

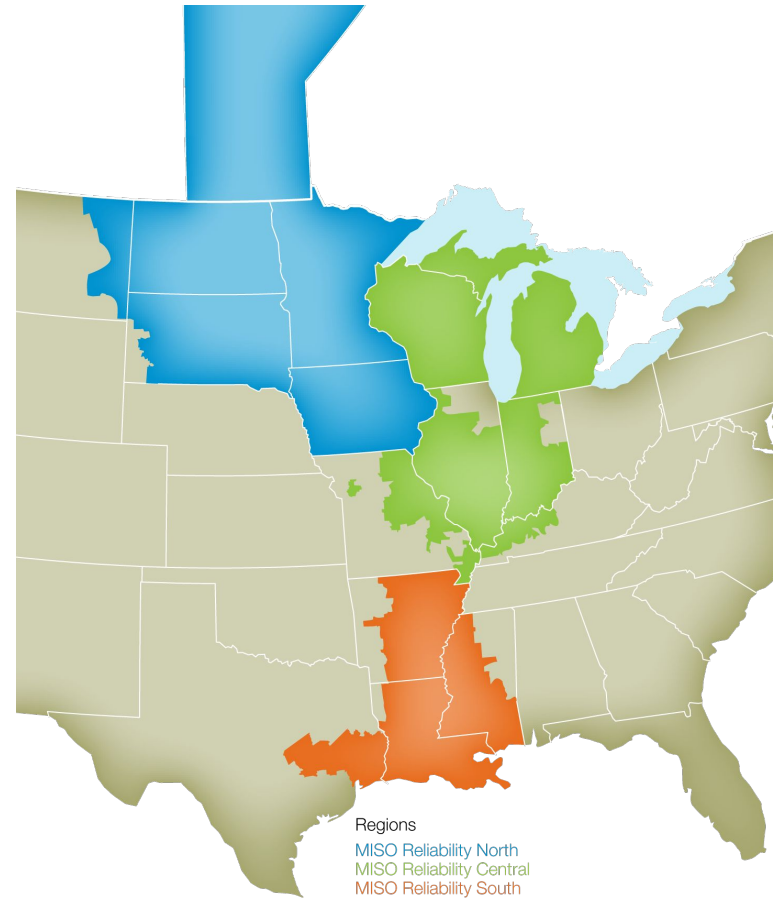


# The Changing Needs of System Operations: MISO's Perspective

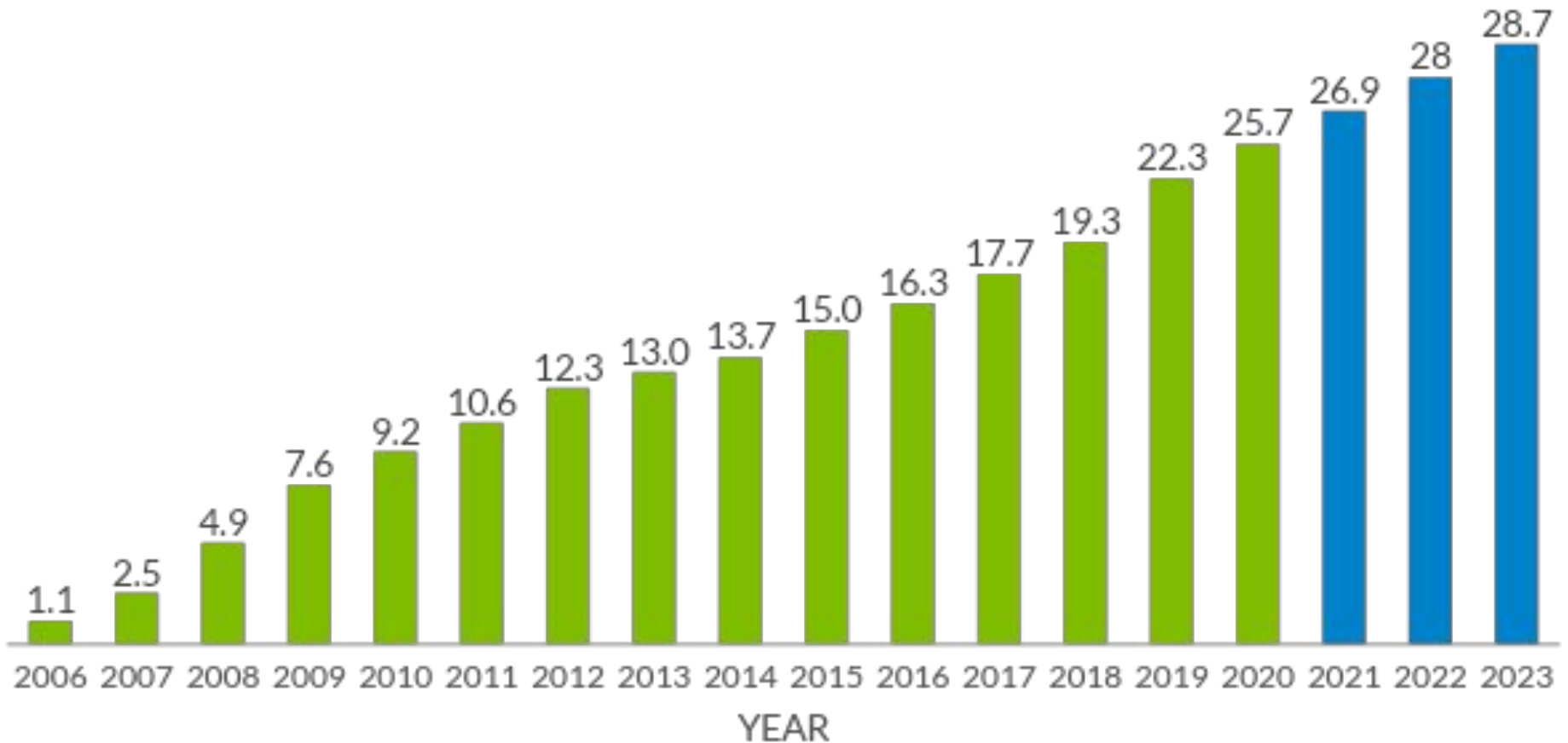
ESIG Educational Session

# MISO Overview

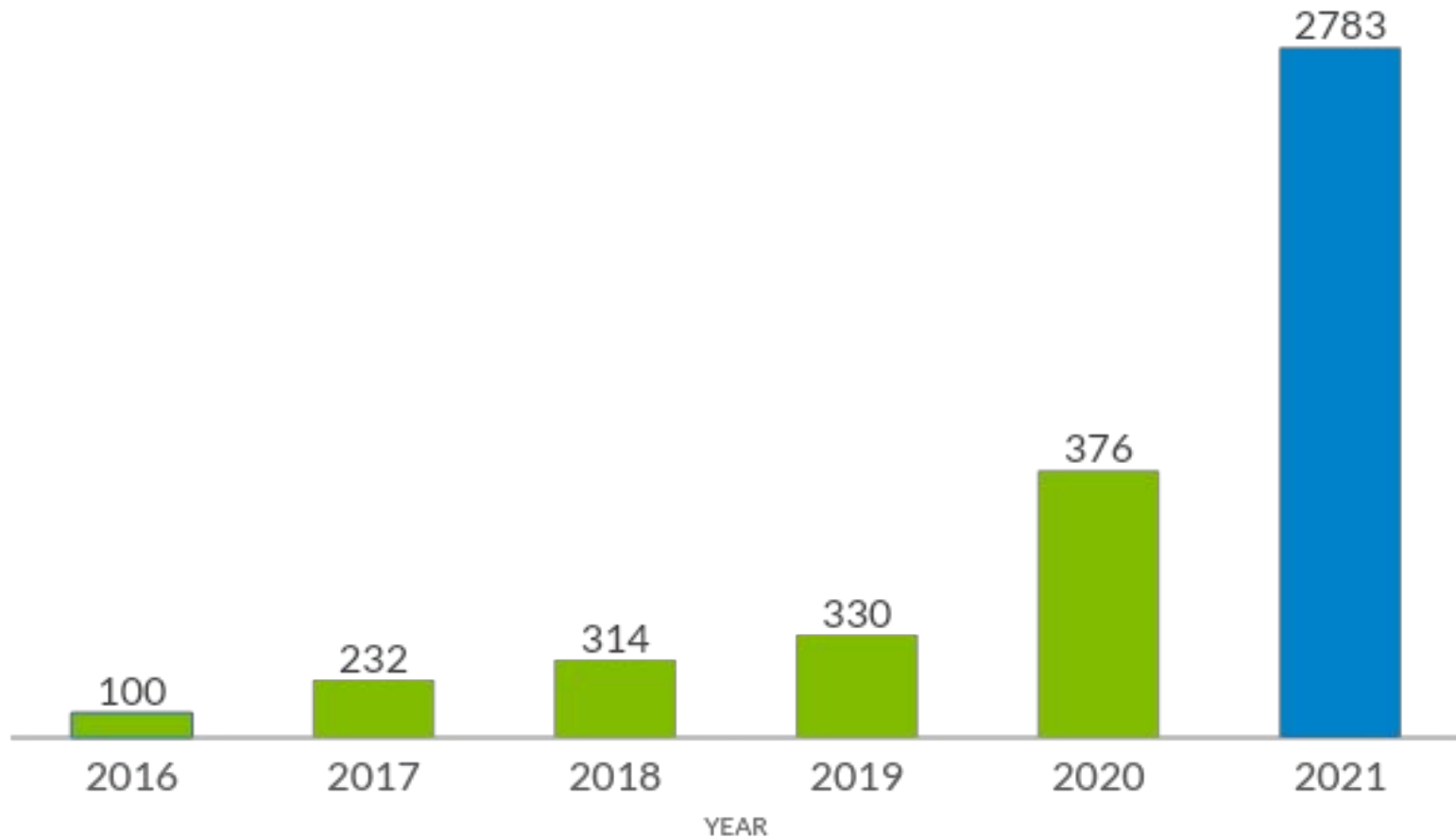
- Peak load July 20, 2011
  - Reliability Footprint: 130.9 GW
  - Market Footprint: 127.3 GW
- Wind peak March 30, 2021
  - 20.7 GW (25.7 GW installed capacity)



