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Maximizing Benefit of Electrical Energy Storage for Behind-the-Meter Applications

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U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration | ESS ENERGY STORAGE SYSTEMS

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Energy Storage Analytics

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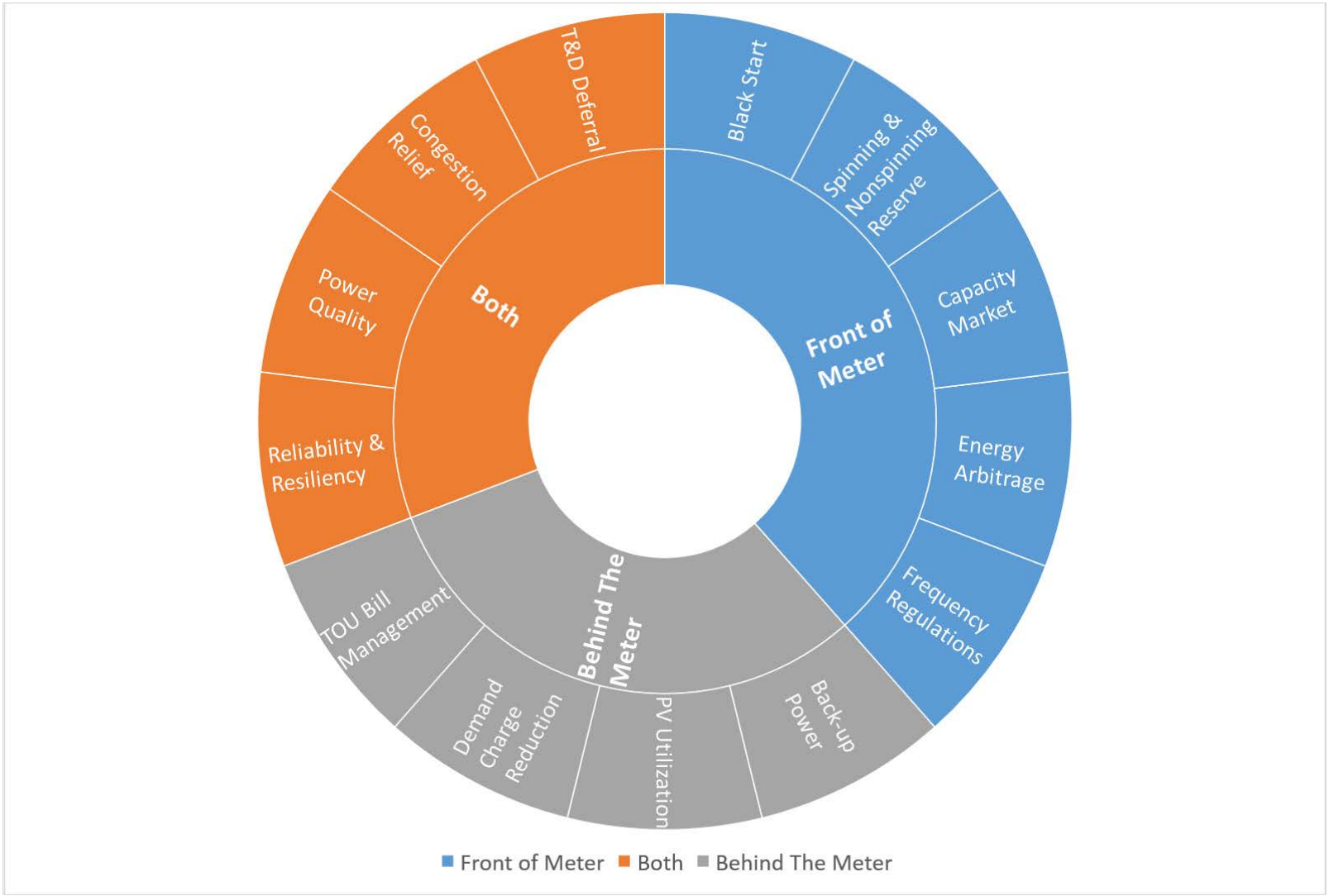
Equitable Regulatory Environment Thrust Area

