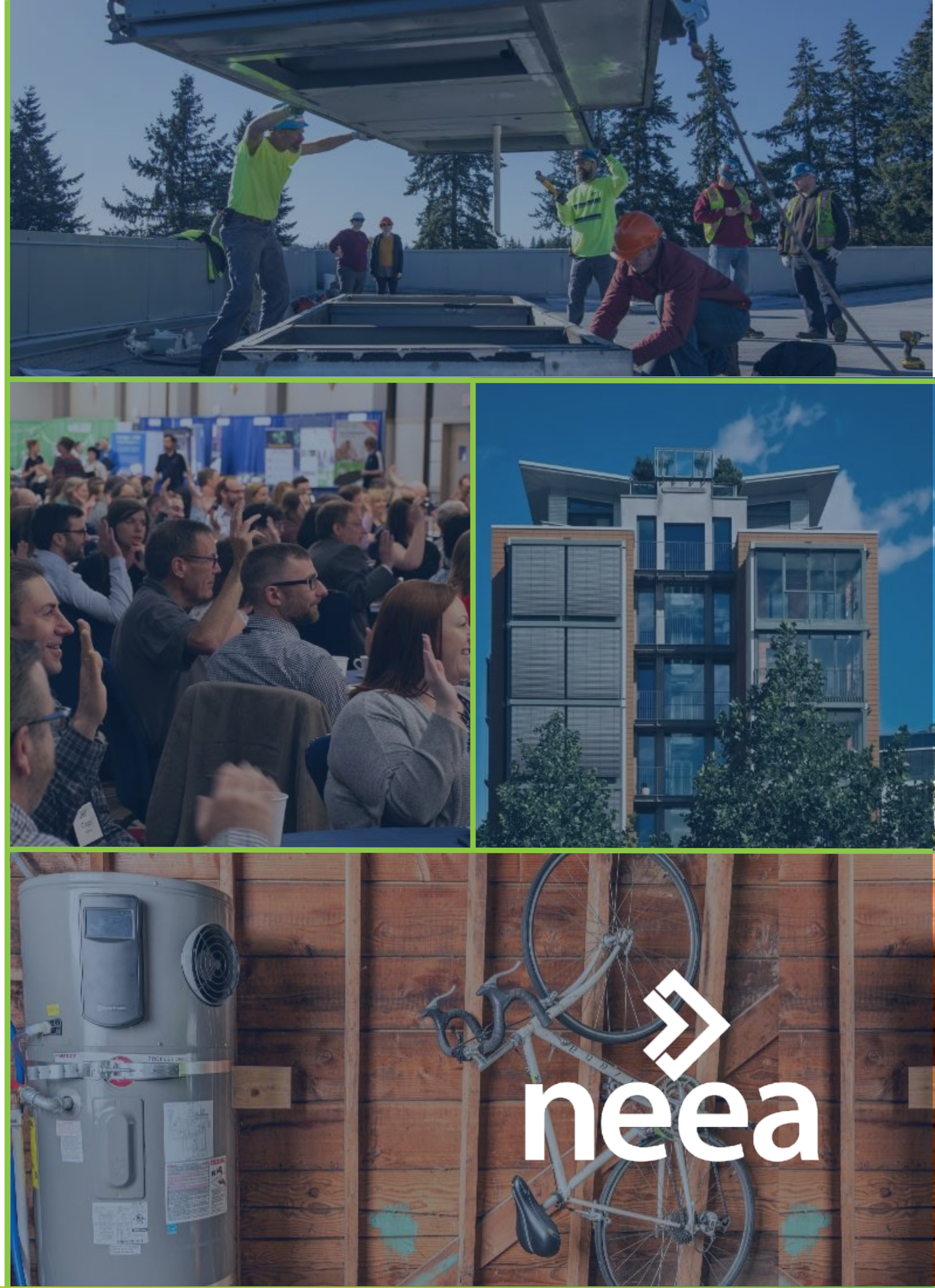
Regional Emerging Technology Advisory Committee (RETAC)

Northwest Energy Efficiency Alliance

Q4 2023 Meeting

December 14, 2023

8:30 a.m. – 12:40 p.m.



CLASSIFICATION LEVEL: PUBLIC

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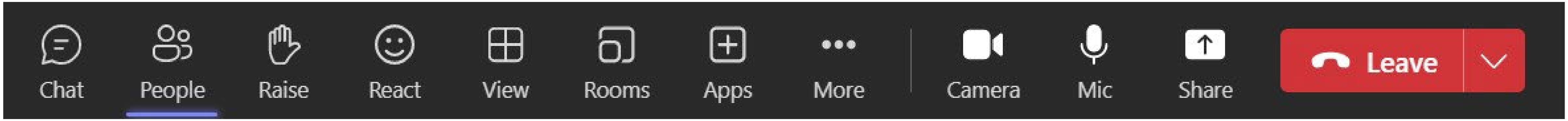
Navigating MS Teams Layout

Camera &
Microphone

Raise Hand



Chat

Exit Call

Note: These options may vary, depending on which version you're using.

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Name,
Title,
Organization
and …

What is your favorite scene in "Elf?"

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Agenda

8:30 am	Welcome and Announcements
9:00 am	*New!* PNNL Emerging Technology Update
10:15 am	*Break*
10:30 am	*New!* Water Heating Update
11:30 am	*New!* Residential HVAC Update
12:30 pm	Wrap-Up

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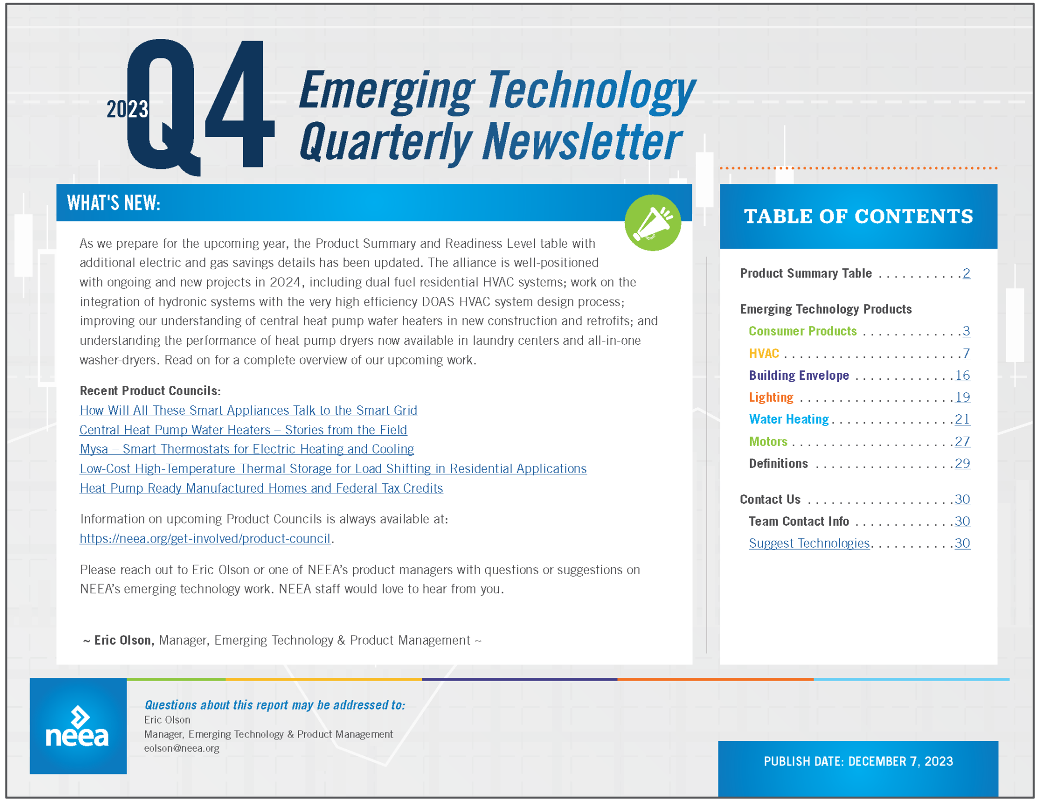
Q4 2023 Emerging Tech Newsletter



2023 Q4 Emerging Technology Quarterly Newsletter

WHAT'S NEW:

As we prepare for the upcoming year, the Product Summary and Readiness Level table with additional electric and gas savings details has been updated. The alliance is well-positioned with ongoing and new projects in 2024, including dual fuel residential HVAC systems; work on the integration of hydronic systems with the very high efficiency DOAS HVAC system design process; improving our understanding of central heat pump water heaters in new construction and retrofits; and understanding the performance of heat pump dryers now available in laundry centers and all-in-one washer-dryers. Read on for a complete overview of our upcoming work.

Recent Product Councils:

How Will All These Smart Appliances Talk to the Smart Grid
Central Heat Pump Water Heaters – Stories from the Field
Mysa – Smart Thermostats for Electric Heating and Cooling
Low-Cost High-Temperature Thermal Storage for Load Shifting in Residential Applications
Heat Pump Ready Manufactured Homes and Federal Tax Credits

Information on upcoming Product Councils is always available at: https://neea.org/get-involved/product-council.

Please reach out to Eric Olson or one of NEEA's product managers with questions or suggestions on NEEA's emerging technology work. NEEA staff would love to hear from you.

~ **Eric Olson**, Manager, Emerging Technology & Product Management ~

TABLE OF CONTENTS

neea

Questions about this report may be addressed to:
Eric Olson
Manager, Emerging Technology & Product Management
eolson@neea.org

PUBLISH DATE: DECEMBER 7, 2023

https://neea.org/resources-reports

- Selected Q4 Highlights
  - Several Product Councils
    - How Will All These Smart Appliances Talk to the Smart Grid?
    - Central HPWHs – Stories from the Field
    - Smart Thermostats for Electric Heating and Cooling
    - Heat Pump Ready Manufactured Homes
    - Low-Cost High Temp Thermal Storage
  - Five projects currently being scoped and put under contract
  - Updated the Product Summary & Readiness Levels separating electric and gas savings potential

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Q4 2023 Emerging Tech Newsletter

Product Summary & Readiness Levels

	PRODUCT OR PROJECT	PROGRAM*	FUEL TYPE	SECTOR	ELECTRIC SAVINGS POTENTIAL[1]	GAS SAVINGS POTENTIAL[2]	PRODUCT PERFORMANCE[3]	MARKET/ COMMERCIAL[3]	PROGRAM READINESS[3]
Products	Ultra-High Definition TVs	RPP			57	N/A	4	5	5
	Residential Laundry Field Study	RPP			N/A	N/A	5	5	5
	Monitors and Commercial Displays	TBD			TBD	N/A	3	5	1
	Laundry Centers & All-in-One Washer-Dryers	RPP			TBD	TBD	4	5	5
HVAC	Very High Efficiency Dedicated Outside Air Systems	VHE DOAS			85	20†	4	3	2
	Efficient Rooftop Units	ERTU			N/A	9	4	3	4
	Heat Pump Rating Representativeness	AHP			TBD	N/A	3	5	4
	Heat Pump Advanced Features and Capabilities	AHP			35†	N/A	3	5	4
	Micro Variable Speed Heat Pump Field Study	TBD			TBD	N/A	1	3	1
	Heat Pump Ready ENERGY STAR® Manufactured Homes	AHP			TBD	N/A	4	5	3
	Dual Fuel Gas-Electric Heat Pump	DFHP			TBD	TBD	5	3	1
Building Envelope	High-Performance Windows	HPW			60	30	4	3	4
	Secondary Windows	Window Attachments			35	23†	4	5	4
Lighting	Luminaire Level Lighting Controls	LLLC			75	N/A	4	4	3
	LLLC with HVAC Control	LLLC			358	TBD	3	2	3
	Parking Lot Lighting with LLLC	TBD			TBD	N/A	3	3	1
Water Heating	Combination Hot Water and Space Heat	N/A			130	N/A	1-4	[illegible]	[illegible]
	Heat Pump Water Heaters in Confined Spaces	HPWH			TBD	[illegible]	[illegible]	[illegible]	[illegible]
	Integrated Residential GHPWH	GHPWH			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Central Commercial Heat Pump Water Heater	HPWH			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Central Commercial Thermally Driven Heat Pump	TBD			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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Other stuff we're doing…

- Concluding second residential laundry field study – results due Q1 2024
- Washer-Dryer Combo and Laundry Centers with heat pump dryers testing work being scoped
- Continue monitoring additional sites with Very High Efficiency DOAS and efficient rooftop units
- Working with other organizations on a GTI ENERGY-led California Energy Commission secondary window field study
- Identified test site for LLLC with HVAC control
- Continue working on energy savings opportunities for Power Drive Systems

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2024 RETAC Meeting Dates (Approved)

Q1	Thursday, March 28
Q2	Thursday, June 27
Q3	Wednesday, September 25
Q4	Thursday, December 12

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Conferences
Product Councils

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Conferences

Past Conferences

- WA Association of Maintenance of Operations Administrators Fall Conference – October 2023
- Oregon CUB Energy Policy Conference – October 2023
- Energy & Environmental Building Alliance Con. – October 2023
- NASEO Annual Meeting – October 2023
- Hydraulic Institute 2023 Annual Conference – October 2023
- ACEEE Energy Efficiency as a Resource – October 2023
- NW SEM Collaborative Fall Workshop – October 2023
- ASHRAE Decarb. for the Built Environment – October 2023
- NEEP Heating Electrification Workshop – October 2023
- IES Street and Area Lighting Conference – October 2023
- Joint Engineers Conference – November 2023
- GTI Emerging Technology Program Fall Summit – November 2023
- ACEEE Behavior, Energy and Climate Change – November 2023
- HARDI International Annual Conference – December 2023
- Clean & Affordable Energy Conference – December 2023

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Conferences

Upcoming Conferences

- IEEE Rising Stars Conference – January 2024
- Consumer Electronics Show – January 2024
- CEE Winter Program Meeting – January 2024
- AHR Expo and ASHRAE Winter Conference – January 2024
- Midwest Energy Efficiency Alliance Conference – January 2024
- AESP Annual Conference – February 2024
- IEEE Integrated Smart Grid Technologies Conference – February 2024
- Building Science Symposium – February 2024
- International Builders Show – February 2024
- EPRI 2024 Conference – March 2024
- ACEEE Hot Water & Hot Air Forum – March 2024
- 2024 HVACR Education Conference – March 2024
- EFX24 – March 2024
- Dry Climate Forum – March 2024

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Q4 2023 Product Council Presentations

Presenter	Topic	Date Scheduled	Webinar Recording
SkyCentrics, eRadio, Shifted Energy	How Will All These Smart Appliances Talk to the Smart Grid?	October 3, 2023	Northwest Energy Efficiency Alliance (NEEA) | How Will All These…
Association for Energy Affordability	Central Heat Pump Water Heaters: Stories from the Field	October 24, 2023	Northwest Energy Efficiency Alliance (NEEA) | Central Heat Pump Water…
Mysa	Smart Thermostats for Electric Heating & Cooling	November 14, 2023	Northwest Energy Efficiency Alliance (NEEA) | Mysa Smart Thermostats…
Steffes	Low-Cost High-Temperature Thermal Storage for Load Shifting in Residential Applications	November 28, 2023	Northwest Energy Efficiency Alliance (NEEA) | Steffes Low-Cost…
Northwest Energy Works	Heat Pump Ready Manufactured Homes and Federal Tax Credits	December 5, 2023	Northwest Energy Efficiency Alliance (NEEA) | Heat Pump Ready…

Upcoming Product Council Presentations

Presenter	Topic	Date Scheduled	Registration Link
Montana State University Integrated Design Lab	Ventilation Requirements for Residential Buildings in Cold Climates	December 19, 2023	Registration Link
Cadeo Group	Low-Load Efficient Heat Pump Virtual Tear-Down	February 2024 (TBD)	Info coming soon!

https://neea.org/get-involved/product-council

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PNNL Emerging Technology Update

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NEEA Regional Emerging Technologies Advisory Committee

PNNL Emerging Technology Update

December 14, 2023

Bing Liu, P.E., FASHRAE
Building Sector Manager

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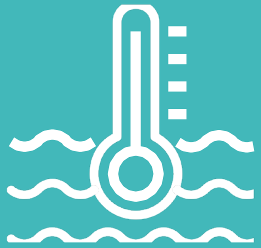
PNNL's Building Program to Support DOE's Priorities

Energy Efficiency

- **Codes & Appliance Standards**
- **Emerging technologies lab testing and field validation**
- **Large scale demonstration and deployment**

Efficient Electrification



Heat Pumps Deployment

- HPWHs
- Cold Climate Heat Pumps
- Workforce training
- Tools and resources

Demand Flexibility

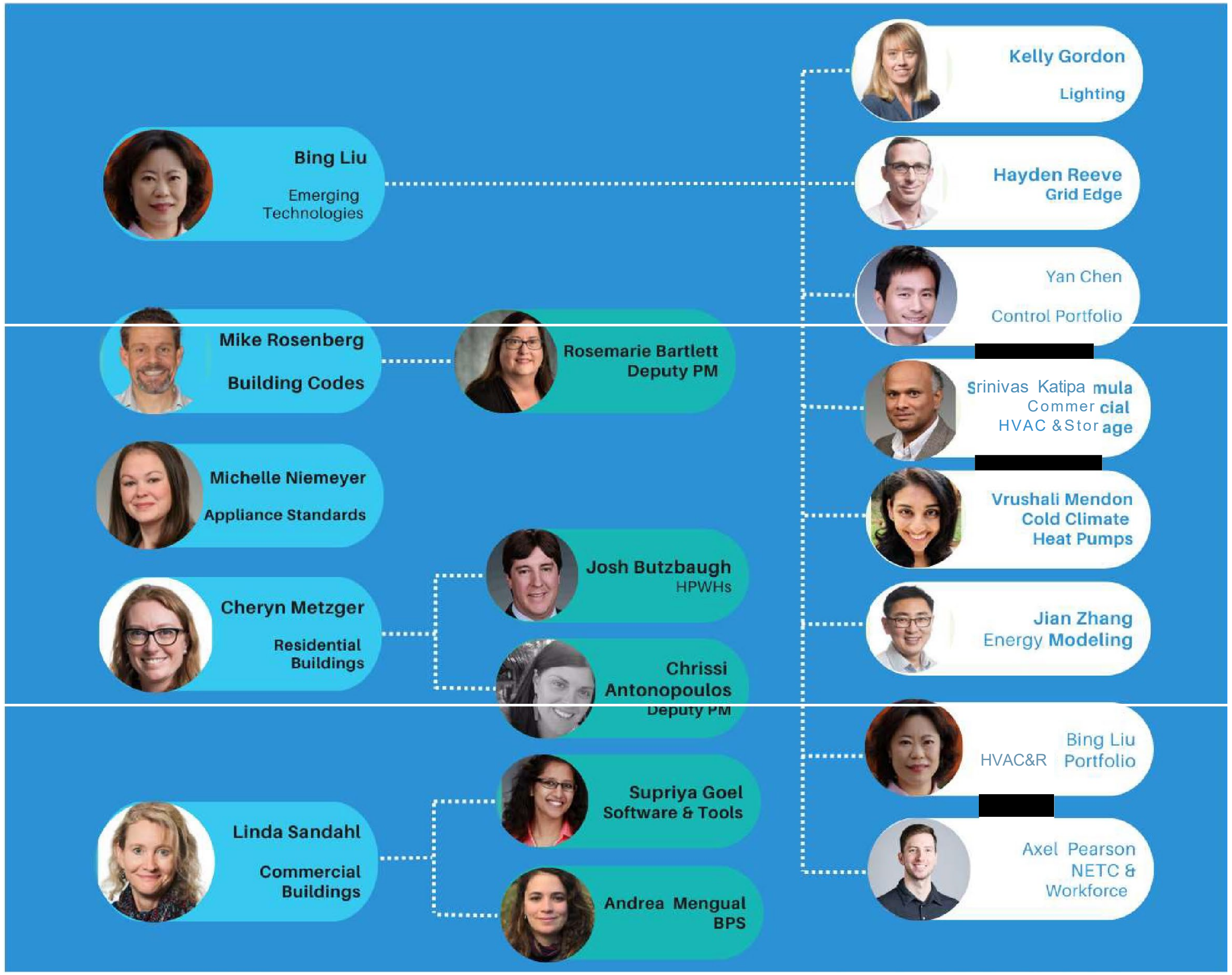
- Connected Communities
- Building controls
- Energy storage
- Cybersecurity controls

OUR CORE TEAM

Bing Liu
Building Sector Manager

Jamie Spangle
Financial

Kelsey Adkisson
Communication



Today's Topics

Axel Pearson

National Emerging Technology Council

Josh Butzbaugh

120V HPWHs

Srinivas Katipamula

Connected Community

Vrushali Mendon

Cold Climate Heat Pump Challenge

Gabe Arnold

GUV Technology

Ruth Taylor

RTU Control Adoption

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National Emerging Technologies Council and Workforce Development

December 14, 2023

Axel Pearson

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National Emerging Technologies Collaborative

Building Technologies Quarterly Report

- Report communicating insights, trends, technologies, metrics, and most relevant information to the buildings industry
- Focused on information and metrics that will meaningfully drive the industry to address EERE decarbonization goals
- Define DOE-relevant innovation in the buildings industry, incorporating defining metrics and information into the report
- Differentiate from existing industry market reports by providing perspectives and insights that serve stakeholders in alignment with DOE's goals

Expect 1st edition in 2024!

Working Groups

- Convenings of key stakeholders to address specific technical and market challenges in the building's technology space
- Each working group will also initiate "sprints," smaller groups that will collaborate on subtopics within the working group.
- Results and findings will be shared with the building sector RD&D community to raise awareness around ongoing activities and pressing industry needs.
- Two working groups are currently active:

1. **Commercial and Large Multifamily Building Decarbonization**
2. **Building Envelope Retrofit for Existing Buildings**

PNNL's Workforce Related Efforts

- **Training content** available through the Building Science Education Solution Center (BSESC)
- DOE Recognition of training and credentials in 4 topic areas:
  - Heat pump **installation** and **comfort advising**
  - Heat pump **water heating installation**
  - **Energy Assessments**
- Outreach project underway to identify **high priority commercial jobs** for workforce development
- Partner* on new effort: Pacific Northwest **Building Training and Assessment Centers (BTAC)**
  - BTAC connects higher-education programs and technical assistance resources for building assessments and student experiences that will help building owners meet net zero emissions targets

*BTAC Partners: University of Washington, South Seattle College, Northwest Indian College

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Update on the 120V HPWH Field Study in New Orleans, LA

December 14, 2023

Josh Butzbaugh
Tyler Pilet
Tabitha Artuso

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Background

- Converting fossil fuel water heaters to heat pump water heaters (HPWH) has the potential to avoid substantial carbon emissions
- Plug-in 120-volt HPWHs are a recently-commercialized water heating technology intended to facilitate energy efficient electrification of the fossil fuel water heater stock.
  - Operate on a 120-volt, 15-amp circuit and can accommodate homes without the electrical service or panel capacity for 240-volt HPWHs
  - May allow for quicker and less expensive installation compared to 240-volt HPWHs because they do not require installation of new electrical panels, new breakers, and/or new wire runs.

Image Source: Getty Images

Background

- This field study was developed to demonstrate the performance of 120-volt HPWHs in the manufacturer-recommended climate zone (shaded portion of map on right), and seeks to:
  - Understand whether 120-volt HPWHs can effectively meet hot water loads in IECC Climate Zone 2 based on home size, water heater location, and temperature/humidity conditions
  - Determine lessons learned for siting, sizing, and installing 120-volt HPWHs at demonstration sites.

- The anticipated impact of this study is to:
  - Develop best practices for 120-volt HPWH siting, sizing, and installation
  - Offer insight for developing electrification policies for residential water heating
  - Provide feedback to manufacturers, and provide guidance to the supply chain and homeowners/consumers

For optimal operation, installation in shaded map zone is recommended.
When installing outside of the shaded zone, consult your local plumbing contractor.

Average Ambient Air Temp in January

Below 37°F
Above 37°F

Study Set-up - Overview

- To perform the demonstration, PNNL recruited single-family homes in the New Orleans area with existing natural gas water heaters.
- For the first ten installations, Rheem was selected as a manufacturer partner, the first manufacturer to bring a drop-in 120-volt HPWH product to market.
- A licensed plumber was recruited, and a Rheem representative attended the first two installations to help train the installer on HPWH installation best practices.
- Monitored data to assess energy efficiency and hot water delivery performance
  - Energy consumption
  - Surrounding air temperature
  - Inlet and outlet water temperatures
  - Hot water flow

Study Set-up – Location

The selected location for this field study is the New Orleans, Louisiana metro area.

