Demand Flexible Line Voltage and Zonal Thermostat Market Scan and Potential Estimate

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cadeo

Project Goals

Understand the existing energy efficiency and demand response (DR) capabilities and future potential of connected line voltage and other zonal thermostats

+ Characterize the current market
+ Identify barriers and opportunities for improving energy savings and DR capabilities
+ Develop an "ideal" connected line voltage thermostat that maximizes energy savings and grid flexibility
+ Recommend **next steps** for advancing the technology and the market

A **line voltage** thermostat:

- ✓ Delivers electricity directly to heaters
- ✓ Typically 120V or 240V

A **low voltage** thermostat:

- ✓ Controls central HVAC systems
- ✓ Typically 12V or 24V

An **infrared thermostat:**

- ✓ Communicates with a mini-split controller, which then controls the mini-split itself

Scope of Work

Literature Review

- Manufacturer websites
- Utility DR program websites and reports
- RTF Measures
- Other existing research

Expert Outreach

- Mysa (leading connected LV thermostat manufacturer)
- Daikin – Leader in DHP controls development
- Larson Energy Research
- AHR attendees

Learnings

- Current market
- Future developments
- Market and technical barriers and opportunities

Technology Review

	Line Voltage Thermostat	Low Voltage Thermostat	Infrared Thermostat (Controller)
Equipment type	Radiant, convection, or resistance heat	Central HVAC system	Mini-split system
Control type	Typically one thermostat per room	Typically one thermostat per system or zone (household)	Technically not a “thermostat”
Communication pathway	Delivers electricity directly to the zonal heating equipment	Delivers electricity to a central HVAC system	Sends control signal to mini-split remote, which controls the equipment

Top LV Thermostat Features

Feature	Energy Savings	Grid Flexibility
Wi-Fi enabling & App Support	Wi-Fi allows for smart home integration; improves accessibility and participation	Wi-Fi required for DR events
Scheduling	Plan reduced usage when away, sleeping, or user not thinking about HVAC	Schedule reduced usage for peak periods; schedule early on to mitigate resident discomfort
Reporting	Review usage to identify when to make smarter HVAC choices	Utilities can track effectiveness of DR events
Geofencing & Zoning	Reduces energy use when residents are not home & in unoccupied rooms	Future use: DR programs can increase energy reduction; opt in certain rooms for DR programs
Multi-equipment optimization	Reduce usage on electrical baseboard when more efficient HVAC also installed	Future use: allows for more flexible DR modes

Top Manufacturers

Confirmed DR Program-Approved LV & IR

mysa

sinopé

Confirmed DR Program-Approved low V

ecobee

sensi
Connect to Comfort

Honeywell Home

Top non-Approved LV & IR Thermostats

king

STELPRO
360 comfort

Gnest

meross

Market Developments

All manufacturers from the previous slide support the features required for DR program approval.

Thermostat Type	Findings
Connected Line Voltage – DR approved	Mysa investing in multi-equipment (baseboard + DHP) optimization, interested in standardized control approaches but waiting for clear demand
Line Voltage – non-DR approved	Did not investigate/contact
Low Voltage DR-approved	All interested in standardized control approaches but waiting for clear demand None interested in adding line voltage/baseboard control as a feature

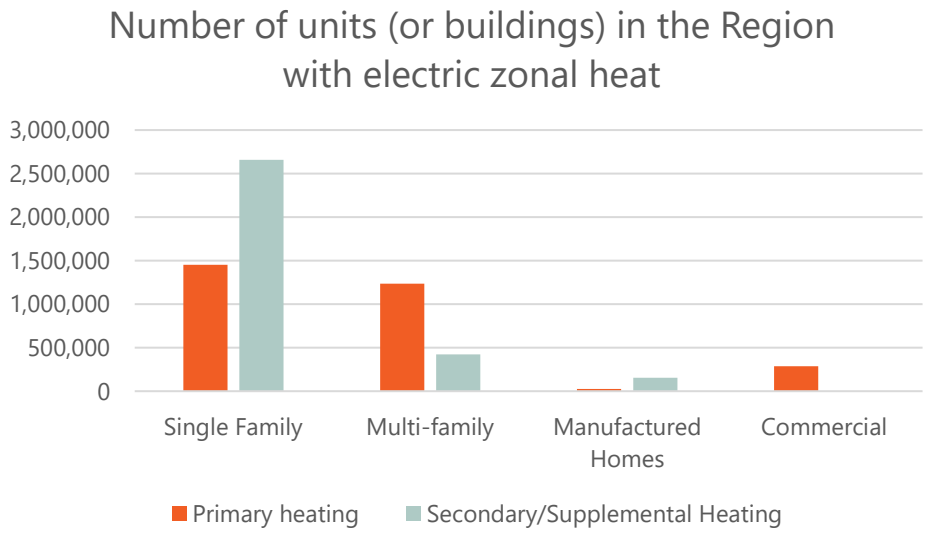
Summary:

Manufacturers are thinking about standardized control approaches but will not invest without discernable market pressure.

Energy Savings and Demand Response Program Opportunities

What's the Potential?