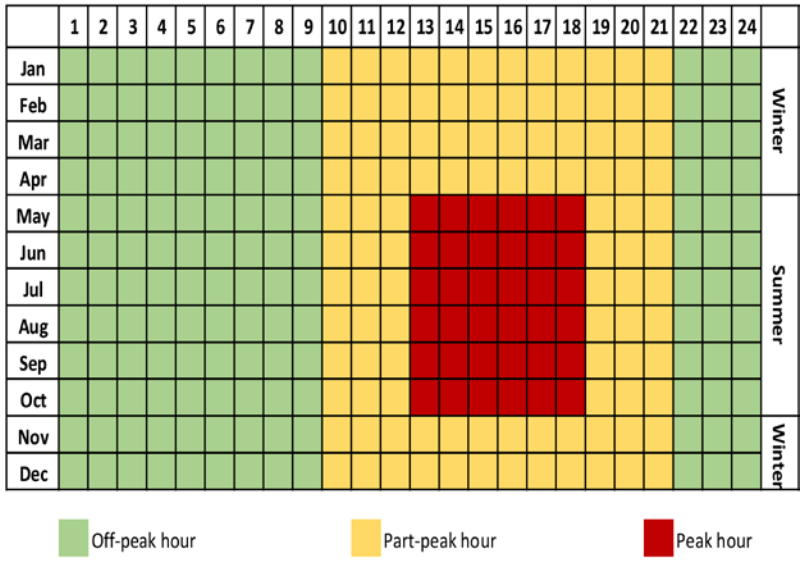
- Goals: Lower barriers to widespread deployment of energy storage by identifying new and existing value streams, quantifying the impact of policy on deployment, and developing new control strategies
- Objectives:
  - Project case studies
  - Tools for storage valuation
  - Identify new and existing value streams
  - Control strategies to maximize revenue/grid benefit
  - Assess policy impact on storage
  - Develop policy recommendations

Energy Storage Applications



Time-of-use Pricing

- TOU pricing is the rate structure in which energy and peak demand prices are time-dependent.
- Time schedules for TOU are commonly classified as followings:
  - Hour: peak hours, part-peak hours and off-peak hours.
  - Day: regular week days, weekend days and holidays.
  - Month: summer months and winter months.



E-19 SCHEDULE'S TOU RATES

	Summer	Winter
Off-peak energy	0.08651 $/kWh	0.09317 $/kWh
Part-peak energy	0.11333 $/kWh	0.10779 $/kWh
Peak energy	0.15384 $/kWh	-
Part-peak demand	5.18 $/kW	0.12 $/kW
Peak demand	18.64 $/kW	-
Maximum demand	16.08 $/kW	16.08 $/kW

Net-metering Program

- Net metering (NEM) programs allow customers who own renewable energy systems to export their excess energy to the grid.
- The net energy exported to the grid will be used to offset the customers' monthly consumption, or be credited to the customers periodically based on the market energy price.

