



# BATTERIES UNLEASHED: SUPERCHARGING BENEFITS THROUGH SMARTER STORAGE PROGRAMS

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# INTRODUCTION

- » Results from recently completed SGIP Impacts Evaluation
  - BTM energy storage and generation technologies receiving SGIP incentives
- » Explore different ways energy storage technologies are utilized
  - How does that behavior/utilization impact GHG emissions, grid needs, customer resiliency, customer bills, utility avoided costs
- » Observed impacts compared to optimal dispatch of storage
  - With perfect foresight, how could storage be dispatched to maximize GHG reductions, utility avoided costs, customer bill impacts

# EVALUATION POPULATION

## Program Count

Nonresidential

**1709**

Residential

**50048**

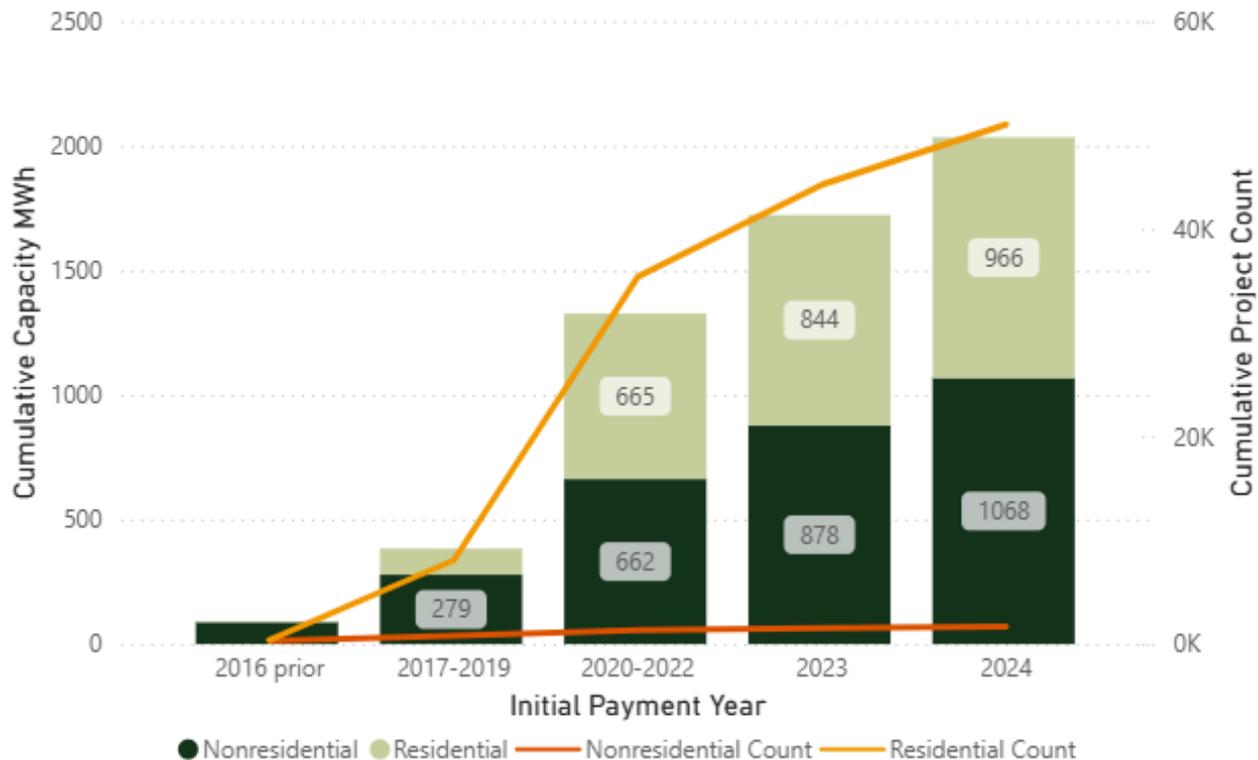
## Program Capacity (MWh)