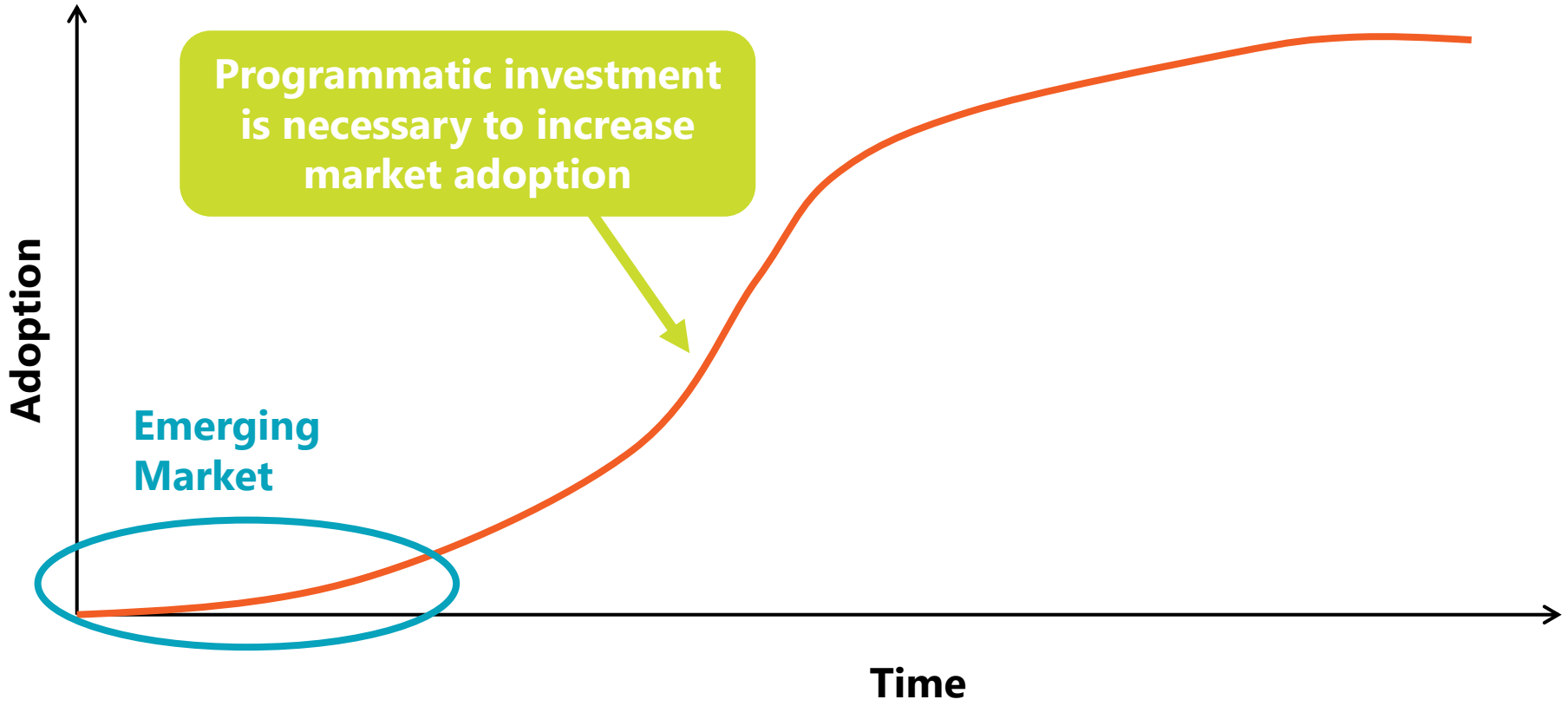
- **Good news** – same as low voltage (long-term)
  - Lots of controllable load
  - Some studies have shown good response-rates (75%)



Barriers:

- Current technology only controls one zone – is this a problem?
- Time and cost are barriers for establishing utility programs – need for standardized control? Is it cost effective?
- Zonal equipment less of a market focus than central HVAC
- Market acceptance of new technology in target markets

Market Adoption



We need more research!

- No robust, publicly available studies available
  - Some limited pilots suggest a range of outcomes
  - NW Power Plan also does not address this technology
- Need to better understand target markets, especially in commercial
  - Understand specific applications, reasonable adoption rates, and barriers to adoption (focus on MF? LI?)
- Need to better understand kW/kWh impacts and cost effectiveness for primary and secondary technologies
  - Need for multi-equipment/zone communication?
  - Standardized communication?

Ideal Thermostat Characteristics

Potential Technology Considerations

- Enhance functionality of top thermostat features
- New features
  - One thermostat controls entire household
  - Open, standardized, and interoperable communication pathway between utility companies and residents

Enhance Top Thermostat Features

Feature	Future Opportunities	Potential Barriers
Wi-Fi enabling & App Support	Internal mesh network or Wi-Fi hotspot functionality	Cost increase; lack of market momentum
Scheduling	Improve early-on functionality and reduce snapback	Low priority for equipment to address snapback
Reporting	Consistent data is shared through aggregator or standard communication protocol	Manufacturers have their own preferences for data sharing
Geofencing & Zoning	Maximize DR response by further reducing temperatures during peak events	Utilities and manufacturers must invest in improving DR communication functionality; Costly; Requires sensor technology in each room; technically complex; market acceptance in target markets
Multi-equipment optimization	More flexible DR response, enhanced energy savings	Costly; technical hurdles such as back-end optimization

One Thermostat per Household

Why it's important:

- Guarantees entire house is enrolled in DR program
- Reduces discrepancies between thermostats & potential take-back
- May improve customer user experience and reduce costs

Barriers

- Difficult installation and calibration
- Less reliable temperature sensing and adjusting
- DR event opt-out impacts entire household

