

# Solar and Battery Customer Response to Time-of-Day Rates

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Fort Collins Utilities

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# About Fort Collins Utilities

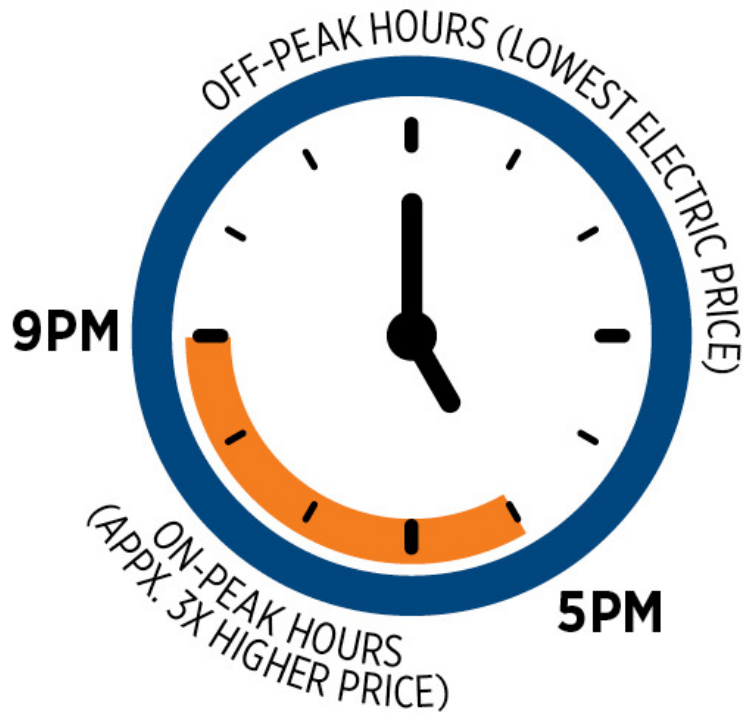
- Population Fort Collins, CO: 172,438
  - 68,000 residential meters
  - 37,900 single-family detached homes
  - Colorado State University: 28,446 students
- Residential Solar PV
  - 1,430 residential installations; >350 installations in 2018
  - Total installed solar capacity: 14 MW; of that 8 MW is residential
  - 621 kW Community Solar, 64 kW Income-Qualified Assistance solar
  - 21 solar + battery residential customers

# Context: Mandatory Residential TOD Rates

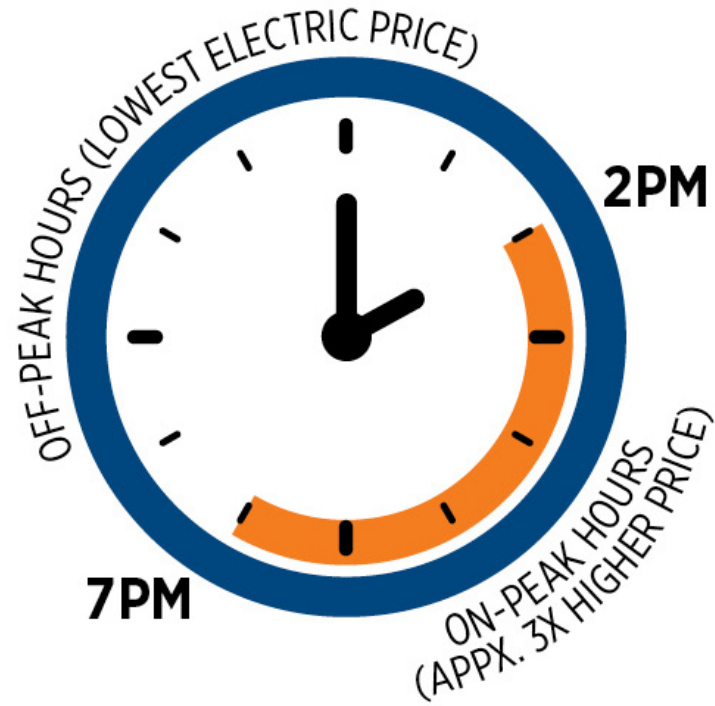
- Implementation October 2018
- Intentions:
  - Reveal seasonal and time-differentiated changes in the cost of generating and delivering energy
  - Revenue-neutral
- Anticipated response: 2.5% reduction in annual consumption for typical residential customers

# Fort Collins Time-of-Day Pricing

**NON-SUMMER**  
OCTOBER-APRIL  
WEEKDAYS ONLY



**SUMMER**  
MAY-SEPTEMBER  
WEEKDAYS ONLY





# Residential Solar TOD Charges and Credits

For homes with non-electric heat

## 2019 Time of Day Pricing

		Rates (cents/kWh)	
Season	Period	Charges*	Solar Credits
Summer	On-Peak	-24.08	22.72
	Off-Peak	-6.93	6.54
Non-Summer	On-Peak	-21.63	20.41
	Off-Peak	-6.74	6.36

\*Charge for all kWh used in excess of 700 kWh per month is 1.94 cents/kWh for non-electric home heat source.