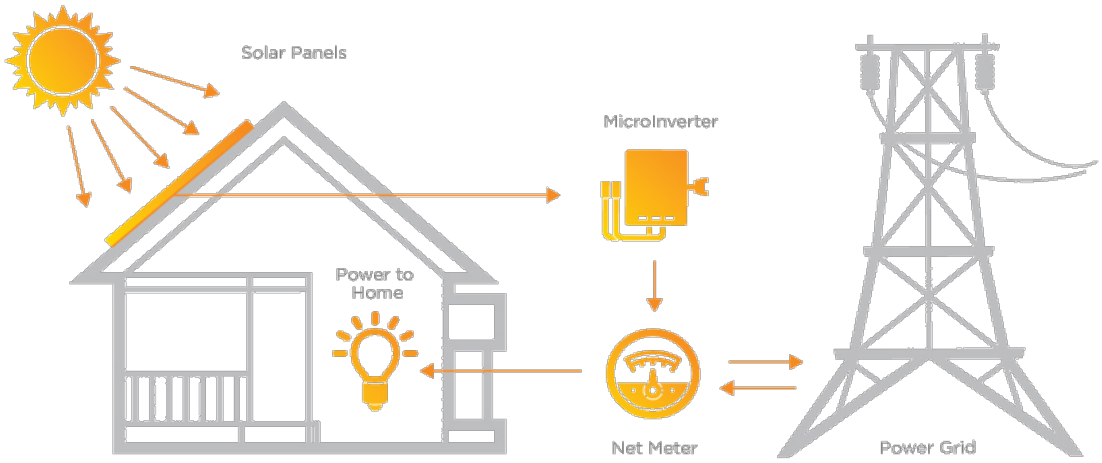


Image Credit - *Lowcountry Solar*

Energy Storage for TOU and NEM Customers

- Energy storage systems could provide a solution:
  - TOU customers could benefit by charging their ESSs during off peak hours and then discharging them during peak.
  - NEM customers can increase their savings by storing the excess renewable energy when the load is low and use that energy later when the load is high.

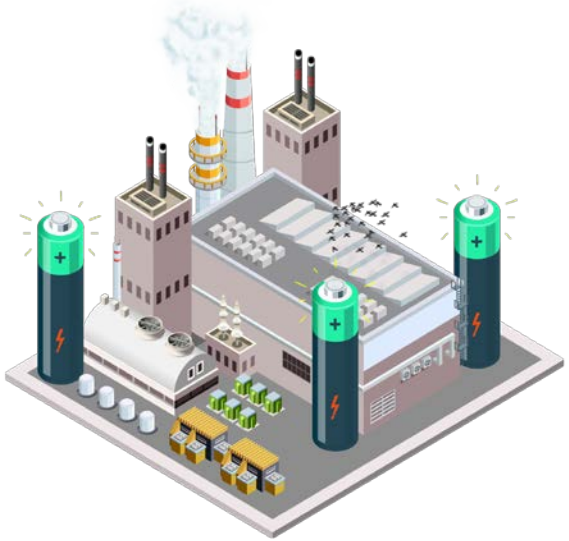


Image Credit - *Landisgyr*

Maximizing Cost Savings for TOU & NEM Customers

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- Given the limitations in ESSs' energy capacities and their round trip efficiencies, it is essential to optimize these factors to maximize the overall benefits for the customers.
- In this work, we find the hourly charge/discharge profile of an energy storage that minimizes the monthly electricity bill of a customer considering energy storage constraints:

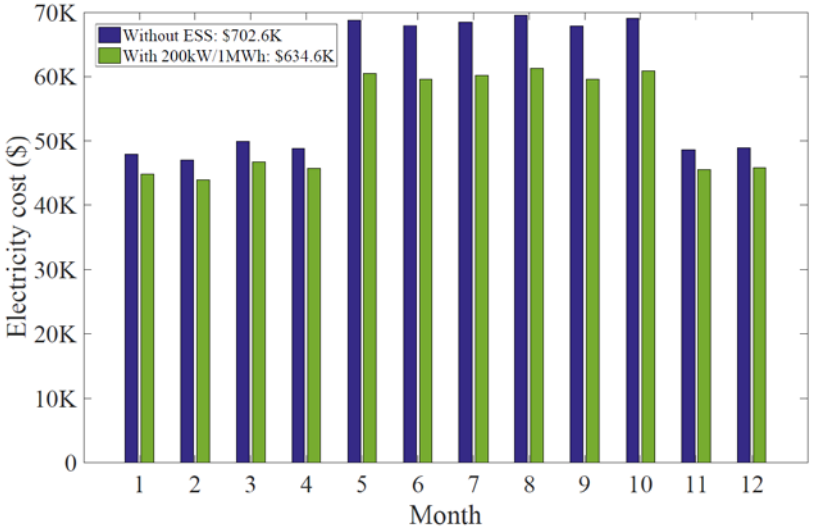
  Monthly bill = min { Energy charge + Demand charge – NEM credit }

