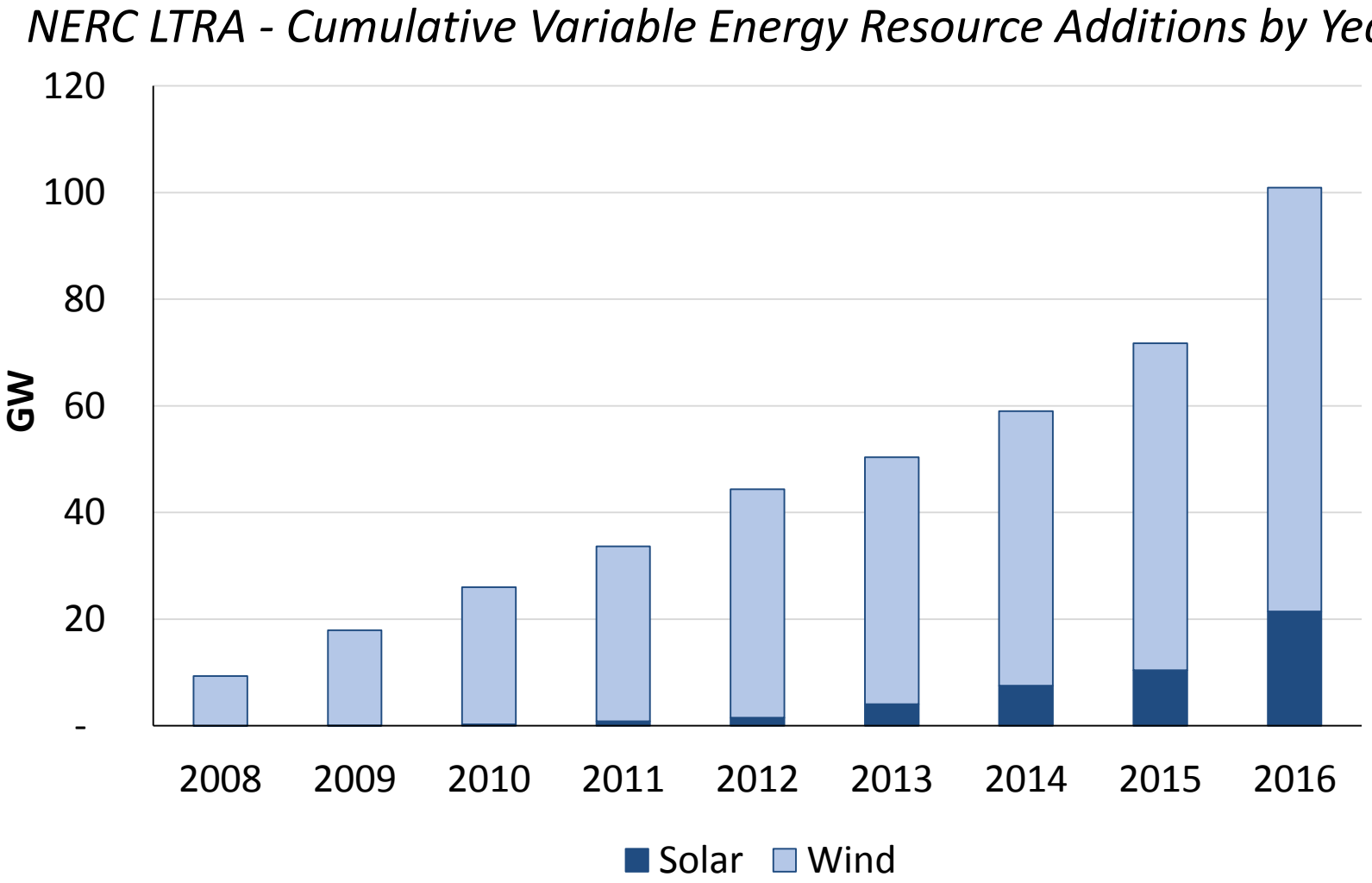
January 1, 2010- December 31, 2017 Operating & Planned Resources

Photovoltaic (PV) and

Wind (WS – Off Shore Wind, WT – Terrestrial Wind Turbine)

