April 2023

HEAT PUMP WATER HEATER TRAINING

From the *Electrify Everything* initiative

Dan Wildenhaus

Sr Technical Manager

Electrify Everything
MINNESOTA

Dan Wildenhaus

- Senior Technical Manager and Residential Advisor
- Former contractor
- Eleven years-experience with inverter heat pumps and heat pump water heaters

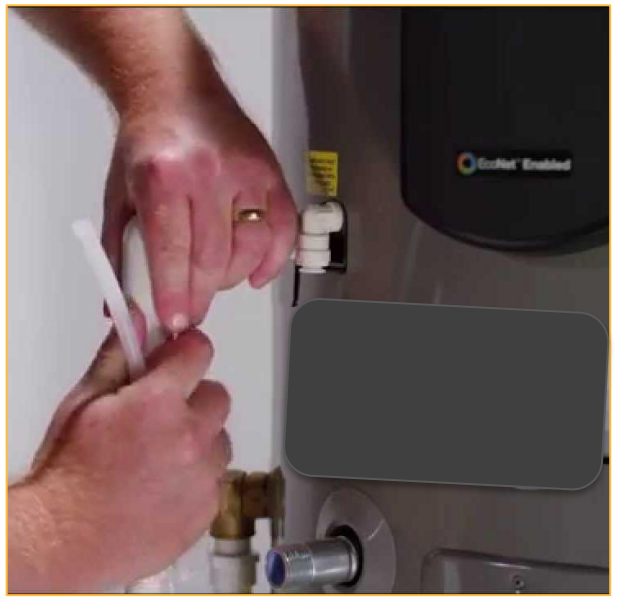
Experience in the Room

Which best describes your business?

- Water Heater Shop
- HVAC Installer
- Plumber
- Home Performance Contractor

How many have sold Heat Pump Water Heaters (HPWHs)?

- 1 year or more
- 2-3 or more
- 5 years or more



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About Electrify Everything

The Electrify Everything program:

- Is supported by the cities of Eden Prairie, Edina, Minneapolis, and St. Louis Park and is managed by Center for Energy and Environment
- Supports the gradual electrification of 1–4 unit homes to promote resident health and climate sustainability.

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Electrification is replacing as gas equipment with efficient electric options

Examples of electrification include:

- Replacing a gas hot water heater with a **heat pump water heater**
- Replacing a gas stove with an **induction stove**

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What's in it for a homeowner?

The main benefits of transitioning to electrically-powered equipment are:

- Improved health and safety
- Better for the climate

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Electrification is confusing. Electrify Everything wants to help residents navigate the choices.

Common questions for a resident interested in electrification include:

- Where should I start?
- When should I think about replacing equipment?
- What are the upfront and operational costs of electric options?
- What resources are available to help?
- Who do I talk to for guidance? Which contractors should I talk to for quality work?

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Our recommendations to residents are to focus on five key areas

Electrification projects in order of energy impact:

- Weatherization
- Heating
- **Water Heating**
- Clothes drying
- Cooking

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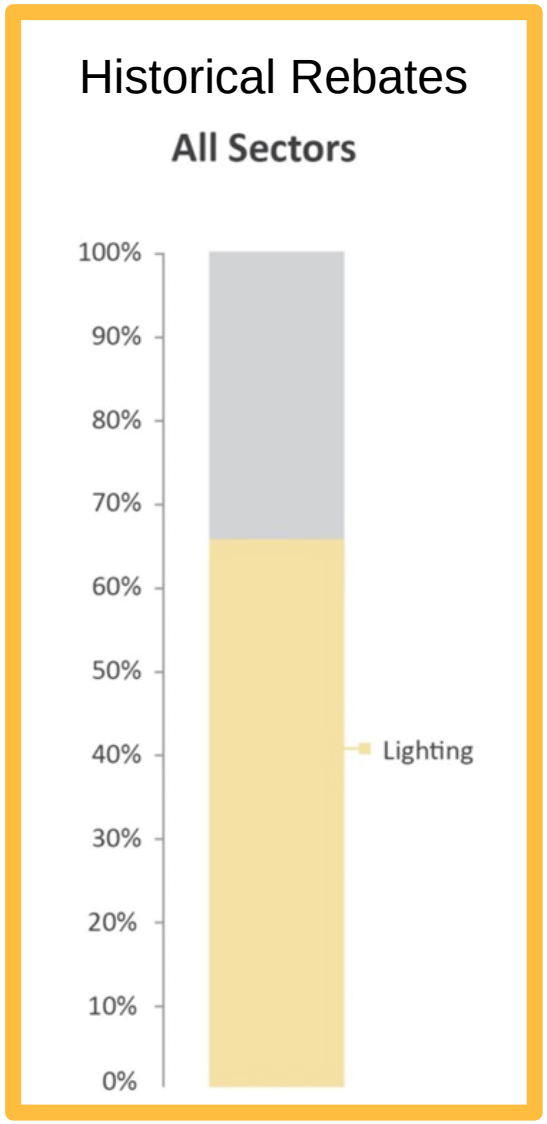
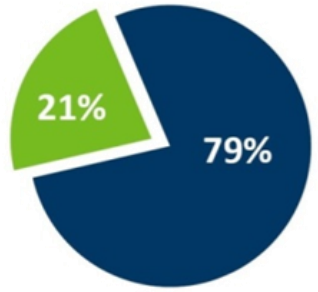
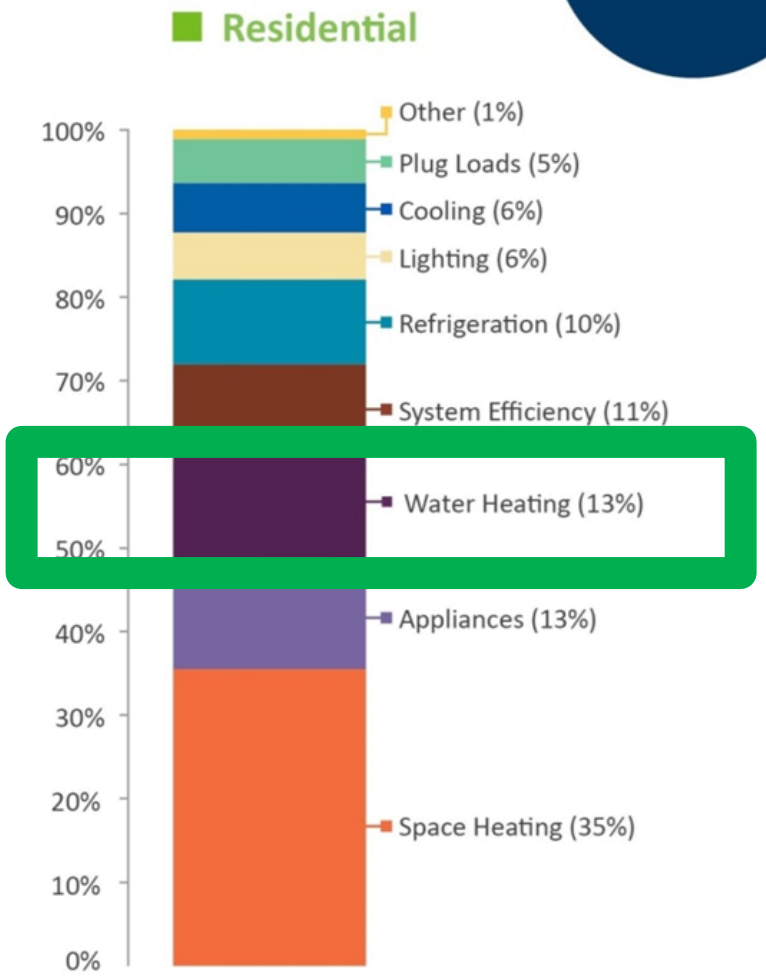
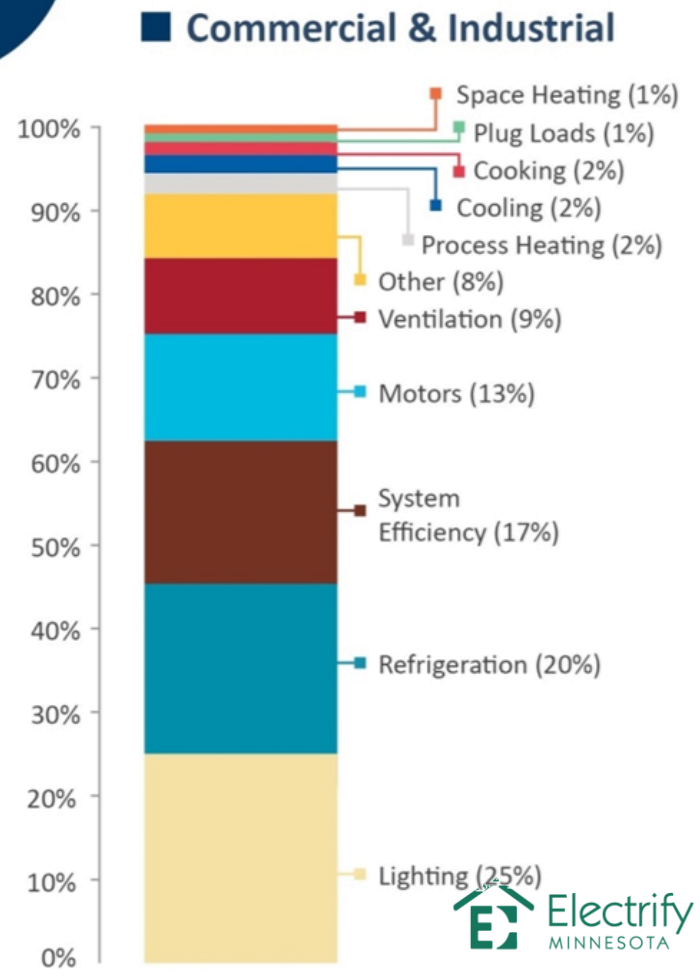
Utilities will need to shift rebates as lighting opportunities diminish









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Most residential emissions come from natural gas. But there is not a promising pathway to cleaning gas.

Greenhouse gas emissions from residential buildings are:

64% from natural gas, and **36%** from electricity

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Electricity has a pathway to becoming cleaner.

Xcel Energy's Carbon Free by 2050 plan aims to **decarbonize electricity generation by 2050.**

There is currently no emissions-free gas alternative to natural gas. Future opportunities with renewable natural gas are unlikely to be cost-effective.

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Can/will homeowners save money?

Courtesy Bradford White

Can/will homeowners save money?

Calculating Annual Operating Cost

Before you can choose and compare the costs of various models, you need to determine the correct size water heater for your home. If you haven't done this already, see **sizing a new water heater**. To estimate the annual operating cost of a storage, demand (tankless or instantaneous), or heat pump water heater, you need to know the following about the model:

- Energy factor (EF) (see above)
- Fuel type and cost (your local utility can provide current rates)

Then, use the following calculations:

FOR GAS AND OIL WATER HEATERS

You need to know the unit cost of fuel by Btu (British thermal unit) or therm. (1 therm = 100,000 Btu)

365 days a year X 0.4105 therms/day ÷ EF X Fuel Cost (therm) = estimated annual cost of operation

Example: A natural gas water heater with an EF of .58 and a fuel cost of $0.00000109/therm

365 X .4105/.58 X $1.09 (the cost of natural gas on the Energy Label) = $282

FOR ELECTRIC WATER HEATERS, INCLUDING HEAT PUMP UNITS

You need to know or convert the unit cost of electricity by kilowatt-hour (kWh).