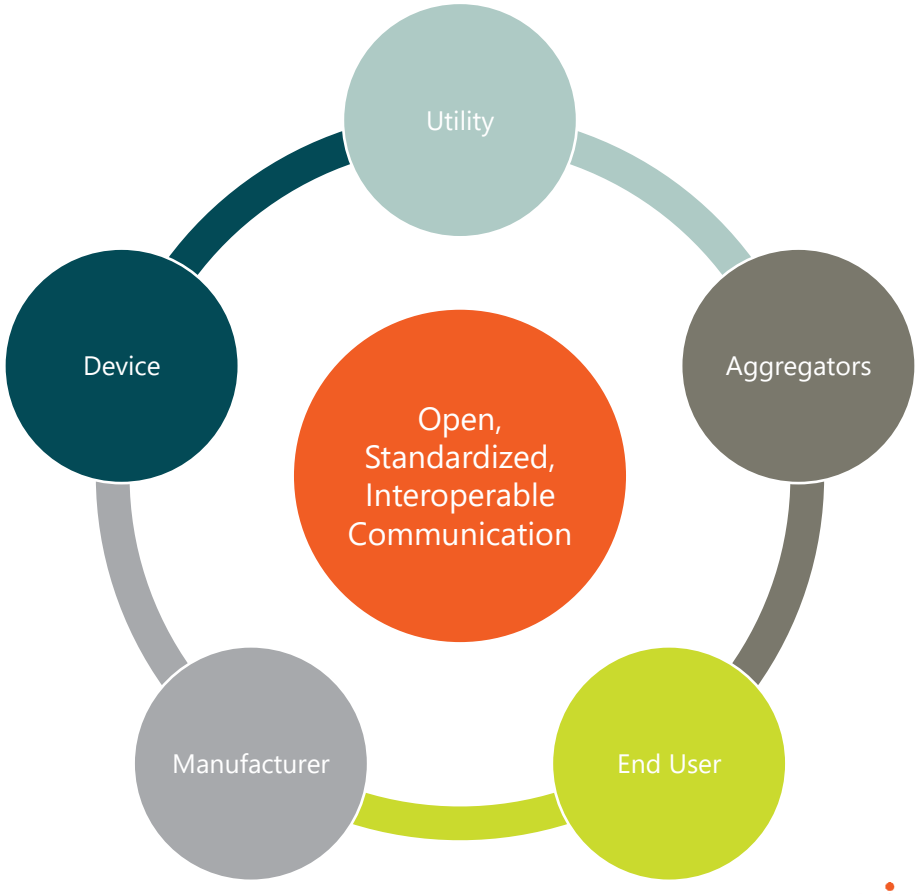
Standardized Communication Pathway

Why it's important:

- Establishing relationships with individual manufacturers and devices is costly and time intensive
- This would streamline DR programs and increase access for more brands to participate

Barriers

- Manufacturers may not want to relinquish control of the utility-customer relationship
- Requires additional hardware (such as with CTA 2045)
- Market pressure needs to increase



Key Take Aways

- DR-enabled line voltage thermostats exist
- Technology could be improved through multi-equipment control/coordination and open, standardized, interoperable communication
- Can be an important technology for rental units, MF/LI
- More research and evaluation is needed to better understand potential impacts and program implementation best practices
- SCL has been successful in piloting and scaling program in several months, so while more research is helpful, we don’t need to wait to get started!

August 27, 2024

Overcoming Winter DR Challenges

RESULTS FROM SEATTLE'S BYOT PILOT

Seattle City Light

cadeo

Presentation Agenda

Intro
- About TempWise
- Why Winter DR in the PNW

Winter Challenges:
- Screening for electric heat
- Baseboard heating
- Customer Experience

Load Impacts

Going Forward
- 2nd year improvements

Intro to Seattle City Light TempWise Pilot

INTRO

Direct load control w/smart thermostat (BYOD)

4
smart thermostat OEMs

Select zip codes in the City Light territory

Initiated
April 2023

17
summer and winter test events

Enrolled
1,796
participants in 1st year

ICF

Kambo energy group

Virtual Peaker

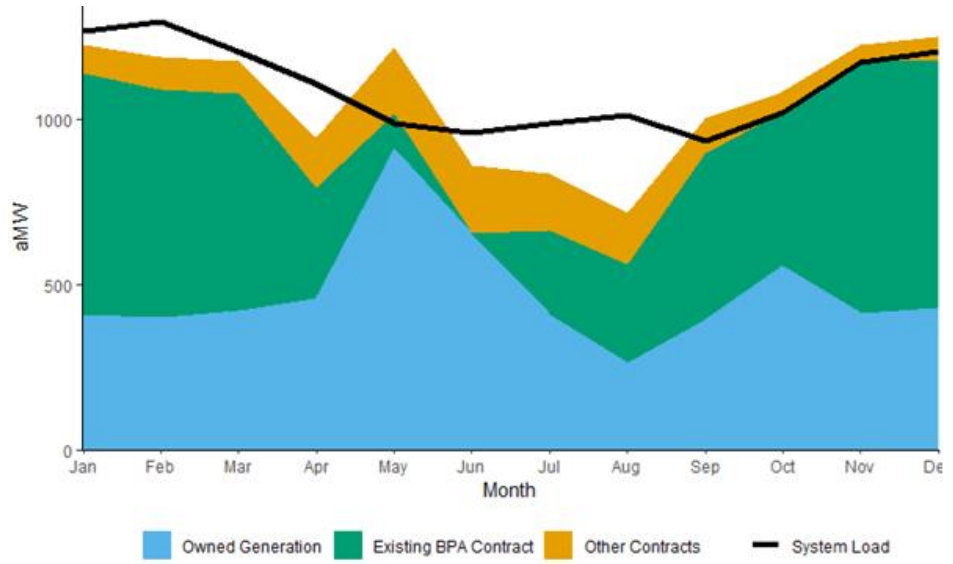
cadeo

VERDANT

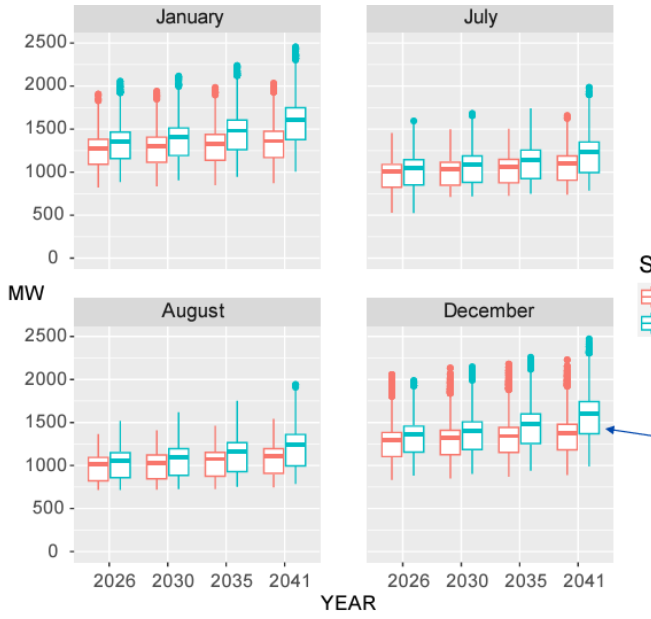
Why Winter DR in the PNW?

