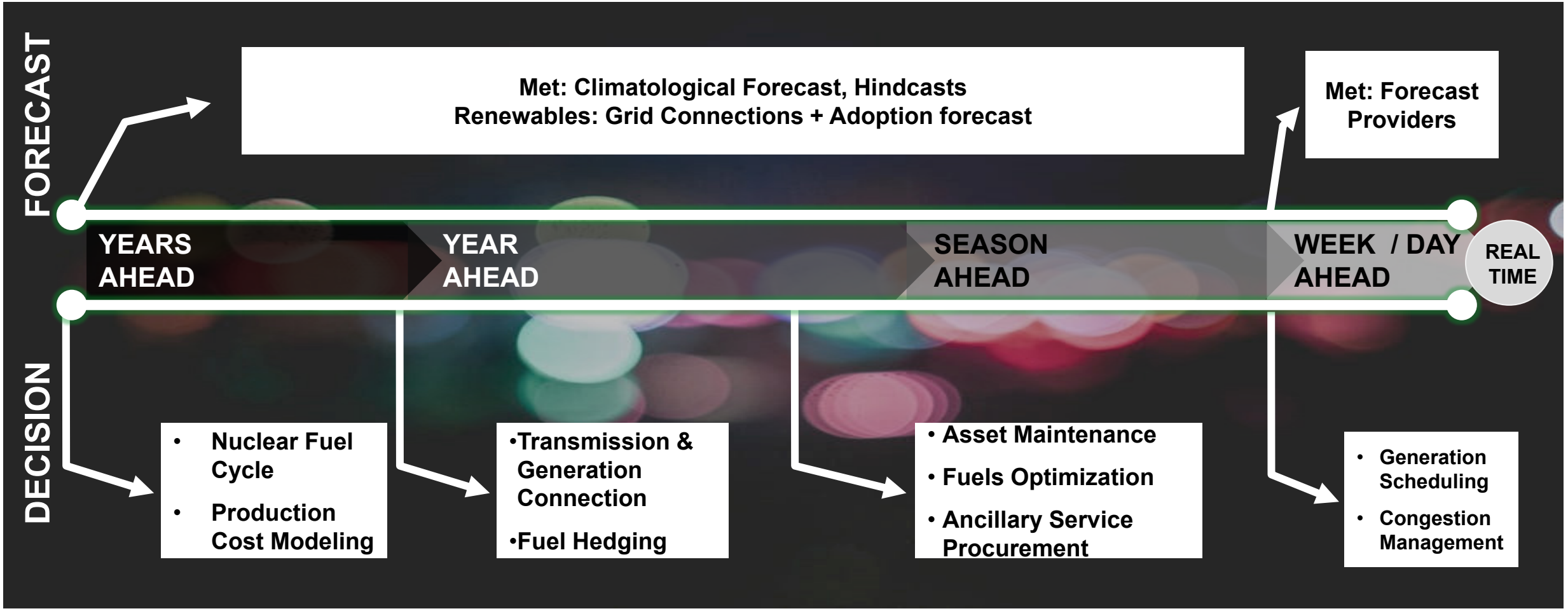
# Progress and Needs for Renewable Energy Forecasting

## IEA Wind Task 51 Workshop

Eamonn Lannoye

Sept 12th, 2022

# Bulk System Forecast Uses




**Similar time frames for distribution**

# Emerging Challenges for Forecasts

## Plant Operations

Hybridization with storage, solar

Active wake steering, plant optimization

## Extreme Conditions

Operational decision making in stressful grid conditions

Impact of wildfire, storm, flood


## End Use Applications

Integration of forecasts into ops planning / balancing

Valuation of forecasts

**Deeper integration into system operations**

# NWP Highlights

## North American Models

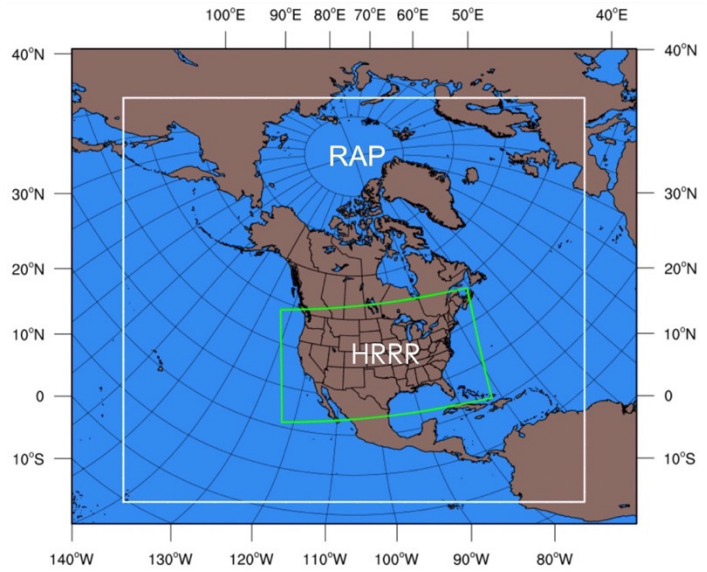
- Extended horizons for rapid refresh (HRRR, RAP) models
- Assimilation of satellite data
- Cloud physics – improves subgrid mesh

