



# Charging Toward the Future of Flexible Load Management: Xcel Energy's Renewable Battery Connect Evaluation

George Jiang | October 7<sup>th</sup>, 2025



# Evaluation Characteristics

## Novel

- First-of-its-kind evaluation of **residential battery demand response** in Colorado

## Comprehensive

- **Randomized control trial (RCT)** and **difference-in-differences (DiD)** for robust impact estimates
- Incorporates participant feedback

## Actionable

- Provides **data-driven insights** for utilities, regulators, and DER aggregators

# The Big Picture



## Grid Reliability

Batteries help manage peak demand and evening ramp



## Renewable integration

Supports higher solar penetration without stressing the grid



## Participant Satisfaction

Delivers benefits without sacrificing comfort or requiring behavior changes



## Future Innovation

Lessons inform Virtual Power Plant design and DERMS integration at scale

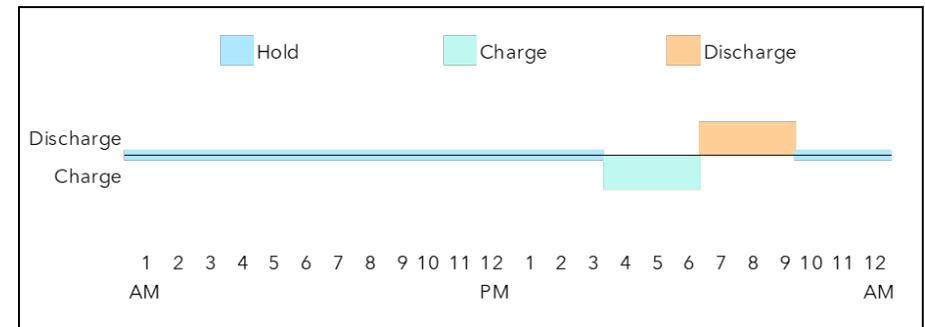
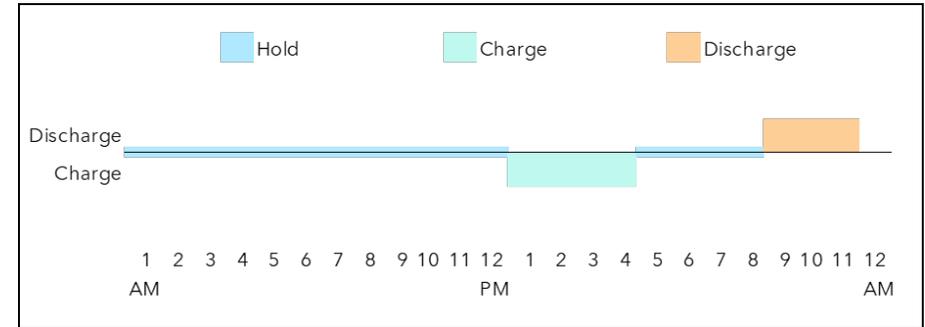
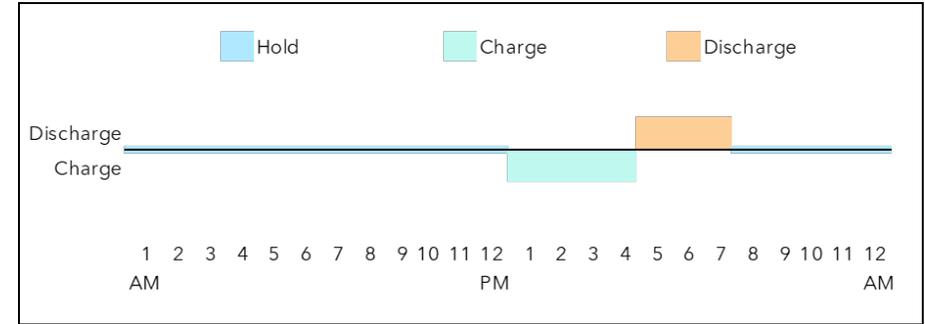
# Renewable Battery Connect Design