INTRO

- Winter peaking utility, but seeing summer shortfalls
- Peaks will increase with electrification
- Climate is changing
  - Record peak of 2,027 MW* on Jan 12, 2024
  - 2023 - Rate Stabilization Account depleted due to extremes



City Light's 2023 Actual Load Resource Balance



2024 DSMPA load forecast for winter is ~25th percentile of median 2022 IRP load forecast by 2041

3 Winter Challenges

1. Screening for Electric Heating
2. Baseboard heating
3. Customer experience

TempWise Strategies

1. Used AMI data, assessor data, and customer self reporting for season assignment
2. Added connected line voltage thermostats to OEM line-up
3. Tested pre-conditioning, customer notification, and short duration cycling

Challenge 1: **Screening for Electric Heat**

WINTER CHALLENGES

- No load relief, lower per device kW values
- Customer incentive payments without system benefit
- Extraneous customer email notifications could lead to fatigue, confusion, and opt outs

Strategy

- AMI data screen for winter season implemented
  - Considered assessor data and self reported information

Outcome

- Went from 49% response to 89% average response

Challenge 2: **Baseboard Heating**

WINTER CHALLENGES

SCL service territory:

- 45% has electric baseboard
- 54% is multifamily housing
- Only 10% of single family has baseboard heating
- 80% of multifamily has baseboard

Strategy

- Added smart line voltage t-stat to pilot in late Dec 2024
- Included energy efficiency rebate at point-of-sale to boost uptake

Outcome

- Enrolled 197 homes (645 devices) in two weeks.
- Mysa participants consisted of 58% multifamily compared to 20% overall

Challenge 3: **Customer Experience**

WINTER CHALLENGES

- People generally don't like to be cold
- Were unsure of customer tolerance for event frequency, duration, temp setback, AM vs PM…

Strategy

- Pre-heating
- Customer notification and awareness of events
  - Day ahead notification
  - Opt – out in email
- Cycling events (short duration events)

Outcome

- High levels of event awareness
- Minor impact to comfort
- High satisfaction; slightly lower than summer
- Nearly all reported ease of participation

Event Log / Participant Survey

WINTER CHALLENGES

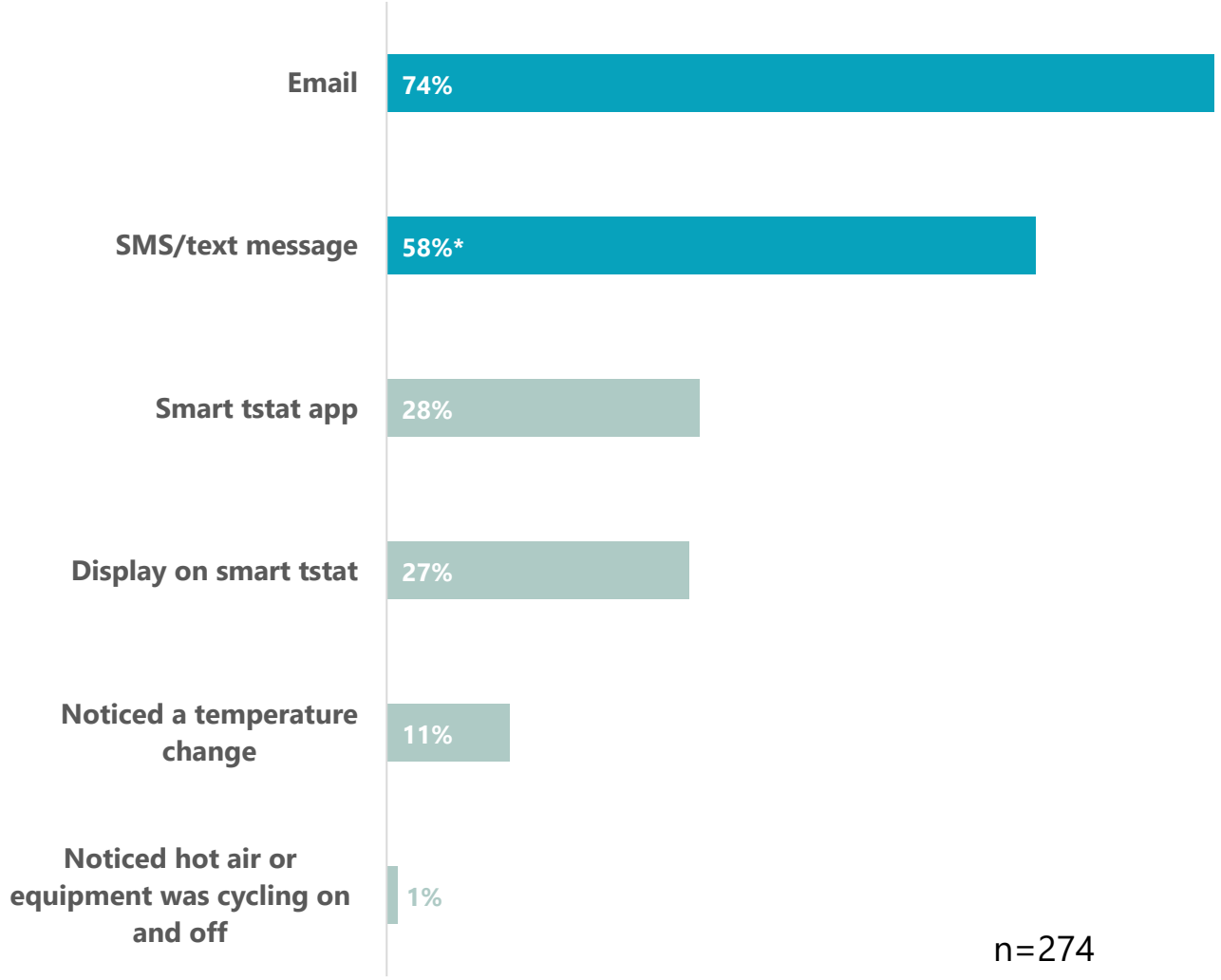
Event	Day of Week	Date	Start Time	Duration	Setback	Avg. Outdoor Temp (°F)	Avg. # of Devices	Dispatch Strategy
1*	Thursday	12/14/2023	6am	2 hrs	2°F	44	1,314	*Combined Platoon – 2 hr, 2°F*
2*	Friday	12/22/2023	6am	2 hrs	2°F	44	1,303	*Combined Platoon – 2 hr, 2°F*
3	Friday	1/12/2024	5pm	2 hrs	2°F+2°F 1 hr preconditioning	16	1,977	*Preconditioning*
4	Tuesday	1/16/2024	5pm	3 hrs	3°F	34	1,976	*Combined Platoon – 3 hr, 3°F*
5*	Thursday	1/18/2024	6pm	2 hrs	2°F	37	1,967	*Combined Platoon – 2 hr, 2°F*
6*	Friday	2/9/2024	6pm	2 hrs	2°F	42	1,962	*Combined Platoon – 2 hr, 2°F*
7	Wednesday	2/14/2024	8am	2 hrs	2°F	45	1,959	*Advanced Notification – 30 min vs. night before*
8	Tuesday	2/27/2024	6am	2.5 hrs	2°F	36	1,956	*5 hr Combined Event*
8	Monday	3/4/2024	7am	3 hrs (1/2 hr intervals)	2°F	39	1,956	*3 hr event at 30 min intervals*
10	Tuesday	3/5/2024	7am	2 hrs	2°F	34	1,956	*Notification with embedded opt-out option*