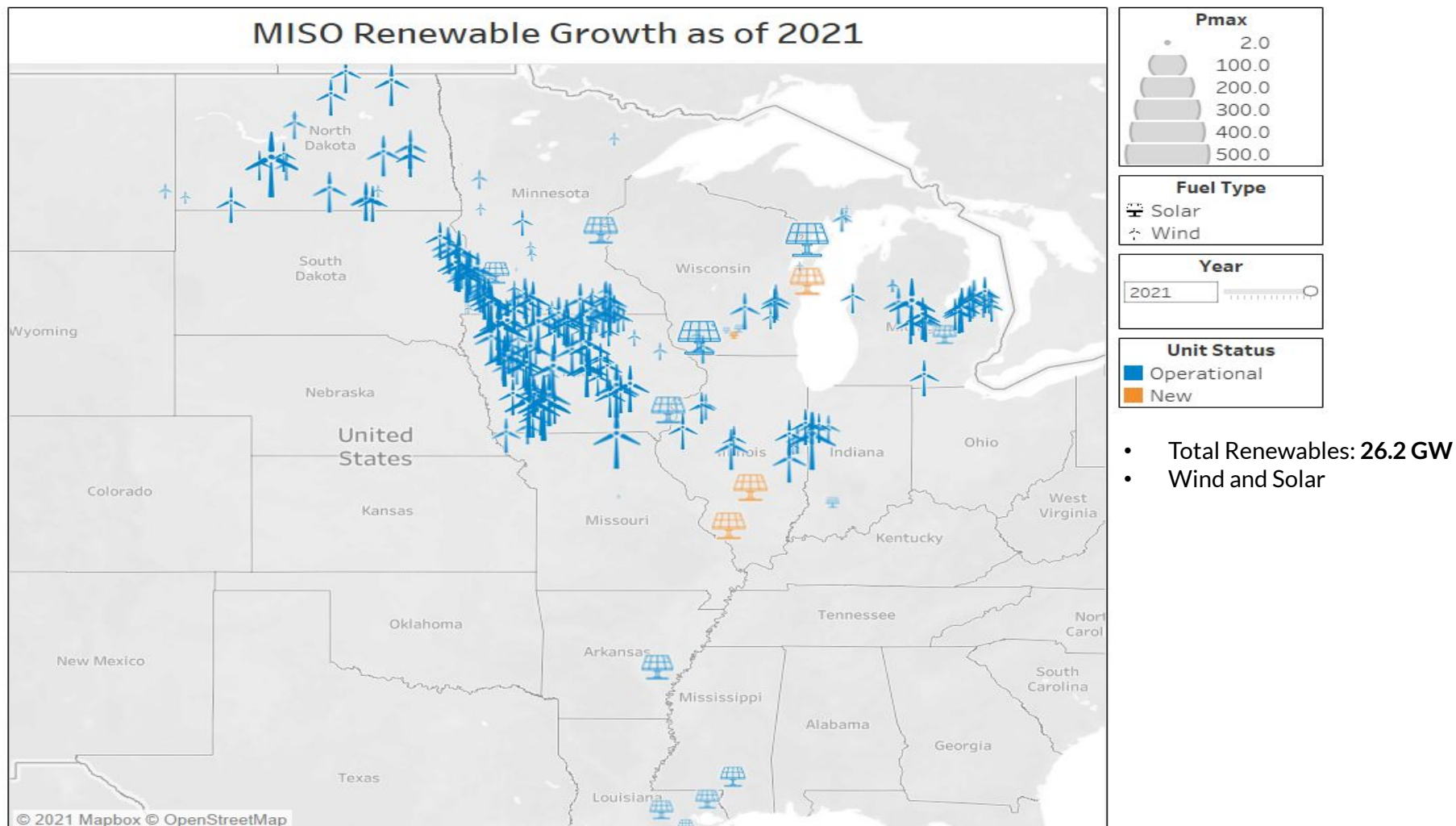
# Wind Capacity in MISO in GW



# Solar Capacity in MISO in MW



# MISO Renewables: Location and Growth



# As wind & solar supply a larger share of energy, forecast uncertainty and variability will grow

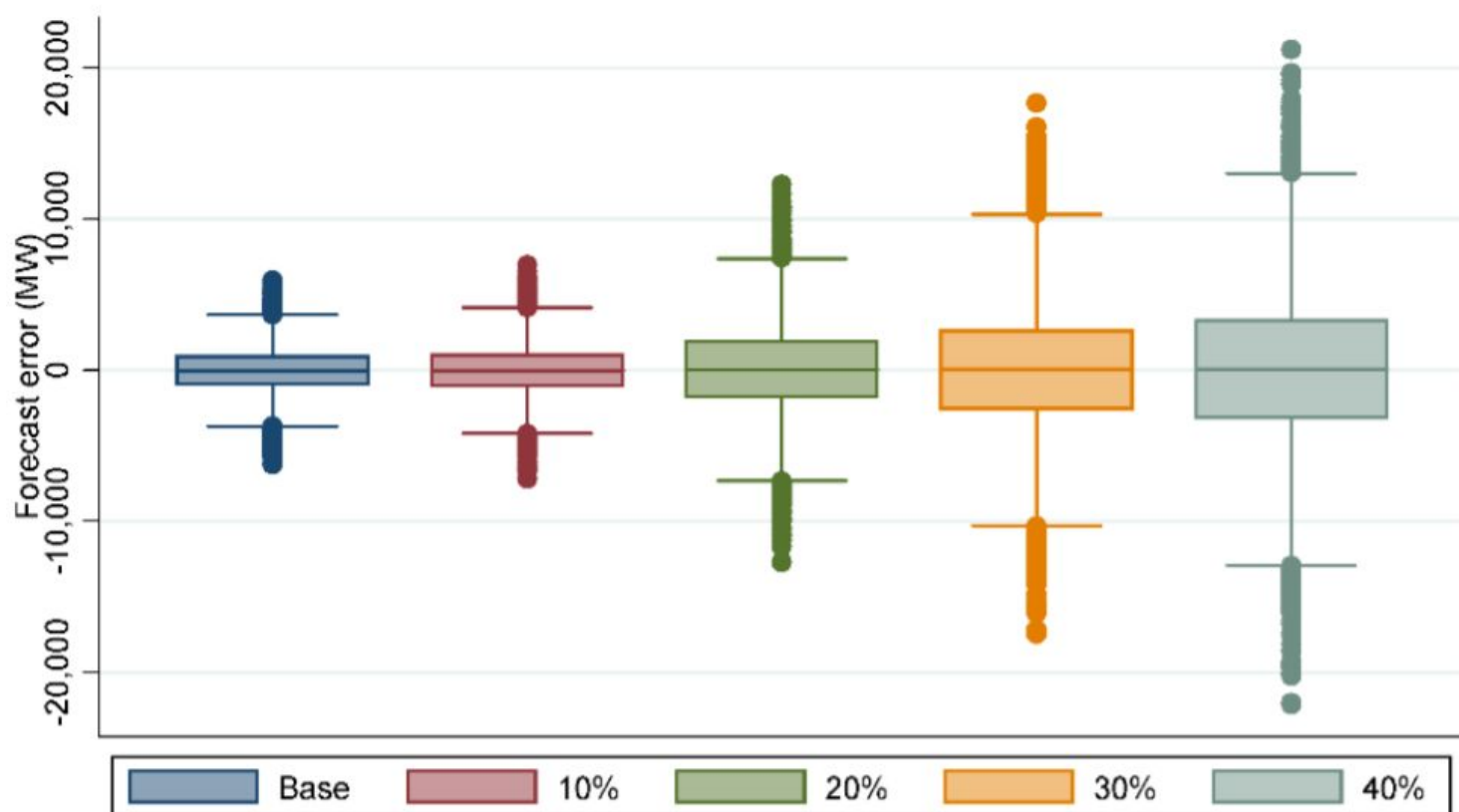
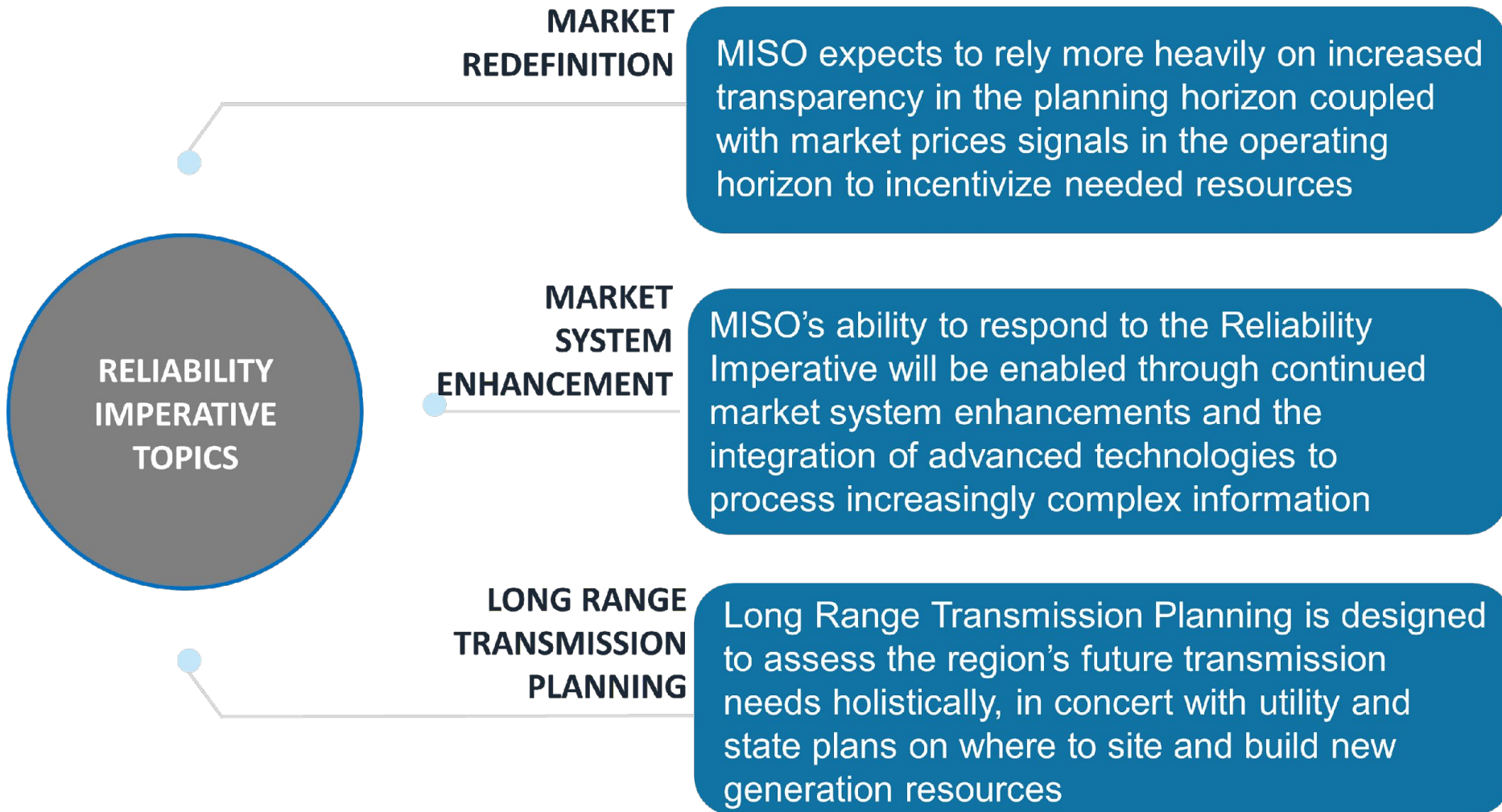


