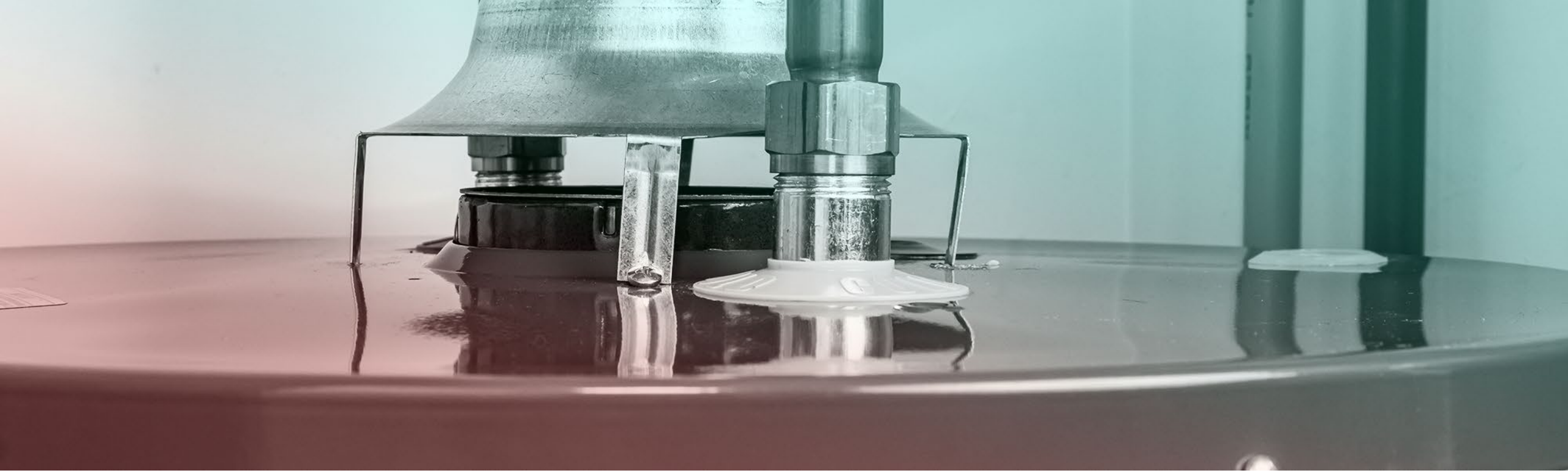
ILLUME



Water Heater Demand Response:

Comparing Full Replacement and After-Market Controllers

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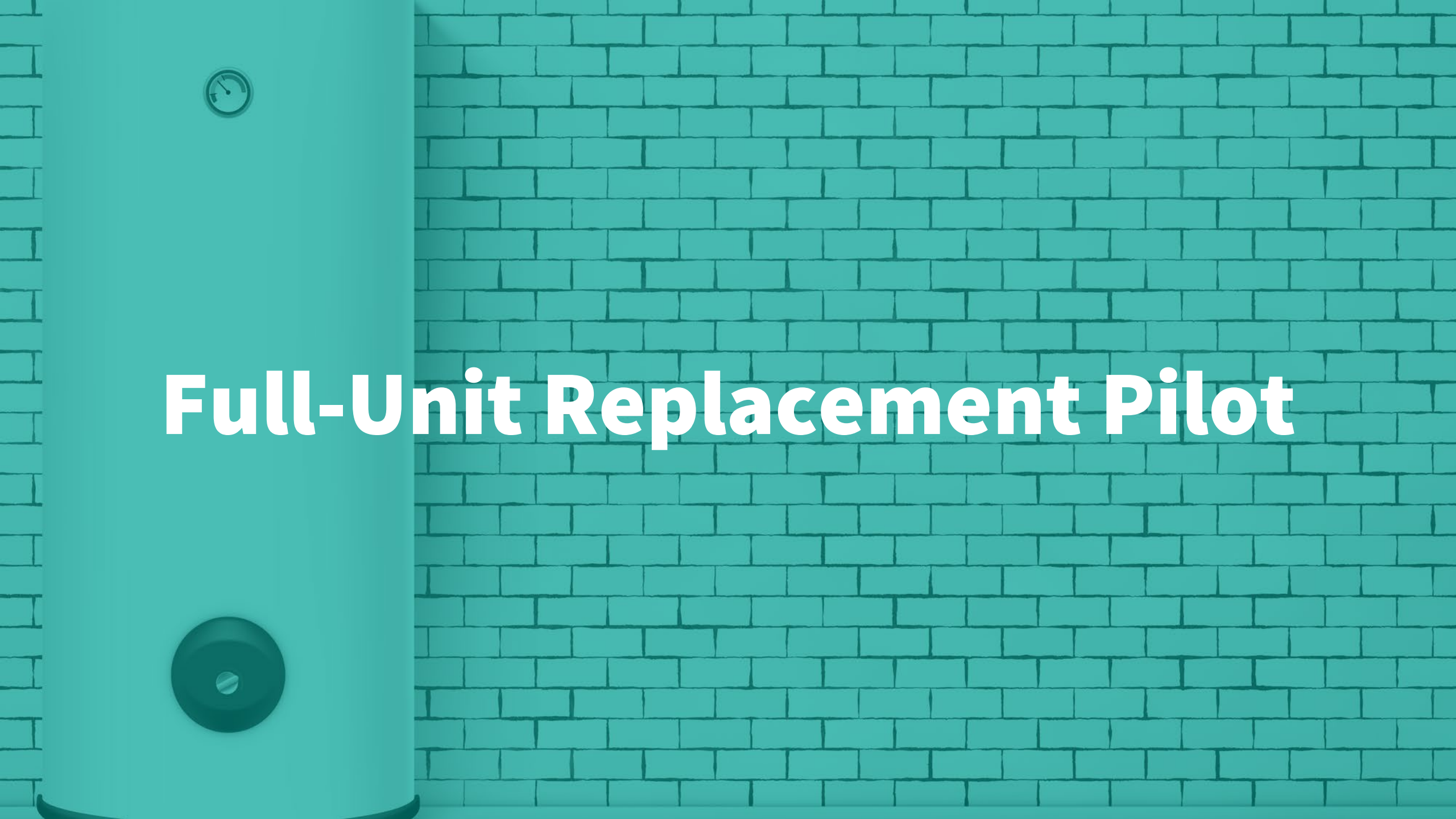
Pace Goodman, Marilla Yaggie, Leith Nye

IEPEC - November 2022

Introduction



Full-Unit Replacement Pilot

Pilot Design

Recruitment & screening:

- Single family home
- 5+ year old WH
- Wi-Fi
- Adequate space to install HPWH

