Spring Cleaning

Organizing the Benefits of Behind-the-Meter Energy Storage

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IEPEC International Energy Program Evaluation Conference

8/21/2019

OVERVIEW

» Self-Generation Incentive Program (SGIP)
  - Types of Energy Storage being utilized
  - Customer Class

» How Energy Storage is being used in SGIP
  - Nonresidential customers
    - *Observed* Dispatch
  - Residential customers

» Conclusions and Recommendations

SELF-GENERATION INCENTIVE PROGRAM

History and Background

» Established legislatively in 2001 to address peak demand issues in California

» Provides financial incentives for installation of distributed generation and energy storage technologies

ENERGY STORAGE IN THE SGIP

Overview

» Behind-the-meter, customer owned

» Electrochemical and thermal technologies are eligible
  - Primarily lithium-ion and flow batteries to date

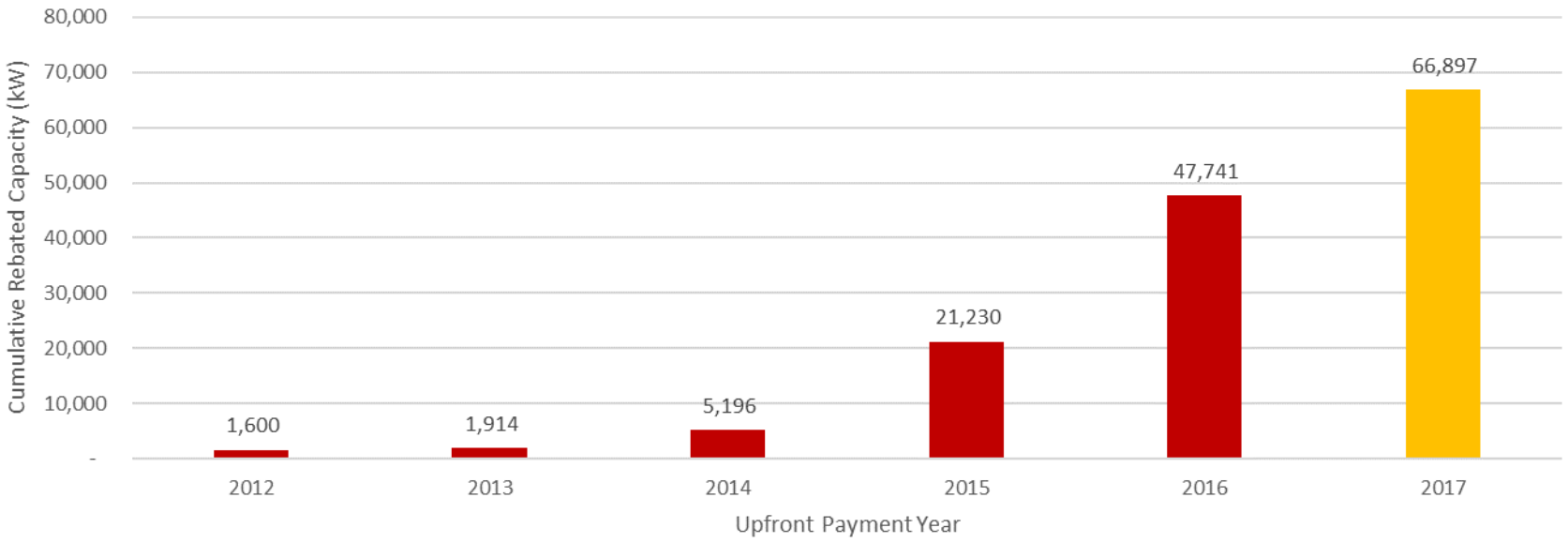
» Residential and nonresidential customers are eligible

