



## Integration of Inverter Based Resources into ERCOT System: Challenges and Solutions

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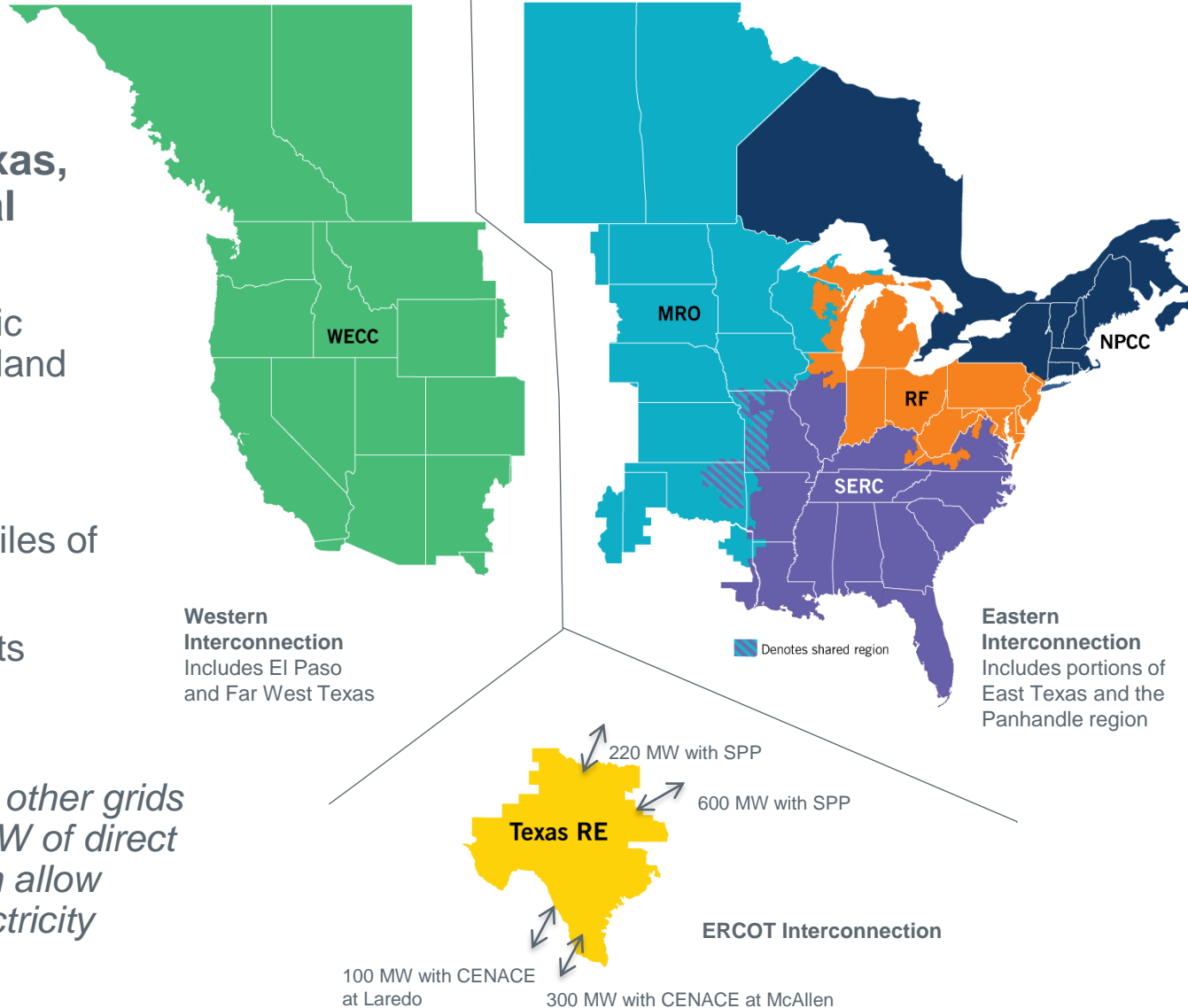
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# The ERCOT Region