Installation:

- Professional installation from electricians
- Plumbers
- 70 Heat Pump
- 30 Electric Resistance

DR Events

- 5 Winter events
- 5 Summer events
- Post-event surveys

Impact analysis

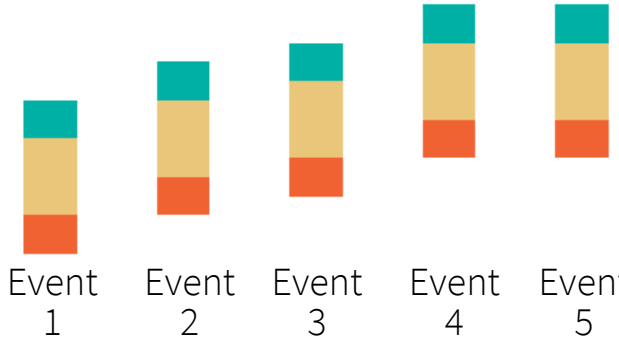
- Within subject baseline modeling

Event Strategy

WINTER

Morning

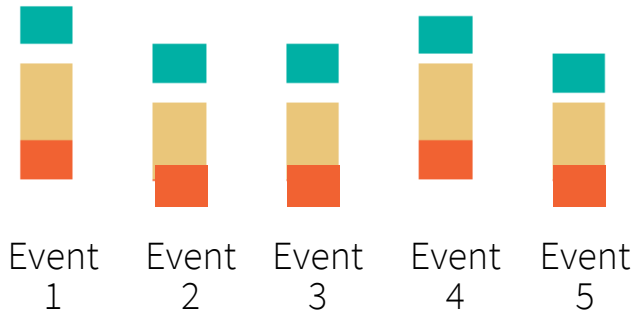
4:00 a.m.
6:00 a.m.
8:00 a.m.
10:00 a.m.