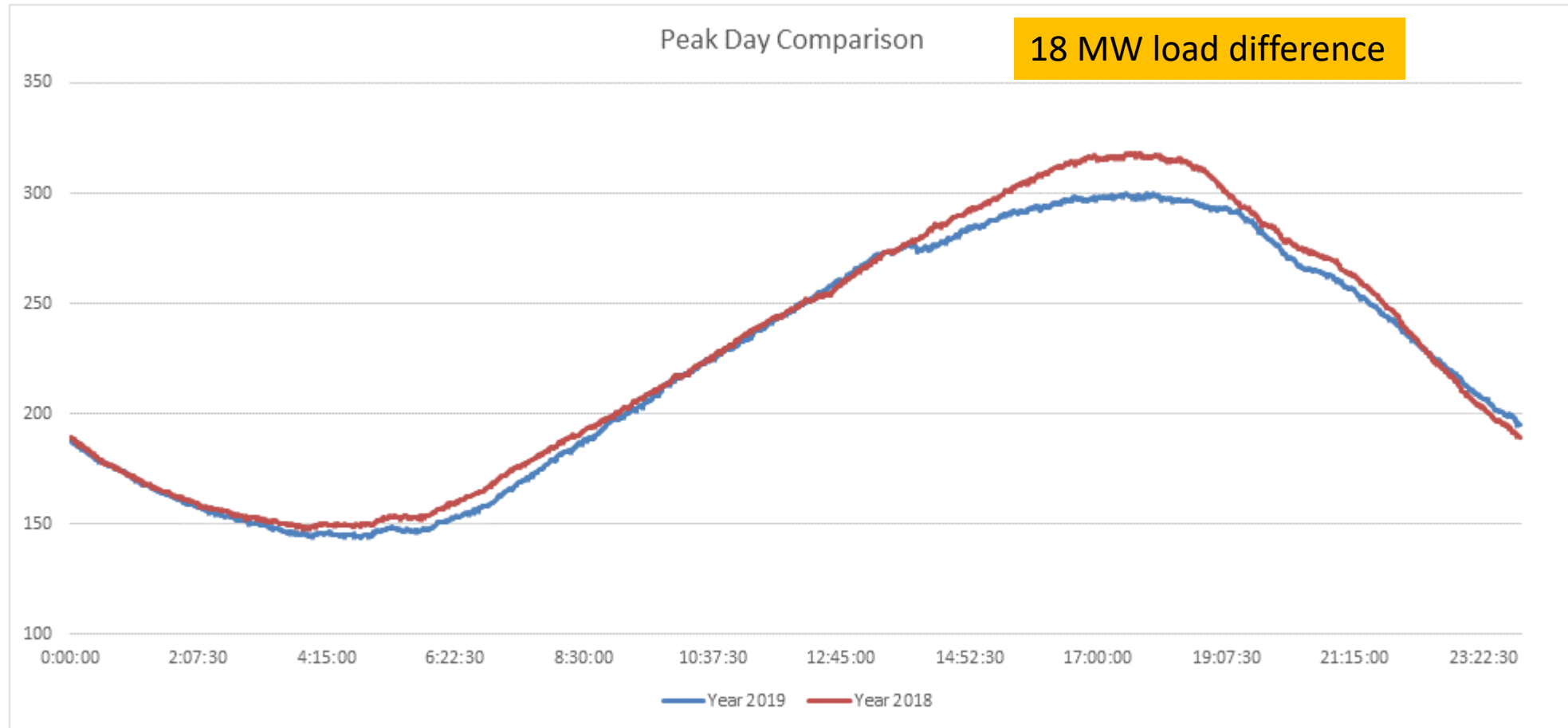
Charges include 6% Payment in Lieu of Taxes

# Will customers respond to rate signals?

- How do residential customers respond to time-variant rates?
  - Shifting load off-peak
  - Conservation
  - Enroll for planned load reductions during on-peak
- What if they have solar PV, or solar PV with battery storage?
  - Solar energy sell-back provisions and credit rates matter
  - Storage discharge to grid is allowed
- Research underway to explore the diversity of customer load responses

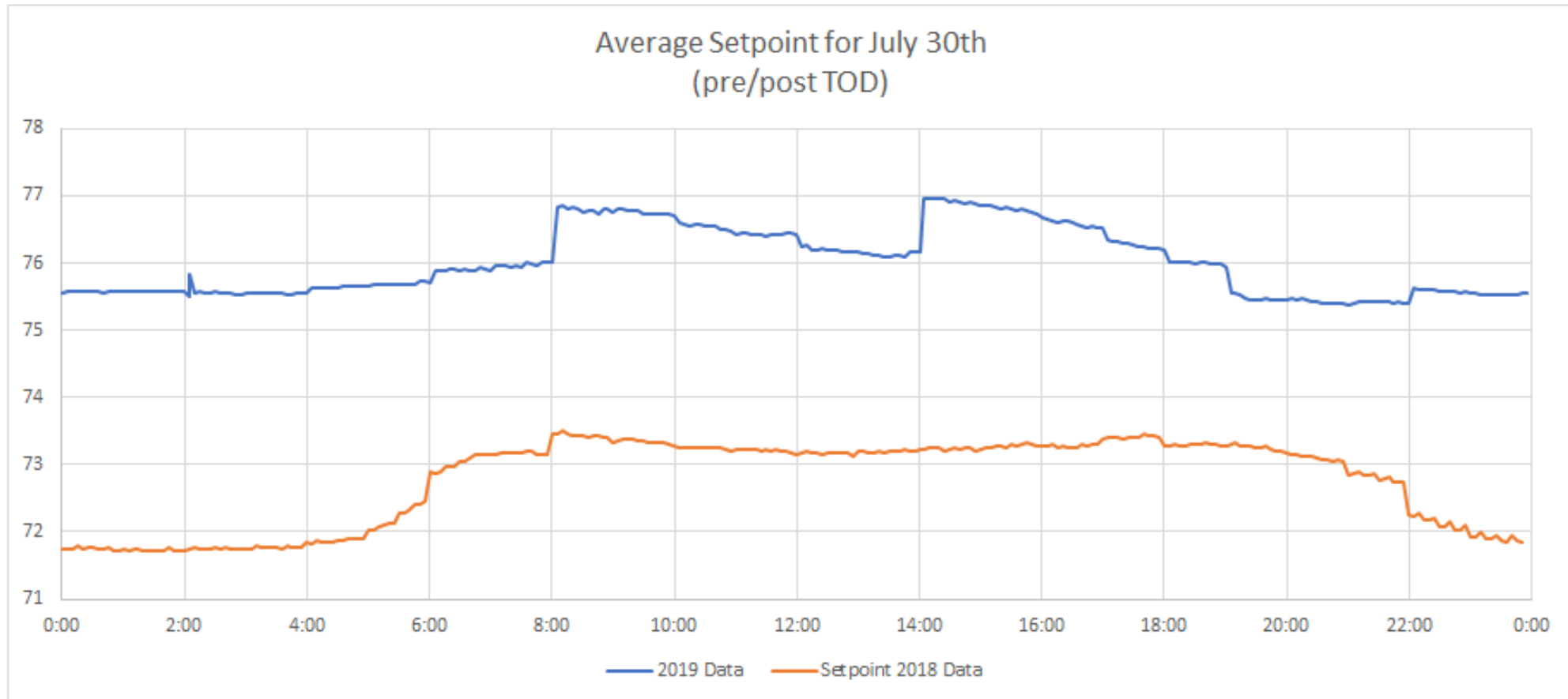
# Indications of Residential sector response:

