Operational Probabilistic Tools for Solar Uncertainty

DOE Solar Forecasting II Program

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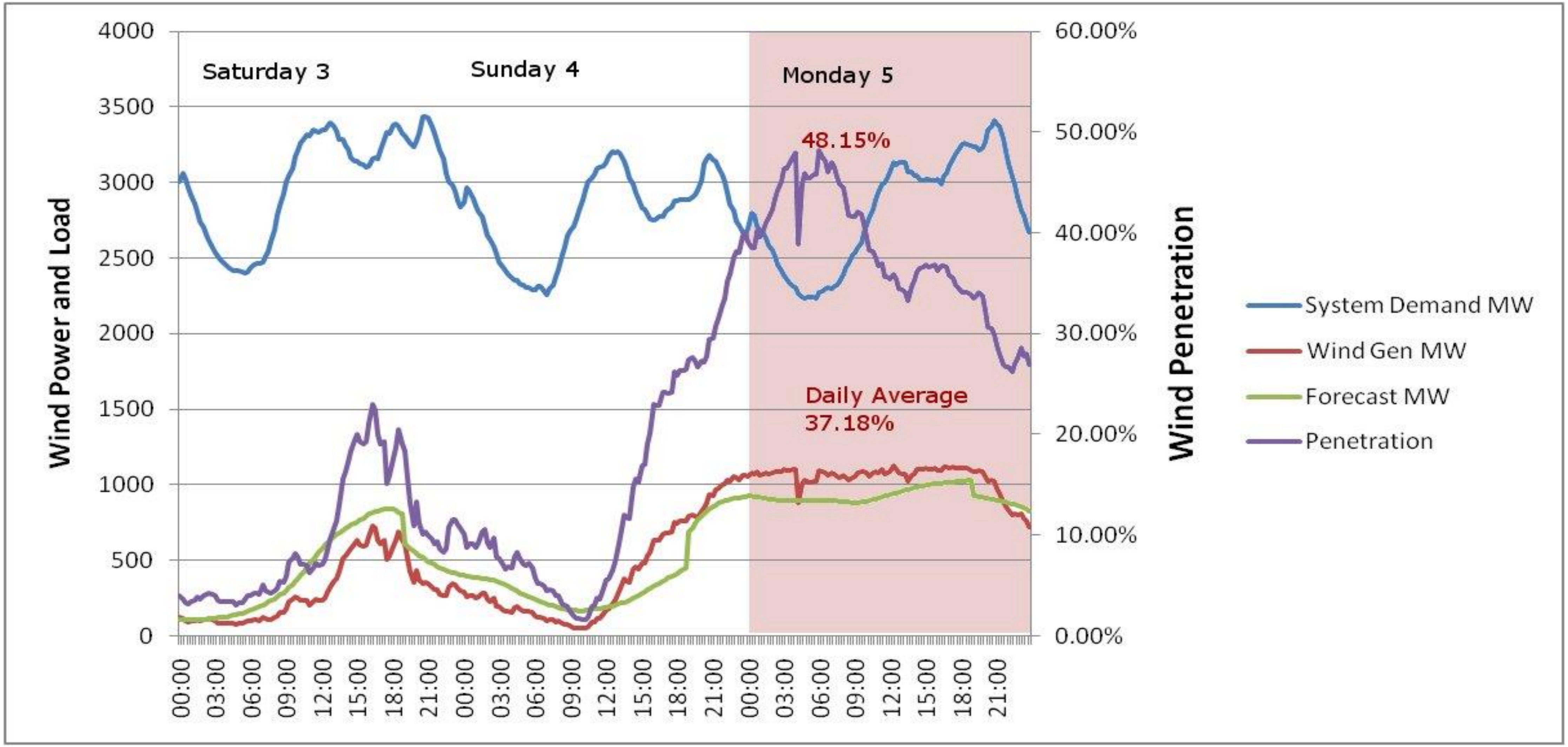
SunShot
U.S. Department of Energy