» Battery power ratings range from 5 kW to 5 MW, primarily 2-hour duration

» Can be paired with a generator (e.g., PV) or standalone

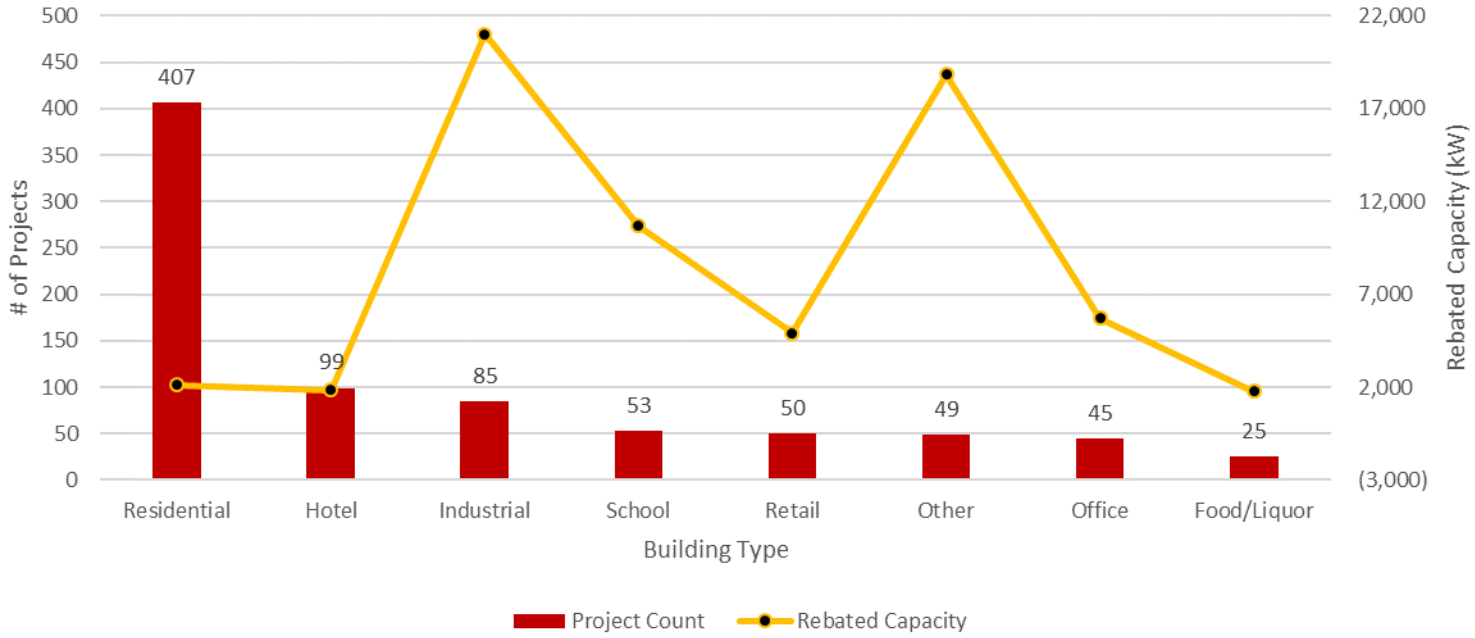
EVALUATED POPULATION

By Upfront Payment Year



EVALUATED POPULATION

By Project Count and Rebated Capacity



INCENTIVE TYPES

Performance Based Incentive vs. Upfront Incentive

100% Upfront Incentive

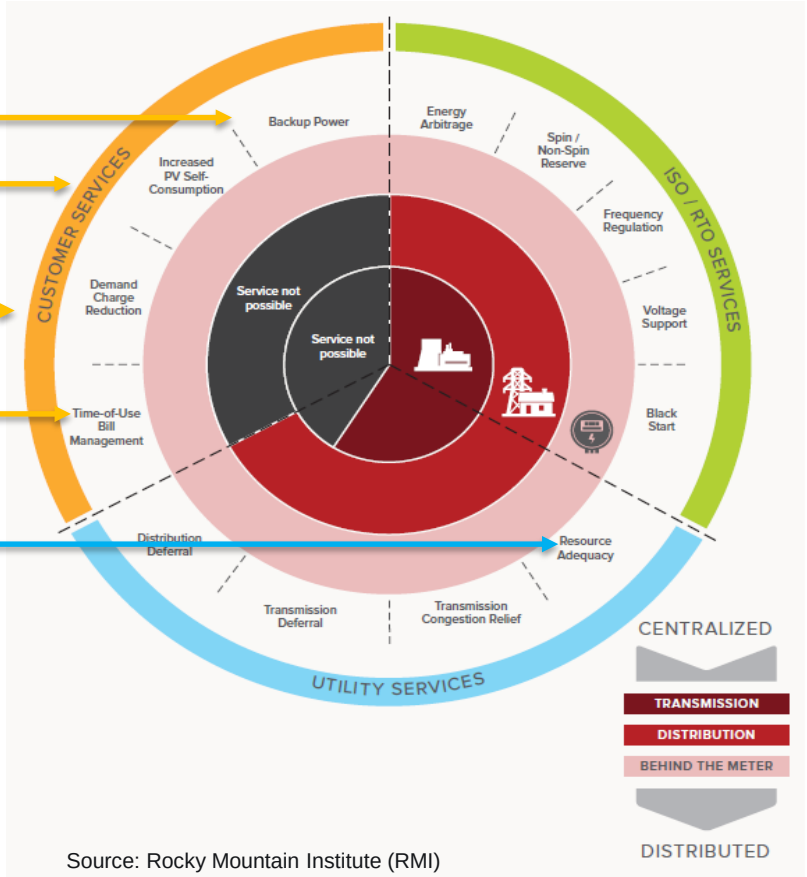
- Systems less than 30 kW
- No data collection requirements or performance monitoring
- 10% of storage population-level rebated capacity

Performance Based Incentive (PBI)

- Systems 30 kW or larger
- 50% of incentive paid upfront, remaining 50% paid over five years
- Incentive payment contingent on system performance over time
- 90% of storage population-level rebated capacity

OBSERVED USE CASES FOR BTM STORAGE IN SGIP?

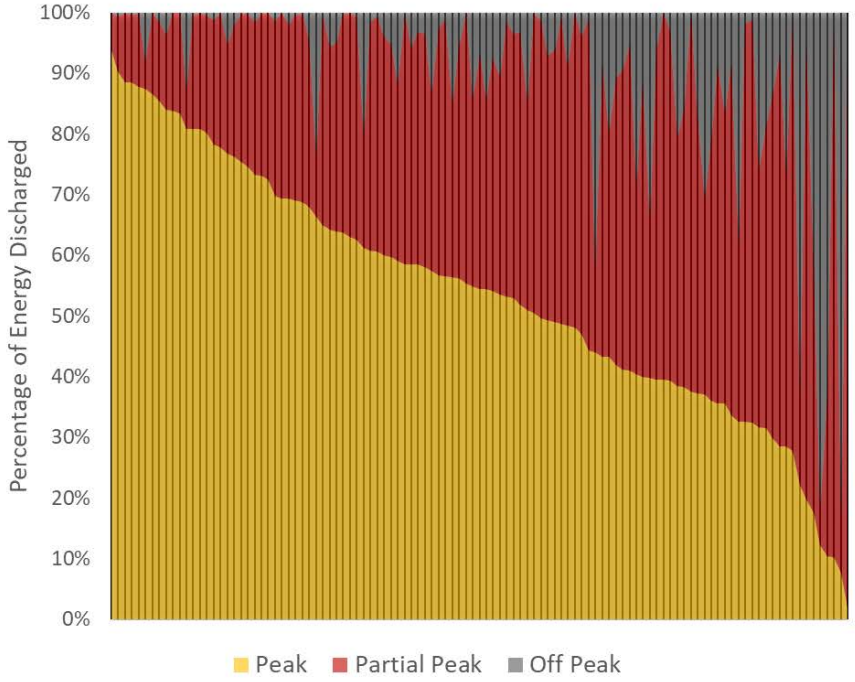
- Backup Power
- PV Self-Consumption
- Demand Charge Reduction
- TOU Bill Management
- Aggregated Demand Response



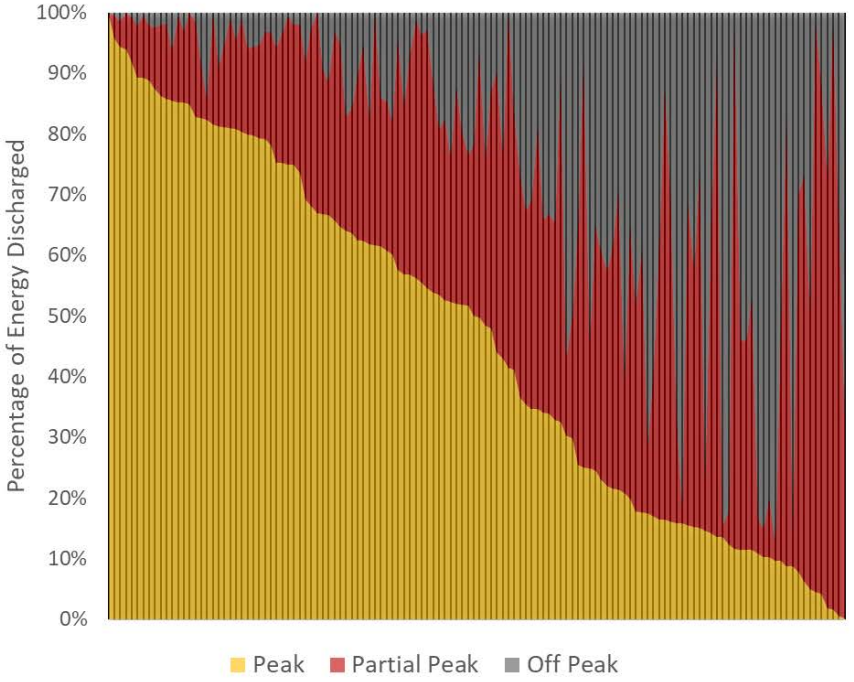
Source: Rocky Mountain Institute (RMI)