365 days/year x 12.03 kWh/day ÷ EF x Fuel Cost ($/kWh) = annual cost of operation

Example: A heat pump water heater with an EF of .0 (this is the highest efficiency unit on the market) and an electricity cost of $0.1301/kWh

365 X 12.03 ÷ 4.0 X $0.1301 (this is the latest cost of electricity used on the Energy Label) = $143

The energy usage per day in the above equations is based on the DOE test procedure for hot water heaters, which assumes an incoming water temperature of 58°F, hot water temperature of 135°F, and total hot water production of 64.3 gallons per day, which is the average usage for a household size of three people.

		per ccf	per therm		
Minnesota average natural gas costs		11.04	1.06460945		
			per kWh		
Minnesota average electricity costs			0.1381		
Gas water heater					
	Assumption 0.4105 therms/day - based on average use patterns and temperature raise required				
Electric water heater					
	Assumption 12.03 kWh/day - based on average use patterns and temperature raise required				
Existing system			New System		
	EF			EF	
Gas system	0.58		Gas system	0.95	
Annual Estimate	242.65		Annual Estimate	148.15	
Existing system			Existing system		
	EF			EF	
Electric system	0.95		Electric system	3.9	
Annual Estimate	638.31		Annual Estimate	155.48	

EXAMPE ONLY- Please Open Workbook

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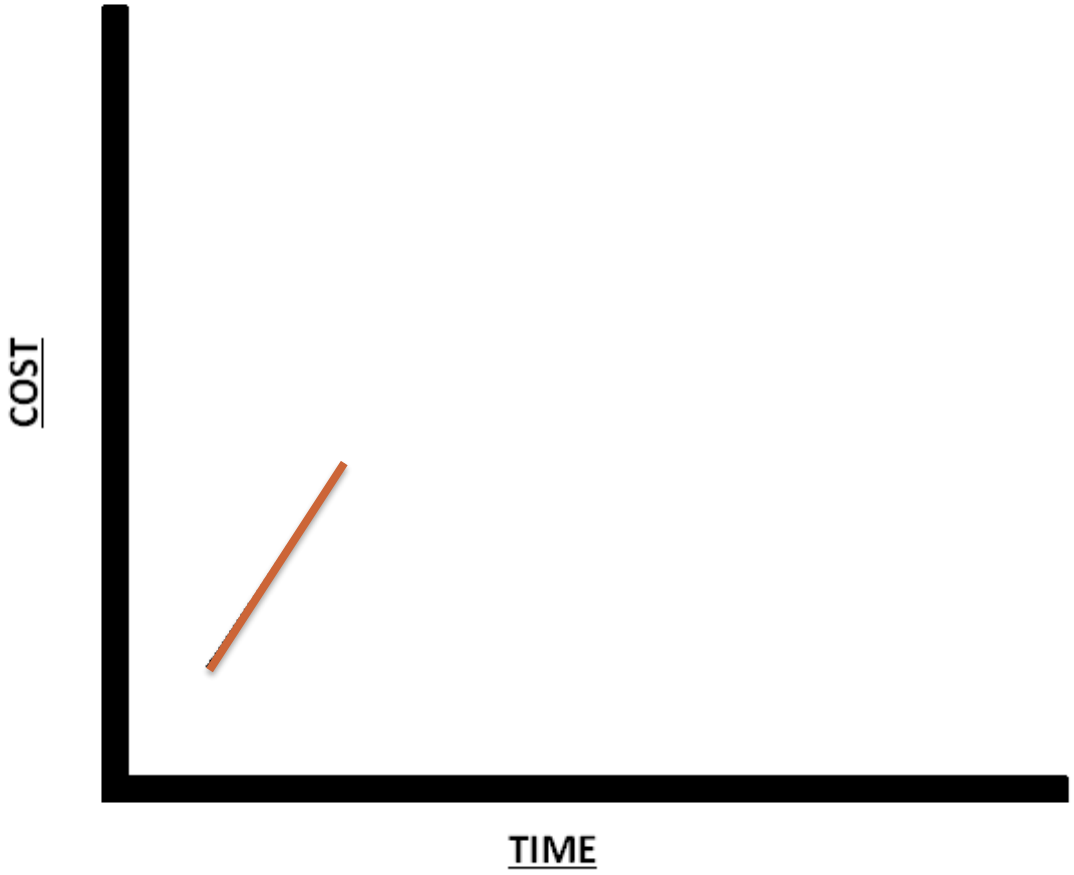
https://www.energy.gov/energysaver/estimating-costs-and-efficiency-storage-demand-and-heat-pump-water-heaters

The New Standard

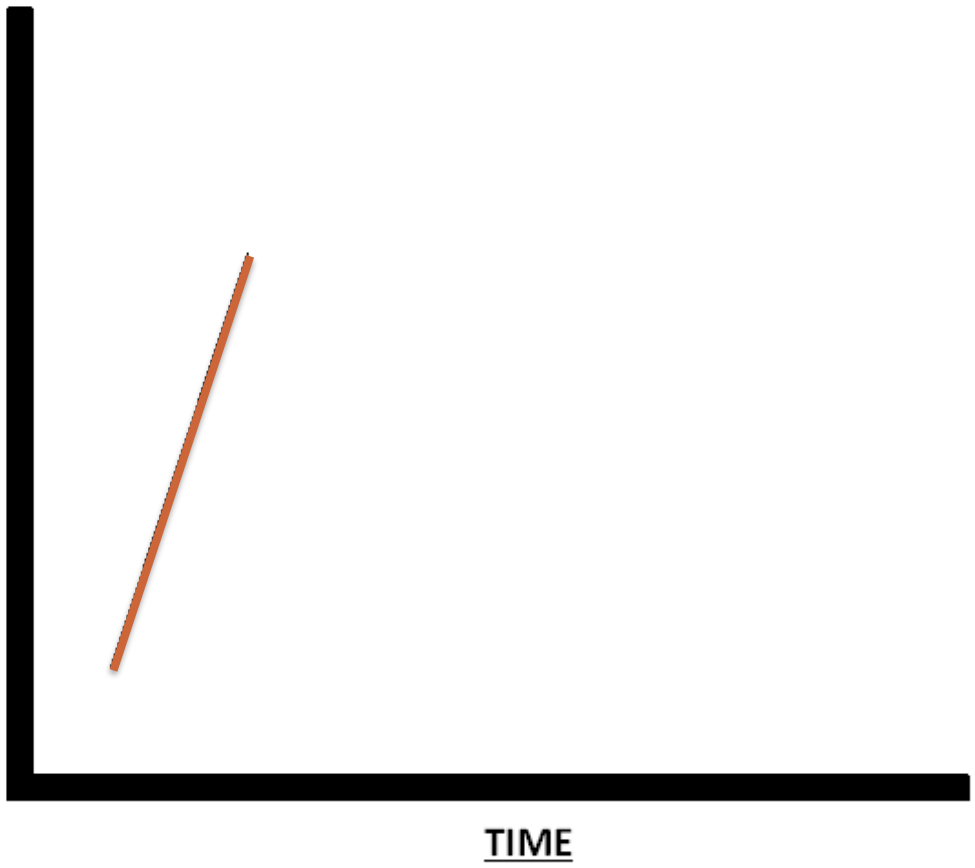
HOT WATER SOLUTIONS

Challenges of using a business case process

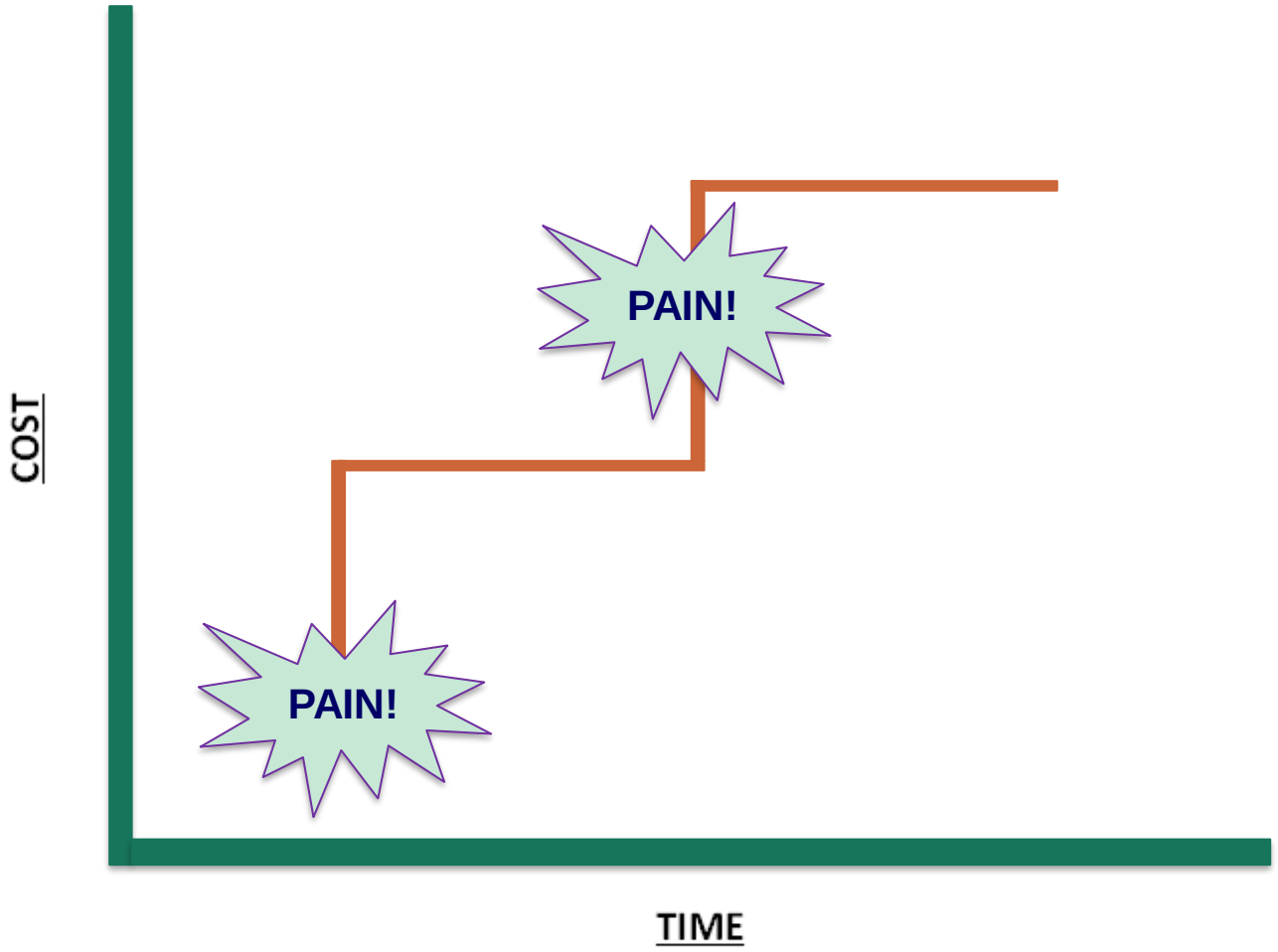
Lowest first-cost option



Efficiency/electrification option



Challenges may change as we look at multiple code/standards cycle changes.