SUMMER

Afternoon

2:00 p.m.
4:00 p.m.
6:00 p.m.
8:00 p.m.



Load Shift Load Shed Post-Event

Lessons Learned →
Phase 2 Planning and Results

COVID Challenges

Phase 2 Pilot delayed:

- Securing installers
- Implementing COVID safety measures
- Robust early response, but then dropped off due to delays

Eligibility and Connectivity

Phase 1 Lessons Learned

Space constraints disqualified some interested customers .

Connectivity affected demand impacts: 15% had trouble connecting to water heater to Wi-Fi.

Connectivity issues may have diminished load shed kW impacts by as much as 25% during the winter and 10% during the summer.

Phase 2 Pilot Approach

After market controllers have fewer space limitations.

Testing two communication protocols – Wi-Fi and cell signal.

Electric resistance water heaters.

Phase 2 Winter Result

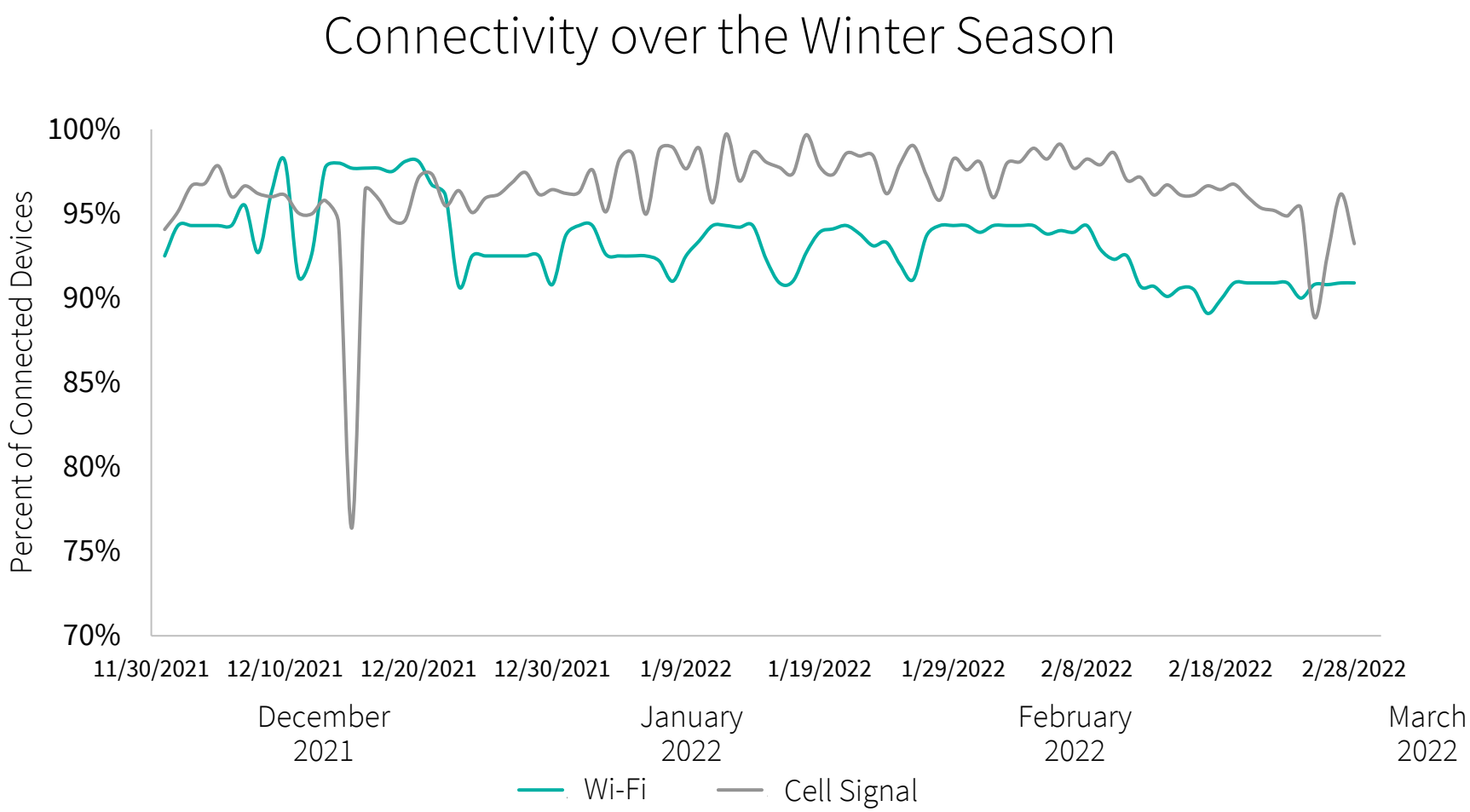
33% receiving Wi-Fi controller had difficulty connecting; 17% receiving controller that uses cell signal had difficulty connecting.

