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Optimal Time-of-Use Management with Power Factor Correction Using Behind-the-Meter Energy Storage Systems

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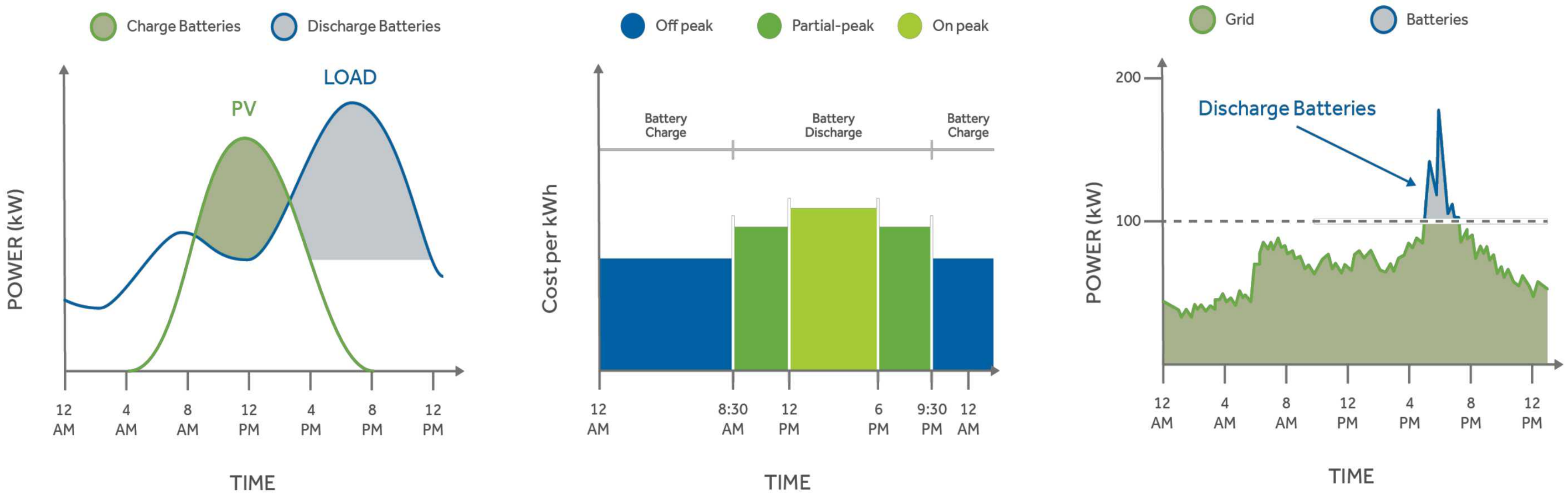
Introduction



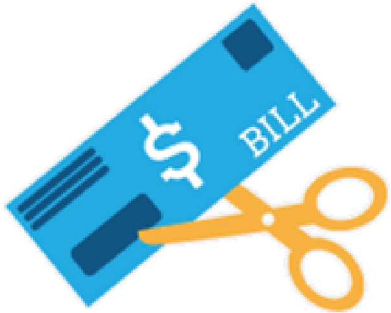
Renewable Time Shift | **Time-of-use Management** | **Demand Charge Reduction**

Image Credit – *Aquion Energy*

- In this paper, we propose an approach to maximize the economic benefit of BTM energy storage for TOU management while providing power factor correction.
- This approach is best suited for large commercial or industrial customers who are often billed for their high peak demand and penalized for their low power factors.

Methodology

- In the proposed approach, an MILP problem is formulated to find the optimal ESS's hourly charge/discharge real and reactive powers that minimizes the monthly electricity bills while correcting the power factor of the customers.
- The constraints of this problem include:
  - **Energy storage constraints:** state of charge constraints.
  - **Inverter constraints:** charge/discharge power constraint, inverter's reactive power constraint, output power factor constraint.
- The problem is then transformed to a Linear Programming (LP) problem using a Minmax technique. The approach assumes perfect foresight of data and therefore provides the results for the best-case scenario.



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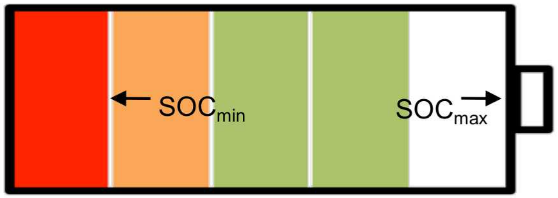
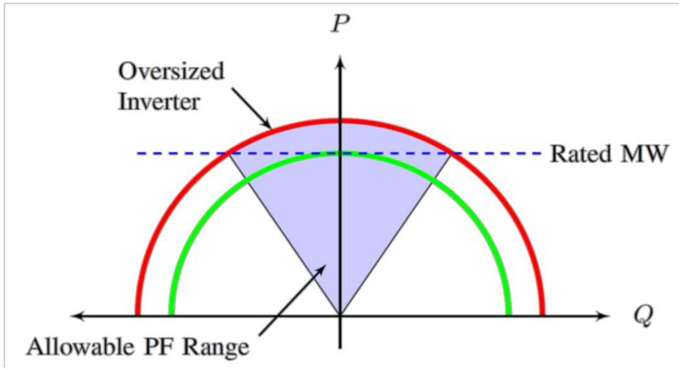