Nonresidential

**1068**

Residential

**966**



# EVALUATION APPROACH

## Observed Impacts and Unobservable Baselines

Shaded yellow = an increase in customer load

Shaded green = a decrease in customer load

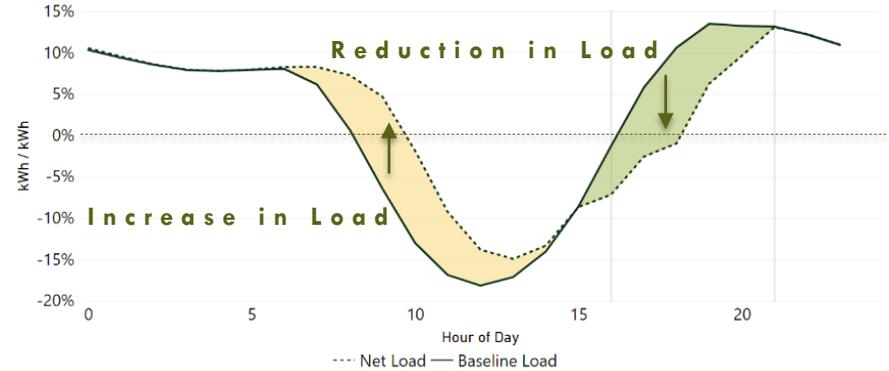
Vertical Lines = 4pm to 9pm on-peak

### » Metered storage charge/discharge

- Actual system characteristics calculated from metered data – RTE, CF, Annual cycles

### » Consumption at the meter in the absence of the SGIP technology – an unobservable baseline requires pre-storage installation assumptions:

- GHG emissions reductions if → emissions avoided during discharge are greater than emissions increases during charging
- Customer bill savings if → discharging occurs during high-priced hours and charging occurs during lower-priced hours

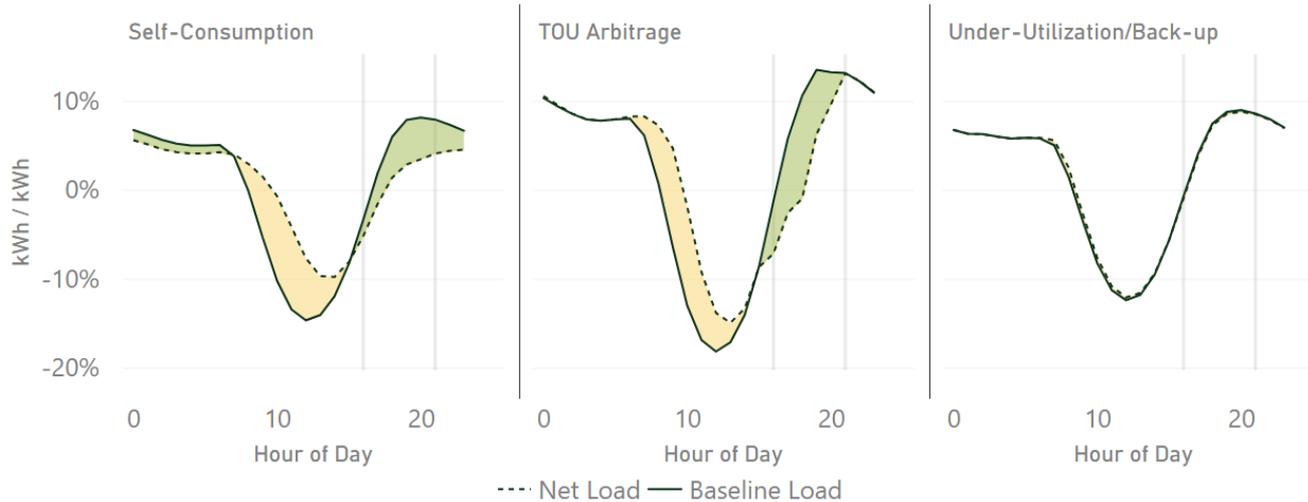


# TYPICAL RESIDENTIAL LOAD SHAPES

## PV Paired by Operating Mode

Shaded yellow = an increase in customer load  
Shaded green = a decrease in customer load  
Vertical Lines = 4pm to 9pm on-peak