|                                       |   |
|---------------------------------------|---|
|                                       |   |
| <b>Impetus</b>                        | Renewable Energy Plan: <b>10 MW of total battery storage by year end 2025</b>   |
| <b>Eligibility</b>                    | New Residential/Small Business battery installations paired with on-site solar in Xcel Energy CO territory  |
| <b>Upfront Incentive</b>              | \$350 per kW max continuous discharge power, capped at \$5,000 (IQ/DIC: \$800 per kW, up to 75% of the equipment-only cost)   |
| <b>Annual Participation Incentive</b> | \$100 annually  |
| <b>Program Term</b>                   | 5-year term (Renewable Battery Connect Agreement)   |
| <b>Events</b>                         | Up to <b>60 events annually</b> , year-round (excluding holidays and weather events)  |
| <b>Duration</b>                       | <b>3-hour</b> dispatch using up to <b>60%</b> of the nameplate storage capacity kWh   |
| <b>Program Info</b>                   | <a href="mailto:BatteryConnect@xcelenergy.com">BatteryConnect@xcelenergy.com</a>   <a href="#">Battery Connect</a>   <a href="#">Renewable Energy</a>   <a href="#">Xcel Energy</a> |

# Battery Pilot Use Cases

- Use cases inform event timing and duration

| Use Case                      | Hold                        | Charge    | Discharge | Notes  |
|-------------------------------|-----------------------------|-----------|-----------|--|
| <b>Peak Period Grid Usage</b> | 12 AM - 12 PM, 7 PM - 12 AM | 12 - 4 PM | 4 - 7 PM  | Align discharge with system peak demand      |
| <b>24-Hour Grid Usage</b>     | 12 AM - 12 PM, 4 - 8 PM     | 12 - 4 PM | 8 - 11 PM | Minimize grid usage across the entire day    |
| <b>Reducing Grid Ramp Up</b>  | 12 AM - 3 PM, 9 PM - 12 AM  | 3 - 6 PM  | 6 - 9 PM  | Reduce grid ramp-up as solar output declines |



