QUANTA TECHNOLOGY

Smart Solutions, Real Results

LOW INERTIA SOURCES AND SYSTEM STABILITY

CAPER Meeting, August 7 & 8, 2017

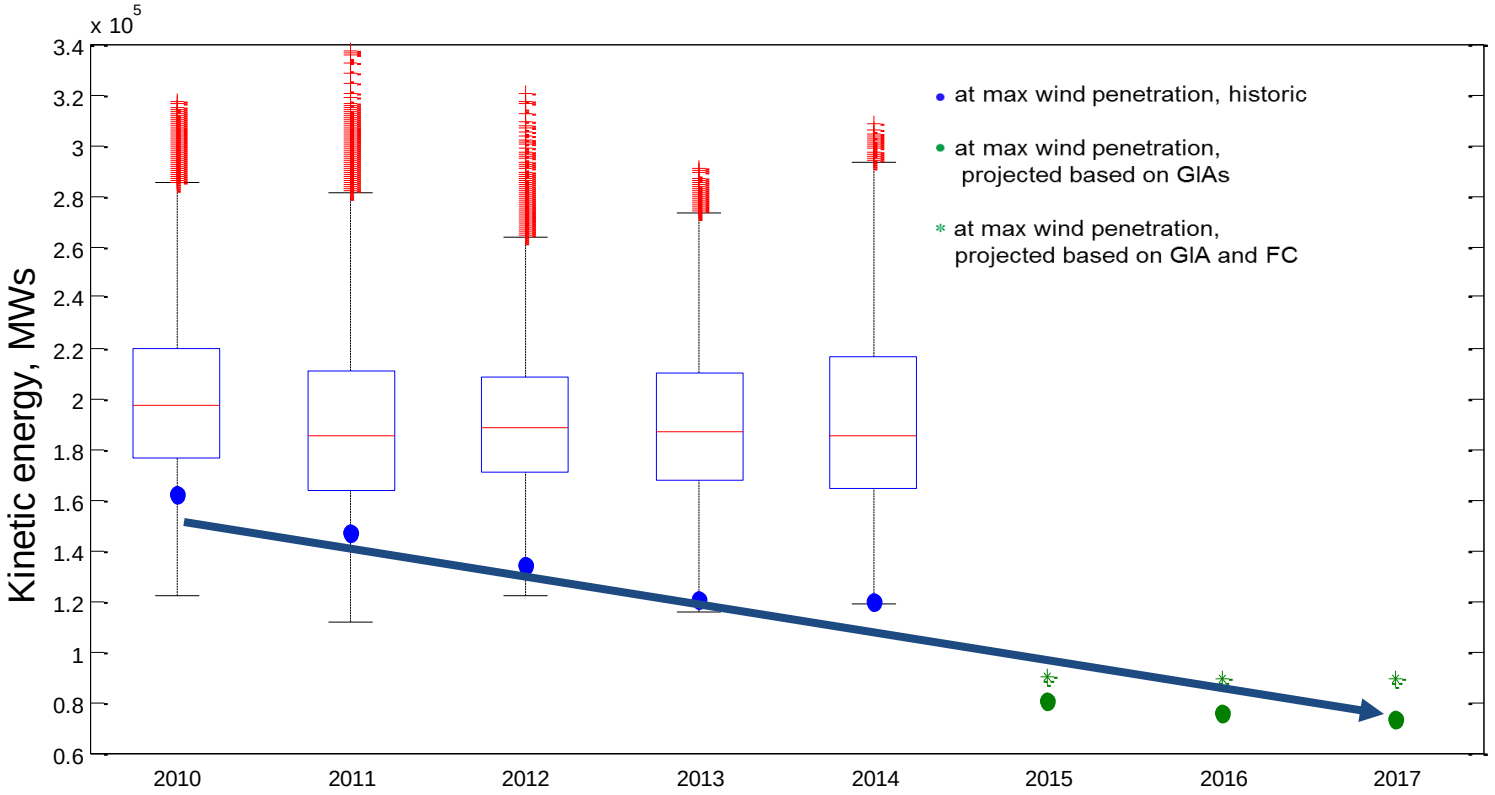
Dino Lelic

Sources of Low Inertial /Governor Response

- High Penetration of Wind and Solar Inverter Based Generation
  - Synchronous machines not scheduled on at peak renewable/low load periods
- Replacement of Induction Motor based load with Variable Speed Drive Technologies
  - Driven by energy efficiency, process control, six sigma ---
- Some places to learn from:
  - Islands: GB, Ireland
  - Electrical Islands: Scandinavia, ERCOT
  - Places with Highest Renewables: CA ISO, Germany
- Other Related Issues
  - Volatility and Forecasting Difficulties
  - Ramping
  - Dispatchability
  - Maintaining Footroom / Headroom for Response and Dispatch