## European Models

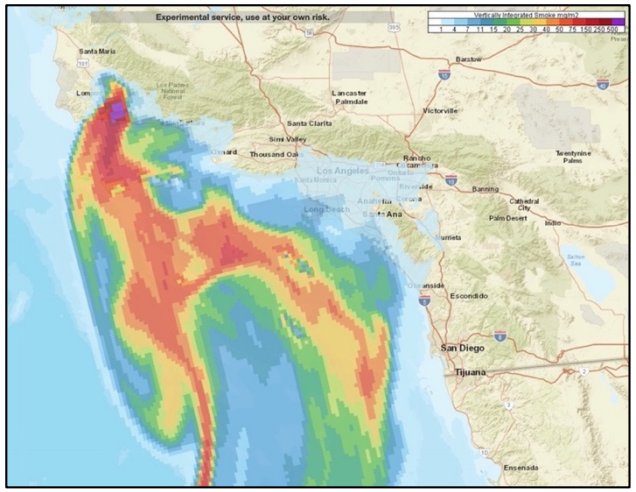
- Improved cloud, precipitation modeling
- Assimilation of satellite data
- Increased vertical resolution

## Wildfire and Smoke

- NOAA HRRR-Smoke and RAP-Smoke models




**Domains of the RAP (13-km resolution) and HRRR (3-km resolution) models.**
**Source: rapidrefresh.noaa.gov**

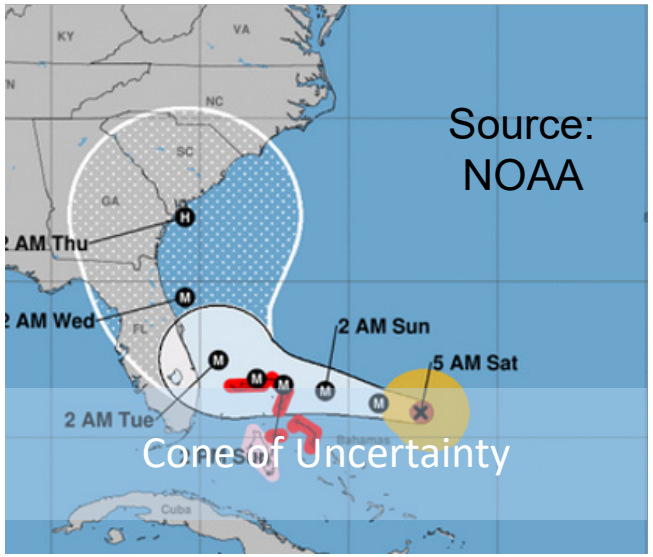


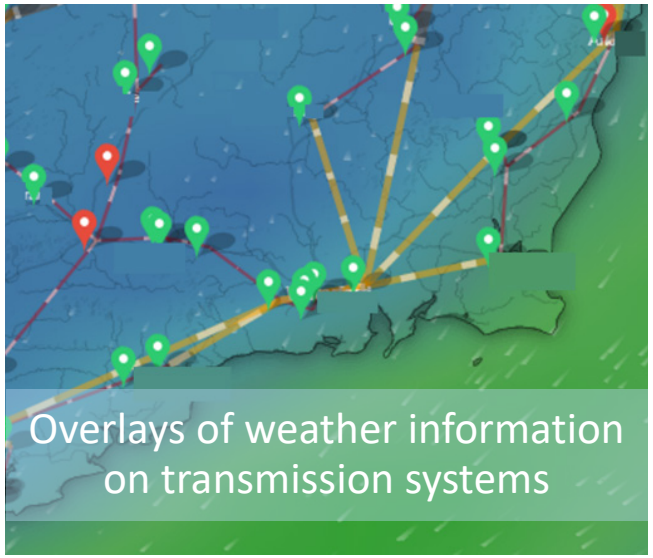

**Sample HRRR-Smoke forecast of vertically integrated smoke from a fire near Santa Barbara, CA on October 12, 2021.**
**Source: rapidrefresh.noaa.gov/hrrr/HRRRsmoke/**

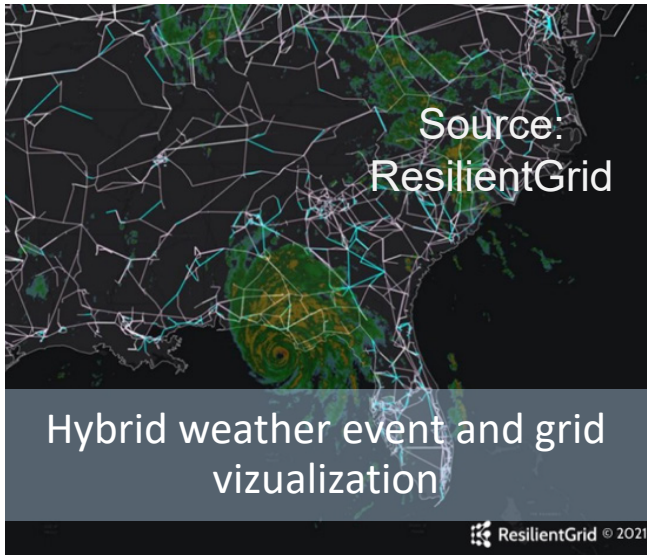
# Forecast in Operator Decisions Highlights

