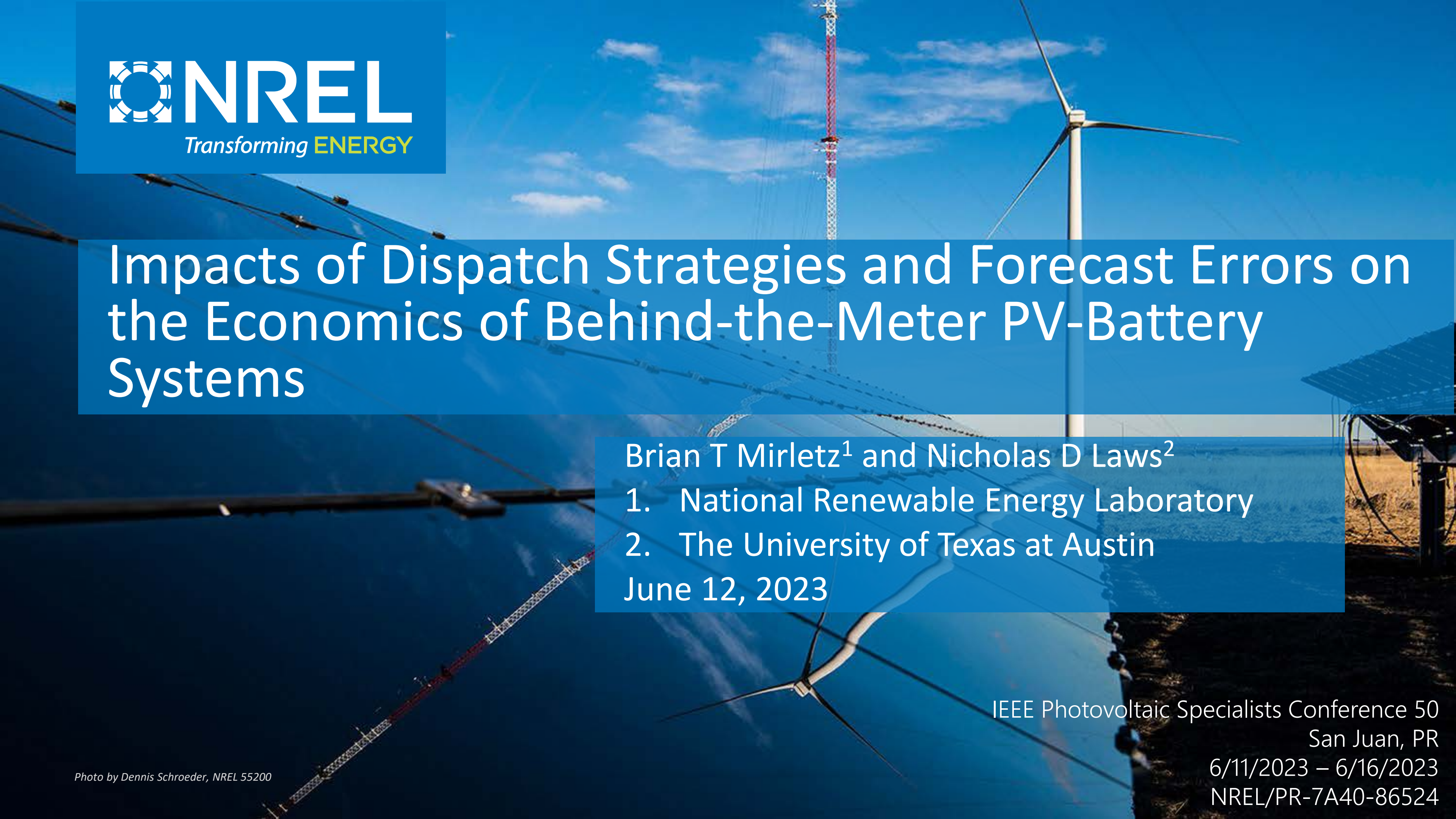

Photo by Dennis Schroeder, NREL 55200

NREL Transforming ENERGY

Impacts of Dispatch Strategies and Forecast Errors on the Economics of Behind-the-Meter PV-Battery Systems

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Overview

1. **Introduction and Prior Work**
2. SAM and REopt technoeconomic analysis tools
3. Case study design and assumptions
4. Results and conclusions

Introduction

- Behind-the-meter PV plus battery systems can provide numerous benefits to customers
  - Utility rate savings, resilience
- Value of these benefits highly dependent on battery control methods for dispatch (charging and discharging) and accurate forecasts of generation and load
- PV forecast errors can range from 3% to 14%
- How does the value provided by a PV plus battery system change with forecast errors?