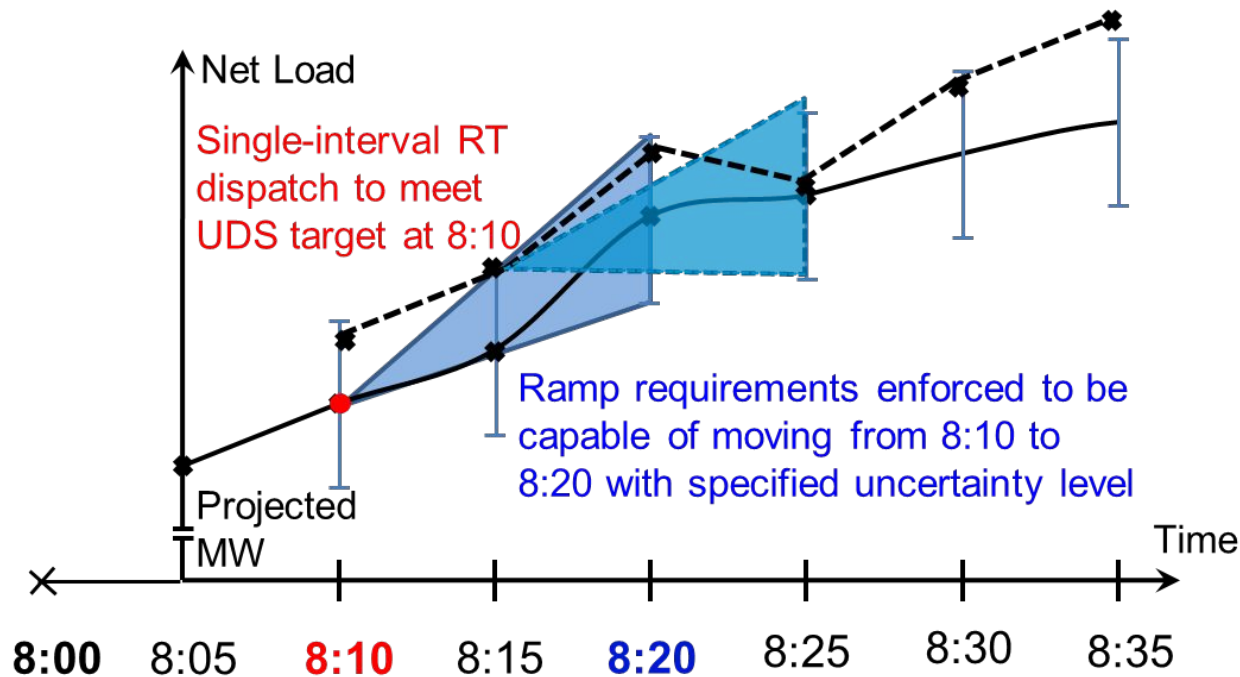
Figure EAD-1: Wind forecast error for various renewable milestones