»Support operator decision making without information overload

»Primarily involves incorporating weather forecasts



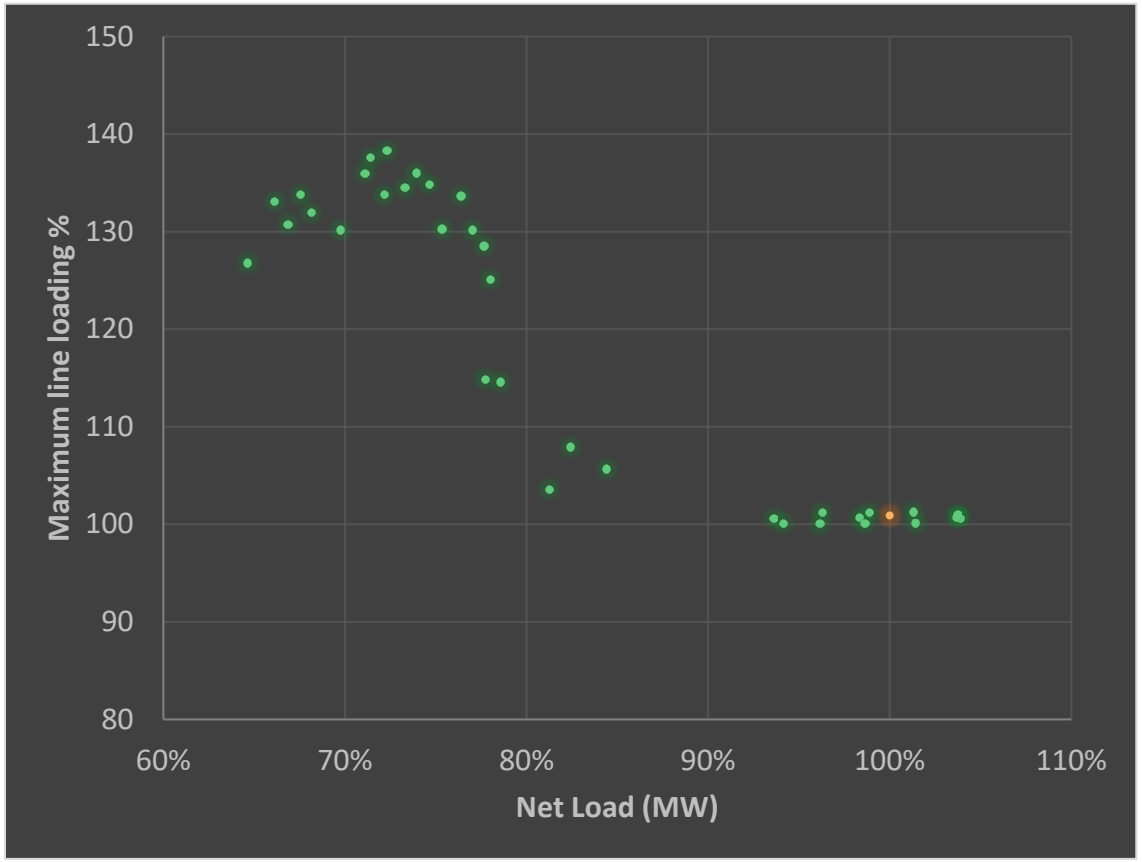



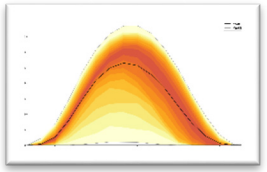

- Robust Data Pipeline and Storage
- New Standardization for Color/Actions Schemas
- Integration with EMS Alarms & Alerts
- Incorporating Condition with Security Analysis
- Standardized forecast Performance and Metrics (Establish Baselines)

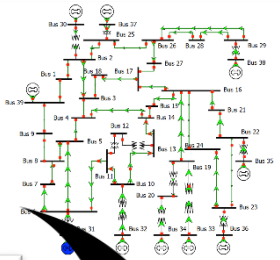
# Days Out Forecasts Help Develop Scenarios to Improve Reliability

High-risk Scenarios Often Not Peak Cases
Thus, Missing in Operations Planning Studies