The interconnected electrical system serving most of Texas, with limited external connections

- 90% of Texas electric load; 75% of Texas land
- 74,820 MW peak, Aug. 12, 2019
- More than 46,500 miles of transmission lines
- 650+ generation units (excluding PUNs)

*ERCOT connections to other grids are limited to ~1,220 MW of direct current (DC) ties, which allow control over flow of electricity*



# ERCOT Facts

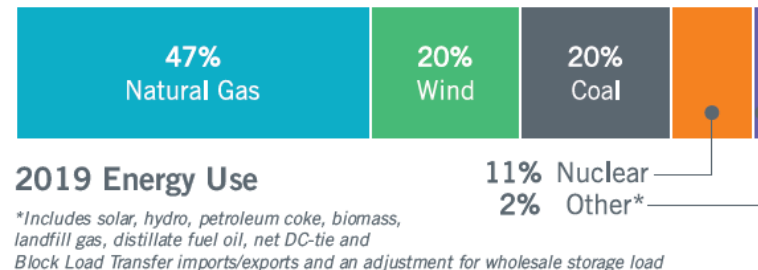
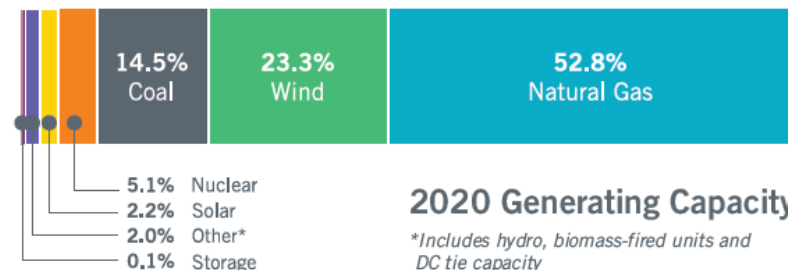
Inverter Based Resources* (IBR)	Installed as of 7/31/2020, MW	Installed by the end of 2022**, MW
Wind	24 976	36 990
Solar PV	3 275	16 225
Battery Storage	153	1 191

\* Includes only resources ≥1MW registered with ERCOT

\*\* Includes existing and planned IBRs with signed interconnection agreements and commercial operation date before the end of 2022.

## Wind Generation Records (instantaneous)

- Output: 21,375 MW
  - June 28, 2020, 11:22 p.m.
- Penetration (load served): 59.30%
  - May 2, 2020 2:10 a.m.
  - Total MW Served by Wind = 19,426 MW



384 billion kilowatt-hours of energy were used in 2019, a 2 percent increase compared to 2018.

# Challenges and Solutions with High IBR

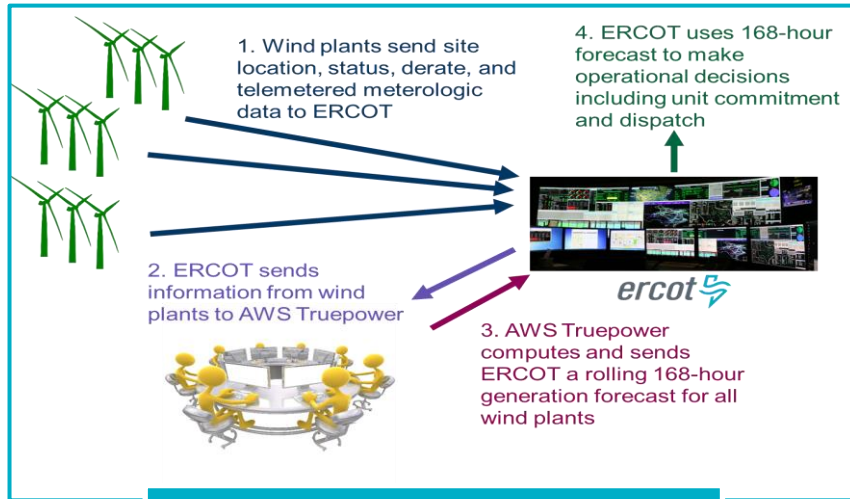
## Challenges

- Variability
- Uncertainty
- Location, need for additional transmission
- Impact on Essential Reliability Services (voltage and frequency support)
- Impacts on system stability
- Modelling challenges and adequacy of the study tools
- Etc...