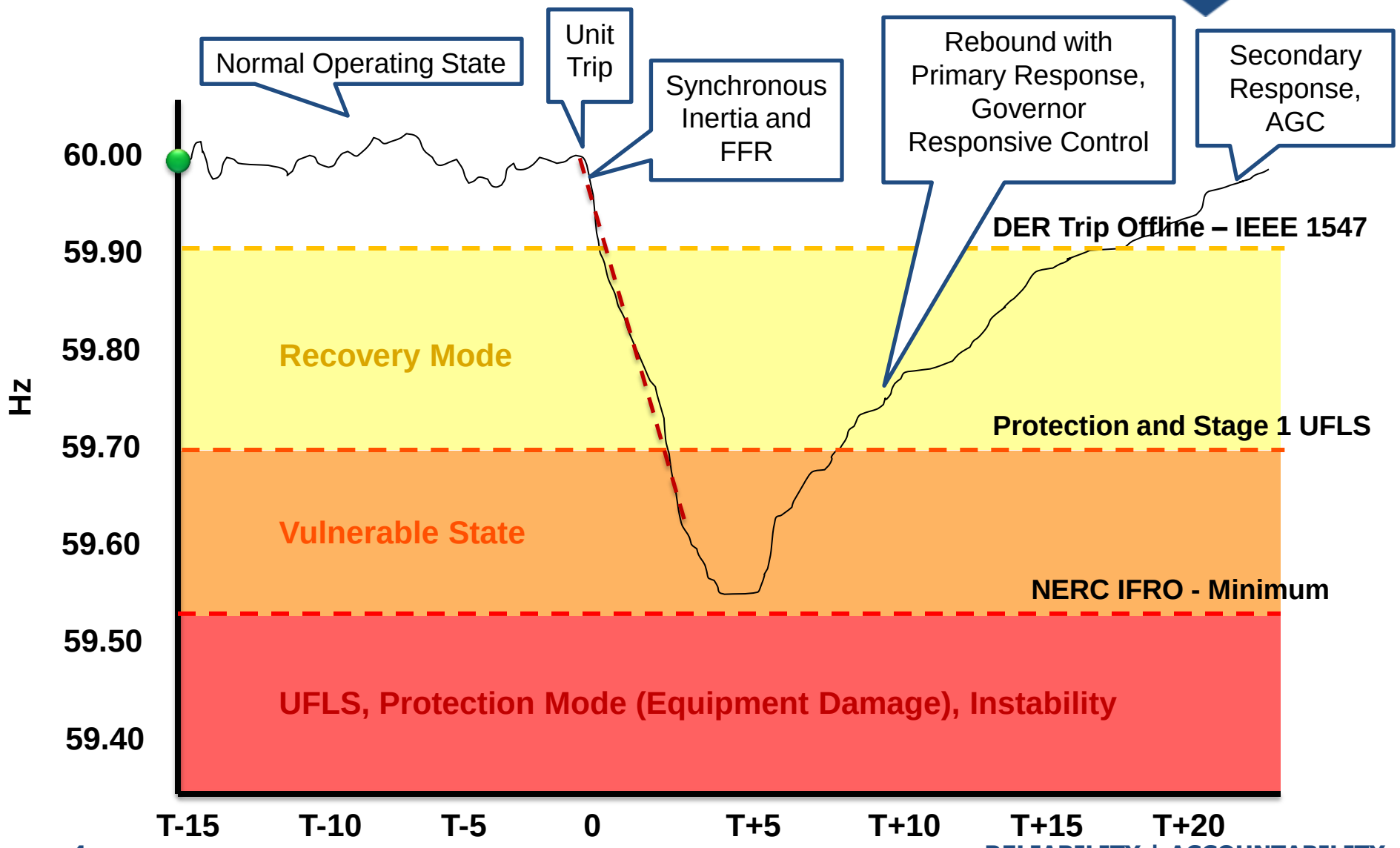
ERSTF Enabled to Monitor Trends in Frequency