Definitions

- Optimization: solve a set of equations to find the best possible solution
- Heuristic solution: follow a set of rules to find a good solution
- Net present value (NPV): sum of discounted cash flows over the life of the project

Prior Work

- Forecast errors can increase cost 1.2 to 7.8% [1-2]
- Prior comparisons of optimal and heuristic dispatch focus on cost of diesel generation on a microgrid [2]
- No known analysis compares the effects of forecast errors on optimal and heuristic dispatch for utility rate savings
  – Utility rate savings introduce multiple value streams

1. D. T. Vedullapalli and R. Hadidi, “Effect of forecaster performance on peak shaving in a university building by battery scheduling” in 2020 IEEE/IAS 56th Industrial and Commercial Power Systems Technical Conference (I CPS 2020
2. S. Mazzola et al. “Assessing the value of forecast-based dispatch in the operation of off-grid rural microgrids,” Renewable Energy 2017

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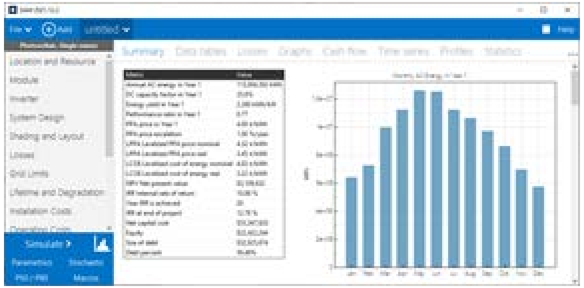
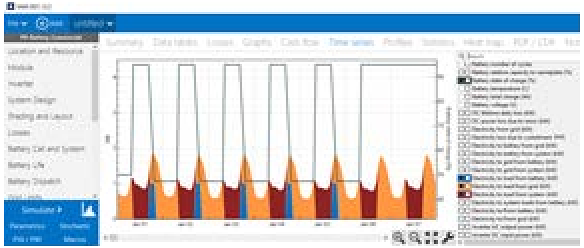
System Advisor Model (SAM)

- Free software for modeling renewable energy projects
- Developed by NREL with funding from DOE
- Desktop app for Windows, Mac, Linux
- Software Development Kit (SDK) with PySAM Python package
- Code is open source on GitHub.com
- One or two new versions per year
- User specifies system size
- Runs one timestep at a time (can use non-convex equations)