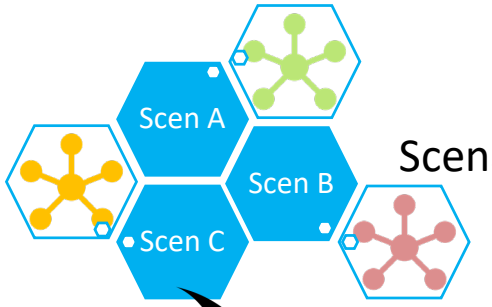

Load, VER, DER Distributions



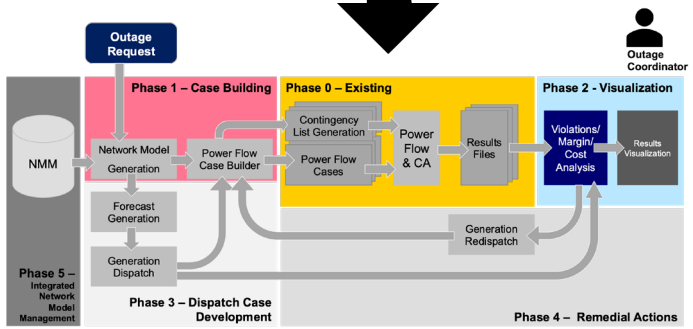


Expected Topology

Weather Event Likelihood

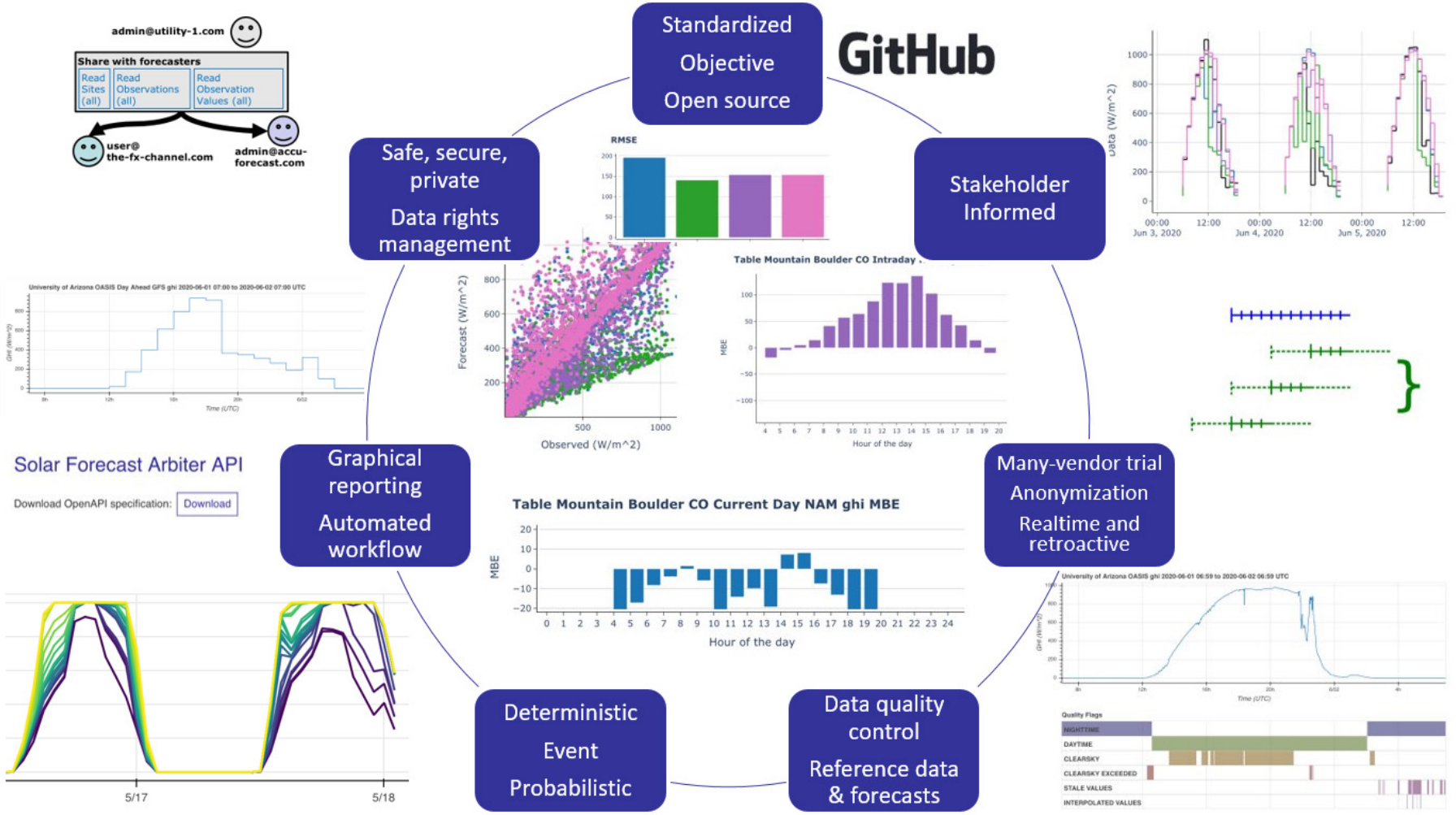



Scenario Development




Days-Weeks Out Outage Studies

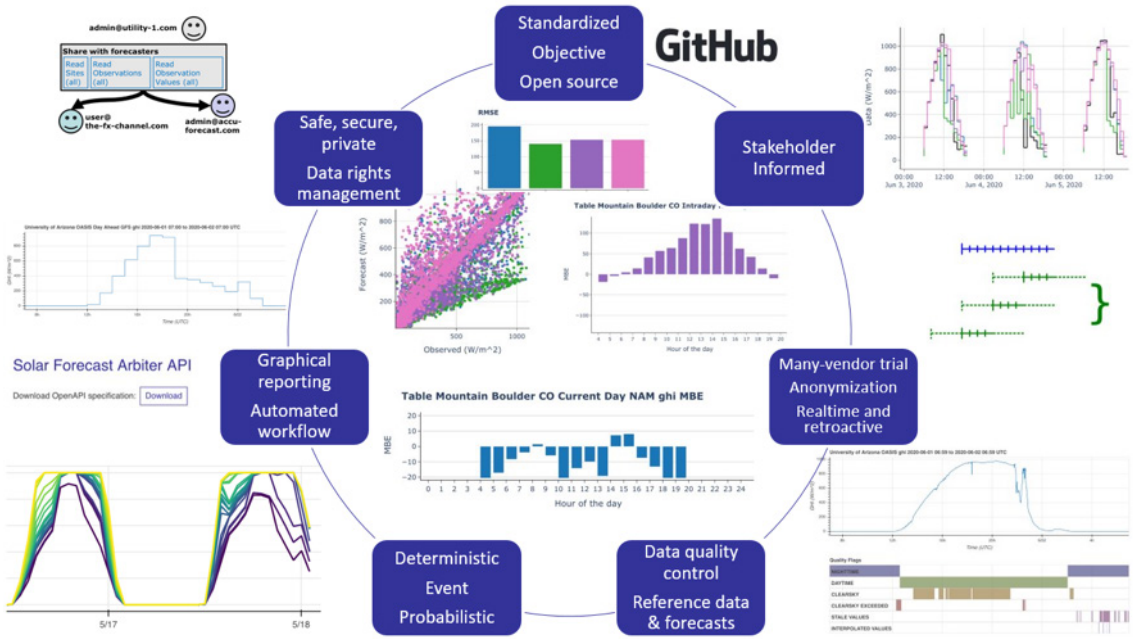
# Solar Forecast Arbiter: https://solarforecastarbiter.org/