Synchronous inertia is declining……

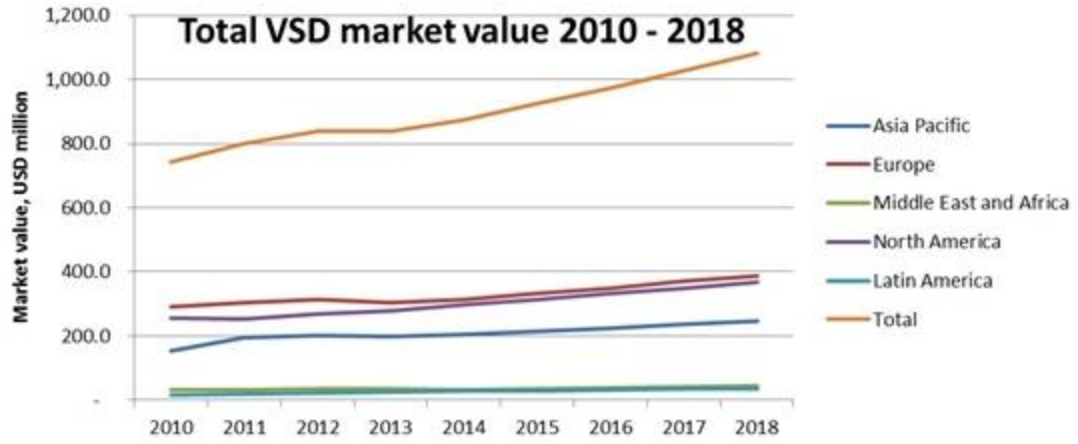


ERCOT Historic Kinetic Energy Boxplots (2010–2017)

Anatomy of a Frequency Excursion with Recovery



The Load is Changing, Too



Variable Speed Drives (VSD) market value 2010 - 2018

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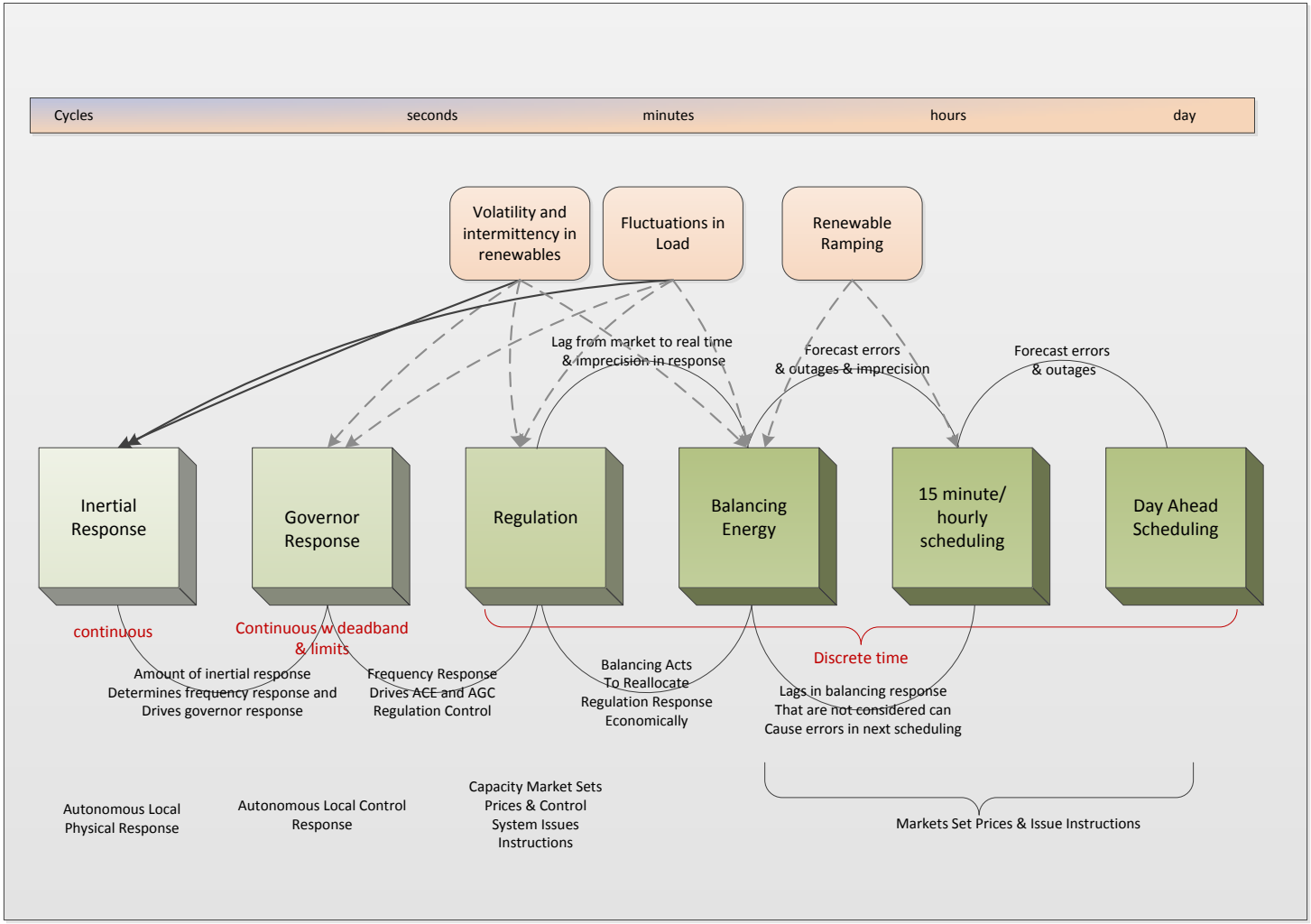
HVAC, Refrigeration, pool pumps, ------

