

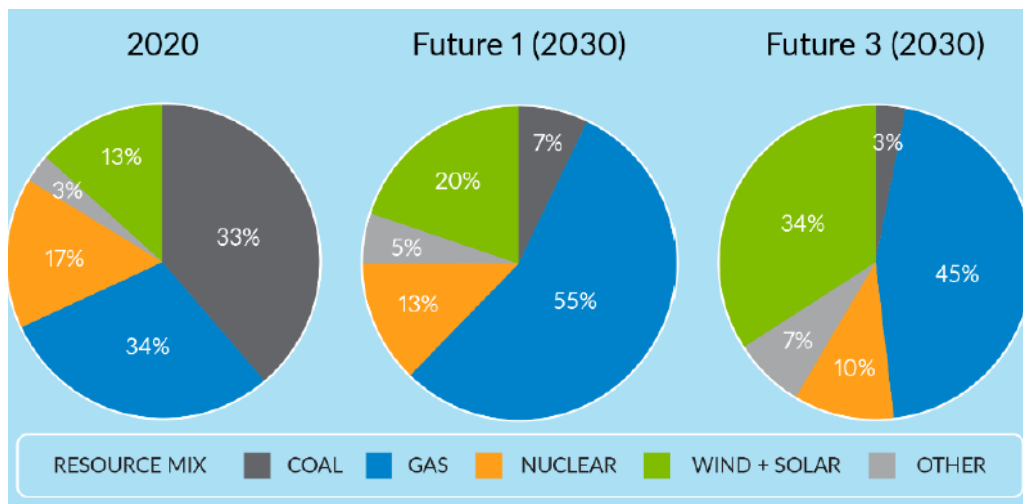


# Forecasting and Market Participation for Large Wind and Solar Power Plants

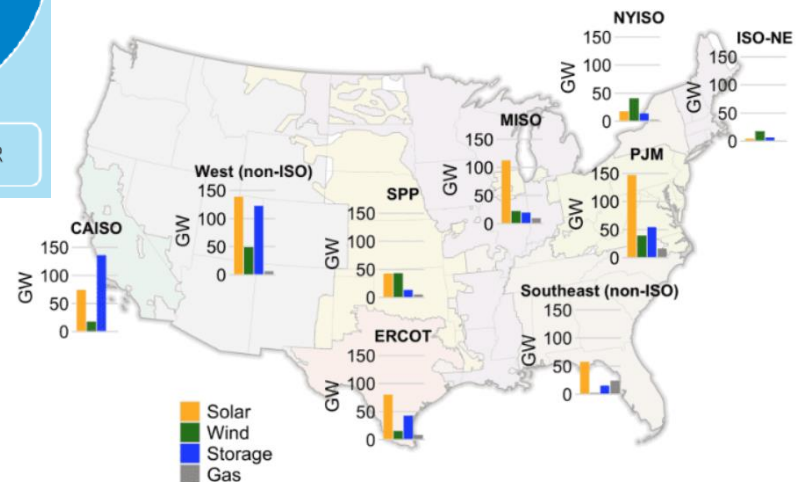
2022 ESIG METEOROLOGY & MARKET  
DESIGN FOR GRID SERVICES WORKSHOP  
June 7, 2022

# Wind and solar are becoming prominent resource types in the evolving fuel fix

MISO Generation Mix (% of total annual energy by fuel type)