Figure #. Annual Additions To NERC BPS By Variable Energy Resources (VER)[6]

[6] *NERC Long Term Reliability Assessments. (2017).* NERC RAPA LTRA Page



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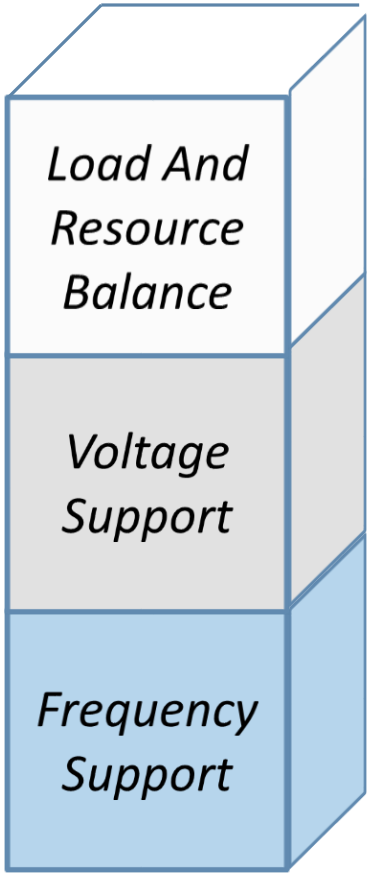
High Level of Utility Renewable Generation : Key Considerations

Reliably integrating a large number of VER into the BPS requires significant changes to traditional system planning & operation methods

Forecasting	*Flexibility*	*Transmission*

• Variable Energy Must Be Used When Available
• Forecast is only information; operator must make informed decisions
• "It's the ramps, not the ripples"
• Methods for calculating expected on-peak capacity
	• More Ancillary Services
	• Larger Balancing Authorities
	• Flexible Resources
	  • *Storage*
	  • *PHEV*
	  • *Leverage fuel diversity of other variable resources*
		• Interconnect variable energy resources in remote areas
		• Construct/site/ permit transmission to deliver power across long distances

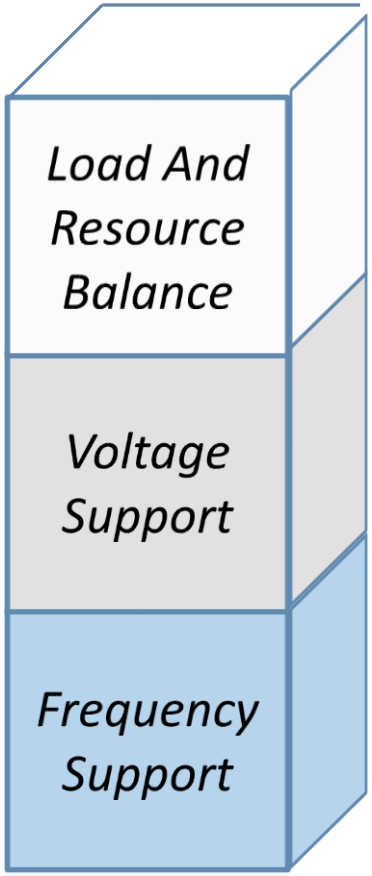
ESSENTIAL RELIABILITY SERVICES (ERS) FUNDAMENTALS



- "Building blocks" of physical capabilities
- Stressed by resource changes
- Not all MWs are equal
- Some partly covered through ancillary services
- Accommodate local/regional needs