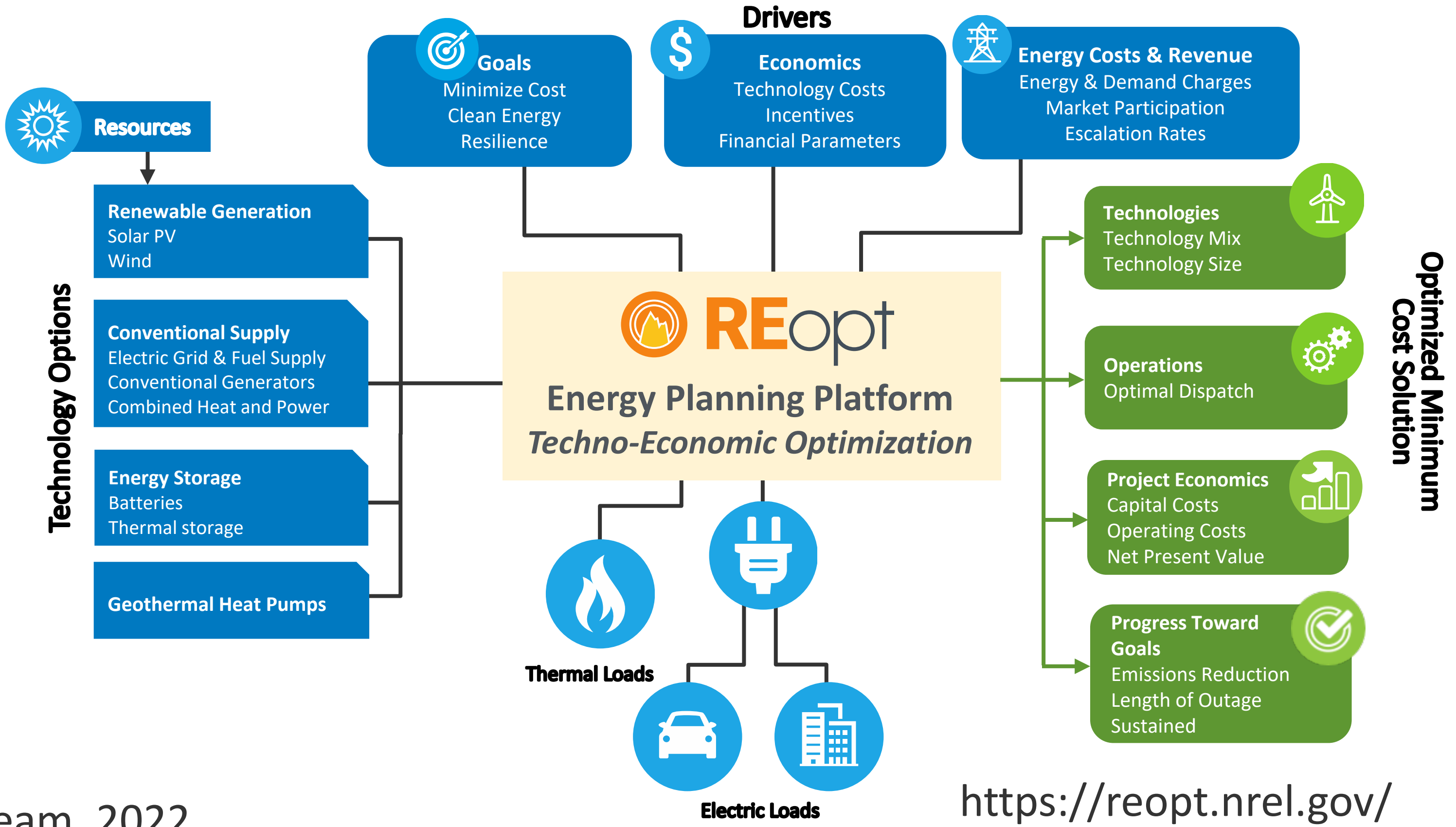




https://sam.nrel.gov

REopt Energy Planning Platform

Formulated as a mixed integer linear program, REopt provides an integrated, cost-optimal energy solution.