**impartial, repeatable & auditable forecast evaluation tool**

# Solar Forecast Arbiter

- online platform that provides transparent evaluation of forecast performance
  - user friendly, with graphical and API interfaces
  - supports anonymized forecast trials
  - open-source code
- currently focused on solar, but is generalizing to cover solar, wind and load forecasts
- will transition to EPRI management starting mid-2022*
  - will be part of a Forecasting Users Group (UG) for utilities/ISOs/RTOs, but still available to the public
  - UG will include annual meetings, updates on performance, support in benchmarks and use




https://solarforecastarbiter.org/

*EPRI was one of the co-developers, along with University of Arizona (lead), Sandia and Sharply Focused, with funding provided by DOE

**Contact David Larson <dlarson@epri.com> or Aidan Tuohy <atuohy@epri.com> for more info**

# Why use the Forecast Arbiter?

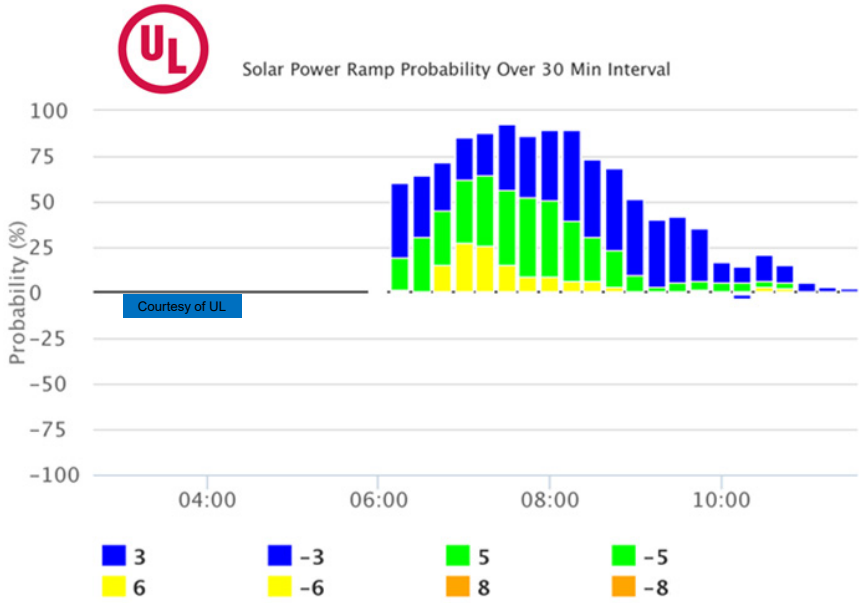
- standardized process to evaluate forecasts
- anonymized, multi-vendor forecast trials
- track forecast accuracy over time
- automated reports with wide range of error metrics
- support for both deterministic and probabilistic forecasts
- benchmark forecasts and reference data for 200+ sites already included
- …and many more features!

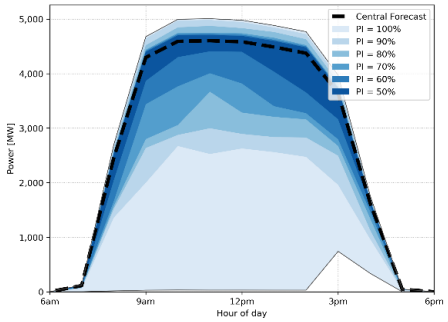

**Figure:** Screenshot of sample report.

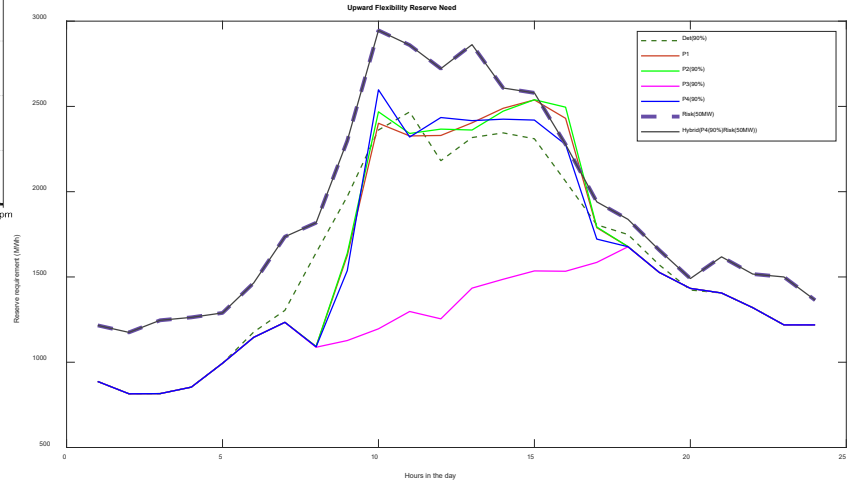
# Probabilistic Forecasts

- Useful for providing additional awareness and insight on uncertainty
- Working on methods to incorporate these directly into decision processes
- Balancing authority is main focus now, but similar concepts could be applied to others