Case studies

- An industrial customer in New Mexico is considered: a water treatment facility (300kW peak load) with 100kW PV.
- Fixed energy rate and TOU demand rate are applied.
- Penalty is applied for power factor lower than 0.9

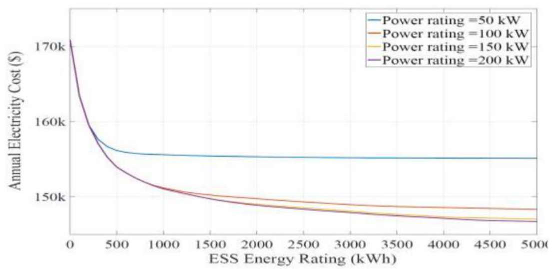
Energy rate: $\text{pr} = 0.04537$ [$\$/kWh$]
Peak-hour (6am-9pm) demand rate: $\text{d}_{\text{pk}} = 24.69$ [$\$/kW$]
Off-peak (9pm-6am) demand rate: $\text{d}_{\text{opk}} = 6.12$ [$\$/kW$]
Net-metering rate: $\text{pr}_{\text{s}} = 0.03$[$\$/kWh$]

Image Credit – *New Mexico Environment Department*

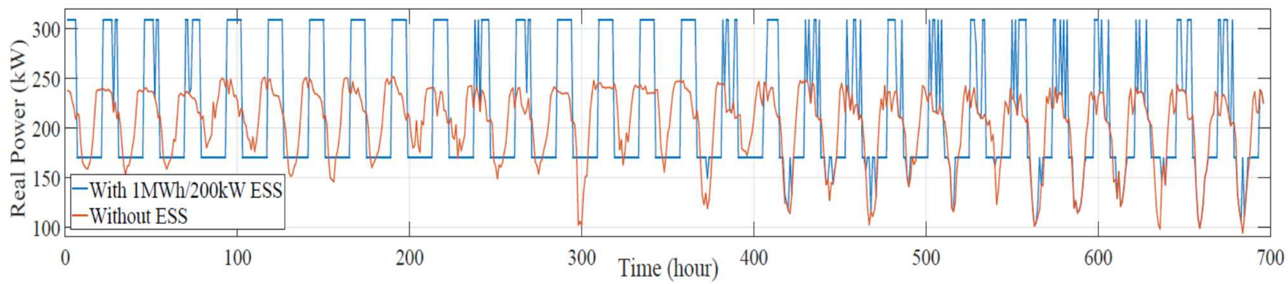
- **Case 1:** TOU management without power factor correction
- **Case 2:** TOU management with power factor correction

Results

Case 1: TOU management without power factor correction

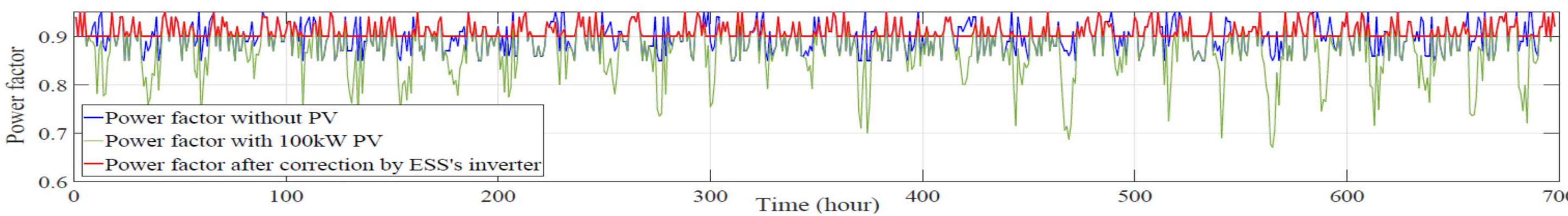


Sensitivity of cost to ESS's size

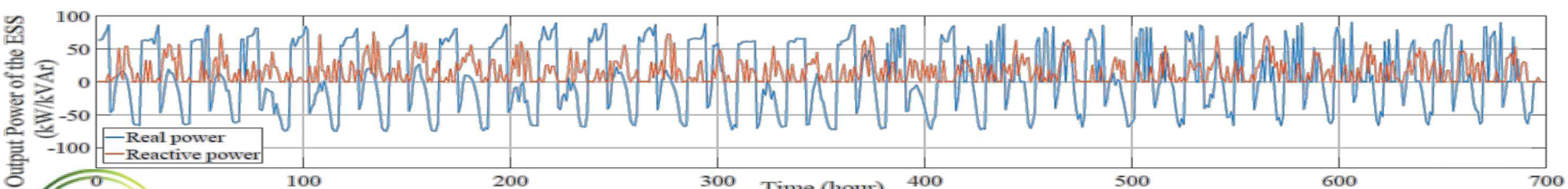


Net load during Feb 2016

Case 2: TOU management with power factor correction



Power factor profile in Feb 2016 assuming 200kW/1MWh ESS



Real and reactive power output in Feb 2016 assuming 200kW/1MWh ESS

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Conclusions

- In this paper, the benefits of behind-the-meter ESSs for TOU management with power factor correction have been studied.

- Specifically, the contributions of this paper include:
  - A formulation of the optimal TOU management combined with power factor correction for BTM energy storage.
  - A Minmax-based technique for transforming the energy storage MINLP problem to a LP problem.
  - Results from case studies at a waste water treatment plant in New Mexico.

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