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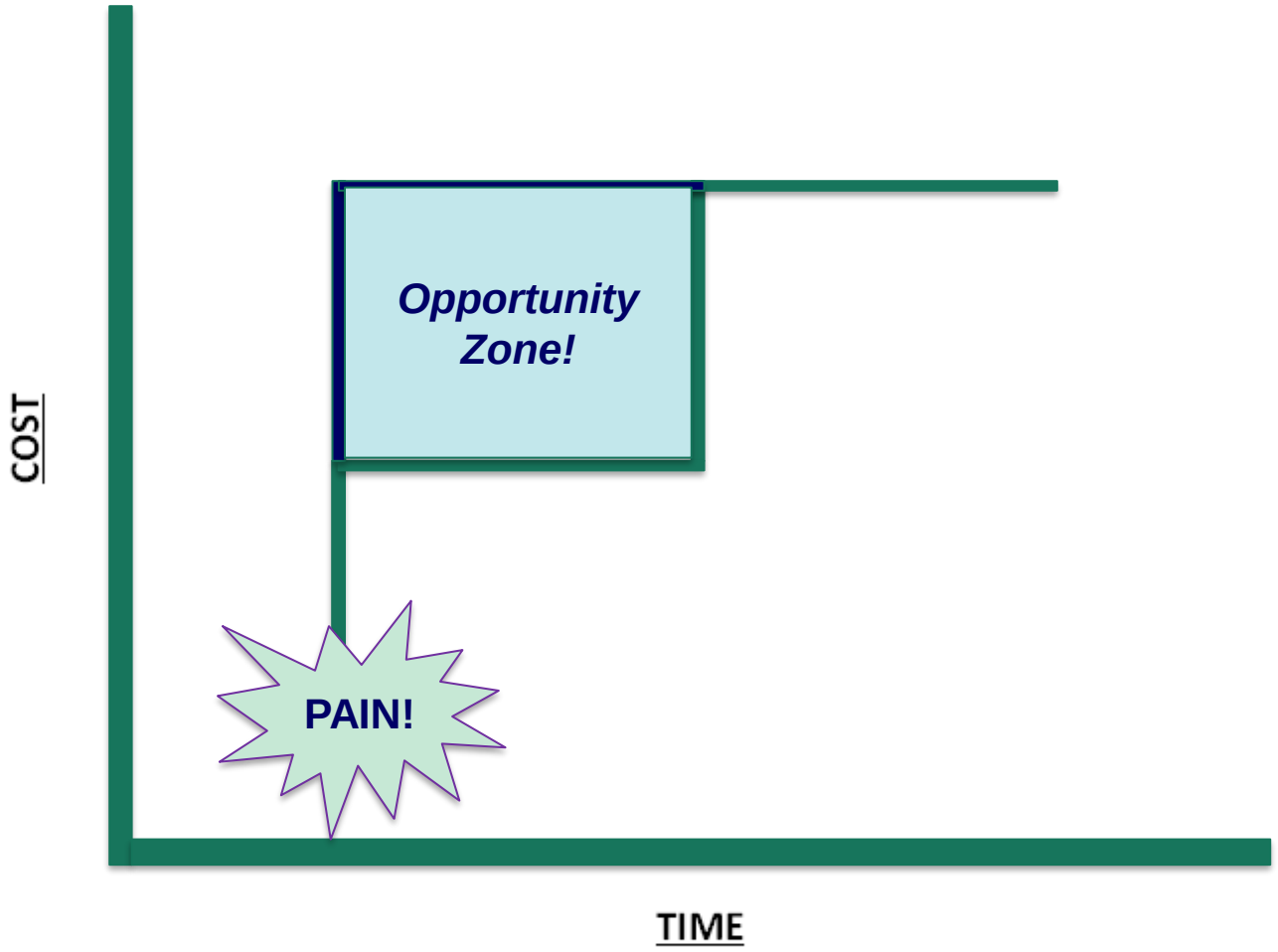
Benefits of adopting efficiency/electrification ahead of code/standards requirements



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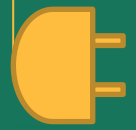

The technology and questions

Mythbusting some common concerns

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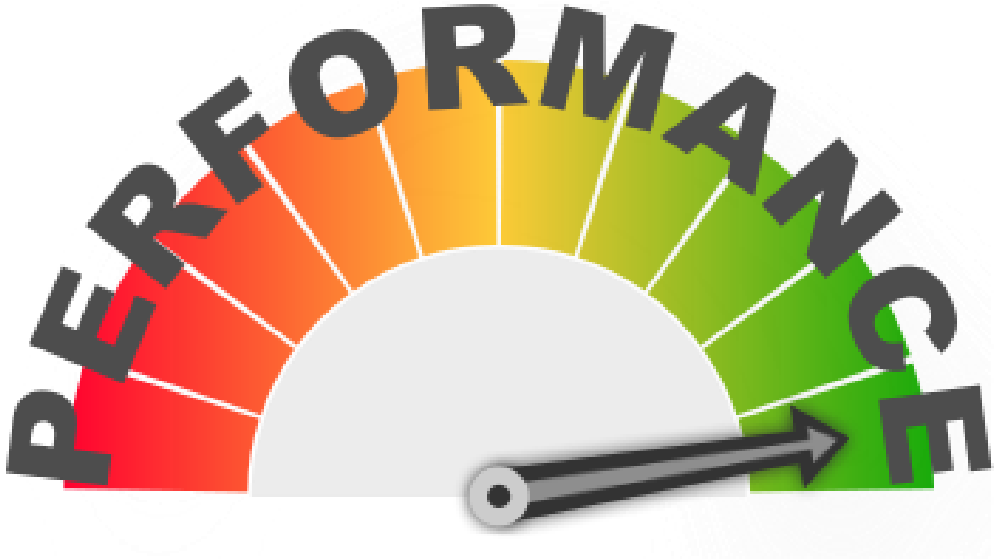
What defines performance of a HPWH?



- Use patterns
- Total usage
- Incoming water temperature
- Incoming air temperature for compressor

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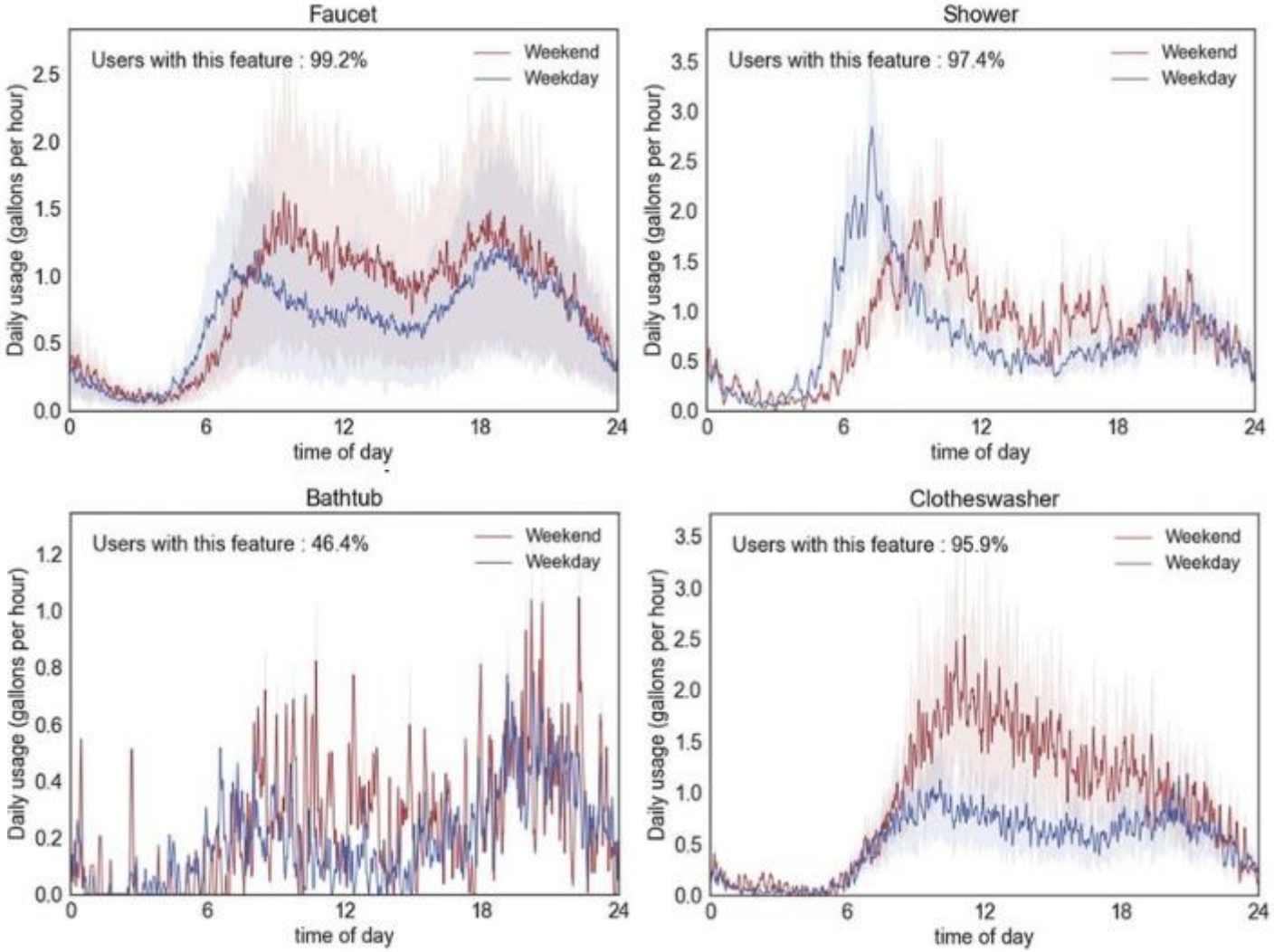
Understanding draw patterns and total draw



Mostafavi, Nariman & Shojaei, Hamid & Beheshtian, Arash & Hoque, Simi. (2018). Residential Water Consumption Modeling in the Integrated Urban Metabolism Analysis Tool (IUMAT). Resources Conservation and Recycling. 131. 64-74. 10.1016/j.resconrec.2017.12.019.

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Understanding draw patterns and total draw

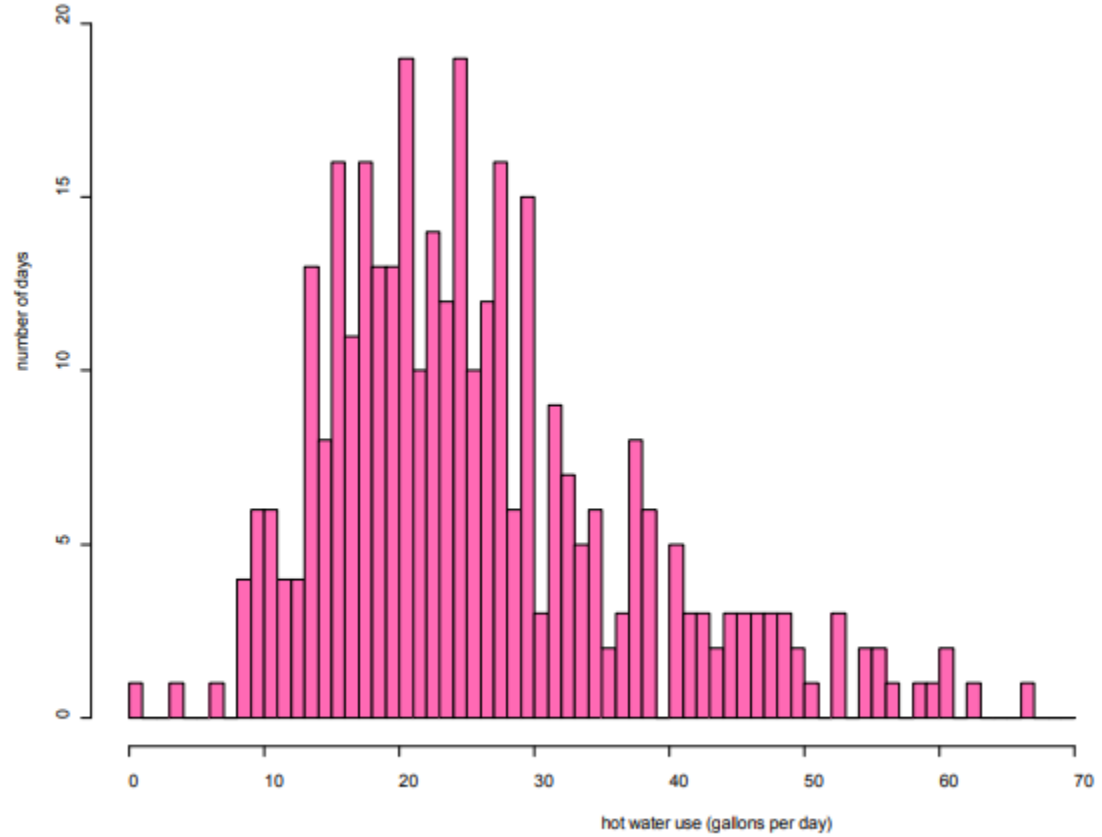

Figure 4 Frequency of Daily Hot Water Use (house_id = GTI_OKL-1_Phase-1)

