Operational Probabilistic Tools for Solar Uncertainty (OPTSUN)

Using Probabilistic Solar Forecasts to Inform Operational Decisions

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EPRI OPTSUN Project – Objectives and Workstreams

- Forecasting: develop and deliver probabilistic forecasts with targeted improvements
- Design: identify advanced methods for managing uncertainty based on results from advanced scheduling tools
- Demonstration: develop and demonstrate a scheduling management platform (SMP) to integrate probabilistic forecasts and scheduling decisions in a modular and customizable manner

UL
DUKE ENERGY
SOUTHERN COMPANY
POLARIS
Hawaiian Electric

Key Lessons Learned

Forecasting workstream

- Considerable forecast improvements based on use of machine learning and additional model data
- Scenario development methods developed to turn probabilistic forecasts into scenarios

Design workstream

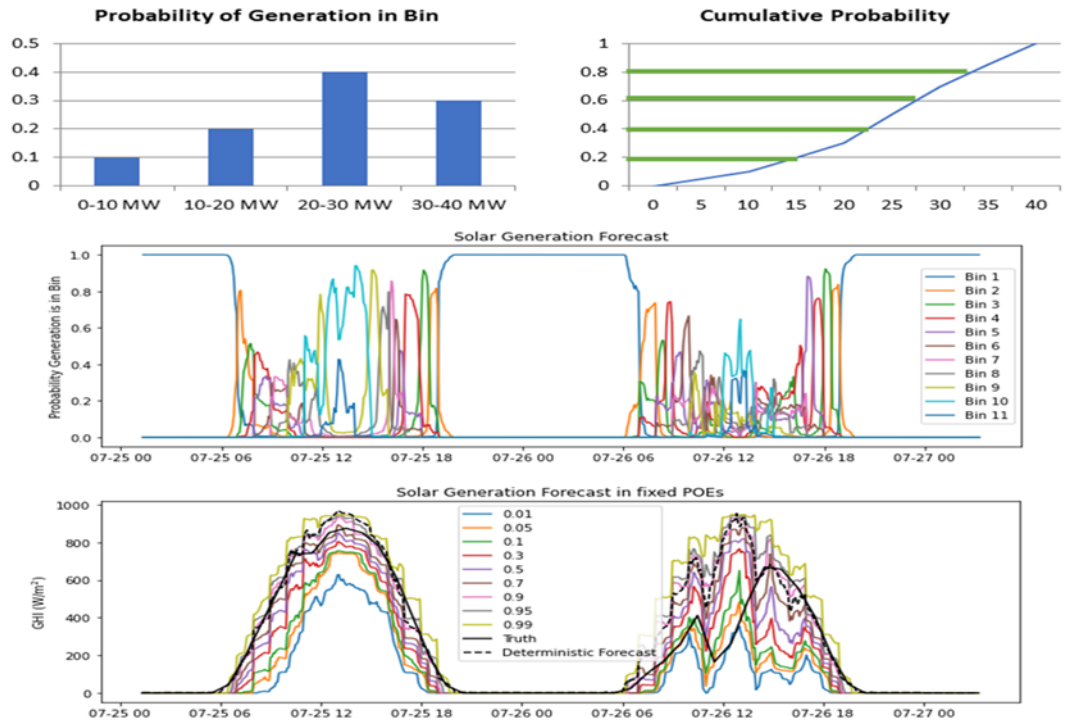
- Proposed probabilistic information-based reserve determination approaches and test on different regions
- Can improve reliability and potentially economics in power systems with increased penetration levels of solar
- Shows trade-offs between robustness levels, costs and reliability metrics
- Deterministic dynamic reserves are already very good – probabilistic forecasts provide additional insights

Demonstration workstream

- Scheduling management platform (SMP) tool (open source) developed and demonstrated to a wide range of operators and stakeholders at all three utilities and improved based on feedback
- The tool will be available as open source on Github