# The Reliability Imperative efforts will enable those member / state goals with coordinated enhancements across multiple areas



# The ramp capability market product balances variation and uncertainty in Real-Time

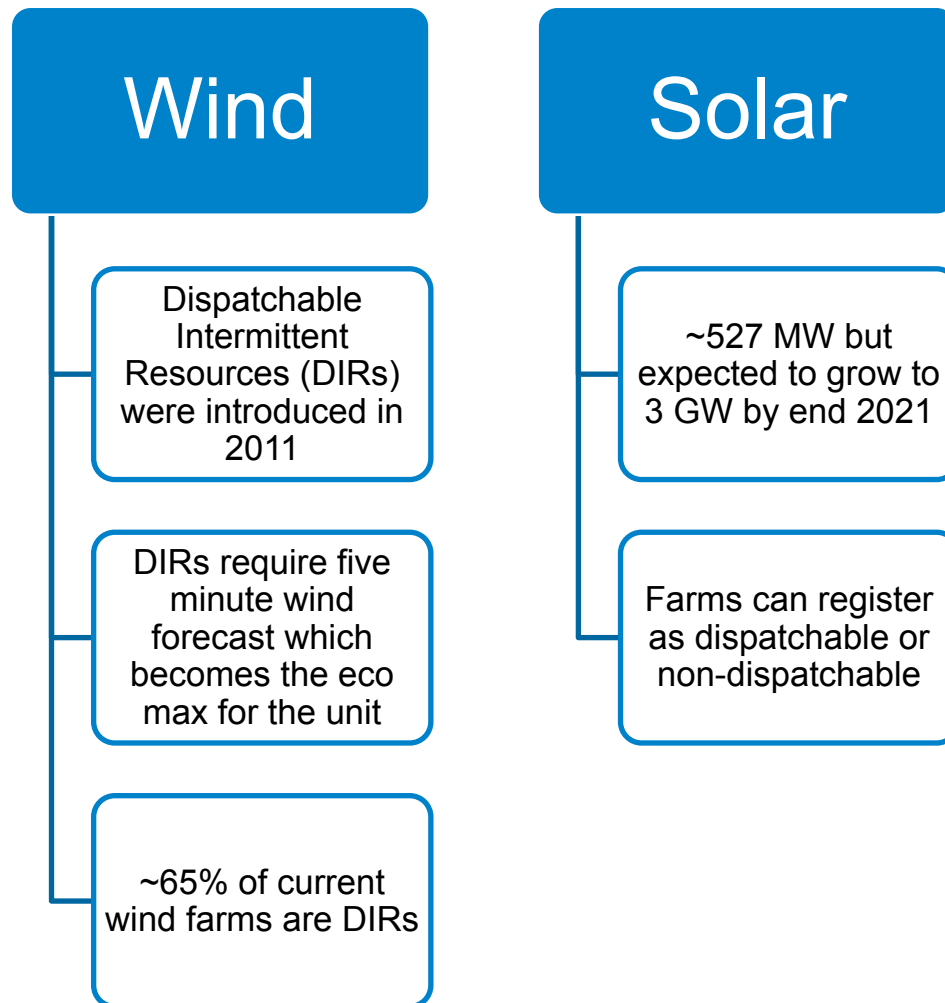
Requirements set to manage net load variations & uncertainty 10min ahead



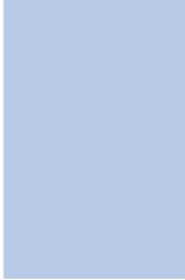
- Systematic approach to pre-position resources
- Market-based approach for ramp management
- The market incurs a modest cost to obtain ramp, more than offset by reduced cost by using that ramp.



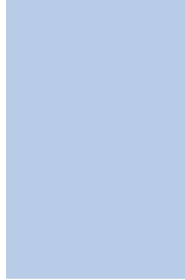
# Operational characteristics of renewables



# Dispatchable Intermittent Resources (DIR) first introduced in 2011



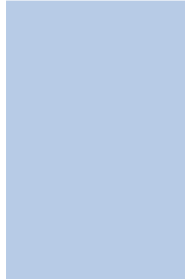
Allow for the dispatch of wind in real-time



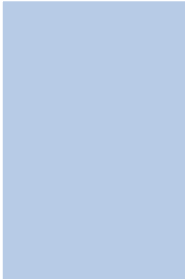
5 minute forecast becomes the economic maximum