Event Awareness

WINTER CHALLENGES

- Majority (94%) aware via several notification options (email, text, phone app, tstat display)
- Majority (80%) indicating pre-notification being helpful

Were you aware of this event? How did you know it was happening?



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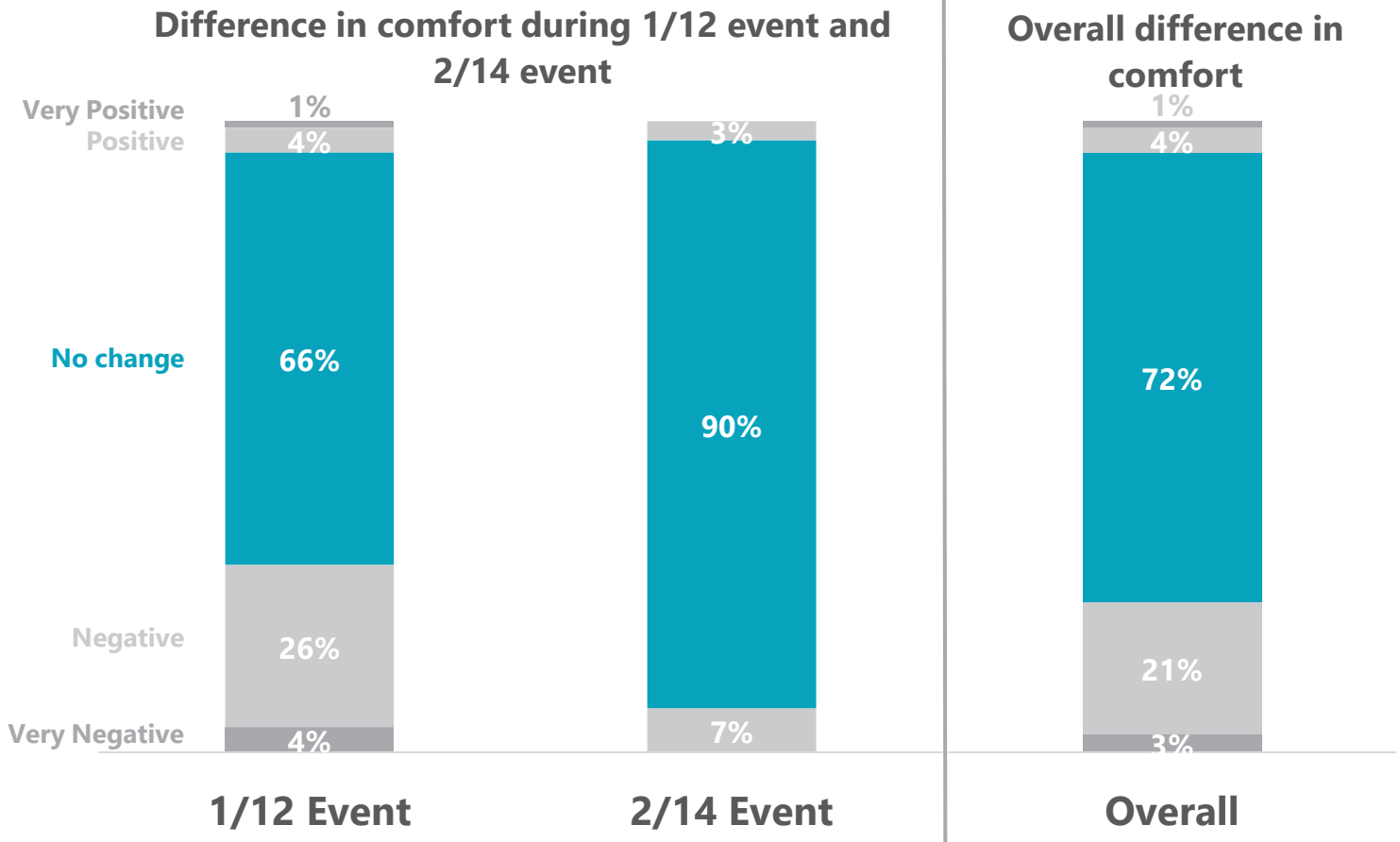
Participant Comfort

WINTER CHALLENGES

- Majority (72%) found no change in comfort
- Higher discomfort shift for 1/12 event (morning, low temp)
- Subtle difference for LV (75%) vs. Non-LV Tstats (79%)