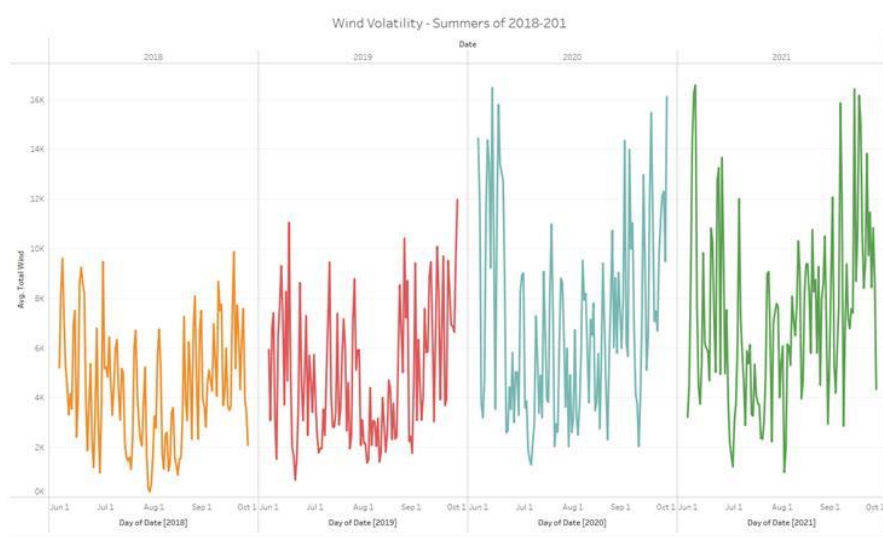
Proposed capacity of wind, solar, storage and gas in various regions across the U.S. 2021  
Source: Berkeley Lab



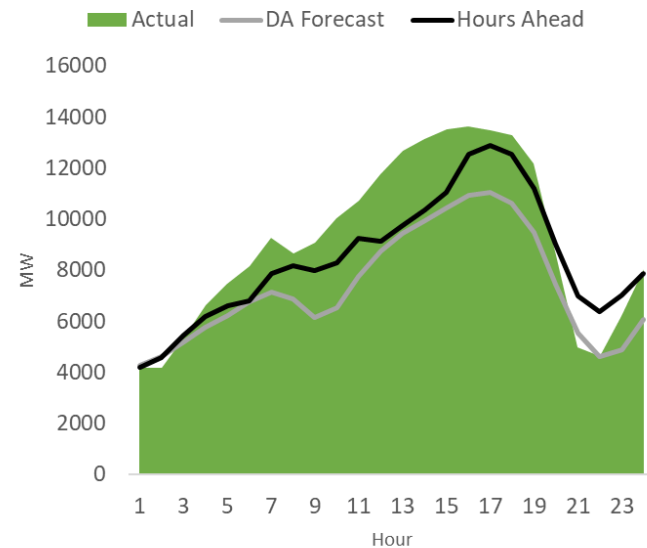
# Weather-dependent intermittent resources magnify reliability challenges

Volatile wind output levels alter supply-demand conditions, especially with tightening reserve margins

Wind ramp and uncertainty increase complexity of unit commitment decisions



Wind forecasts vs actual 4/21/2021



# Forecasting provides critical foresight for markets and operations decisions



	Hourly forecast up to 7-day ahead	Market Participant (MP) Offer	Hourly forecast Day-Ahead	Hourly and 5min forecasts hours ahead	5min forecast by MISO or MP
<b>Current state</b>	Deterministic + scenario/risk analysis	Deterministic	Deterministic + scenario/risk analysis	Deterministic + scenario/risk analysis	Deterministic
<b>Research</b>				Stochastic LAC	

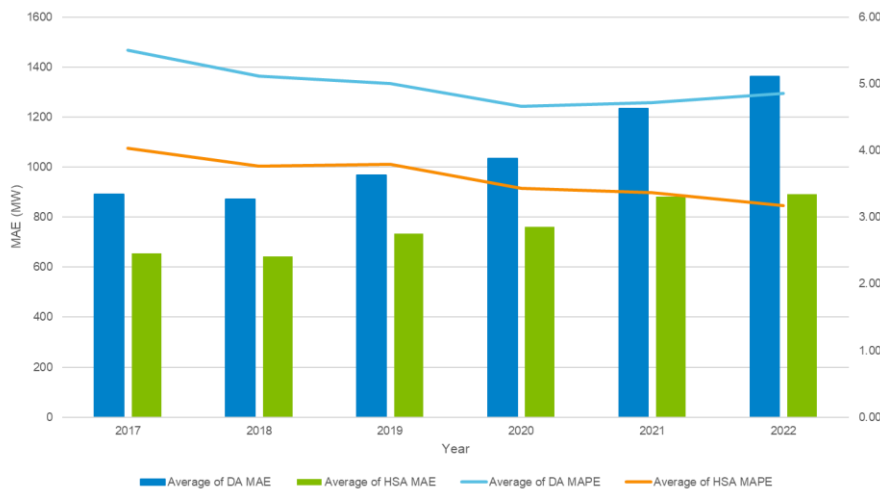
# Forecast accuracy improvements have tangible economic and reliability benefits