Slight difference by device type in maintaining connection:

Cell signal: 97%

Wi-Fi: 93%

Phase 2 Winter Connectivity



Cost and Resources

Phase 1 Lessons Learned

Pilot sponsor invested time and resources:

- Screened prospective participants.
- Provided professional installation including electrical and plumbing.
- Customers reported installation took 2 to 6 hours to complete.

Phase 2 Pilot Approach

Pilot sponsor:

- Maintained screening process.
- Provided professional installation.

Phase 2 Winter Result

Customers report that most installations took 1 visit.

50% took less than 30 minutes.

40% took 30 to 60 minutes.

Customer Experience

Phase 1 Lesson Learned

Participants generally highly satisfied:

- Few issues reported or routines disrupted
- 94% satisfied/ 2% neutral about unit
- Neither advance notice nor pre-heating affected customer experience

Phase 2 Pilot Approach

Conducted similar number of winter and summer events

No pre-heating

Phase 2 Winter Results

Participants highly satisfied:

- Few routines disrupted
- 76% satisfied/21% neutral with the controller
- About 6% reported an issue with hot water availability

Pre-Notification

Phase 1 Lessons Learned

Customers who received advanced notice did not opt-out prior to the events, but appreciated the notification

Few (<1%) opt-outs, on average

75% would participate again

Phase 2 Pilot Approach

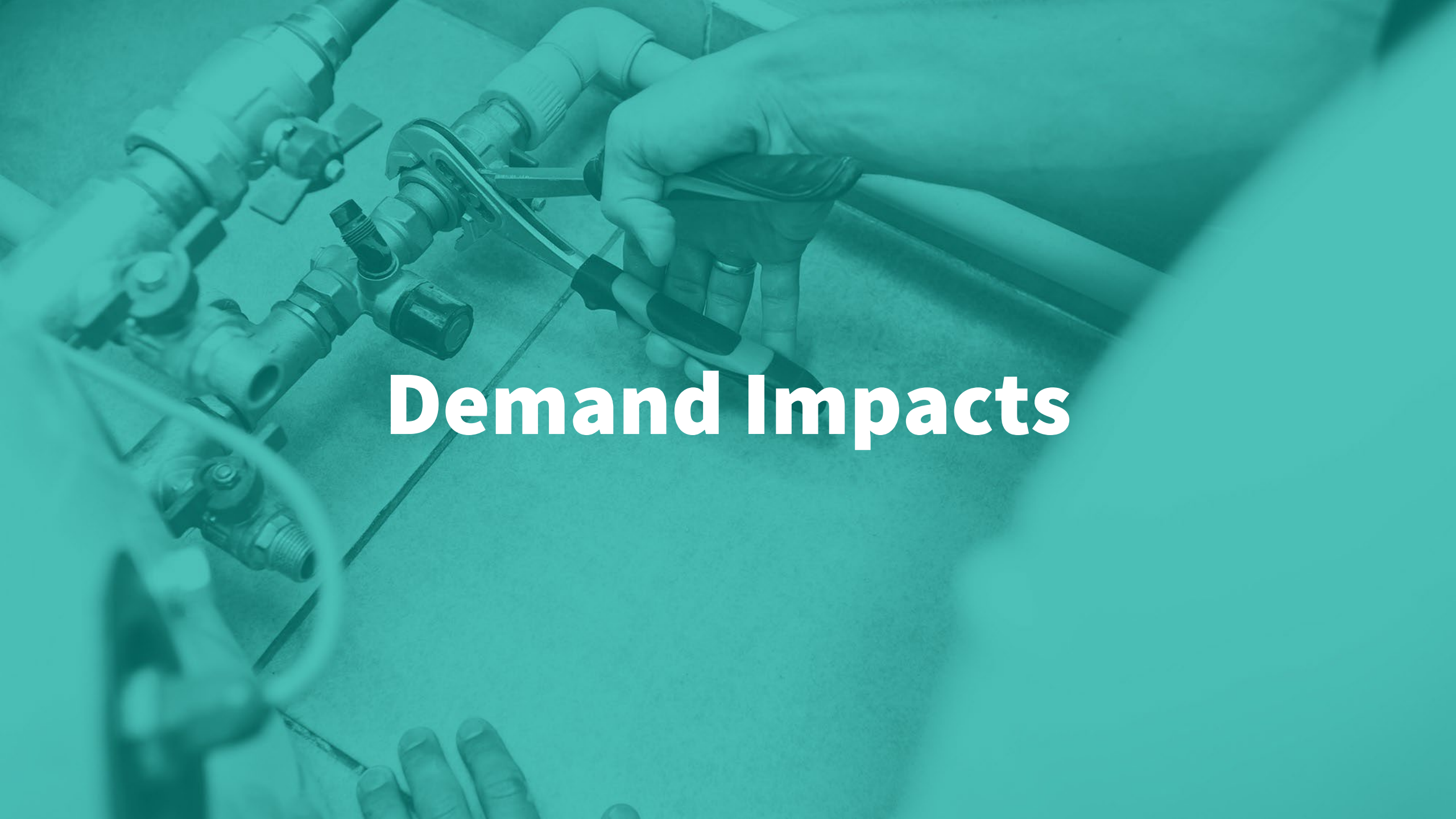
Provided advanced notification of planned events