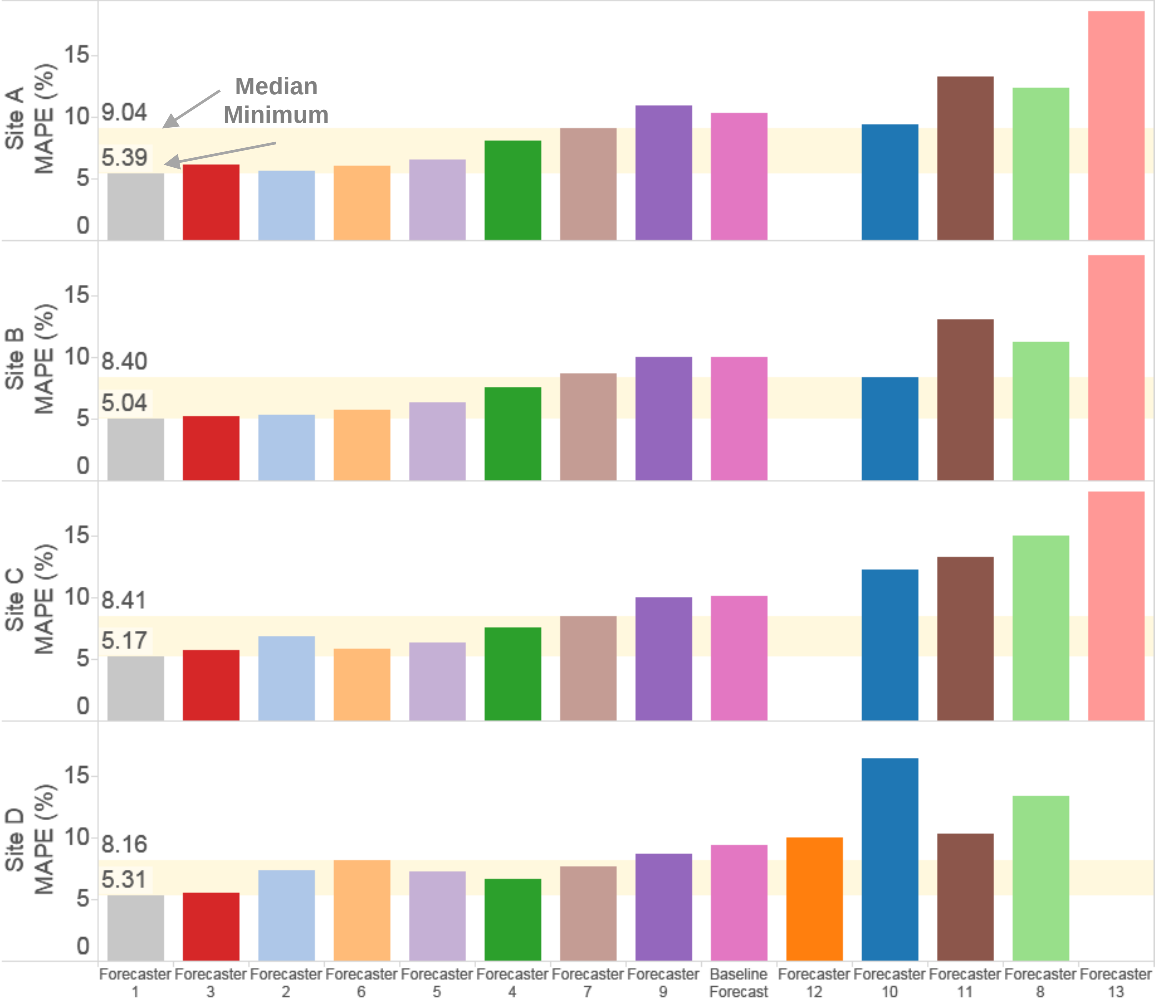
Wind & PV Variability/Uncertainty Challenges System Operations