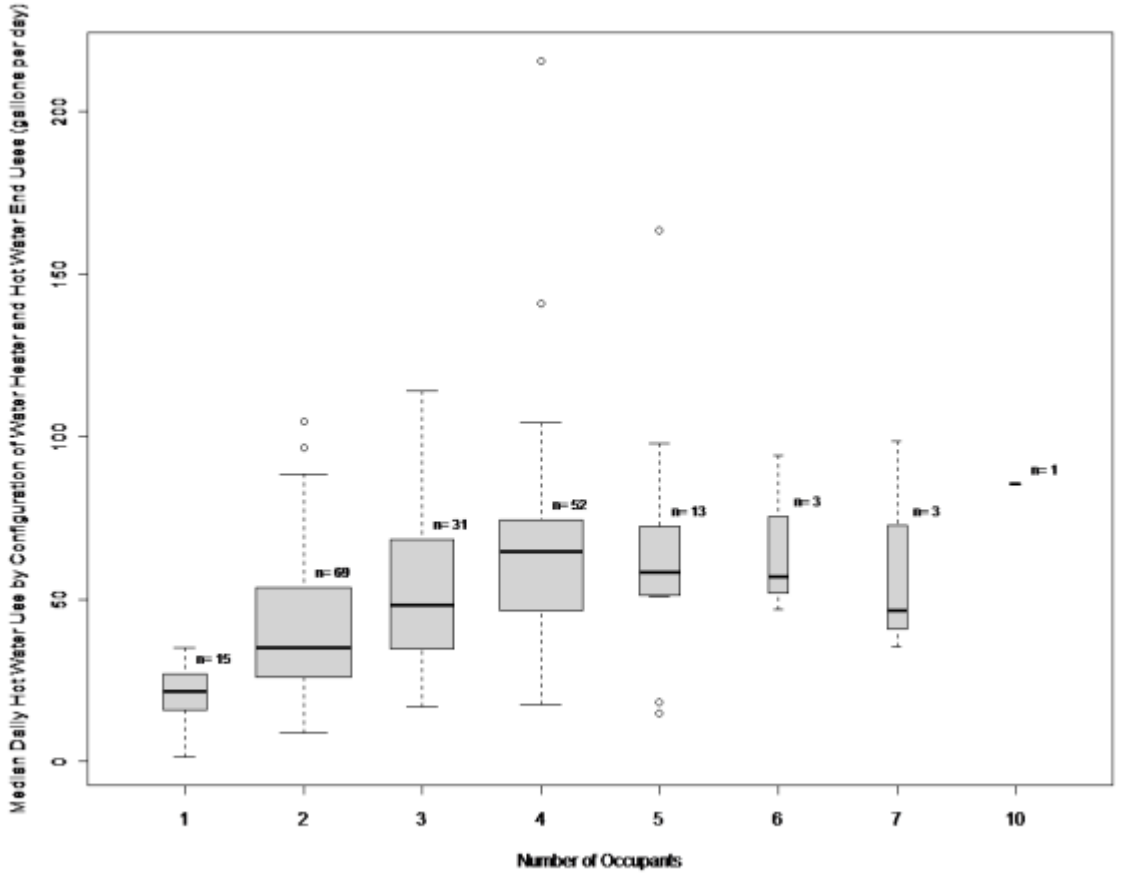

Figure 6 Median Daily Hot Water Use by Number of Occupants

Hot Water Draw Patterns in Single-Family Houses: Findings from Field Studies - J.D. Lutz, Renaldi, A. Lekov, Y. Qin, and M. Melody
Lawrence Berkeley National Laboratory

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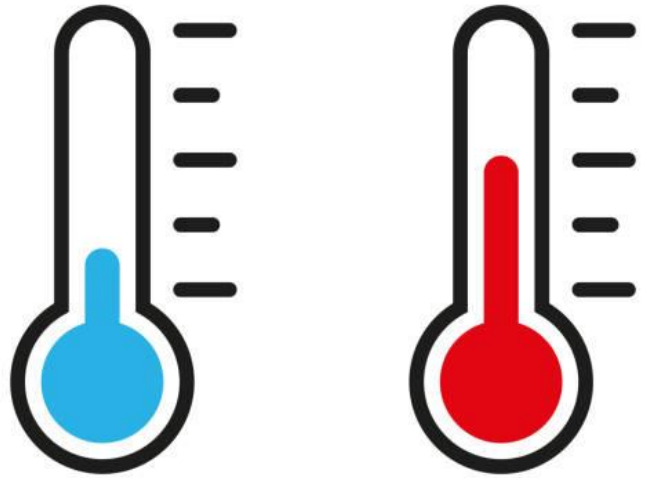
Understanding average incoming water temperature

- National Average = 52ºF
- Minnesota Average = 45ºF



https://www.hydroflow-usa.com/minnesota-groundwater-temperature

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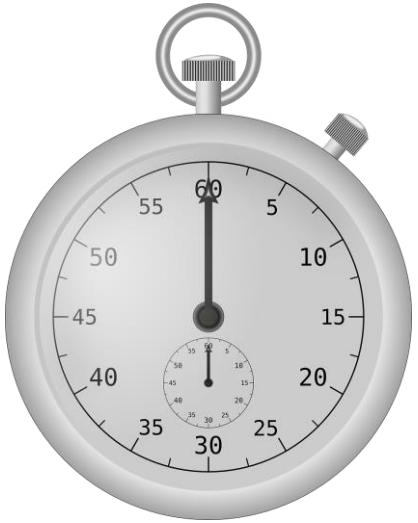
Solutions

- Use patterns
- Total usage



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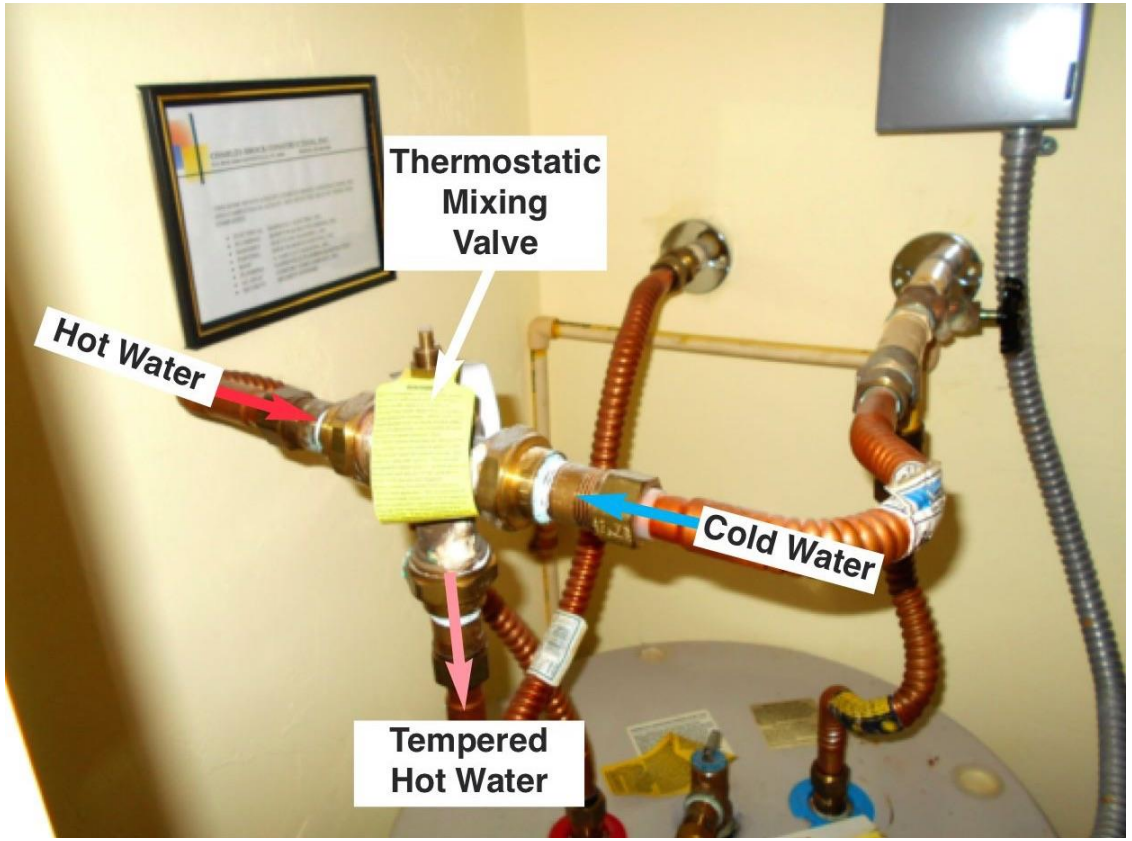
Solutions

- Incoming water temps



https://www.howtolookatahouse.com

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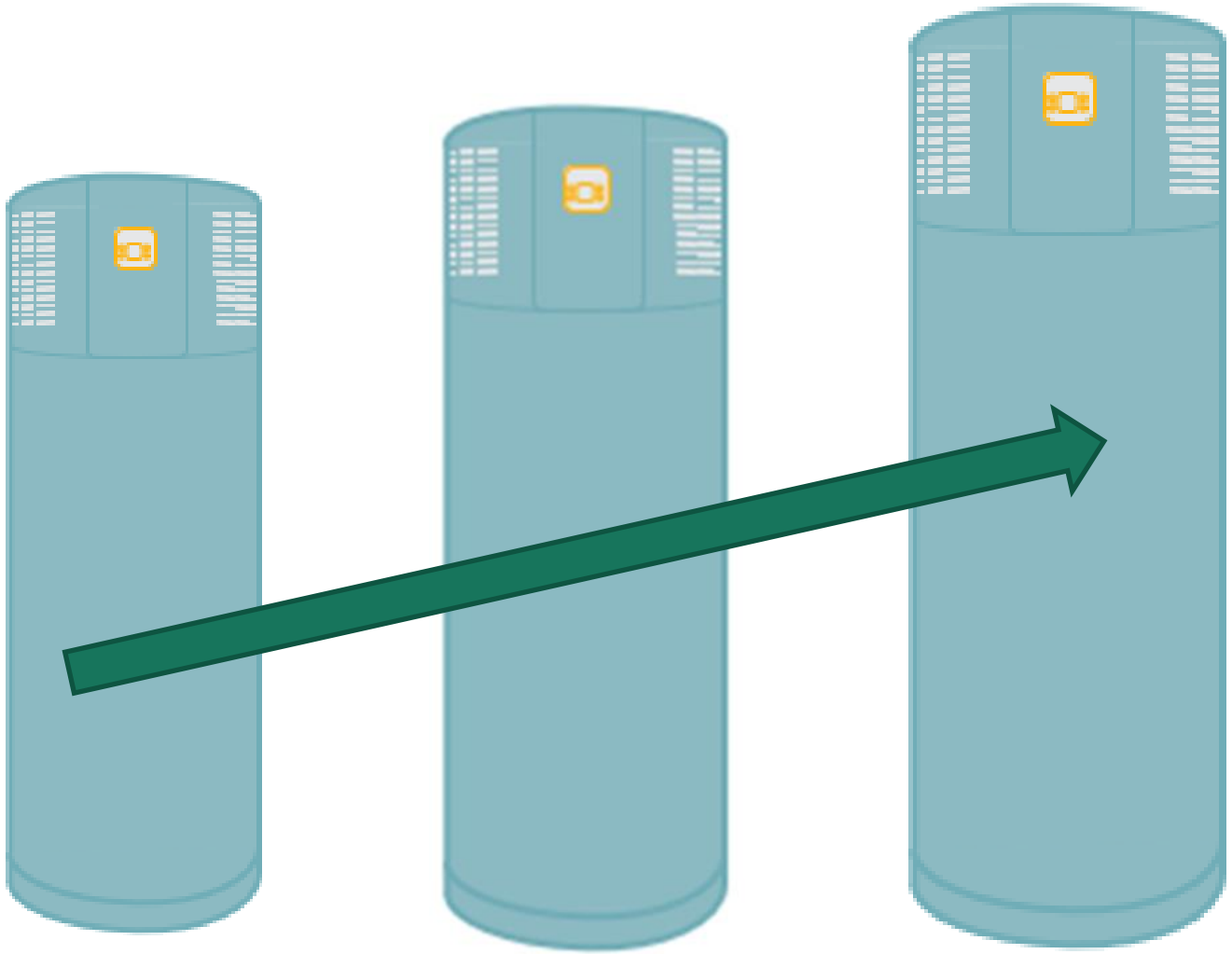
Solutions

- Use patterns
- Total usage
- Incoming water temps



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Is the home and occupant appropriate?