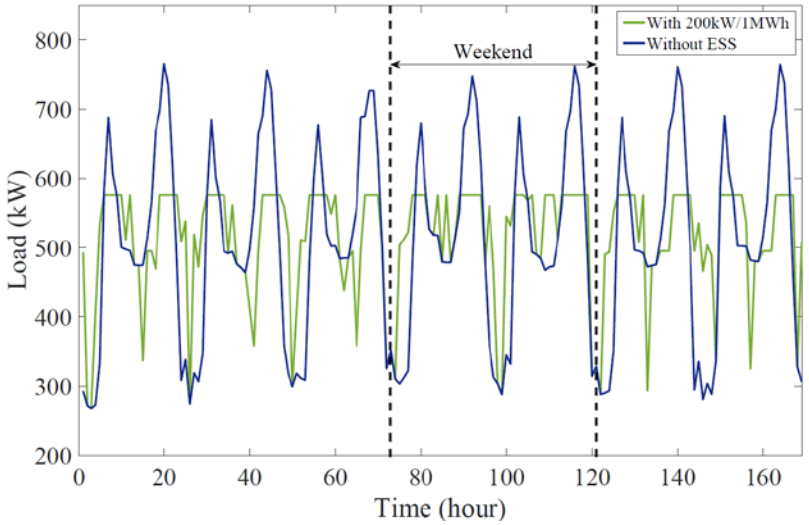
- The optimization problem is formulated as a Linear Minimax problem and solved using Pyomo optimization modeling language.

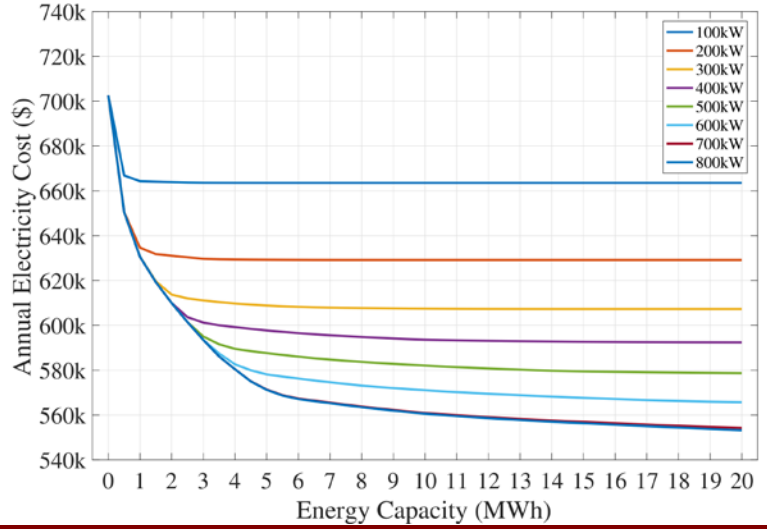
Case studies - Inputs

- Case studies are conducted for PG&E's customers in San Francisco including:
  - A medium-size commercial TOU customer (large hotel)
  - A typical-size residential TOU and NEM customer (3-bedroom house)
- Hourly load profiles for a year is given by Energy Information and Data (OpenEI.org)
- It is assumed that the commercial customer follows PG&E's TOU schedule E19 and the residential customer follows PG&E's E-TOU/Option-B.
- 5kW PV rooftop system is installed at the residential customer's site. The NEM energy price is $0.03/kWh.