Lower city-wide consumption on summer peak day



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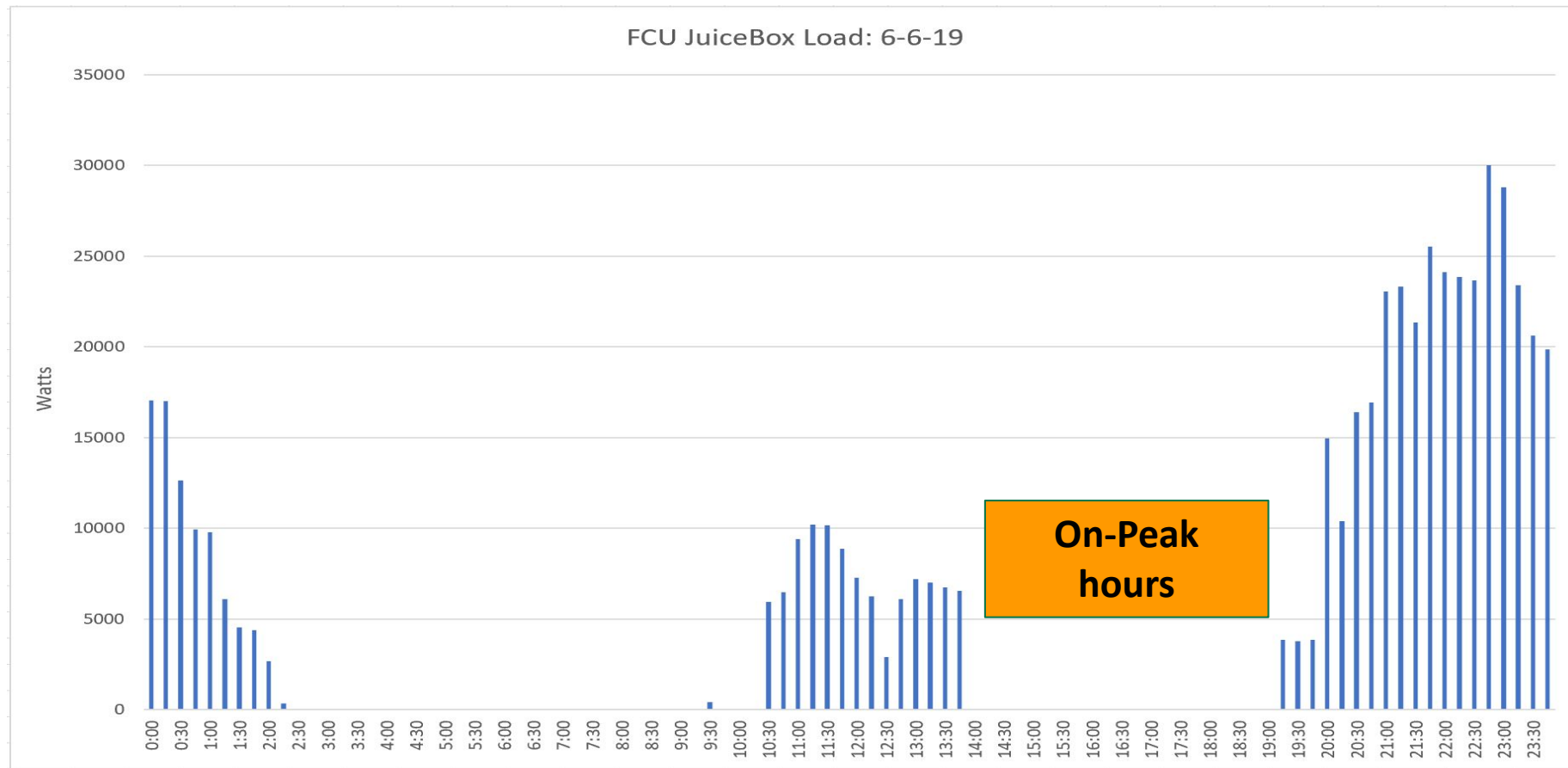
Apparent average thermostat setpoint