- New Orleans was selected due to:
  - Location in manufacturer-recommended climate zone
  - Significant percentage of fossil fuel water heating, both storage and tankless
  - Variety of water heater locations and installations, including space constrained and non-traditional locations (e.g., outdoor enclosures, sheds, attics)

- HPWH installations in New Orleans provide:
  - A diverse range of home sizes and water heater locations
  - Opportunities for unique ducting configurations
  - Interesting HPWH relocation scenarios (e.g., replacing tankless units)
  - Strategies for electrification in a gas-prevalent market

Image Source: Adobe Stock Images

Study Set-up – Participant Summary

Nine participants with installed 120-volt HPWHs in the study thus far

- Sizing was based on the number of bedrooms and bathrooms, given that the typical home is sold within the lifetime of the water heater
- Additional sizing considerations included presence of indoor spa and combination of existing water heater and whether the home already experiences hot water run outs

Site Number	Date Installed	Model Type	HPWH Location	Location Vol (ft3)	Space Conditioning	Ducted?	Duct Flow	Louvers/grills?	Bedrooms	Bathrooms	Occupants
HPWH01	10/24/2022	65-gal, shared circuit	Utility/laundry closet	275	Conditioned	No	NA	Yes	2	1	1
HPWH02	10/25/2022	65-gal, shared circuit	Utility/laundry room	520	Conditioned	No	NA	No	3	2	1
HPWH03	11/1/2022	65-gal, shared circuit	Outdoor enclosure	65	Unconditioned	Yes	Exhaust	Yes	3	2	2
HPWH04	10/31/2022	65-gal, shared circuit	Outdoor shed	300	Unconditioned	Yes	Intake	No	2	1	1
HPWH05	1/23/2023	65-gal, shared circuit	Indoor closet	200	Conditioned	Yes	Exhaust	No	2	2	3
HPWH06	1/18/2023	65-gal, shared circuit	Indoor closet, no door	250	Conditioned	Yes	Exhaust	No	3	2	2
HPWH07	1/20/2023	65-gal, shared circuit	Outdoor attached shed	650	Unconditioned	Yes	Exhaust	No	2	1	2
HPWH08	2/8/2023	50-gal, shared circuit	Outdoor attached shed	650	Unconditioned	No	NA	No	1	1	1
HPWH09	2/14/2023	65-gal, shared circuit	Outdoor enclosure	65	Unconditioned	Yes	Exhaust	Yes	2	2	1

Installation Lessons Learned and Best Practices

Water heater relocation may be necessary, but it increases installation cost

Site HPWH05

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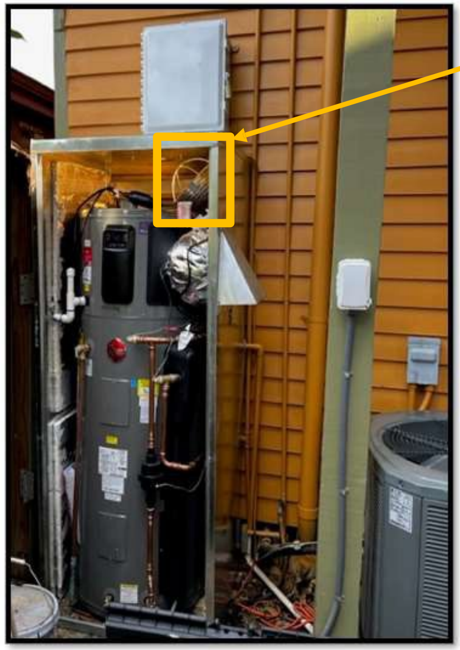
Installation Lessons Learned and Best Practices

Challenging water heater locations for compressor cutoff temperature: outdoor enclosures, detached garages/sheds, and attics



Dimmable heat lamp

Site HPWH03

New Orleans Temps < 40° F

- During study:
  Dec 23-26, 2022: 70 hrs

- Past five years:
  Jan 12-19, 2018: 109 hrs
  Jan 1-5, 2018: 97 hrs

Installation Lessons Learned and Best Practices

Summary of installation lessons learned and best practices

- While 120V HPWHs often avoid the need for multiple contractors on-site for a gas-to-HPWH replacement, expect plumbers to be onsite longer than a conventional install. Every installation thus far has taken 6+ hours.
- HPWHs require planning for sizing to peak load, clearance/space, air volume (including ducting), and condensate drainage, especially for installers who are just becoming familiar with the technology and circumstances for gas replacement
- The lack of effective backup heat in 120V HPWHs in the market can limit their viable installation locations due to compressor cutoff temperature, even in warm–hot climates (e.g., detached garages, sheds)
- Water heater relocation may be necessary.
  - Space constraints, whether at location or pathway to location, can necessitate relocation
  - Even in conditioned or semi-conditioned spaces, direct swap-out of a gas water heater to a 120V HPWH may lead to considerable costs, depending on the circumstances (e.g., 120V receptacle, wiring, circuit).

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Next Steps

- Expanding study to include the A.O. Smith 120V HPWH models
- Recruitment for next round of installations is complete, and installations are underway
  - Garage installations
  - Homes sized for 80-gallon 120V HPWHs
- Continue data collection, validation, and analysis for installed sites
  - Daily COP analysis
  - Hot water delivery analysis
    - ✓ Analyze hourly and sub-hourly hot water consumption and temperature data prior to run outs
    - ✓ Investigate run outs for participants with below median GPD
  - Installation cost analysis
- 2023 Hot Water Forum presentation
- Energy and Buildings journal article

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Connected Communities Projects

December 14, 2023

Srinivas Katipamula, Ph.D.
Sr. Staff Scientist

Project Team:
Don Hammerstrom, Robert Lutes,
Roshan Kini, and Woohyun Kim

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PNNL-SA-182204

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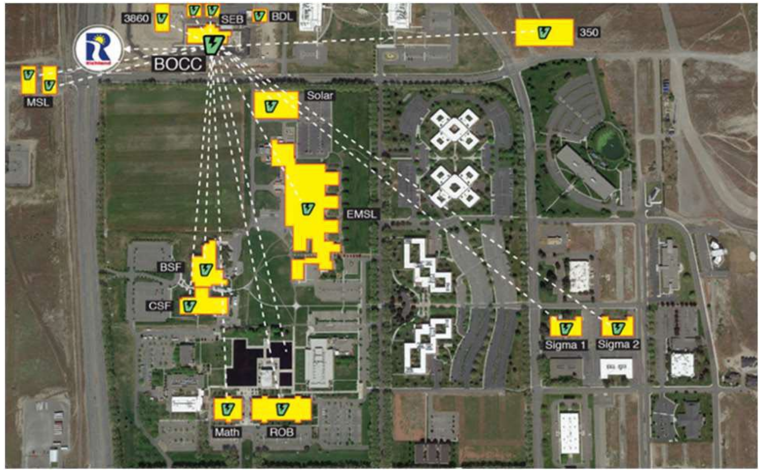
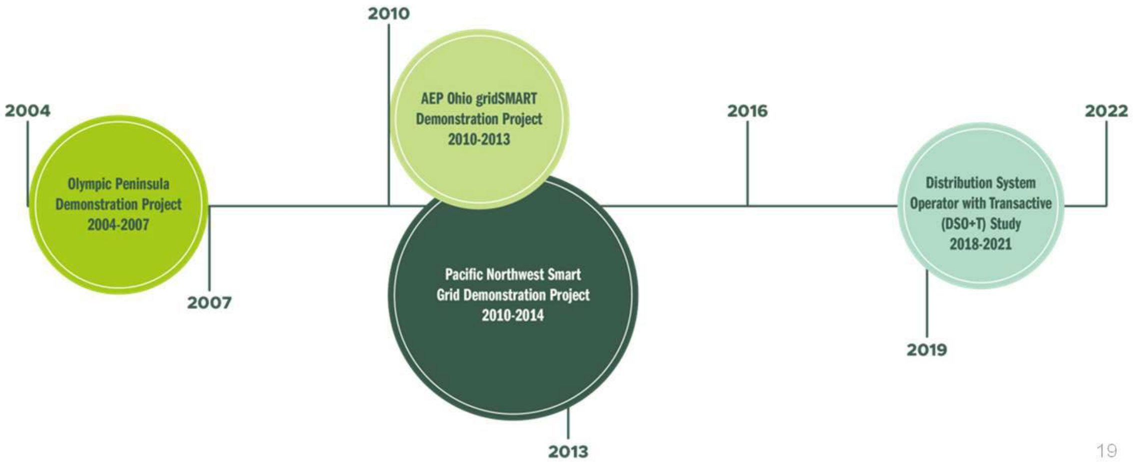
Outline

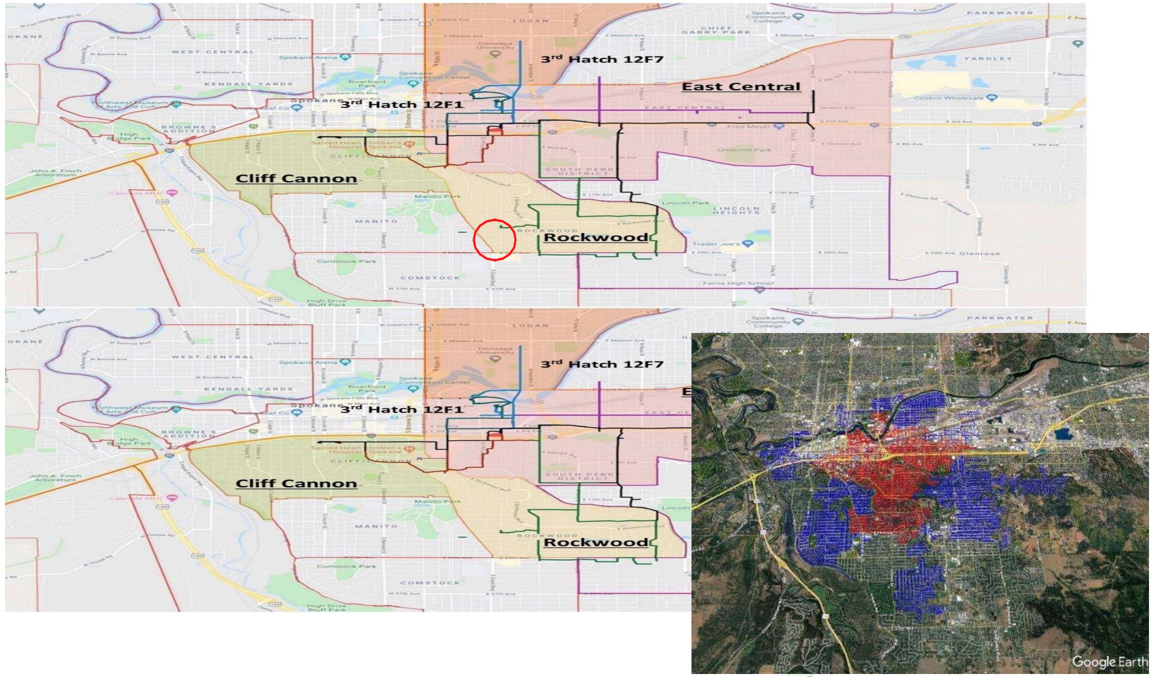
- Spokane Connected Community Project
- UDERMS iCommunity: Utility Managed Distributed Energy Resources (DERs) Intelligent Community – Salt Lake City
- Building Technologies Office/Pacific Northwest National Laboratory Technology and Role





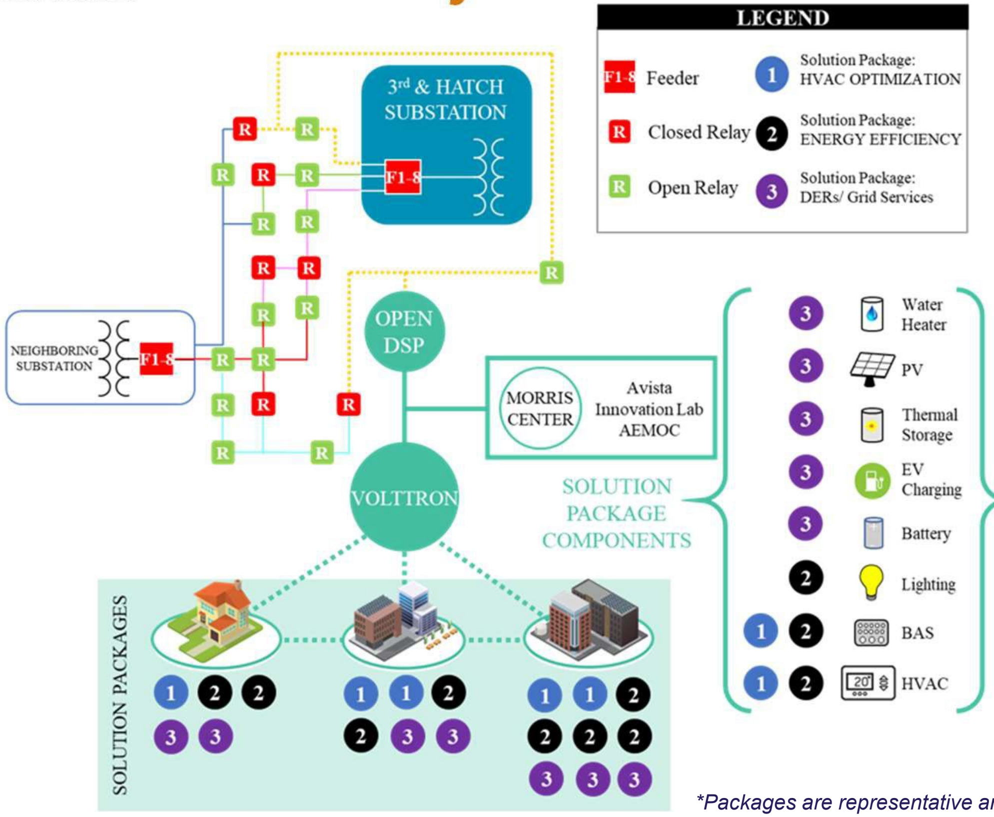
Spokane Connected Community (SCC) Project

We are driven by common goals of addressing climate change and social inequity and doing so in a way that is replicable and scalable



- ✓ Focused on one substation nearing capacity (3rd & Hatch)
- ✓ Engage 75 to 125 customers with demand flexibility (DF) and energy efficiency (EE) solutions
  - ✓ Residential, multifamily, small commercial, and commercial and industrial
- ✓ The project will unlock:
  - ✓ 1.0 to 2.25 MW of DF using buildings & distributed energy resources
  - ✓ Save up to 900 MWh/yr from EE measures
  - ✓ Reduce emissions by up to 650,000 lb CO_2e/yr
- ✓ Playbooks to scale

Connected Community: *Engaging customers served by 3rd & Hatch*



- All buildings served by one substation in opportunity zone
- Mixture of new and existing commercial (25 to 50) and residential (50 to 75) buildings
- Electric vehicle (EV) charging stations, photovoltaic generation, battery and thermal storage, heat pumps, etc.
- Leveraging Opensource

**Packages are representative and exploratory - we will work closely with project partners during the first year to identify packages to prototype and test in the lab*

Expected Outcomes for SCC Project

- **Measure how much DF buildings can provide**
  - Measure how much DF different types of buildings can reliably provide
  - Measure cost/benefit to 3rd & Hatch substation; estimate impact beyond
- **Demonstrate communications platform that optimizes DF dispatch**
  - Distribution grid optimization
  - Communications platform that dispatches portfolios of buildings, distributed energy resources management system (DERMS)
- **Learn what motivates customers to participate in DF programs**
  - Work with Avista to create new options for engaging customers
  - Identify incentives that are effective & could be scaled in new programs
- ***Advance non-wires alternative options***

Utility Managed Distributed Energy Resources ent Community: Salt Lake City (SLC)

- ✓ Resources distributed across the Salt Lake Region
- ✓ Project will unlock DF up to 8 MW using flexible loads in buildings augmented by other DERs
- ✓ EE measures will result between 30% and 50% energy savings

Salt Lake City Connected Community

- UDERMS iCommunity project will implement a **utility managed** “behind the meter” DER control program that integrates diverse types of buildings with a range of flexible loads to optimize grid services and improve building energy efficiency
- Grid services objectives are to:
  - Effectively integrate intermittent renewable resources
  - Enhance resiliency and outage response at the distribution level
  - Ensure resource adequacy particularly during periods of disruptive events, and
  - Defer capital expenses for distribution infrastructure upgrades that serves the community of buildings (8.26 MW)
- Energy efficiency objectives are to:
  - Show that significant savings through design changes to new buildings (30% to 50%) and
  - Operational improvements for existing buildings (10% to 15%)
- Buildings range from:
  - Large suburban apartment complex
  - Downtown complex of mixed-use retail and apartments
  - University laboratory and office building with a microgrid
  - A mass transit transportation center
  - Manufacturing building, and
  - Single-family homes

Project	Location	Description	DERs	Flexible load and Efficiency
Soleil Lofts	Herriman, UT (Suburban Multi Family)	All-electric 610-unit state-of-the-art multi-family community of 22 buildings (12 buildings currently occupied rest constructed in 2021) owned and operated by the Wasatch Group. The complex has on site solar that feeds batteries in each apartment.	Solar: 5.2 MW Batteries: 5 MW and 12.6 MWh EV Chargers: 100-6.6 kW and 2-50 kW	Building Peak Load: 5 MW Flexible: 100% EV load: 760 kW Flexible: 50% Energy Efficiency: 5.6 million kWh-57% saved
Project Open	Downtown SLC, UT (affordable Multi Family)	All-electric three-phase affording housing development with 233 units, spread across 4 buildings developed by the Giv Group. Phase1and 2 are compete, but Phase 3 is still under design. The solar and batteries have not been installed.	Solar: 250 kW Batteries: 136 kW and 240 kWh EV Chargers: 36 Level 2 6.6 kW	Building Peak Load: 3 MW Flexible: 15% EV load: 238 kW Flexible: 50% Energy Efficiency: 1.02 million kWh-49% saved
Diamond Rail	Downtown SLC, UT (affordable Multi Family)	An 80-unit all-electric affording housing apartment complex with street front retail space. The development is currently under construction and is expected to be completed in 2021. Diamond Rail is owned by the Giv Group. It is fed by the same substation as Project Open,	Solar: 60 kW Batteries: 34 kW and 60 kWh water heat pumps:36 kW EV Chargers: 14-6.6 kW	Building Peak Load: 1 MW Flexible: 15% EV load: 92 kW Flexible: 50% Energy Efficiency: Savings TBD 30-50%
UTA Bus Depot	Downtown SLC (Transit Center)	An 80,000-sf bus maintenance and garage facility designed to house 132 electric buses. The facility is currently under construction and will be completed in 2022. It is located at a multi-modal transit hub.	Solar: 250 kW Batteries: 136 kW and 240kWh EV Chargers: 26-60 kW(depot) 3-350kW (hub)	Building Peak Load:1.6 MW Flexible: 50% EV load: 1 MW Flexible: 50% Energy Efficiency: Savings TBD 30-50%
Packsize	West SLC (Industrial park)	A manufacturing and office facility with roof top solar and EV chargers for employees and visitors. The team will explore electrification of warehouse NG heaters that will act as flexible load.	Solar: 200 kW EV Chargers: 50-6.6 kW	Building Peak Load:400 kW Flexible: 15% EV load: 300 kW Flexible: 50% Energy Efficiency: Savings TBD 30-50%
USU ASPIRE Research Center	Logan, UT (rural)	A University microgrid research facility with EV test track located off campus. The building is expanding, and the project team will help design the expansion.	Solar: 250 kW Batteries: 136 kW and 240 kWh EV Chargers: 1- 50 kW, 2-350 kW, 1-500kW	Building Peak Load:350 kW Flexible: 15% EV load: 1 MW Flexible: 50% Energy Efficiency: Savings TBD 30-50%

SCC/SLC Project 5-Year Plan

Budget Period (BP) 1	BP 2	BP 3	BP 4	BP5
• T1: Project Coordination & Support Development of Project Planning Docs • T2: Measurement and Verification (M&V) Plan Development • T3: Avista, Simulation & Modeling, Design of Software, Dev of Incentive Design • T4: Technology Identification, Adaptation & Development	• T5: Project Coordination • T6: Support Testing First Cohort of Buildings and Homes	• T7: Project Coordination • T8: Support Deployment and Testing • T9: Test M&V Approach	• T10: Project Coordination • T11: Technical Support and M&V	• T12: Project Coordination and Closeout
Help draft various project plans and adaptation of BTO/PNNL technologies	**Support pilot test the technologies**	**Deployment Support**	**Help execute M&V process**	

Budget Periods 1 and 2 – PNNL Role: Primarily Technology Provider

- Technical support in finalizing grid service and energy efficiency use cases
- Support drafting the measurement and verification (M&V) plan to quantify energy efficiency and grid service benefits:
  - Behind-the-meter assets (building owner or aggregator perspective)
  - Quantify the value of energy efficiency and grid service use cases to the grid (utility perspective)
- Technical support to identify right mix of building and DER portfolio through simulation and modeling activity that would meet the project goals
- Support in defining the right control solutions for commercial and residential (including multi-family) buildings
- Support Edo in integrating OpenDSO, Eclipse VOLTTRON™ and Edo Controller
- Support PacifiCorp in integrating Eclipse VOLTTRON with OSI (Open Systems International) DERMS

Concluding Remarks: What Success Looks Like

- Successful transfer of BTO-funded, PNNL-developed opensource technologies to our project partners
- Technologies will result in achieving scalable:
  - Demand flexibility between 10% and 20%
  - Reductions in commercial building energy consumption between 10% to 20% through operational improvements
- We have not worked with multifamily buildings, so we are looking forward to that challenge
- We are looking forward to working with small and medium size commercial buildings as well

DOE's Residential Cold Climate Heat Pump Challenge

Vrushali Mendon

Julia Rotondo

Kevin Keene

Sam Rosenberg

Michael Brambley

PNNL is operated by Battelle for the U.S. Department of Energy

Pacific Northwest NATIONAL LABORATORY

Objectives

Accelerate the development and deployment of cold climate heat pump (CCHP) technologies by:

- Developing a new technology specification for a high-performance CCHP that meets consumer needs in partnership with heat pump manufacturers
- Demonstrating the CCHP performance in the lab and in the field
- Launching pilot programs with partners, such as utilities, to identify and alleviate installation challenges

Scope of the Current Challenge: Residential, Centrally Ducted, Electric-only HPs that perform better than today's products

Effort At A Glance

Partner Engagement (2021 – 2023)
- Major manufacturing partners
- Utility & Coop Partners across northern US

Lab Testing (2022 – 2023)
- Lab testing of units at ORNL in collaboration with Guidehouse
- Pass/Fail result

Field Validation (2022 – 2024)
- PNNL leading field validation effort
- NREL facilitating DR tests on units

Analyzing & Reporting (2023-2025)
- PNNL analyzes performance data
- DOE publishes anonymized fundings; coordinates with utility and coop partners for potential inclusion into incentive programs

Public Launch

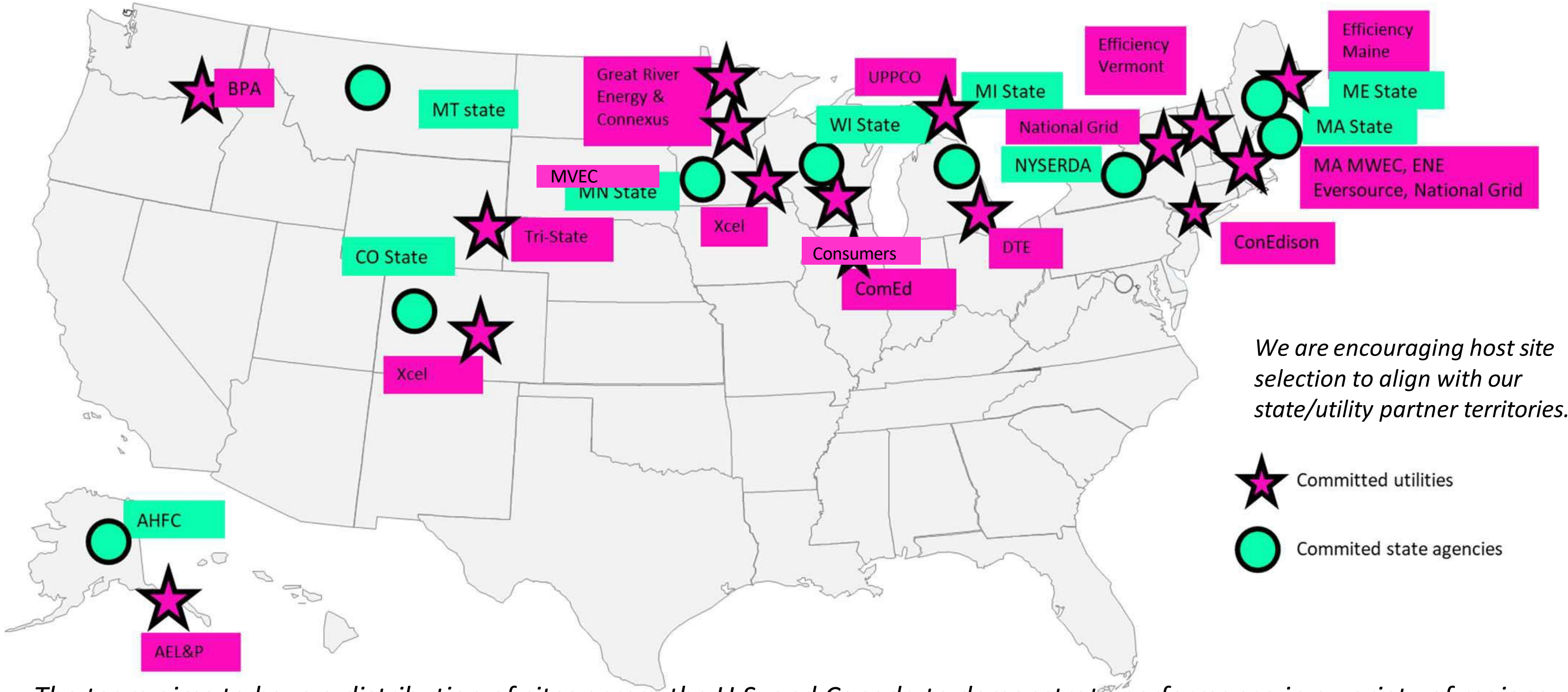
- At the November 2021 launch event, VP Harris and Sec. Granholm recognized six leading HVAC manufacturers for their commitment to the Challenge. Four other manufacturers have subsequently joined.
- DOE conducted roundtable discussions in Massachusetts and then the Upper Midwest in December 2021, including DOE leadership, members of Congress, manufacturer partners, state/utility partners, and other stakeholders.
- In January 2022, Secretary Granholm also announced the state and utility partners participating in the Challenge.

