Should Storage-Centric Tariffs be Extended to Commercial Flexible Demand?

UNIVERSITY of WASHINGTON

Lane D. Smith and Daniel S. Kirschen

Department of Electrical and Computer Engineering, University of Washington, Seattle, WA 98195 USA

Emails: {ldsmith, kirschen} @uw.edu

Background and Motivation

- Electrification of demand is poised to introduce a host of new loads to electric grids, including electric vehicles and heat pumps
- These new loads will reshape the profile of net demand in ways that electric utilities and power system operators have not previously encountered
  - Current demand peaks may be greatly amplified
  - New seasonal demand peaks may be formed
- Fortunately, new electric loads are likely to be flexible and can help grid operators by shifting consumer demand from times of peak demand
- Failing to capitalize on this opportunity, utilities, including Pacific Gas and Electric Company (PG&E), appear to instead prioritize the flexibility that can be obtained from distributed battery energy storage (BES) systems, going so far as to develop new tariffs that encourage their deployment by consumers
- With these tariffs not requiring operational characteristics unique to BES, they should be technology agnostic, allowing new flexible demand to also be engaged
- **We examine the impact, on both the utility and the consumer, of extending PG&E's storage-centric tariff to include consumers with flexible demand**

Overview of PG&E's Commercial Tariffs

- In March 2021, PG&E began offering new tariffs to their commercial consumers
- While base time-of-use (TOU) tariffs still featured the same demand and energy charges, the TOU periods were shifted to better align with the profile of prices observed in the California Independent System Operator wholesale markets
  - Peak and partial-peak periods now occur later to better reflect peak demand
  - A super-off-peak period was created to provide low prices during times with cheap midday solar
- PG&E also introduced a rider (Option S for Storage) that is available to consumers with BES that is rated to at least 10% of their maximum annual demand
- PG&E's storage-centric tariff aims to incentivize consumer flexibility:
  - Lower demand charges over the month, including daily demand charges
  - Higher TOU energy charges, particularly during peak hours

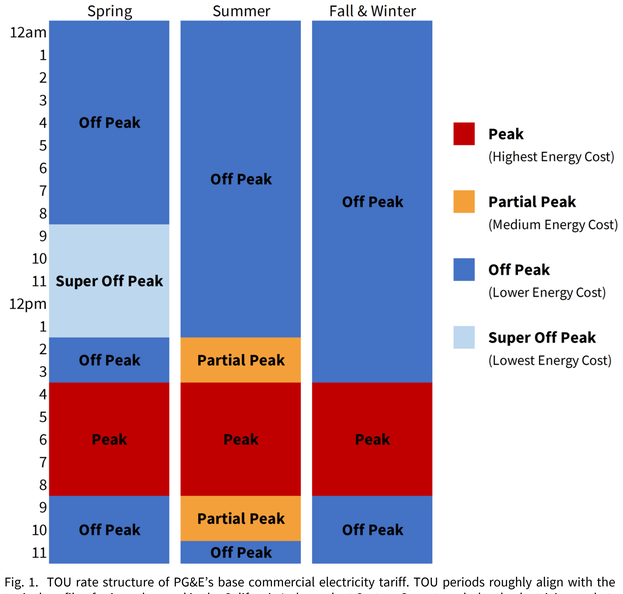

Fig. 1. TOU rate structure of PG&E's base commercial electricity tariff. TOU periods roughly align with the typical profile of prices observed in the California Independent System Operator wholesale electricity market.

Mathematical Formulation

- We formulate a linear program that minimizes the consumer's monthly electricity bill, comprised of costs from TOU rates and revenues from net metering, subject to technological operating constraints:
  - Flexible demand: demand deviation bounds, load balancing duration
  - BES: state of charge, charging/discharging power bounds, non-export
- Simulated demand and photovoltaic (PV) generation are provided as parameters
- The optimization is repeated for each of the 12 months to obtain the total annual electricity bill

Case Study

- We consider a simulated commercial consumer with the following characteristics:
  - Morning-and-evening-peaking demand profile shape
  - Solar PV system that is sized to roughly equal the maximum annual demand
  - Either flexible demand or a BES system
  - Participation under one of two electricity tariffs: "base" or "storage-centric"
- Impacts of extending the storage-centric tariff to flexible demand are considered from perspective of two different stakeholders:
  - **The utility**, through impacts on net demand ramp rates and net demand during peak-pricing periods
  - **The consumer**, through impacts on total electricity bill

Impact on Peak-Period Net Demand Ramp Rates

- Figures 2 and 3 show the mean net demand ramp rate under the storage-centric tariff relative to that under the base tariff during peak hours for a consumer with flexible demand and a consumer with BES, respectively
- Under the storage-centric tariff, peak-period mean net demand ramp rates are lower for consumers with flexible demand
- As demand flexibility percentage increases, mean net demand ramp rates decrease for consumers with flexible demand under the storage-centric tariff
- Generally, similar differences between the base and storage-centric tariffs are observed for consumers with flexible demand and consumers with BES systems: increased operational flexibility makes the storage-centric tariff more appealing
- Apparent variability and general non-monotonicity are due to the discrete pricing periods (less-flexible resources cannot shift outside) and the similar response of highly flexible resources

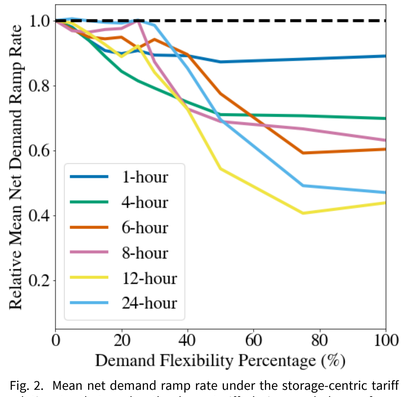

Fig. 2. Mean net demand ramp rate under the storage-centric tariff relative to that under the base tariff during peak hours for a consumer with flexible demand. Different load recovery periods are compared over the range of demand flexibility percentages.