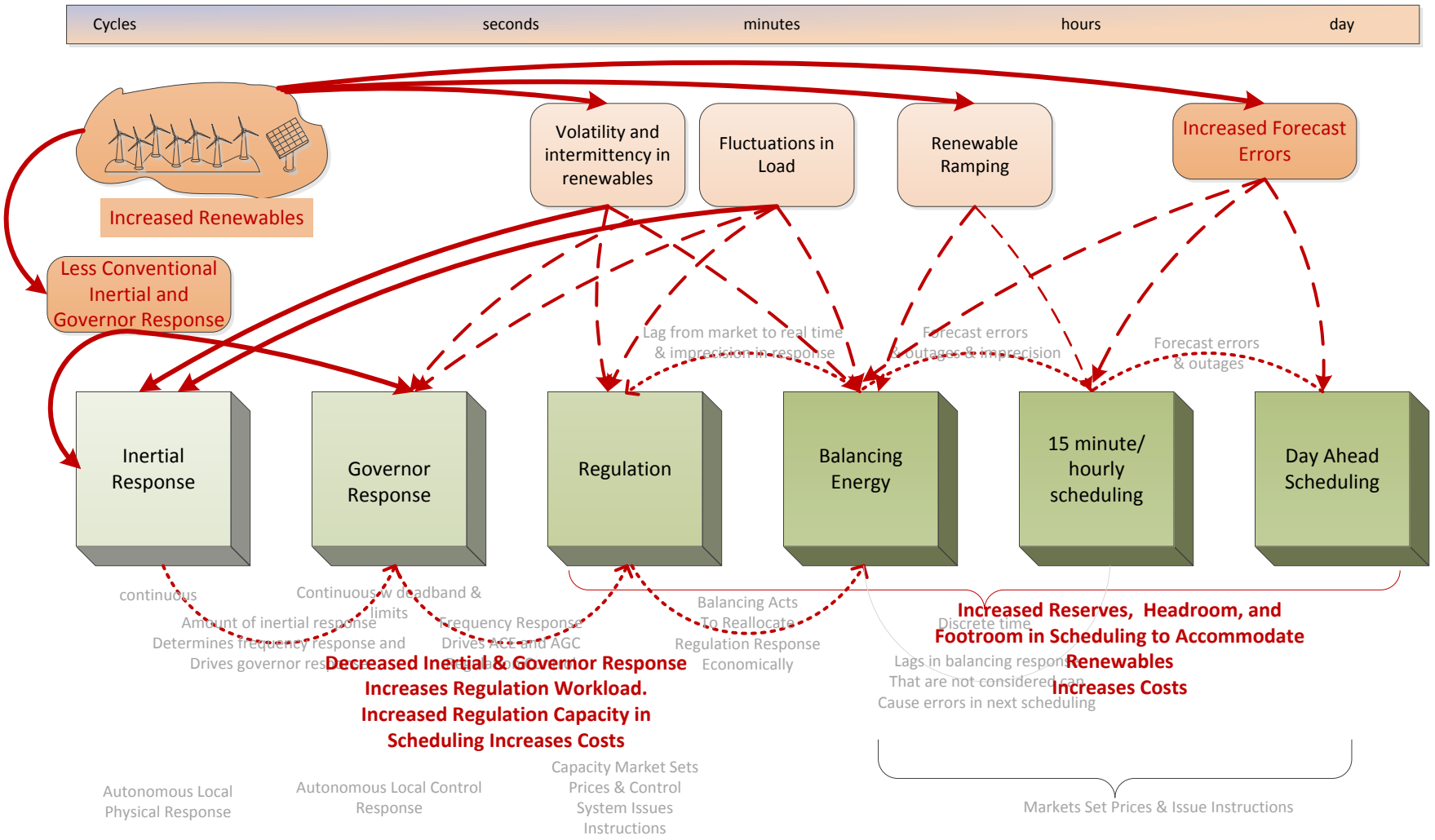
Industrial processes where speed control is critical to quality