Nov. 1st Launch with VP Harris and Sec. Granholm in NY

Dec. 3rd Event in Massachusetts

Jan. 26th Event with Leaders in MN and Other Midwest States

Current State & Utility Partners



We are encouraging host site selection to align with our state/utility partner territories.

The team aims to have a distribution of sites across the U.S. and Canada to demonstrate performance in a variety of regions, climate zones, and home designs to support greater industry knowledge and market acceptance.

Scope of the CCHP Challenge

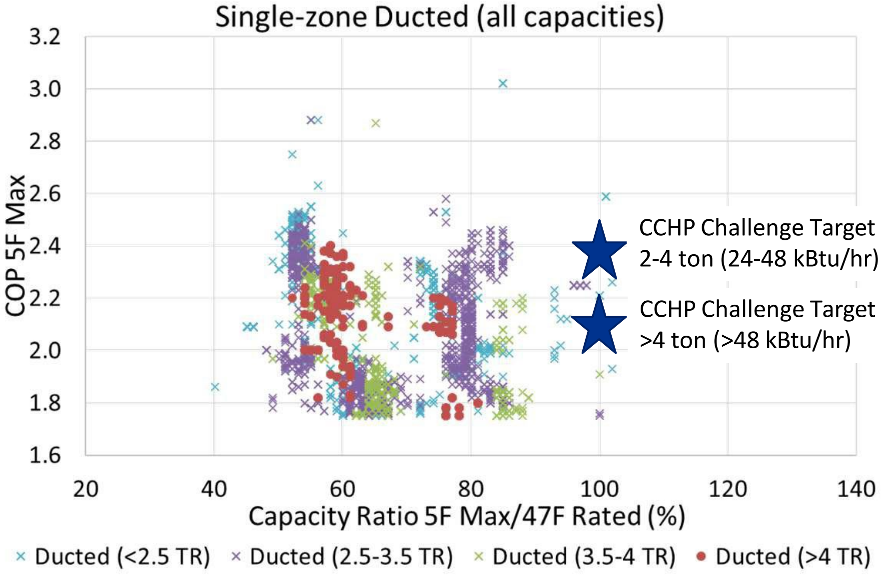
Residential, centrally ducted, electric-only HPs that perform better than today's products:

- Nominal cooling capacity 24,000 – 65,000 Btu/hr
- Comply with all applicable federal and state standards
- Perform efficiently in cold climates (capacity and COP challenge specification for 5 °F [-15 °C] and optional challenge for -15 °F [-26 °C] outdoor temperatures)
- Employ low-GWP refrigerants (< 750 GWP, AR4 100 year)
- Incorporate advanced controls and grid-interactive capabilities

Out-of-Scope: Air-to-water, Ductless, Multi-split, Hybrid/dual fuel, Commercial (may be considered in the future)

Challenge Specification

Comparison with Commercially Available Products from the NEEP CCHP Database



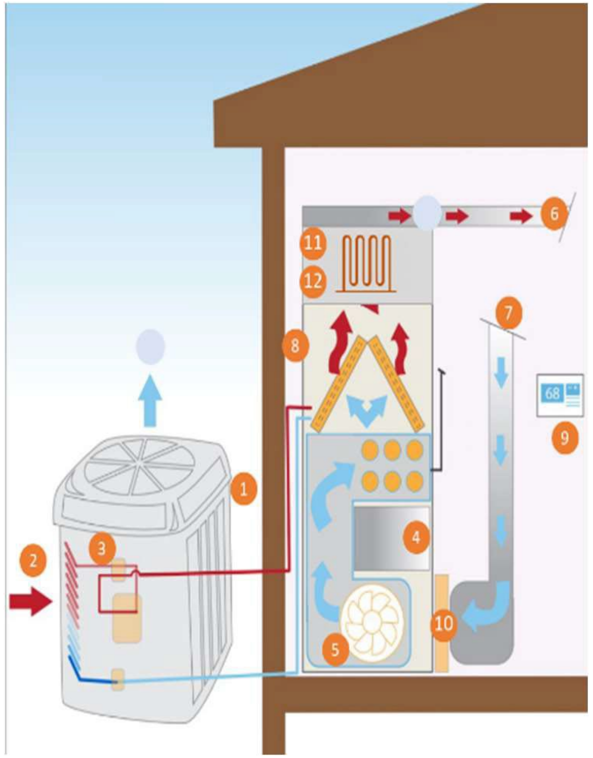
Full specification and test procedure can be found on the DOE Cold Climate Heat Pump Challenge website.

Challenge Specifications:

- High efficiency (COP): 2.1 (>4 ton) or 2.4 (2-4 ton) COP at 5 °F
- Capacity turndown ≥ 30%
- Strong capacity maintenance (i.e., 100% heating capacity at 5 °F, strong performance to below 0 °F)
- Low temperature compressor cutout below -10 °F or -20 °F (optional)
- Auxiliary heat staging (most 3+ stages)
- Low GWP refrigerants (< 750 GWP)
- Grid-interactive capabilities to assist with installation, fault detection, demand response, and other activities (AHRI 1380).

Instrumentation and Data Acquisition Strategy

Inst. ID	System	Parameter	Measuring equipment	Location	Sampling Interval
1	Outdoor unit	Power	Power meter + current transducer	Outdoor unit circuit	1 second
2		Temperature/RH	TC/RH sensor, solar shield	Outdoor unit inlet	5 minutes
3		Heat / cool / defrost mode	Relay	At reversing valve	1 second
4	Indoor unit	Power	Power meter + current transducer	Indoor unit circuit	1 second
5		Fan power	Power meter + current transducer	Indoor fan circuit	1 second
6		Temperature/RH	(4) TC/(4) RH sensors	Supply air outlet	1 minute
7		Temperature/RH	TC/RH sensor	Return air inlet	1 minute
8		Temperature/RH	TC/RH sensor	Unit Ambient	1 minute
9		Temperature/RH	(3)TC/(3) RH sensor	Indoor conditioned space	1 minute
10		Air flow	Airflow metering plate	Air handler return / filter housing	Upon installation, airflow rate will be correlated with fan power
11	Auxiliary Heat	Power	Current transducer	Electric heat strip	1 second



Adapted from MN CEE Field Study (2017)

Year 1 Winter Performance Results

- Winter performance data collected to date looks promising, but
  - Too early to make a dedicated public announcement outside more technical gatherings of SMEs
- Positive trends
  - Most installed HPs are operating well with no major operational issues
  - Most HPs are providing the majority of the heating load with little assistance from auxiliary heat
- Key limitations
  - Limited amount of data (12 units, ~3-16 weeks of data collection depending on installation date, reliability issues with specific units limiting trend analysis)
    - ✓ Need more data to confirm in-field performance levels for some units as they have had persistent operational issues
  - Need more colder temperature performance data for assessment for some sites

Field Validation Progress and Next Steps

- Year 1 Sites
  - Continue monitoring the installed prototype units through March 2023
  - Compile survey data results and evaluate non-energy metrics
- Year 2 Sites
  - Install new units and M&V equipment for new sites. Will be in field through August 2024
- Next Steps (2024)
  - Monitor installed prototype units and compile overall trends and de-identified, aggregated data for sharing with partners
  - Work with state/utility partners to incorporate the findings into their CCHP programs, trainings, marketing materials, and other deployment resources to support commercialization efforts

DOE Heat Pump Database

[redacted]

Heat Pump Database

About Study Data Site Data Add Data Log in

Heat Pump & Heat Pump Water Heater Field Database

Residential and commercial heat pump technologies are field tested by programs across the United States. The Heat Pump Field Database is a centralized data repository that provides easy data upload and download for the nation's leading heat pump and heat pump water heater researchers. Users can use the buttons below to get started on any of the actions described.

- **Upload Your Complete Datasets**:
  - Publish data to a publicly accessible database that is accessible via the cloud.
- **Download Custom Datasets**:
  - Create queries using project metadata to filter for only the datasets that are relevant to your research.
  - Includes visualizations of data

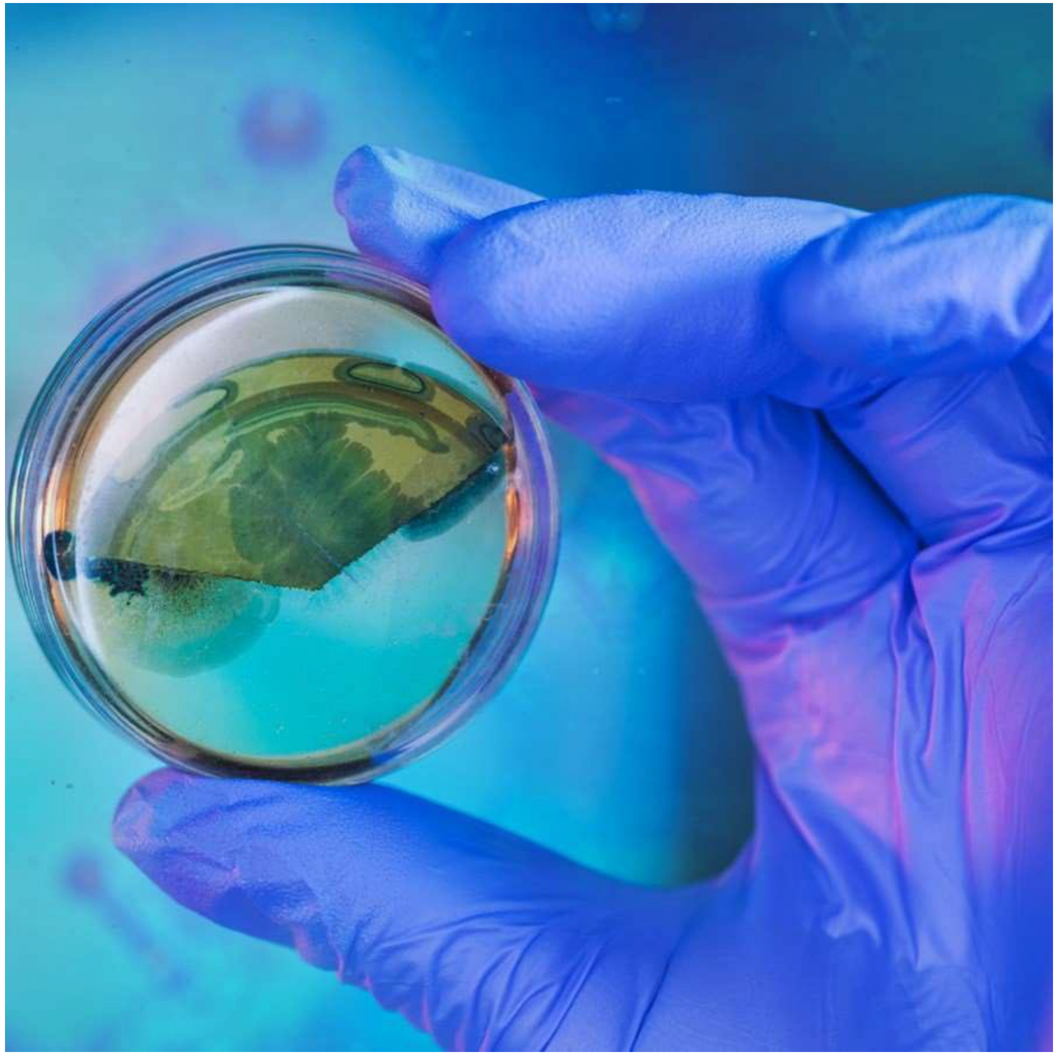
Want Heat Pump data? Check out our data catalog linked below. You can search through the available datasets using filters and find just the data that you are looking for!

Go to the DATA CATALOG

Reducing Airborne Disease Transmission with Least Energy and Carbon Emissions

Gabe Arnold
Belal Abboushi
Cary Faulkner
Jason Tuenge

Pacific Northwest National Laboratory
U.S. Department of Energy
Berkeley Lab
Lawrence Berkeley National Laboratory



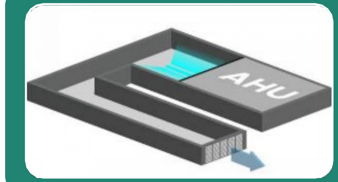
Germicidal Ultraviolet (GUV) Air Disinfection Technology

Upper-room GUV

- Typically low-pressure mercury (254nm) or LED (265-280nm)
- Disinfects air in region above occupants
- Relies on room air-mixing for disinfection

Whole-room GUV

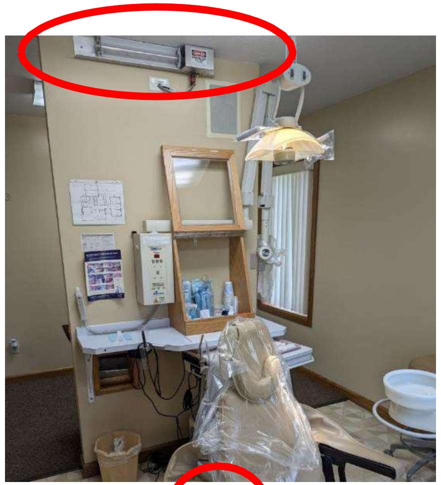
- Typically krypton excimer (222nm)
- 222nm has much higher safety limits than 254nm, safer for direct human exposure
- Directly disinfects air in occupied zones

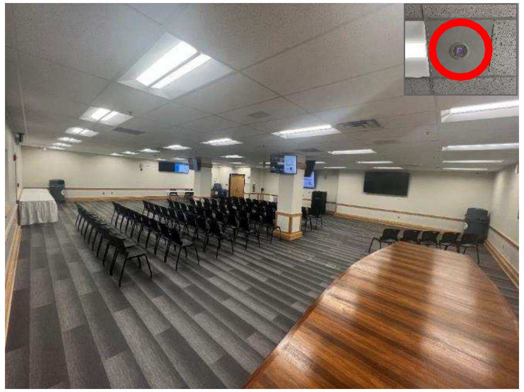


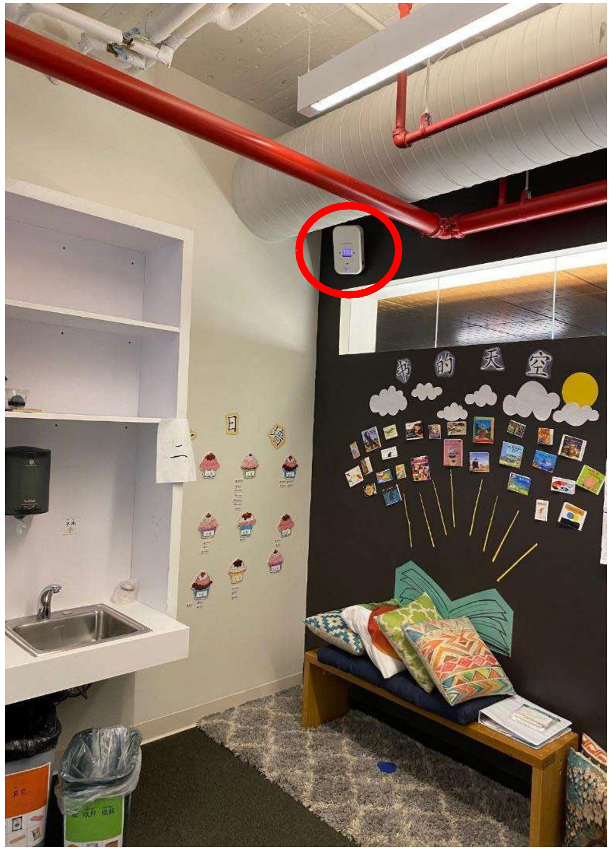
In-duct GUV

- Typically low-pressure mercury (254nm) or LED (265-280nm)
- Only disinfects recirculated air
- Less effective for in-room person-to-person transmission

Examples of GUV installations PNNL is evaluating







In May 2023, CDC announced new ventilation recommendations

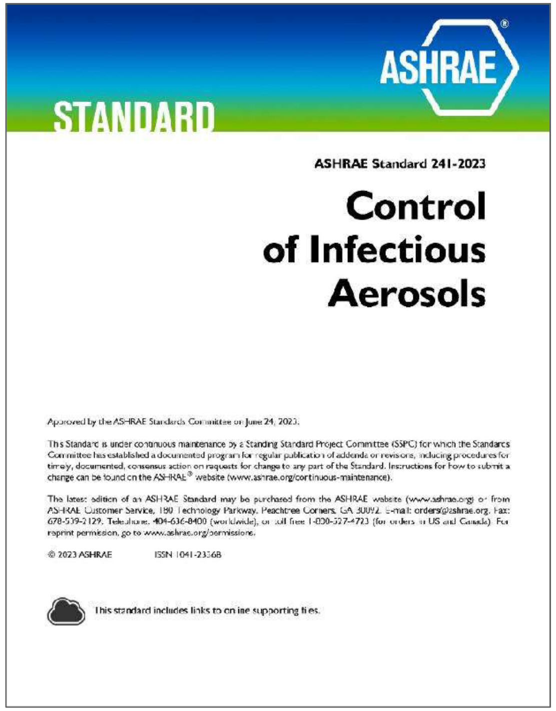
CDC sets first target for indoor air ventilation to prevent spread of Covid-19

by Brenda Goodman
Published 5:51 PM EDT, Fri May 12, 2023

- Recommends 5+ equivalent air changes per hour (eACH) in occupied spaces
- https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

Images Source: Mariano Safra / Javier Salas / EL PAIS

In July 2023, ASHRAE released ASHRAE 241: Control of Infectious Aerosols


STANDARD

ASHRAE Standard 241-2023

Control of Infectious Aerosols

Approved by the ASHRAE Standards Committee on June 24, 2023.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 180 Technology Parkway, Peachtree Corners, GA 30092. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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This standard includes links to online supporting files.

- Establishes design targets for Equivalent Clean Air (ECAi) to be provided during Infection Risk Management Mode (IRMM)
- IRMM = Periods of increased airborne infection risk, to be defined or determined by building designer, operator, and/or owner
- Expected to be codified over time

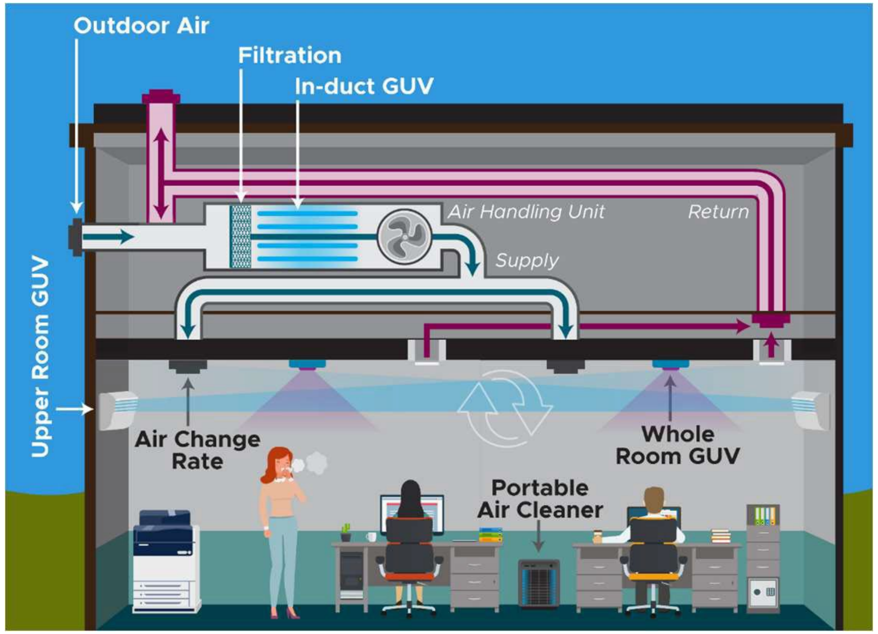
Images Source: Mariano Safra / Javier Salas / EL PAIS

New ASHRAE Standard 241 and CDC targets have large potential energy and climate impacts

Comparison of recommended eACH for common space types assuming 1,000 sq. ft. room, 8 foot ceiling, and ASHRAE 62.1 default occupancy levels

Space Type	ASHRAE 62.1 eACH	CDC eACH	ASHRAE 241 eACH
Office	0.6	5	1.1
Classroom	2.8	5	9.4
Restaurant dining	5.3	5	31.5
Retail	1.3	5	4.5
Gym	2.4	5	4.2
Public assembly	6.0	5	56.3
Place of religious worship	5.0	5	45
Healthcare exam room	2.0	5	6
Healthcare patient room	2.5	5	10.5
Healthcare waiting room	2.0	5	13.5

What measures are most effective and energy efficient to achieve ASHRAE Standard 241 and CDC targets?

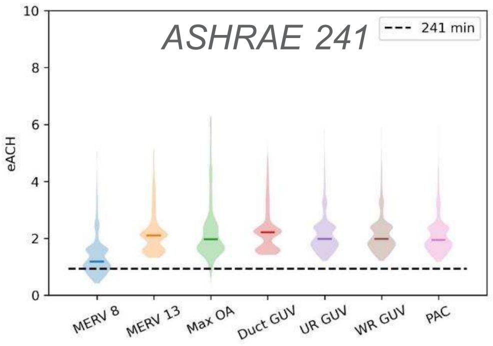


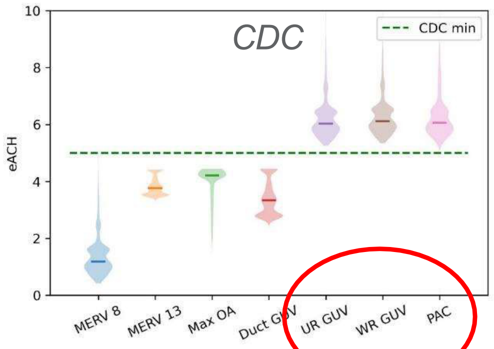
Tools in the toolbox:

- Increase outdoor air ventilation
- Improve ventilation filtration (e.g., MERV13, HEPA)
- Increase room air change rate (ACH)
- Install in-duct GUV
- Install upper-room GUV
- Install whole-room GUV
- Install portable air cleaner

Preliminary simulation results for medium office building

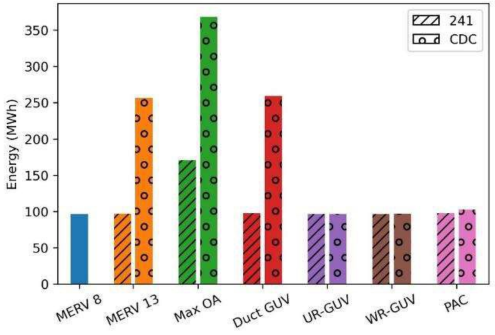
What measures can achieve ASHRAE 241 and CDC targets in prototypical office building?





Only in-room measures achieve CDC targets

What measures are most energy efficient to achieve ASHRAE 241 and CDC targets in prototypical office building?



Total annual energy usage

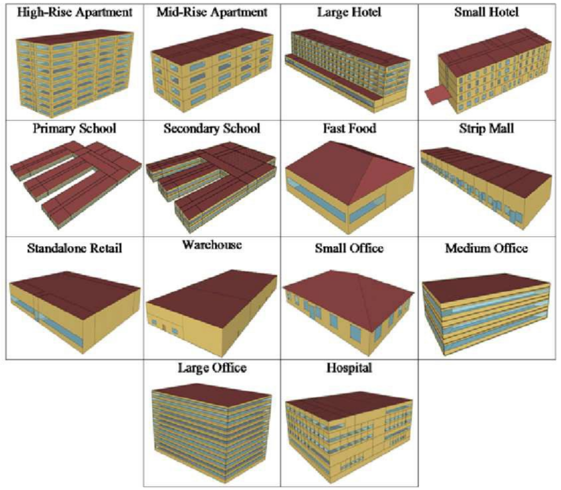
Measure	ASHRAE 241	CDC
MERV 8 filter	19 kWh/eACH	
MERV 13 filter	9 kWh/eACH	14 kWh/eACH
Max Outdoor Air	19 kWh/eACH	21 kWh/eACH
Duct GUV	9 kWh/eACH	16 kWh/eACH
Upper Room GUV	10 kWh/eACH	3 kWh/eACH
Whole Room GUV	10 kWh/eACH	3 kWh/eACH
Portable Air Cleaner	11 kWh/eACH	3 kWh/eACH

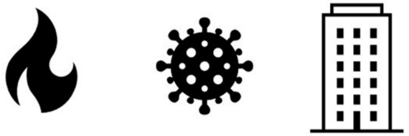
Average energy usage per effective hourly air change

80% less energy per eACH

Next Steps

- Office building results have been submitted to peer-reviewed journal
- Expanding model to other building types (school, restaurant, public assembly, etc.)
- Conducting life cycle economic analysis of GUV vs. other measures
- Conducting multi-contaminant analysis also including wildfire smoke
- Working with GSA to validate energy/carbon reductions in real-world settings





Current GUV Project Activities

Simulation Models

- Assess effectiveness, efficiency, life cycle costs of mitigation measures across building types and climate zones
- Consider multiple contaminants with airborne pathogens and wildfire smoke

Framework Development

- Propose metrics and considerations to improve comparability of mitigation measures
- Define standard reference scenarios

GUV Field Evaluations

- Assess real-world performance (energy, effectiveness, safety, acceptance, etc.) of GUV across wide range of applications
- Deep dive comparison of GUV and HVAC energy performance in GSA facilities

GUV Product Testing and Evaluations

- DOE CALiPER Program
- Independently test commercially available GUV products
- Assess current test methods; reduce inaccurate product claims; educate

Pacific Northwest
NATIONAL LABORATORY

Understanding the Human Element in Advanced RTU Controls Adoption

Ruth Taylor
Jessica Kelly
Jeff Wanner

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

Background – NGLS Living Labs

- Focus on the intersection of technology and its implementation.
- Maintain ongoing, dynamic installations: upgrade, renew, and expand over several years.
- Engage multiple constituents: manufacturers, owners, users, and design and construction participants.
- Follow rigorous installation, configuration, operation, and evaluation protocols.
- Provide both quantitative and observational research results.
- Operate with the guidance of diverse teams of designers, engineers, utility consultants, and others drawn from the lighting profession.