ENERGY STORAGE DISCHARGE BY UTILITY TOU

Non-PBI Projects (Summer weekday/non-holiday)



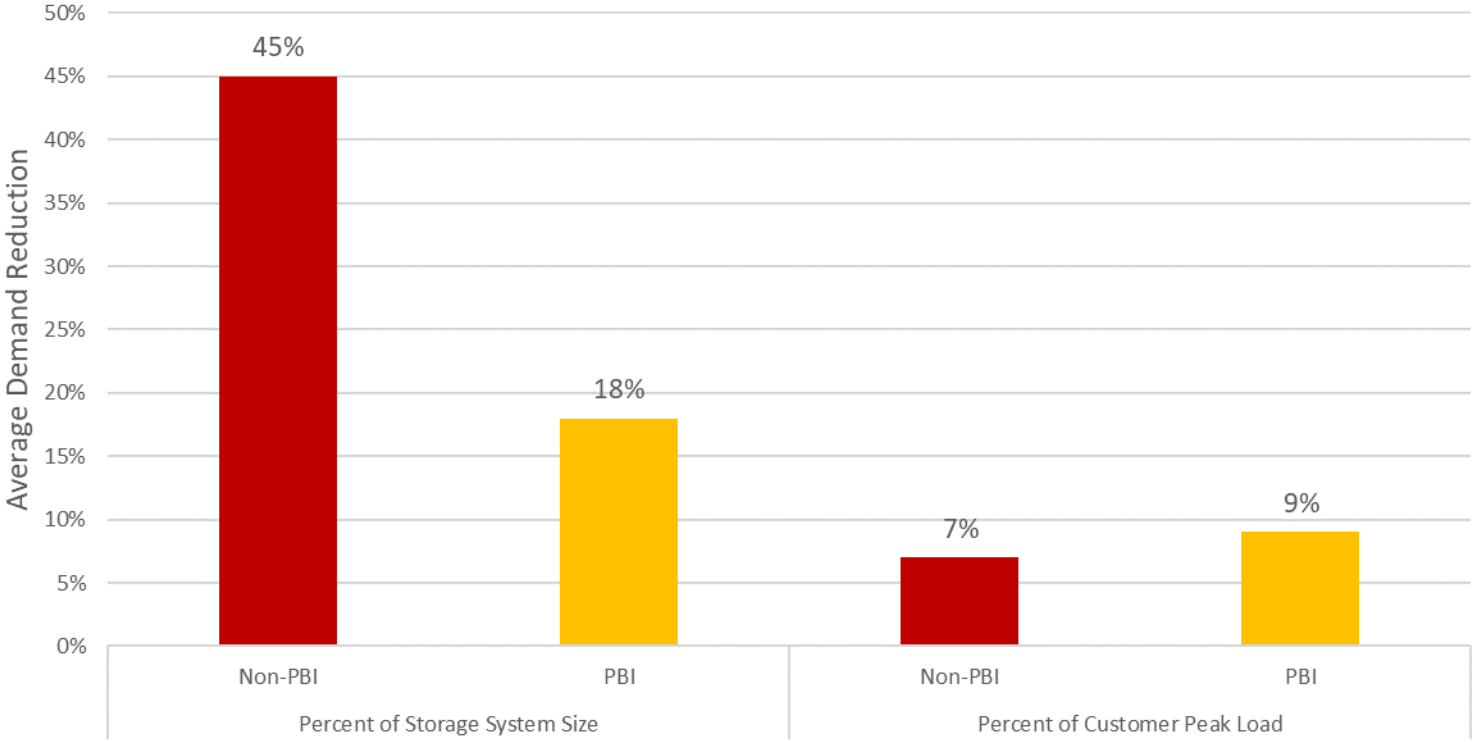
PBI Projects (Summer weekday/non-holiday)



CUSTOMER IMPACTS

Non-Coincident Peak Demand Reduction

Non-PBI: < 30 kW
PBI: > 30 kW



BILL COMPONENTS

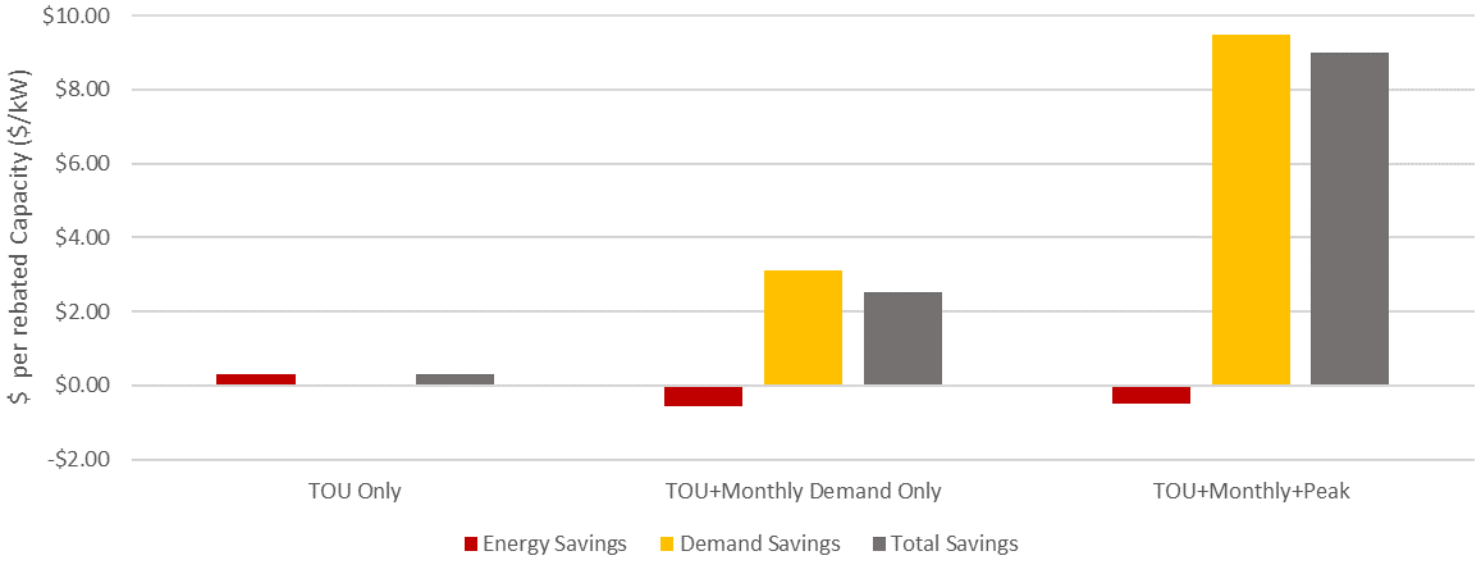
Energy and Demand

» SGIP storage participants are grouped into three bins:

- TOU Only: Customer is on a time-of-use (TOU) rate with no demand charges
- TOU + Monthly Demand: Customer is on a TOU rate with a monthly demand charge assessed at monthly level
- TOU + Monthly & Peak Period Demand: Customer is on a TOU rate with a monthly demand charge **and** a separate demand charge assessed during the peak TOU period

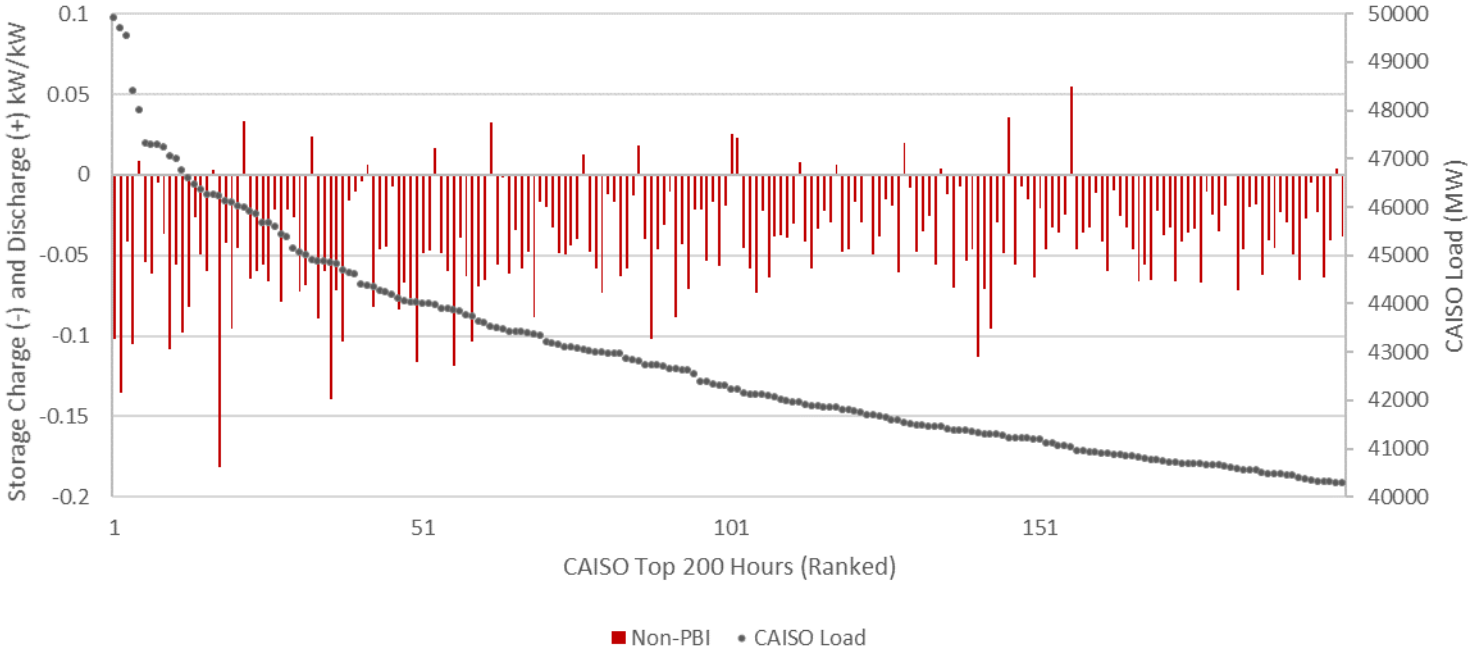
CUSTOMER IMPACTS

Nonresidential Bill Impacts