Over 90% of Market Participants use MISO's forecast

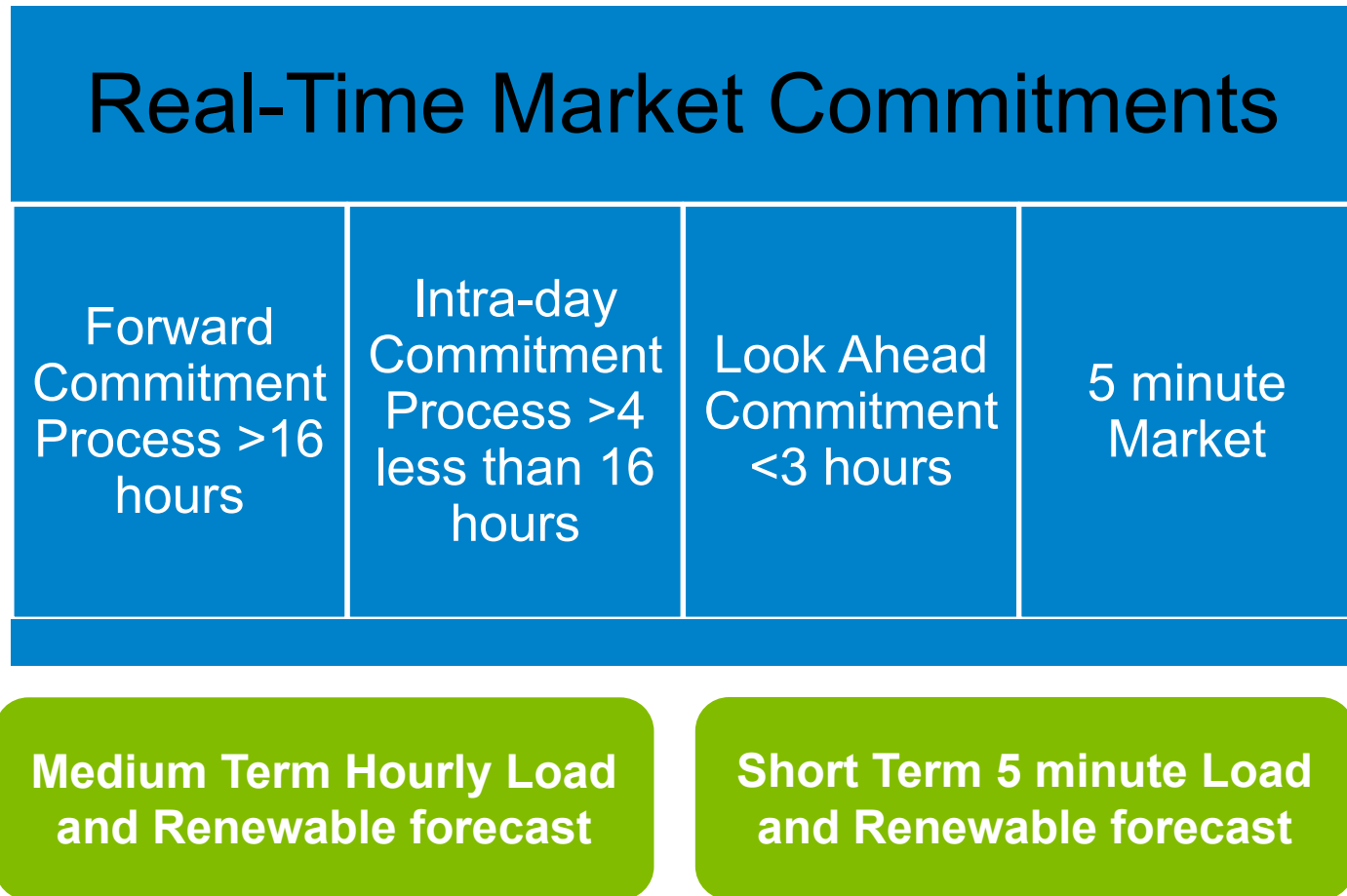


DIR forecast accuracy is integral in ensuring system reliability and market efficiency