Next Generation
LIGHTING SYSTEMS

NGLS seeks to provide robust input to those who make the products and those who use them, with the goal of improving the human and energy performance of the next generation of lighting systems.

Conducting Observational Research

Key elements of conducting observational research about building systems:

- Collect qualitative and quantitative data
- Hear from multiple perspectives and avoid research bias
- Human observation and synthesis provide the WHY

QUALITATIVE & QUANTITATIVE

MULTIPLE PERSPECTIVES

HUMAN OBSERVATION & SYNTHESIS

Technology Categories

Baseline: Status Quo/ Standalone

Standalone systems lack communication infrastructure and must be locally controlled and operated.

Control Upgrade 1: Networked Thermostats

Connected thermostats can communicate with each other as well as with a centralized data collection platform. Networked equipment also allows for easy access and control of thermostats.

Control Upgrade 2: Advanced RTU Control

Mechanical components, such as economizers, are added to existing equipment. Other retrofit solutions can integrate occupancy sensors or variable speed fans and provide automatic fault detection.

Control Upgrade 3: Light Commercial BAS

A software platform is integrated to support demand flexibility, automatic fault detection and energy use optimization.

Equipment Upgrade: Unit Replacement

- Selected 10 vendors for observations
- Pelican has dominated installations and conversations for simple upgrades

FY23 Pilot Field Observations

Observation 1
Control Upgrade: Option 1

Technology: Pelican networked thermostat

Site: LBNL FLEXLAB

Observation 2
Control Upgrade: Option 1 & 2

Technology: Pelican networked thermostat, occupancy sensors, PEARL economizer controller

Site: LBNL B90 Conference rooms and B90c Trailer

Observation 3
Control Upgrade: Option 1 & 2

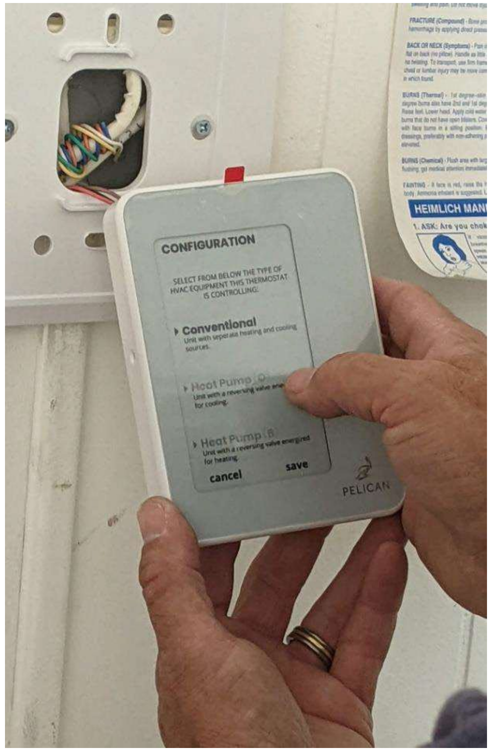
Technology: Pelican networked thermostat with DCV and PEARL economizer controller

Site: Shane Co jewelry store in San Mateo, CA

FY23 Observation Takeaways

Technology:

- A thermostat is one component of a larger system – ability to problem-solve based on unknown existing conditions is critical.
- Thermostat replacement, baseline commissioning, verification, and troubleshooting took between 1 and 5 hours (included economizer upgrade). Equipment costs were under $500.
- Pelican documentation was “exceptional” compared to other manufacturers. Web interface is not intuitive – lots of important settings buried under “Admin”.



Methodology:

- Observers/Evaluators should be comfortable with technical language related to technology & varying perspectives (steering committee) are invaluable.
- Team needs to consider verification protocols for standardized product review. Varying levels of automated commissioning/ performance verification, equipment limitations, and complex Sequence of Operations (SOO) need to be considered.

FY24 Task Details

Task 1: Field Observations
Location: Onsite
Talk to: Installing contractors, property managers, facility staff, tenant
Share with: Manufacturers, workforce
Focus on: Design, installation, startup/programming, contractor verification
All observed sites will also be evaluated and surveyed/interviewed.

Task 2: Performance and User Evaluations
Location: Onsite
Talk to: Tenant, Owner-Occupants
Share with: Workforce, owners, property managers
Focus on: Operation and ongoing maintenance
All evaluated sites will also be surveyed/interviewed

Task 3: Surveys and Interviews
Location: Offsite
Talk to: Building owners, tenants, property managers
Share with: Utility programs, other DOE programs, owners, tenants
Focus on: Decision-making, product selection, operation, ongoing maintenance

Task 4: Coordinate with other Programs
Location: Offsite
Talk to: All parties
Share with: Researchers, DOE
Focus on: All phases

Kimco Partnership

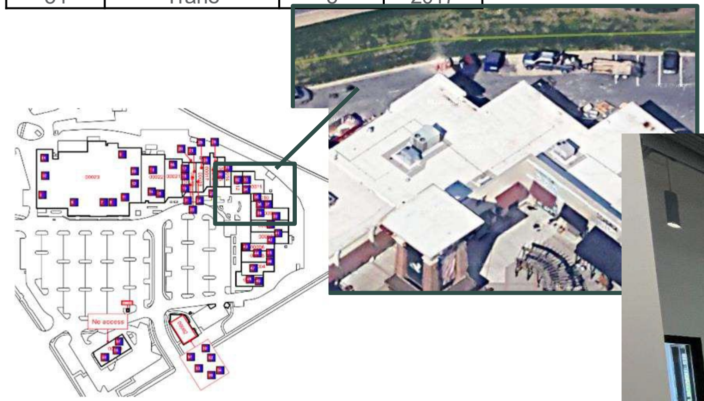
- Established, long term relationship
- Extensive national portfolio
- Variety of tenants (chains and local)
- Diversity in types of leasing agreements
- Mixture of building types – strip malls, indoor malls, stand alone

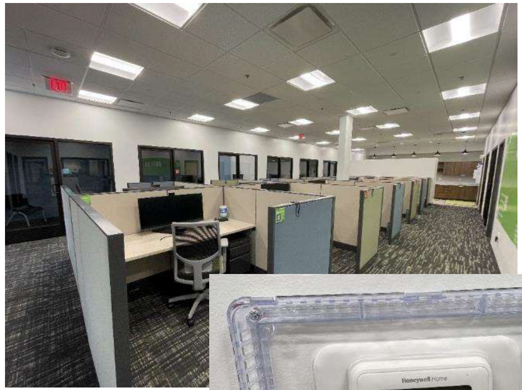
Business	Chain	Local	Size		Use
Vacant			2300		Strip mall
Novant Medical Group		x	4000		Medical
Salsarita's Mexica G	x		2400		Restaurant
Orangetheory Fitne:	x		3057		Fitness
Quail Hollow Vet Hospital		x	2972		Medical
Quail Cleaners		x	1800		Strip mall
Umai Sushi		x	3305		Restaurant
Fresh Dental			3661		Medical
Vacant - former restaurant			4673		Restaurant
Waterbean Coffee		x	1242		Restaurant
Kimco Office	x		7960		Office
McDonalds	x		2300		Restaurant
Wolfman Pizza		x	1665		Restaurant
Nail Tek		x	1775		Strip mall
UPS	x		1700		Strip mall
Dominos Pizza	x		1700		Restaurant
Rusty's Deli		x	1775		Restaurant
Queen City Dance		x	5368		Fitness
Walgreens	x		8649		Pharmacy
Harris Teeter	x		51486		Grocery
Wells Farog ATM	x		400		Strip mall

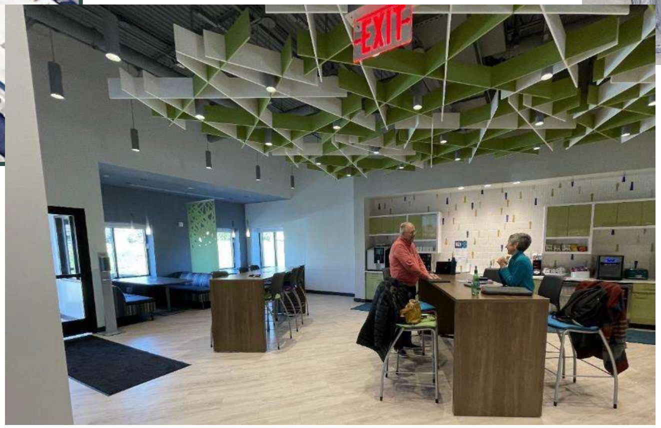
Kimco Regional Offices

ID	Manufacturer	Size (tons)	Install Date
29	Carrier	7.5	2004
30	York	5	2011
32	Goodman	6	2013
33	Trane	20	2014
34	Trane	5	2017

Charlotte, NC
Kimco Regional Office – 7960 ft²
5 RTU replacements







- Multiple thermostat manufacturer installations
- Kimco basic requirements (remote access, communication between thermostats)
- Kimco will select ‘winning’ thermostat for permanent installation

Synergies with:
- Smarter Small Buildings Campaign
- Energy Star for tenants

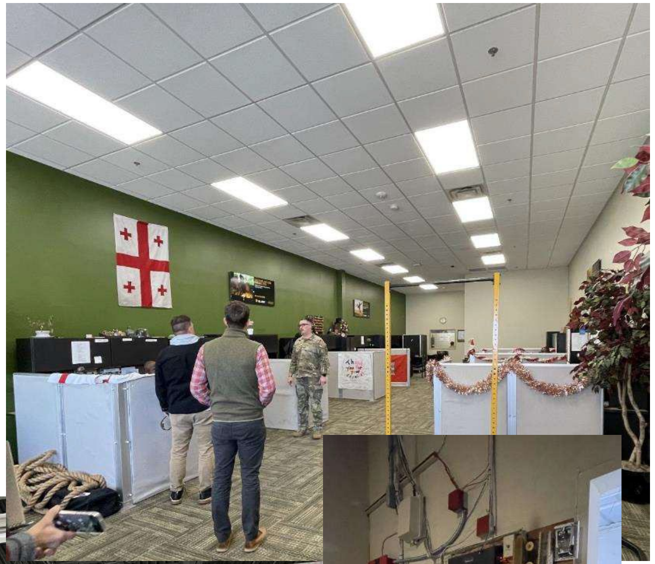
Other Kimco Observation Sites

Tyvola Mall, Charlotte, NC
Army Recruitment Center

- Occupied space
- Gross lease
- Explore options to test ‘worry free lease’

Crossroads Plaza, Raleigh NC
US Recruitment Office

- Unoccupied space, new buildout
- Kimco managing and funding buildout
- Worry free lease possibility

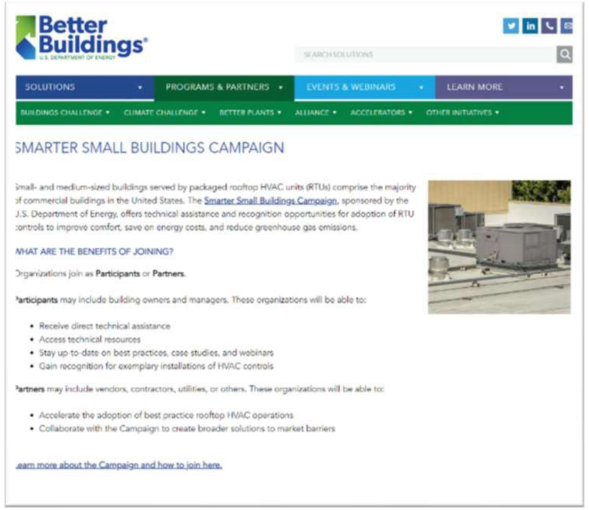


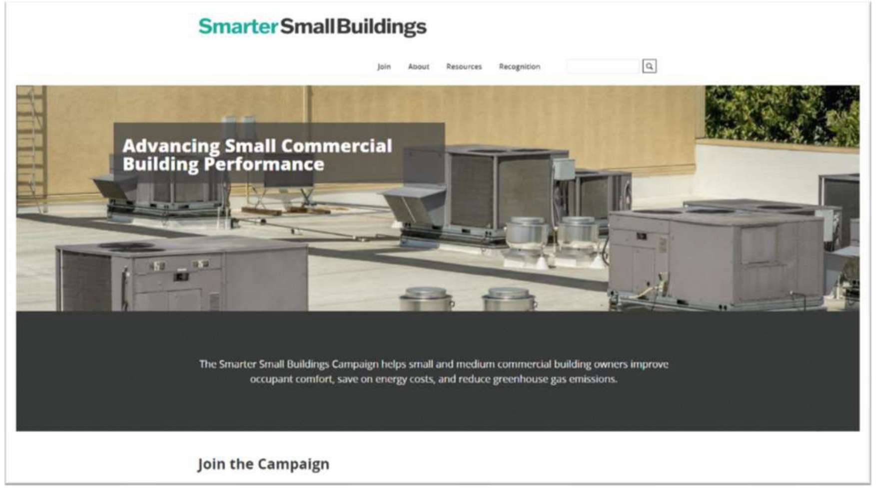
Coordinate with Intersecting Programs

- CBI Smarter Small Buildings Campaign (LBNL - Crowe)
- CBI Heat Pump RTU Campaign (PNNL - Wanner)
- CBI Small Buildings Energy Equity Scoping Study (PNNL - Mayhorn)

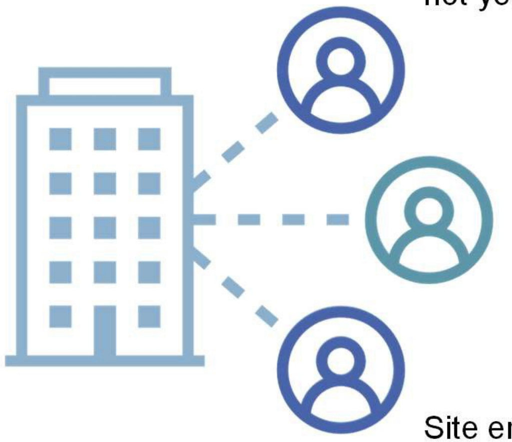
Outcomes/Impact

- Avoid duplication of efforts across BTO portfolio
- Advance outcomes and technology adoption





SSBC Coordination Example



SSBC connects with a site that is engaged but not yet ready for the campaign.

Human Factors of RTU Controls observes future/planned installation.

Site enrolls in the SSBC after installation is complete.

Love to hear from you and collaborate!

Axel Pearson

National Emerging Technology Council

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Break

Return @ 10:45 AM

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Agenda

8:30 am	Welcome and Announcements
9:00 am	*New!* PNNL Emerging Technology Update
10:15 am	*Break*
10:30 am	*New!* Water Heating Update
11:30 am	*New!* Residential HVAC Update
12:30 pm	Wrap-Up

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Water Heating Update

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https://commercialhvactoronto.ca/rooftop-units/

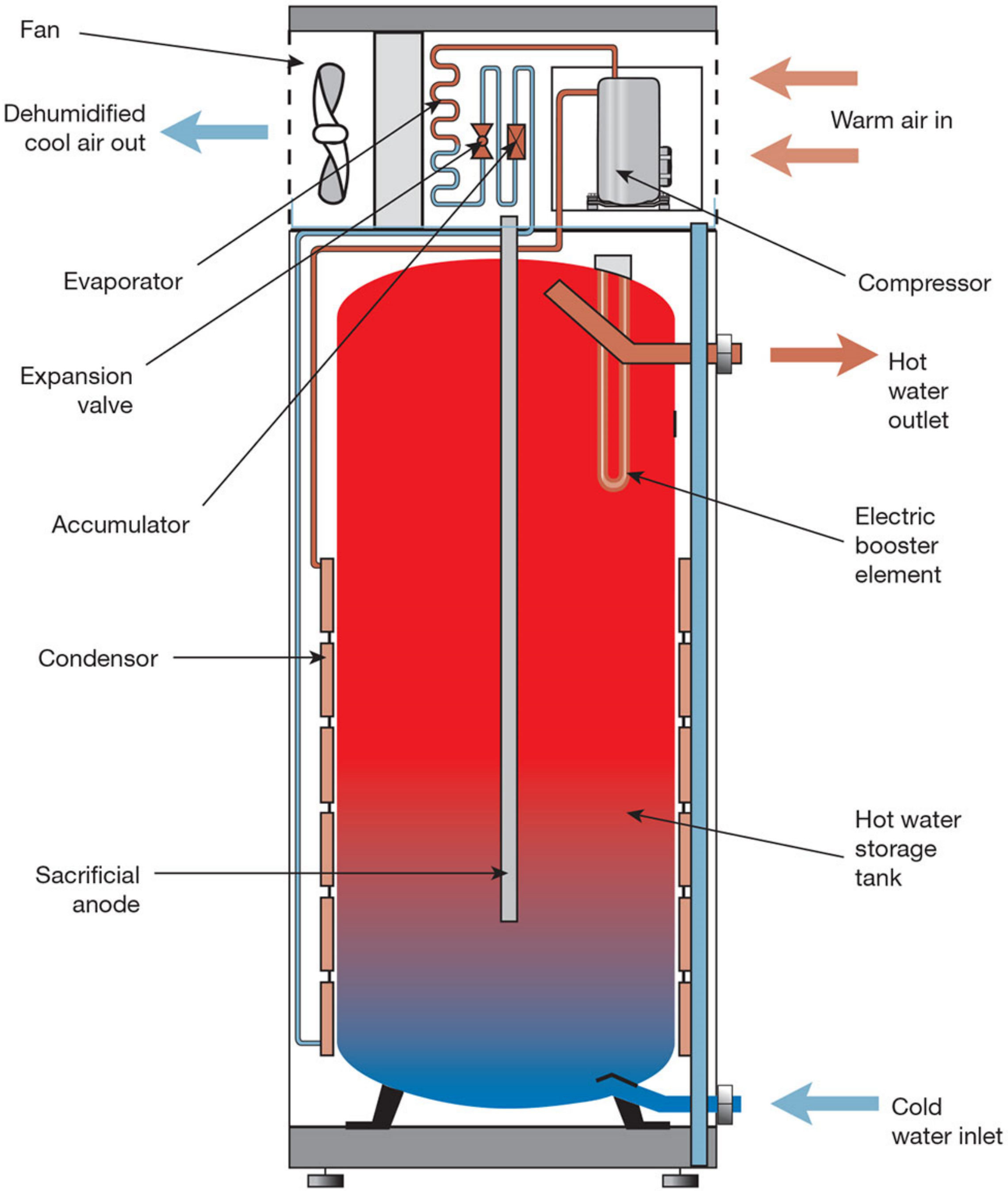
RETAC Water Heating Update

Noe Contreras, Geoff Wickes, Keshmira McVey

BPA, NEEA

December 14th, 2023

CLASSIFICATION LEVEL PUBLIC



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Electric Unitary 2023 Summary

Completed 2023
Planned 2024

Geoff Wickes

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✓Research Completed 2023 (Unitary)

- Completed:
  - ✓ Space constraint Study "Amazing Shrinking Room" leveraged Outside of region money for additional insights
  - ✓ Research supporting DOE proposed rule making
  - ✓ Developed initial draft of "x" Prize socialized with national labs
  - ✓ Support ACEEE Hot Water forum – three panels. Confined space, multifamily and connected water heaters
  - ✓ Updated technical bulletins and installation guides with market partners – Better Bricks, RHA and ENERGY STAR ®
  - ✓ Tested several new products on the market from new actors – more coming all the time

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Updated Technical Bulletins and Spec Sheets

- Better Bricks – Single Family & Multifamily Tech Sheets – Q1-2024 publishing
- Location by Climate Zone One Pager Q1-2024 publishing
- Technical Presentations on water heater locations in new construction for single family, townhomes and multifamily one to one. ACEEE, ENERGY STAR ®, AWHI, CA Tech Program
- Supported AWHI in Builders Council – 4 different sessions
- RHA Technical Training Manual and Assessment Tool

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How is the load spread out by building type? – Unitary has a role

- According to Residential Building Stock Assessment II (RBSA II)
  - Most Low-Rise buildings…
    - have in-unit water heater,
    - which is electrically heated,
    - and is installed within the dwelling unit in a space <1,000 ft3.

- This is for all existing buildings, but new construction can be designed for HPWH.
- In the 2021 Power Plan, the Northwest Power and Conservation Council expects construction of **20,000+** low-rise dwelling units per year for the foreseeable future.

	0–55 Gal	>55 Gallon	All Sizes
Electric	87%	2%	88%
Natural Gas	12%▲	0%	12%
All Types	98%	2%	100%

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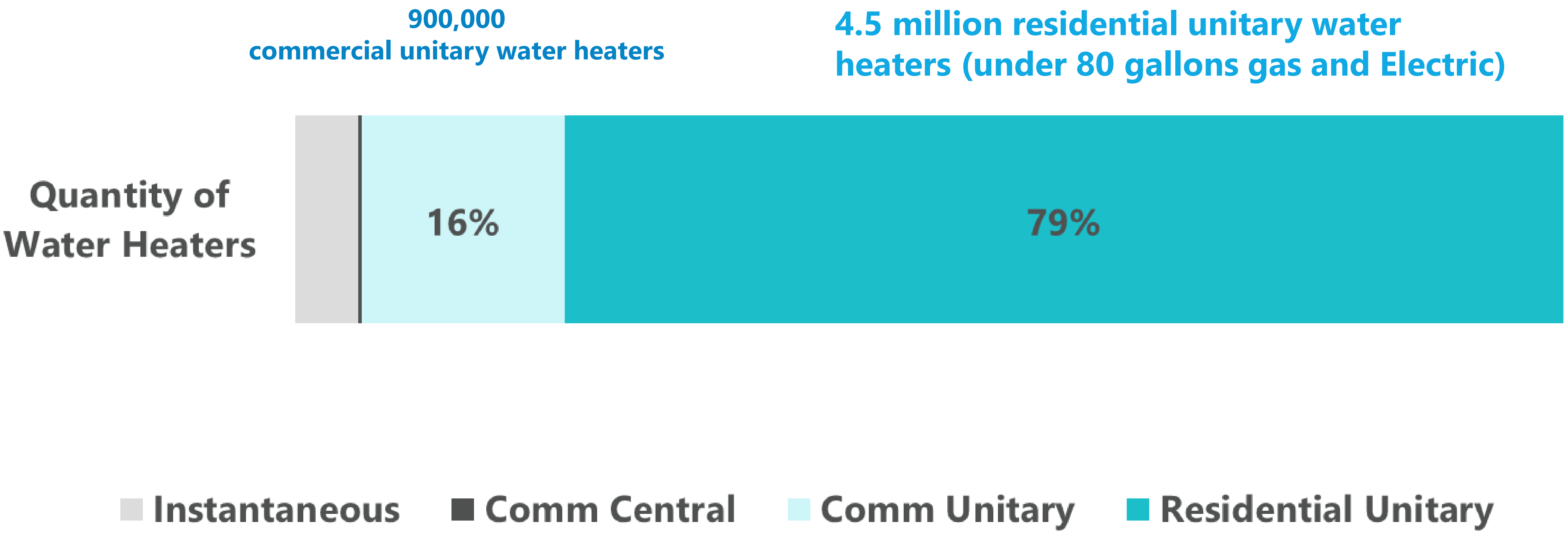
Residential unitary water heaters represent 79% of the existing water heaters in the Pacific Northwest