# Indications of Residential sector response:

EV Distributed Charging Study peak day charging profile

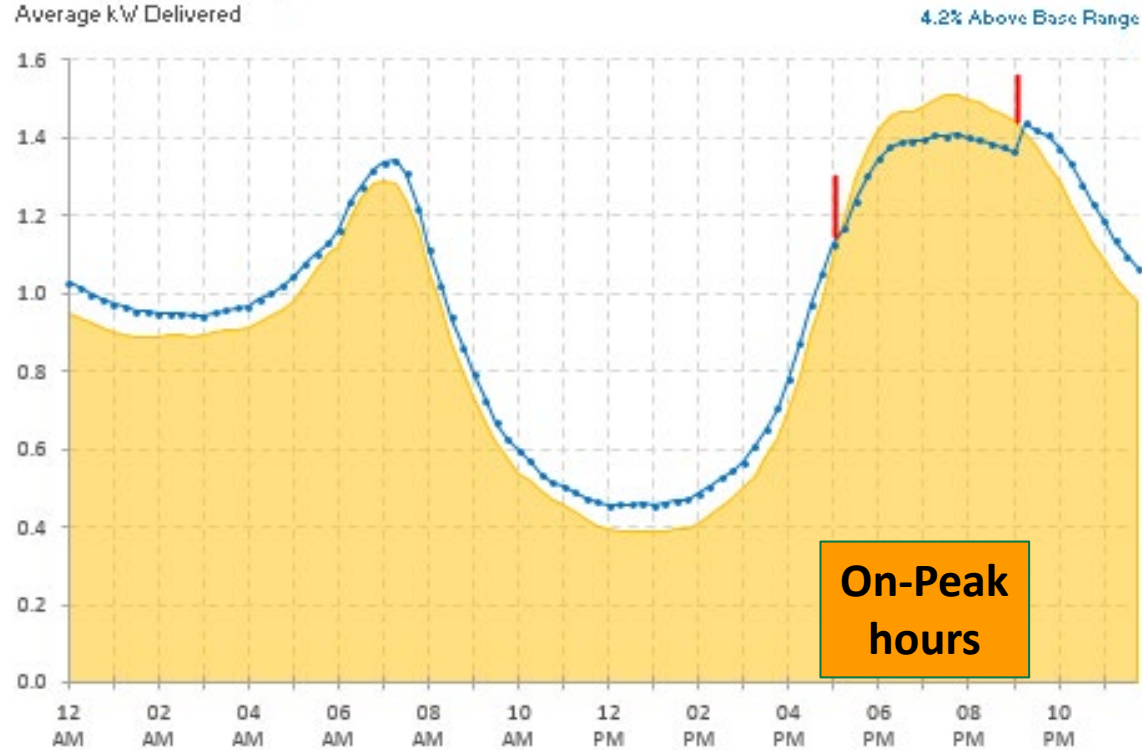


# Indications of Residential solar response:

Solar customers shift load away from peak periods

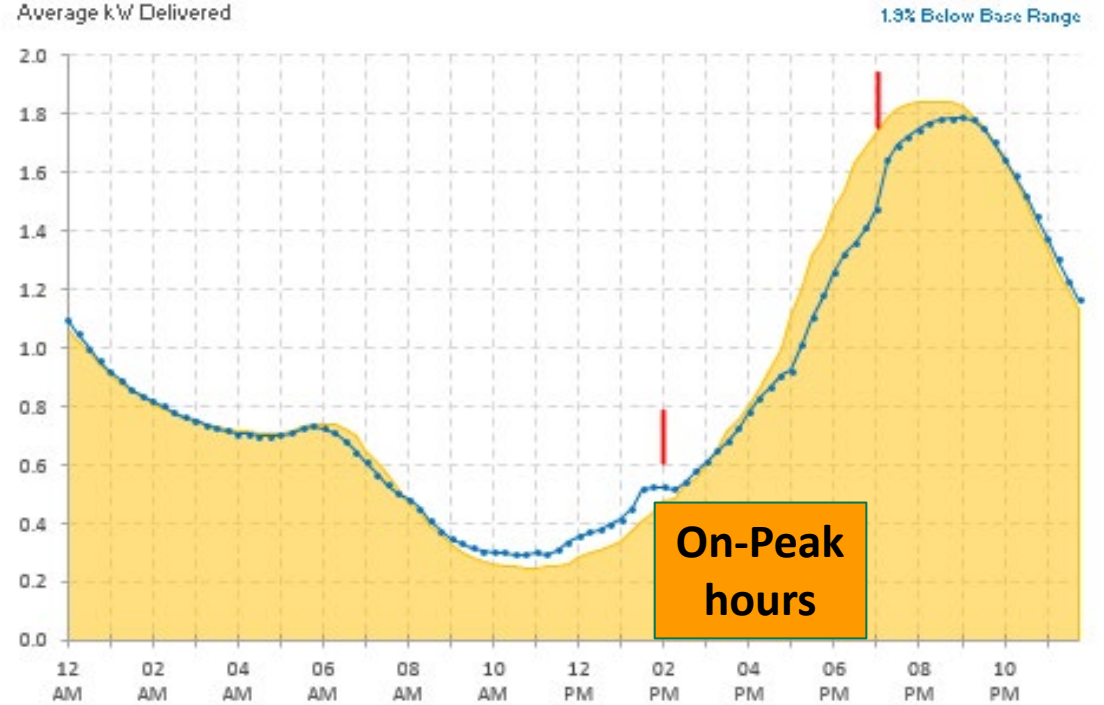
## Winter weekdays

Electricity Demand | Winter  
Average kW Delivered



## Summer weekdays

Electricity Demand | Summer  
Average kW Delivered



# Observation: Battery owners reserve capacity

- Battery owners may not exercise storage resources in response to price signals
- Battery owners may reserve their battery capacity for several reasons:
  - Reliability
  - Minimize degradation due to battery cycling
  - Belief in a no-discharge-to-grid constraint
  - Technical limits of battery management controller
  - Lack of knowledge or consideration of option to operate a TOD strategy



