Heuristic Dispatch Based on Price Signals for Behind-the-Meter PV-Battery Systems in the System Advisor Model

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Abstract

The economic potential of a behind-the-meter (BTM) PV-battery system depends greatly on how the battery is dispatched. Different utility rates, system sizes, generation and load profiles can all require different dispatch strategies.
This paper presents price signals dispatch, a new algorithm for automated economic dispatch of BTM PV-battery systems, which utilizes 24-hour PV and load forecasts, degradation data, and utility rates. The algorithm is integrated with the System Advisor Model (SAM) tool and is tested with a nonlinear generic electrochemical battery model. Price signals dispatch outperforms SAM's existing algorithms in cases requiring a balance between demand charge management and energy arbitrage, and in cases where battery degradation imposes a significant cost.

Dispatch Planning

The algorithm plans dispatch in the following steps:

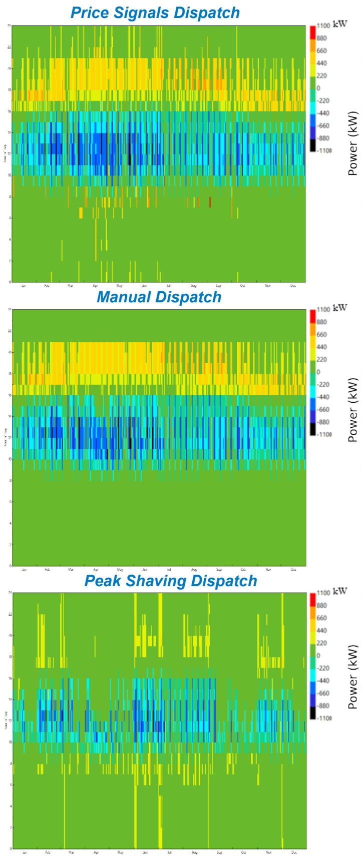
1. Forecast utility bill cost without dispatch
2. Schedule discharge to the load for the highest cost periods according to:
   $$P_{discharge,t} = \frac{E_{remaining,t} * C_t}{(\sum_{i=t}^{p} C_i) * dt}$$
3. Schedule charging for the lowest marginal cost periods
4. Reduce discharging or charging based on expected SOC
5. Repeat 2-4 to generate plans with 0 to 12 hours of dispatch
6. Select lowest cost plan according to:
   $$C_{total} = C_{utility\_bill} + C_{cycle} * n_{cycles} - E_{remaining} * C_{marginal}$$

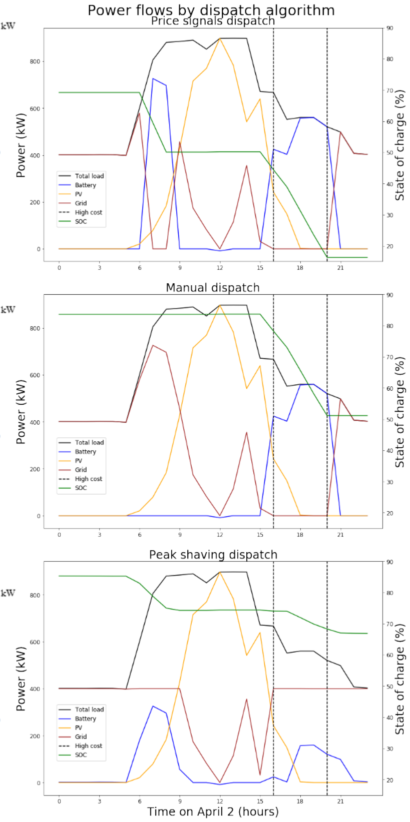
Case Study

To evaluate the performance of price signals dispatch, we test the algorithms in a case study for a PV + Battery system using a representative load profile for a San Diego Hospital. The system was sized using REopt Lite.

Variable	Value
Location	San Diego
Building Type	Hospital
Utility Rate	SDG&E DG-R Primary
Peak Load	1,186 kW
Annual Energy Consumption	5,475 MWh
PV Capacity	1,500 kWac
Battery Power	974 kW
Battery Energy	7,356 kWh

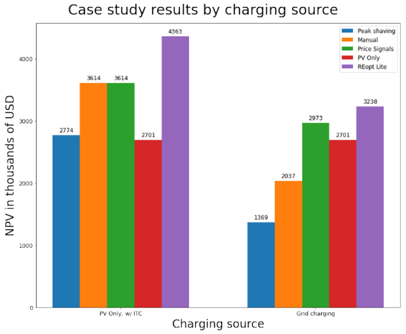
Case Study Results





Top left: Heat maps of the three SAM dispatch strategies executed over year 1 for the case study. Negative numbers indicate battery charging; positive numbers indicate discharging; units are kW. The high energy cost period is from hour 16 to 21 each day.