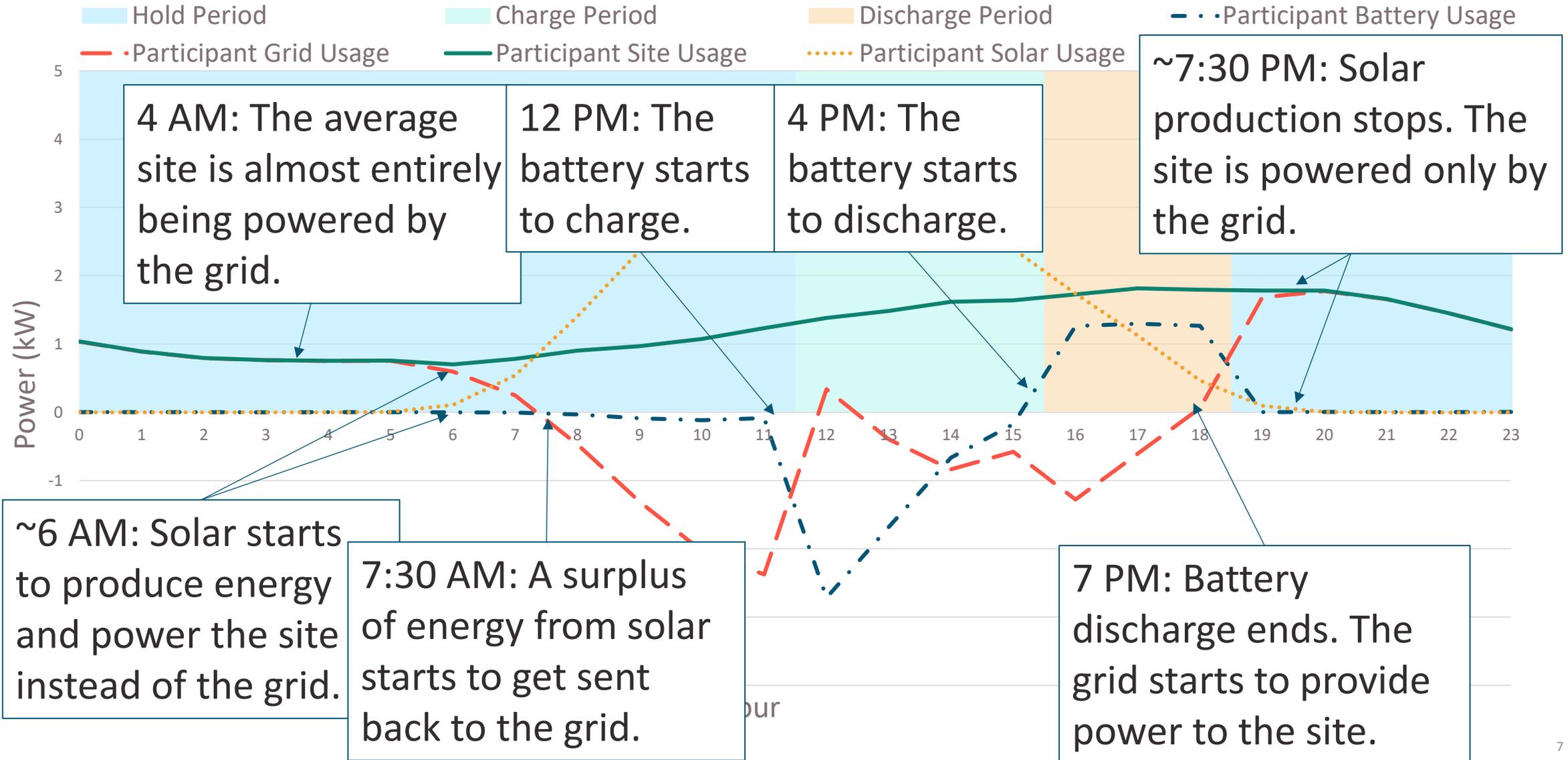
# Research Methodology

- **Randomized Control Trial (RCT)**
  - Participants randomly assigned to **treatment and control groups**
  - During event days, only treatment groups received the event signals
  - Alternating groups throughout season
- **Difference-in-Differences (DiD)**
  - Adjusts for **pre-existing differences** between treatment and control groups
  - Compares **change in usage** from non-event to event days across both groups