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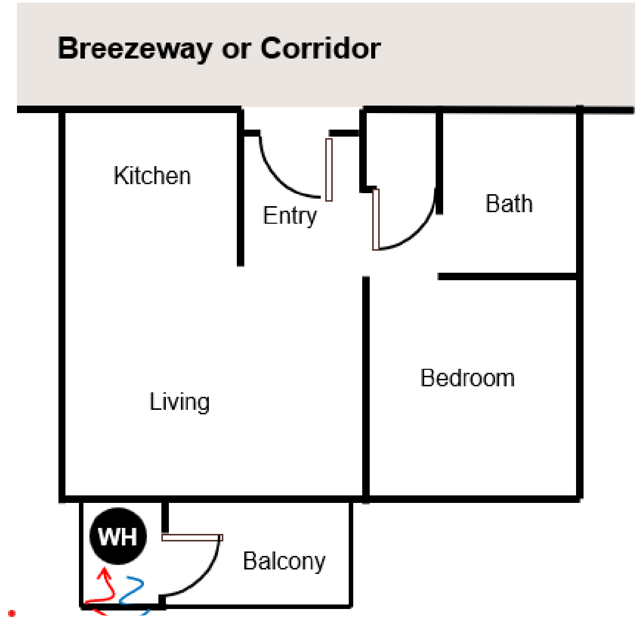
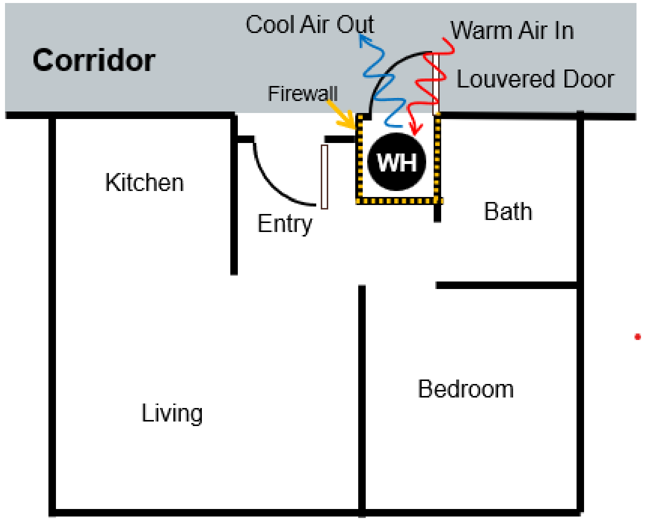
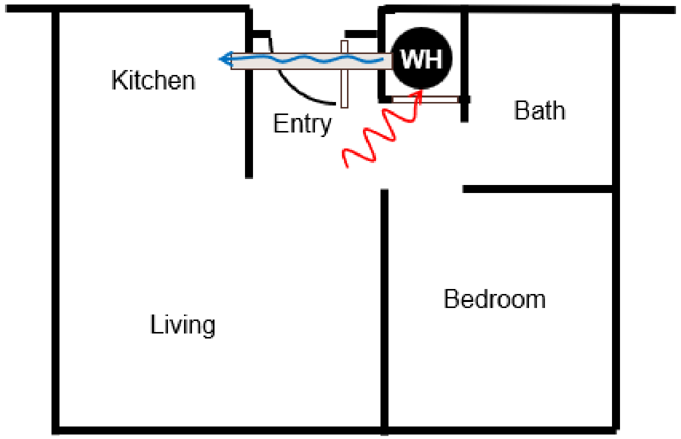
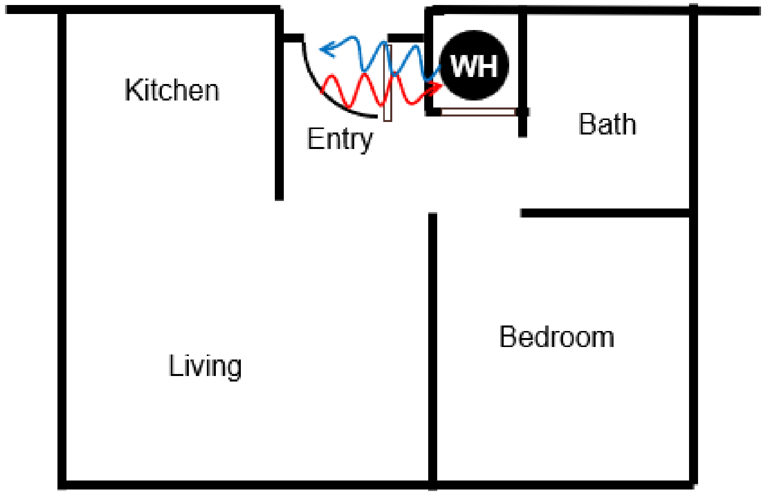
Examples of designs and locations in Multifamily

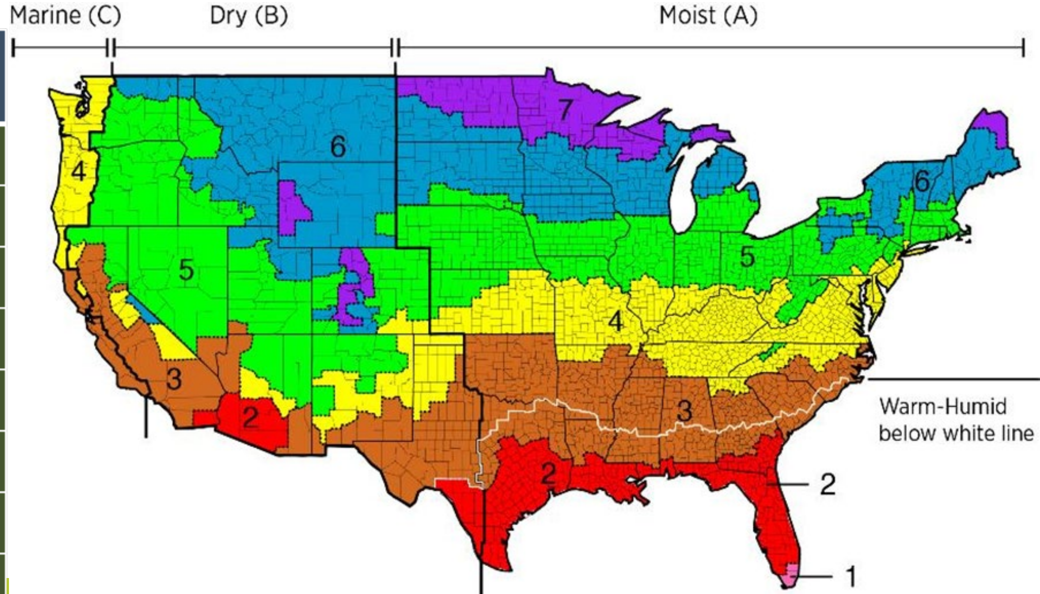




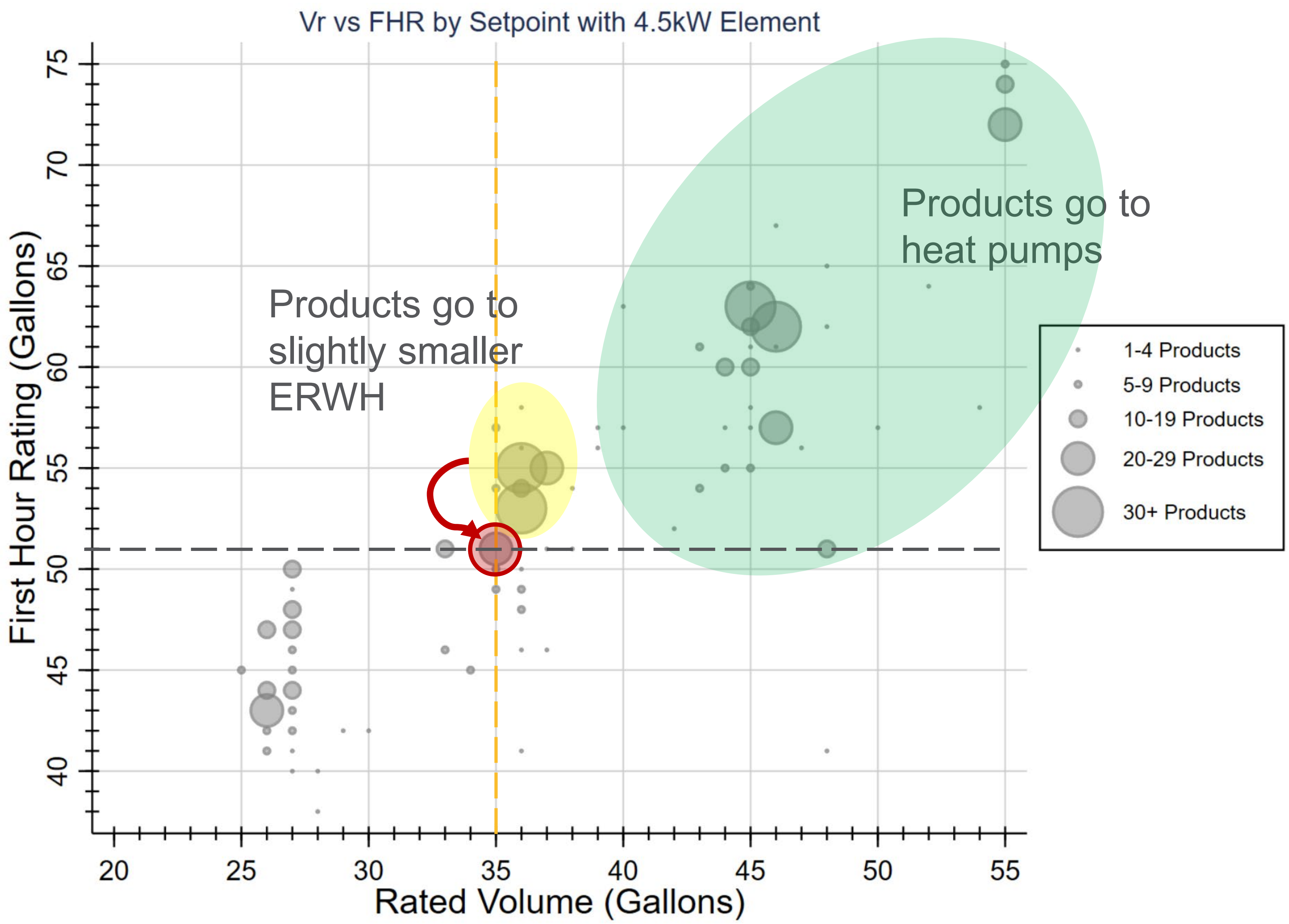




Climate Zone	Corridor Closet	Exterior Closet	Interior Closet
1			
2			
3			
4 A+B			
4 C			
5			
6			
7			



DOE NOPR Electric The Future Market Set to take effect 2029



In a future market, where ERWHs are limited in FHR ≤50 gallons, we expect that existing products, with significantly larger FHRs, will be replaced with heat pumps (green area).

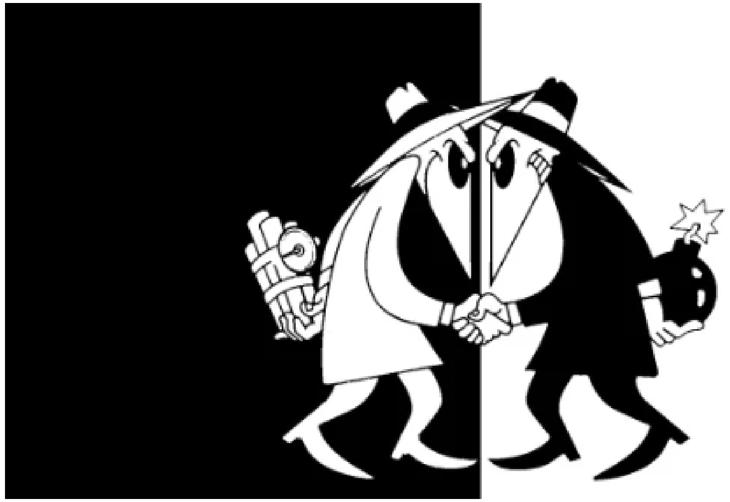
The cluster of models with a 40-gallon nominal volume (36-gallons rated) will not necessarily transition to heat pumps (yellow area). These models could convincingly be replaced by a new set of ERWHs with a 38-gallon nominal volume (35-gallon rated) (red area). The FHR would be 2-5 gallons less (10%), depending on the exact existing design. For most replacement applications, a 38-gallon nominal (35-gallon rated) will provide equivalent performance to a 40-gallon nominal model.

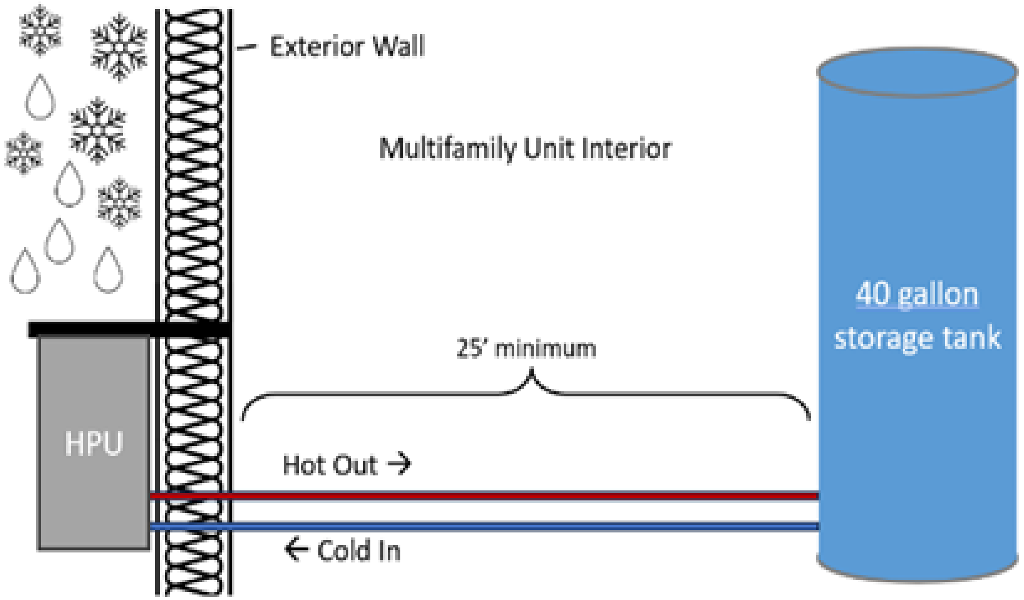
In contrast, replacing a nominal 40-gallon model with a nominal 30-gallon model, would not provide enough hot water in most installation applications.

What is planned for 2024 Unitary

- Phase two of “Amazing Shrinking Room” report out
- Finalize update to AWHS 8.1 – Minor Tweaks to Sound, Testing and Documentation
- Promote and engage market actors for targeted Split System for low rise proposed product requirements “xPrize”
- Design Charrette multifamily low rise existing construction “mitigation strategies”
- Support new products coming to market from overseas
- ACEEE Hot Water Forum Panel Management and Paper Presentations (3)
  - Flexible load management, Amazing Shrinking Room, Multifamily Family Solutions
- Compliance and Conformance Testing and Validation to support EE performance and “Flexible Load Management”
- Planning on getting in front of the electric resistance work arounds with the new standard

- What else are we missing? (Discussion)





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Electric Central 2023 Summary

Completed 2023
Planned 2024

Keshmira McVey

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What does this building stock look like?

Few to many

One to many

One to one

Samples of Multifamily Projects we are helping with.

Location	Type of water heating	Units	Flexible Load Management
Tacoma Housing Authority	Central	231	Yes
Meridian Gardens	Central	85	Yes
Bayview Tower	Central	100	Yes
Pepsi Blocks	Multiple Central	120	Yes
Market Rate Development	One to One	12	Yes
Low Income NE PDX	Commercial Unitary	56	No
Low Income Hood River	One to one, one to few and central	120	?

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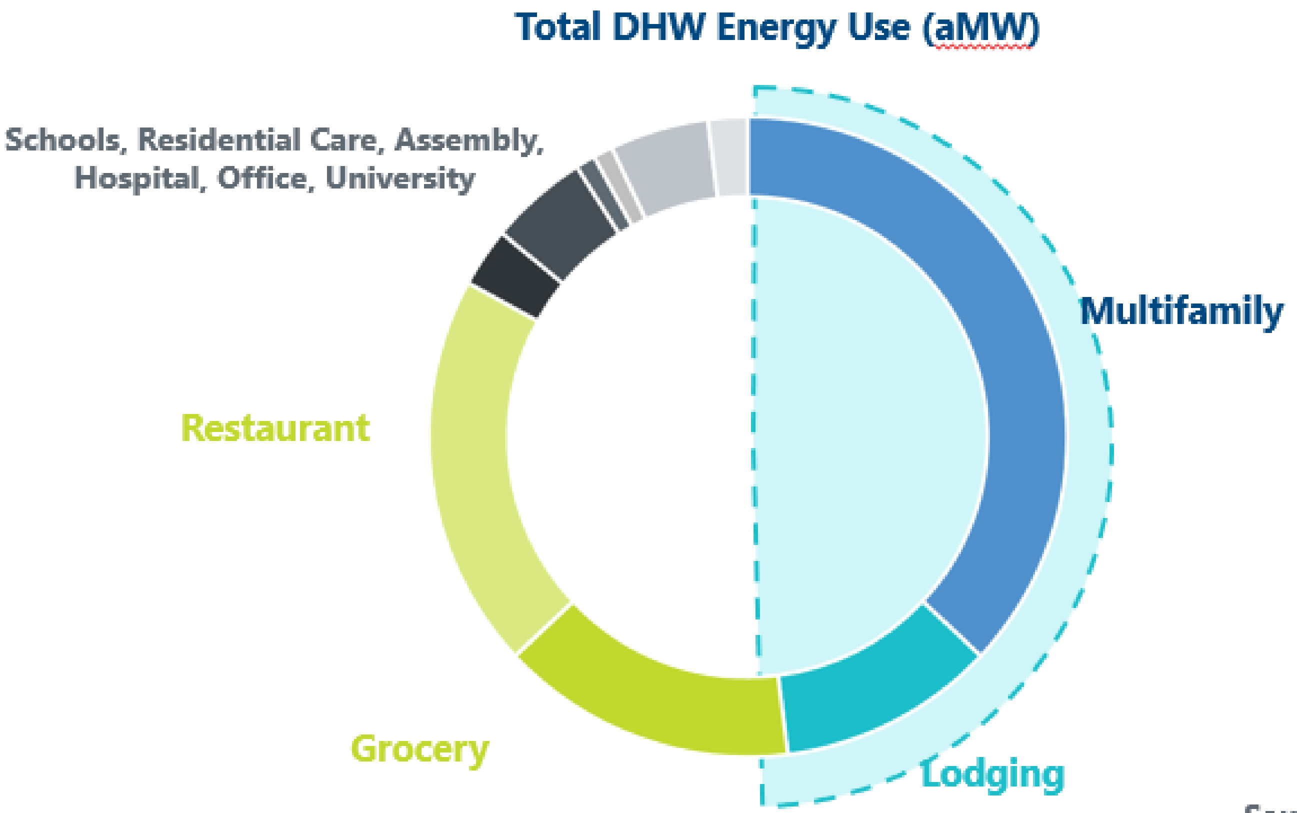
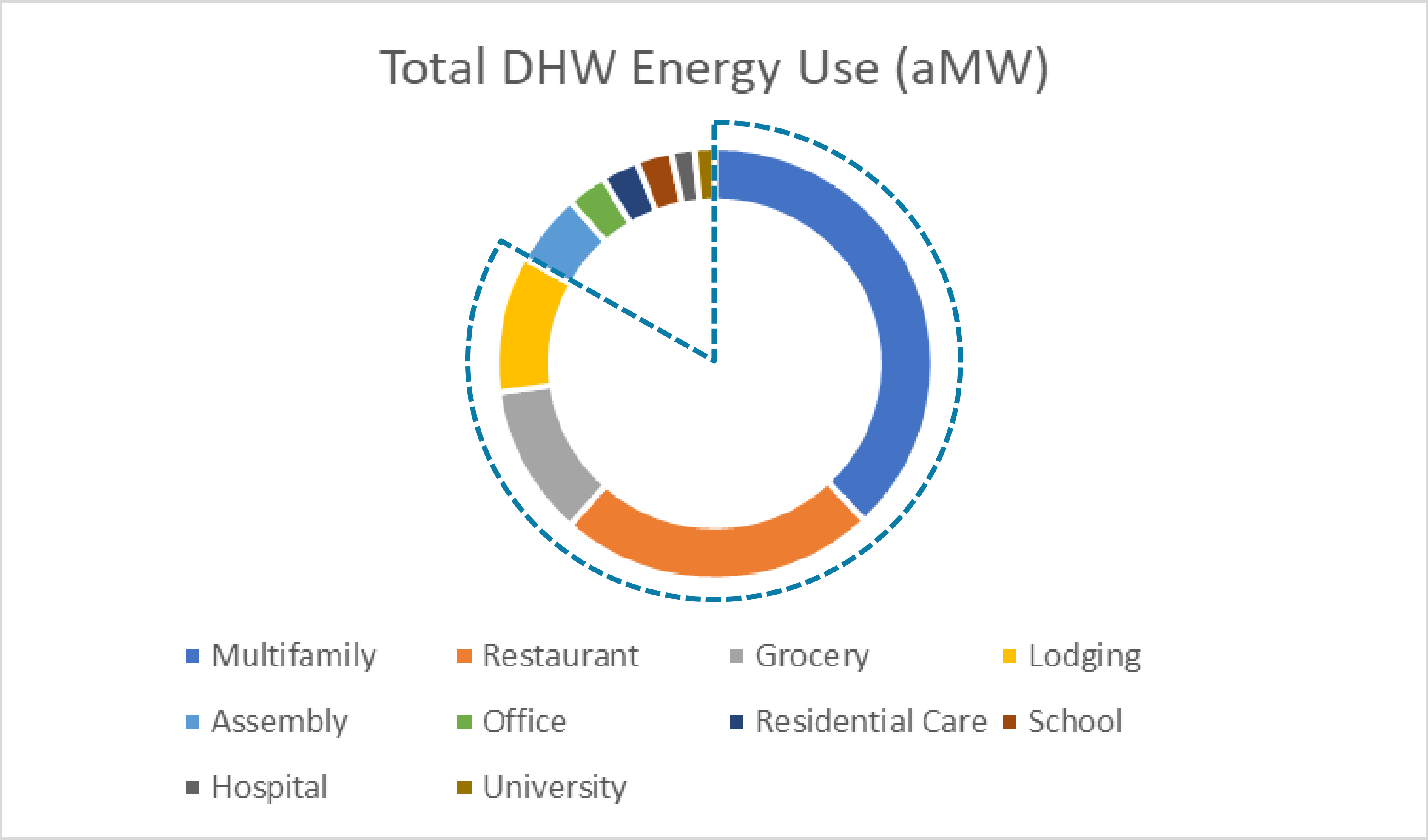
Solutions for multifamily non – one to one

Up to half of the commercial & multifamily hot water load potentially could be met with a **central HPWH solution**



Source: Ecotope Analysis

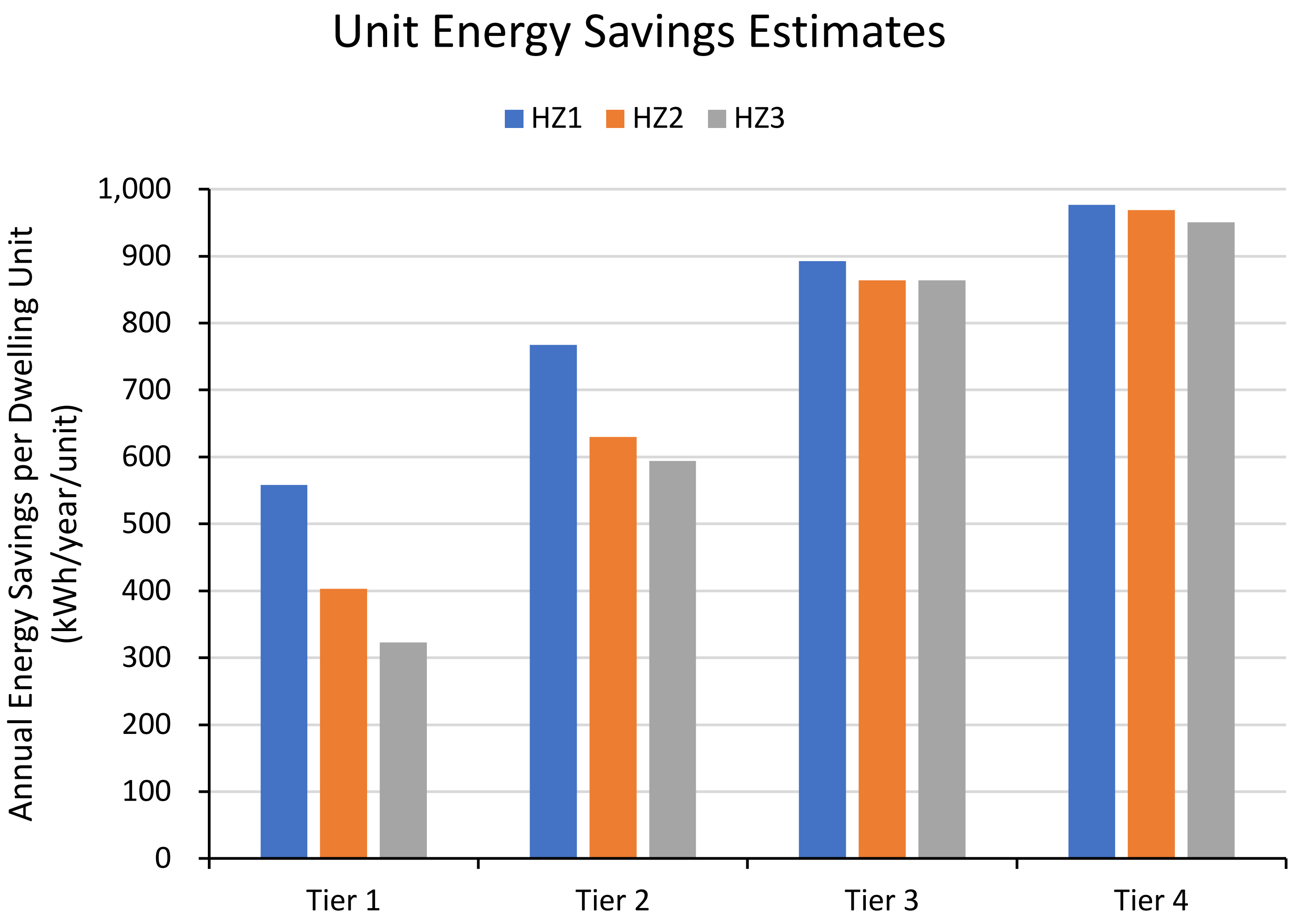
Targeting Commercial Sectors by Energy Use – *PNW Region*



Four building types represent over 80% of total DHW load

- Lodging
- Grocery
- Food Service
- Multifamily

CHPWH Unit Energy Savings: First Look



Very Approximate Cost Estimate $850 per dwelling

Conversation Market Potential finds

- How big is this market?
- What does it include?
  - Multifamily mid and high rise 25-60 mWs
  - Space Heating
  - Hospitals/Nursing Homes
  - Hospitality/Hotels/Health clubs/Swimming pools/Laundry
  - Campus/Universities/schools
  - Food Service/Grocery
  - Food Processing/Bottling/Wash down/Dairy/Breweries
  - Manufacturing: Wood products/Concrete/Gypsum Plants/Textile/Automotive/chemical
  - Industrial scrubbers
- Are we being too focused on residential hot water?