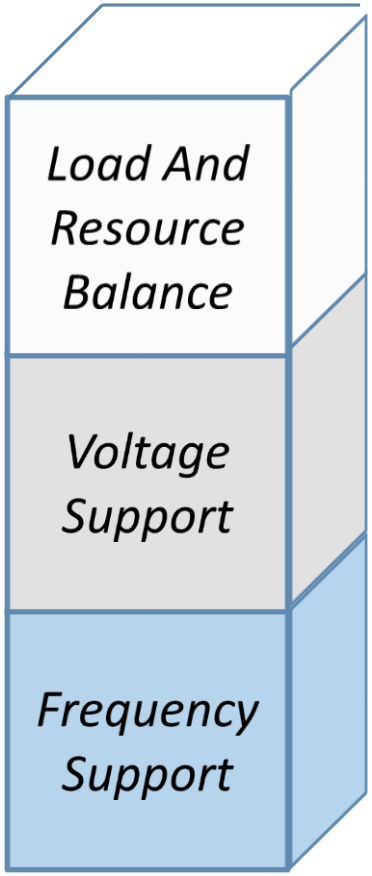
Reliability Assessments URL

Frequency Support



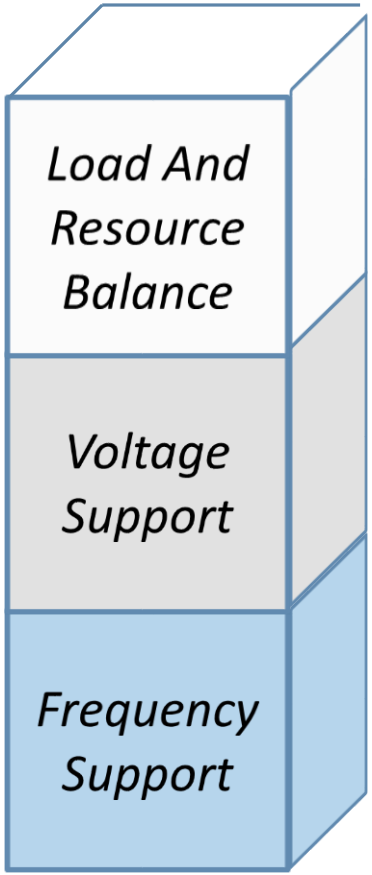
- Frequency is an indication of the real-time balance between supply and demand.
- Frequency Support ensures the frequency of the BPS can be synchronized and stabilized for both normal and contingency conditions.
- Frequency control can be broken into 4 stages:
  1. Inertial Response
  2. Primary Frequency Response
  3. Secondary Frequency Response
  4. Tertiary Frequency Response
- Daily operation of the BPS requires a continuous balance of load and resources
- Operational flexibility is needed to manage real-time changes in load and generation.

Frequency Deviations Risks



- Large frequency deviations can result in equipment damage and power system collapse.
- Interconnection frequency deviation can result in:
  - Load Shedding
  - Interconnection Islanding
  - Direct risk to BPS Stability and Reliability
  - Imbalance in generation and load which can overload transmission facilities
  - Protection equipment malfunctioning and damage
- **Prolonged imbalance can result in violation of NERC Reliability Standard (BAL-001-1)**

Voltage Support

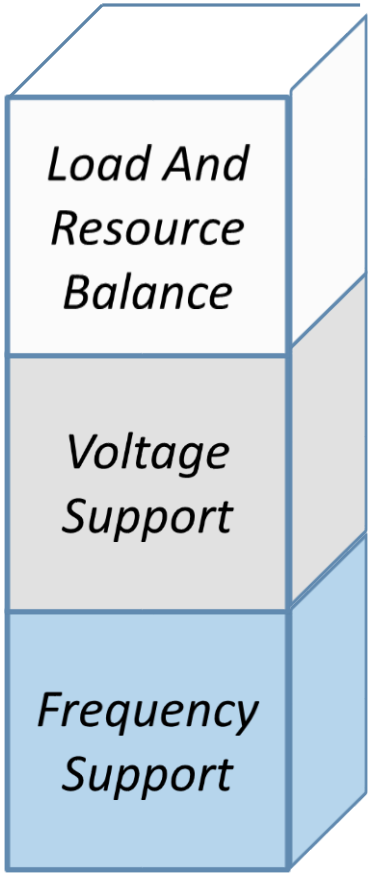


- The primary objective is to maintain the voltages in the transmission system within a secure, stable range.
- Voltage Support is location specific and requires reactive power control from reactive resources distributed throughout the power system.