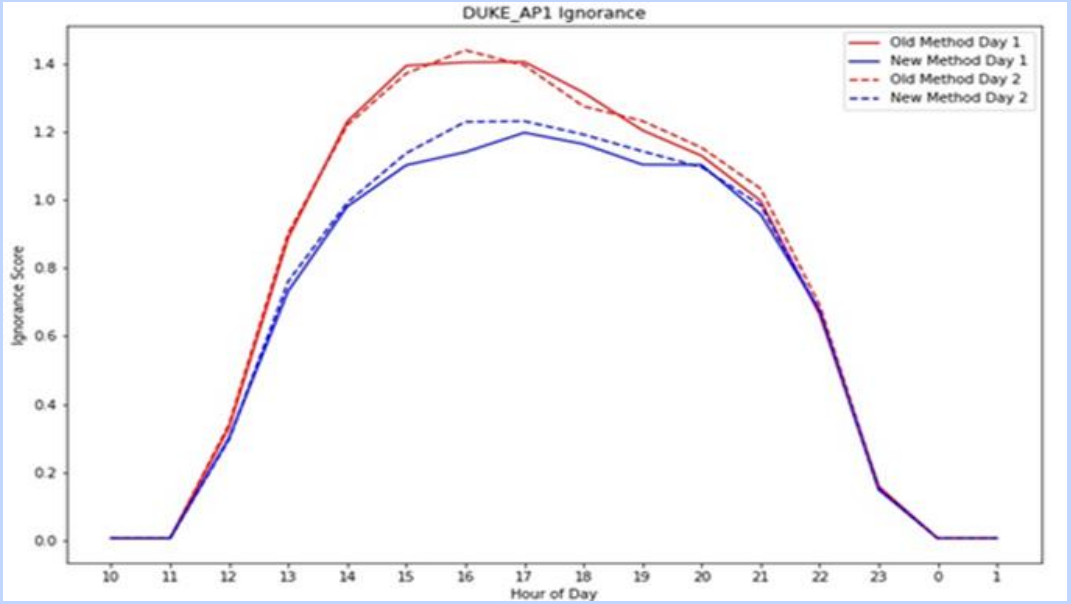
www.epri.com/optsun for more details (final report later in summer)

Probabilistic Forecasts



Probabilistic solar forecasts were delivered for each region as well as CAISO with continued improvement throughout the project

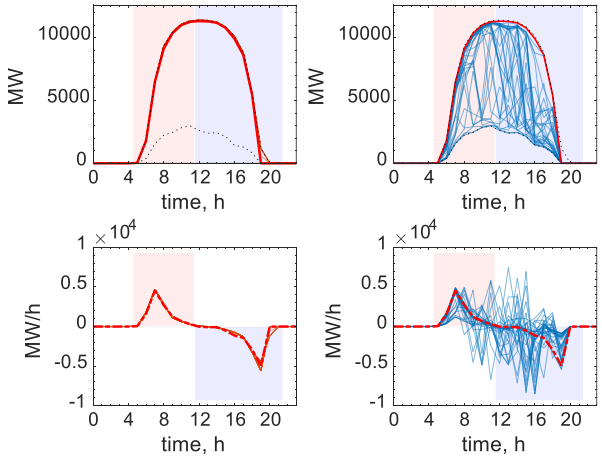
Improvement based on ignorance score was shown using machine learning methods and multi-model ensembles

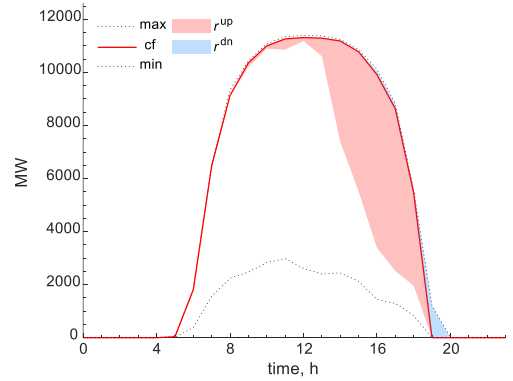


Probabilistic forecasts for reserve requirements

- Based on historical observations:
  - P1 – All scenarios: How much reserve is needed considering all possible materializations w.r.t. to observations?
  - P2 – Extreme scenarios: How sensitive are reserves to the worst possible conditions w.r.t. observations?