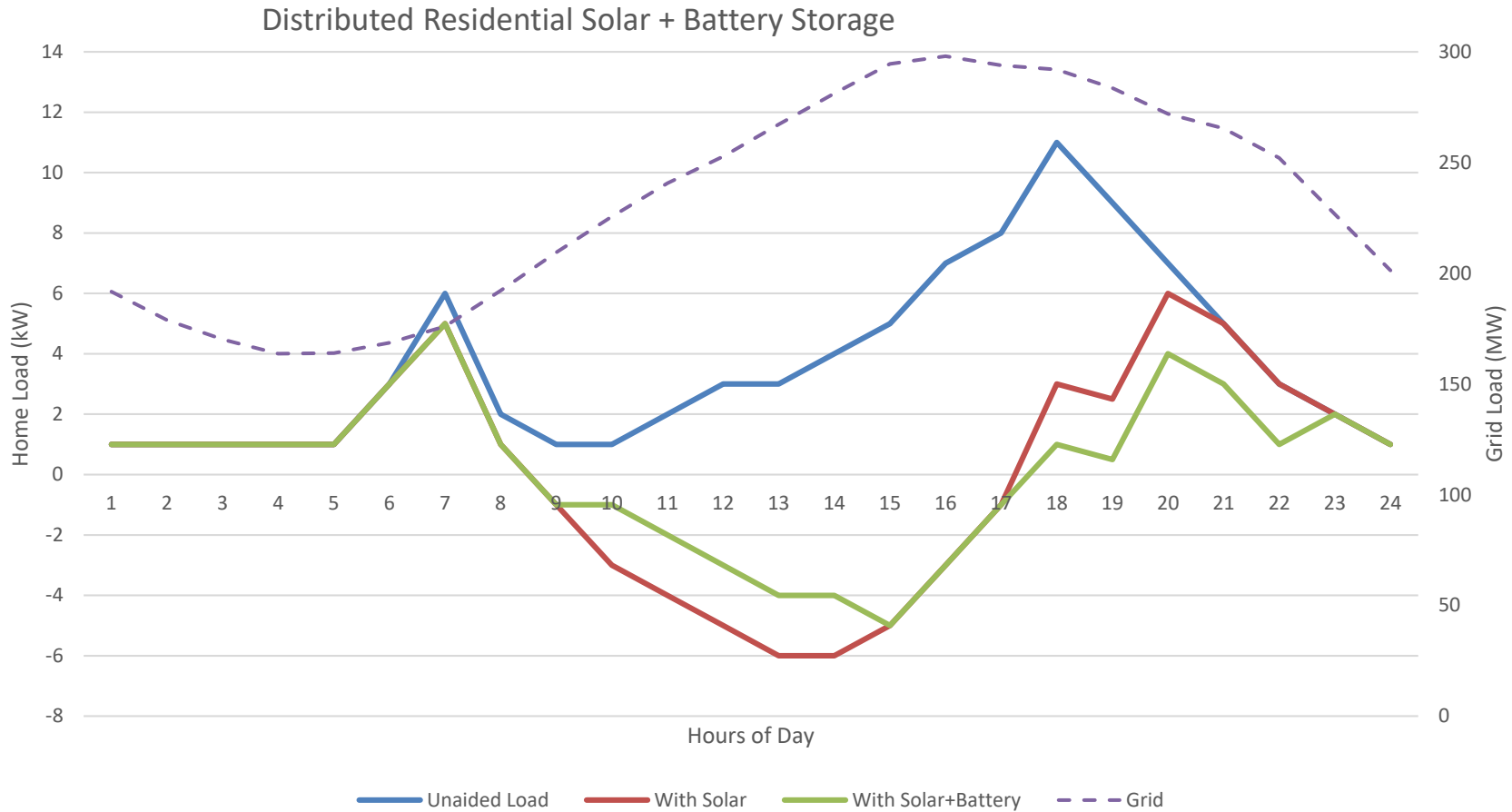
# Observation: Battery owners display a variety of battery control programs

- Battery management controller programs observed:
  - Solar storage (minimize grid purchase/discharge)
  - Load following: during on-peak or all hours
  - Optimize rate arbitrage