Side note – resistive load (lighting) also decreasing

It is all Related



Increased Renewables & Impacts



Responses to Increased Renewables

- Increasing the Headroom and Footroom in Scheduling to Accommodate Renewable Variability and Forecast Error
  - Increased MW and MW/min available to balancing market
  - Increased regulation capacity available
- Increased Costs of Scheduling (higher LMP) due to additional constraints
- Increased Costs for Regulation due to Additional Capacity Payments and Additional Pay for Performance Payments
- New Products (CA ISO Fast Ramping Service) Developed
- Costs Pushed to Wind Farms (firm scheduling and balancing cost exposure) to Reduce Direct Market Costs
  - Unknown indirect effect on wind investment and on market costs
- Shift from HA Scheduling to Intra-Hour (15 minute) Scheduling to reduce ramping impacts and balancing costs
- Focus on improved forecasting DA – HA – intra hour
- *Requiring grid connected solar and wind farms to provide governor response*
- *Developing Rate of Change of Frequency (ROCOF) as synthetic inertial response*
- *Making governor response and ROCOF ancillaries market products*

Inverter Based Resources are as (more) capable than conventional ones

The ISO, First Solar and NREL demonstrated how a 300 MW solar PV plant can provide essential reliability services

	Test	Performance
Ramping	• Ramp its real-power output at a specified ramp-rate • Provide regulation up/down service	
Voltage	• Provide reactive power support in various modes - Control a specified voltage schedule - Operate at a constant power factor - Produce a constant level of MVAR - Provide controllable reactive support (droop setting) - Capability to provide reactive support at night	
Frequency	• Provide frequency response for low frequency and high frequency events - Control the speed of frequency response - Provide fast frequency response to arrest frequency decline	

Types of Analyses Done Today

- Methodologies to Estimate Increased Regulation / Balancing Needs due to Renewable Penetration (GE, NREL, DNVGL)
- Simulations of Increased Renewables at Different Time Scales – Regulation to Annual Production Costs
  - Used to assess impact, validate assessments of increased balancing and regulation costs, assess system dynamic performance.
- A very few studies of the inter-relationship of performance and costs – UK study, for example of inter-relationship of regulation vs faster balancing market and of delays in balancing market response.
- Very few studies of the benefits of improved forecasting on scheduling and balancing costs
- Very few studies focused on impact of reduced governor and inertial response
- Transient stability issues unexplored as compared to frequency response
- Understanding the economics of market products for ROCOF and Primary Response – and use of storage as adjunct to wind/solar farms

There is a need/opportunity to develop a mathematical analysis of these interrelationships to allow trade-offs in constraints and services procurement

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Thank You!

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