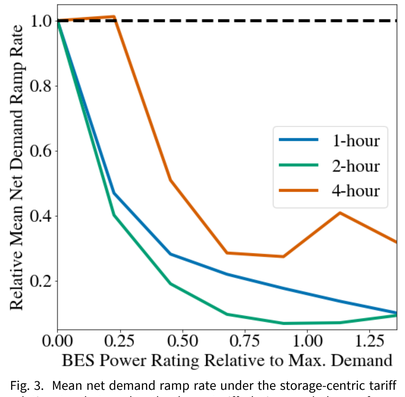

Fig. 3. Mean net demand ramp rate under the storage-centric tariff relative to that under the base tariff during peak hours for a consumer with BES. Different battery durations are compared over the range of battery power ratings (relative to maximum demand).

Impact on Peak-Period Net Demand

- Greater levels of flexibility result in lower peak-period mean net demand under the storage-centric tariff
- Lower levels of flexibility cannot shift enough demand outside the peak pricing period, resulting in similar peak-period net demand profiles

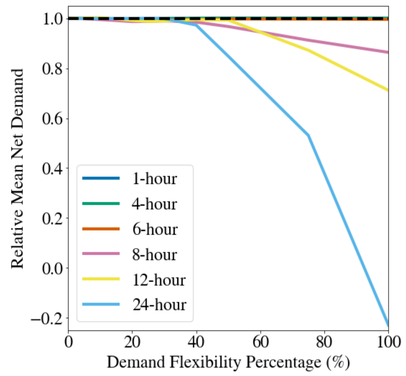

Fig. 4. Mean net demand under the storage-centric tariff relative to that under the base tariff during peak hours for a consumer with flexible demand. Different load recovery periods are compared over the range of demand flexibility percentages.

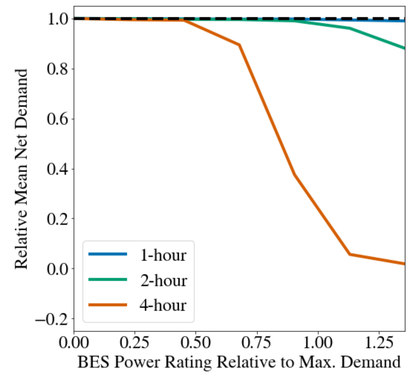

Fig. 5. Mean net demand under the storage-centric tariff relative to that under the base tariff during peak hours for a consumer with BES. Different battery durations are compared over the range of battery power ratings (relative to maximum demand).

Impact on Total Electricity Bill

- The storage-centric tariff is only beneficial to highly-flexible consumers (demand must be able to shift at least 12 hours, at least 60% of demand must be flexible)
- Less-flexible consumers cannot avoid the higher energy charges imposed by the storage-centric tariff

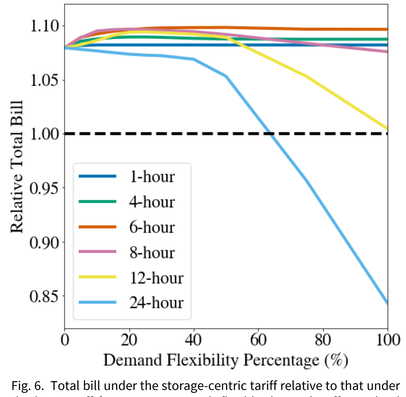

Fig. 6. Total bill under the storage-centric tariff relative to that under the base tariff for a consumer with flexible demand. Different load recovery periods are compared over the range of demand flexibility percentages.

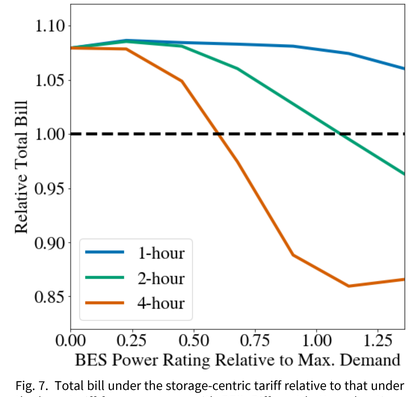

Fig. 7. Total bill under the storage-centric tariff relative to that under the base tariff for a consumer with BES. Different battery durations are compared over the range of battery power ratings (relative to maximum demand).

Conclusions and Future Work

- Extending storage-centric tariffs to consumers with flexible demand **is beneficial from the utility's perspective** (lower net demand ramp rates and net demand during peak hours), but is **restrictive to most consumers** as currently constructed
- It makes sense to consider rates that have a similar structure to the storage-centric tariff, but are beneficial to a wider range of consumers
- Future work will explore electricity rate optimization considering consumer response