Lack of Voltage Support could lead to:

- Localized issues that spread can lead to a loss of load
- Voltage exceedance which breaks down insulation in equipment
- Under-voltage can lead to equipment overheating and motors stalling
- Voltage collapse can lead to cascading drop in voltage

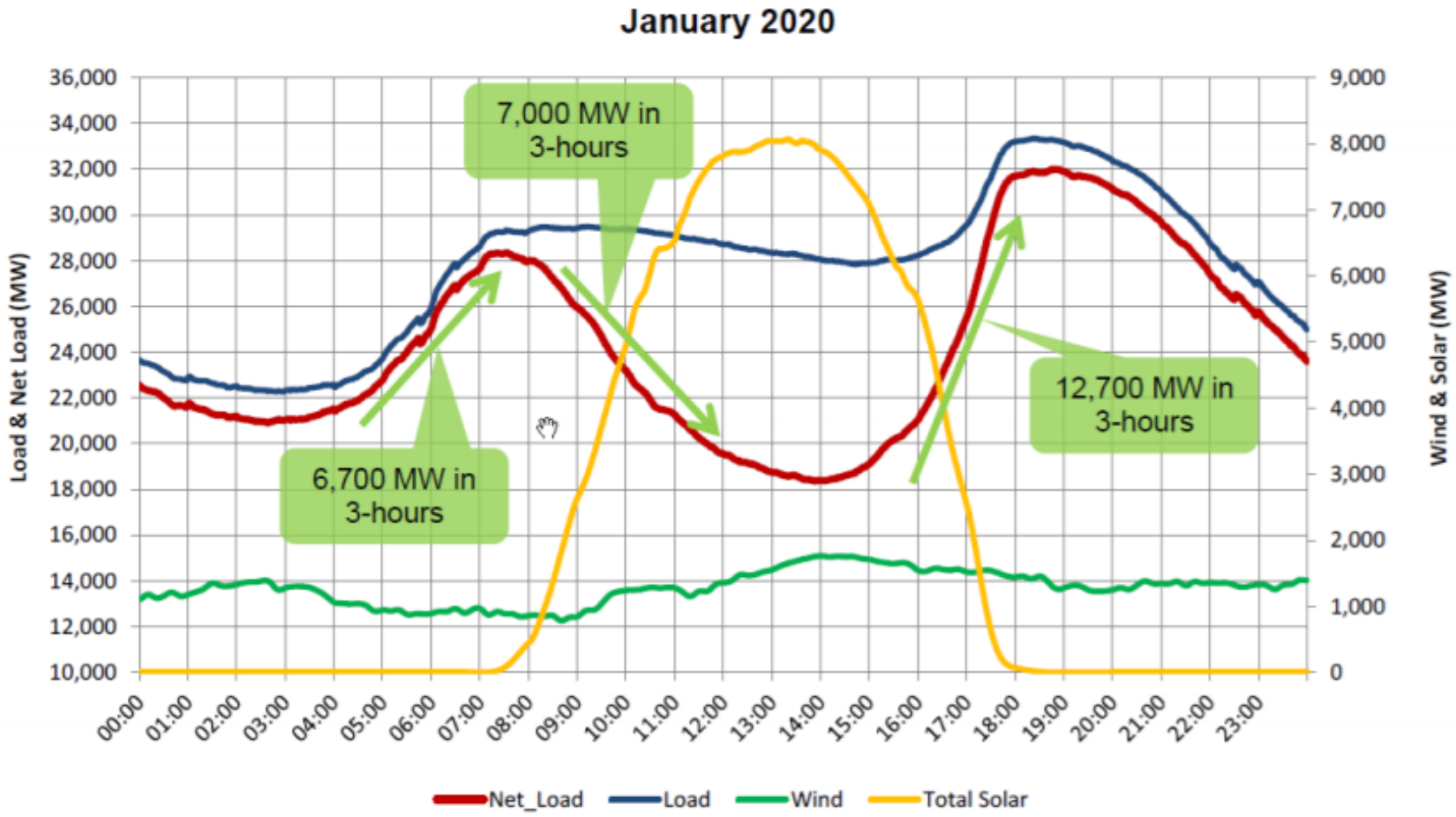
Load and Resource Balance (Ramping/Load Following Capability)



- Ramping capability is the ability to use real-power control to raise or lower resources over a period of time to maintain the load - generation balance.
- Real power control is needed when major load shifts, e.g. morning ramp-up, afternoon ramp-down, and evening ramp-up.
- As the typical daily load curve changes due to integration of off-peak electrical loads ramping needs may also change to off-peak ramps.