Phase 2 Winter Results

Nearly all survey respondents recall receiving notification

Few (<3%) opt-outs on average

97% would participate again



Demand Impacts

Demand Impacts

Within Subject Baseline

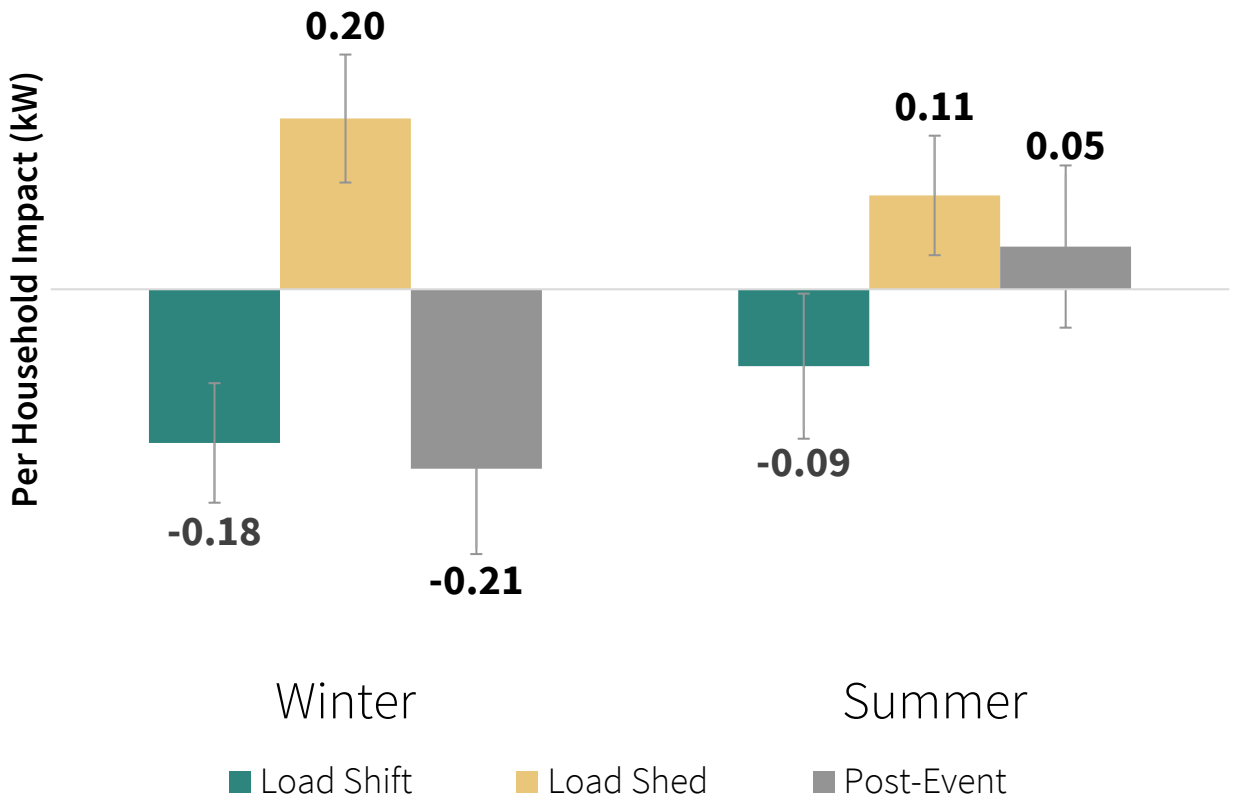
- Within 2 weeks of matching event day
- Not a holiday or weekend
- Not another event or test day

Model

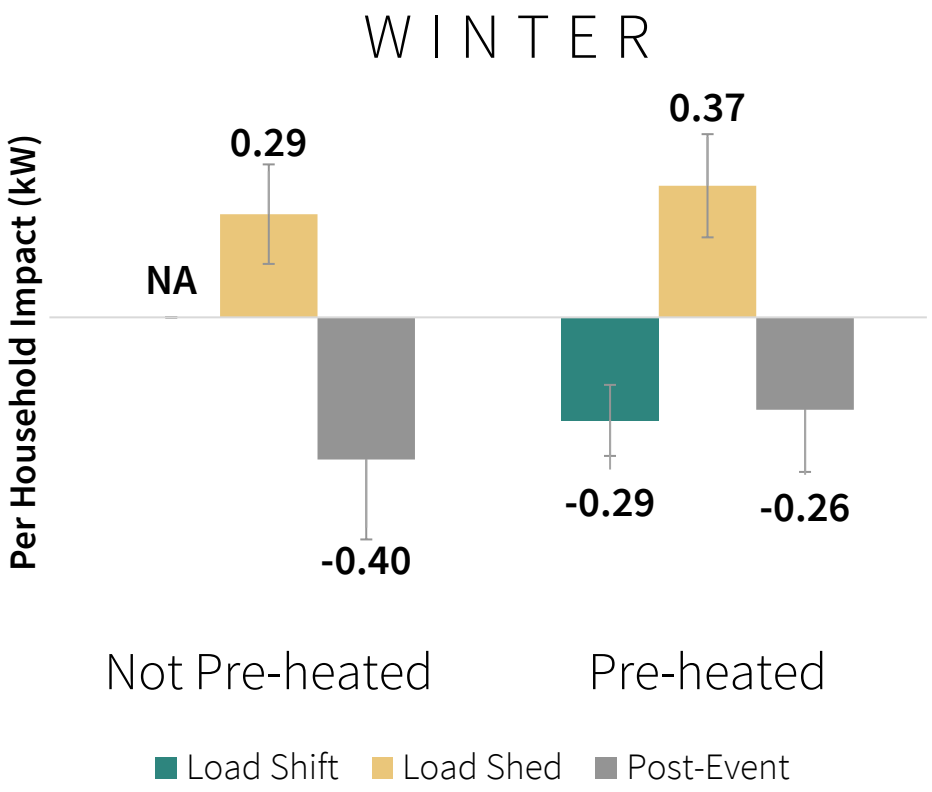
Fixed effects model with:

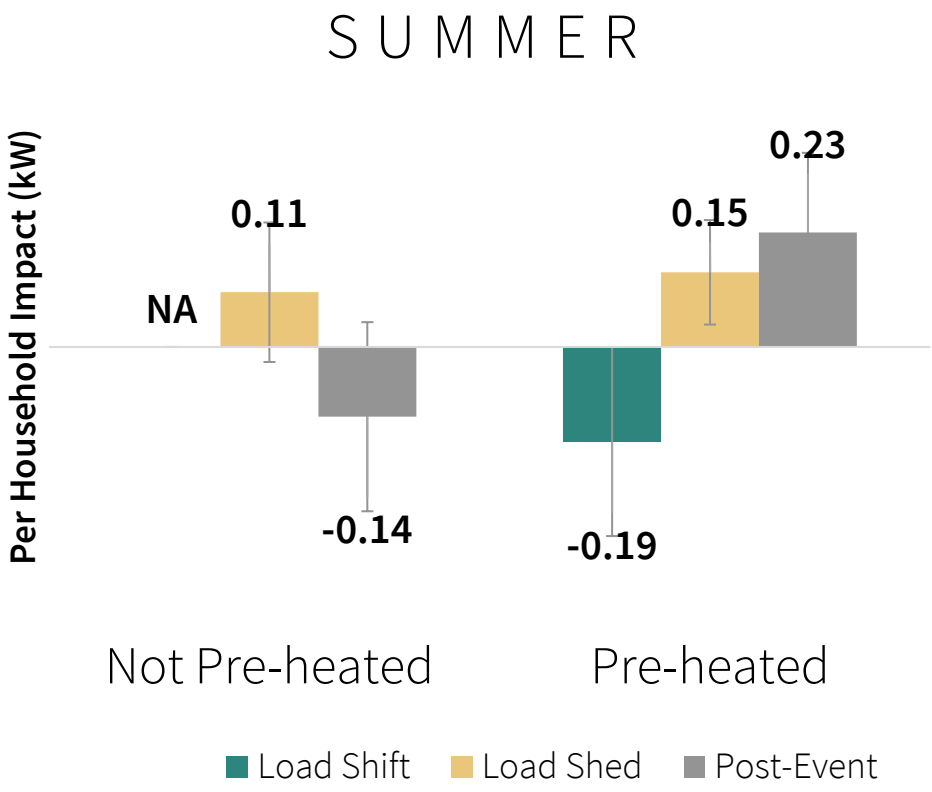
- Heating Degree Hours
- Cooling Degree Hours
- Load Shift, Load Shed, Post-Shed Hours Flags (Phase 1)
- Load Shed flag (Phase 2)