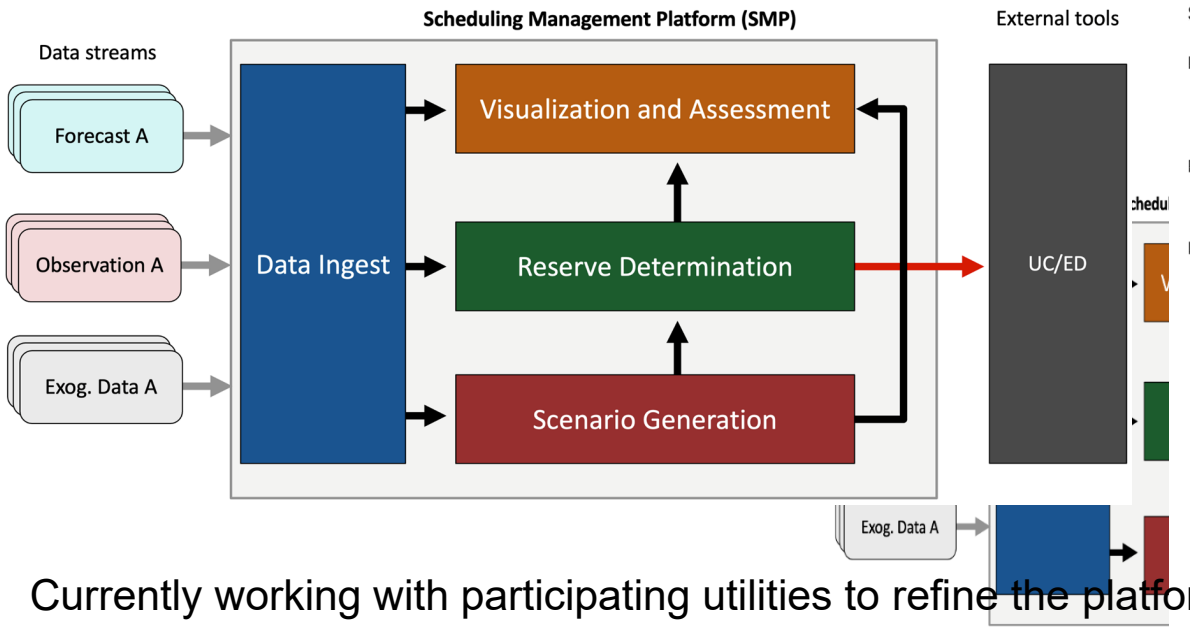

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

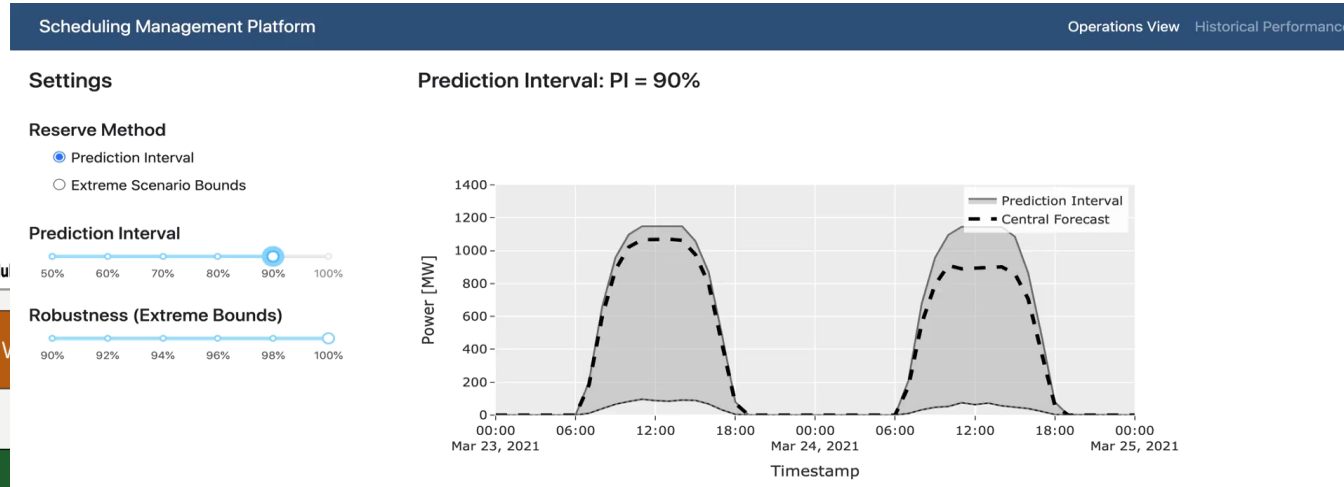


# Software Tool to Support Integration with Operations




Currently working with participating utilities to refine the platform

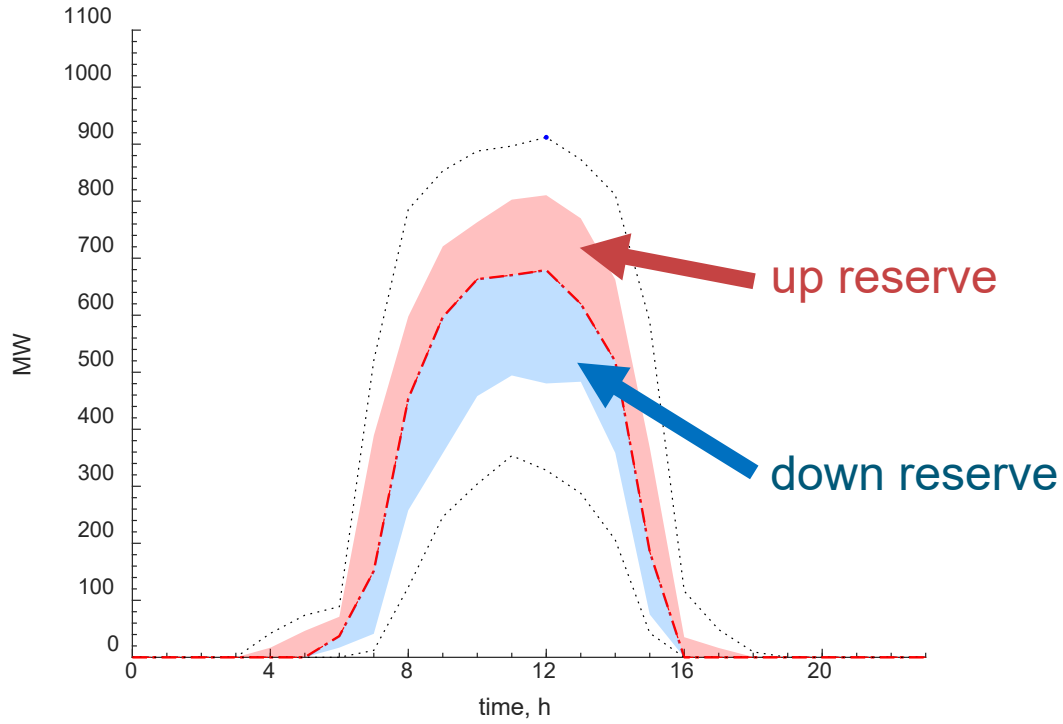
- Reserve requirements for different risk preferences and methods
- Scenario generation for UC
- Link to unit commitment/economic dispatch
- Visualize and assess forecasts and reserves