SYSTEM IMPACTS

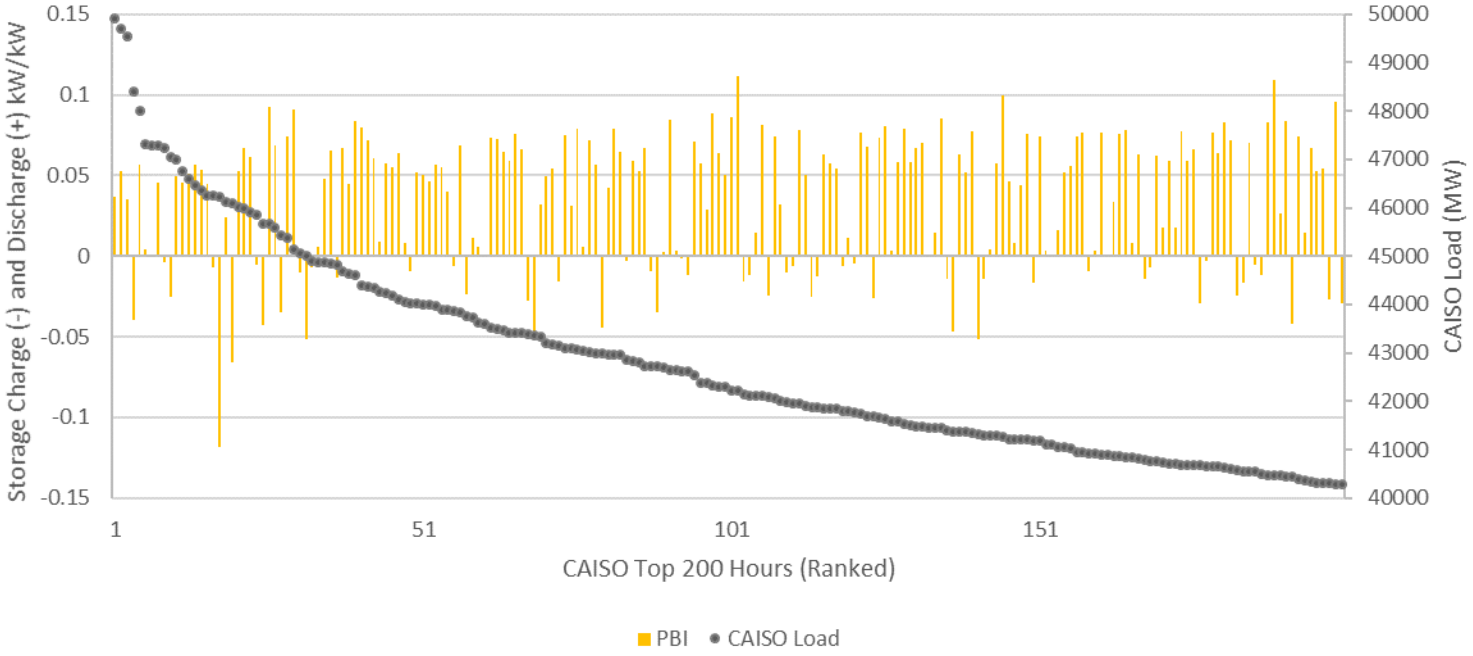
CAISO Top 200 Hours – Non PBI



Non-PBI: < 30 kW

SYSTEM IMPACTS

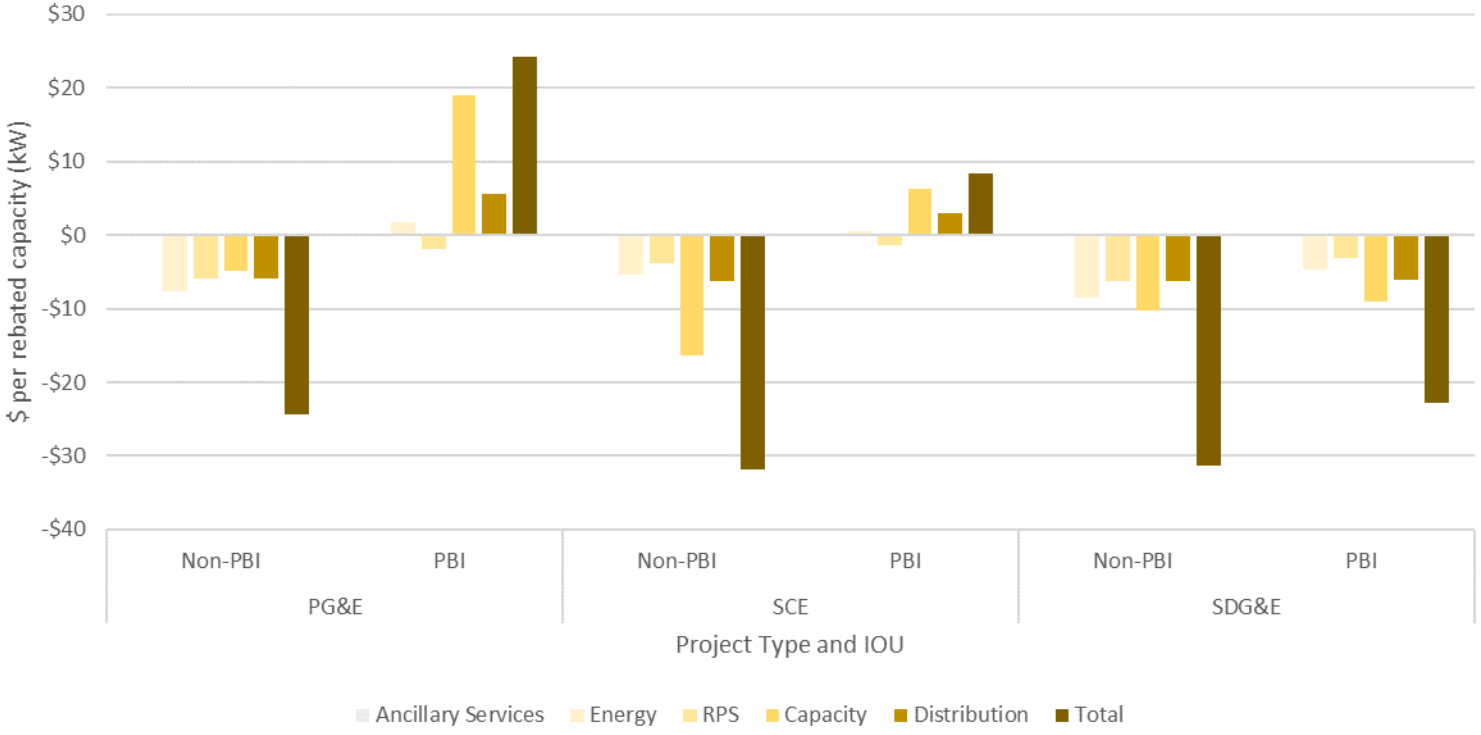
CAISO Top 200 Hours - PBI



PBI: > 30 kW

UTILITY MARGINAL COST IMPACTS

Nonresidential

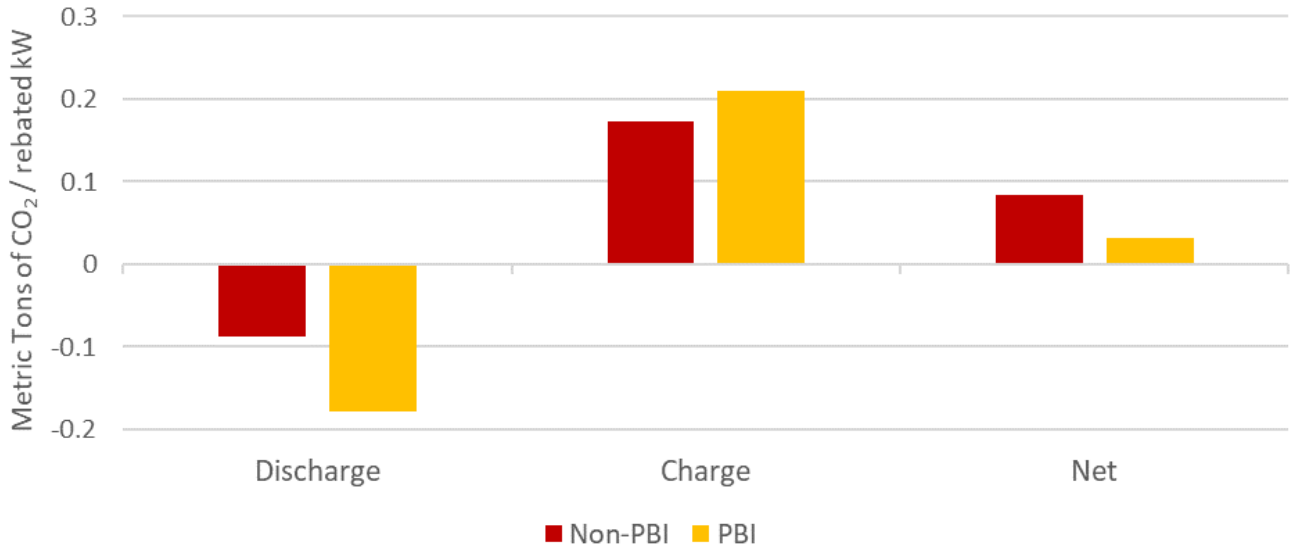


ENVIRONMENTAL IMPACTS

» Energy storage systems do not inherently emit or avoid greenhouse gases (GHGs)