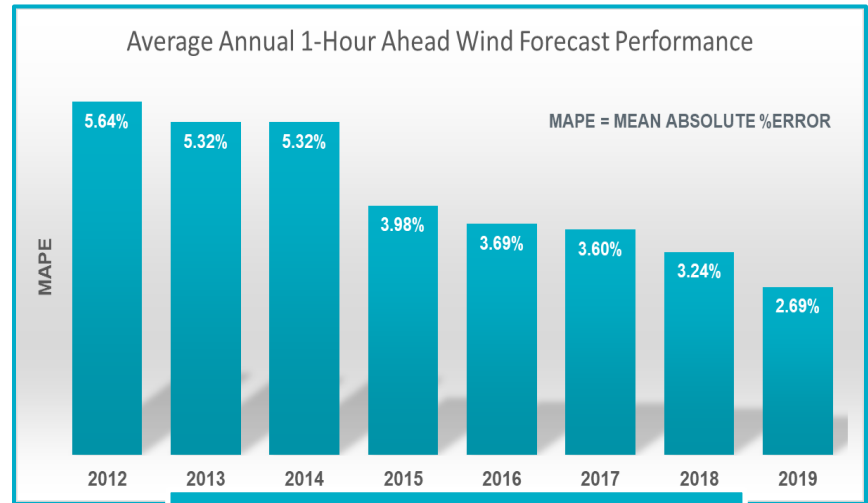
## Solutions

- Forecasting
- New Ancillary Services
- Reserve requirements based on changing system conditions
- Real time studies and situational awareness
- Real time limits on some transmission corridors
- Transmission reinforcements
- Modelling guidelines
- Etc...

# Wind and Solar Forecasting



Centralized forecasting



Improving forecast accuracy

- Wind forecasting in use since 2009. Average MAPE for day-ahead and hour ahead wind forecast was 4.6% and 2.7% respectively in 2019
- Solar forecasting was introduced in 2017. Average MAPE for day-ahead and hour ahead solar forecast error was 6.6% and 5.7% respectively in 2019.
- Currently, ERCOT uses a 168-hour rolling forecast with hourly resolution for all wind/solar resources. ERCOT also uses 15 min real-time forecasts in dispatch.

# Ancillary Services Changes

## New Framework, NPRR 863

Regulation Up

157 to 687 MW

Regulation Up

157 to 687 MW

### Responsive Reserve Service (RRS)

Fast Frequency Response (FFR)

Load Resources on UFR

Primary Frequency Response (PFR)