Average Residential Summer Weekday Daily Load Shapes (PV Paired)



- » **64%** of sampled projects
- » Zero out imported load
- » Discharge outside on-peak

- » **30%** of sampled projects
- » With and without export
- » Discharge on-peak only

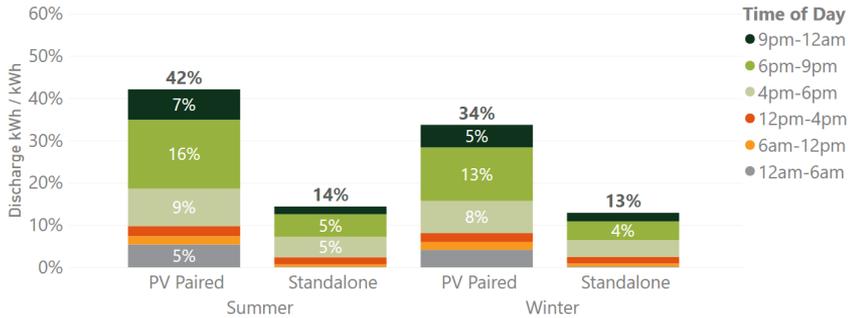
- » **6%** of sampled projects
- » Not allowed in SGIP
- » Observed infrequently

# RESIDENTIAL STORAGE DAILY KWH UTILIZATION

## PV Paired vs. Standalone by Season

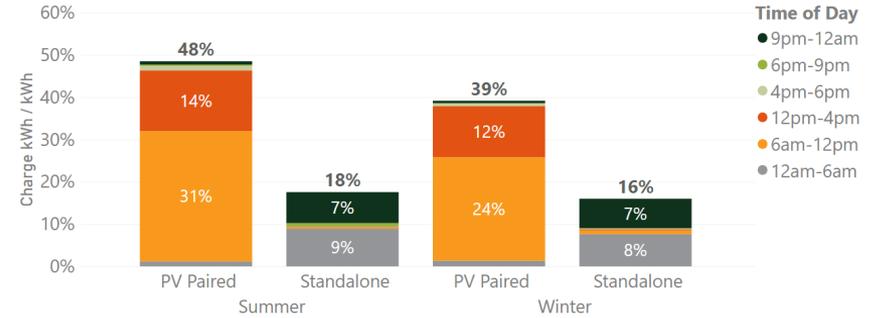
### Discharge kWh per Capacity kWh

Residential Discharge kWh per Capacity kWh by Time of Day



### Charge kWh per Capacity kWh

Residential Charge kWh per Capacity kWh by Time of Day



- » PV Paired utilized ~42% of battery capacity daily in Summer
- » Most discharge comes between 4pm-9pm
- » Standalone utilized ~14%

- » PV paired early morning solar charging
- » Standalone system overnight charging

# RESIDENTIAL STORAGE HOURLY KWH UTILIZATION

## PV Paired Charging from Solar (Weekdays Only)

Average Hourly Residential PV Paired Net Discharge kWh / kWh Capacity (Charging from Solar)