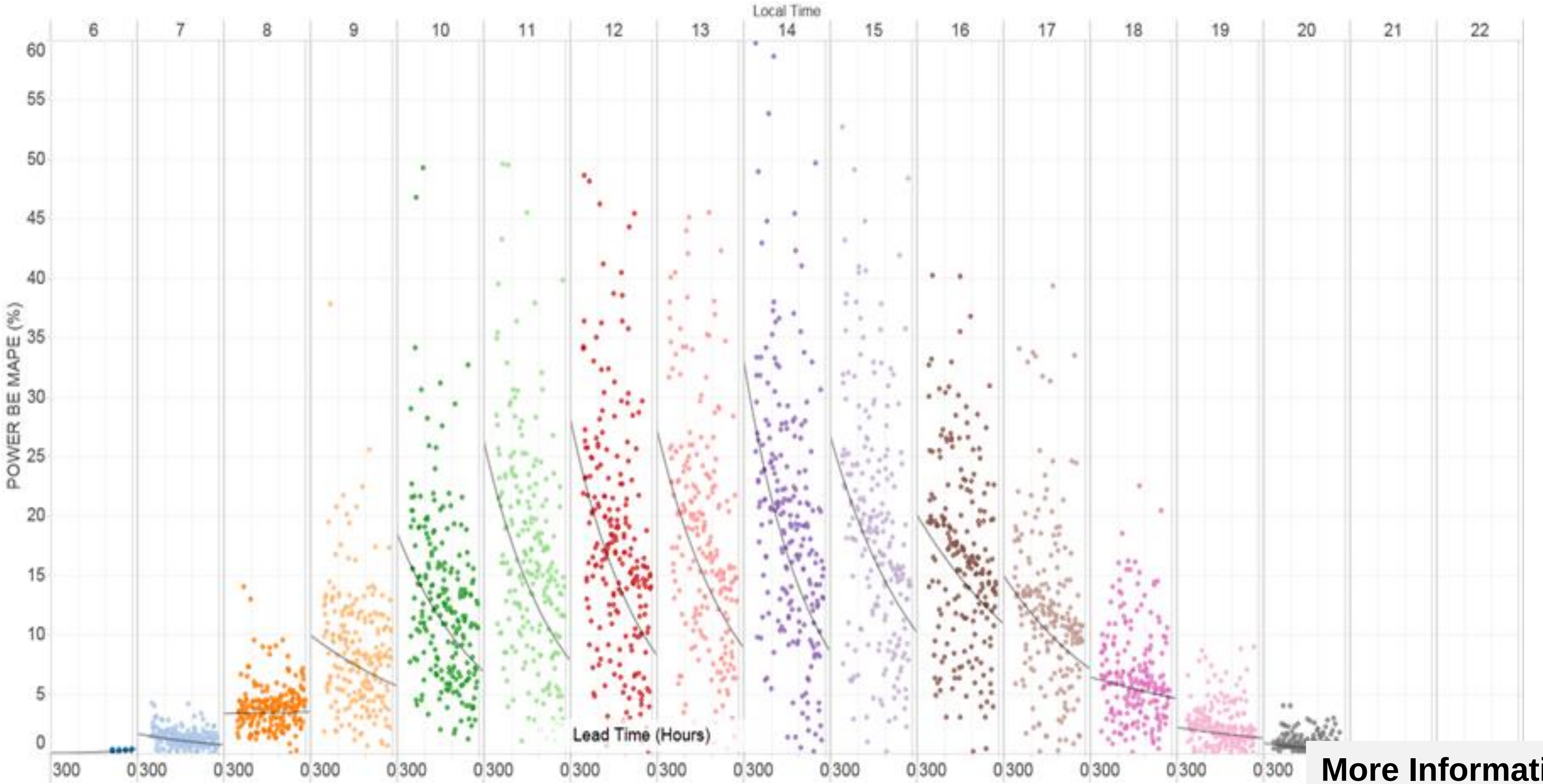
Source: Constructed from EIRGRID online data (www.eirgrid.com).

Solar Forecasting Performance

- EPRI assessed solar forecasting performance with two members across 6 months – CPS Energy (2014) and Southern Company (2016)
- Anonymized forecasts from 10+ commercial providers to assess current state of the art
- Mean Absolute Percentage Error (MAPE) is a useful summary metric of performance – average error normalized by capacity
- Performance showed similar performance in different regions (GA, TX, CA) while improving from 2014 to 2016
- Other metrics and analysis provide additional insights into performance