2,300 to 3,200 MW

### ERCOT Contingency Reserve Service (ECRS)

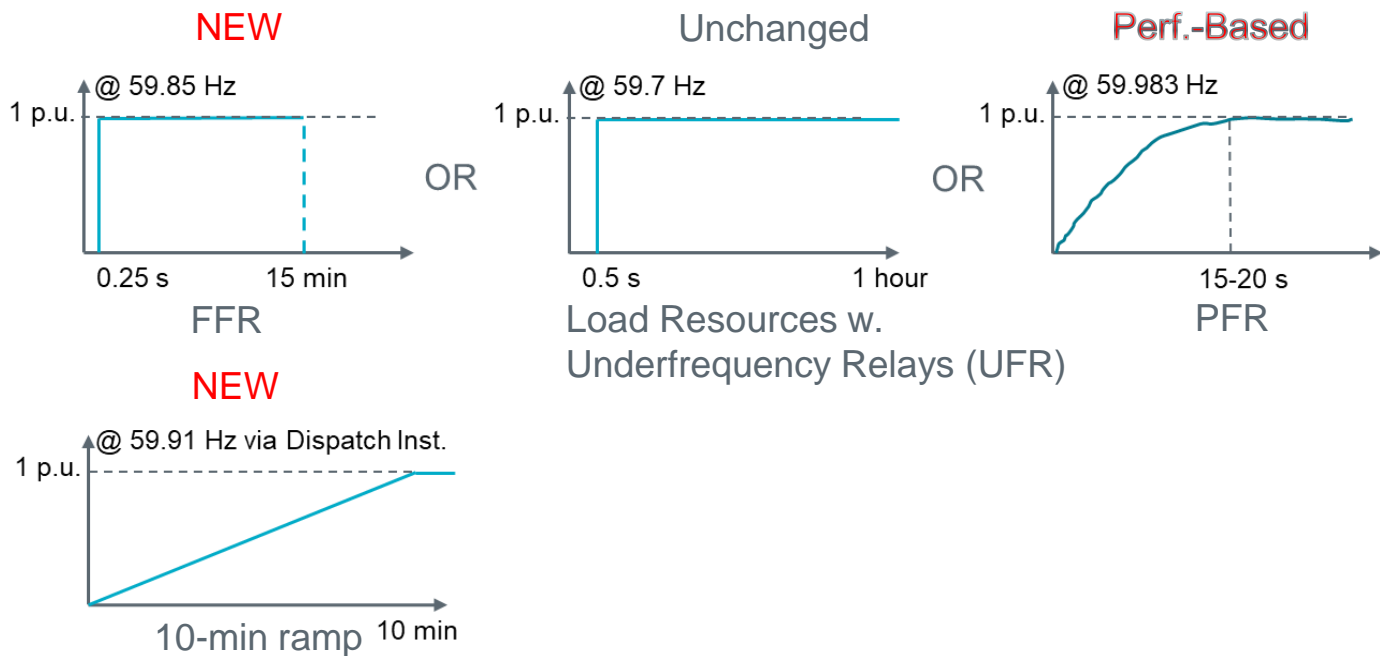
10 minute ramp

Load Resources may or may not be on UFR

508 to 1,644 MW

Non-Spin

0 to 1,180 MW



Overall A/S: 3,807 to 5,958 MW\*

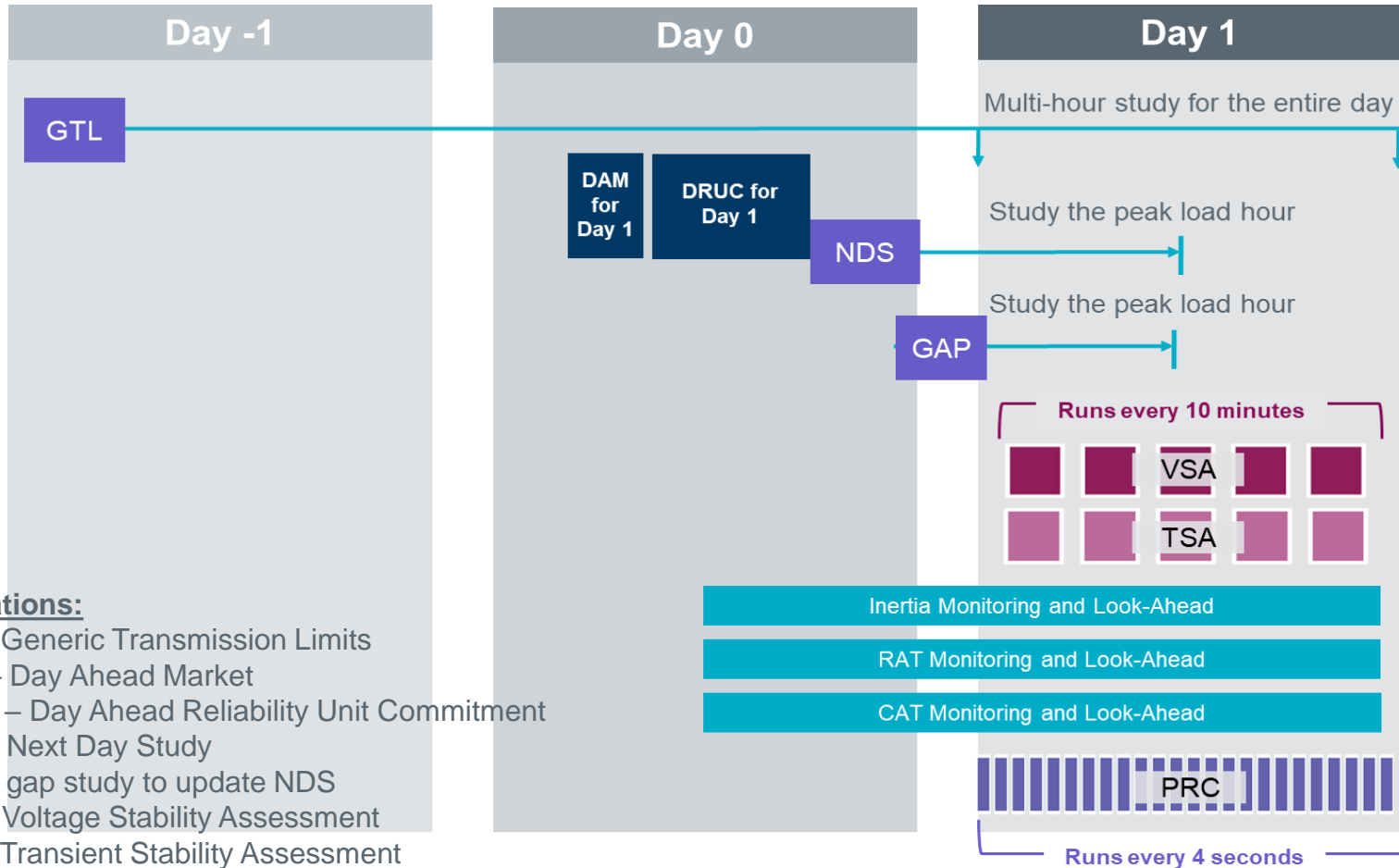
FFR implemented on 3/1/2020 and ECRS will be implemented in 01/2024



# Interconnection Requirements for IBRs

- **Voltage Support:** to provide leading and lagging reactive capability with 0.95 power factor. This capability limits has to be provided continuously independent of the active power output level;
- **Frequency Support:** to provide primary frequency response with maximum 5% droop and maximum frequency dead-band of +/-0.017 Hz when frequency responsive headroom is available.
- **Voltage and Frequency Ride Through Capability:** to maintain the ability to remain connected to the grid and providing necessary support during voltage and frequency events of pre-defined severity.