BY MONTH, HOUR

Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
January	0%	0%	0%	0%	0%	0%	0%	-0%	-2%	-4%	-6%	-6%	-5%	-3%	-1%	0%	3%	4%	5%	3%	2%	1%	1%	1%
February	1%	1%	1%	0%	0%	0%	0%	-0%	-3%	-6%	-8%	-7%	-5%	-3%	-2%	-0%	3%	5%	6%	4%	3%	2%	2%	1%
March	1%	1%	1%	0%	0%	0%	0%	-0%	-3%	-5%	-7%	-6%	-5%	-3%	-2%	-1%	2%	3%	5%	4%	3%	2%	2%	1%
April	1%	1%	1%	1%	1%	1%	1%	-0%	-4%	-7%	-9%	-8%	-5%	-3%	-1%	-0%	2%	3%	4%	4%	4%	3%	2%	2%
May	1%	1%	1%	1%	1%	1%	1%	-1%	-3%	-6%	-8%	-7%	-5%	-4%	-2%	-1%	1%	3%	4%	4%	4%	3%	2%	2%
June	2%	1%	1%	1%	1%	1%	1%	-1%	-4%	-7%	-8%	-8%	-6%	-4%	-2%	-0%	2%	3%	5%	4%	4%	3%	3%	2%
July	1%	1%	1%	1%	1%	1%	0%	-1%	-5%	-8%	-10%	-9%	-6%	-3%	-1%	0%	4%	5%	6%	6%	5%	3%	2%	2%
August	1%	1%	1%	1%	1%	1%	0%	-1%	-4%	-8%	-10%	-9%	-7%	-4%	-2%	-0%	3%	5%	6%	6%	5%	3%	2%	2%
September	1%	1%	1%	1%	1%	1%	1%	-0%	-3%	-6%	-9%	-9%	-7%	-4%	-2%	-0%	3%	5%	6%	6%	5%	3%	2%	2%
October	1%	1%	1%	1%	1%	1%	1%	0%	-2%	-6%	-9%	-9%	-7%	-4%	-2%	-0%	3%	5%	6%	6%	4%	3%	2%	1%
November	1%	0%	0%	0%	0%	0%	0%	-1%	-3%	-6%	-8%	-7%	-5%	-3%	-1%	1%	4%	5%	5%	4%	3%	2%	1%	1%
December	0%	0%	0%	0%	0%	0%	0%	-0%	-2%	-5%	-6%	-6%	-5%	-3%	-1%	1%	4%	5%	5%	3%	2%	1%	1%	1%

# RESIDENTIAL STORAGE HOURLY KWH UTILIZATION

## Standalone and PV Paired Charging from Grid (Weekdays Only)

» Similar dispatch patterns between standalone and PV Paired systems charging from grid

» Greater utilization from the latter

» Charging begins 9pm local time

» Greatest magnitude after midnight

- More than half of PV paired systems are on an EV rate

Average Hourly Residential Standalone Net Discharge kWh / kWh Capacity

BY MONTH, HOUR																								
Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
January	-5%	-3%	-0%	0%	-0%	-0%	-0%	0%	-1%	0%	0%	0%	0%	0%	0%	1%	2%	2%	2%	1%	1%	-2%	0%	-3%
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May	-5%	-2%	0%	0%	-0%	-0%	-0%	0%	-0%	0%	0%	0%	0%	0%	0%	1%	2%	2%	2%	1%	1%	-2%	0%	-3%
June	-6%	-3%	-0%	-0%	-0%	-0%	-0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	2%	2%	1%	1%	-2%	0%	-3%
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September	-5%	-2%	0%	-0%	-0%	-0%	-0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	2%	2%	1%	1%	-2%	0%	-3%
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November	-5%	-2%	-0%	-0%	-0%	-0%	-0%	0%	-1%	0%	0%	0%	0%	0%	0%	1%	2%	2%	2%	2%	1%	-2%	0%	-3%
December	-6%	-2%	-0%	-0%	-0%	-0%	-0%	0%	-1%	0%	0%	0%	0%	0%	0%	1%	2%	2%	2%	2%	1%	-2%	0%	-3%

Average Hourly Residential PV Paired Net Discharge kWh / kWh Capacity (Charging from Grid)

BY MONTH, HOUR																								
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August	-13%	-7%	-1%	-1%	-0%	-0%	-0%	-0%	-0%	-0%	-1%	-0%	-0%	-0%	1%	2%	7%	9%	8%	5%	3%	-7%	-4%	-4%
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December	-13%	-7%	-1%	-0%	-0%	-0%	-0%	-0%	-2%	-2%	-1%	-0%	-0%	0%	1%	2%	6%	7%	6%	4%	3%	-3%	-1%	-3%