» They influence the behavior of the marginal grid generator during charge/discharge by modifying load

ENVIRONMENTAL IMPACTS



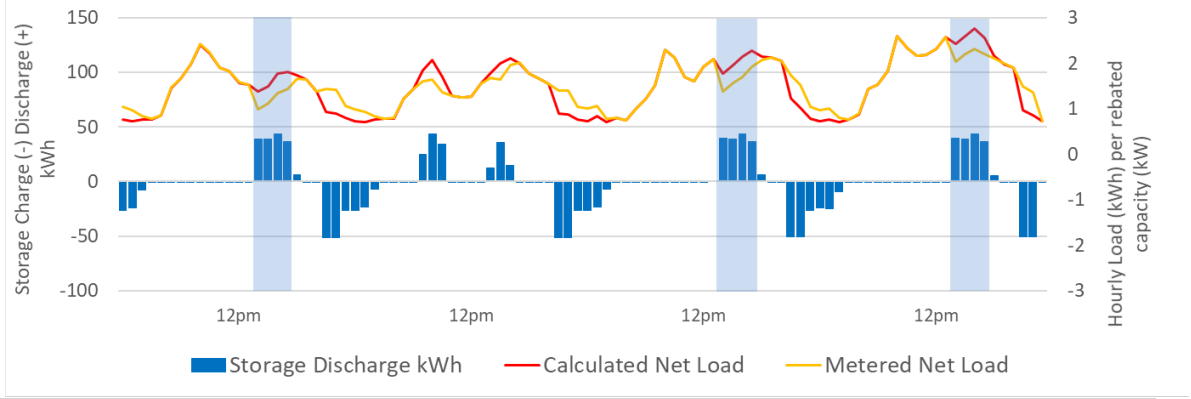
DEMAND RESPONSE EXAMPLE

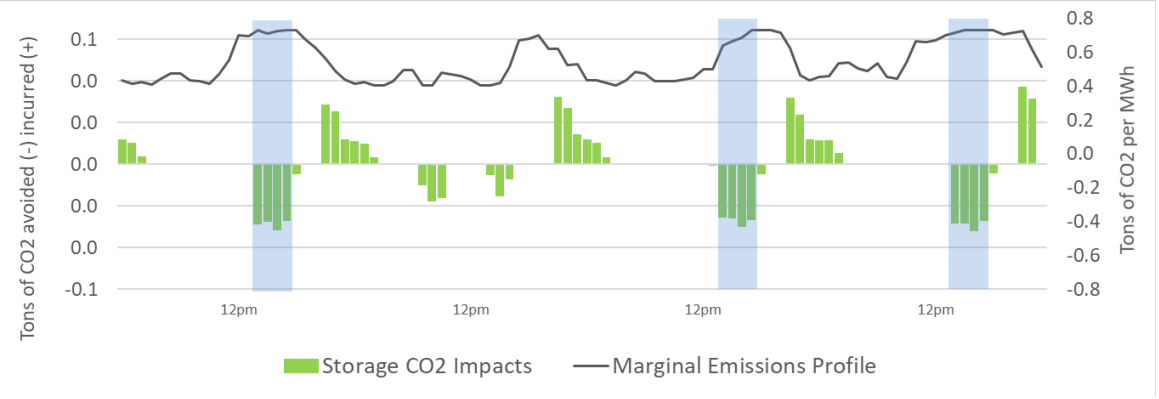
100 kW System

» Day 1, 3 and 4
- Ignores non-coincident peak
- Responds to DR signal
- Discharge high marginal emission periods
- Decrease in emissions

» Day 2
- No DR event
- Discharges during facility peak ramps
- Increase in emissions

» Utilization identical on 4 days
» Timing of charge/discharge

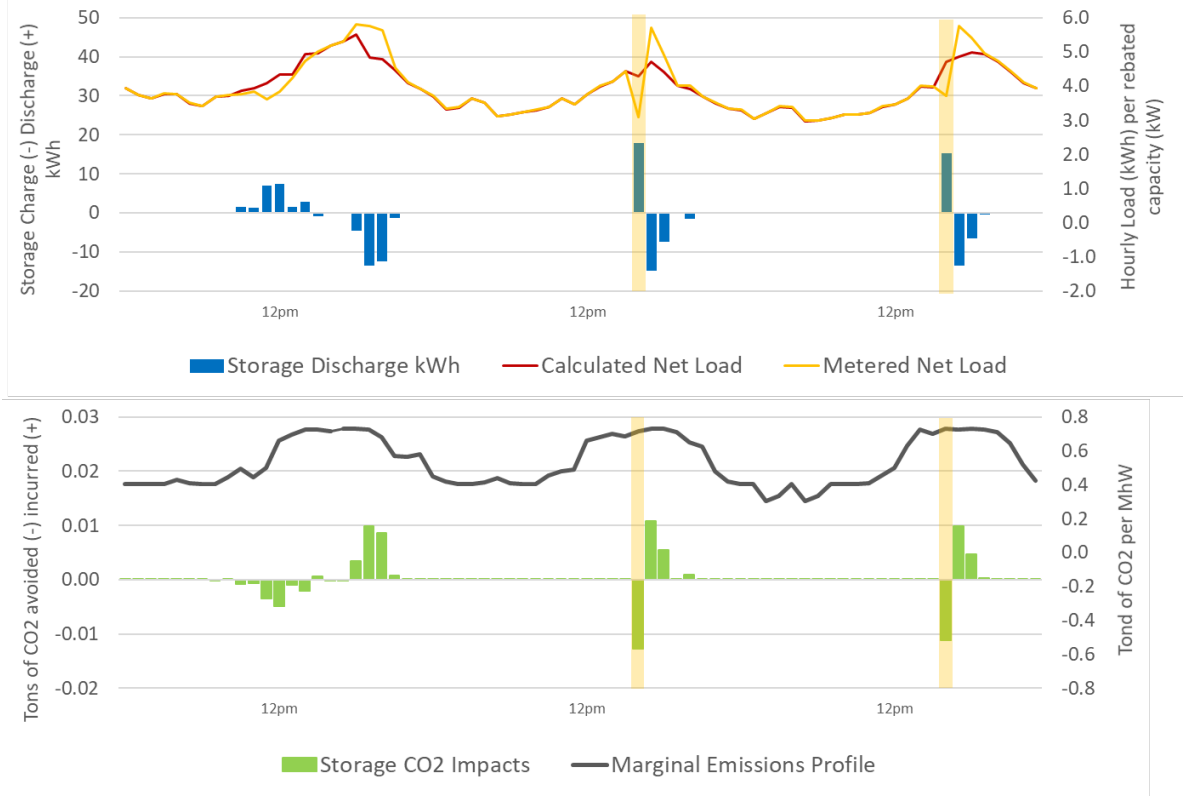




DEMAND RESPONSE EXAMPLE

15 kW System

- Day 2 and 3
  - Responds to 1-hour DR event
  - Charges immediately after
  - “snap-back”
  - Increase in emissions
- Day 1
  - No DR event
  - Discharging during morning ramp
  - Increase in emissions
- Utilization identical on 3 days
- Charging during high marginal emission periods