- Renewable penetration is outpacing forecast improvement

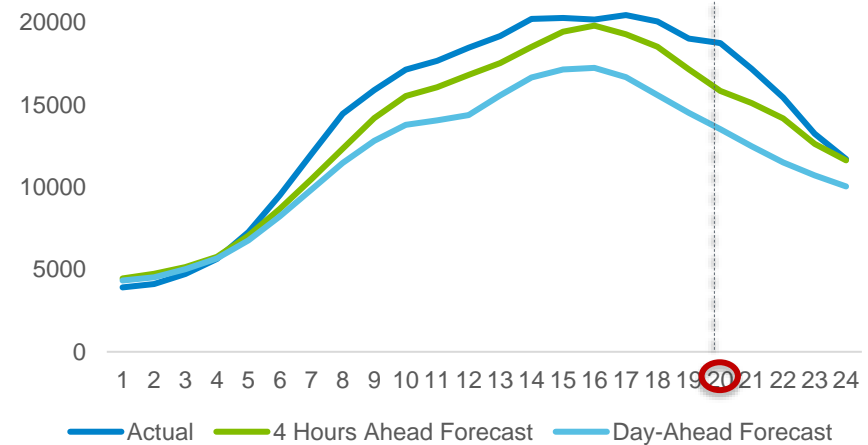
*Illustrative economic benefits*

$$300MW \times \$1/MWh \times 8760h = \$2.6 M$$

- While modest on average, large forecast errors are still experienced, resulting in commitment complexity and even shortages