# ENERGY STORAGE GHG IMPACTS

Charging from on-site solar critical to GHG reductions in the energy storage sector

## » Residential energy storage sector

- PV paired charging from solar – average GHG reductions of 19 kg per kWh capacity
- PV paired charging from grid – average GHG increases of 2 kg per kWh capacity
- Standalone systems increase emissions by almost 5 kg per kWh capacity
- Idle/under-utilized systems increase emissions slightly

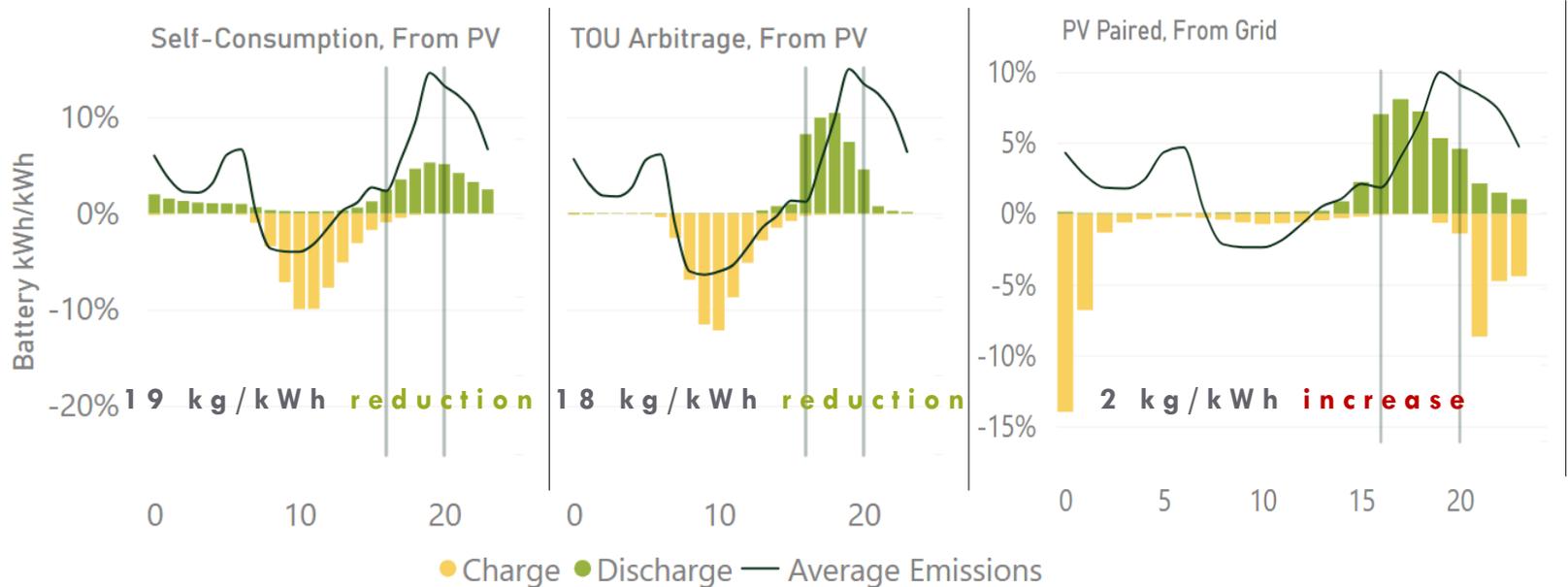
## » Nonresidential energy storage sector

- PV paired average GHG reductions of 14 kg per kWh capacity
- Standalone systems reduced emissions by 3 kg per kWh capacity
  - Medium duration batteries – public utilities (ERB)
  - More targeted dispatch – EV stations