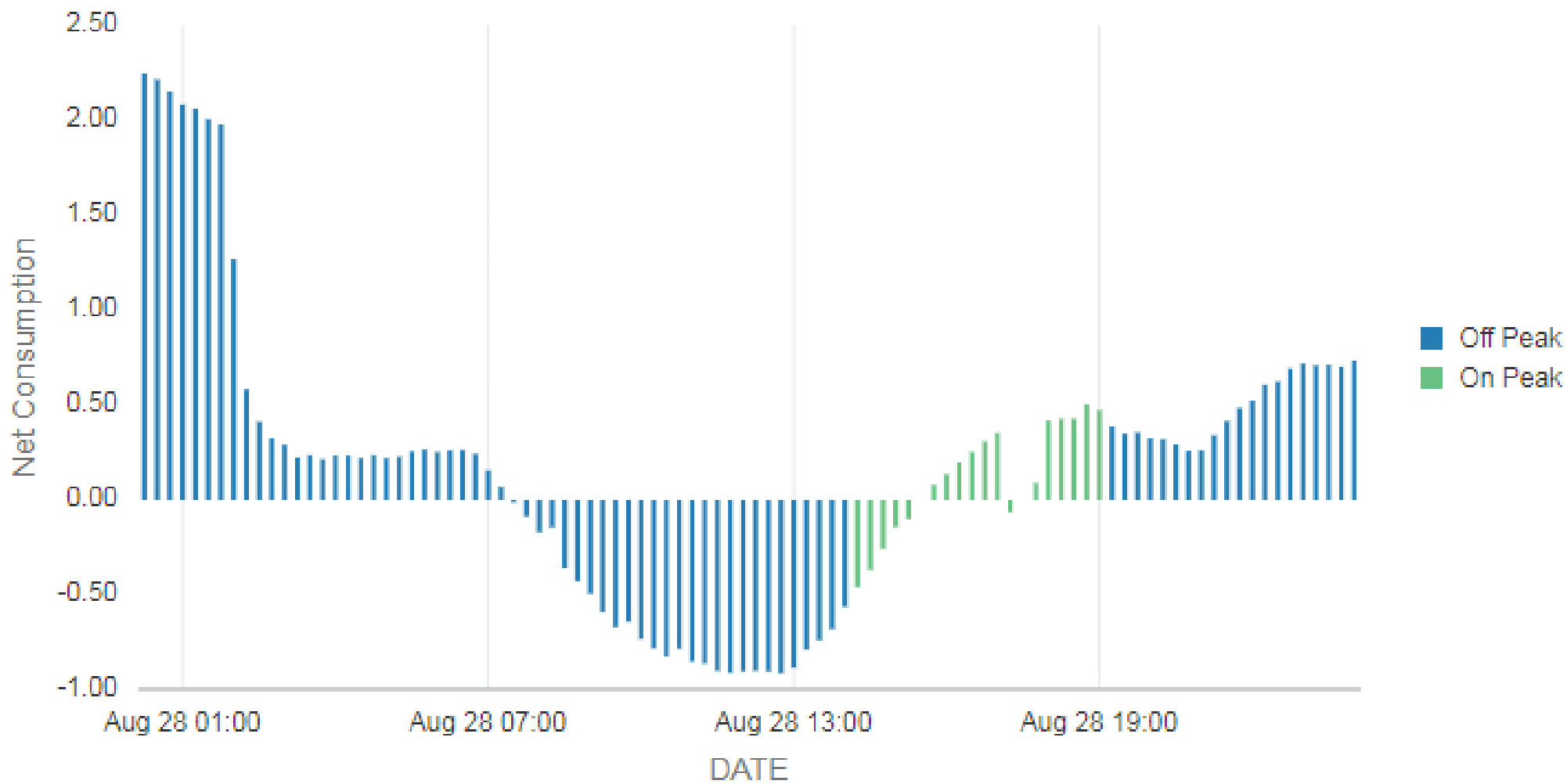


# Example residential net load curve

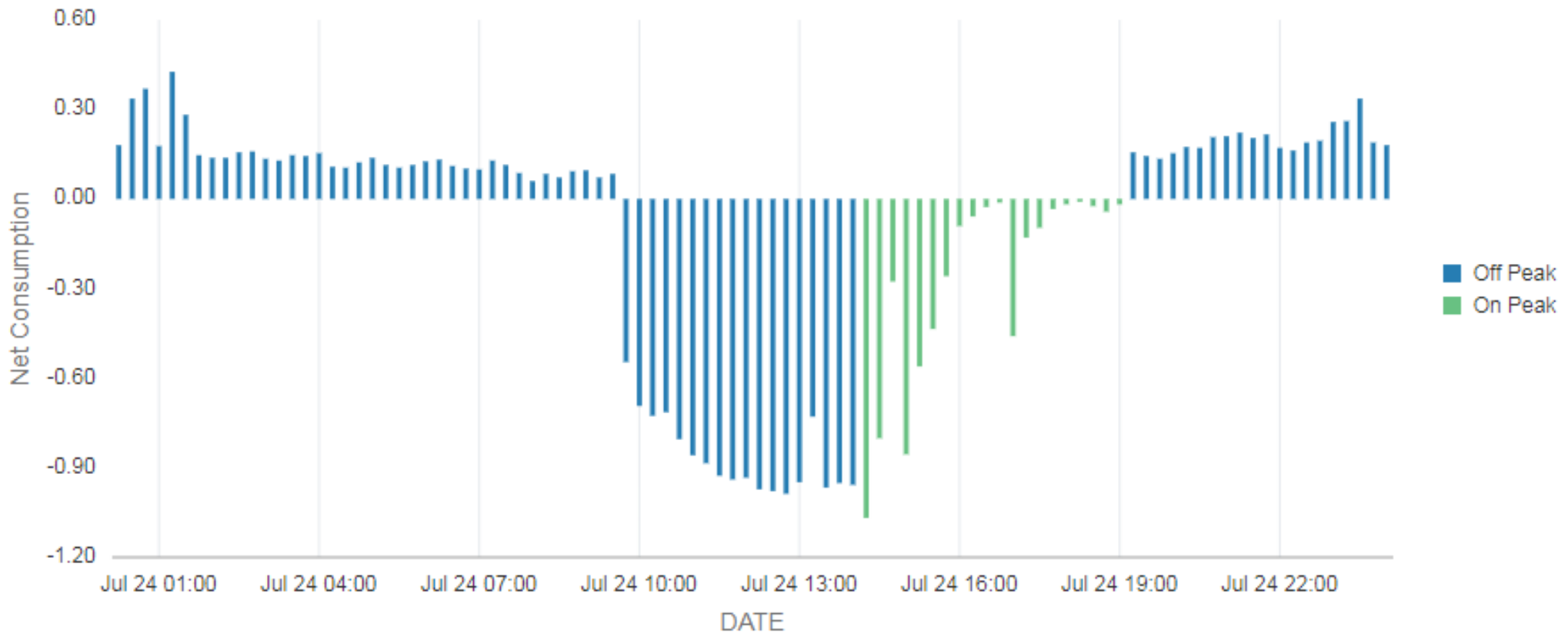
(Not responsive to Time of Day rates)