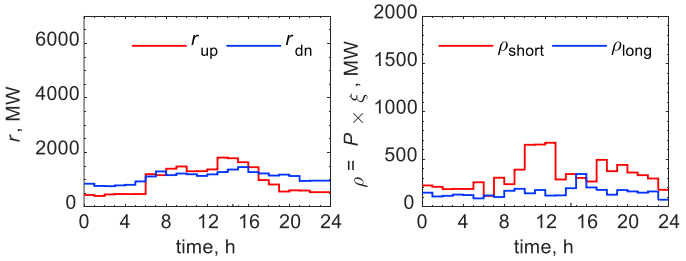
- Based on anticipated conditions alone:
  - P3 – Bounds of extreme scenarios: Based on anticipated uncertainty (disregarding past observations), what is the worst we can expect?
    - Focus on the tails if the distribution
  - P4 – Prediction interval: Based on anticipated uncertainty (disregarding past observations), how much should we carry to capture a desired percentage?
    - Focus on the center of the distribution



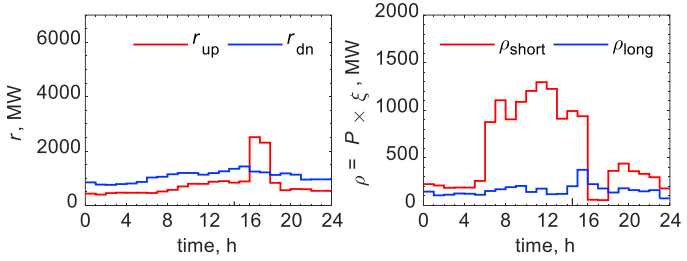


Risk based reserves

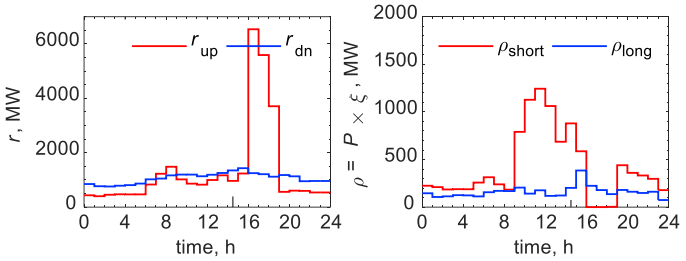
All scenarios ~ Extreme scenarios



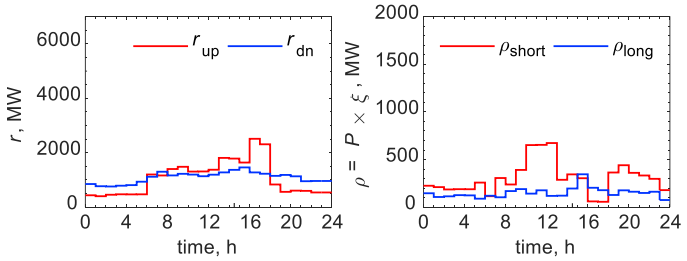