# RESIDENTIAL ENERGY STORAGE GHG IMPACTS

## PV Paired by Operating Mode

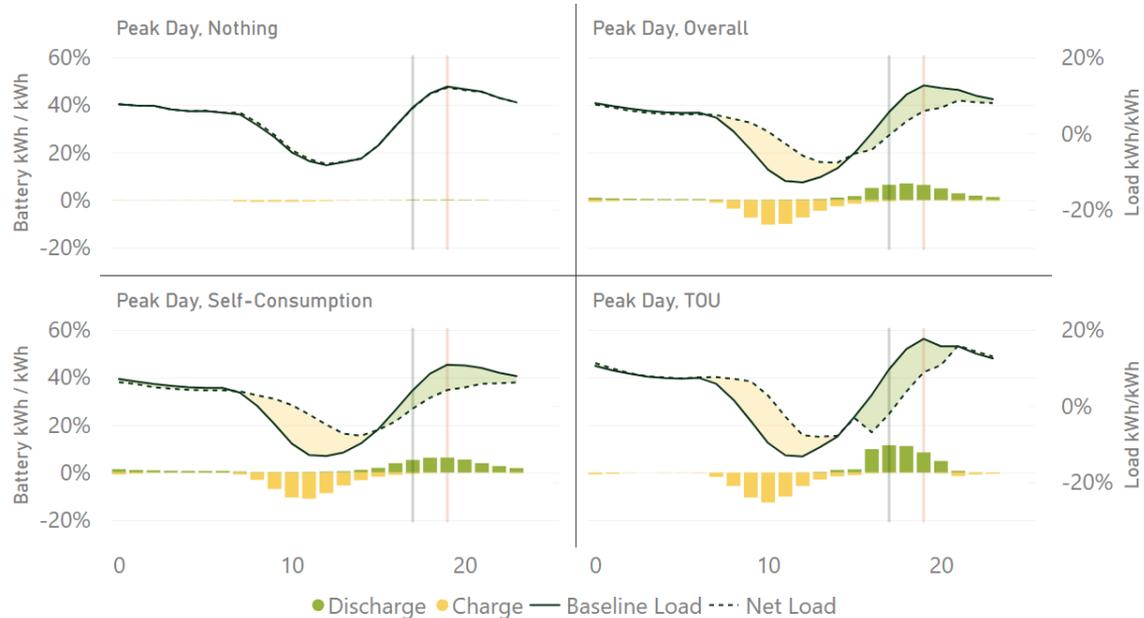
Residential PV Paired Battery Charge (-) Discharge (+) and Average Summer GHG Emissions Factor by Operating Mode



# RESIDENTIAL LOAD AND STORAGE DISPATCH

## By Operating Mode on Peak CAISO Day (8/15/2023)

Baseline and Metered Net Load with Battery Charge (-) and Discharge (+) 8/15/2023 (CAISO Net Peak Day)



**Green Vertical Line** = Peak Gross Load Hour (5-6pm)  
**Red Vertical Line** = Peak Net Load Hour (7-8pm)

# RESIDENTIAL UTILIZATION AND GRID NEEDS

## Demand Response Participation (ELRP)

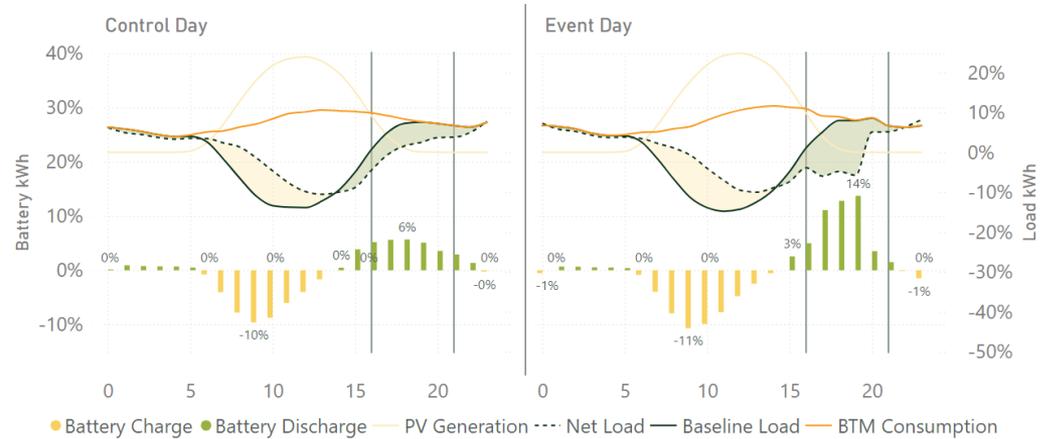
### » Control days

- Similar non-event days
- Typical dispatch patterns and magnitudes (6% peak hourly discharge)