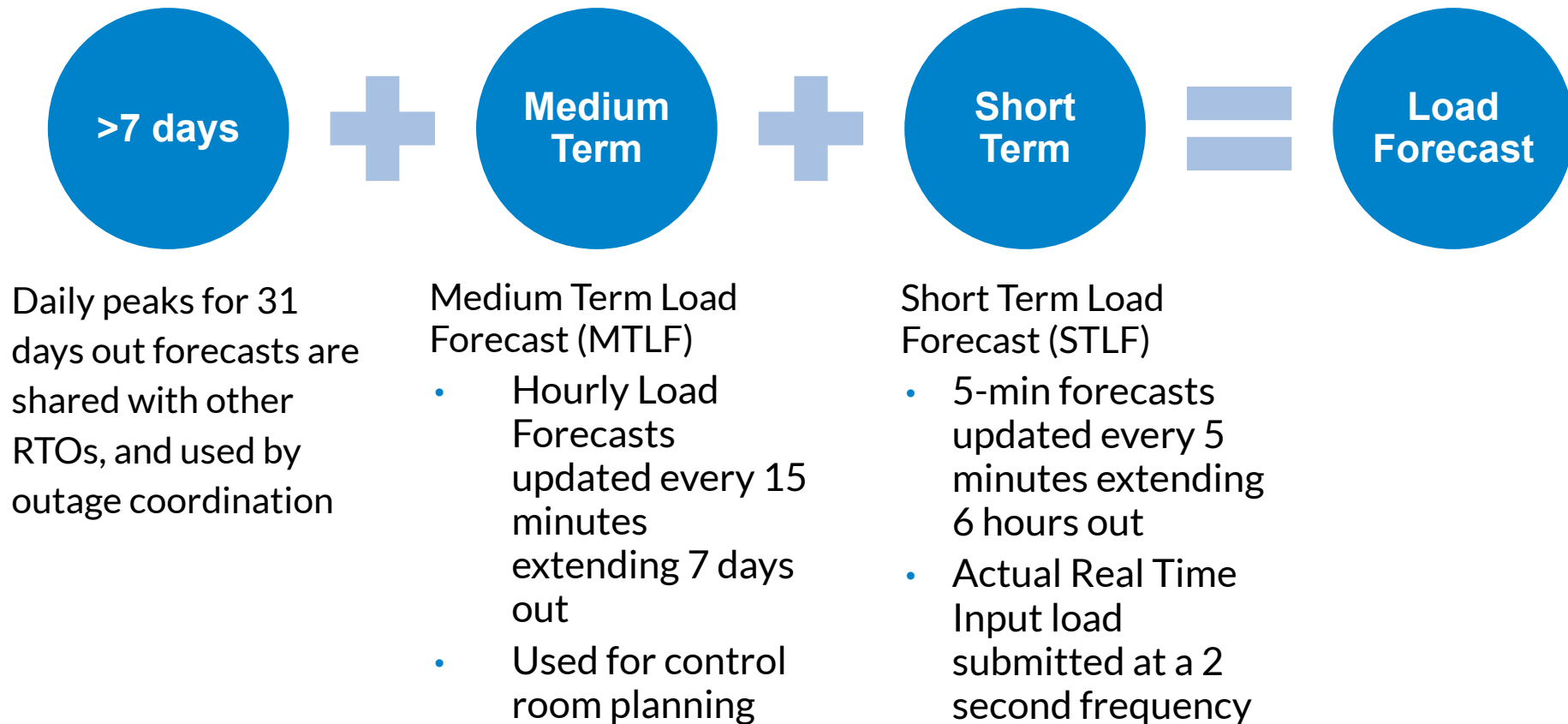


MISO uses regulation to balance the system for forecast errors

# Forward and Real-Time commitment is highly dependent on forecasts



# Load Forecasting is used by MISOs commitment & planning processes



# Renewable Forecasting Process Overview