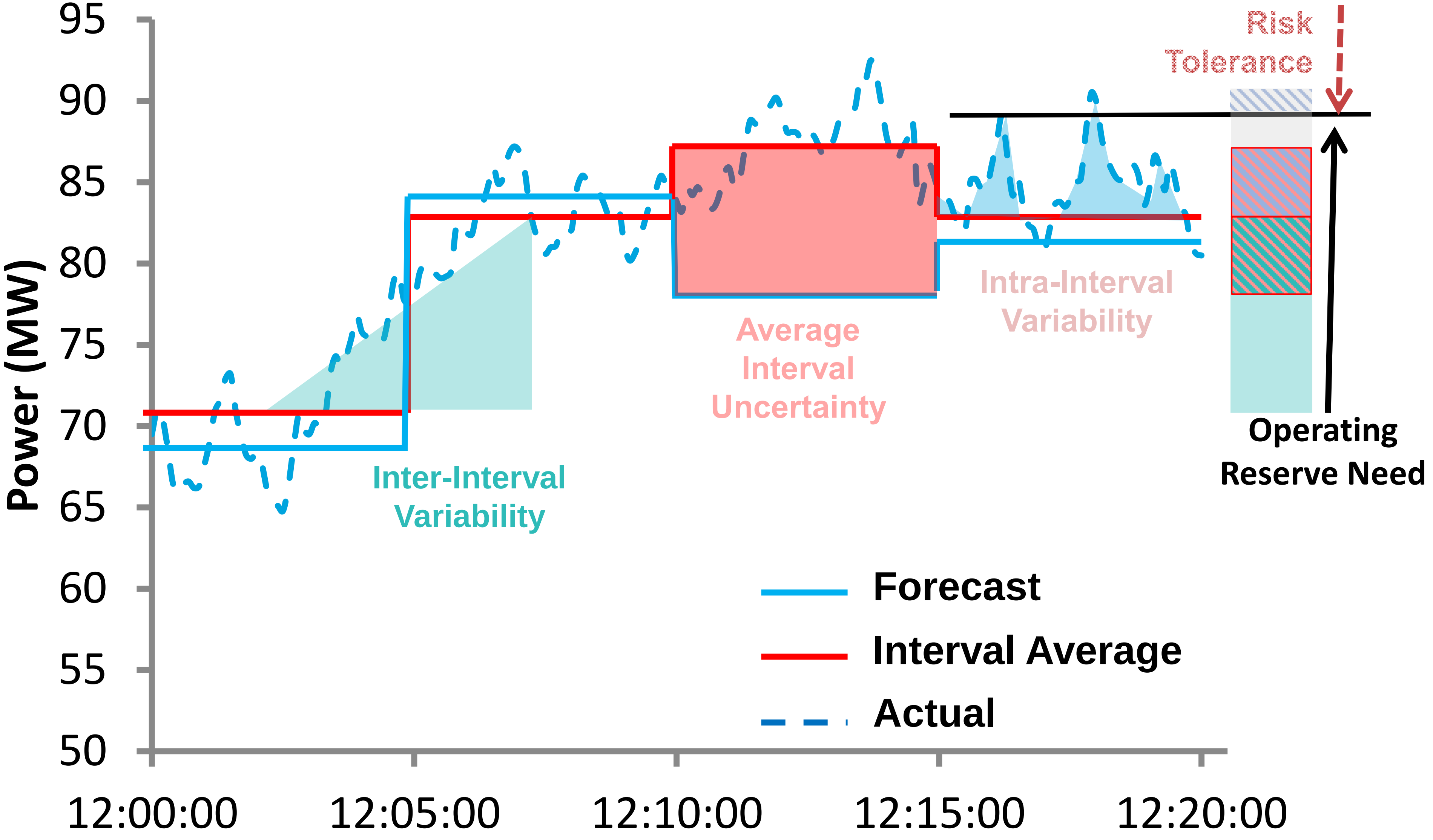
More uncertainty in performance than summary metrics show



More Information:

Solar Power Forecasting for Grid Operations: Evaluation of Commercial Providers, EPRI, 3002012135

Deterministic Methods - Three Central Reserve Needs



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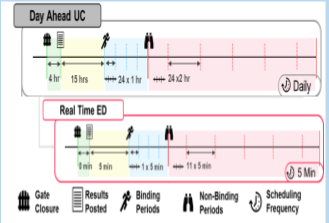
EPRI Dynamic Reserve Method

Scheduling Procedures

- When reserve is held and when released
- Scheduling interval length, horizons



Historical Forecast and Actual Data

- Wind, solar, load
- Forecast error

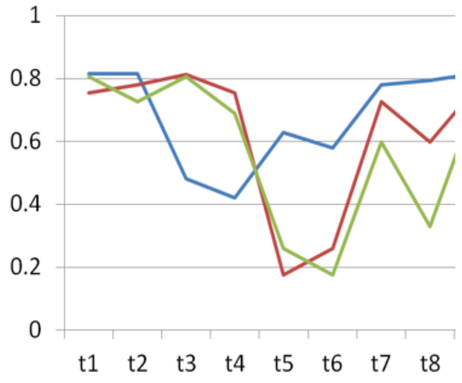
Current and Anticipated Conditions

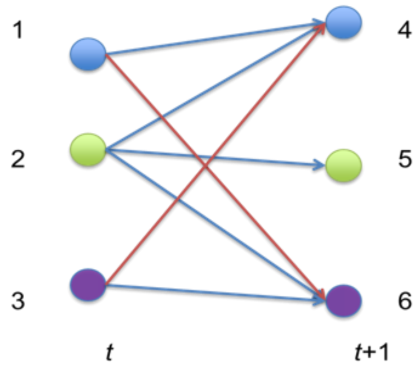
- Known data about current or future conditions
- Forecasts, time of day, probabilistic data