### » Event days

- ELRP events called
- Similar PV generation, consumption
- Greater discharge magnitudes (14% peak hourly discharge)
- Excess capacity discharged to grid

Average Hourly Load Shapes and Storage Charge (-) Discharge (+) ELRP Event Days and Control Days



**Shaded yellow** = an increase in customer load

**Shaded green** = a decrease in customer load

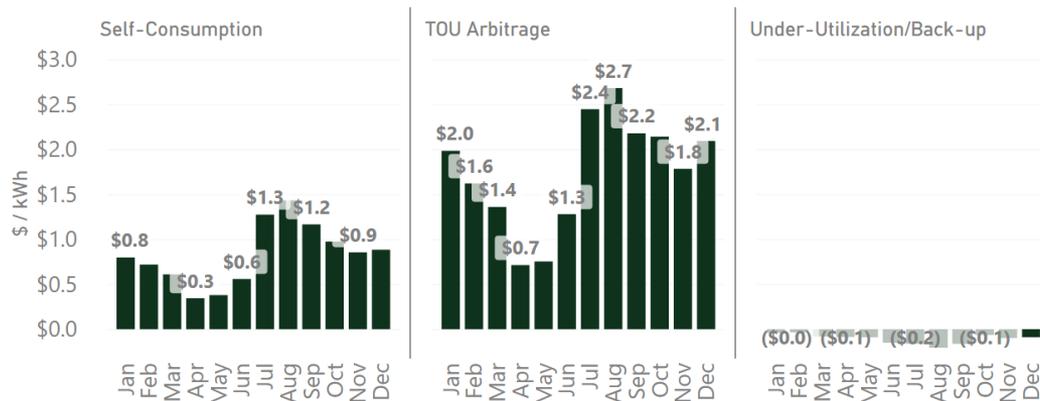
**Vertical Lines** = 4pm to 9pm on-peak

# RESIDENTIAL CUSTOMER BILL IMPACTS

## By Month and Operating Mode

- » Monthly variability in bill impacts
- » Slight bill increases for under-utilized systems
- » Greatest savings come for TOU arbitrage (and in summer months)

Observed Residential Monthly Bill Savings per kWh Capacity (by Operating Mode)



**Self-consumption - \$10/kWh annual savings**

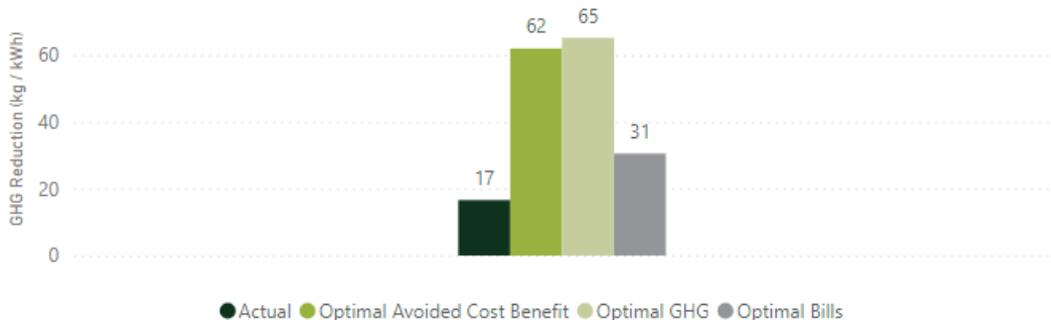
**TOU Arbitrage - \$20/kWh annual savings**