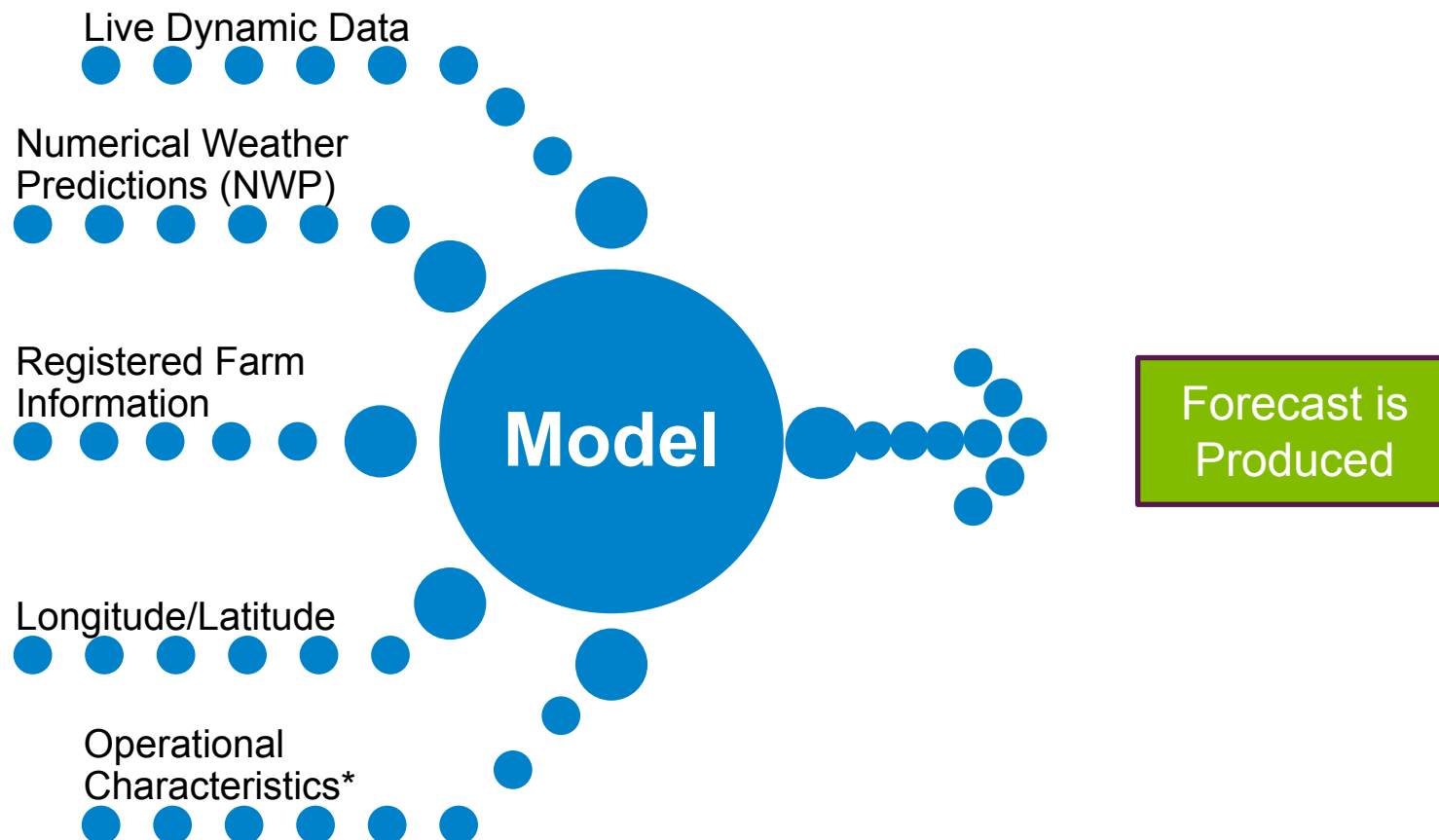
## Medium Term Wind Generation Forecast (MTWGF)

- Hourly Load Forecasts updated hourly rolling 168 hours out, at a farm level
- Used for control room planning

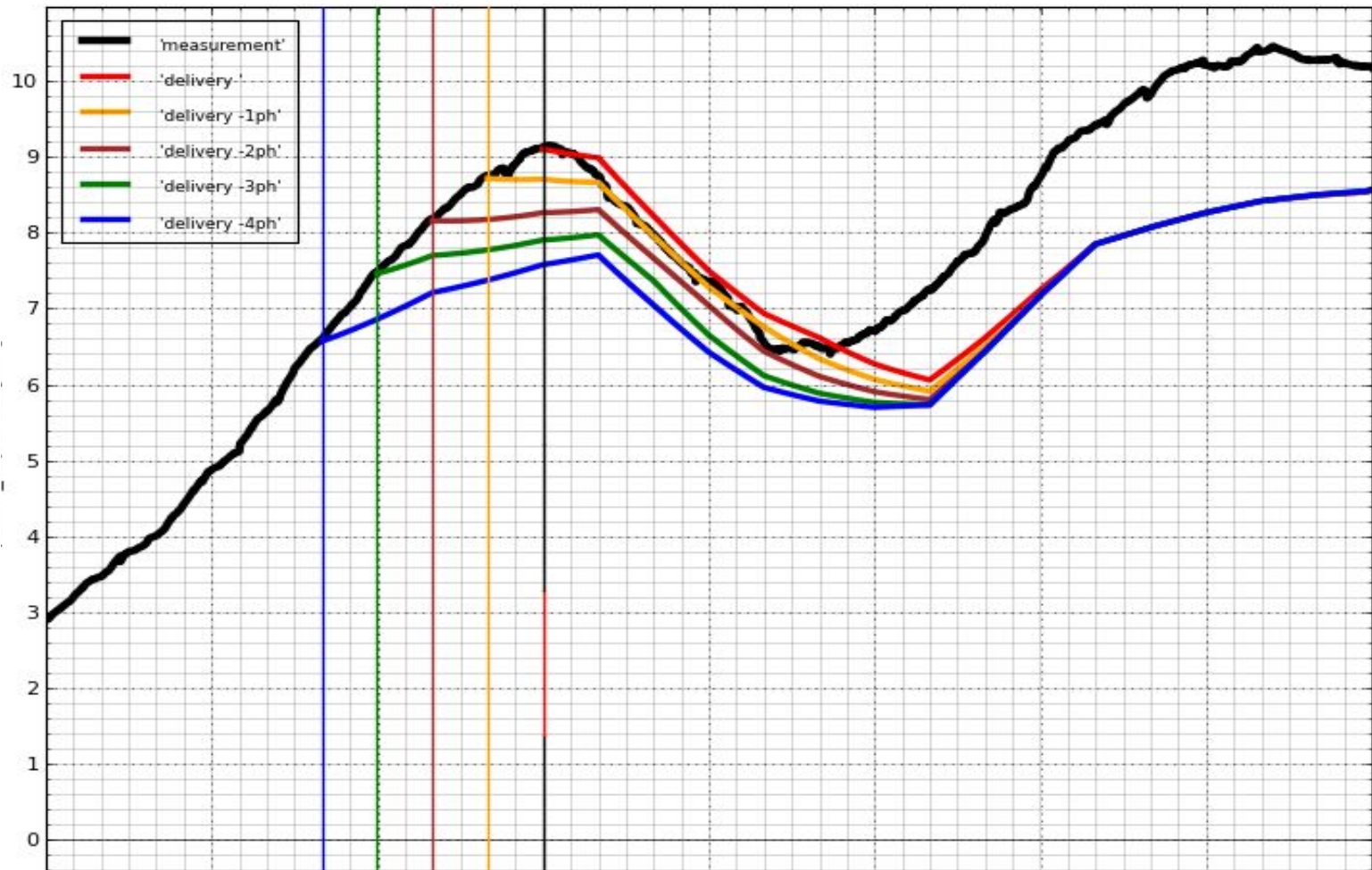
## Short Term Wind Generation (ST WGF)