HOT WATER SOLUTIONS

Are you a homeowner?

Do you have an existing tank water heater?

Where is your water heater located?

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Potential HPWH Customers

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Most homeowners with a tank water heater

- Interested in saving money over time
- Going through energy retrofits
- Currently have other heat pump technology
- Emergency replacement with new standard!

Compatible water heater location

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Locations

HOT WATER SOLUTIONS

1. Insulated garage
2. Attic
3. Uninsulated garage
4. Laundry room
5. Heated basement
6. Basement mechanical room (staircase from hell)
7. Dugout crawl space
8. Closet built around existing water heater
9. Unheated basement
10. Low boy under the sink

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https://www.energystar.gov/products/ask-the-experts/do-heat-pump-water-heaters-work-in-cold-climates#:~:text=Yes%2C%20today's%20heat%20pump%20water,or%20above%2040%C2%B0F.

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Space Heat Interaction

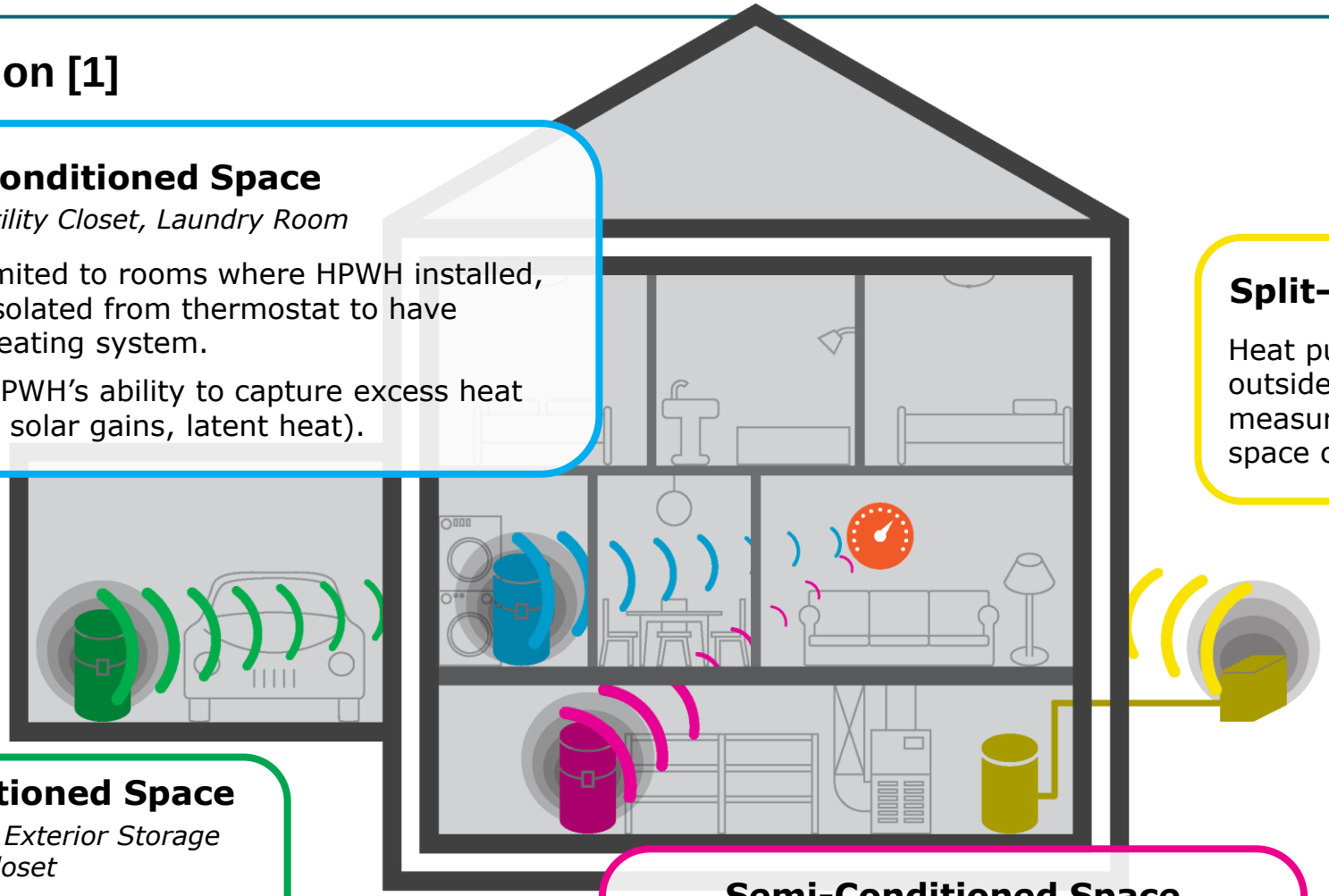
Space Heat Interaction [1]

Fully-Conditioned Space

Mainfloor Utility Closet, Laundry Room

Cooling effect is largely limited to rooms where HPWH installed, and typically sufficiently isolated from thermostat to have minimal effect on space heating system.

Effect further limited by HPWH's ability to capture excess heat (heating shoulder season, solar gains, latent heat).



Split-System HPWH

Heat pumps installed outside a house have no measurable impact on space conditioning.

Non-Conditioned Space

Garage, Attic, Exterior Storage Closet

No noticeable impact on space-heating system. Heat is replaced from outside.

Semi-Conditioned Space

Basement

In spaces within insulated building envelope but not actively heated, feedback to space heating system is limited even further than in fully conditioned spaces.

[1] Ben Larson, Larson Energy Research

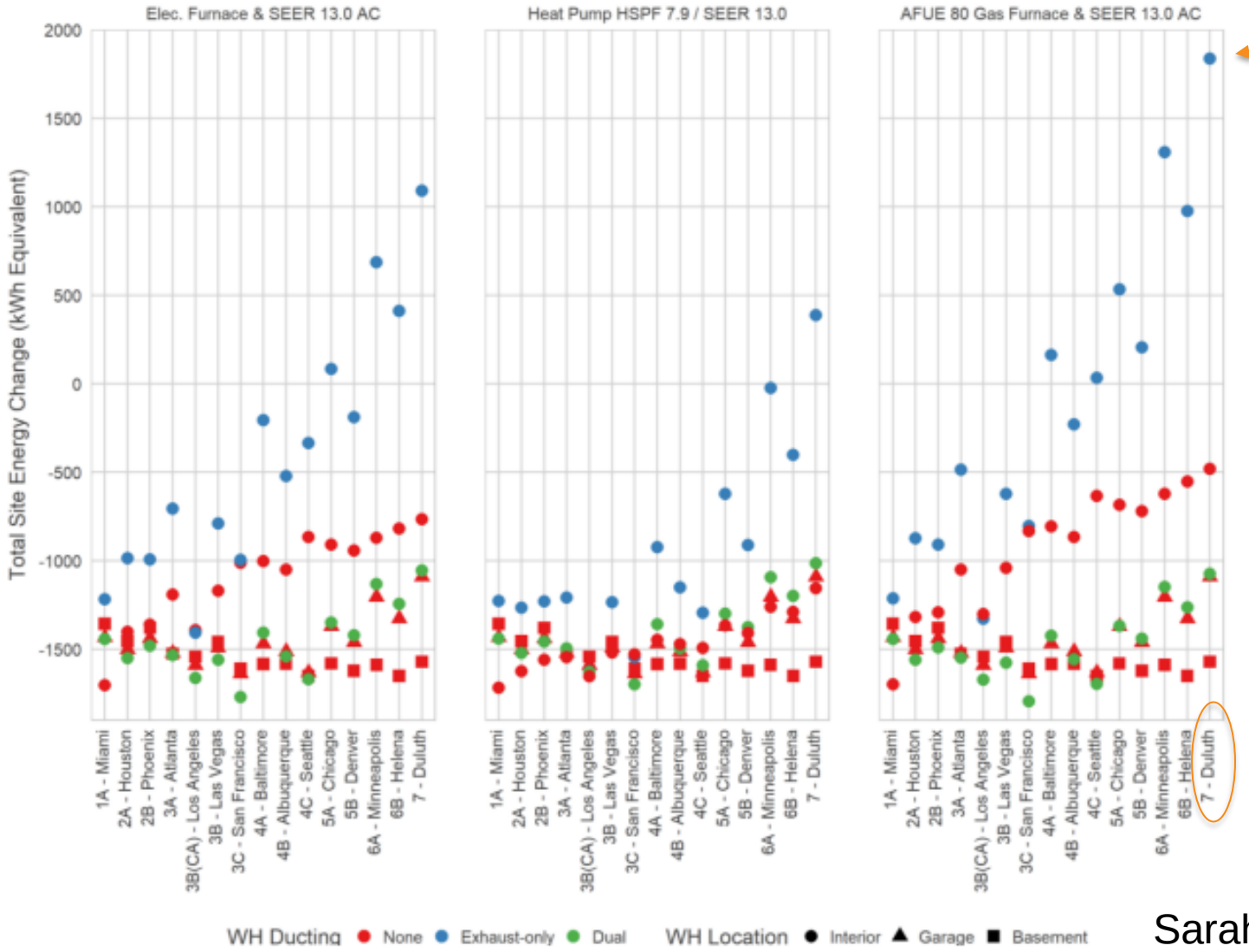
HPWHs and Space Heat Interaction

1-2 degrees temperature impact during heating months

Effects are felt **only when the unit is running**, 3-5 hours/day

Only impacts installs in conditioned space; **not garage or basement**

In Duluth Don’t Exhaust Duct Only!



Don’t do this

Sarah Widder, PhD, Cadeo Group LLC Ben Larson, Ecotope, Inc

HPWH / Furnace Interactions

Interaction between Heat Pump Water Heaters or Other Internal Point Source Loads and a Central Heating System – Pacific Northwest 2017 – PNNL/NEEA

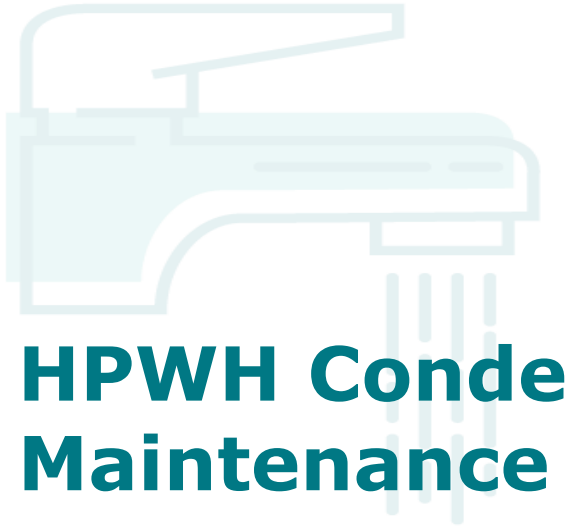
"…the thermal distance of the load from the thermostat [is] the dominant factor in determining the degree to which the load "interacted" with the space conditioning system. "

https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26447.pdf

Heat pump water heaters in cold climates – Michigan 2022 - Slipstream

"Customer satisfaction wasn't an issue in our study. Our monitored installations were all in basements of single-family homes, and we couldn't detect an increase in space heating from using a heat pump water heater. Residents rarely complained about the HPWH affecting their comfort in their home. In fact, overall, our survey respondents reported high satisfaction with the technology."

https://slipstreaminc.org/research/heat-pump-water-heaters-cold-climates



HPWH Condensate Management and Maintenance

Installation considerations

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Condensate Production

Condensate is produced when water vapor in the air condenses on the cold evaporator coil while the compressor is running.

Condensate is **not** produced when incoming air temperature is below 36 F⁰.