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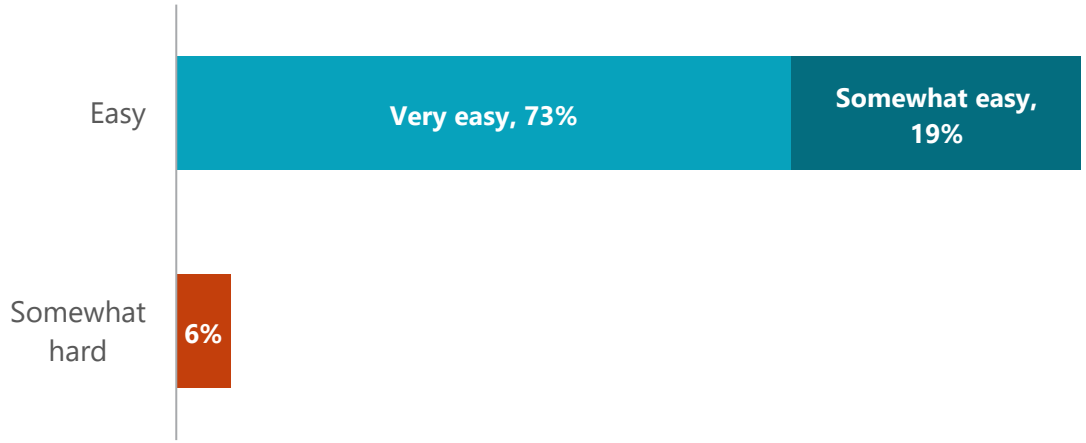
Customer Satisfaction

WINTER CHALLENGES

The majority of respondents said that the event was **easy (93%)** and were **satisfied (82%)** with the TempWise program

How easy was this event for your household?



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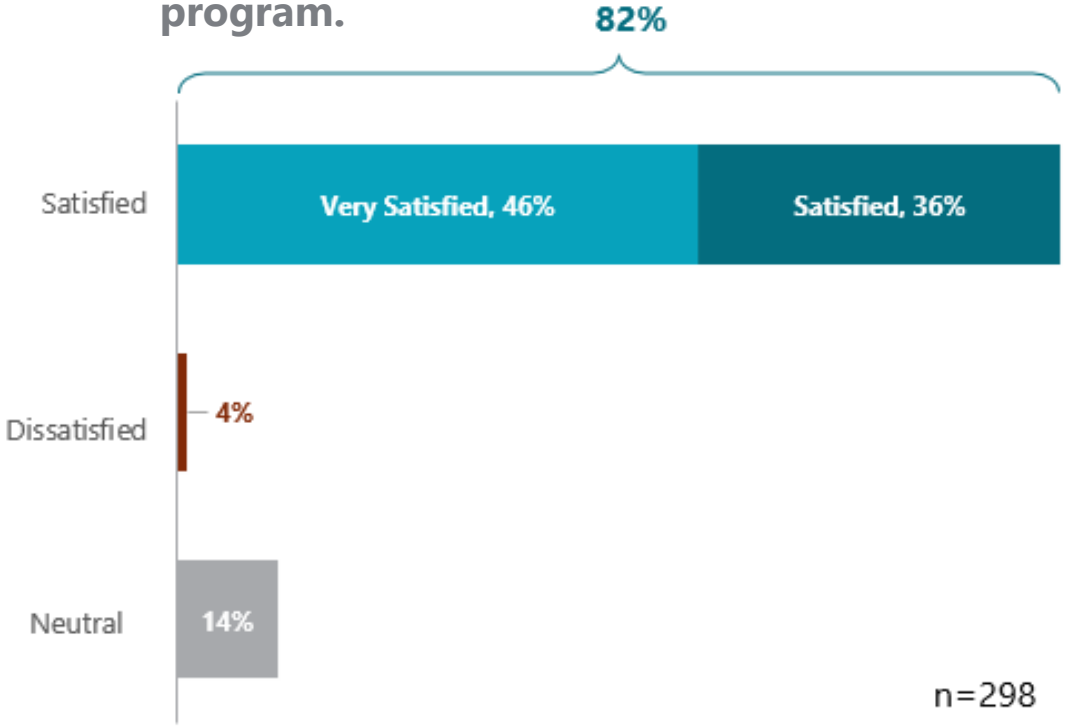
Rate your satisfaction with the TempWise program.



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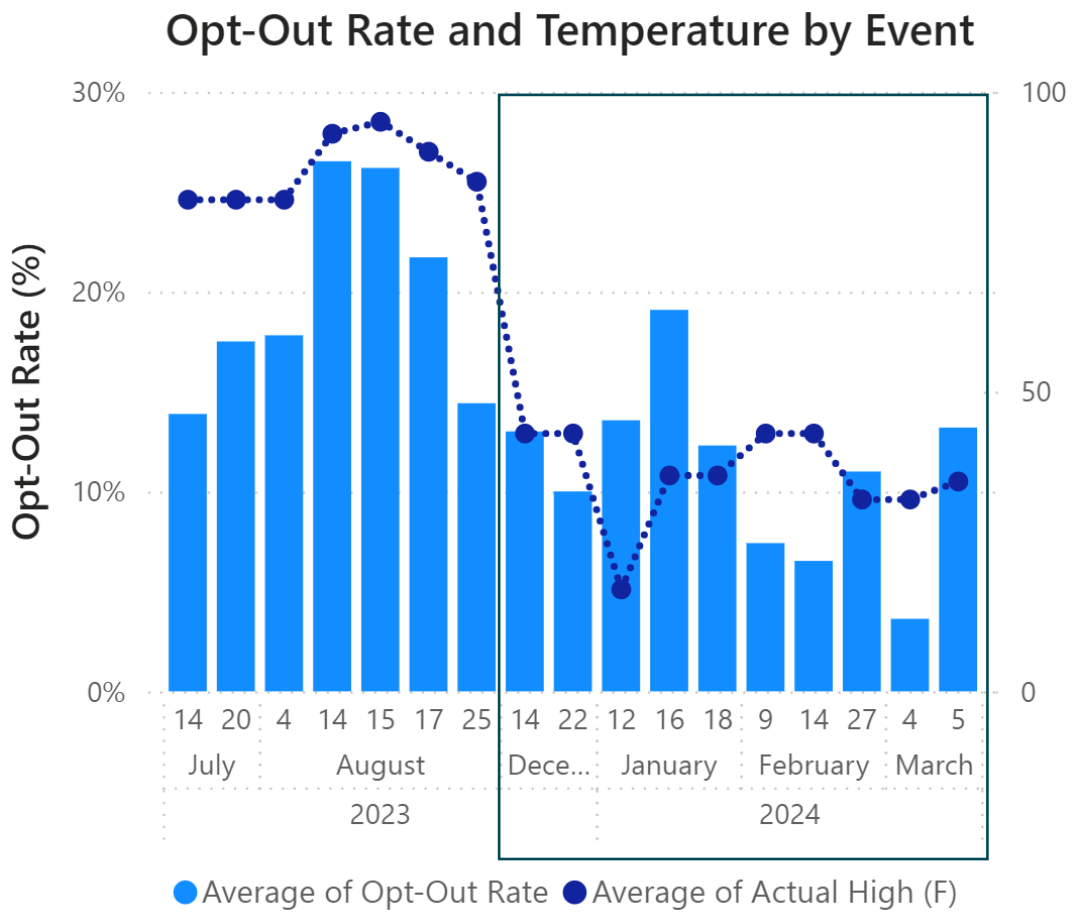
Opt out and Unenrollment results

