

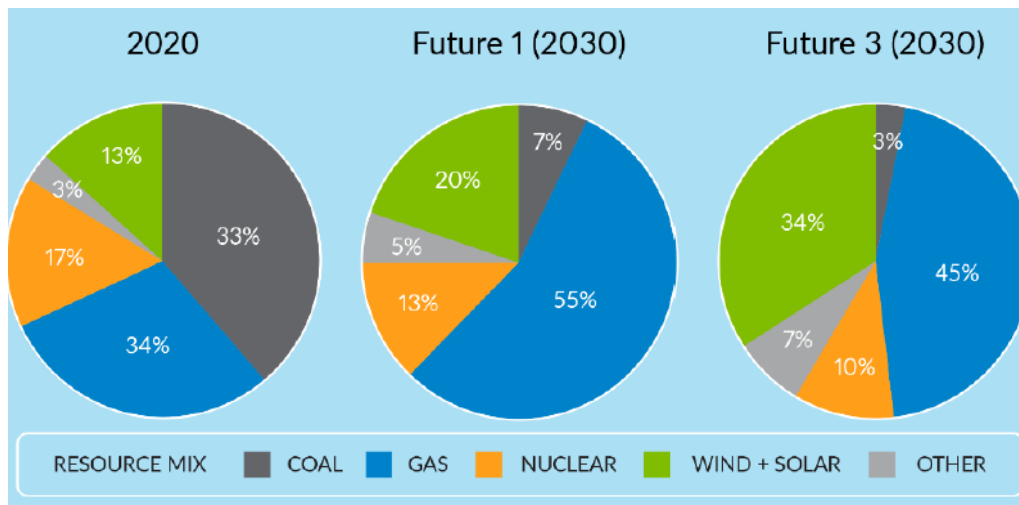


Forecasting and Market Participation for Large Wind and Solar Power Plants

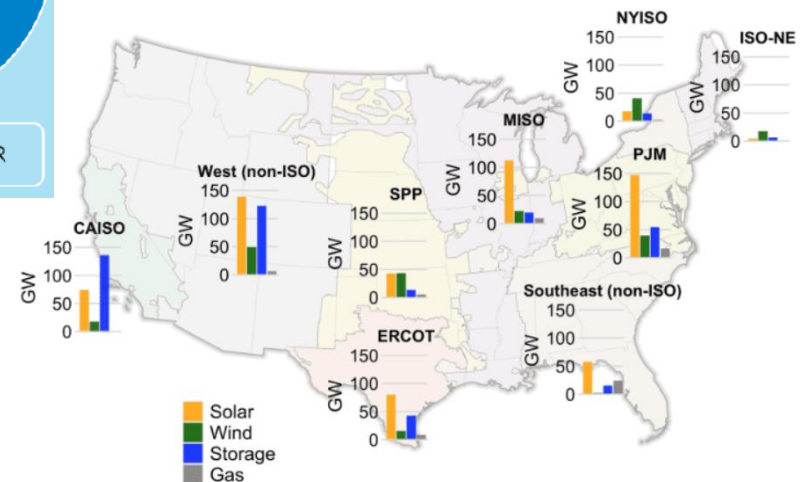
2022 ESIG METEOROLOGY & MARKET
DESIGN FOR GRID SERVICES WORKSHOP
June 7, 2022

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

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



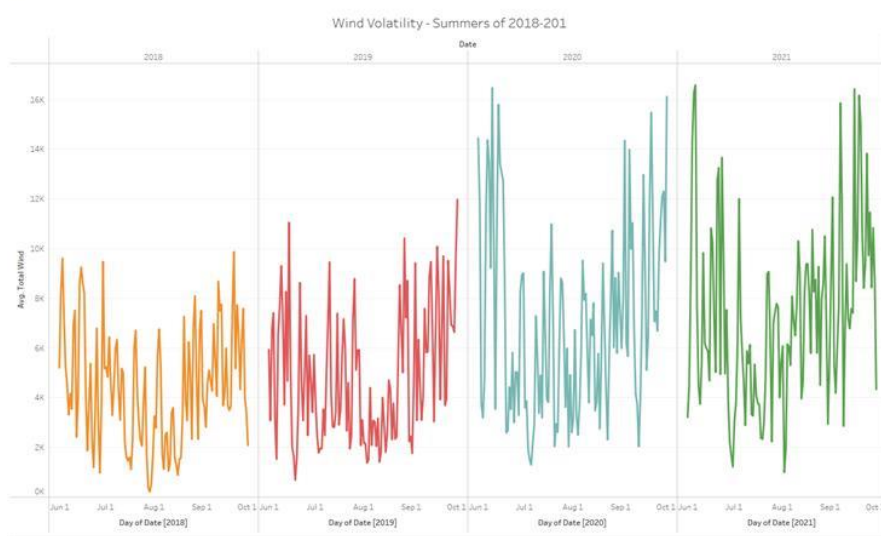
Proposed capacity of wind, solar, storage and gas in various regions across the U.S. 2021
Source: Berkeley Lab