ENERGY STORAGE CHARGE/DISCHARGE PROFILES

Residential Projects

Average Hourly Discharge (kW) per Rebated Capacity

Hour	Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
11	0.053	0.053	0.049	0.041	0.046	0.053	0.036	0.038	0.047	0.081	0.139	0.158
12	0.052	0.052	0.046	0.066	0.072	0.078	0.060	0.063	0.059	0.087	0.139	0.158
13	0.052	0.050	0.046	0.065	0.073	0.077	0.060	0.062	0.053	0.035	0.022	0.055
14	0.052	0.050	0.046	0.067	0.075	0.079	0.062	0.063	0.053	0.034	0.017	0.054
15	0.034	0.040	0.039	0.063	0.066	0.070	0.057	0.055	0.040	0.028	0.016	0.044
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.012	0.040
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Average Hourly Charge (kW) per Rebated Capacity

Hour	Jan 1	Feb 2	Mar 3	Apr 4	May 5	Jun 6	Jul 7	Aug 8	Sep 9	Oct 10	Nov 11	Dec 12
0	-0.007	-0.010	-0.013	-0.012	-0.012	-0.010	-0.010	-0.010	-0.009	-0.008	-0.006	-0.007
1	-0.007	-0.009	-0.011	-0.010	-0.010	-0.009	-0.011	-0.009	-0.008	-0.008	-0.007	-0.006
2	-0.007	-0.009	-0.011	-0.009	-0.010	-0.009	-0.010	-0.009	-0.008	-0.009	-0.007	-0.007
3	-0.006	-0.010	-0.010	-0.008	-0.009	-0.009	-0.009	-0.008	-0.010	-0.009	-0.007	-0.007
4	-0.006	-0.009	-0.009	-0.009	-0.009	-0.009	-0.008	-0.009	-0.008	-0.008	-0.007	-0.007
5	-0.005	-0.007	-0.009	-0.009	-0.009	-0.010	-0.009	-0.010	-0.008	-0.009	-0.007	-0.008
6	-0.005	-0.008	-0.010	-0.010	-0.010	-0.011	-0.009	-0.010	-0.011	-0.009	-0.008	-0.007
7	-0.007	-0.009	-0.010	-0.010	-0.011	-0.011	-0.009	-0.010	-0.010	-0.009	-0.008	-0.007
8	-0.007	-0.008	-0.009	-0.009	-0.009	-0.010	-0.009	-0.011	-0.008	-0.010	-0.007	-0.007
9	-0.006	-0.008	-0.010	-0.009	-0.009	-0.009	-0.009	-0.010	-0.009	-0.010	-0.008	-0.007
10	-0.006	-0.008	-0.009	-0.009	-0.010	-0.010	-0.010	-0.009	-0.009	-0.009	-0.007	-0.008
11	-0.005	-0.006	-0.008	-0.008	-0.009	-0.008	-0.008	-0.008	-0.007	-0.005	-0.003	-0.001
12	-0.004	-0.006	-0.009	-0.008	-0.008	-0.008	-0.009	-0.007	-0.006	-0.006	-0.003	-0.001
13	-0.005	-0.007	-0.008	-0.008	-0.007	-0.008	-0.010	-0.008	-0.010	-0.028	-0.053	-0.045
14	-0.005	-0.006	-0.008	-0.008	-0.007	-0.008	-0.009	-0.008	-0.015	-0.060	-0.129	-0.110
15	-0.006	-0.007	-0.010	-0.008	-0.008	-0.010	-0.009	-0.011	-0.021	-0.064	-0.133	-0.115
16	-0.046	-0.047	-0.048	-0.050	-0.054	-0.061	-0.046	-0.045	-0.049	-0.038	-0.038	-0.043
17	-0.044	-0.047	-0.045	-0.055	-0.060	-0.064	-0.051	-0.052	-0.051	-0.033	-0.019	-0.037
18	-0.043	-0.044	-0.042	-0.054	-0.060	-0.064	-0.051	-0.052	-0.050	-0.038	-0.023	-0.063
19	-0.042	-0.044	-0.041	-0.060	-0.063	-0.070	-0.058	-0.061	-0.057	-0.052	-0.040	-0.094
20	-0.041	-0.044	-0.042	-0.060	-0.066	-0.069	-0.054	-0.052	-0.042	-0.039	-0.033	-0.078
21	-0.040	-0.043	-0.043	-0.059	-0.065	-0.069	-0.054	-0.054	-0.041	-0.036	-0.030	-0.074
22	-0.038	-0.041	-0.039	-0.051	-0.058	-0.058	-0.048	-0.049	-0.041	-0.032	-0.025	-0.061
23	-0.021	-0.027	-0.026	-0.039	-0.036	-0.033	-0.029	-0.029	-0.022	-0.015	-0.009	-0.011

FINDINGS AND CONCLUSIONS

» Customers realizing bill savings

» Demand reduction overriding price signal relative to TOU price differential

» Larger projects provide demand reductions during top CAISO hours

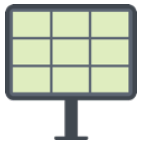
» Increased GHG emissions

» Residential customers only benefit from backup services

RECOMMENDATIONS

- More dynamic rates
  - Optimizing for bill savings leads to increases in GHG emissions and utility marginal costs

- Demand response programs
  - Could help satisfy utility and environmental needs
  - Consideration of “snap-back” so benefit of DR signal is not lost