  - Produces incremental load and bill impact estimates at hourly level

# Data Sources

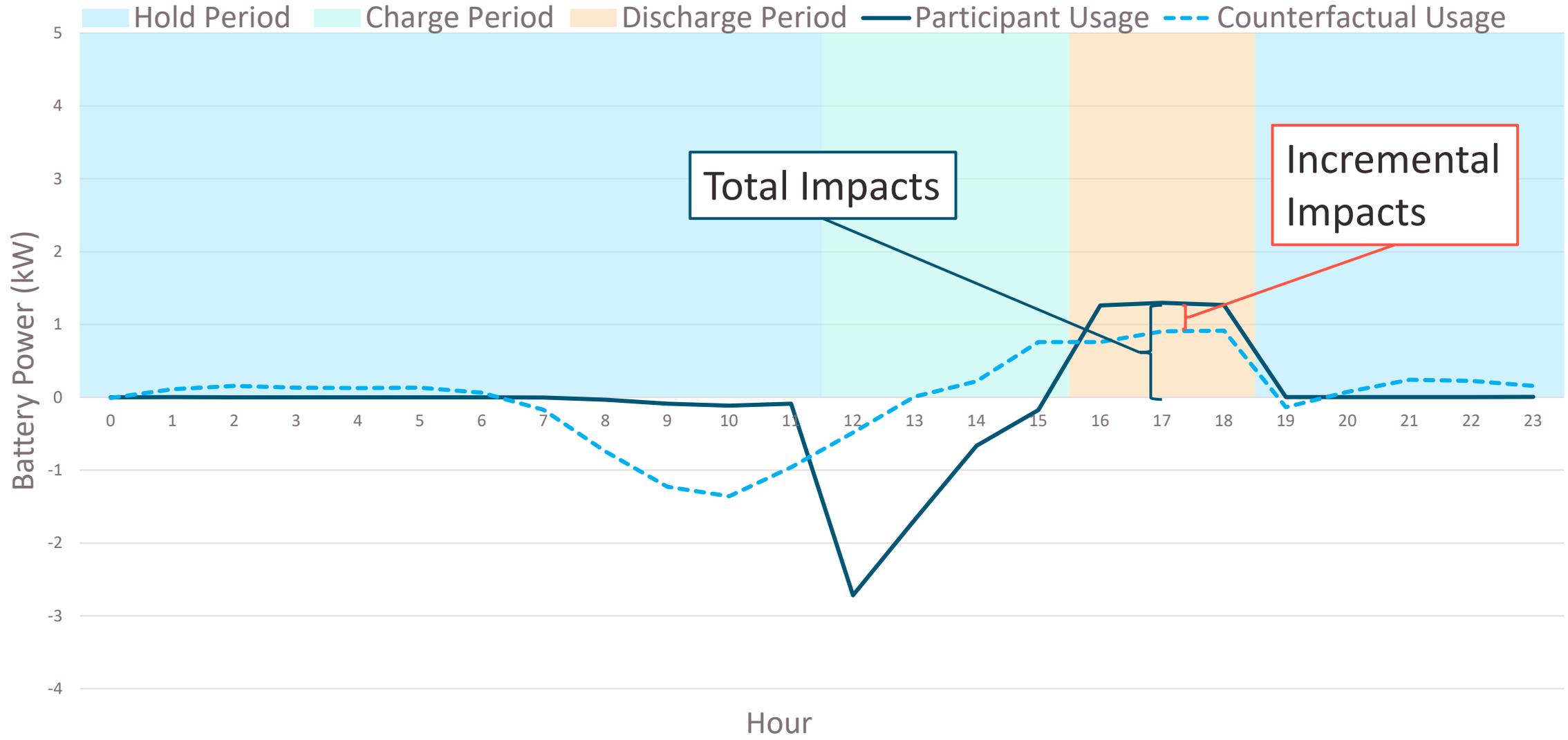
- **15-minute telemetry** from Tesla Powerwalls
  - Grid, battery, and solar flows
- **Event-level data**
  - 26 events across the 2024 summer season (Jun-Sep)
- **Customer characteristics:**
  - Billing rate, group assignment
- **Participant contact information:**
  - Post-event customer survey to assess satisfaction and engagement