Focus on MF due to size, beachhead, code opportunities and limited resources

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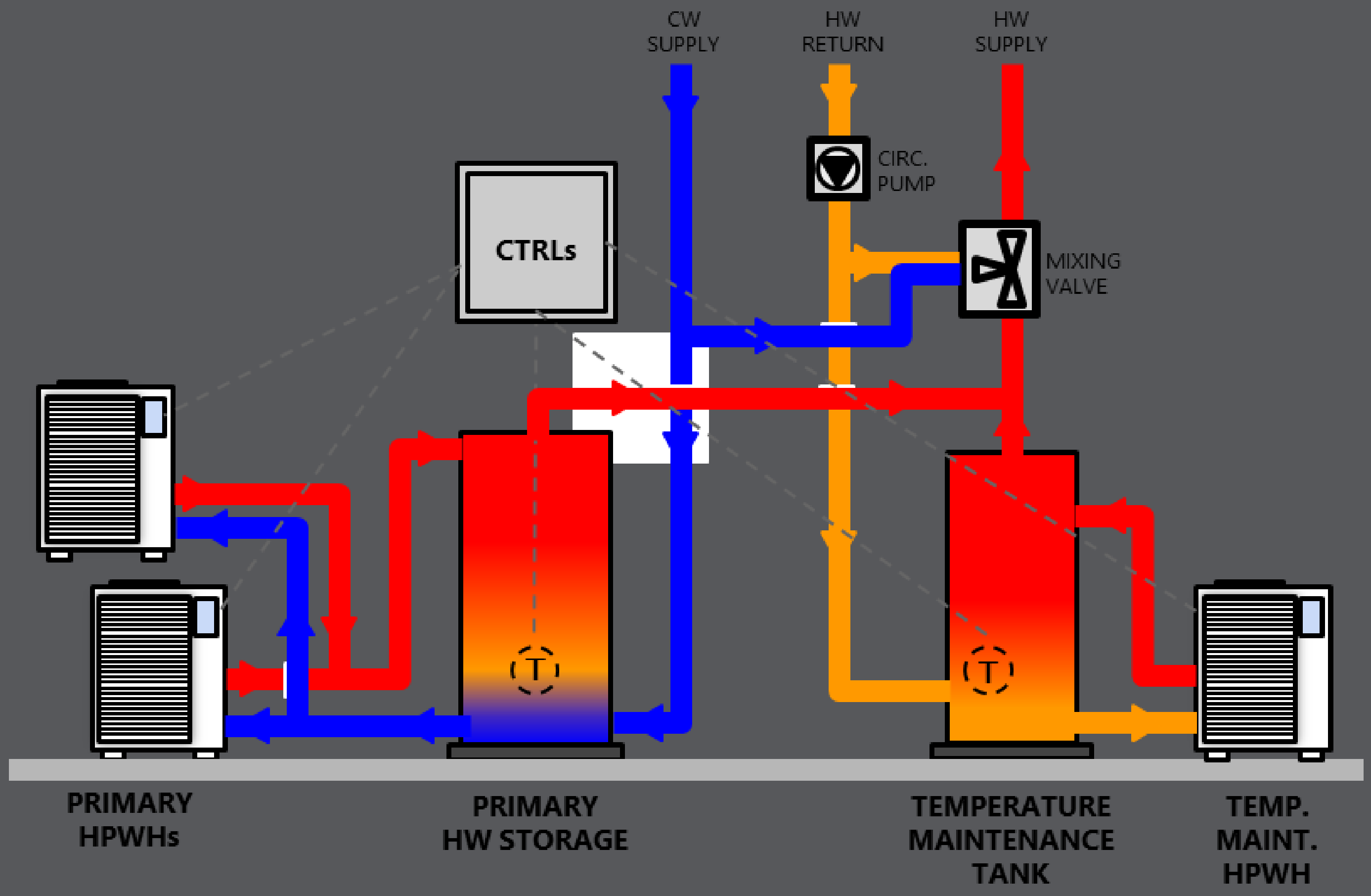
AWHS & QPL

- **NEW** Commercial Heat Pump Water Heater Specification **8.0**
  - **4 Components**
- Performance measured from a "system" level
- Basis for utility incentive program
- **QPL v1**



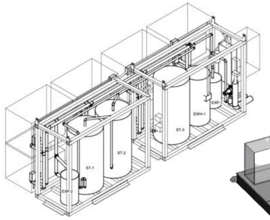
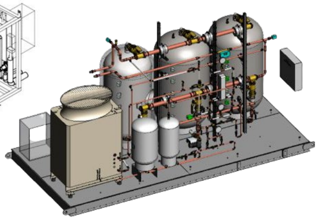
https://neea.org/our-work/advanced-water-heating-specification

Products for Every Application







	Various Residential Integrated Units	SaCnO$_2$	AO Smith	Mitsubishi	Colmac	Nyle	WaterDrop	Origin
Size	> 1ton	1.25 tons	2.5 tons	10 tons	10 - 30 tons	10 - 30 tons	varies	varies
Market delivery	unitary	split	unitary	split	split	split	fully packaged	fully packaged
System design	multi pass	single pass	multi pass	single pass	single or multi pass	single or multi pass	single pass	single pass
COP	3.0 - 4.0 (UEF)	2.8 - 5.5	4.2	3.0 - 4.0	4.0 - 4.4	3.0 - 5.0	2.8 - 5.5	3.0 - 4.0
Refrigerant	R-134a	CO_2 /R-744	R-134a	CO_2 /R-744	R-134a	R-134a	CO_2 /R-744	CO_2 /R-744
Minimum ambient air temperature	~45 °F	-20 °F	45 °F	-15 °F	40 °F	40 °F	-20 °F	-15 °F
Maximum ambient air temperature	~120 °F	104 °F	110 °F	110 °F	110 °F	120 °F	110 °F	110 °F
Maximum outlet water temperature	145 °F	149 °F	150 °F	165 °F	160 °F	160 °F	149 °F	165 °F

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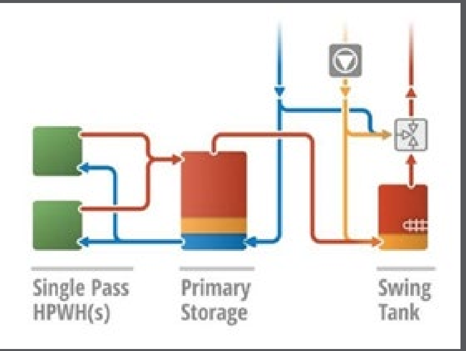
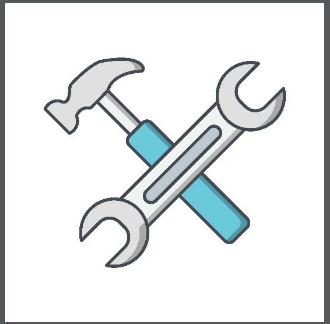
✔Accomplishments

PRODUCTS



- 12 Manufacturer products engaged in Technology Innovation Model
  - 9 feasibility studies
  - 8 application/bench tests
  - 14 demos sites w M&V
  - 5 low gwp + 6 more...
  - 2 PnP + 2 more...
- Developed standard system design

TOOLS



- Ecosizer (multi-family system sizing tool)
  - New load shapes
  - Improving load shifting algorithms
- Ecosim (load modeling tool)

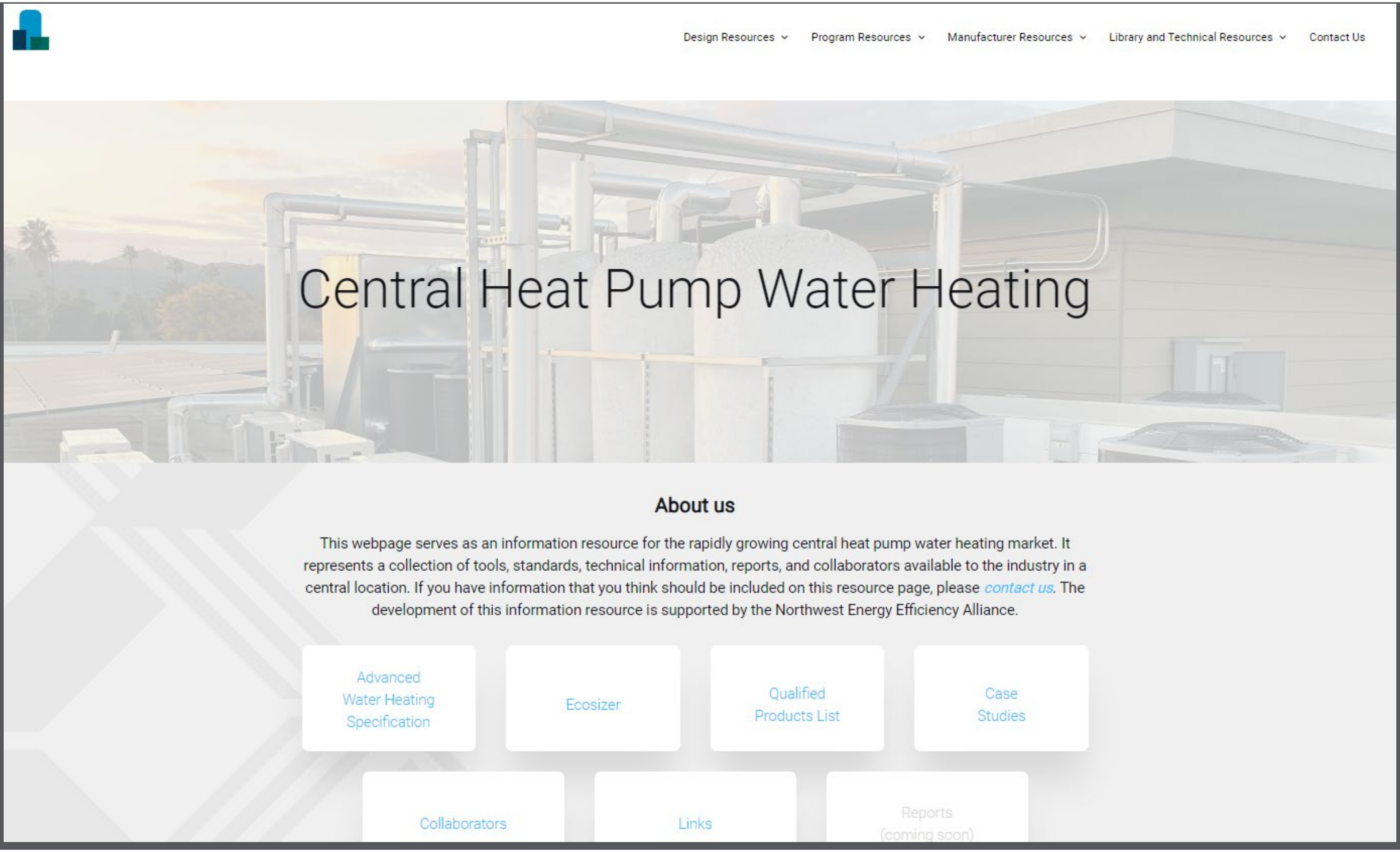
STANDARDS

- New commercial Seattle and new MF in WA
- Baseline multifamily in CA
- AHRI 1430 DR EcoPort
- Qualified Products List v1
- Qualified Products List v2
- New Multifamily Measure

ENGAGEMENT

- 5 virtual interactive tours
  - Code compliance, maint & operations; manufacturer resources; M&V; successful installations; system components; sizing & design;...
- 5 instructor led webinars
- Multiple case studies
- CHPWH.org Website launched

CHPWH.org


Design Resources
Program Resources
Manufacturer Resources
Library and Technical Resources
Contact Us
Central Heat Pump Water Heating
About us
This webpage serves as an information resource for the rapidly growing central heat pump water heating market. It represents a collection of tools, standards, technical information, reports, and collaborators available to the industry in a central location. If you have information that you think should be included on this resource page, please contact us. The development of this information resource is supported by the Northwest Energy Efficiency Alliance.
Advanced Water Heating Specification
Ecosizer
Qualified Products List
Case Studies
Collaborators
Links
Reports (coming soon)

BetterBricks Added Water Heating

betterbricks/

Energy Solutions | Resources | Utility Programs | About

Water Heating

By moving heat from one place to another instead of generating heat directly, gas or electric heat pump water heaters are up to three times more energy efficient than conventional water heaters. Explore a variety of commercial products and applications for this efficient water heating solution.

Featured Downloads

Water Heating

The Best Solutions Come in Easy-to-Use Packages

Central heat pump water heater (CHPWH) systems serve the domestic hot water needs of a building in one central plant. Though they have become a key decarbonization technology by reducing greenhouse gas emissions and saving energy and costs, their complex design and installation requirements can pose barriers to widespread adoption. Packaged CHPWH systems reduce this complexity by simplifying design and installation.

Water Heating

Project Spotlight: Central Heat Pump Water Heaters

Central heat pump water heater (CHPWH) systems serve the domestic hot water needs of a building in one central plant. Though they have become a key decarbonization technology by reducing greenhouse gas emissions and saving energy and costs, their complex design and installation requirements can pose barriers to widespread adoption. Packaged systems reduce this complexity by simplifying design and installation.

What is planned for 2024 Commercial

- Update Commercial Section of AWHS 8.1 to include
  - New Bin Tool- validated with PG&E lab testing
  - Type of System – Engineered, Kit and Skid
  - Performance Map to Align with ANSI to account for defrost
- Add twenty-five additional products to the Central QPL
- Planning Status at Regional Technical Forum
- Publish Finalize the Design Charrette for low rise multifamily
- Further load flexibility for commercial water heating, standard and specification
- What else are we missing? (Discussion)

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Gas Water Heating 2022 Summary

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RETAC - Gas Water Heating Product Group Updates

Noe Contreras

Senior Product Manager

CLASSIFICATION LEVEL: PUBLIC

neea

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2023 Activity – Water Heating

- Lab testing of unitary gas heat pump water heater
- Lab testing of a monobloc gas heat pump
- Field test of a monobloc gas heat pump at a 6 Unit Multifamily building (DHW)
- Field Test at 2 x single family (Combi)
- Opportunity advancement approval to review commercial water heating with a thermally driven heat pump

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DOE NOPR Gas The Future State Set to take effect 2029 Tank

Product Class	Effective Storage Volume and Input Rating* *(if applicable)*	Draw Pattern	Proposed Uniform Energy Factor	Current UEF
Gas-fired Storage Water Heater	New Size Class < 20 gal	Very Small	$0.2062 - (0.0020 \times V_{eff})$	
		Low	$0.4893 - (0.0027 \times V_{eff})$	
		Medium	$0.5758 - (0.0023 \times V_{eff})$	
		High	$0.6586 - (0.0020 \times V_{eff})$	
	≥20 gal and ≤55 gal	Very Small	$0.3925 - (0.0020 \times V_{eff})$	$0.3456 - (0.0020 \times V_r)$
		Low	$0.6451 - (0.0019 \times V_{eff})$	$0.5982 - (0.0019 \times V_r)$
		Medium	$0.7046 - (0.0017 \times V_{eff})$	$0.6483 - (0.0017 \times V_r)$
		High	$0.7424 - (0.0013 \times V_{eff})$	$0.6920 - (0.0013 \times V_r)$
	>55 gal and ≤100 gal	Very Small	$0.6470 - (0.0006 \times V_{eff})$	
		Low	$0.7689 - (0.0005 \times V_{eff})$	
		Medium	$0.7897 - (0.0004 \times V_{eff})$	
		High	$0.8072 - (0.0003 \times V_{eff})$	
	> 100 gal	Very Small	$0.1482 - (0.0007 \times V_{eff})$	
		Low	$0.4342 - (0.0017 \times V_{eff})$	
		Medium	$0.5596 - (0.0020 \times V_{eff})$	
		High	$0.6658 - (0.0019 \times V_{eff})$	

No commercially available products in these ranges

DOE NOPR Gas The Future State Set to take effect 2029 Tankless

Product Class	Effective Storage Volume and Input Rating* (if applicable)	Draw Pattern	Proposed Uniform Energy Factor	Current UEF
Instantaneous Gas-fired Water Heater	<2 gal and ≤50,000 Btu/h	Very Small	0.64	
		Low	0.64	
		Medium	0.64	
		High	0.64	
	<2 gal and >50,000 Btu/h	Very Small	0.89	0.80
		Low	0.91	0.81
		Medium	0.91	0.81
		High	0.93	0.81
	≥2 gal and ≤200,000 Btu/h	Very Small	$0.2534 - (0.0018 \times V_{eff})$	
		Low	$0.5226 - (0.0022 \times V_{eff})$	
		Medium	$0.5919 - (0.0020 \times V_{eff})$	
		High	$0.6540 - (0.0017 \times V_{eff})$	

Unitary Gas Heat Pump Water Heater

- Cost-effective high performance drop-in replacement gas-fired heat pump water heater (GHP-WH) for the residential market in North America with a UEF of 1.1-1.25.
- Performance - Gas fuel consumption reduced by ~50 % compared to current product standards
- Meet end user demands - Possible to direct fire with burner
- Robustness - Hermetically sealed Heat Pump Module with no moving parts

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Reminder: Commercial Gas Absorption Heat Pump unit

- Replacement of conventional commercial-use gas-fired domestic water heating (DHW) equipment such as boilers and water heaters
- Multifamily, lodging, and restaurants likely have the greatest savings potential due to high occupant density (or meals in the case of a restaurant), and equipment with large water demand per occupant (or meal) which results in high water use
- Buildings with high daily hot water demand (and ideally moderate peak demand) to take advantage of the higher average annual COP
- If the building has large, non-sequential hot water demand draws that will also allow the GAHP to perform well and have time to recover

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2024 Planned Activity

- Extended lab testing of unitary gas heat pump water heater
- Field testing of unitary gas heat pump water heater
- Lab testing of commercial gas heat pump for DHW
- Field testing of commercial gas heat pump for DHW

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Residential HVAC

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Electric ResHVAC

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Outline

2023 Recap

- Micro HP
- Advanced Features & Capabilities
- Heat Pump Paper Teardown
- HP Ready Manufactured Homes
- Rating Representativeness Project
- BPA HPHC
- Chelan PUD Metering Analysis
- EULR – HEMS Analysis

2024 Prospective

- Connected Commissioning (CCX)
- Baseline Performance Project
- ResHVAC Demand Response
- 2nd Gen Micro Heat Pump Field Testing

Micro Heat Pump Field Study

- ROs – understand consumer experience, usage and identify likely challenges
- Phase 1 – moderated research online community (n=36)
- Phase 2 – field testing, customers asked to perform activities over 8 weeks (n=14)

Saddlebag

Window AC

Portable

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Micro HP Primary Research Findings

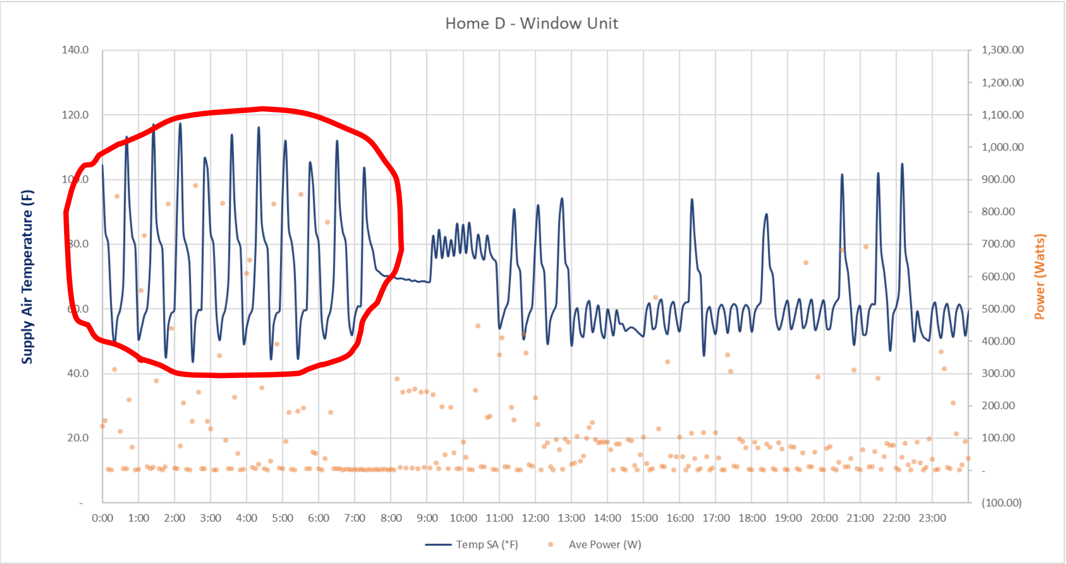
Phase 1

1. Most customers are familiar with multiple HVAC sources and they use portable solutions to supplement specific areas
2. 72% of participants found the concept of a window based all in one heating/cooling solution appealing
3. Portability and 120V outlet compatibility drives interest
4. Some concerns about space and appearance

Phase 2

1. Many homes are not good candidates (multiple reasons)
2. Window AC and Portable styles units were not used much for heating
3. Customer found units requiring outdoor air to be > 40F confusing and less satisfying
4. Auto-mode was most frequently chosen and resulted in poor performance

Commonly observed on-off cycling in “auto” mode



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Future “Cold Climate Capable” Versions are coming

- Much larger (physically). Capacity ~12,000Btuh
- Operates when outdoor temperature down to 5°F or lower
- Estimated at $3-4,000, available 2H 2024
- DOE/EPA developed interim heating season test procedure – comments due Jan 10th
- Pilot testing needed mostly to determine how many runtime hours

Heat Pump Advanced Features and Capabilities

SME Work Sessions, Savings Estimates, and Workplans

Improvement	Abv.	Description	MT Status	MT End State	Baseline	Energy Savings	Peak Savings
Low Load Efficient	LLE	Top Quartile MinCapCOP47 (> 4.5 for ducted >5.0 for ductless)	validation & socialization	market adoption	2018 current practice	4-12%	0.0 kWp
Cold Climate Capable	CCC	ENERGYSTAR v6.1 (COP 5F>1.75, 70% cap ratio)	early market development	market adoption	2019 current practice	7-11%	1-4 kWp
Connected Commissioning	CCX	certified CX report provides feedback and verifies correct charge, airflow, settings	emerging technology	market adoption	2020 current practice	5%	0.0 kWp
Minimize Supplemental Heat	MSH	ER heat not used when HP can provide sufficient heat within 60 minutes	incorported elsewhere	market adoption	2021 current practice	5%	0.0 kWp
No Duct Losses	NDL	replace poor ducts (>10% losses) with whole home ductless solution	savings & spec needed	market adoption	2022 current practice	6%	0.0 kWp
Auto Demand Response	ADR	heat pump can automatically connect to DR system w/o customer intervention	emerging technology	market adoption	2023 current practice	0%	0.4 kWp

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LLE Heat Pump Paper Teardown

- Questions
  - How reliable is NEEP data?
  - Why is LLE not reflected in HSPF2 or SEER2 ratings?
  - Are there underlying reasons why some HPs have superior LLE?
  - What is the incremental cost (not price) of LLE heat pumps?
    - Controls
    - Expansion Device
    - Compressor
    - Heat Exchanger
- Cadeo and OTS Energy findings due January 2024

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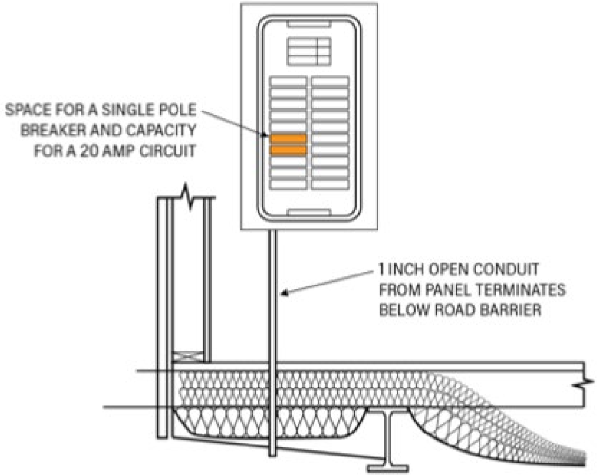
HP Ready Manufactured Homes