Phase 1: Winter and Summer Impacts

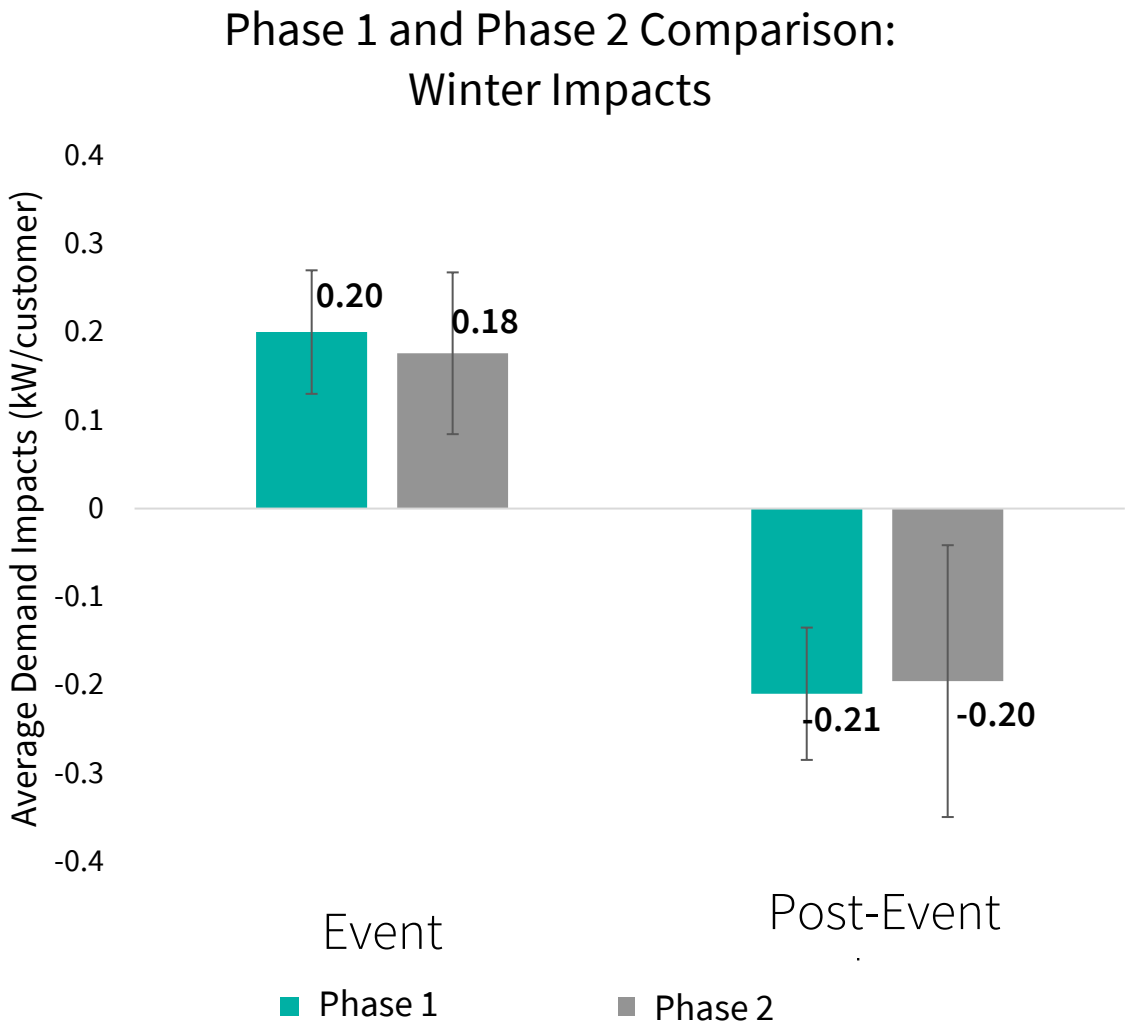


Phase 1: Pre-Heating Impacts





Water Heater DR Pilot Impact Comparison



Next Steps

Conclusions

1. Using lessons learned in one pilot to inform design of the next pays off.

2. Water heater demand reductions are small but pilots had high customer satisfaction.

3. Connectivity continues to be an issue with Wi-Fi and cell networks.

4. Controllers show promise as a more cost-effective option to enable water heater demand response, but is this model scalable? How can utilities interest customers in adding a controller to an appliance they don't think about much.

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