Condensate Drainage Options

Condensate drainage locations:

- Floor drains
- Outside
- Laundry tubs
- Washing machine vent

Tank must be level for drain pan to drain properly.

Condensate Quantity + Pumps

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- Amount of condensate produced depends on the amount of moisture in the air
- Average production of about 2 quarts per day
- An existing AC condensate pump can handle extra load
- A 2-gallon per minute pump is sufficient
- If installed in basement, double the available lift

Condensate pH (Non-Acidic)

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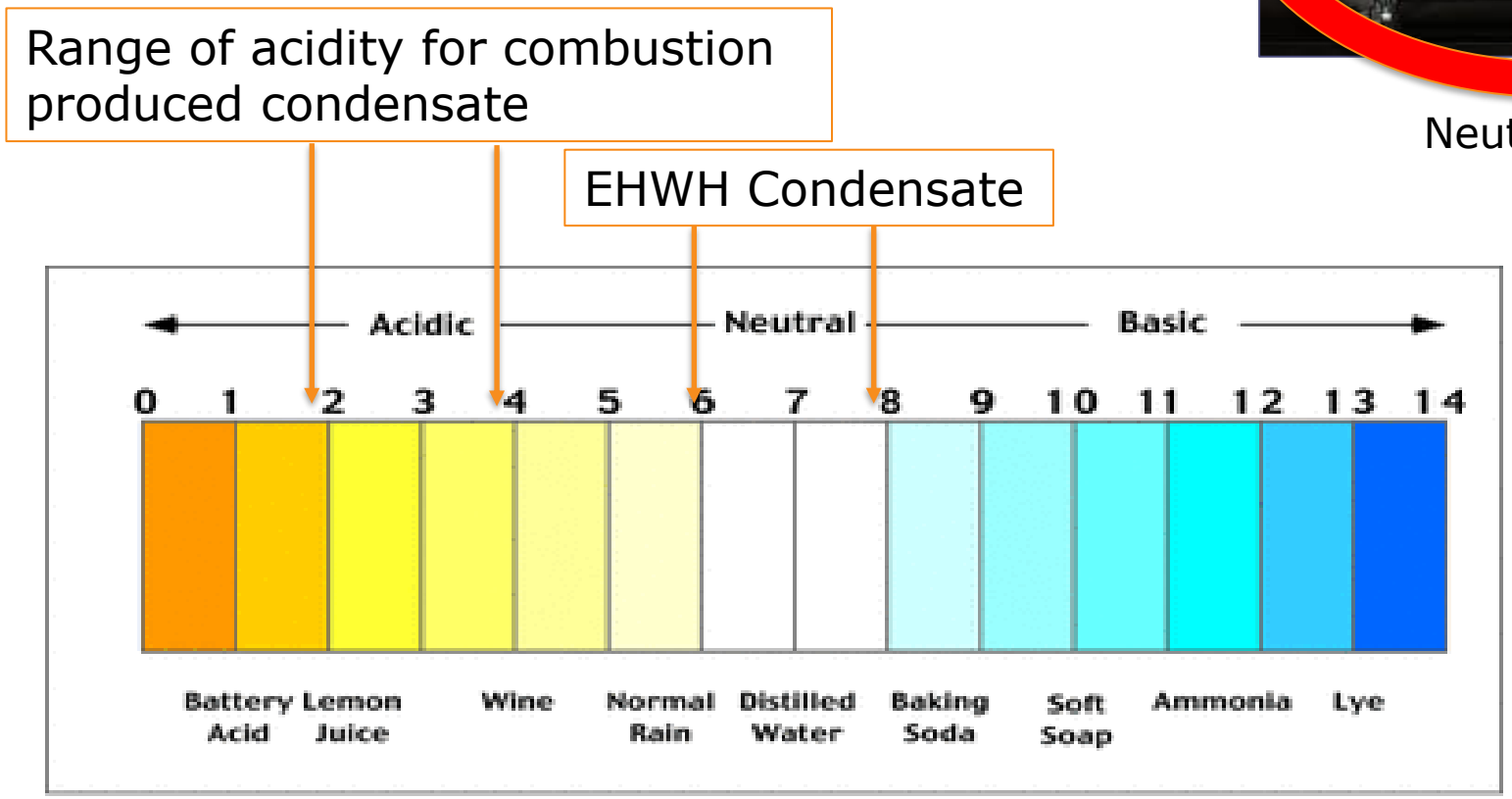
HPWH condensate is like condensate from an air conditioner.

Not like condensate from a condensing gas water heater.

Neutralizers



Condensate: “T” the Condensate Line

A “T” connector allows for easy cleanout of the condensate line – a code requirement in many locations.

Where Not to Run Condensate Drainage

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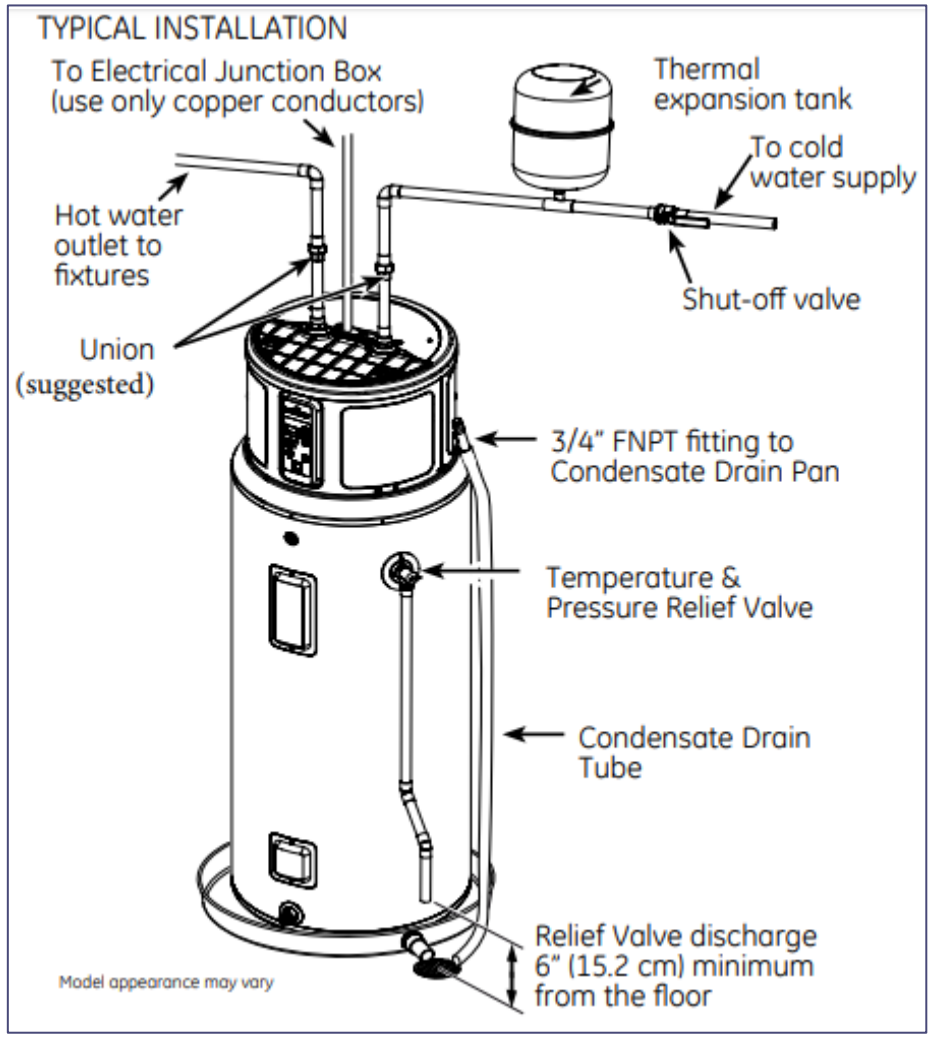
- Sidewalks, any walking surfaces or areas subject to freezing temperatures
- Above/near foundation of the house
- Directly into a sewer line

Clogged Condensate Alarm

- If evaporator drain main becomes clogged, compressor will shut off
- Fault code F20* will display, and an alarm will sound
- Touching any key will silence the alarm



*Different brands will have different fault codes

Condensate Management Summary

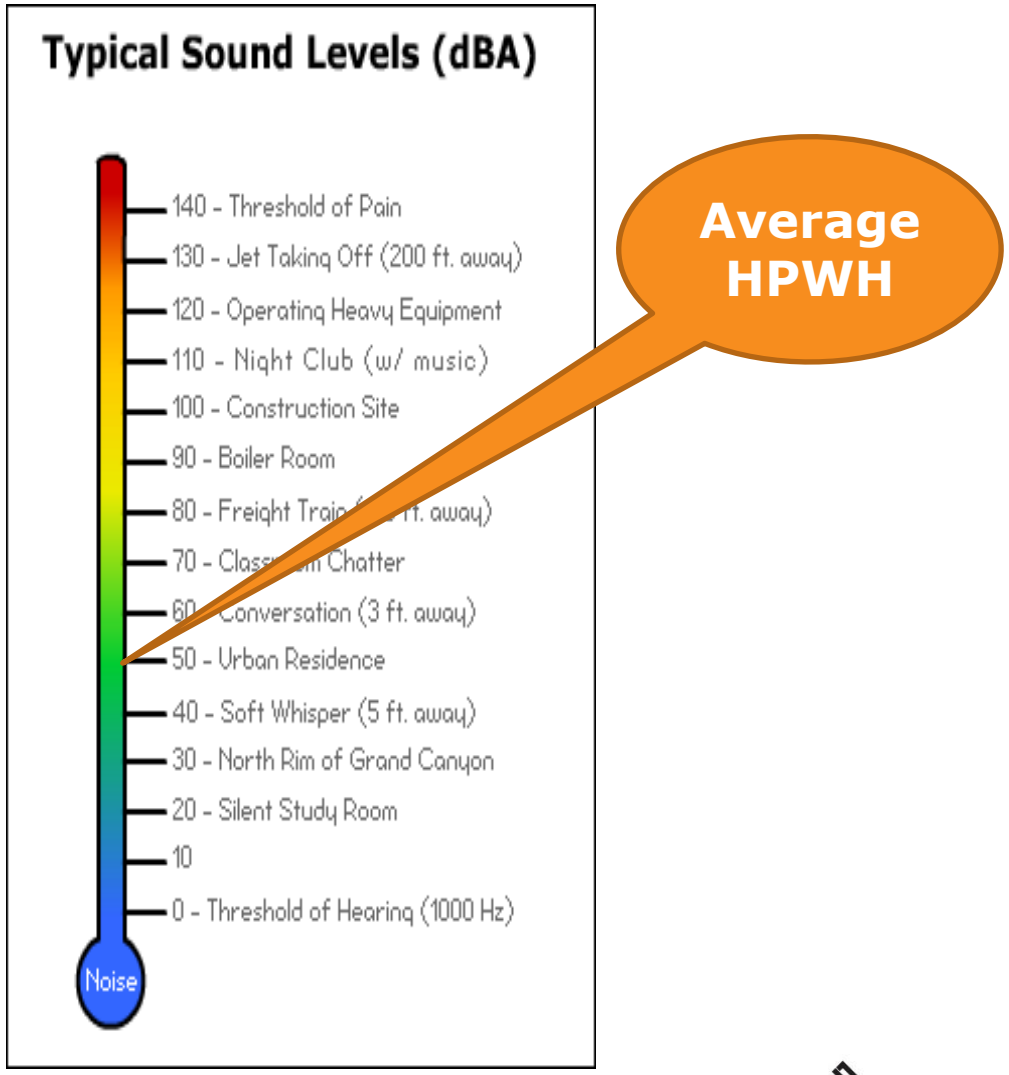
HOT WATER SOLUTIONS

- Condensate only produced when compressor is running
- Condensate is not acidic
- 2 gallons is an appropriate size for a condensate pump
- Follow applicable code for condensate line and drainage
- Installing a “T” connector rather than elbow at the start of the condensate line allows the line to be cleared of blockages and maintained

Clearance: Filter access

Noise

- Heat pump water heaters range in decibel ratings of **45 to 52** decibels.
  - About the same level as a modern dishwasher.
- The decibel scale is logarithmic.
  - A decibel increase of 10 represents a doubling of perceived loudness.