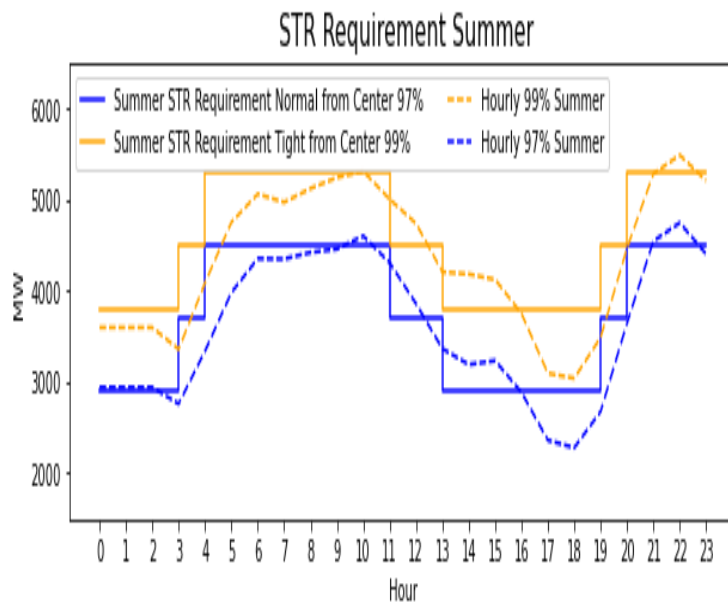


A bad forecasting performance day

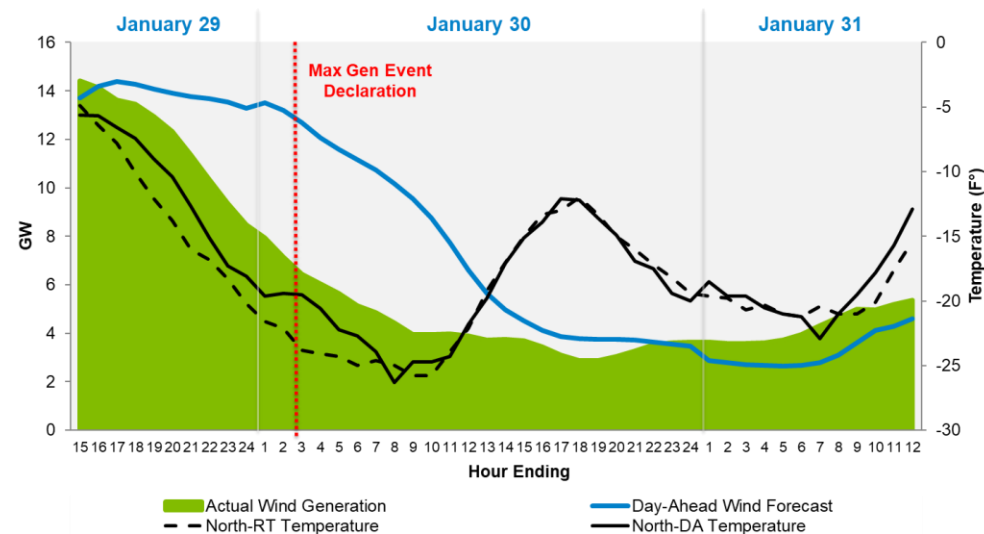


# Risk assessment allows dynamic reserve requirements & pre-identifying extreme events

- Reserve requirements are defined based on varying risks by season and by hours of the day
- Weather risk assessment to identify pre-indicators of extreme wind and solar events

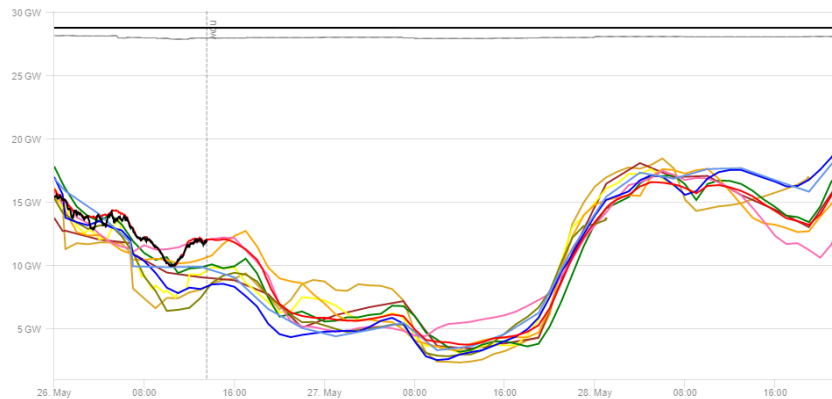


## Example: Cold temperature and icing risk



# Probabilistic forecast is being researched, and key is to integrate into operations processes

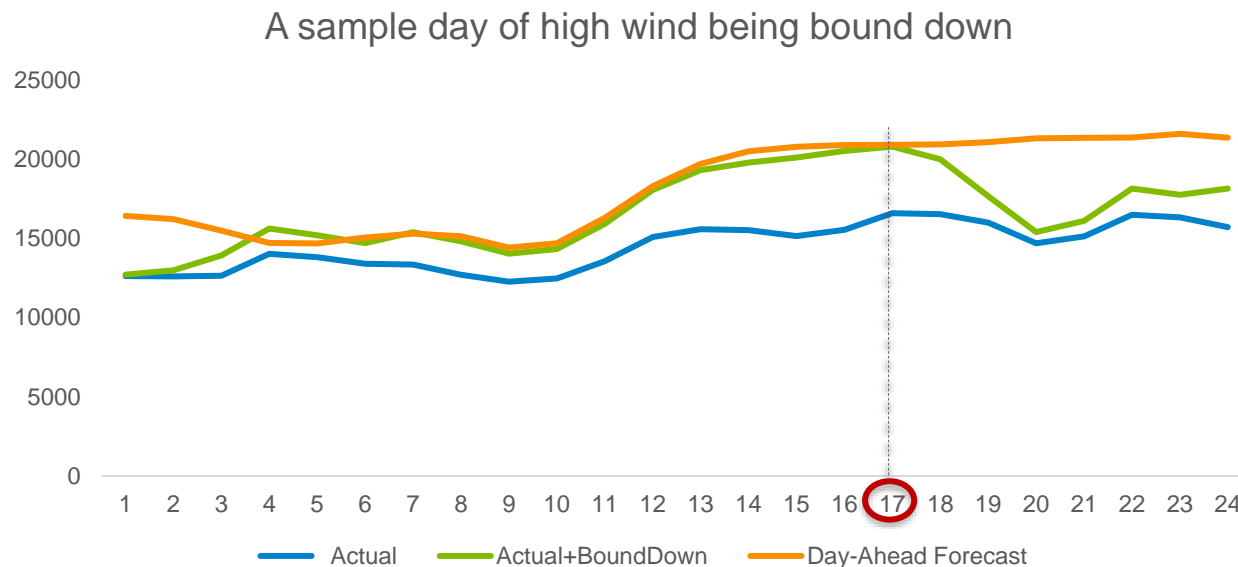
- Uncertainty spread/scenarios are developed based on multiple Numerical Weather Prediction models
  - These scenarios are used in operations planning