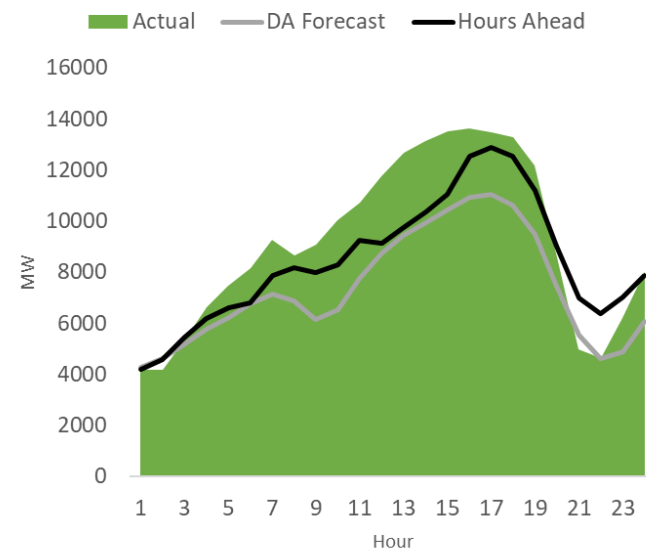
Weather-dependent intermittent resources magnify reliability challenges

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
Current state	Deterministic + scenario/risk analysis	Deterministic	Deterministic + scenario/risk analysis	Deterministic + scenario/risk analysis	Deterministic
Research	Stochastic LAC				

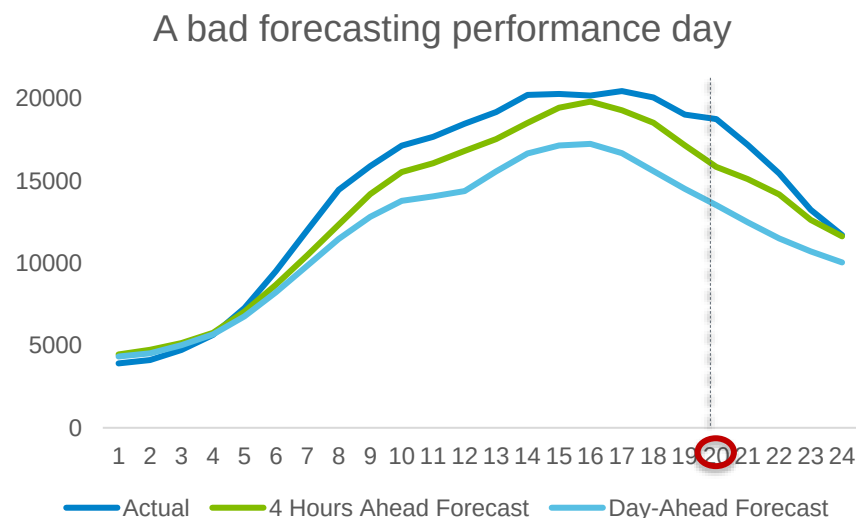
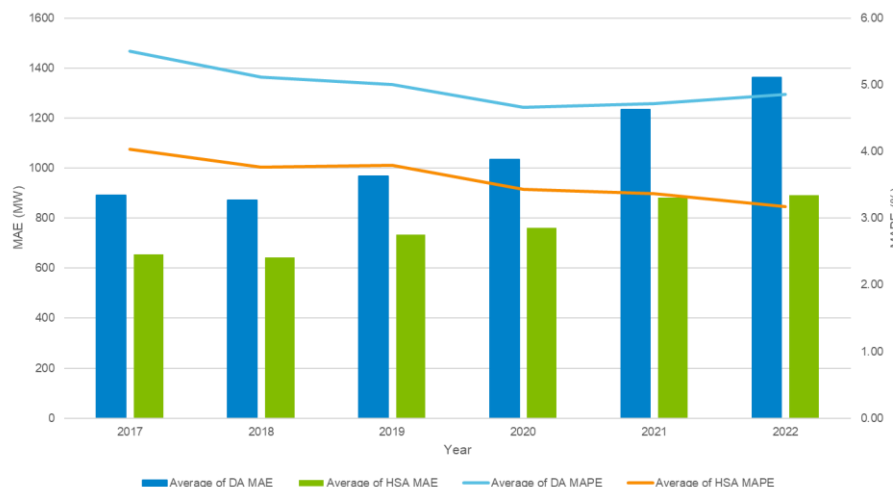
Forecast accuracy improvements have tangible economic and reliability benefits