- **Dispatchability:** to follow the dispatch instructions for maintaining or adjusting power output in a timely and precise manner.
- **Ramping:** to limit ramp rate of each wind or solar resource to 20% per minute of its MW nameplate rating, when responding to ERCOT dispatch instructions.
- **Telemetry:** to provide numerous telemetry data points to ERCOT with time resolution of 2 to 10 seconds. These data points are critical to operation studies and situational awareness tool as well as for offline analysis.

# Operations Analysis and Studies

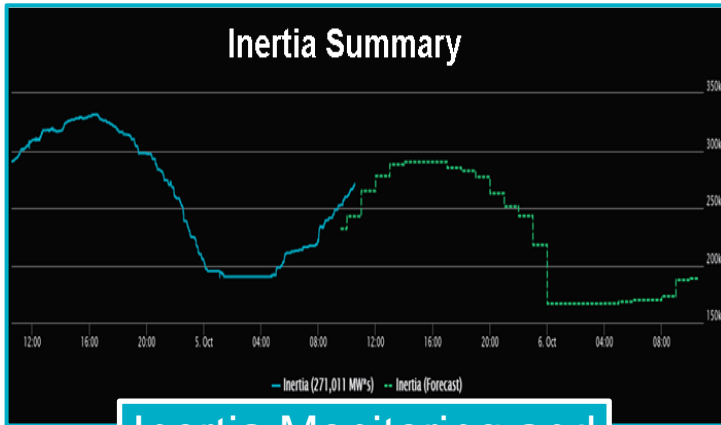


**Abbreviations:**

- GTL – Generic Transmission Limits
- DAM – Day Ahead Market
- DRUC – Day Ahead Reliability Unit Commitment
- NDS – Next Day Study
- GAP – gap study to update NDS
- VSA – Voltage Stability Assessment
- TSA – Transient Stability Assessment
- RAT – Reserve Adequacy Tool
- CAT – Capacity Adequacy Tool
- PRC – Physical Responsive Capability



