Customer Bill Savings from Behind-the-Meter Storage: Some Illustrative Analyses

Galen Barbose

NARUC Annual Meeting
November 17, 2019

This work was funded by the U.S. Department of Energy Office of Electricity and Solar Energy Technologies Office, under Contract No. DE-AC02-05CH11231.
A few relevant Berkeley Lab analyses

Implications of Rate Design for the Customer-Economics of Behind-the-Meter Storage

Naïm Darghouth, Galen Barbose, Andrew Mills

Lawrence Berkeley National Laboratory

August 2019

This analysis was funded by the Office of Electricity of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Solar + Storage Synergies for Managing Commercial-Customer Demand Charges

Pieter Gagnon, Anand Govindarajan, and Lori Bird

National Renewable Energy Laboratory

Galen Barbose, Naïm Darghouth, and Andrew Mills

Lawrence Berkeley National Laboratory

October 2017

This analysis was funded by the Solar Energy Technologies Office, Office of Energy Efficiency and Renewable Energy of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

Impacts of Solar-Export Credit Rates on Solar Deployment, Utilities, and Customers

Galen Barbose (research assistance from Sydney Forrester)

National Lab Technical Workshop on Distributed Solar Grid Impacts

Utah Public Service Commission Docket No. 17-035-61

July 11, 2019

This work was funded by the U.S. Department of Energy Office of Electricity, under Contract No. DE-AC02-05CH11231.

Studies available here: https://emp.lbl.gov/publications

A few relevant Berkeley Lab analyses

Focus on commercial customers with solar+storage and demand charges

Focus on residential customers with solar+storage and net-billing rates

Covers both residential and commercial customers with a wide range of rate designs

Studies available here: https://emp.lbl.gov/publications
Demand charge savings from BTM storage depend on…

- Rate design details
- Load shape
- Control strategy
- Storage kW
- Storage kWh

Demand charge savings
Variation in demand charge rates

- Demand charge rates vary significantly by utility and by customer class and size.
- Most are in the $2-15/kW range, with a national median of $7/kW.
- Previous analyses by NREL (2017) and McKinsey (2017) identified $10-15/kW as the threshold for BTM storage cost-effectiveness.

Other important demand charge design details

Demand charge rate is the most critical element, but others also matter, particularly:

- Use of coincident peak demand charges
- Definition of peak period
- Averaging intervals

### Annual demand charge savings from BTM storage

Example: Shopping Center, 2-hr storage

<table>
<thead>
<tr>
<th>Annual bill savings ($ per kW of storage capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>80</td>
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<td>70</td>
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<td>20</td>
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<td>10</td>
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<td>0</td>
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</tbody>
</table>

- **Demand charge rate**: 8am-6pm, 5pm-10pm
- **Coincident peak definition**: 5 minute, 60 minute
- **Averaging interval**: 60 minute, 5 minute
- **Seasonal rates**: Jun-Aug 4x, Oct-Feb 4x, 90% of last 12 months, 60% of summer months only
- **Ratchet**
Examples showing the effects of storage duration and customer load shape

- Longer duration storage is more effective at reducing demand charges—but gains are not proportional.
- Storage is most effective at reducing demand charges for customers with narrower peak loads.
Solar + Storage synergies in managing demand charges

**Synergy #1:** Solar creates narrow peaks in the shoulder hours that storage is able to easily clip.

**Load net of solar with shoulder-hour peaks**

**Load without solar or storage**

**Load net of solar + storage**

**Solar generation**

**Storage dispatch**

**Synergy #2:** Storage can buffer transient dips in solar production.

**Transient spike in load (net of solar) due to passing cloud**
Solar + storage synergies based on building type & climate

**Cooperation ratio**
(a measure of solar+storage synergy)

Solar + storage synergies relatively high for:

- Buildings with relatively wide peak load periods that extend beyond daylight hours (e.g., hospitals and office buildings)
- Locations with intermittent clouds but an otherwise strong solar resource (e.g., Miami)
Recent rate reforms for NEM customers have prompted rapid growth of solar + storage in several jurisdictions.