WINTER CHALLENGES

- ***Unenrollments:*** 6 customers unenrolled due to winter events impact
- ***Opt-Outs/Overrides***:
  - Fewer avg. opt-outs in winter (10%) vs. summer (20%)
- ***LV vs. Non-LV***
  - Survey found sig. difference in active overrides between LV homes (6%) and non-LV (18%)
  - Opt-out data found slightly lower rates of opt-out for LV *devices* (8%) than non-LV (10%)



AMI Impact Analysis (Winter)

LOAD IMPACTS

Overall: 0.25 kW (14%)

Morning Events: 0.23 kW

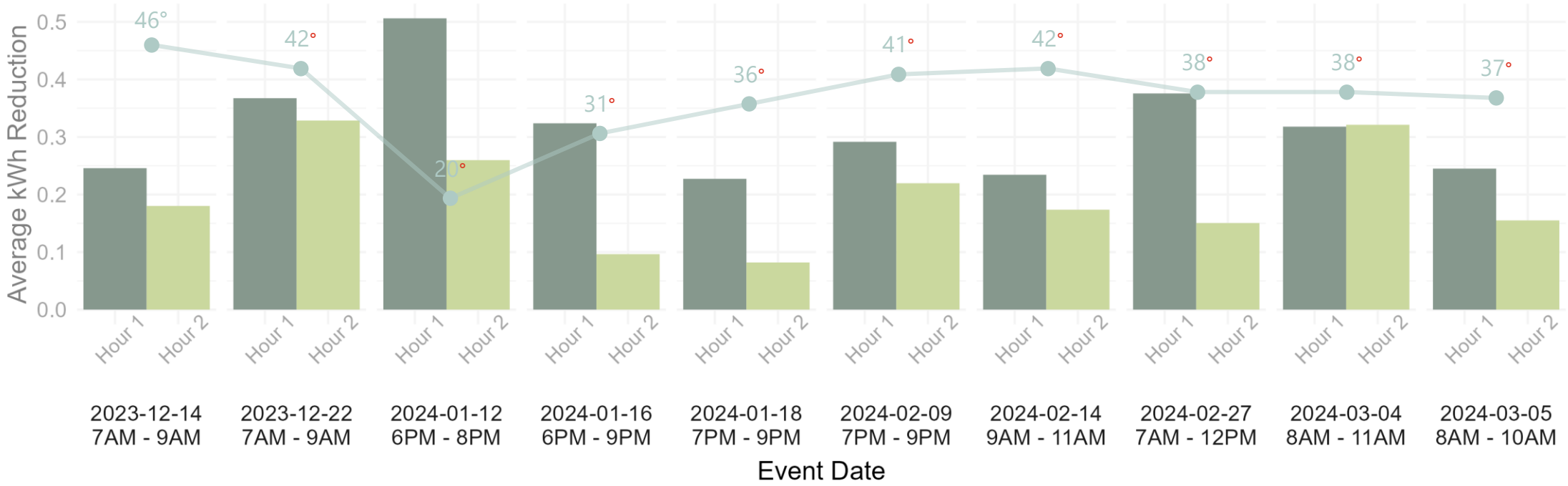
Evening Events: 0.26 kW

Plat. A: 0.22 kW

Plat. B: 0.27 kW

Plat. C: 0.26 kW

Plat. D: 0.27 kW



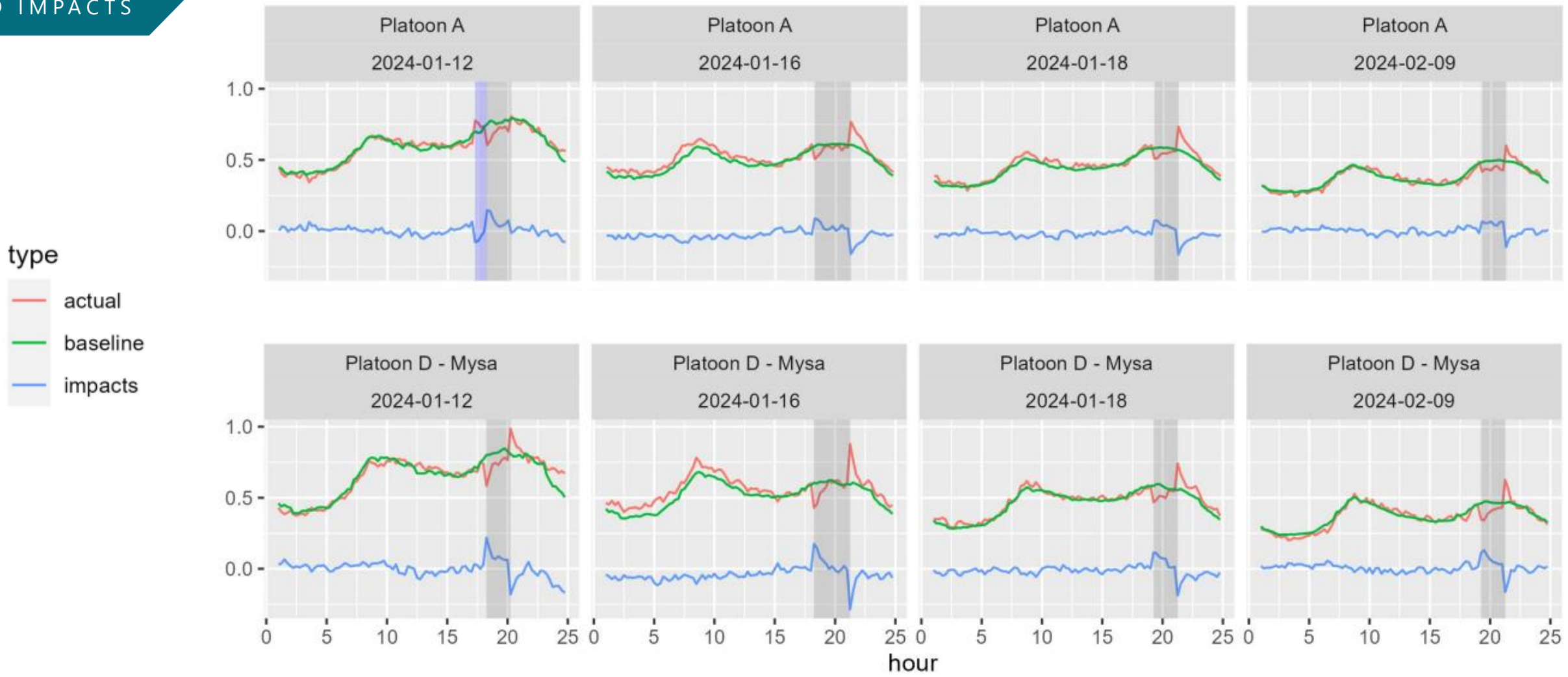
AMI Impact Analysis (Winter)

LOAD IMPACTS

Platoon	Avg. Devices	Avg. kW Reduction per HH			
		Overall	Hour 1	Hour 2	% Change
Morning Events (n=6)					
Platoon A	558	0.21	0.29	0.14	52%
Platoon B	601	0.26	0.35	0.20	43%
Platoon C	55	0.20	0.31	0.10	68%
Platoon D (LV Tstat)	600	0.27	0.44	0.15	66%
Total	***1,813***	***0.24***	***0.34***	***0.16***	***53%***
Evening Events (n=4)					
Platoon A	558	0.24	0.29	0.20	31%
Platoon B	603	0.28	0.31	0.24	23%
Platoon C	67	0.26	0.31	0.21	32%
Platoon D (LV Tstat)	632	0.27	0.34	0.19	44%
Total	***1,859***	***0.26***	***0.30***	***0.21***	***30%***

AMI Impact Analysis (Winter)

LOAD IMPACTS



AMI Impact Analysis (Winter)

LOAD IMPACTS

Event Characteristics							Reported Load Reductions	Draft Evaluation Load Impacts							
Date	Start Time (PT)	End Time (PT)	Platoon	Pre Heat	Event Max (F) Model Data	No. of Houses	Avg Reduction (kW/House)	Average Event Hour Load Reduction (kW) Per Service Point	Percent of Reference Load	Pre Condition	Hour 1	Hour 2	Hour 3	Post Event Hour	Change From Hour 1 to Hour 2