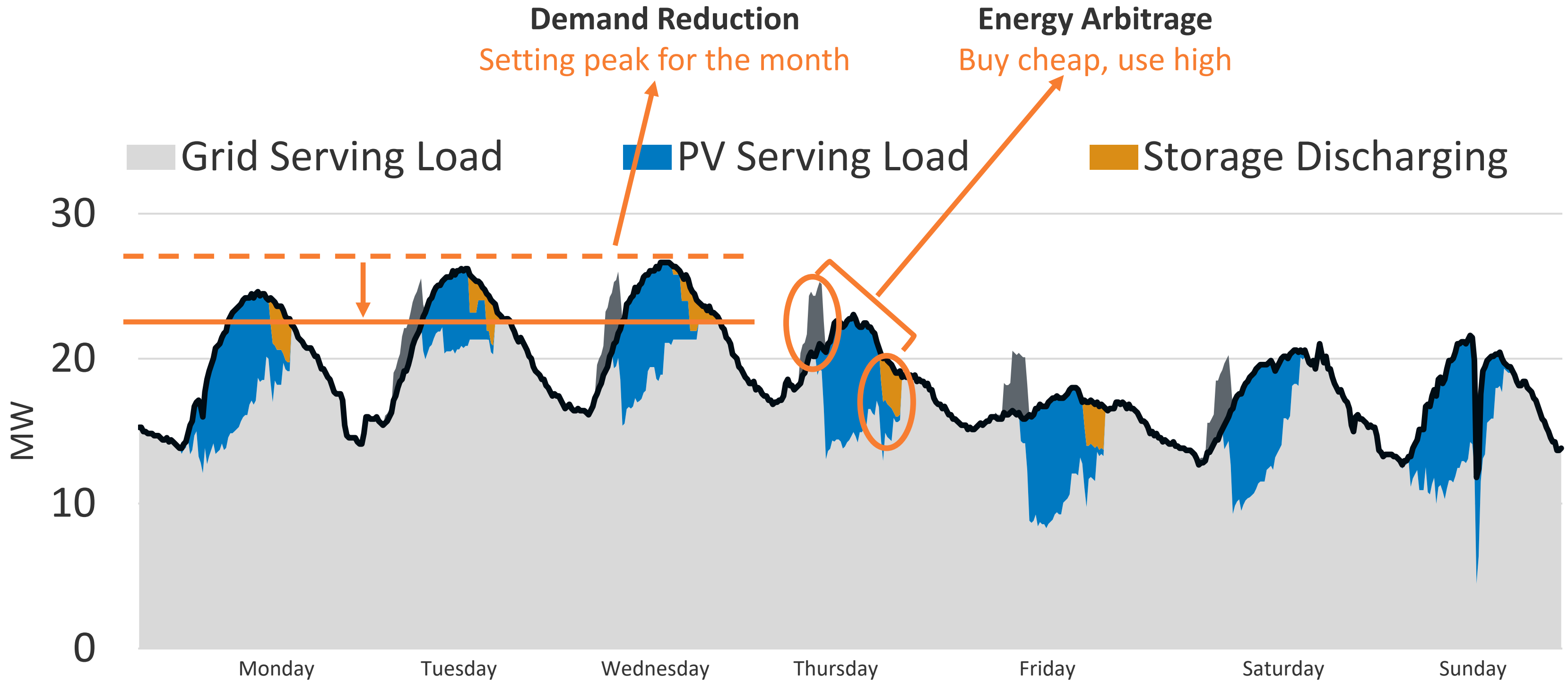


REopt Team, 2022

https://reopt.nrel.gov/

How Does REopt Work?

REopt considers the trade-off between ownership costs and savings across multiple value streams to recommend optimal size and dispatch.



Example of optimal dispatch of PV and BESS

REopt Team, 2022

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Assumptions

- Hospital in San Juan, Puerto Rico
  - 2018 weather data
  - 6,800 MWh of electric load annually
  - 1,267 kW peak
  - LUMA's Time of Use at Primary Distribution Voltage rate
- 2022.11.21 SAM defaults for costs and financial assumptions
- Must survive 24-hour outage with 50% critical load

System Sizing

- Economically optimal size
  - 3630 kW-ac of PV
    - Might require ground mount nearby
  - 151 kW, 280.8 kWh battery
- Sizing including resilience, 70% minimum state of charge for battery operation, rounded to 50 kW battery sizes
  - 3660 kW-ac of PV
  - 550 kW, 6,500 kWh battery

Dispatch Methods

Name	Method	Available Forecast Data	Forecast Length	Value Streams
Peak Shaving	Heuristic	Generation, Load	24 hours	Peak Shaving
Price Signals	Heuristic	Generation, Load, Utility Rates	24 hours	Multiple
Model Predictive Control (MPC)	Optimization	Generation, Load, Utility Rates	24 hours	Multiple
Full-year optimization	Optimization	Generation, Load, Utility Rates	8760 hours	Multiple