**Hawaii** *(net billing or prohibition on exports)*

- **65%** Percentage of Residential PV Installations with Battery Storage

**Salt River Project** *(demand charges for PV customers)*

- **20%**

**California** *(TOU rates required for solar PV customers)*

- **5%**

**Arizona Public Service** *(net billing)*

- **2%**
Energy arbitrage savings under different types of rate designs and pricing differentials

- Wide range in arbitrage savings across TOU rates
- CPP arbitrage driven mostly by underlying TOU rates, but also by CPP events
- RTP arbitrage value is relatively modest
- Arbitrage under net billing rates (for PV customers) largely driven by approach to setting grid-export rate

### Annual energy charge savings from BTM storage

2-hr storage, illustrative range of rates

<table>
<thead>
<tr>
<th></th>
<th>Annual Bill Savings ($ per kWh of storage capacity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOU</td>
<td>ConEd GS-2</td>
</tr>
<tr>
<td>CPP (+TOU)</td>
<td>SCE Res CPP</td>
</tr>
<tr>
<td>CPP days only</td>
<td>DTE DPP</td>
</tr>
<tr>
<td>RTP</td>
<td>ERCOT</td>
</tr>
<tr>
<td>Net Billing</td>
<td>∆10¢ x 365 days</td>
</tr>
</tbody>
</table>

- ∆49¢ x 10 days
- ∆91¢ x 20 days
- ∆1¢ x 365 days

**Legend:**
- TOU
- CPP (+TOU)
- CPP days only
- RTP
- Net Billing

**Notes:**
- ConEd GS-2
- SCE Res CPP
- DTE DPP
- ERCOT
- ∆10¢ x 365 days
- ∆49¢ x 10 days
- ∆91¢ x 20 days
- ∆1¢ x 365 days
Storage utilization rates (aka duty cycle)

- I.e., How frequently does the storage unit get (fully) cycled?
- Another key determinant of the annual bill savings value
- Constrained by:
  - Minimum pricing differential needed to warrant cycling on any given day
  - Limits on grid exports from storage
- Under net billing, will be driven by load shape and PV system size (see figure)
- But an important consideration under other rate designs as well

**Example:** Utilization rates for a 13-kWh/5-kW battery storage system under a net billing rate

- Derived from sample of hourly interval load data
Comparing demand charge vs. energy arbitrage savings from BTM storage

Energy arbitrage savings can rival demand charge savings under some circumstances

- TOU with high peak-to-off-peak pricing differentials
- Longer duration storage
Question 1: Do utility bill savings offer a compelling value proposition for customer investment?

- For reference, current BTM storage costs are ~$1000-2000 per kW (for 2-hour duration)
- To achieve a 10-yr payback would require bill savings of at least $100-200 per kW of storage
- As shown, it’s possible to hit that range under some optimistic rate scenarios, but that’s more of an exception than the rule
- Value stacking (bill savings plus other value streams) essential to customer value proposition in most contexts
Question 2: Do bill savings align with utility system value (avoided utility costs)?

An example where they do not…

BTM Storage Dispatch on the System Peak Day under 2 Rate Designs

Net Billing with Flat Rates

- System Load (scaled)
- Storage Dispatch (averaged over all customers)

Charge

Discharge

Capacity credit ≈ 0%

- Relatively little PV exports on peak load days
- No price signal to discharge during system peak hours

Capacity credit = 20-100%

- Range reflects different calculation methods
- Constrained by energy-limited nature of battery storage

Hourly Time-Varying Rates
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For more information
Download publications from the Electricity Markets & Policy Group: https://emp.lbl.gov/publications
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Acknowledgements
This work was funded by the U.S. Department of Energy Office of Electricity and Solar Energy Technologies Office, under Contract No. DE-AC02-05CH11231.
The national leader in solar, storage, & home energy management.

22 states + DC & Puerto Rico
Active in policy throughout country.

More than a quarter million customers nationwide

On average, every 2.3 minutes a new system is installed

Sunrun customers have saved over $300 million on electricity bills

And produced 5 billion kWh of clean energy

The solar installer is the fastest growing job in America.

Sunrun alone has created more than 4,000 jobs & thousands more through our partners.

More than 5,000 Brightbox home batteries are providing back up power during outages.
Brightbox: Product and Markets

Brightbox meets needs of residential customer + grid at lowest cost.

- **Back-Up Power** (Island during Outage)
- **Grid Services** (Capacity, Voltage, Active/Passive)
- **Bill Management** (TOU, CPP, Hourly)
- **Energy Self-Supply**

Now Available In: HI, CA, AZ, NY, MA, FL, PR, TX, VT, & NJ

2-10 kW Solar + 9.8 kWh / 5 kW Storage
Brightbox for Time Shifted Solar

Illustrative Residential Solar+Storage & Load Curve

Brightbox manages residential load shift in CA - managed for TOU, to minimize midday solar exports, and to flatten evening load - with flexibility for DR or other targeted shift, while maintaining charge for backup.
Home Solar & Batteries: the future, today

**Wholesale: e.g., ISO-NE**
- 20 MW bid won in 2019 Forward Capacity Auction
- Spread through number of New England states & ~5,000 homes
- First in nation
- Still providing backup power!