# Example of Event Day Data

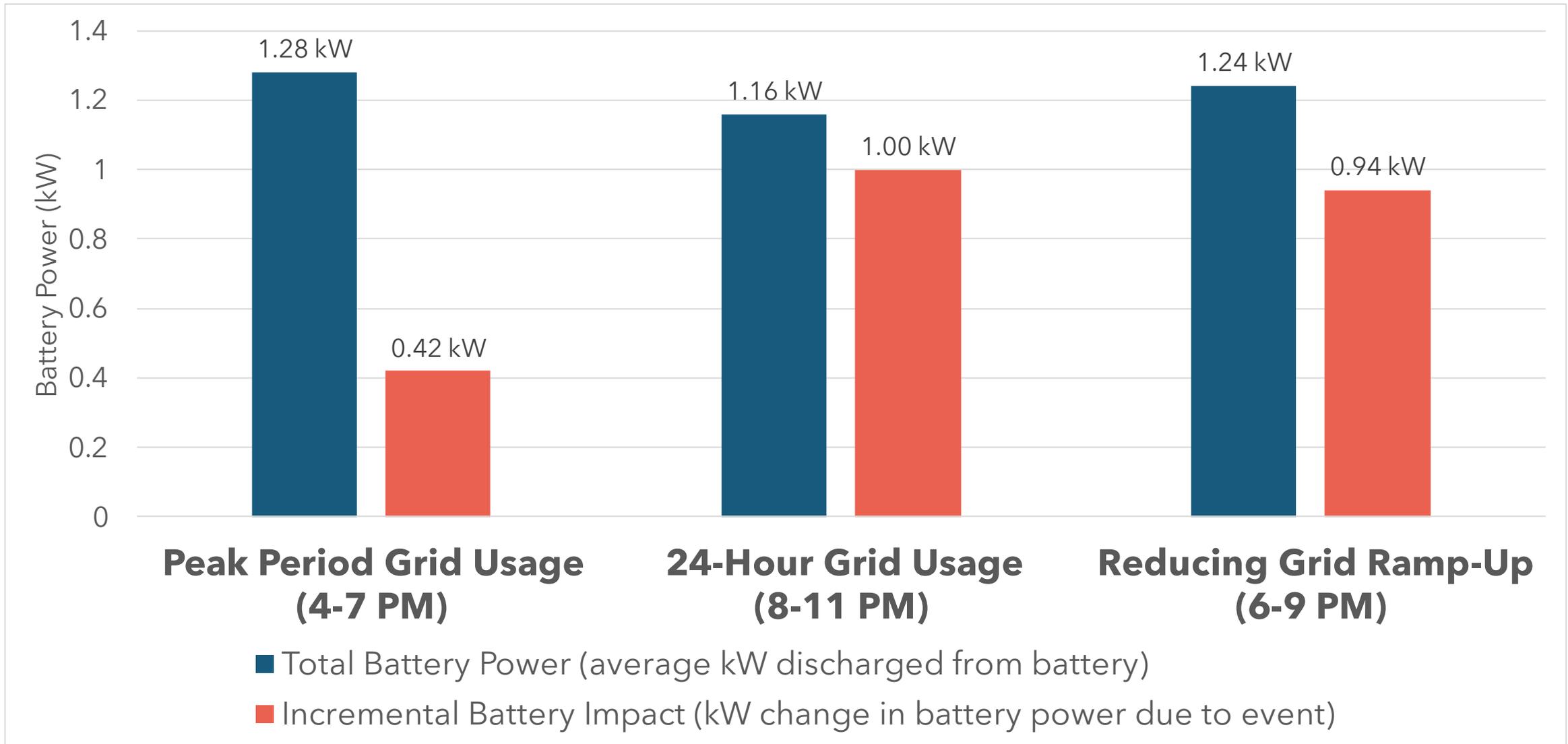


# Event Day Impacts Estimation

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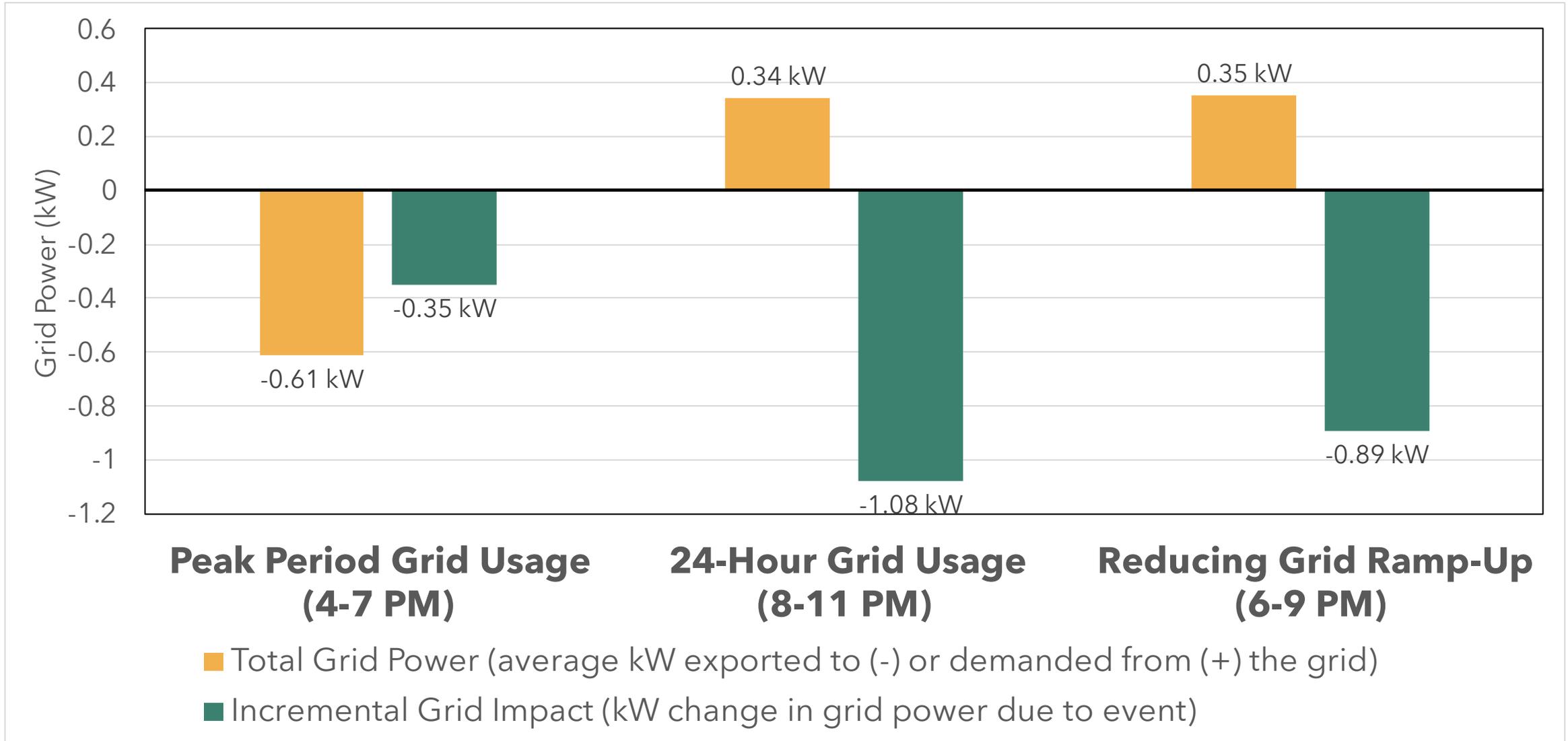