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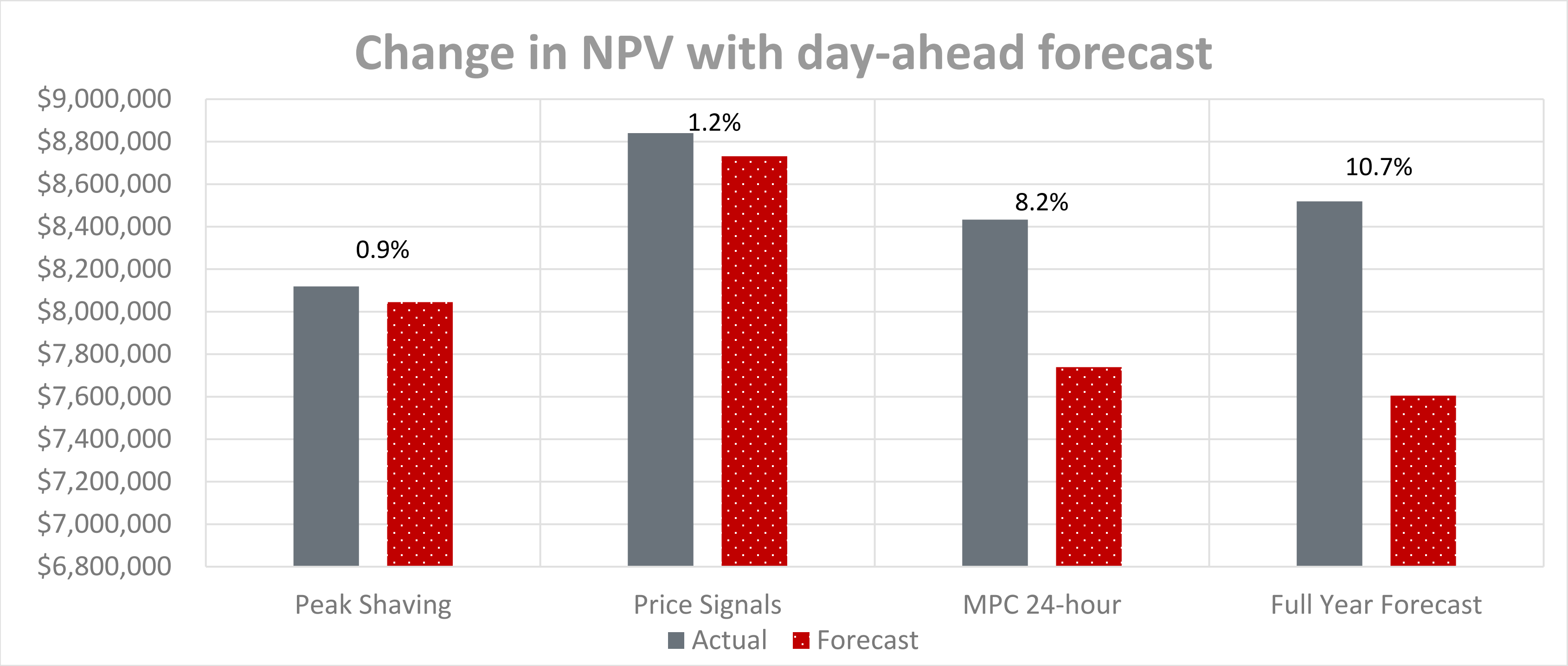
Forecast Errors

Weather data from National Solar Radiation Database and day-ahead forecasts from Puerto Rico 100% renewable study