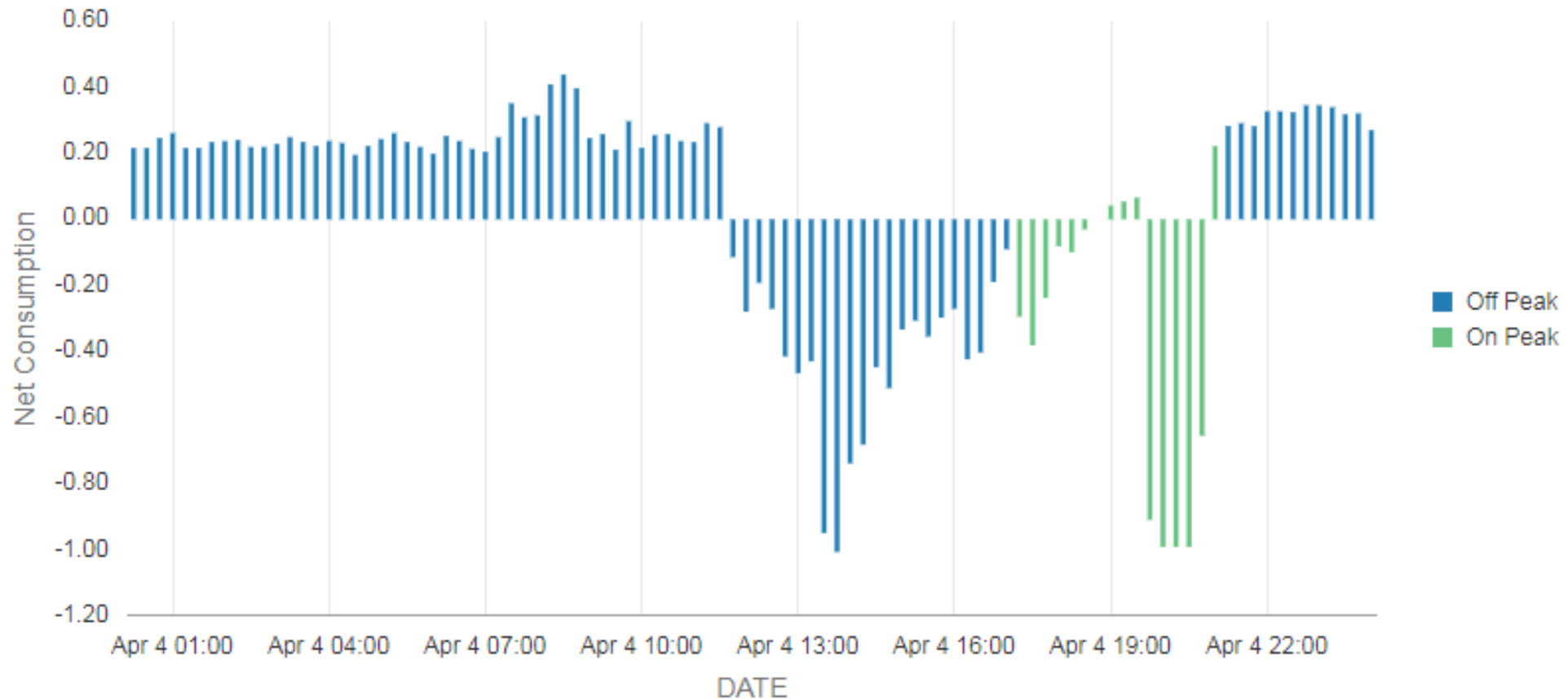
# Solar only net load



# Solar+battery, battery power reserved

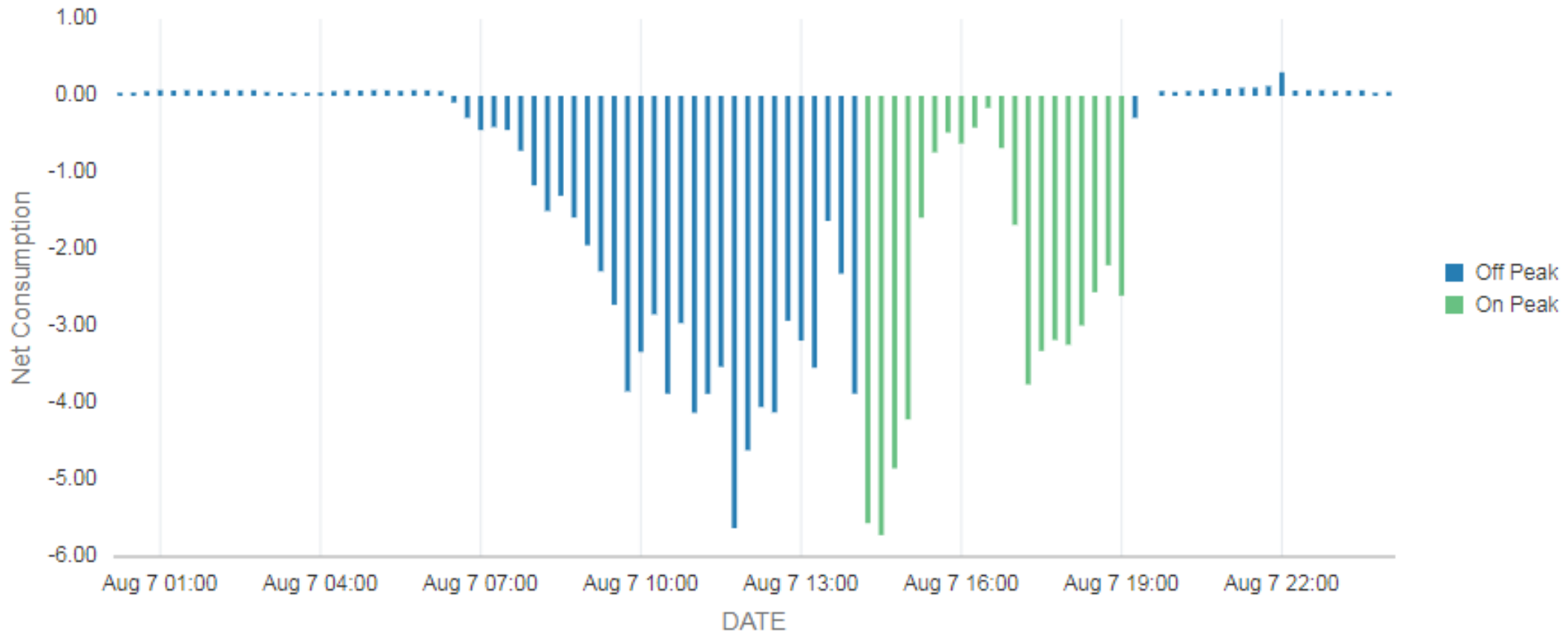


# Solar+battery – battery exercised in peak period

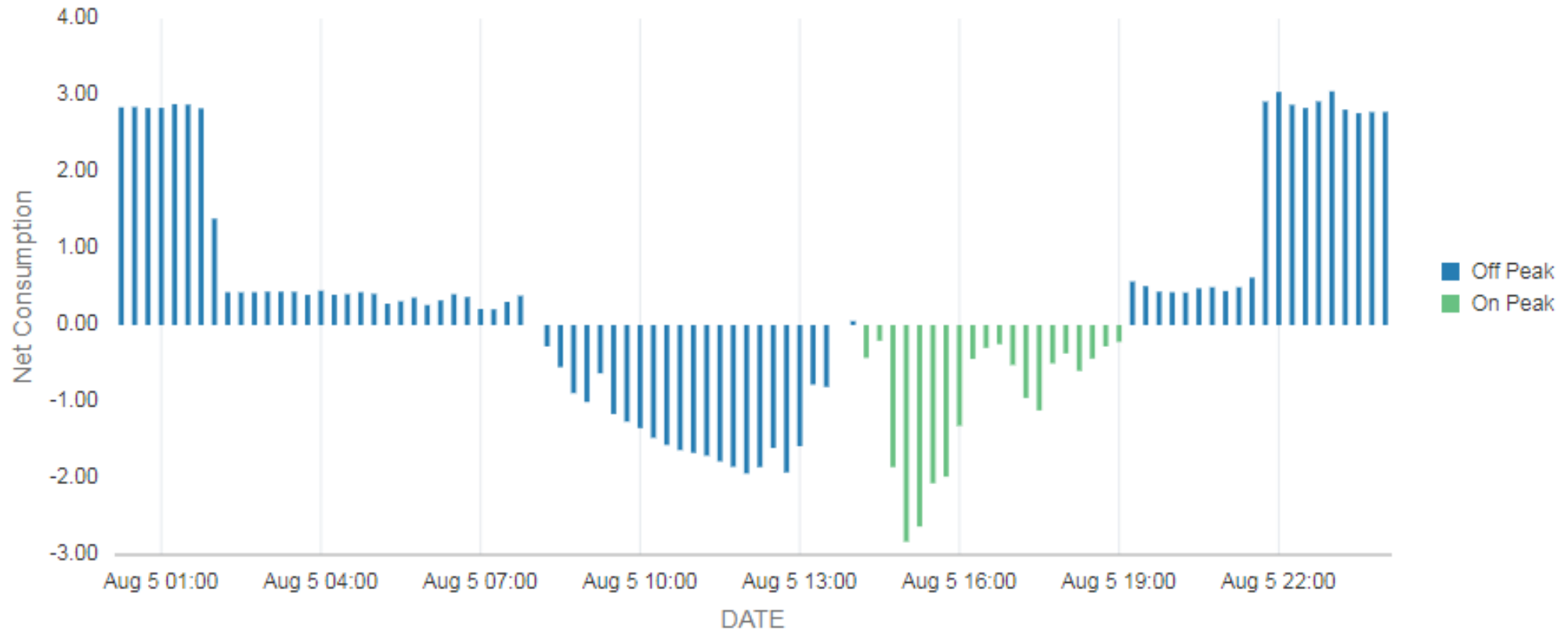




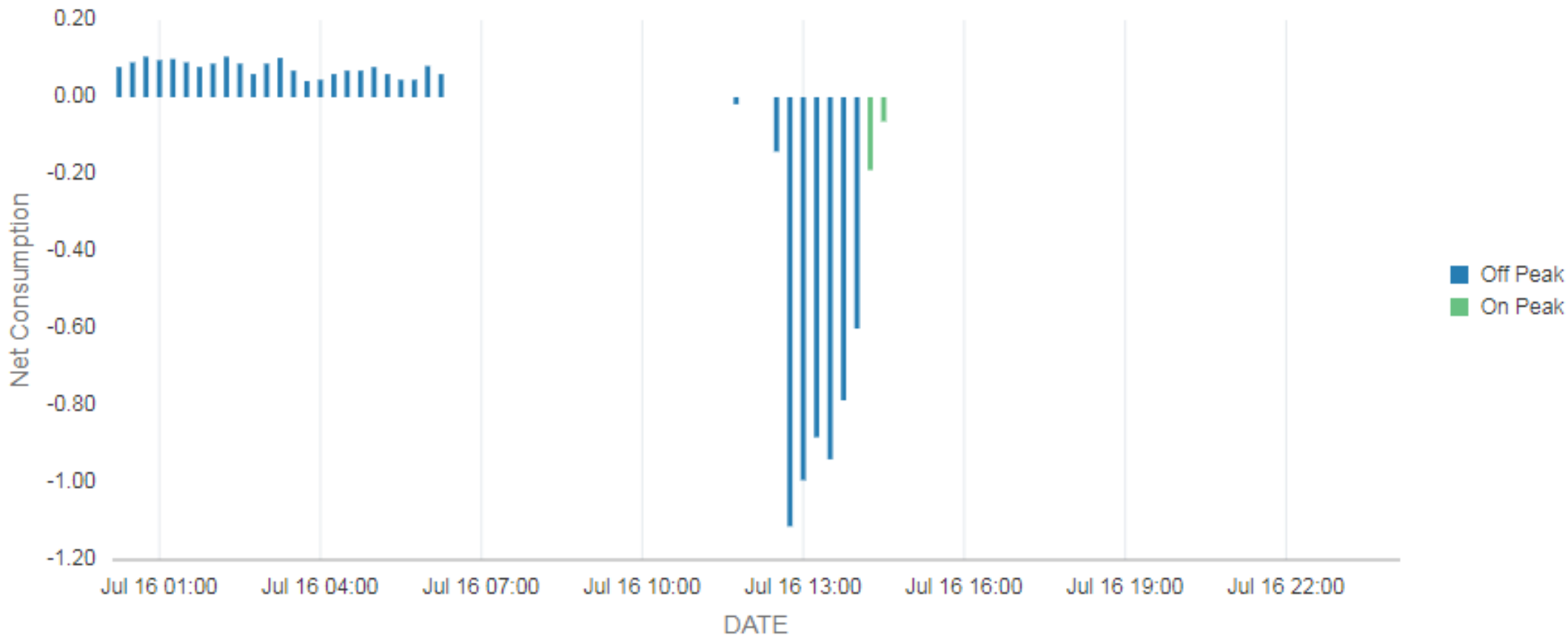
# Solar+battery minimal purchase, maximum discharge



# EV, solar+battery



# Solar+battery self-consumption, minimal purchase



# Fort Collins Utilities supports battery storage

- Allow behind-the-meter use and storage
- Allow battery discharge to grid
  - Unrestricted battery size, kWh discharged
- Allow battery-only installations
  - Same net metering credit rate as discharge from any renewable resource
- Provide customer support
  - Advice for optimizing use to meet customer objectives
  - Support control programming changes



# Benefits of using battery storage for rate arbitrage

Consumer perspective:

- Storing solar generation for on-premises use
- Avoid on-peak purchases
- Exercise portion of capacity to optimize economics of on-peak discharge

Utilities perspective:

- Reduce city aggregate load during hours likely to be coincident peak

# Closure

- Results are preliminary!
- Customers respond to rate signals
- Additional research to isolate behavioral responses to TOD rate
- Monitor and explore customer uses of energy storage in response to economic signals, education, technical support

# Questions?



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