- Storage co-located or paired with renewable generation
  - PV self-consumption

ACKNOWLEDGEMENTS

Itron

PG&E

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PUBLIC UTILITIES COMMISSION · EUREKA · STATE OF CALIFORNIA

SDGE

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THANK YOU

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ENERGY STORAGE CHARGE/DISCHARGE PROFILES

PBI Projects >30 kW

Average Hourly Net Discharge per Rebated Capacity

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1	2	3	4	5	6	7	8	9	10	11	12
0	-0.172	-0.159	-0.195	-0.196	-0.210	-0.264	-0.265	-0.263	-0.255	-0.229	-0.228	-0.231
1	-0.151	-0.139	-0.155	-0.155	-0.152	-0.187	-0.200	-0.198	-0.187	-0.154	-0.208	-0.207
2	-0.103	-0.100	-0.110	-0.110	-0.118	-0.115	-0.105	-0.105	-0.109	-0.101	-0.155	-0.154
3	-0.053	-0.060	-0.071	-0.074	-0.086	-0.076	-0.066	-0.054	-0.062	-0.066	-0.106	-0.116
4	-0.039	-0.043	-0.054	-0.050	-0.060	-0.053	-0.046	-0.033	-0.034	-0.040	-0.065	-0.077
5	-0.031	-0.025	-0.038	-0.035	-0.040	-0.037	-0.030	-0.025	-0.019	-0.026	-0.041	-0.051
6	-0.021	-0.001	-0.011	-0.009	-0.014	-0.009	-0.011	-0.001	0.001	-0.001	-0.011	-0.016
7	-0.010	0.020	0.012	-0.001	0.000	-0.002	-0.001	0.008	0.005	0.006	0.000	-0.005
8	-0.004	-0.024	-0.020	-0.020	-0.011	-0.012	-0.012	-0.011	-0.008	-0.009	-0.005	-0.005
9	0.000	-0.025	-0.027	-0.021	-0.015	-0.009	-0.013	-0.012	-0.008	-0.008	0.002	-0.002
10	0.004	-0.008	-0.010	-0.003	0.003	0.003	0.006	0.008	0.006	0.005	0.011	0.001
11	0.001	-0.007	-0.003	0.010	0.029	0.033	0.031	0.028	0.036	0.032	0.024	0.013
12	0.009	-0.001	0.001	0.014	0.039	0.040	0.042	0.043	0.044	0.040	0.021	0.011
13	0.005	0.001	0.004	0.016	0.050	0.051	0.054	0.062	0.065	0.053	0.020	0.013
14	0.000	0.009	0.005	0.014	0.079	0.141	0.123	0.135	0.112	0.070	0.030	0.017
15	0.012	0.012	0.016	0.016	0.098	0.165	0.147	0.169	0.129	0.073	0.035	0.028
16	0.015	0.020	0.033	0.041	0.118	0.176	0.171	0.192	0.140	0.093	0.047	0.041
17	0.040	0.035	0.083	0.119	0.077	0.033	0.045	0.032	0.034	0.095	0.078	0.072
18	0.075	0.066	0.158	0.198	0.138	0.105	0.114	0.096	0.122	0.181	0.126	0.114
19	0.131	0.135	0.190	0.229	0.179	0.137	0.132	0.116	0.151	0.180	0.173	0.177
20	0.130	0.160	0.136	0.101	0.080	0.099	0.089	0.071	0.090	0.071	0.156	0.186
21	0.017	0.035	-0.025	-0.101	-0.117	-0.092	-0.098	-0.091	-0.109	-0.161	0.034	0.076
22	-0.115	-0.125	-0.107	-0.115	-0.147	-0.186	-0.163	-0.188	-0.173	-0.141	-0.144	-0.160
23	-0.034	-0.068	-0.164	-0.223	-0.248	-0.299	-0.288	-0.295	-0.280	-0.258	-0.125	-0.100

ENERGY STORAGE CHARGE/DISCHARGE PROFILES

Non-PBI Projects <30 kW

Average Hourly Net Discharge per Rebated Capacity

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1	2	3	4	5	6	7	8	9	10	11	12
0	-0.018	-0.028	-0.035	-0.036	-0.035	-0.037	-0.030	-0.028	-0.031	-0.029	-0.032	-0.030
1	-0.025	-0.028	-0.026	-0.027	-0.027	-0.028	-0.026	-0.026	-0.028	-0.026	-0.028	-0.032
2	-0.020	-0.024	-0.022	-0.023	-0.022	-0.023	-0.022	-0.022	-0.022	-0.022	-0.025	-0.028
3	-0.019	-0.019	-0.020	-0.022	-0.021	-0.021	-0.021	-0.021	-0.022	-0.020	-0.022	-0.021
4	-0.019	-0.020	-0.019	-0.020	-0.019	-0.020	-0.020	-0.020	-0.021	-0.019	-0.020	-0.018
5	-0.016	-0.017	-0.017	-0.018	-0.017	-0.019	-0.019	-0.019	-0.019	-0.017	-0.017	-0.014
6	-0.006	-0.013	-0.015	-0.017	-0.015	-0.017	-0.016	-0.017	-0.020	-0.019	-0.014	-0.009
7	-0.011	-0.015	-0.013	-0.013	-0.010	-0.011	-0.011	-0.011	-0.015	-0.015	-0.013	-0.012
8	-0.007	-0.011	-0.012	-0.012	-0.008	-0.006	-0.007	-0.012	-0.012	-0.013	-0.012	-0.013
9	-0.016	-0.016	-0.022	-0.020	-0.019	-0.017	-0.018	-0.022	-0.014	-0.015	-0.018	-0.024
10	-0.030	-0.028	-0.023	-0.022	-0.017	-0.011	-0.013	-0.017	-0.009	-0.011	-0.017	-0.024
11	-0.033	-0.027	-0.022	-0.018	-0.015	-0.003	-0.015	-0.015	-0.009	-0.012	-0.017	-0.024
12	-0.026	-0.019	-0.022	-0.016	-0.013	-0.009	-0.011	-0.015	-0.015	-0.013	-0.013	-0.021
13	-0.018	-0.012	-0.018	-0.016	-0.012	-0.011	-0.014	-0.014	-0.015	-0.013	-0.016	-0.020
14	-0.022	-0.012	-0.020	-0.019	-0.017	-0.016	-0.016	-0.014	-0.015	-0.015	-0.021	-0.021
15	-0.023	-0.020	-0.022	-0.018	-0.018	-0.013	-0.014	-0.003	-0.018	-0.020	-0.026	-0.020
16	-0.020	-0.029	-0.020	-0.005	-0.017	-0.019	-0.004	-0.029	-0.016	-0.028	-0.019	-0.014
17	0.015	-0.006	-0.019	-0.022	-0.038	-0.044	-0.043	-0.045	-0.047	-0.028	0.005	0.006
18	0.007	0.002	0.005	-0.011	-0.030	-0.045	-0.044	-0.029	-0.022	-0.015	-0.007	-0.001
19	-0.008	-0.014	-0.008	-0.020	-0.007	-0.028	-0.028	-0.017	-0.026	-0.020	-0.024	-0.010
20	-0.038	-0.037	-0.019	-0.025	-0.021	-0.034	-0.027	-0.029	-0.036	-0.036	-0.041	-0.026
21	-0.037	-0.035	-0.033	-0.035	-0.037	-0.036	-0.038	-0.031	-0.033	-0.029	-0.030	-0.020
22	-0.038	-0.045	-0.051	-0.047	-0.054	-0.051	-0.048	-0.038	-0.042	-0.035	-0.045	-0.035
23	-0.037	-0.041	-0.044	-0.035	-0.039	-0.040	-0.032	-0.029	-0.030	-0.027	-0.041	-0.036