Bounds of extreme scenarios, 90%

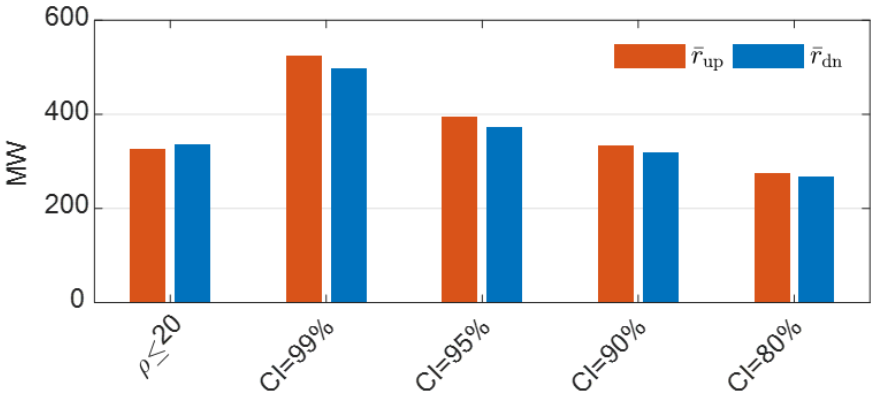


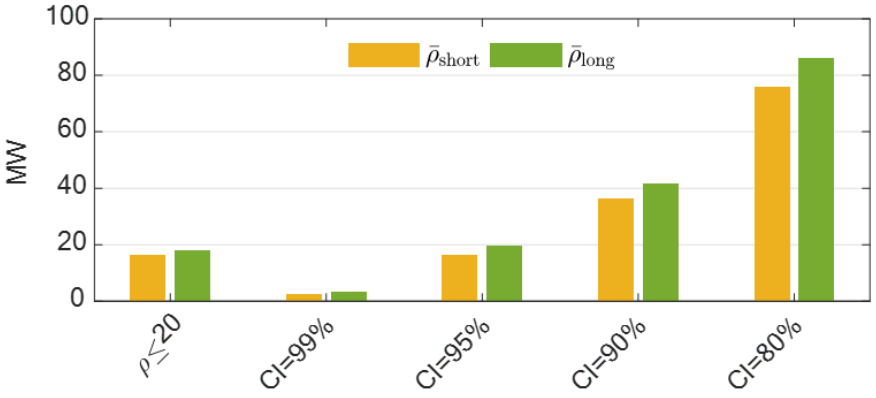
Prediction interval, 90%



max(Sce, Bounds 90%)



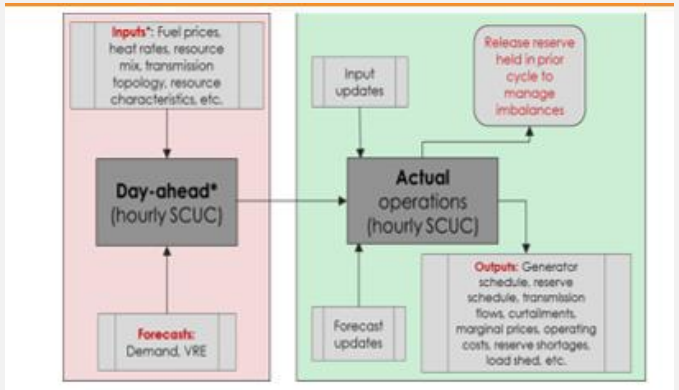




M. A. Ortega-Vazquez, N. Costilla-Enriquez, E. Ela, A. Tuohy, "Risk-Based Reserve Procurement," *2020 International Conference on Probabilistic Methods Applied to Power Systems* (PMAPS), Liege, Belgium, Aug. 18-21, 2020.

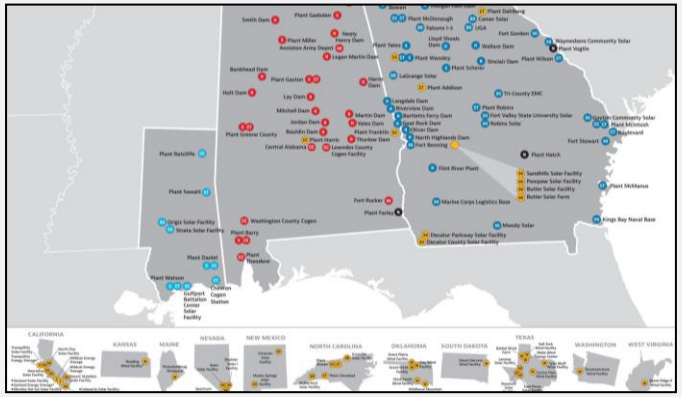
Method allow for comparison between risk and procurement targets – certain methods seem to perform best though region specific (CAISO shown here)