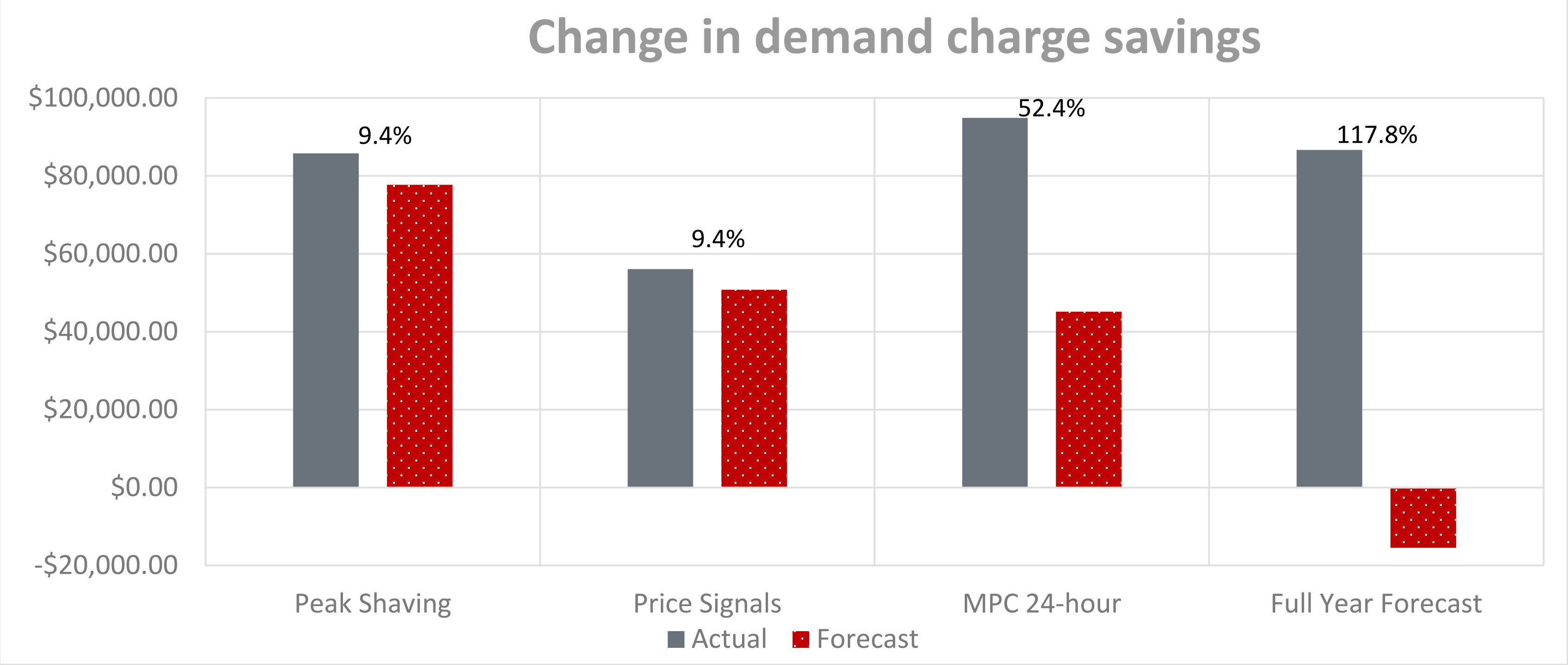
Metric	Root mean squared error	Mean average error	% of maximum value
Direct Normal Irradiance	140 W/m^2	75 W/m^2	13.6%
PV Generation	493 kW	249 kW	13.6%
Load	33.4 kW	25.2 kW	2.6%