1/12/2024	5:00 PM	7:00 PM	Platoon D	No	32	197	0.42	0.40	0.12		0.51	0.29		-0.31	44%
1/16/2024	5:00 PM	8:00 PM	Platoon D	No	31	197	0.56	0.18	0.07		0.47	0.04	0.01	-0.36	91%
1/18/2024	6:00 PM	8:00 PM	Platoon D	No	34	197	0.42	0.24	0.10		0.38	0.11		-0.29	72%
2/9/2024	6:00 PM	8:00 PM	Platoon D	No	42	197	0.21	0.28	0.15		0.40	0.16		-0.16	61%
2/14/2024	8:00 AM	10:00 AM	Platoon D	No	38	196	0.28	0.17	0.11		0.29	0.06		-0.22	79%
2/27/2024	8:30 AM	11:00 AM	Platoon D	No	32	197	0.32	0.40	0.20		0.47	0.34	0.40	-0.07	28%
3/4/2024	7:30 AM	10:00 AM	Platoon D	No	36	197	0.42	0.29	0.15		0.30	0.28		-0.11	7%
3/5/2024	7:00 AM	9:00 AM	Platoon D	No	36	197	0.21	0.20	0.09		0.32	0.09		0.03	73%

2nd Year Improvements

GOING FORWARD

Customers report that program is easy to participate in and are largely satisfied, with limited comfort impacts.

Takeaways

- Success with winter heating screen increased response rates from 49% to 89%
- Line voltage t-stat OEM had positive impact on program
- Clear impact seen in AMI data, but lower kW values per household than expected

Updates

- Adding HVAC screen for both seasons
- Expand participation options, continue with LV t-stat, explore further screening for load relief
- Update expected values & refine dispatch strategy
- Track long-run participation metrics / impact of cumulative participation / fatigue

Thank you!

Emma Johnson
Seattle City Light

Scott Reeves
Cadeo

Multi Family Line Voltage Load Flex Study

- Studying load shift potential and customer comfort of line voltage thermostats
- Analyze impact when LVTs are applied to entire building
- Survey customers to gain insights into their experience
- Identify device tech/feature upgrades to support performance and open connectivity

Questions?