# Battery Impacts During Discharge Events



# Grid Impacts During Discharge Events

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# Customer Experience

## Bill Impacts

- RBC participants experienced average bill increases ranging from **\$0.27 to \$0.61 during each event day**
- This increase was higher for TOU participants (\$0.35 to \$0.87)
- Bill impacts on event days under new 2025 TOU rates would be smaller

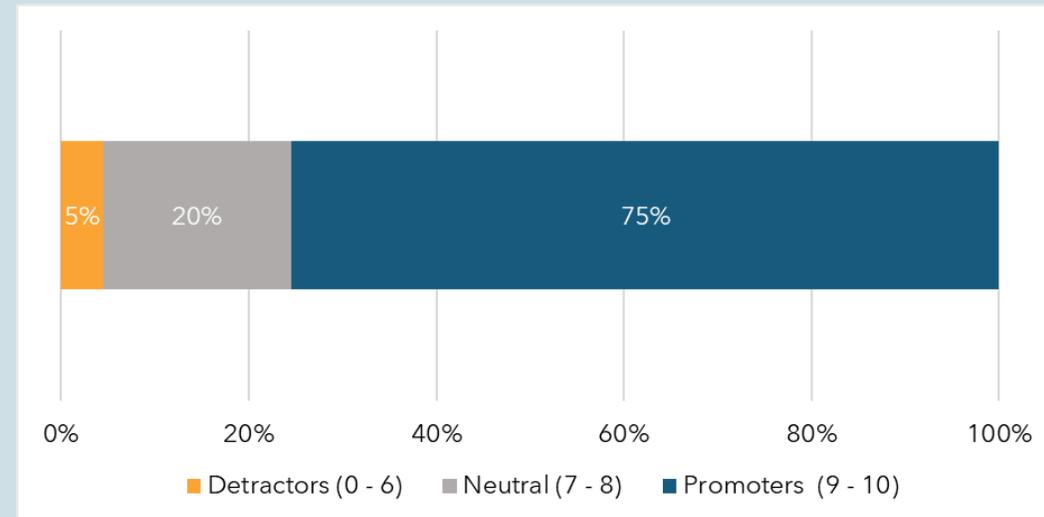


## Enrollment Motivation

- Most respondents (82%) reported that **financial incentives** motivated them to enroll
- Other motivations, such as helping the environment (47%) and improving grid reliability (39%), were also noted



## Net Promoter Score = 70



# Learnings and Considerations

1

## Event Timing

**Learning:** Overlap with TOU self-dispatch reduces incremental benefit of RBC events

**Consideration:** Schedule RBC events outside typical TOU discharge windows to maximize additional grid value, considering locational constraints

2

## Battery Reserve Requirement

**Learning :** 40% reserve limited discharge depth during RBC events

**Consideration:** Lower reserve thresholds (20-30%) could improve grid and bill impacts and still maintain backup reliability

# Learnings and Considerations

3

## Customer Engagement

**Learning:** RBC participants are satisfied, engaged, and motivated by financial incentives and societal benefits

**Consideration:** Xcel Energy should clearly state the financial incentives for participation while also highlighting the environmental and societal benefits of the program

4

## Program Design

**Learning :** Current incentive model drives enrollment but may not sustain long-term engagement and scalability

**Consideration:** Transition to pay-for-performance and integrate with DERMS for real-time, locational dispatch

## Next Steps

- DERMS integration and deployment
  - Recently completed
- Transition to a Pay-for-Performance model
  - Progressing toward a Virtual Power Plant (VPP) tariff structure
- Locational dispatch for constrained feeders
  - Focused on summer, winter, and dual-peaking feeders



Thank You!

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