- 5-min forecasts updated every 5 minutes extending 6 hours out at a farm level

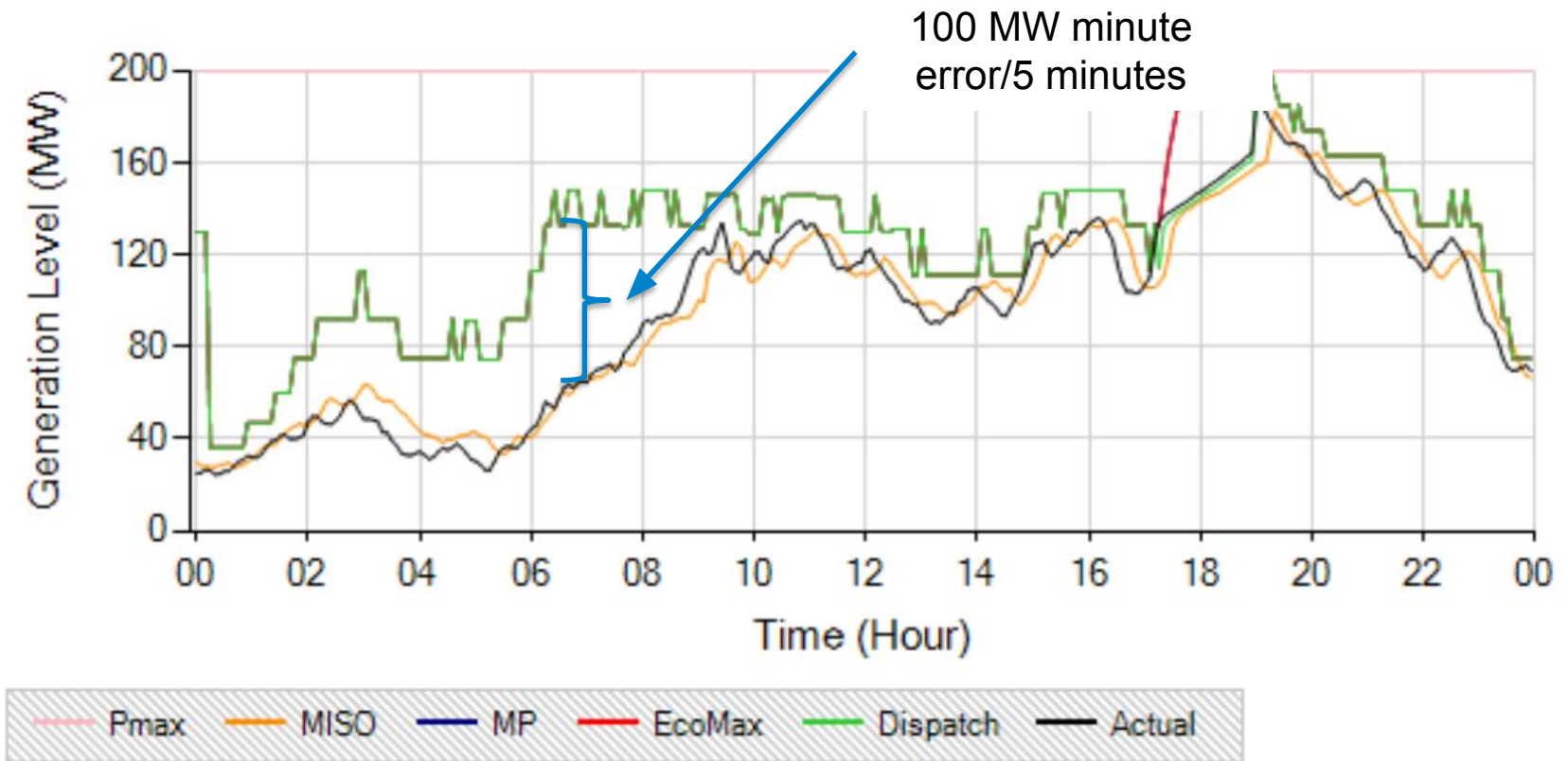
# How do we build a renewable forecast?



# MISO Short Term Wind Forecast changes as it updates



# Wind Alerting System Monitors DIR forecast accuracy & produces reports





# MISO Renewables: Weather Phenomena of Conc

- Turbine Icing
- High Wind Speed Cut Outs
- High/Low Temperature Turbine Cut Outs
- Low to Negative Production Periods: High Pressure with Cloudy Conditions.
- Nocturnal Low-Level Jet