**SMP to be released as open-source at end of DOE project**

# Use of Probabilistic Forecasts in Operations

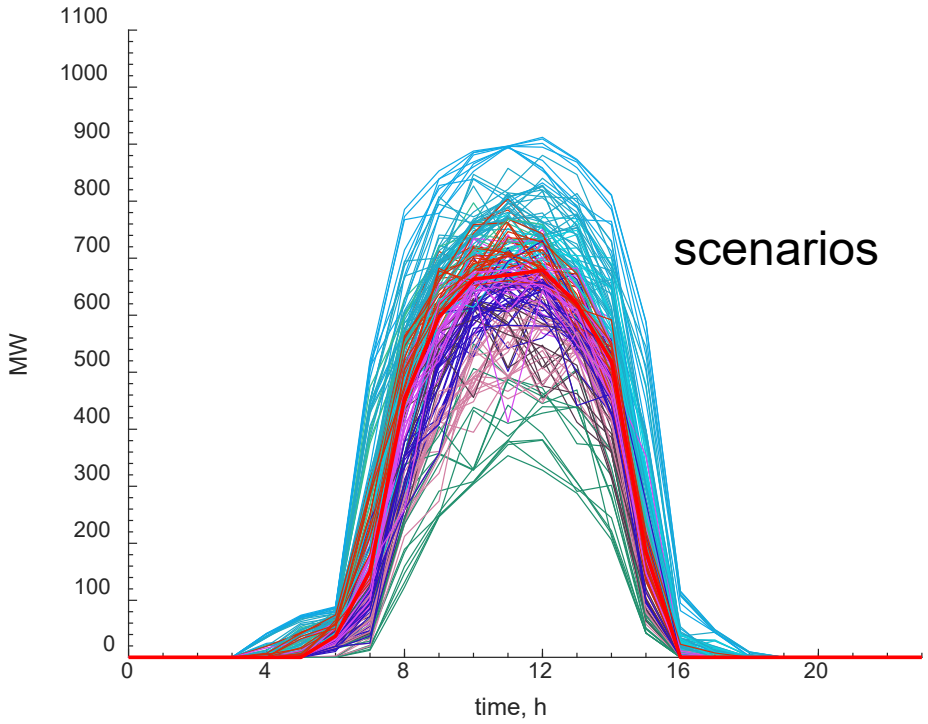
## Use #1: Directly use to set reserves

» Set operating reserves based on probabilistic forecasts – different methods can be used



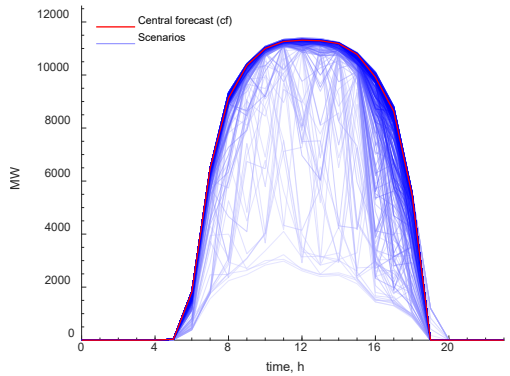

## Use #2: Scenario Generation for UC or reserves

» Transform probabilistic info into scenarios, which can be used in a UC model to allow for stochastic UC