Simulation Based Case Studies



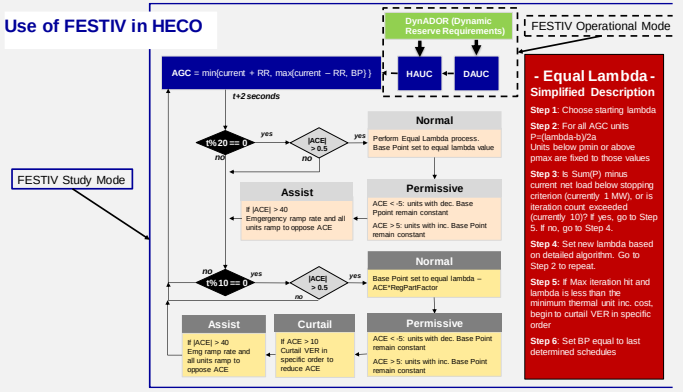
Duke Energy Carolinas

- Current and future solar penetrations
- Modeled week ahead to real time operations
- 2 adjoining balancing areas



Southern Company

- 7 GW – 20 GW solar
- Weeks ahead to hour ahead type analysis
- Also examined stochastic unit commitment



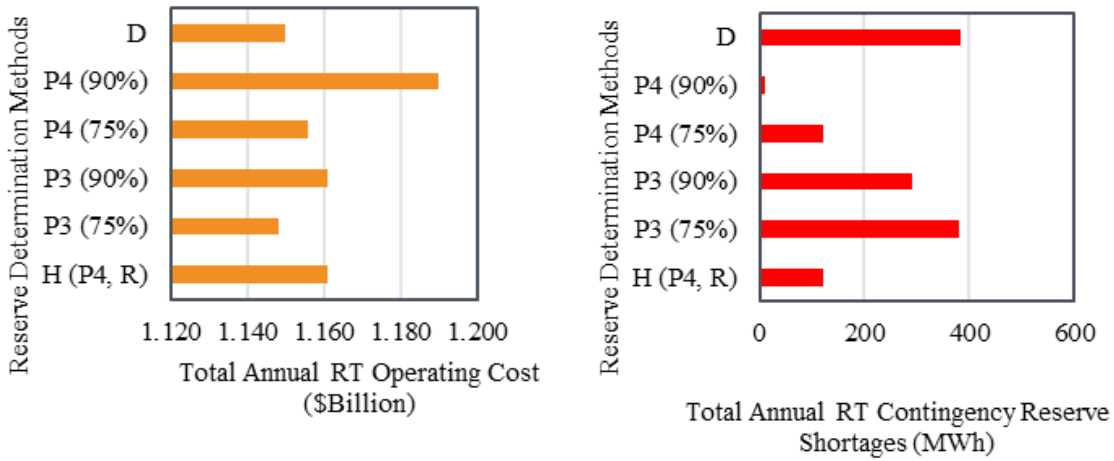
Hawaiian Electric Oahu

- Current system for several weeks
- Several specific HECO-developed metrics
- Modeled to 2 second resolution