Noise Mitigation

HOT WATER SOLUTIONS

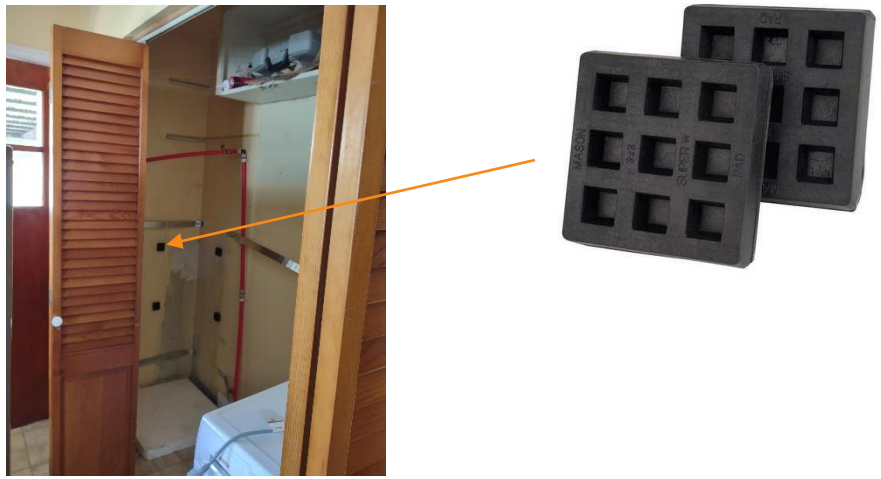
Low-Noise Tips for Installation:

- Choose the right location for installation
- Don’t put in high occupancy areas where the noise will become bothersome to the homeowner

Seismic strapping considerations:

- If installing in an area that requires seismic strapping, the vibration from the tank will travel through the wall and echo

Example: Isolation pads are an option to further reduce noise and vibrations between EHWH and two walls.



Neoprene washers or stand-offs are used to anchor seismic straps.

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App Enablement: Benefits

- Leak detection notification
- A contractor can enter his contact info
- Controllability of the unit
- Filter alarm
- TOU programming
- Energy usage reports
- Health alerts
- Available hot water in the tank
- Shutoff valve control
- Condensate management alerts

How would you respond?

HOT WATER SOLUTIONS

It's too expensive…

Up to 60% savings and incentives

I'm not sure these are Reliable…

10 year warranty

The technology is too new…

Heat pump technology has been around for over 60 years

I don't want to run out of hot water…

Same delivery as a standard tank

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What about incentives and rebates?

Utility Incentives

- Xcel Energy (electric to electric upgrade)
  - $400 heat pump water heater
  - $500 smart electric heat pump water heater
- Dakota Electric (electric to electric upgrade)
  - $500 ENERGY STAR rated heat pump water heater

Inflation Reduction Act

- 25C Tax Credit
  - 30% of project costs up to $2,000
- HOMES (TBD)
  - Home gets 20% savings
    - Income qualified 80% project costs up to $4,000
    - Non-income qualified 50% project costs up to $2,000
- HEEHRA
  - All income qualified
    - $1,750 for Heat Pump Water Heater

https://mn.my.xcelenergy.com/s/residential/home-rebates/water-heaters
https://www.dakotaelectric.com/member-services/programs-rebates/for-your-home/energy-wise-rebates/

Additional Sizing, Selection, and Installation guidance

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General recommendations for success!

Rough sizing guestimator

Tank Size (gallons)	# or Occupants
50	2-3
65/66	2-4
80	3-6

Consider going up a size when…

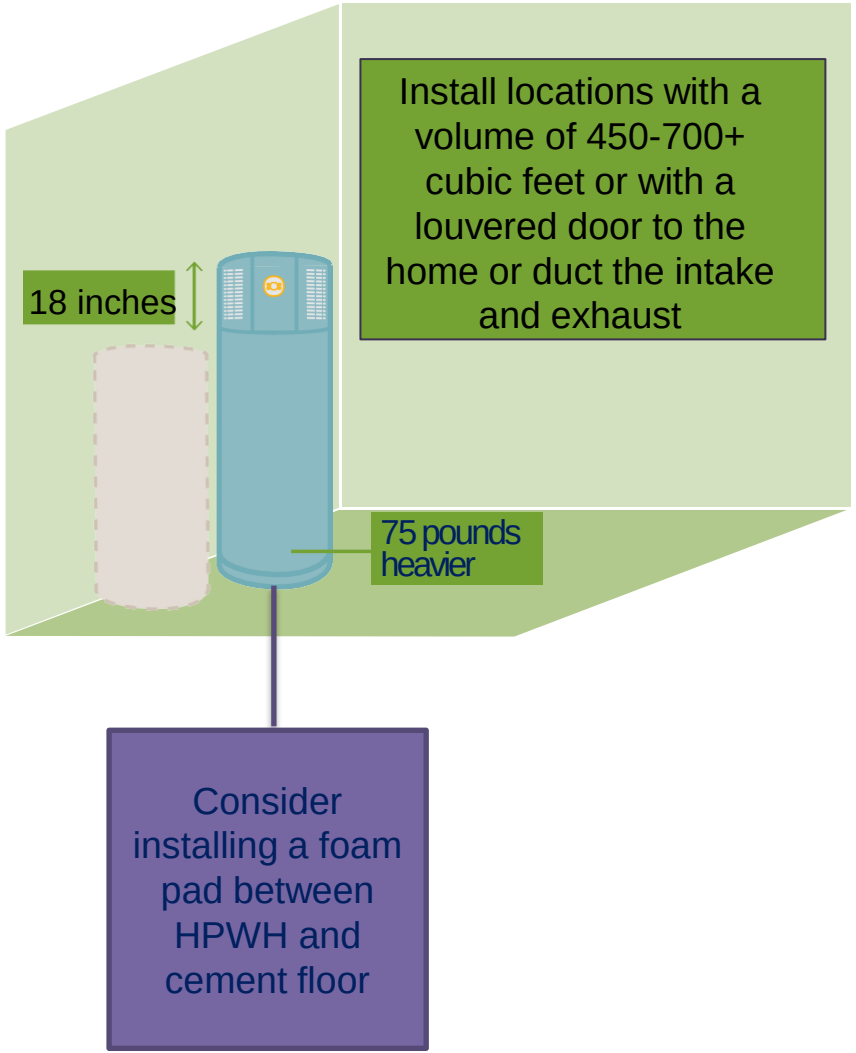
- Going from gas storage unit to a HPWH
- House includes children or teenagers
- Occupancy likely to change within 5 years

Setting expectations through estimations

	HPWH	Gas tank	ER tank
Showers - # consecutive showers delivered	2.75 – 3.25	3.5	3.25
Efficiency (UEF) – The higher the better!	2.9+	0.61 – 0.70	0.92 – 0.95
First Hour Rating - # of gallons hot water delivered in first hour	67	67	66
Recovery Rate – Gallons a heater can raise by 90ºF in one hour	29	40	22
Average Warranty in Years	10-12	6-10	6-10

General recommendations for success!

Location, location, location…



A la modes…

Hybrid or Auto mode: This is typically the best combination of efficiency and performance. The heat pump does most of the heating with small boosts from resistance elements when needed.

Heat Pump or Efficiency mode: For homes with two people or fewer, or less than average water use. This mode relies solely on the heat pump.

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Installation Guidance from the pros!

HOT WATER SOLUTIONS

- Thanks to HotWaterSolutionsNW.com

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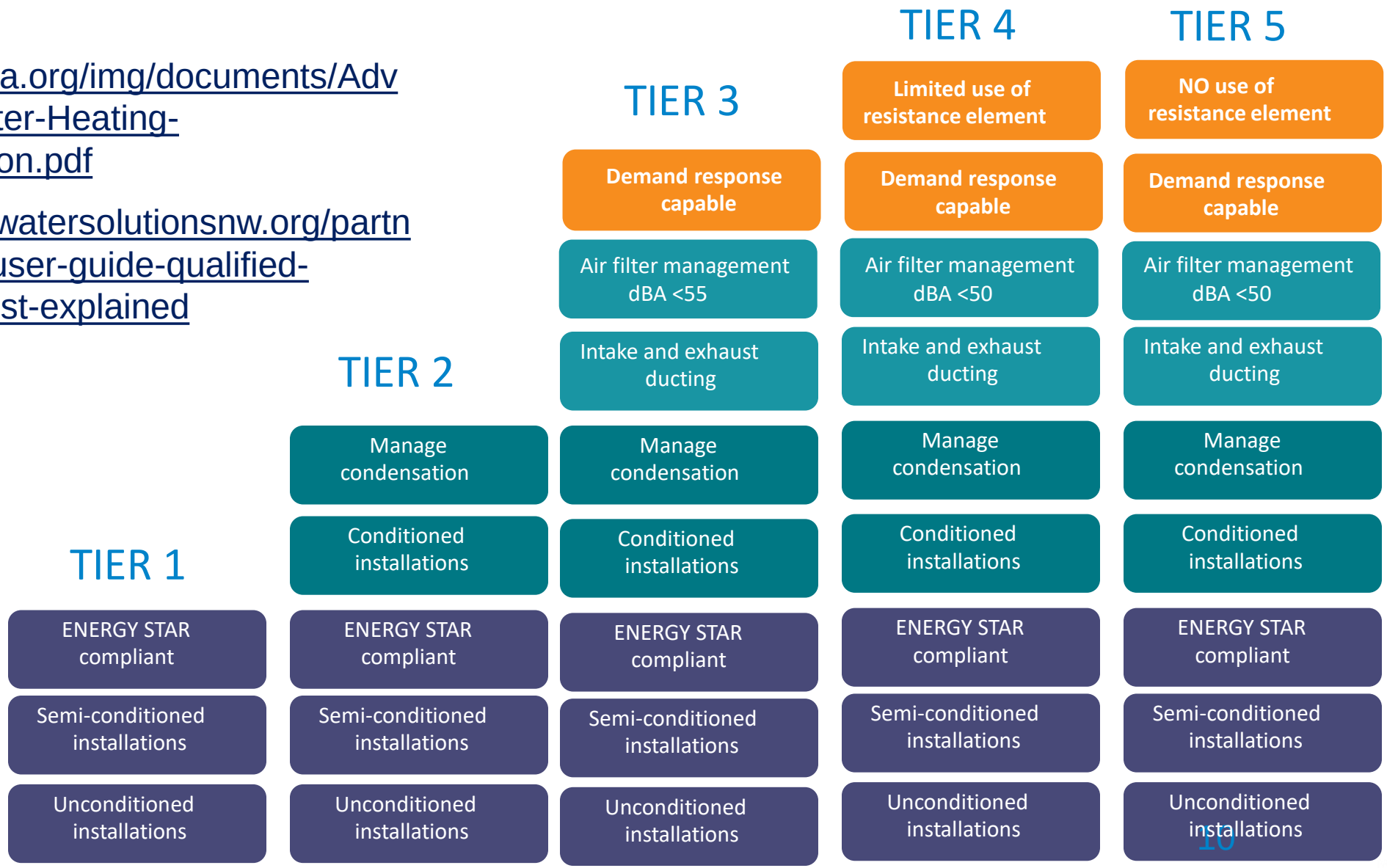
Product Tier Overview

HOT WATER SOLUTIONS

https://neea.org/img/documents/Advanced-Water-Heating-Specification.pdf

https://hotwatersolutionsnw.org/partners/news/user-guide-qualified-products-list-explained



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Advanced Water Heater Specification

Cool Climate Efficiency

- Tier 3
  - CCE of 2.6 or higher
- Tier 4
  - CCE of 3.0 or higher

Recommended efficiency thresholds for installations in semi-conditioned or unconditioned spaces

Uniform Energy Factor

- Tier 3
  - ENERGY STAR
  - UEF 2.8 or higher
- Tier 4
  - UEF 3.45 or higher

Recommended efficiency thresholds for installations in conditioned spaces

Advanced Water Heater Specification

March 1, 2022

A Specification for Residential, Commercial – Multifamily, and Industrial Water Heaters and Heating Systems
Advanced Water Heating Specification
Version 8.0

Effective Date: March 1, 2022

1.0 Introduction

This document succeeds the Northwest Energy Efficiency Alliance's (NEEA's) previous Advanced Water Heating Specification (AWHS Version 7.0). This version has been expanded to include commercial, multifamily, and industrial water heating systems in addition to residential water heaters. Notably, this version has no substantive changes to the residential water heater portion of the specification compared to Version 7.0.