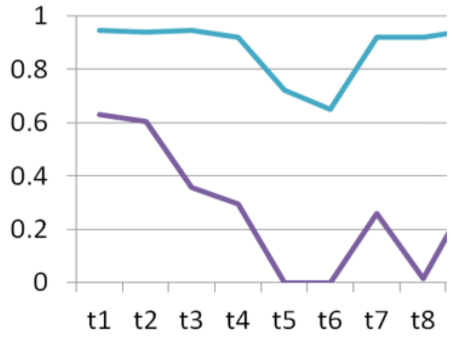
- Multiple utility case studies have shown benefits to dynamically setting reserve requirements
- Both economic (several $m) and reliability benefits (area control error) can be observed
- Recent improvements to the tool include addition of neural network to forecast reserve requirements

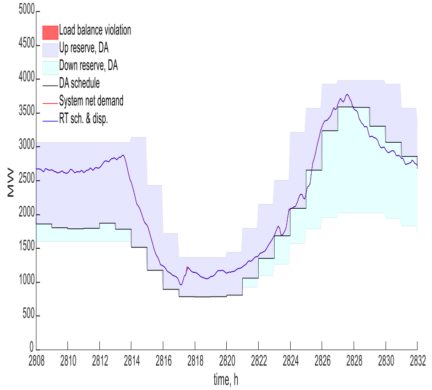
Dynamic Operating Reserve Assessment and Determination (Dynador) Tool

Project Motivation: Using Advanced Methods for Operating Systems With Uncertainty