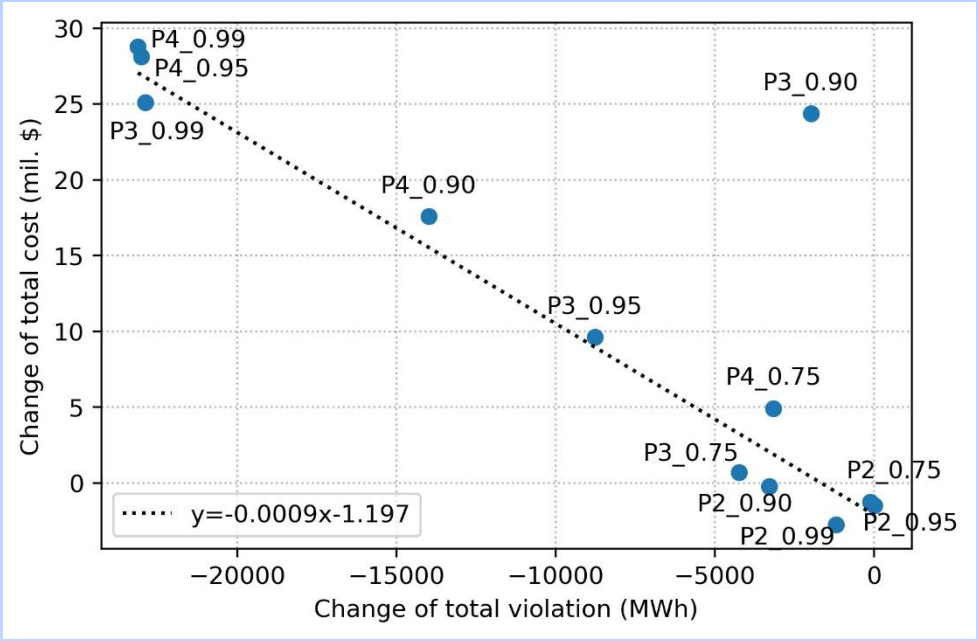
Also studied CAISO for reserves, but not full system model

Case Studies – Key Results

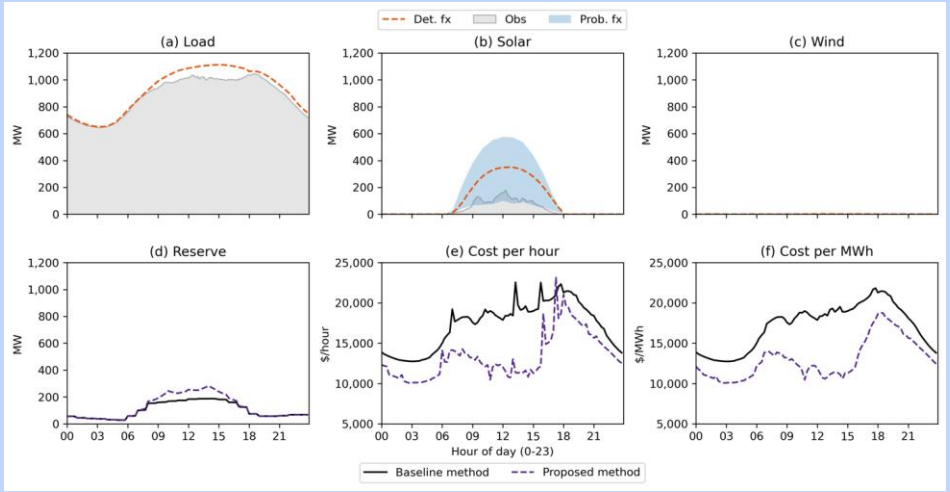
- Detailed hourly modeling shows the potential uses of enhanced reserve requirements
- Existing cutting edge (deterministic) dynamic reserve determination methods are already very good
- Potential value in better preparing for challenging days but challenging to identify specific metrics and cost benefits are typically small fraction of overall costs, even if $m themselves
- Choice of parameters will be important



Duke high PV- methods can reduce violations at some cost impact



Southern high PV– clear balance between reliability and economics



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

Ch. 6 - Scheduling Management Platform

- Developed a modular and customizable scheduling management platform (SMP) to integrate probabilistic forecasts and scheduling decisions
  - runs autonomously
  - implements scenario generation and reserve determination methods from the project
- Demonstrated the SMP in conditions that mimic “real-world” operations with each of the partner utilities (Duke Energy, Southern Company, Hawaiian) using live forecasts from UL
- Open-source code release will encourage adoption