# Reliability Risk Desk, Situational Awareness

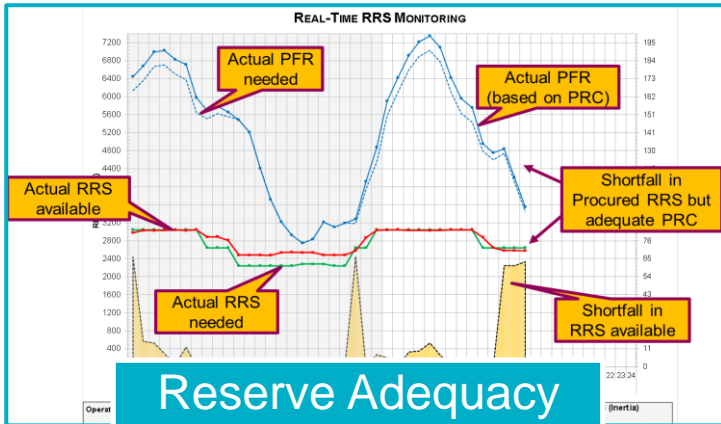


Inertia Monitoring and Forecasting

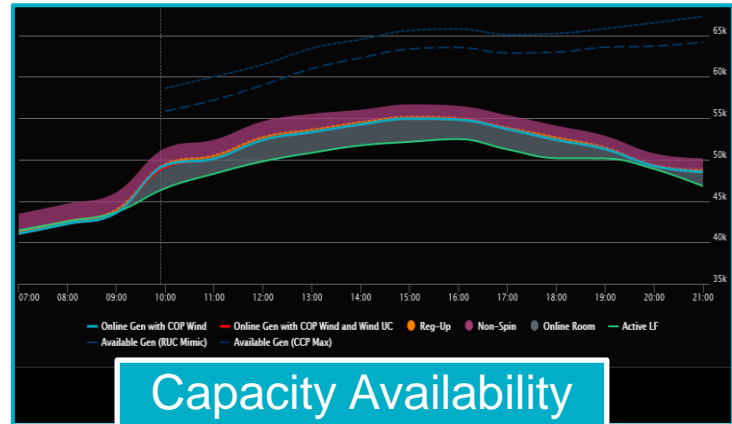
- 120 GW\*s >= Inertia **Normal**
- 120 GW\*s > Inertia >= 110 GW\*s **Yellow**
- 110 GW\*s > Inertia >= 100 GW\*s **Orange**
- 100 GW\*s < Inertia **Red**

Emergency BPs	Inactive
System Inertia	99,999 MW-s
SCED	00:04:00
RLC	00:00:06
STLF Forecast High	21.6
STLF Next 30 Mins	Normal
QSE ICCP	Normal

Critical Inertia alerts



Reserve Adequacy Tool



Capacity Availability Tool

## Key Takeaways

- System operators in areas with growing amounts of renewables face challenges with system balancing (uncertainty, ramping, variability, voltage and frequency control);
- Granular real-time dispatch and accurate forecasting is key;
- Real-time studies and awareness tools are essential for efficient and reliable operations with high levels of renewable resources;
- Accurate models of inverter-based resources in all planning and operations study tools are becoming extremely important.
- Ancillary Services can satisfy essential reliability needs for the system
  - Use market-based solutions as much as possible
- Some of the reliability requirements need to be implemented through grid codes. Modern renewable generation technology can provide grid support.

*Resolving integration issues increasingly requires ongoing coordination between grid/market operators, generation owner/operators and turbine/control manufacturers*

# Thank you! Questions?



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