- Renewable penetration is outpacing forecast improvement

Illustrative economic benefits

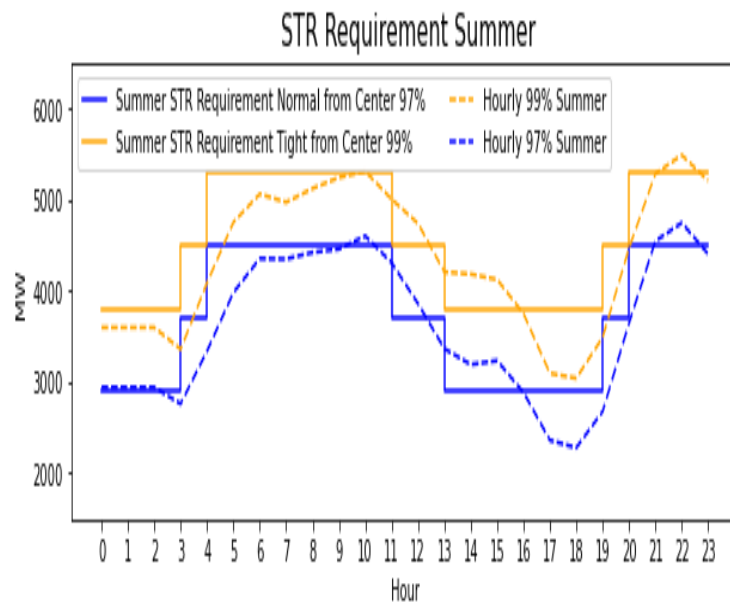
$300\text{MW} \times \$1/\text{MWh} \times 8760\text{h} = \2.6 M

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

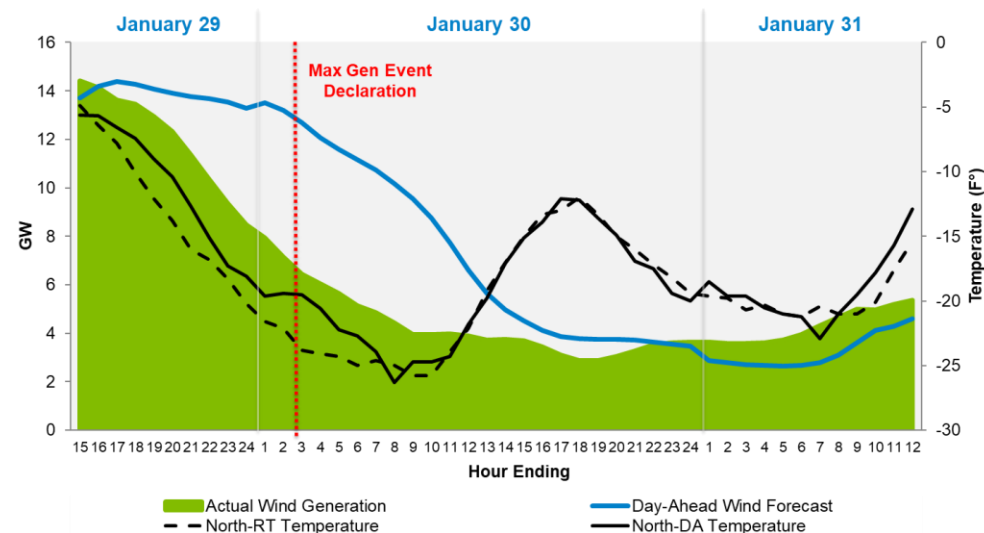


Risk assessment allows dynamic reserve requirements & pre-identifying extreme events