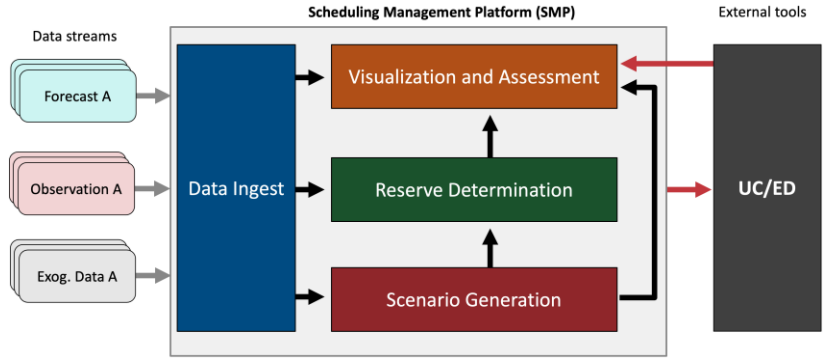


Figure: Overview of SMP and its modules.

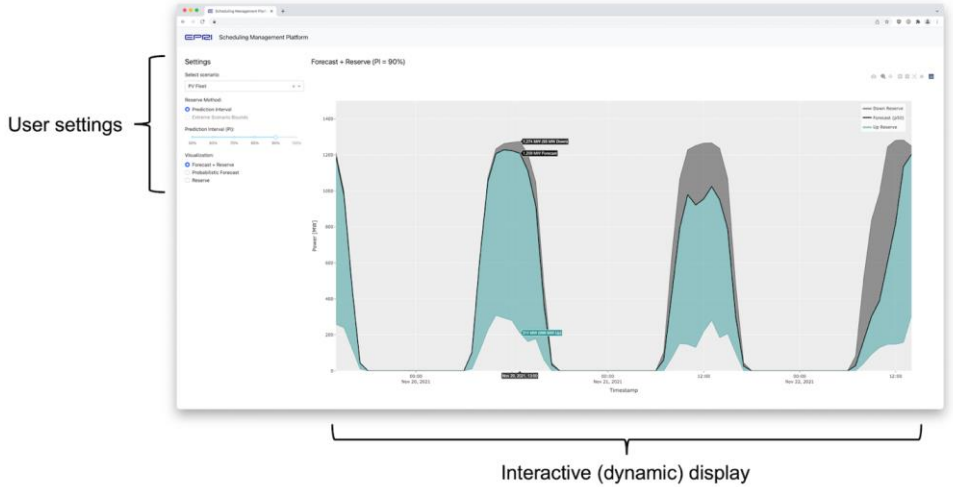


Figure: Example of the SMP user interface.

Next steps and future work

Based on detailed discussions with other utilities and ISO members, and the results presented here, several next steps have been identified:

- **Continued improvement of probabilistic forecasts**
- **Further demonstration of use of probabilistic forecasts for reserve requirements**
- **Further demonstration and refinement of the SMP**
- **Engagement with operations and operations planning at utilities/ISOs**

Short term:

- **Sharing open source code for SMP**
- **Website with SMP demo and papers/results/videos**
- **Finalize report**

References

- Q. Wang, W. B. Hobbs, A. Tuohy, and M. Bello, “Evaluating Potential Benefits of Flexible Solar Power Generation in the Southern Company System”, IEEE Journal of Photovoltaics, Vol. 12, Issue 1
- S. Bhavsar, R. Pitchumani, M. A. Ortega-Vazquez, “Machine Learning Enabled Reduced-Order Scenario Generation for Stochastic Analysis of Solar Power Forecasts” Applied Energy, vol. 293
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- www.epri.com/optsun will house all the deliverables/videos and links to papers

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