Case studies – TOU Commercial Customers

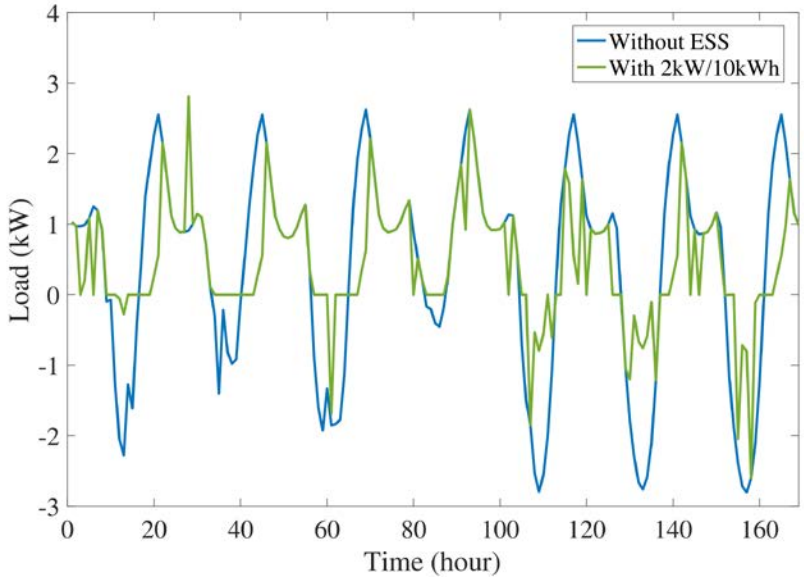


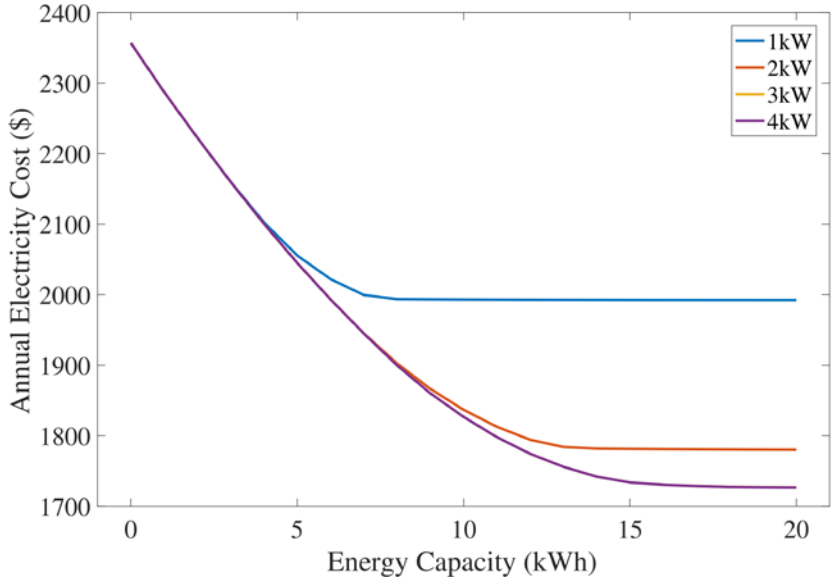




- There are better savings during the summer months.
- The peak load is significantly shaved
- ESS charges at higher rate during weekends.
- The total annual cost at each ESS's power rating decreases as the energy rating increases.

Case studies – NEM & TOU Residential Customers





- The energy sold to the grid is reduced by charging the ESS when renewable energy generation exceed the customer's consumption.
- The peak-shaving in this case is not significant. This is because there is no peak demand charge.

Conclusions and Future Work

- The benefits of behind-the-meter ESSs for TOU and NEM customers have been reviewed.
- An optimization problem is formulated to find the hourly charge/discharge profile of an energy storage that minimizes the monthly electricity bill of TOU and NEM customers.
- Future work in this area would analyze the impact of BTM energy storage to the reliability and resiliency of distribution networks considering the uncertainties of forecast and energy storage model.

Acknowledgment

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Questions