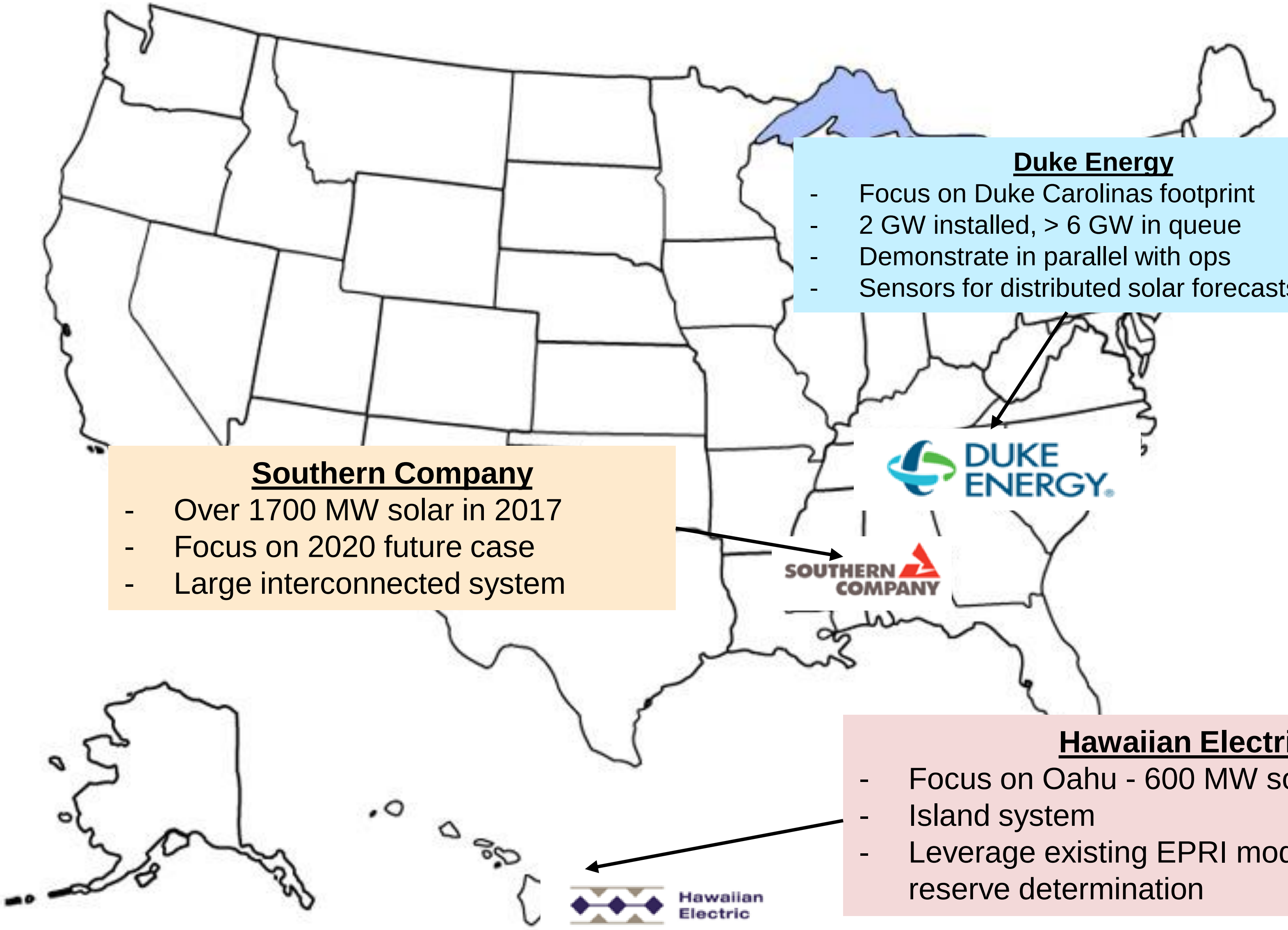




	Stochastic UC	Interval UC	Robust UC	Dynamic Reserves
Uncertainty Model	Scenarios	Inter-temporal rates	Uncertainty range	Requirements
Objective	min E{cost}	Minimize cost to meet central forecast	min{max{min *f*}}	Minimize operating cost to meet forecast
Security	Depends on the scenarios	Inter-temporal ranges	Uncertainty Budget	Confidence interval
Scalability	Low	High	Variable (high)	High

Can we use other methods to deal with uncertainty/variability?

Utility Demonstrations



Duke Energy
- Focus on Duke Carolinas footprint
- 2 GW installed, > 6 GW in queue
- Demonstrate in parallel with ops
- Sensors for distributed solar forecasts

DUKE ENERGY

Southern Company
- Over 1700 MW solar in 2017
- Focus on 2020 future case
- Large interconnected system

SOUTHERN COMPANY

Hawaiian Electric
- Focus on Oahu - 600 MW solar installed
- Island system
- Leverage existing EPRI modeling on reserve determination

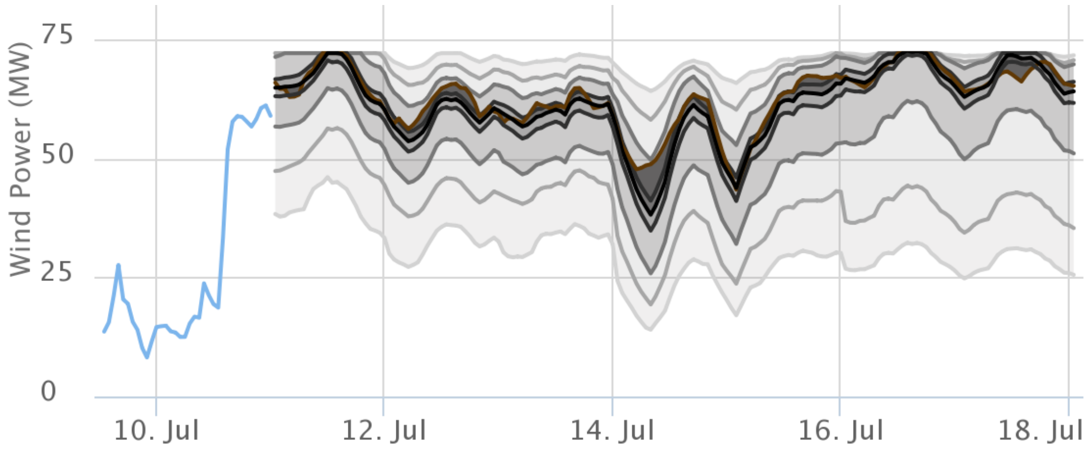
Hawaiian Electric

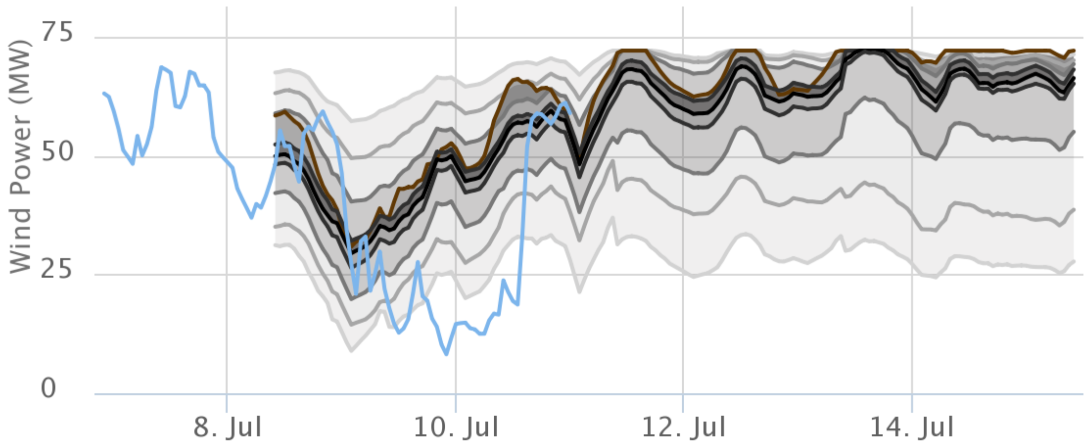
1. State of the Art Probabilistic Forecasting (UL)