# RESIDENTIAL OPTIMIZATION

## GHG Scenario

- » 17 kg/kWh observed GHG reduction
- » Over 3x improvement in GHG when optimized for it
- » Similar improvement when optimized for avoided costs
- » ~2x improvement when optimized for bill savings

GHG Emissions Impact



# RESIDENTIAL OPTIMIZATION

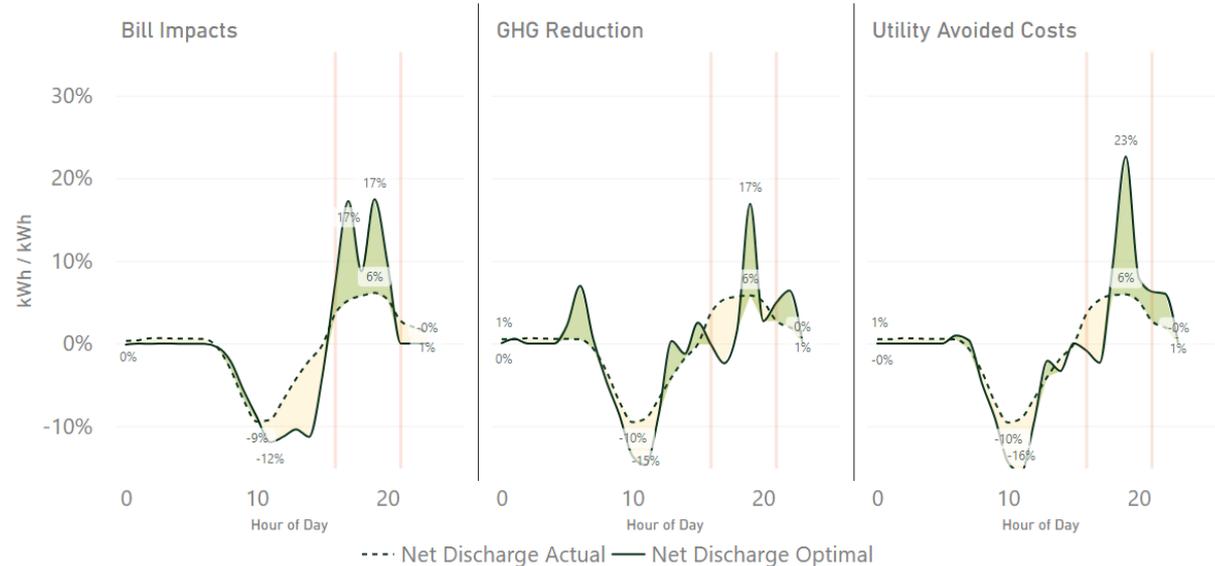
## Actual Storage Discharge and Optimized Discharge (August 2023)

Shaded yellow = more charging than actual

Shaded green = more discharge than actual

Vertical Lines = 4pm to 9pm on-peak

- » Actual Discharge
  - 40% kWh
- » Optimal Bill Discharge
  - 59% kWh
- » Optimal GHG Discharge
  - 64% kWh
- » Optimal AC Discharge
  - 65% kWh



# CONCLUSIONS AND RECOMMENDATIONS

- » GHG emissions differentials between charging overnight and discharging on-peak are **not sufficient to realize emissions reductions** like observed with PV paired systems charging from on-site PV
- » Residential and nonresidential systems are **not discharging the total capacity of the system regularly** and many residential customers are limiting discharge to maintain net zero load rather than exporting
- » SGIP energy storage systems were not performing too differently during capacity constrained hours than they were ordinarily in 2023. But, **ELRP participation is where we observe differences in storage dispatch** between event and control days
- » Optimization modeling revealed that the average actual avoided emissions of 17 kg of GHG per kWh of capacity **would more than triple if optimized for GHG reductions** or utility avoided costs. They would almost double if customer bill savings were optimized.



# THANK YOU

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 VERDANT