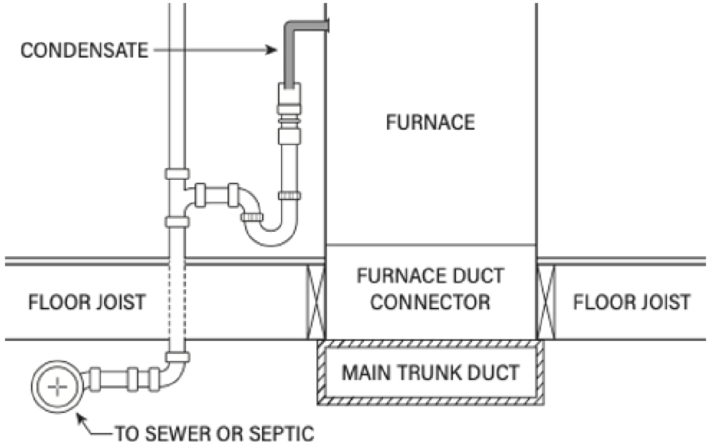
- Factory Changes that reduce installation cost
- Ties to ENERGY STAR and DOEZER tax credit criteria
- Gathers data to confirm installation

HVAC Closet

Electrical



Condensate



Thermostat

Rating Representativeness Project

- Phase 1 – field testing completed
  - Identical Manufacture Homes in Lincoln Nebraska
  - 3 Ductless, 3 central ducted
  - Lab grade monitoring system
- Phase 2 – lab testing (partially completed)
  - AHRI 210/240 – static testing
  - SPE07 – load based testing

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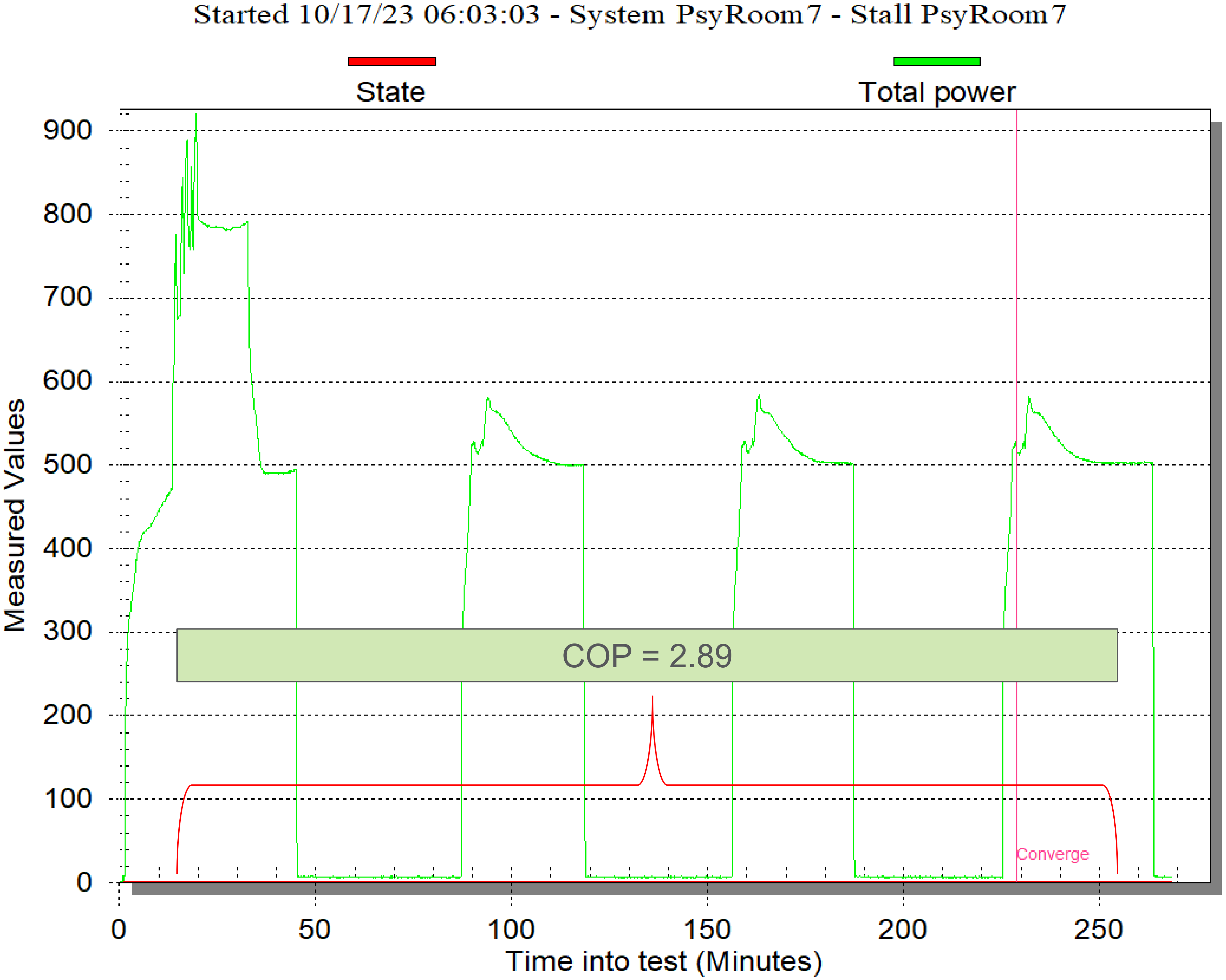
Unit F: HF_C

- Convergence is not evaluated with HF intervals
- COP calculated across the entire 4 h bracketed time frame
- COP from 0:15:00 to 4:15:00 (h:min:sec)

Note: the "Converge" annotation is not relevant

	IDDB	IDWB	ODDB	ODHR	ODWB
HF_C	74	61.6	54	0.0045	45.1
HE_C	74	61.6	47	0.0042	41.0
HD_C	74	61.6	34	0.0031	31.2
HD_M	74	61.6	34	0.0035	32.2
HC_C	74	61.6	17	0.0013	15.0
HB_C	74	61.6	5	0.0008	4.1
HL_C	74	61.6	-13	0.00055	-13.8

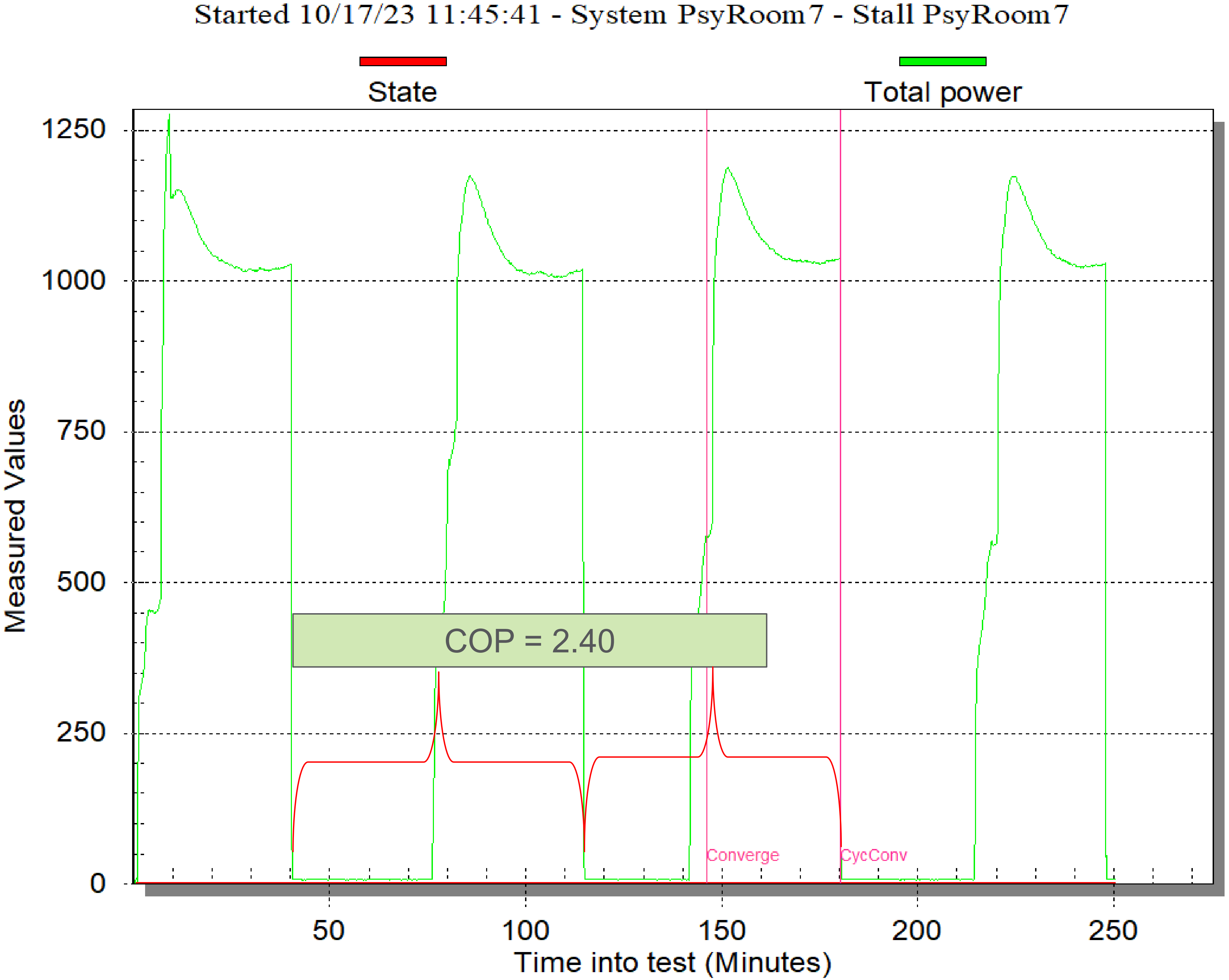


Unit F: HE_C

- Convergence occurred across the two, bracketed ON/OFF cycles
- The COP for the interval is the average of the COP values for each ON/OFF period
- COP from 0:40:26 to 3:00:16 (h:min:sec)

Note: the “Converge” annotations are not relevant

	IDDB	IDWB	ODDB	ODHR	ODWB
HF_C	74	61.6	54	0.0045	45.1
HE_C	74	61.6	47	0.0042	41.0
HD_C	74	61.6	34	0.0031	31.2
HD_M	74	61.6	34	0.0035	32.2
HC_C	74	61.6	17	0.0013	15.0
HB_C	74	61.6	5	0.0008	4.1
HL_C	74	61.6	-13	0.00055	-13.8

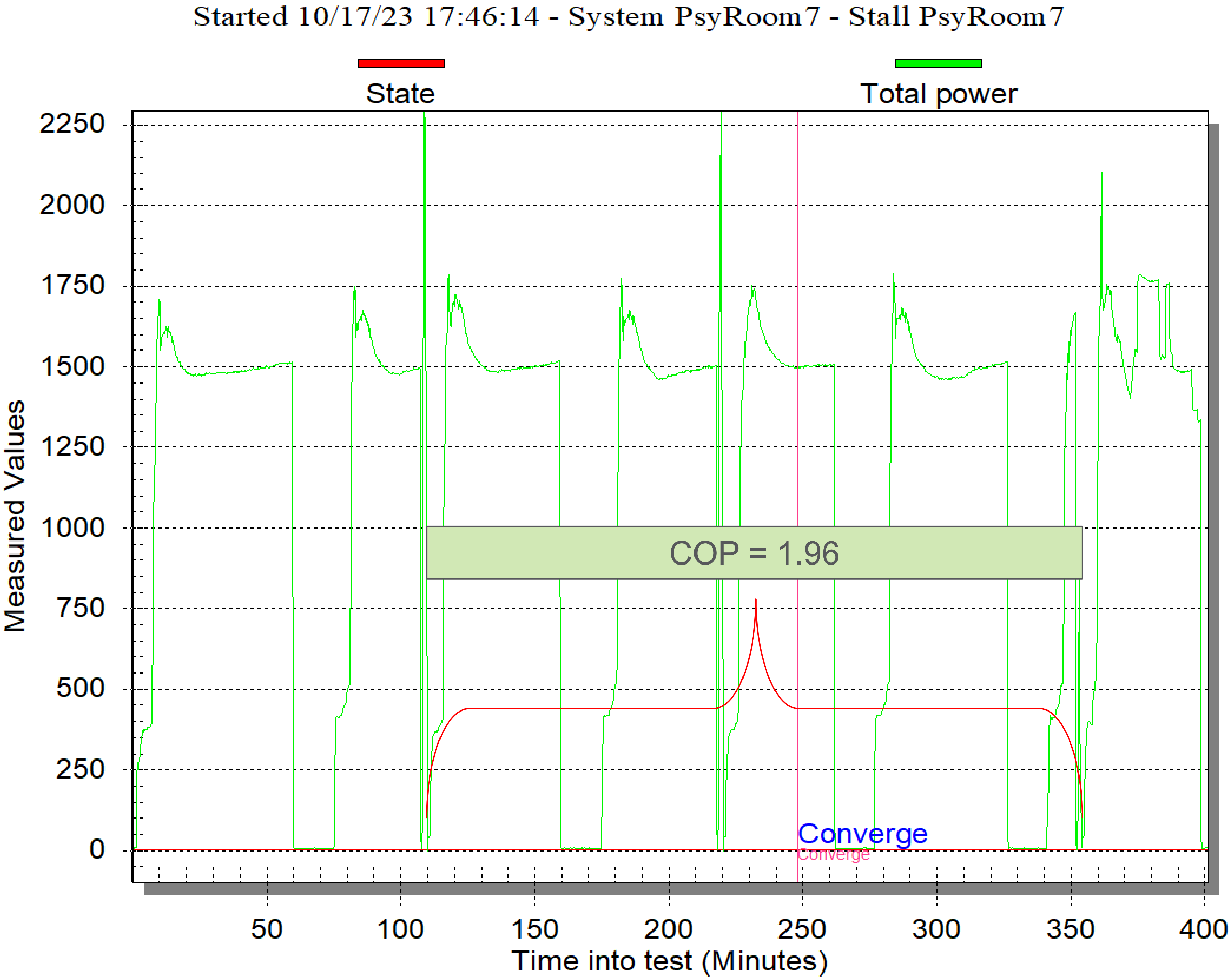


Unit F: HD_C

- Convergence is not evaluated with HD intervals
- COP calculated across the two complete defrost cycles during the 6 h interval
- COP from 1:50:56 to 5:54:46 (h:min:sec)

Note: the “Converge” annotations are not relevant

	IDDB	IDWB	ODDB	ODHR	ODWB
HF_C	74	61.6	54	0.0045	45.1
HE_C	74	61.6	47	0.0042	41.0
HD_C	74	61.6	34	0.0031	31.2
HD_M	74	61.6	34	0.0035	32.2
HC_C	74	61.6	17	0.0013	15.0
HB_C	74	61.6	5	0.0008	4.1
HL_C	74	61.6	-13	0.00055	-13.8

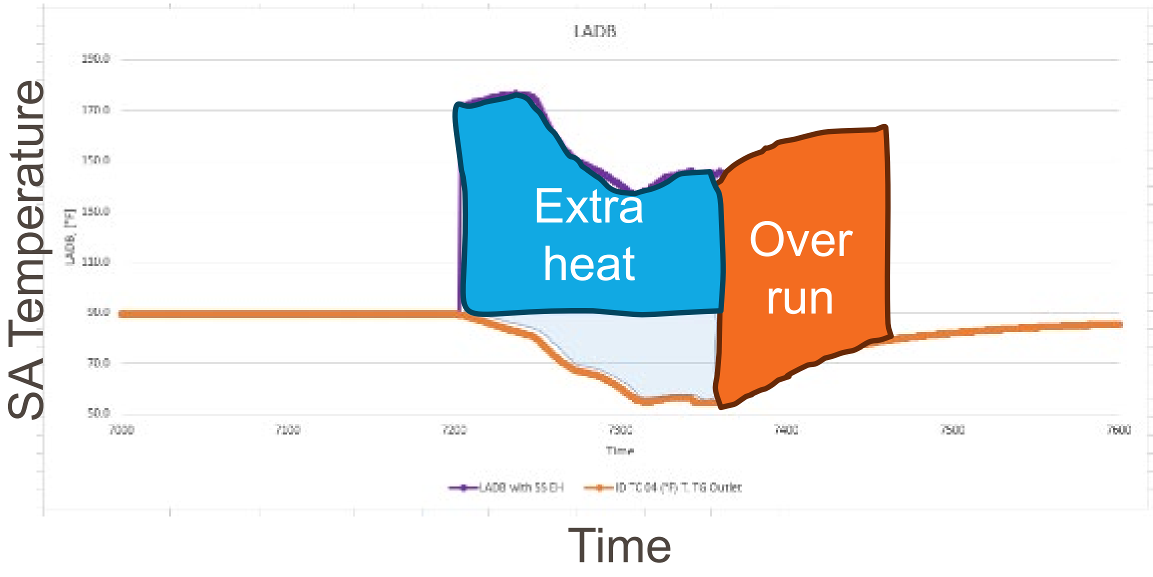


HPHC Data Influenced AHRI Test Procedure

- Data showed ER heat during defrost
  - Extra Heat (1-7% impact)
  - Overrun Heat (1-10% impact)
- New TP adds "penalty" if ER heat can be used during defrost
  - 2% reduction for Extra heat
  - 2% reduction for Overrun heat

Defrost Cycle Use of ER Heat

Daikin Plot



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Chelan PUD Metering Analysis

- Description
  - 104 variable speed heat pumps
  - Replaced either eFAF or an existing ASHP with eFAF backup
  - PTCS required
  - Installations during 2020-2022
- Findings
  - ~50% increased load on the grid and ~50% showed savings
  - No clear correlation between equipment, installer, or thermostat and savings

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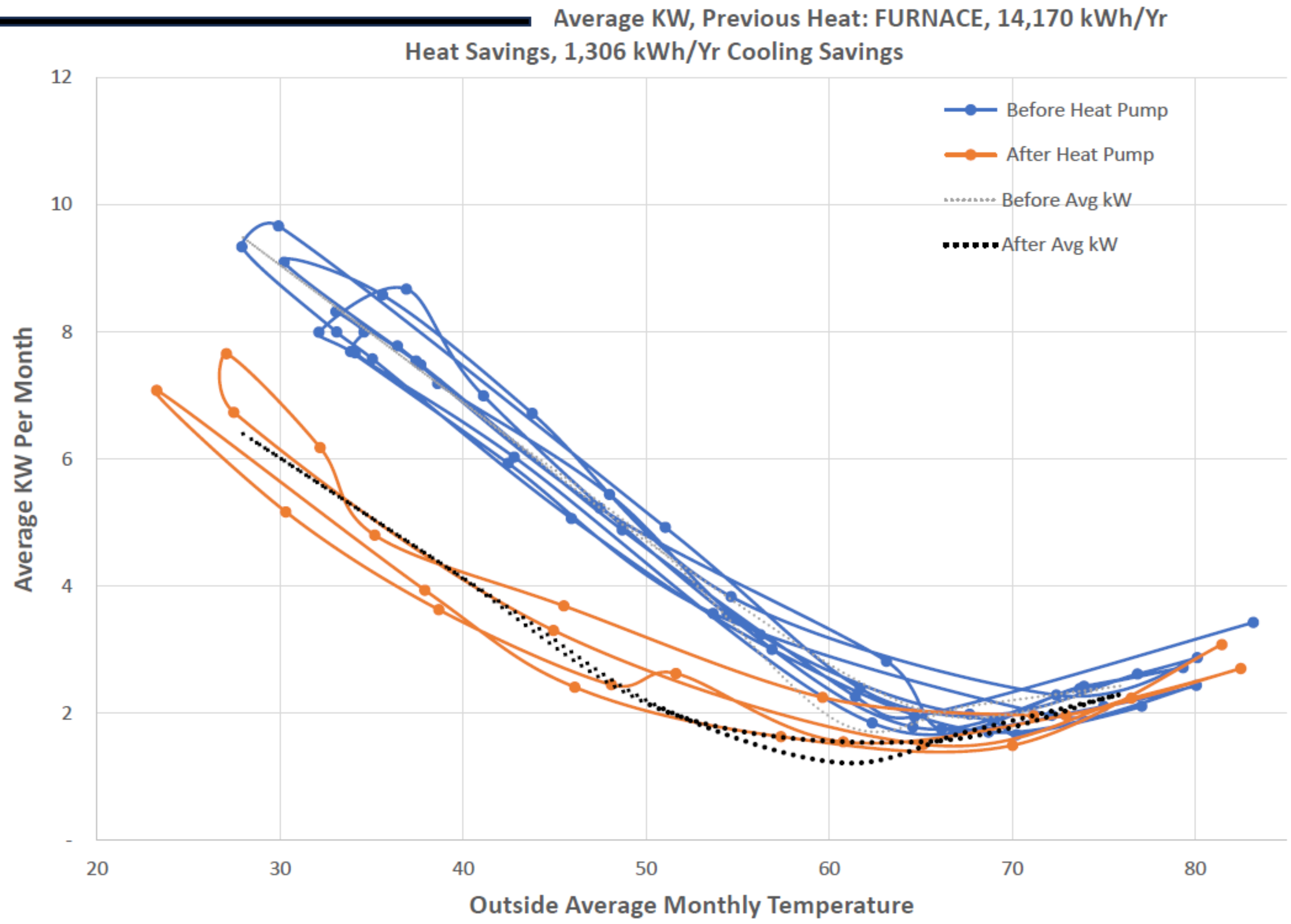
Primary Driver of Savings
Displacing electric resistance heat

Property Number 1

- HP Brand: **Daikin**
  - Indoor: DZ16TC048
  - Outdoor: DV37PTCC
- Thermostat: **Honeywell**
  - VisionPro 8000 Wifi
- Sqft: **1,350**
- Heating Savings: **14,170 KWh**
- Cooling Savings: **1,306 KWh**
- Installer D
- Same Owner



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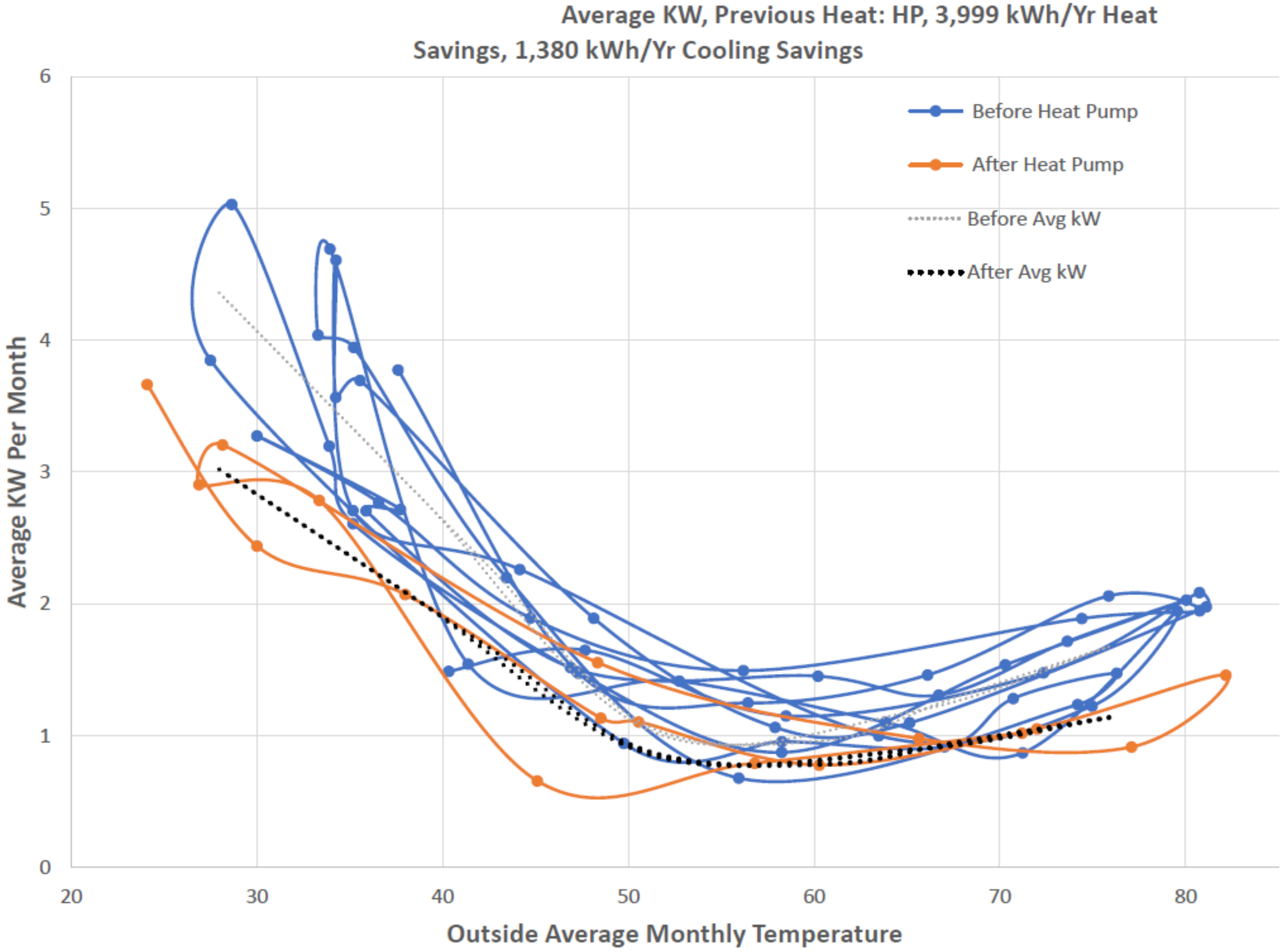
Secondary Driver of Savings