- Improved modeling of uncertainty for solar PV
  - Forecast model ensembles will be customized for each utility's application
  - Ensembles will include NWP and other forecast models: e.g. time series, satellite cloud tracking
  - Will consider uncertainty factors typically not well represented in NWP ensembles such as sub-grid scale cloud effects, aerosol variations and irradiance to power

- Targeted visualization of probabilistic forecasts
  - Build on existing UL displays
  - Scenario generation methods will be examined

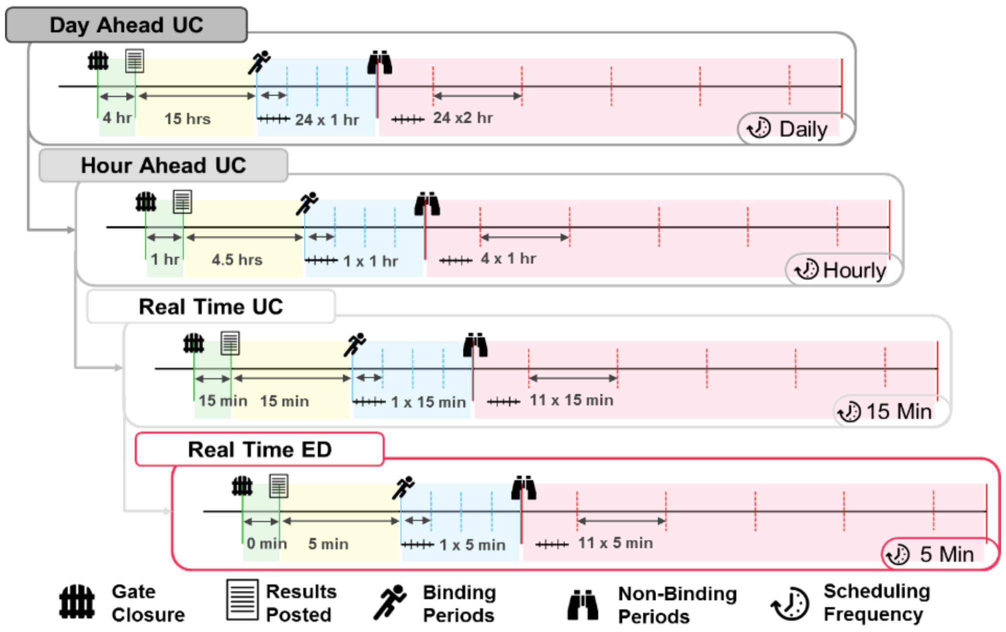
- Ongoing evaluation and improvement of probabilistic forecasts
  - Move from quantile regression to more sophisticated machine learning approaches to calculating the probability distribution of our ensemble forecasts
  - Rigorously track these improvements using appropriate measures of probabilistic forecast skill, such as Ignorance