- 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

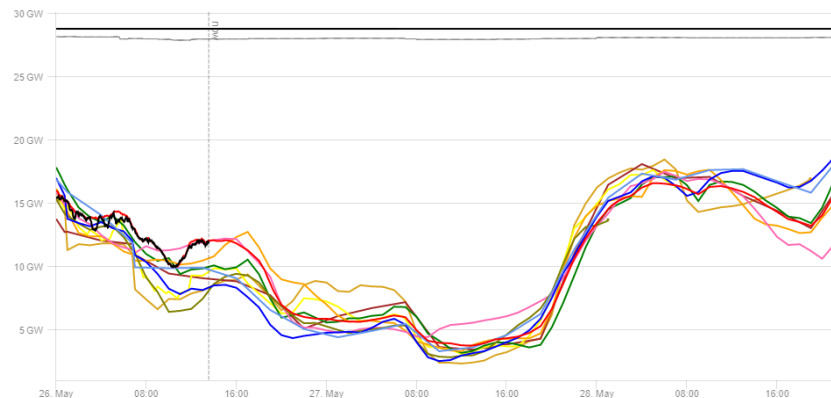


Example: Cold temperature and icing risk



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

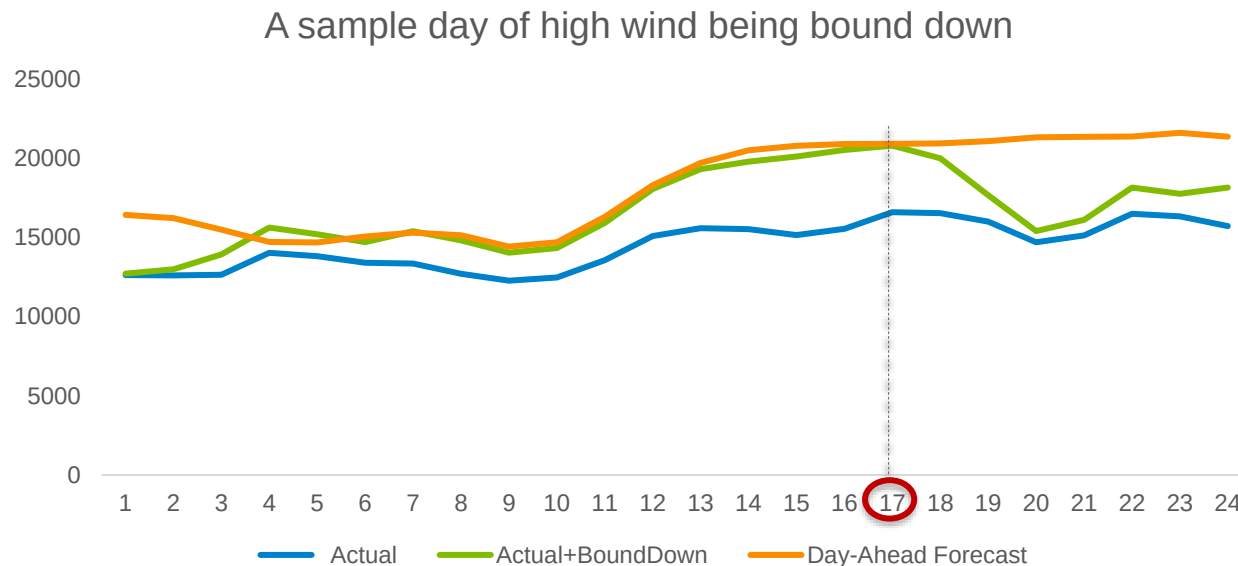
- Uncertainty spread/scenarios are developed based on multiple Numerical Weather Prediction models
 - These scenarios are used in operations planning



- 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



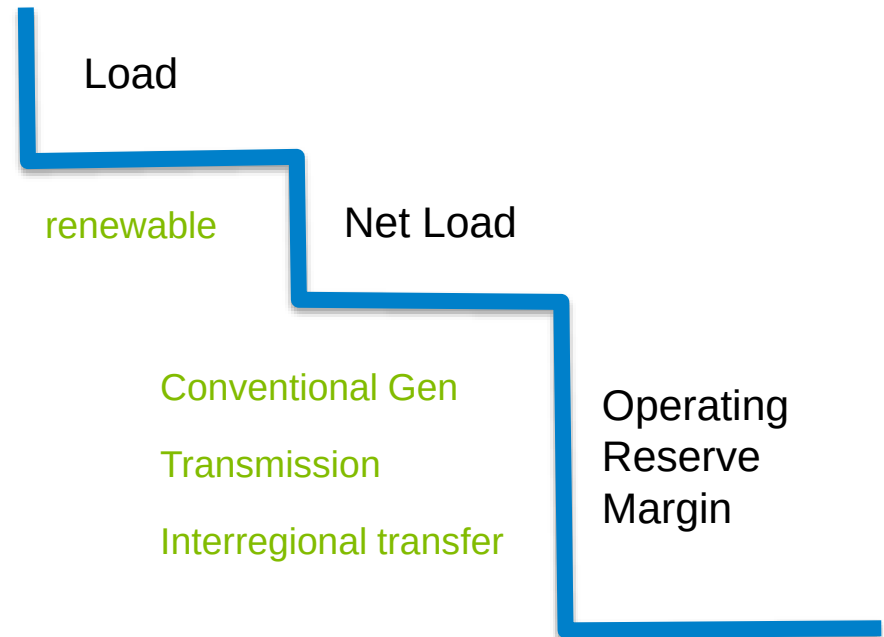
Transmission, North-South Contract



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

Innovation and solution needed for increasing and emerging challenges

Analytics & meteorological techniques to assess risks

Dynamic reserves

Probabilistic models in operations processes & tools

Foresight of congestion and wind curtailment

Aggregated uncertainty management

Fast solar growth and changing risk profile