- Probabilistic forecast and its use cases in commitment processes are jointly researched
  - Probabilistic Solar Power Forecasts (JHU NERL IBM UTD)
  - Stochastic look ahead commitment (ASU NERL Sandia Nexant MISO)

# Challenges increase with transmission congestion and wind curtailment\*








- Despite good forecasting record till HE18, wind materialized much less than forecasted due to congestion
- The wind risk contributed to Capacity Emergency in real-time





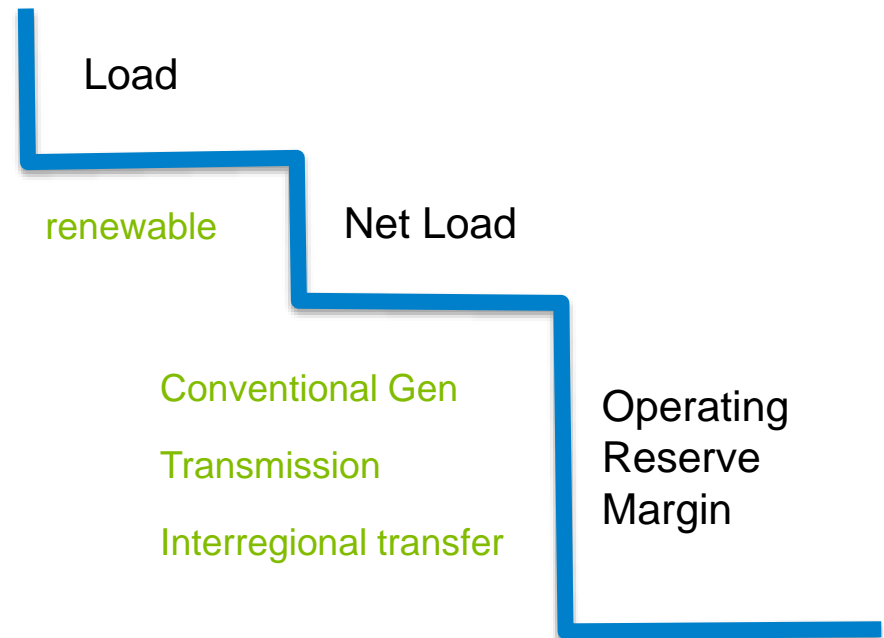
# Renewable risks, combined with other sources of uncertainty, complicate decisions

## Source of Uncertainty

-  Load
-  Wind
-  Solar
-  Forced Generator outages
-  Gas/Coal Fuel Risk
-  Transmission, North-South Contract
-  Non-firm Imports

Individual uncertainties can be correlated

Operations decisions have to manage **aggregated uncertainty**



# Reliable and efficient integration of renewables is part of MISO's reliability imperative\*

**Forecasting provides critical foresight for markets and operations decisions**

**Characterizing risks helps to better manage variability and uncertainty of renewables**

**Analytics & meteorological techniques to assess risks**

**Dynamic reserves**

**Probabilistic models in operations processes & tools**

**Innovation and solution needed for increasing and emerging challenges**

**Foresight of congestion and wind curtailment**

**Aggregated uncertainty management**

**Fast solar growth and changing risk profile**