Top right: Details of power flows on April 2 of year 1 for the San Diego Hospital system with PV only charging. Negative numbers for battery power indicate charging from PV. No power is sent to the grid during the period shown.

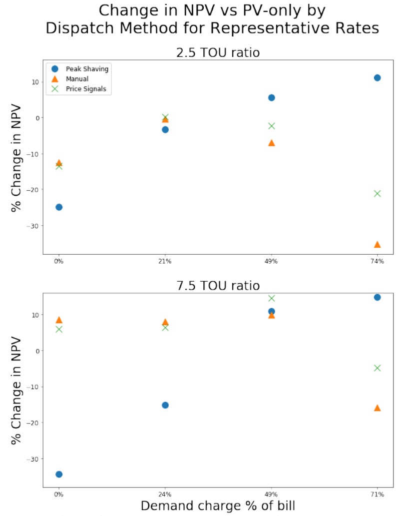


Net Present Value (NPV) results for each of the dispatch algorithms, in thousands of dollars.

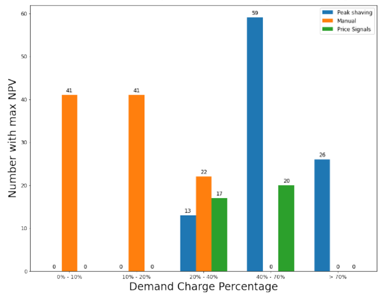
Sensitivity Analysis

We conducted a sensitivity analysis on the utility rate structure. We varied the following parameters, generating 625 rates:

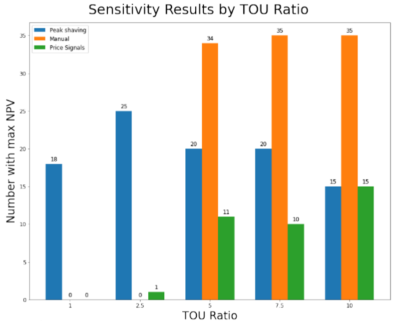
Parameter	Min Value	Max Value
Max Energy Charge	$0.10/kWh	$0.50/kWh
Ratio of TOU Periods	1	10
Fixed Demand Charge	$0/kW	$59.05/kW
TOU Demand Charge	$0/kW	$13.45/kW



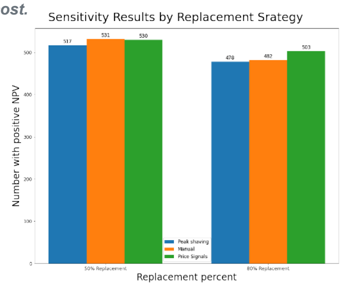
NPV of the SAM dispatch methods for eight representative cases. The y-axis shows the ratio of the NPV with a battery dispatched by each algorithm versus the PV-only system.

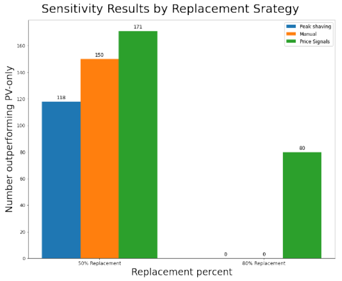


Results of the sensitivity analysis by TOU ratio. Neither manual dispatch nor price signals dispatch achieves the highest NPV when the TOU ratio is 1; both algorithms improve their relative performance at higher ratios. PV only performs best in cases with low utility bills and has a lower upfront cost.



Results of the sensitivity analysis by demand charge percentage without system. Price signals dispatch achieves the highest NPV when the demand charge is between 21% and 57% of the bill. PV only performs best in cases with low utility bills and has a lower upfront cost.





Results of varying the replacement strategy between 50% of nameplate capacity and 80%. Price signals dispatch is the only algorithm to outperform PV only with the 80% replacement strategy.

Conclusions

Our results show an improvement in NPV for PV-battery systems using the price signals dispatch algorithm described in this paper and quantifies the tradeoffs between three heuristic dispatch algorithms. For the case study, the price signals dispatch algorithm achieved additional utility bill savings over the peak shaving algorithm via savings on energy charges, while allowing a higher average monthly demand charge. To maximize value for a system, the best choice of dispatch algorithm within SAM depends on the utility rate structure. If a high TOU ratio is present with minimal demand charges, manual dispatch is a good choice. Peak shaving performs well for reducing demand charges. Price signals dispatch performs best in cases requiring a balance between these two revenue streams, or cases when battery replacements would be a significant cost.

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