Results: Differences in Net Present Value



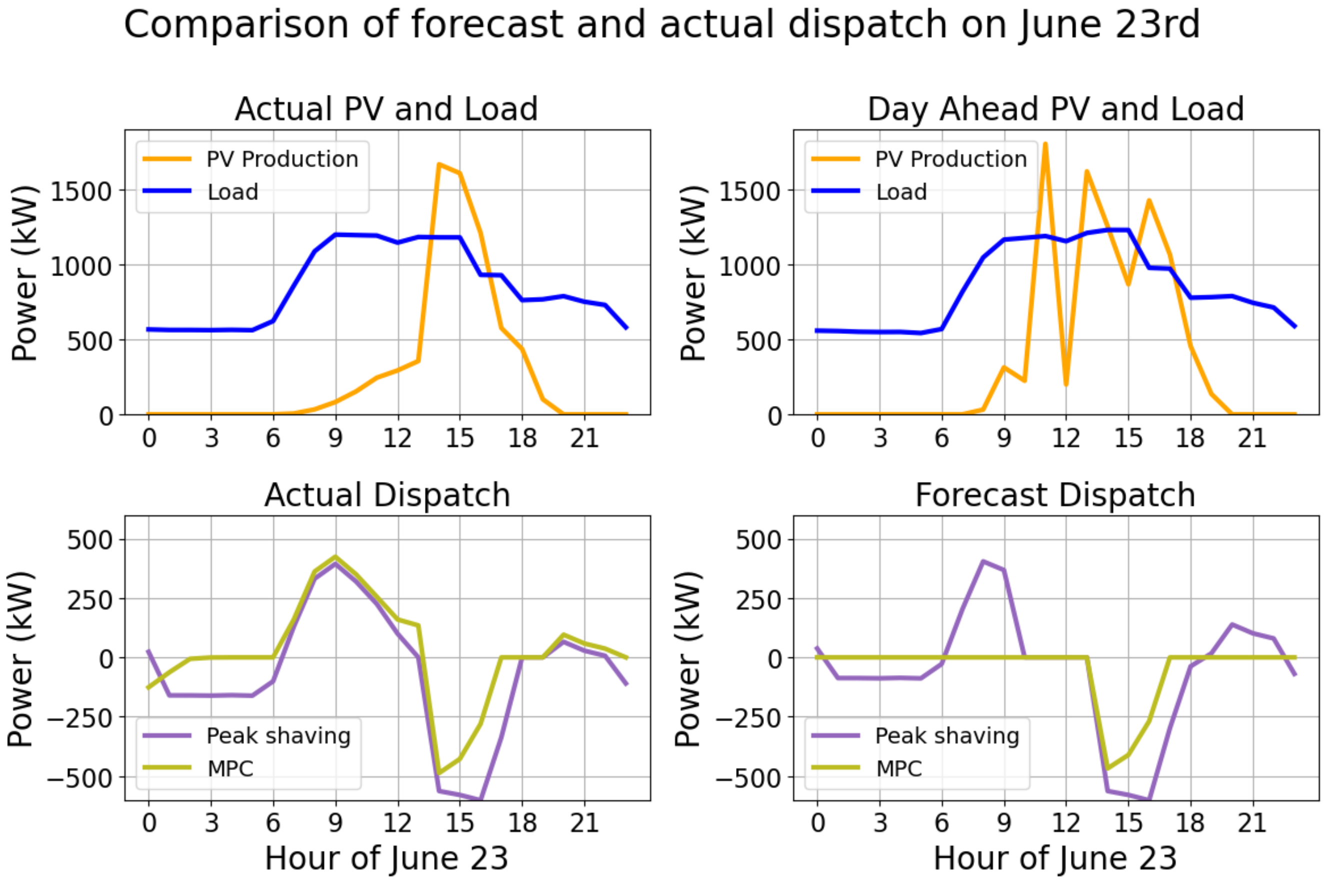
Caveat: differences in battery model and net metering credits implementation between REopt and SAM means NPVs between algorithms are not directly comparable.

Results: Changes in Utility Rate Savings



Caveat: full year forecast does not have access to real time information

Results: One Day of Dispatch



Positive is discharging, negative is charging

Conclusions

- Perfect forecasts can overestimate the value of utility rate savings between 1% and 8%
- Availability of real time information is key
  - Providing real time power and load to price signals eliminated 75% of the difference between forecast and actual
- Simplest algorithms are most robust to forecast errors
  - Peak shaving dispatch sets a “grid power target” charges when grid uses is below this value and discharges above

Thank you! Questions?

B. T. Mirletz and N. D. Laws "Impacts of Dispatch Strategies and Forecast Errors on the Economics of Behind-the-Meter PV-Battery Systems" in 2023 IEEE 50th Photovoltaics Specialists Conference (PVSC) Jun. 2023

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Project Websites:

https://sam.nrel.gov/

https://reopt.nrel.gov/

Code & data:

Paper code: https://github.com/NREL/sam-analyses

SAM GitHub: https://github.com/NREL/SAM/

REopt GitHub: https://github.com/NREL/REopt.jl