# Probabilistic Scenarios to Reserve Requirements

» From scenarios to reserve requirements




load

wind

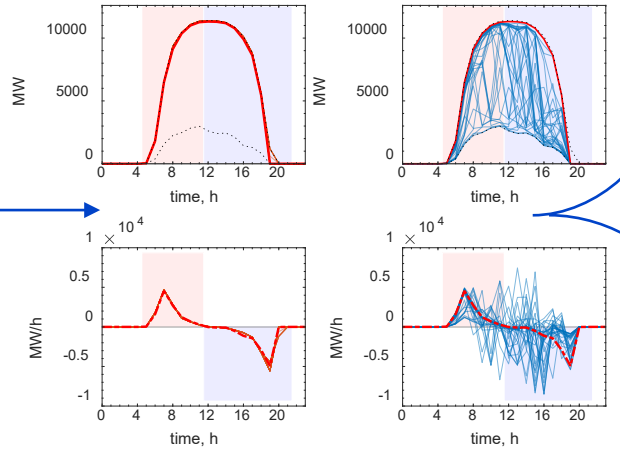
DynADOR

$|S|$

**Method 1**

Consider all scenarios and historical data

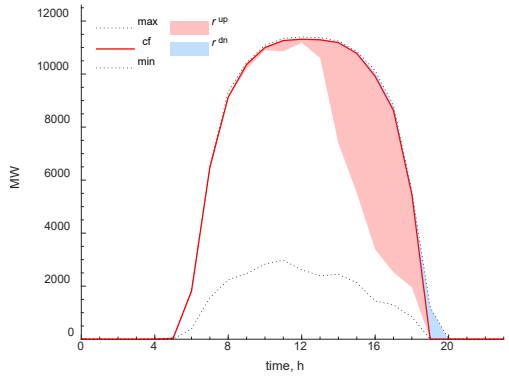
Given the explanatory variable, generate subsets ($S^{up}$, $S^{dn}$) of extreme scenarios




**Method 2**

Extreme scenarios and historical data

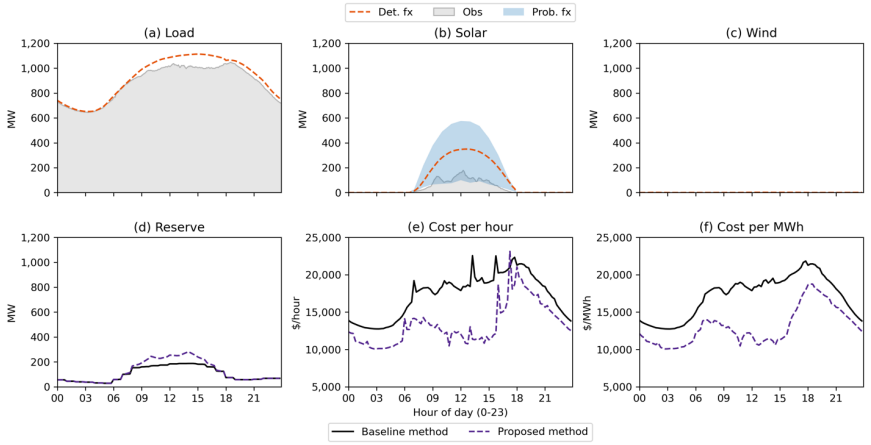
**Method 3**



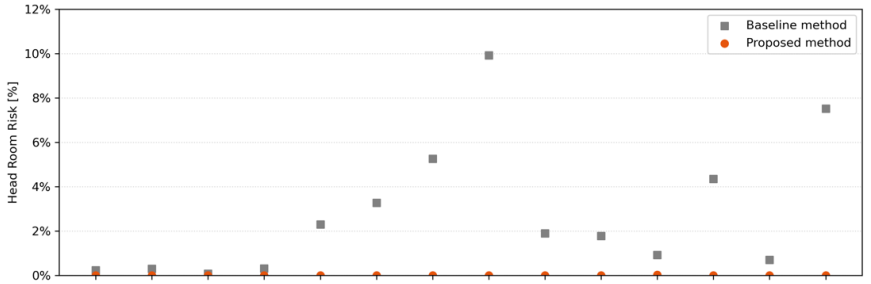
# Utility Case study results (Hawaiian Electric)

» Using probabilistic forecasts to set reserves:

- increased reserves during middle of the day (when solar generation peaks)
- did not conclusively increase or decrease costs, but led to more consistent operating costs week-to-week
- improved operating conditions, including lower head room risk (< 1%) and more consistent frequency compliance




Day where prob. forecasts increased reserves, but lowered costs.

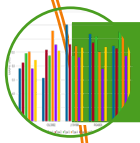


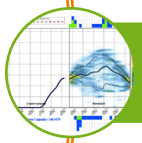

Prob. forecasts (orange) led to lower risk (< 1%) for all weeks simulated.

# EPRI Short Term Forecast Integration Efforts

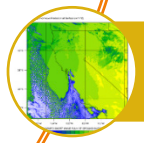

Renewable Forecasting Landscape Document

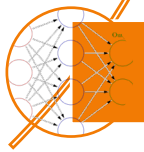

Behind the Meter PV Impact on Load Forecast


Solar Forecast Performance Utility Trials


Operational Probabilistic Tools for Solar Uncertainty


NY Sky Imager Deployment and Advanced Forecasts


California Forecasting Improvement Projects


Artificial Neural Network Short Term Load Forecaster

# For more info on the Forecast Arbiter

»ESIG blog post: https://www.esig.energy/the-solar-forecast-arbiter/

»webcast (~14-min): https://youtu.be/oqidNhlAkAo

»main website: https://solarforecastarbiter.org/