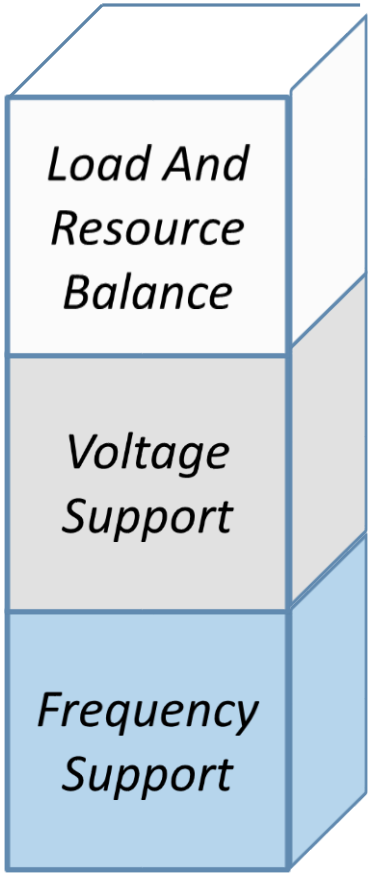
Lack of Ramping Capability Can Lead to System Imbalance

Example Daily Generation and Load Curves in Year 2020



Wind and Solar Baseload Scenario for Ramping in 2020

ERS Creation of Historic and Forward Looking Measures



[ERSTF Framework Report - URL]

Load & Resource Balance (Ramping & Balancing)

- Track and project the maximum one-hour and three-hour ramps for each balancing area

Voltage (V) Support

- Track and project the static and dynamic reactive power reserve capabilities to regulate V at points in the system
- Review the short circuit current at each transmission bus in the network, and calculate short circuit ratios

Frequency Support *(restoring after a major unit loss)*

- Track minimum frequency & its response post N-1 event
- Track & project level of conventional synchronous inertia
- Track & project the initial frequency deviation in the 1st $^1/_2$ second following the largest N-1 event

ERS Working Group Background on Activities and Deliverables

- 2015 Deliverables
  - Framework Report with **10 Preliminary Measures** for Investigation by ERO
- 2016 Activities and Deliverables
  - Perform process development and investigation on ERS Measures
  - A whitepaper on methodology for ERS Measures Sufficiency Guideline
- 2017 Activities and Deliverables
  - Develop 3-5 page papers on ERS Measures data collection and reporting
  - Goal is to clearly document how each respective measure's data is used:
    - Historical reporting → State of Reliability report, NERC PAS reports
    - Future reporting → Long Term Reliability Assessment report

BPS VER Generation Reliability Requirements

Maintaining BPS reliability requires grid support from VER

1. Active power control (APC) capabilities include:
   - *Ramp-rate limiting controls*
   - *Active power response to BPS contingencies*
     - Inertial (H) response
     - Primary frequency response (PFR)
     - Secondary frequency response, or participation in Automatic Generation Control (AGC) , Fast Frequency Response (FFR)
2. Performance during and after disturbances
   - *Fault ride-through (low voltage, frequency)*
   - *Short-circuit current contribution*
3. Dynamic and steady state control and regulation:
   - *Voltage, Reactive Power, Power factor*

Future VER Work

The impact of VER on the BPS is not a simple issue

- At lower penetration levels, the overall impact of is minor and can be managed by existing BPS resources
- At higher penetration levels, issues may develop in transmission line loading, grid voltage, and system frequency during normal or disturbed operation if ERS measures are not considered

NERC continues to work with the Industry to:

- Trend and Improve ERS Measures
- Include ERS Measures in BPS Planning and Operations
- Include ERS Measures in NERC Annual Reports

Links to ERS Activities

NERC ERS Homepage

- 2014 Concept Paper on ERS
- Videos : The Basics of Essential Reliability Services
- Tutorial : Maintaining BPS Reliability & Adapting to Changing Resource Mix
- ERS Framework Report
- ERS Sufficiency Guideline Report
- DERTF Workshop on Reliability of BPS with large amounts of DER
- Reliability Guideline for Reactive Power Planning – URL
- Integration of Wind Generation into Weak Grids
- EPRI Flexibility Assessment Metrics

Questions and Answers