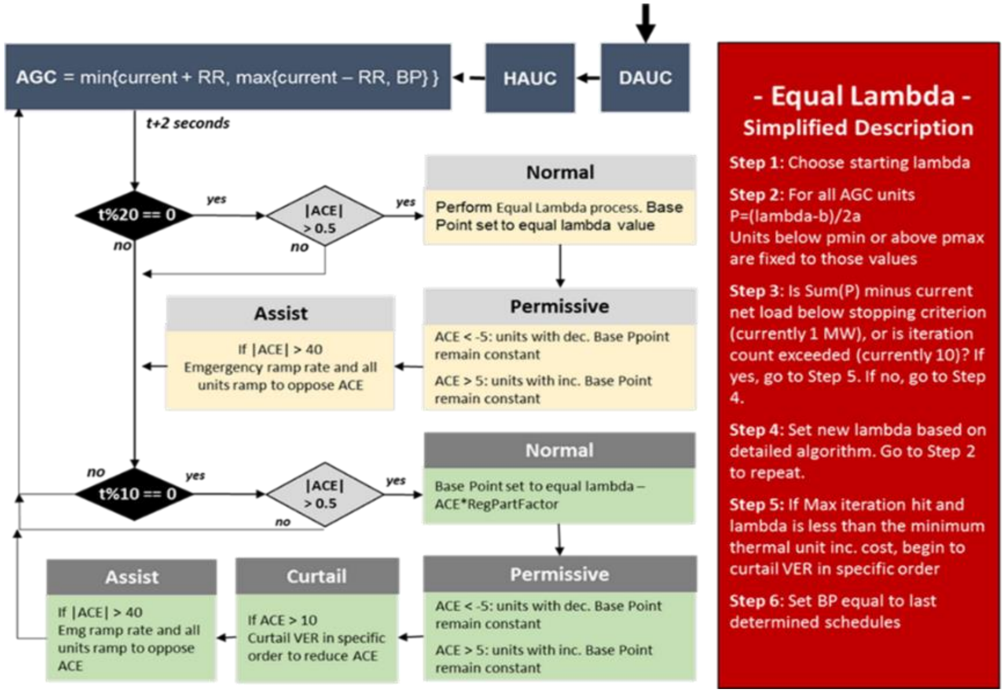




2. Industry Leading Multi-Stage Operational Simulation Tools (EPRI)

- Develop accurate models to understand how best to use probabilistic forecasts
  - Represent Day(s) Ahead, Hour(s) ahead and real time commitment and dispatch of the system
  - Include **forecast uncertainty** and means to manage risk (stochastic programming & reserves)





- **PSO** to be used for Duke and Southern: Focus on 5-minute and longer intervals
  - Have used to study CAISO/WECC and TVA in the past
  - Will produce specific designs for operational processes
- **FESTIV** is used for Hawaiian Electric case study – 2 second time resolution
  - Necessary for smaller island systems
  - Will add stochastic programming capabilities and probabilistic forecasting

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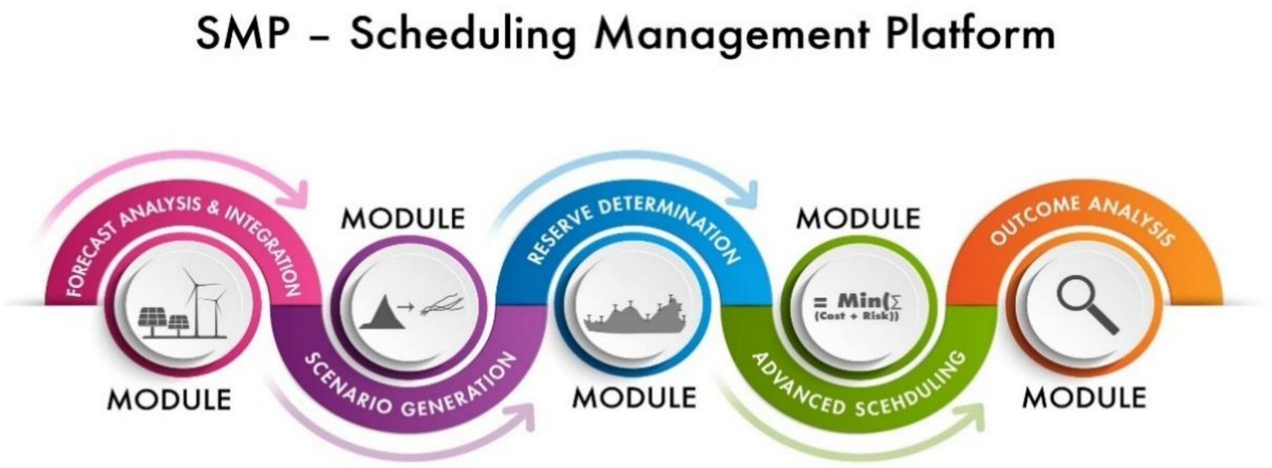
3. Scheduling Management Platform (EPRI)



- Results from Workstreams 1 and 2 will inform development of a Scheduling Management Platform
  - Modular approach to allow for more flexibility and further development in future R&D and demonstrations
  - Customized, where appropriate, for each utility, to ensure that their specific energy management processes can leverage toolset

- Demonstration will run for at least six month period in a development environment – ongoing analysis of the outcomes to demonstrate the benefits of probabilistic methods

- Individual modules developed will be delivered as code/software tool, with guidelines for incorporation into other systems based on their specific needs

Summary/Conclusions

Reliably and Efficiently Integrating Renewables

Improved probabilistic renewables forecast

Advanced operating practices and tools

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VT

POLARIS
SYSTEMS OPTIMIZATION

DUKE ENERGY.

Southern Company

Hawaiian Electric

Currently developing datasets/models and starting to deliver forecasts for the three utility systems to be studied – initial results to come later in year!

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