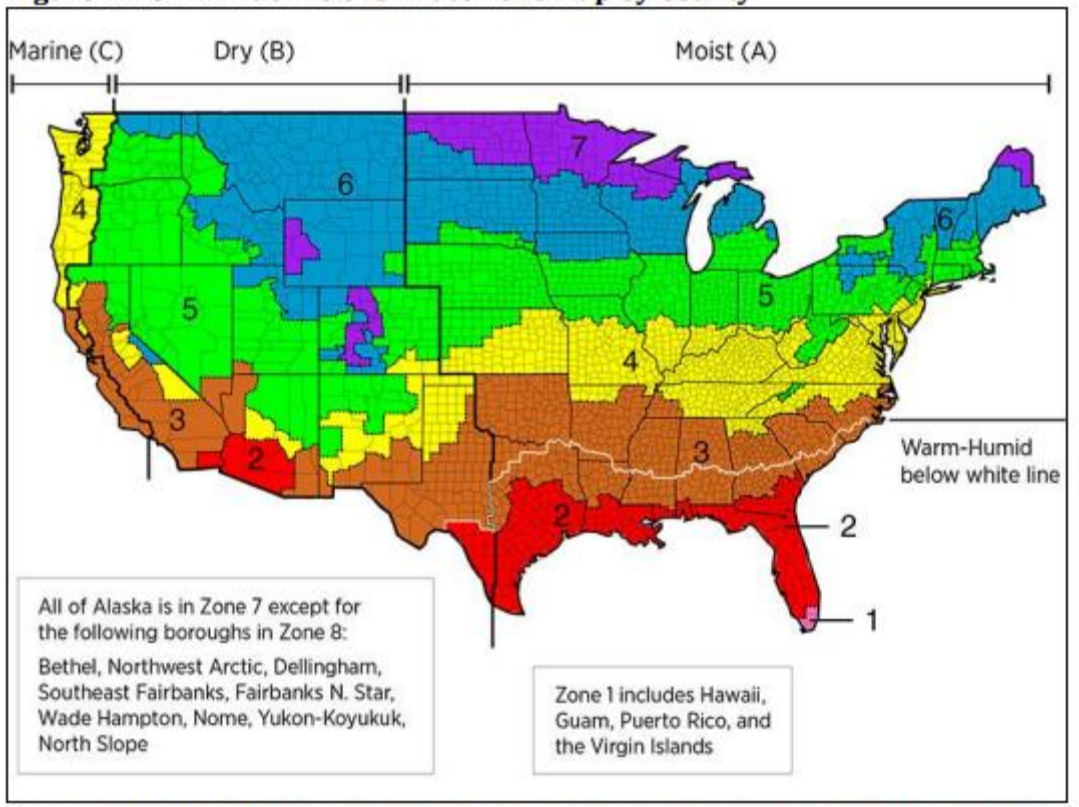
Chapter 3—Commercial/Multifamily Water Heating Systems is in an initial draft phase, and NEEA welcomes feedback from experts on the proposed draft content. If you have feedback, please contact Geoff Wickes at NEEA: gwickes@neea.org.

1.1 Background

In the early 1980s, electric utilities in colder portions of North America introduced heat pump technology into the domestic water heating market (mostly in the residential market). Heat pump water heater programs have subsequently spanned three generations of technology and produced detailed measurements of technical performance and consumer acceptance. The experience gained from these programs yields definitive direction about key consumer needs as well as important technical and reliability criteria for proper application of this technology throughout a range of climates.

The ENERGY STAR® program released its first specification for residential water heaters in 2008, which included qualifying criteria for heat pump water heaters (HPWHs). ENERGY STAR included requirements for efficiency (EF 2.0 or better), capacity (first-hour rating 50 gallons), longevity (warranty ≥ 6 years), and electrical safety (UL 174 and UL 1995). While these requirements are important, the ENERGY STAR program did not address critical performance and comfort issues that have inhibited widespread adoption of HPWHs in colder climates. In 2009, several major manufacturers launched integrated HPWH units in North American markets that were ENERGY STAR-qualified but failed to address key performance issues. No *system-level* energy efficiency qualifications currently exist for commercial products in the ENERGY STAR program, just discrete components, e.g., the water heater.

Figure 1. ASHRAE 90.1 U.S. Climate Zone Map by County



Source: *ANSI/ASHRAE/IES Standard 90.1-2019 -- Energy Standard for Buildings Except Low-Rise Residential Buildings*

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

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Advanced Water Heater Specification

Table 1. Integrated HPWH Product Tier Overview

	Minimum Cool Climate Efficiency (CCE)*	Minimum Features	Sound Levels**	Demand Response-Enabled?
Tier 1.0	2.0	• ENERGY STAR compliance • Freeze protection	dBA < 65	Optional
Tier 2.0	2.3	Tier 1 plus: • Minimal use of resistance heating elements (see Section 2.5.1) • Compressor shut-down/notification • 10 year warranty • Condensate management	dBA < 60	Optional
Tier 3.0	2.6	Tier 2 plus: • Simultaneous intake and exhaust ducting capabilities • Air filter management • Override and default mode behavior as per Section 2.6.1	dBA < 55	Required
Tier 4.0	3.0	Tier 3 plus: • Physical design or default controls that limit resistance element heating to less than upper 50% of tank	dBA < 50	Required
Tier 5.0	3.5	Tier 4 plus: • No resistance element usage in default	dBA < 50	Required

** See Appendix B.1.2 for details on Cool Climate Efficiency definition and calculation method.*
*** See Appendix D for details on Sound Level definition and calculation method.*

AWHS Testing Requirements

DOE Testing for UEF

AND

Testing Requirements

The following tests (in addition to the Department of Energy 24-hour Uniform Energy Factor (UEF) and first-hour rating tests) from the Advanced Water Heating Specification (AWHS) are required:

- CCE at 50°F ambient air / 50°F inlet water
- Compressor cutoff temperature
- Sound pressure measurement test

The Heat Pump Water Heater Installer Network

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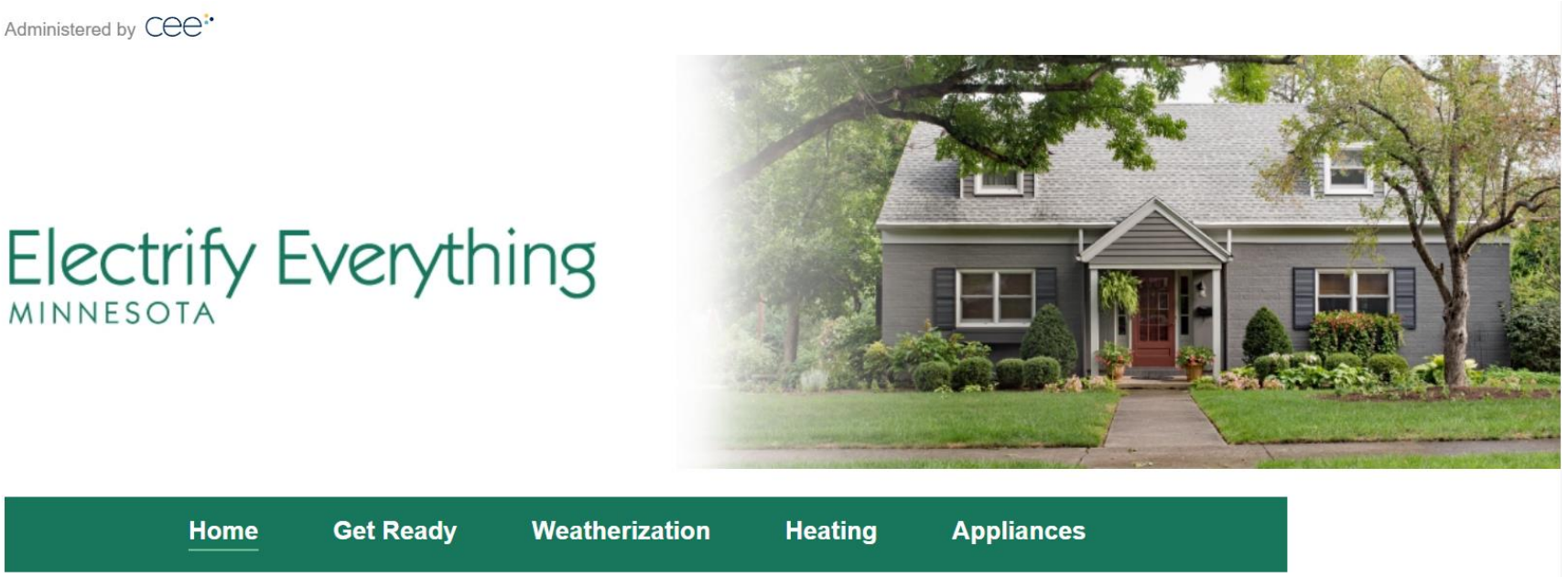
Electrify Everything will create an Installer Network to accelerate the adoption of HPWHs

The HPWH Installer Network will be listed on our website and referred to during resident engagement.



Only paperwork is left to have your company listed

Listing criteria:

- ☑ Attending this training
- ☐ **Completing the Participation Agreement**
- ☐ **Sending proof of license bonding**
- ☐ **Sending proof of insurance**

Copies of the Participation Agreement are available here, and Arbor will email about the rest.

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Membership lasts for one year before needing a simple renewal

Criteria for renewed membership after 1 year:

- You (the employee who attended this training) are still employed with the company
- The company has installed at least one HPWH in the last year

Arbor will contact you / your company near the end of the membership year to start the process.

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Arbor will be in touch this week about follow-up

Expect an email in the next few business days about completing the last steps to being listed on the HPWH Installer Network.

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Visit our website to follow along

ElectrifyEverythingMN.org

- Upfront and operational cost ranges for equipment
- Details of technology options
- Notes on installation concerns and considerations
- Links to resources and additional information

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Manufacturer Resource Links & Contact Information

HOT WATER SOLUTIONS

A. O. Smith

https://www.hotwater.com/

- Support – (877) 552-0010
- Training - https://university.hotwater.com/contact/
- Sales Representatives - https://www.hotwater.com/where-to-buy/trade-professionals/
- Distributors - https://www.hotwater.com/where-to-buy/search/
- User Manuals - https://www.hotwater.com/resources/product-literature/instruction-manuals/residential-electric/
- Spec Sheets - https://www.hotwater.com/resources/product-literature/spec-sheets/residential-electric-(uef)/

Bradford White

https://www.bradfordwhite.com/forthepro

- Support – (800) 523-2931
- Training – https://www.bradfordwhite.com/training/
- Sales Representatives – https://www.bradfordwhite.com/rep-locator/
- Distributors - https://www.bradfordwhite.com/resources-for-professionals-wholesaler/
- User Manuals & Spec Sheets - https://www.bradfordwhite.com/documentation/usa/residential/tank-type-gas

Rheem

https://my.rheem.com/

- Support – (800) 621-5622
- Training – https://www.rheemacademy.com/
- Sales Representatives – https://www.rheem.com/find-a-pro/
- Distributors – https://www.rheem.com/find-a-pro/
- User Manuals & Spec Sheets - https://www.rheem.com/products/residential/water-heating/heat-pump-water-heaters/

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Special Thanks To:

https://hotwatersolutionsnw.org/

https://www.advancedwaterheatinginitiative.org/

Rheem, AO Smith, and Bradford White

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THANK YOU!

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Of find me on LinkedIn!

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