**Retail: e.g. BYOD**
- Bring Your Own Device: reduce G, T&D costs
- Utility program reducing wholesale or utility costs
- MA, VT, NH, NY, soon CT
- Low risk, pay for performance
- Still providing backup power!

**Utility: e.g. Aggregation**
- Virtual Power Plant Procurement
- NWA - locational
- Peaker replacement
- Low-income/multifamily
- Still providing backup power!
Behind the Meter Storage: What opportunities exist for customers to reduce their demand and energy charges?

NARUC - Staff Subcommittee on Rate Design
November 17th, 2019
Exelon Corp Overview

- $23B: Being invested in utilities through 2022
- $51M: In 2018, Exelon gave approx. $51 million to charitable and community causes
- 212 TWH: Customer load served
- 32,500: Megawatts of total power generation capacity
- 10M: Six utilities serving 10M electric and gas customers, the most in the U.S.
- 240,000: Employee volunteer hours
- 1.8 million (Approx.): Exelon’s Constellation business serves residential, public sector and business customers
- 33,400: Employees
- $35.9B: Operating revenue in 2018
Exelon Utilities - Strong Operational Performance

<table>
<thead>
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<th>Operations</th>
<th>Metric</th>
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<td>OSHA Recordable Rate</td>
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<td>2,5 Beta SAIFI (Outage Frequency)</td>
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<td>Yellow</td>
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<tr>
<td></td>
<td>2,5 Beta CAIDI (Outage Duration)</td>
<td>Red</td>
<td>Green</td>
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<tr>
<td>Customer Operations</td>
<td>Customer Satisfaction</td>
<td>Red</td>
<td>Red</td>
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<tr>
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<td>Service Level % of Calls Answered in &lt;30 sec</td>
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<td>Abandon Rate</td>
<td>Yellow</td>
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<tr>
<td>Gas Operations</td>
<td>Percent of Calls Responded to in &lt;1 Hour</td>
<td>Yellow</td>
<td>Green</td>
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<td>Overall Rank</td>
<td>Electric Utility Panel of 24 Utilities(1)</td>
<td>23rd</td>
<td>2nd</td>
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<thead>
<tr>
<th></th>
<th>YTD 2019</th>
<th>BGE</th>
<th>ComEd</th>
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<td>Yellow</td>
<td>Green</td>
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<tr>
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<td></td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
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</tbody>
</table>

Performance Quartiles:
- Q1
- Q2
- Q3
- Q4
We believe the future will be oriented around Connected Communities
Storage can provide a wide variety of benefits

Source: The Economics of Battery Energy Storage, Rocky Mountain Institute
Maryland Energy Storage Pilot Project Act

• Building on work done in the Transforming Maryland’s Electric Grid proceeding (PC44), Maryland passed the Energy Storage Pilot Project Act in March of 2019
• The Bill requires the MD PSC to mandate each MD IOU to solicit offers to develop energy storage projects under the following commercial and regulatory models:
  • Utility - Only Model
  • Utility and Third-Party Model
  • Third-Party Ownership Model
  • Virtual Power Plant Model
• All PSC-approved storage projects to become operational by no later than February 28, 2022
• The cumulative size of the pilot projects beneath the program must be between 5 to 10 MW, with a minimum of 15 MWhs
Demand Charge relief for Electric Vehicles

Maryland - Pepco and BGE Maryland

- “Demand Charge Credit” program would be available to “demand-billed” non-residential customers who install EV chargers at their workplace or for fleet use.
- A bill credit would be provided for a portion of the maximum distribution demand that results from the addition of EV chargers to the customer’s load.
- The credit is for a fixed amount at 50 percent of the maximum nameplate capacity of the L2 or DCFC equipment installed for up to 30 months or the end of the five-year program.

Pennsylvania - PECO

- Electric Vehicle DCFC Pilot Rider (EV-FC) – PECO should calculate and apply a fixed demand (kW) credit, initially equal to 50% of the combined maximum nameplate capacity rating for all DCFCs connected to the service, to the customer's billed distribution demand.
- The pilot began on July 1, 2019 and will continue for five years, expiring on June 30, 2024