Increasing the efficiency of the heat pump

Property Number 14

- HP Brand: **Carrier**
  - Indoor: FE4ANF002L00
  - Outdoor: 25VNA836A003
- Thermostat: **Temparary**
  - Te 755
- Sqft: **1,614**
- Heating Savings: **3,999 KWh**
- Cooling Savings: **1,380 KWh**
- Installer A
- Same Owners



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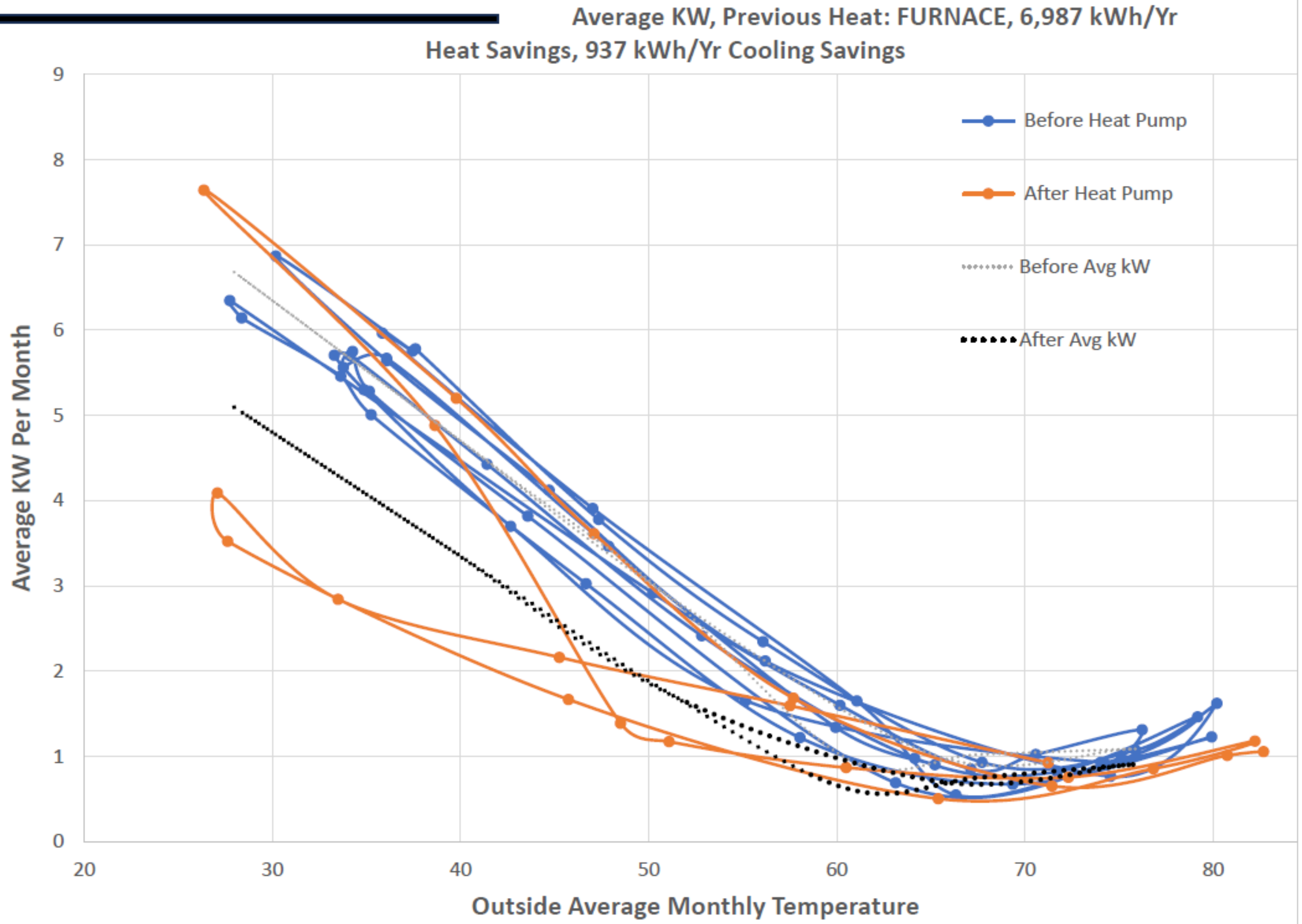
Savings can Disappear

Likely from Control Setting Change

Property Number 32

- HP Brand: **Carrier**
  - Indoor:
  - Outdoor: 25VNA848A003
- Thermostat: **Carrier**
  - SYSTXCCITC01-B
- Sqft: **2,736**
- Heating Savings: **6,987 KWh**
- Cooling Savings: **937 KWh**
- Installer A
- Same Owners



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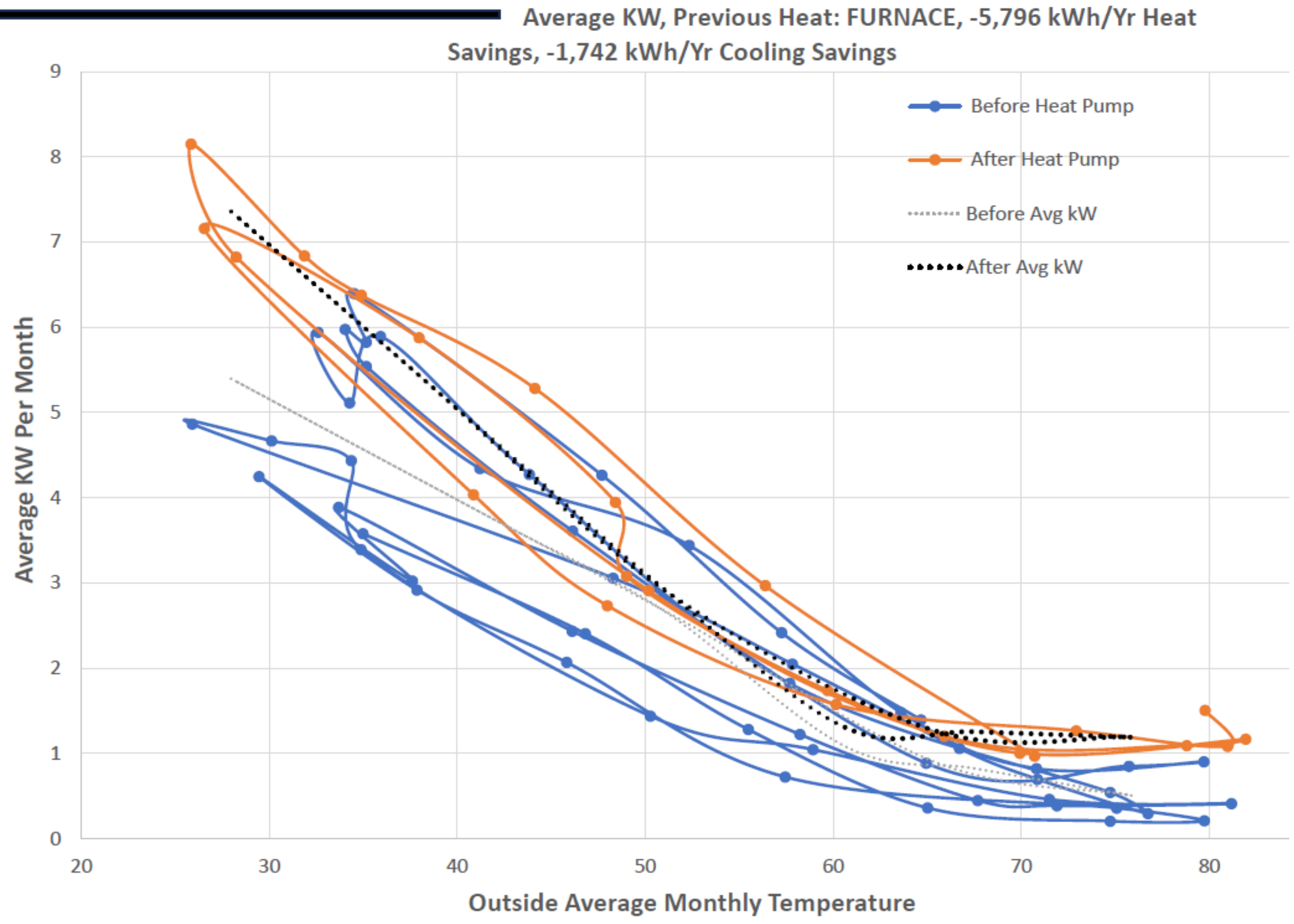
Negative savings is not an outlier

Property Number 20

- HP Brand: **Carrier**
  - Indoor: FE4ANF002L00
  - Outdoor: 25VNA824A003
- Thermostat: **Carrier**
- Sqft: **1,240**
- Heating Savings: -**5,796 KWh**
- Cooling Savings: -**1,742 KWh**
- Installer A
- Same Owners



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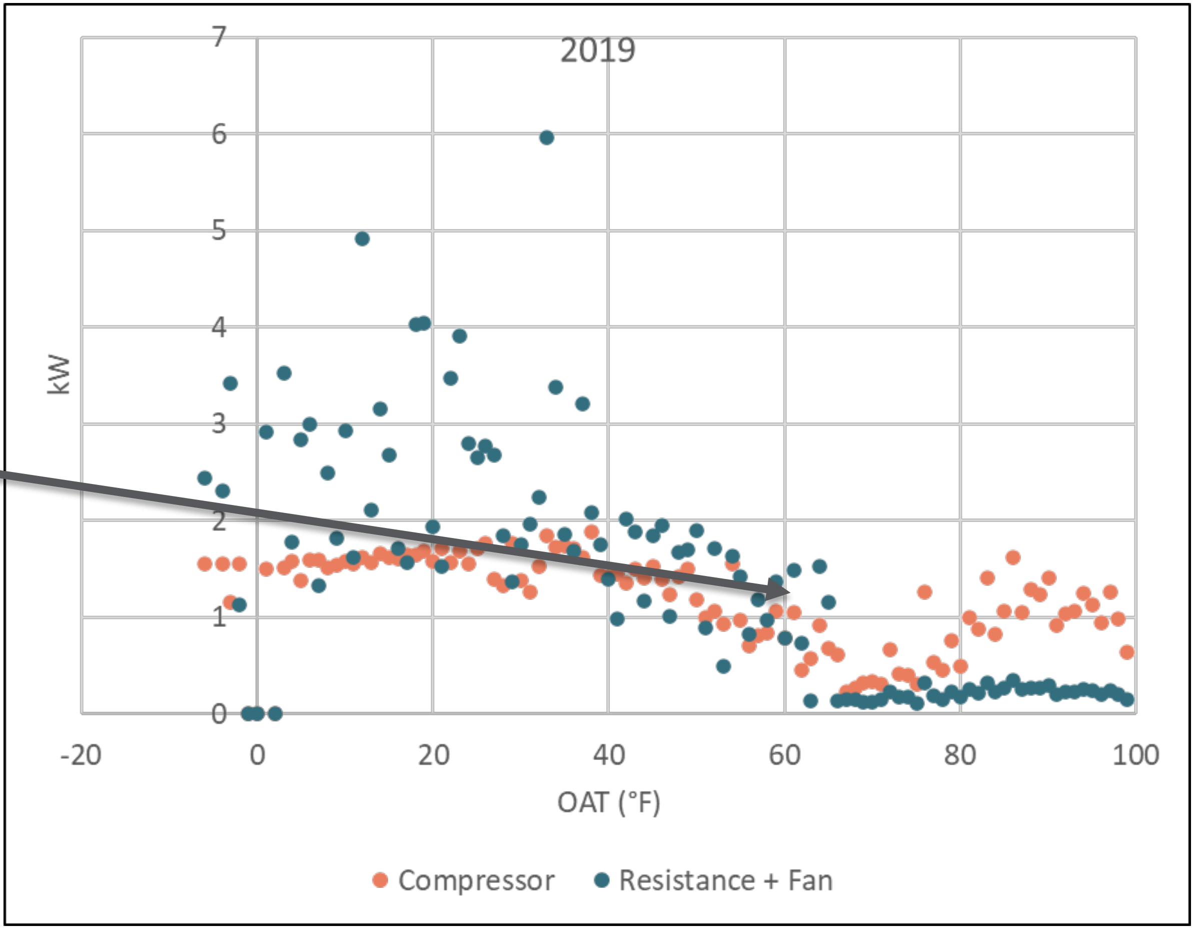
HEMS Lesson 1:
Electric Resistance Heat Lockout is Lacking

NEEA Home Energy Monitoring Study Results for Homes with Central Heat Pumps:

- The bad news (for efficiency): Most sites look like they do *not* lock out the resistance backup

- The small silver lining (for energy efficiency): Most sites look like they do not lock out the compressor



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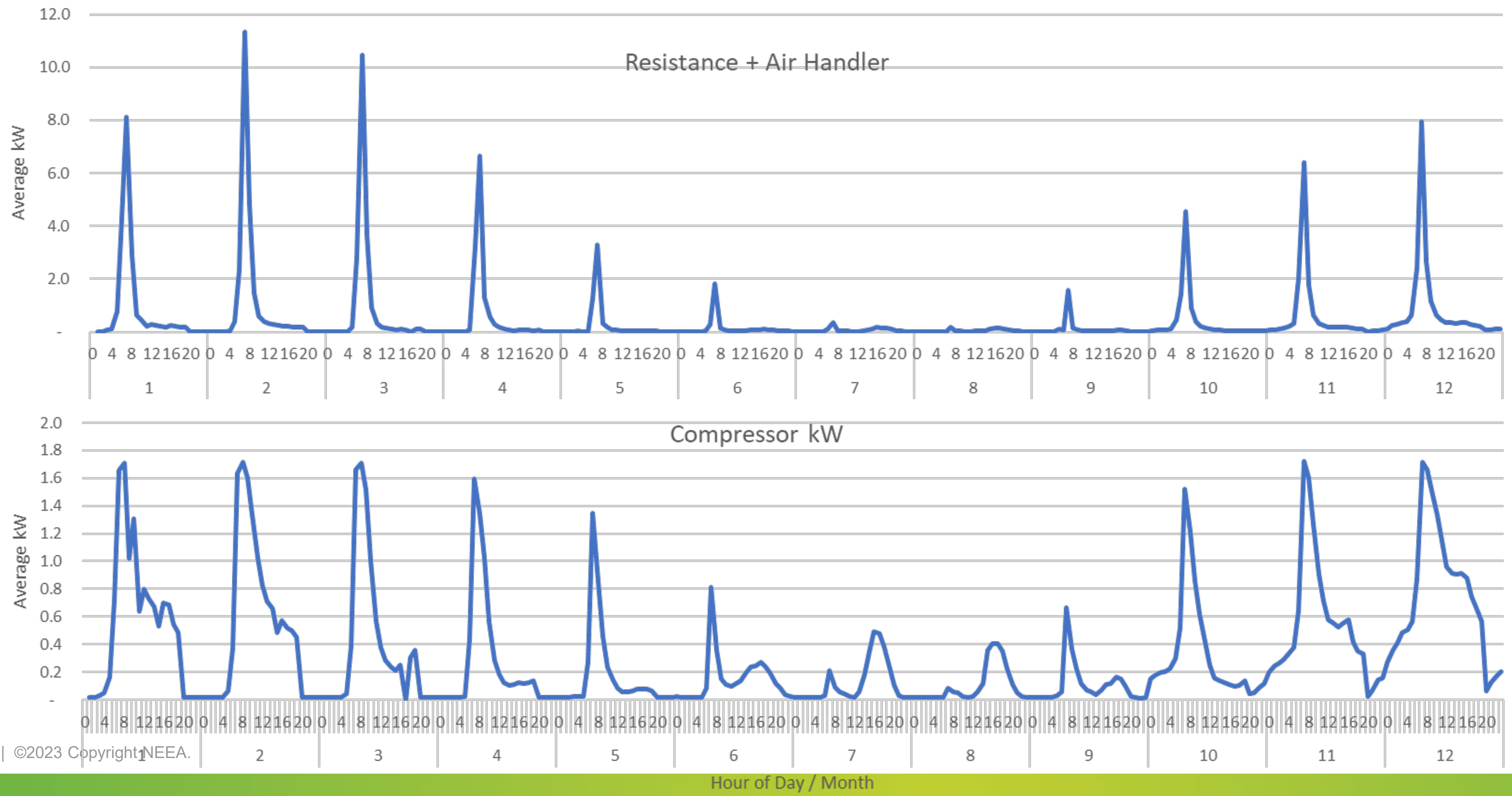
RTF

HEMS Lesson 2:

"Typical" Setbacks Can Exacerbate Demand Issues at Peak Times

Apparent setpoint schedule: 69° F daytime / 60° F nighttime



It is possible that the setback is the only reason that the electric resistance is used in this house.

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2024 NEEA ResHVAC Prospective

1. **Micro Heat Pumps** – get use data from field testing, work w/CalMTA
2. **Connected Commissioning** – Work with OEMs to develop spec/criteria
3. **Demand Responsive ResHVAC** - scoping, use cases, mkt size
4. **Dual Fuel Advanced Controls** – develop specification with OEMs
5. **Natural Refrigerants** – scoping project, when and how this shift will occur
6. **Ducting** – explore new biz models
7. **Heat Pump Price Reduction** – business models, price transparency
8. **Whole-House Multi-head Split Systems** – system efficiency, collaborate with NYSERDA, analyze BPA HPHC data

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2024 ResHVAC Prospective – Other Orgs

1. Tacoma Power Setback Impact Investigation
2. BPA HPHC project
3. DOE National Field Validation Partnership

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Gas ResHVAC

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Q4 Dual Fuel RETAC

- 2023 Recap
  - Pilots across the region
  - Market Research
  - Collaboration
  - Dual Fuel Metric
  - Advisory Boards
  - Manufacturer engagement
- 2024 Prospective
  - Lab Testing
  - Standard Testing
  - Advanced Control Strategy

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Dual Fuel Recap

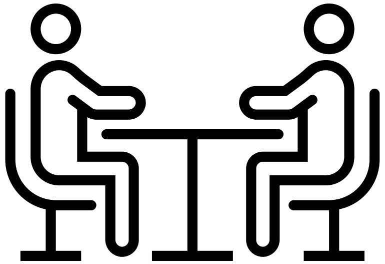
Pilots

- Energy Trust of Oregon
- Avista
- PSE

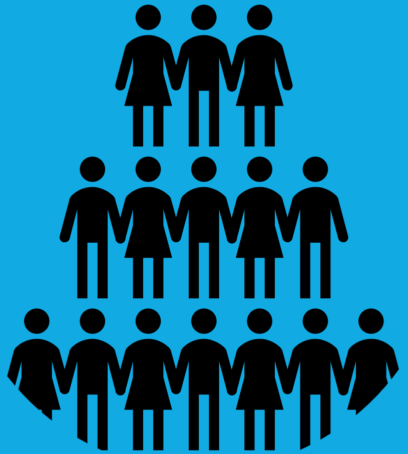
Market Research

- Market Assessment
- Displacing CAC with ASHPs
- Residential dual fuel HPs
- Market Research
  - Buyers want comfort and cost savings
  - Contractors like no electric back-up
- Barriers
  - Buyer: Cost, reliability concerns, installation
  - Contractors: Unfamiliarity or unfavorable experience, technology resistance

Collaboration



- CLASP Hybrid Homes proposal
  - HEATR and COOLER Act
- RTF
- CEE Integrated Controls
- CEE (MN) – Field pilots



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Dual Fuel Recap

Dual Fuel Metric

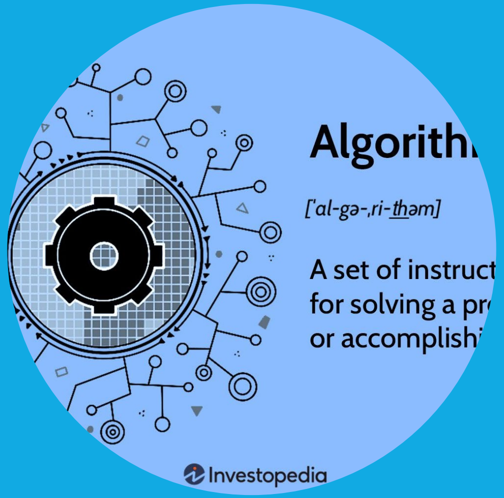
- CSA JB121.16 performance standard
  - Moving into AHRI 210/240
  - Natural Gas Technology Centre calculator

Advisory Boards

- Newport Partners leading
- Dual fuel heating controls
  - 53% normalized heat & energy use
  - 16% normalized heat and energy cost
  - 18% normalized CO_2 emissions

Manufacturer Engagement

- Major manufacturers & focus players
- How to optimize?
  - Outdoor switchover temperature
  - Cloud based controls with multiple inputs



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Dual Fuel 2024

Lab Testing

- Understanding performance
- Optimization

Standard Test

- Development of testing that captures actual energy use

Advanced Control Strategy/Specification

- Development of controls specs and best practices

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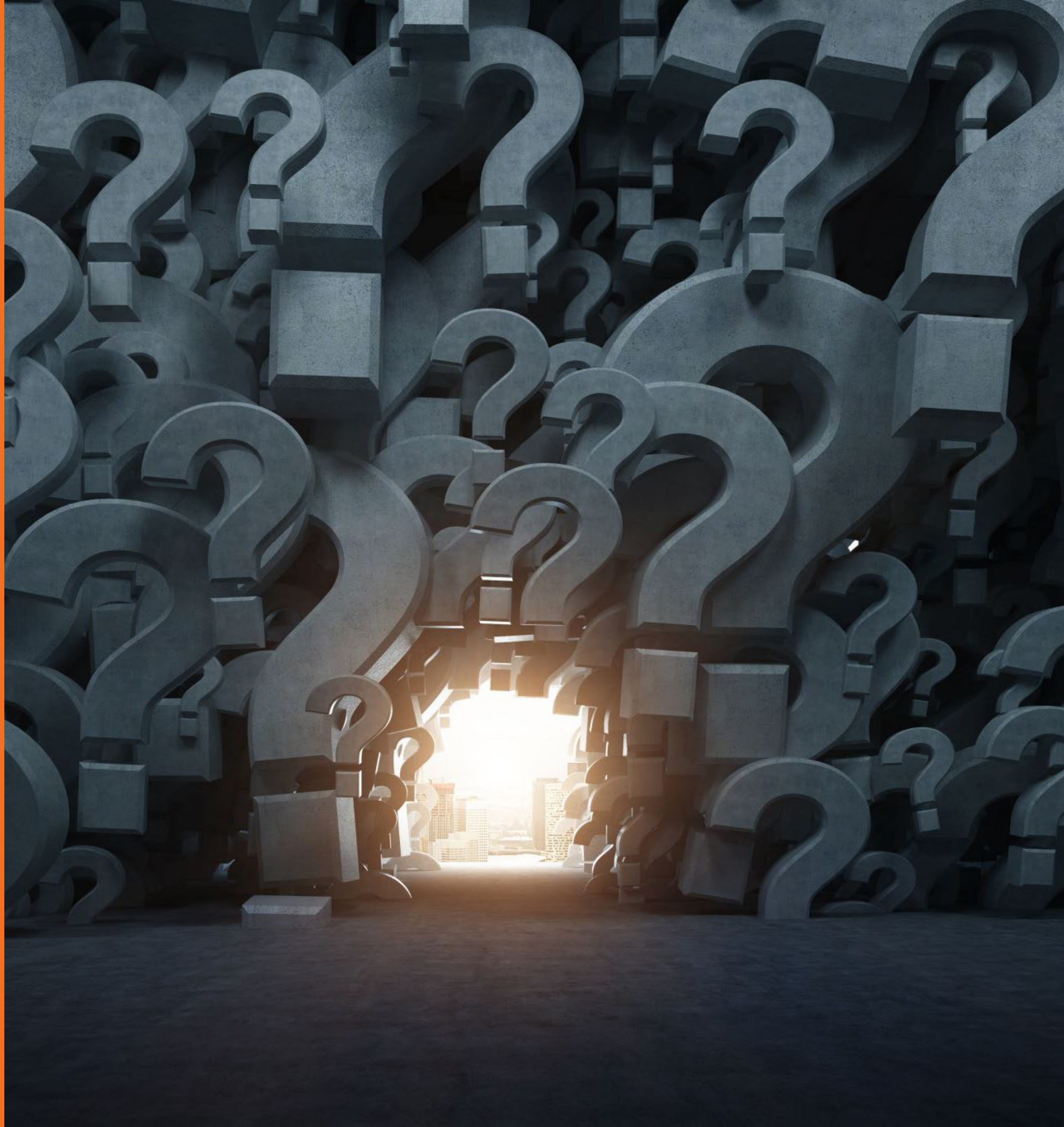
Questions and Discussion



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CLOSING

- Public Comments/Q&A
- Poll Questions

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How did we do this quarter?

1. **What's one thing you appreciated about this meeting?**
2. **Are there specific topics you'd like the committee to explore in 2024?**
3. **How would you rate the overall value of Product Councils this year?**

If the poll didn't work for you, please let us know in the chat box what the problem was: if you used the app or browser, and the error message you got, if any.

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Thank You!!

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