

120-Volt Heat Pump Water Heaters

Prepared for Focus on Energy

Slipstream

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Core research team



- **Kevin Gries**, project manager
- **Zak Paine**, HVAC installation advisor
- **Claire Cowan**, director of program design and delivery
- **Diba Malekpour**, researcher/analyst
- **Justin Margolies**, project advisor



- **Amruta Khanolkar**, senior project manager
- **Mischa Egolf**, technical associate
- **Kevin Carbonnier**, senior technical associate
- **Joe Wachunas**, project manager

Agenda

1. Background
2. 120V HPWH economics
3. Modeled performance
4. Market potential
5. Proposed field study
6. Discussion



Background

Project goals

- Assess the market availability of 120V HPWHs in Wisconsin
- Model the 120V performance, operating costs, and hot water shortages in Wisconsin
- Determine best use cases and the scale of market potential
- Estimate typical electric upgrade costs for natural gas or propane-to-HPWH retrofits
- Identify best applications and recommendations for 120V HPWHs in Wisconsin

Research Methods

- 120V HPWH performance and operating costs
 - Open Studio modeling led by New Buildings Institute (NBI)
 - Developed custom 120V performance curves and control logic based on data provided by manufacturers
 - Modeled three 120V HPWH models for 2 to 6 occupant homes with typical climate and housing characteristics
- Market assessment and opportunities
 - Supply chain interviews: plumbers (11), distributor/retailers (5), manufacturers (4), code enforcement officials (8)
 - Public data
- Electric upgrade costs:
 - Project invoices in WI, MI, and IL
 - Leveraged research from ComEd's Home Electric Upgrade project
 - Interviews (plumbers, distributors, electricians, manufacturers)
 - Secondary research and public data

A HPWH that plugs in

- Operates on a 120V, 15-amp shared circuit
 - Plugs into a standard wall outlet
- Designed for fuel switching retrofits
 - Can reduce home electric upgrade costs
 - With an outlet nearby, plumber can install without electrician
- Similar equipment efficiency to standard HPWH
 - UEF in the range of 3 to 3.5

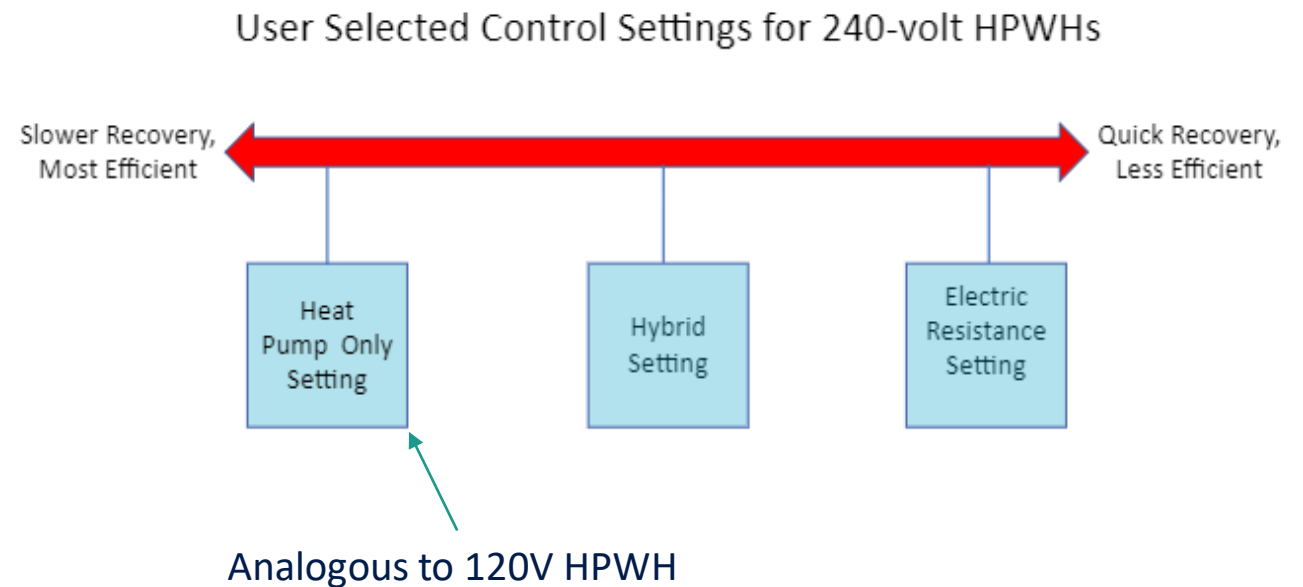


Rheem Proterra Plug in

Source: www.rheem.com/ProTerra

Reduced or removed electric resistance

- 240V HPWHs heat water with:
 - Efficient heat pump compressor
 - Inefficient electric resistance heating elements
- Lower power draw results in:
 - Reduced or removed electric heating elements
 - System relies heavily on heat pump compressor



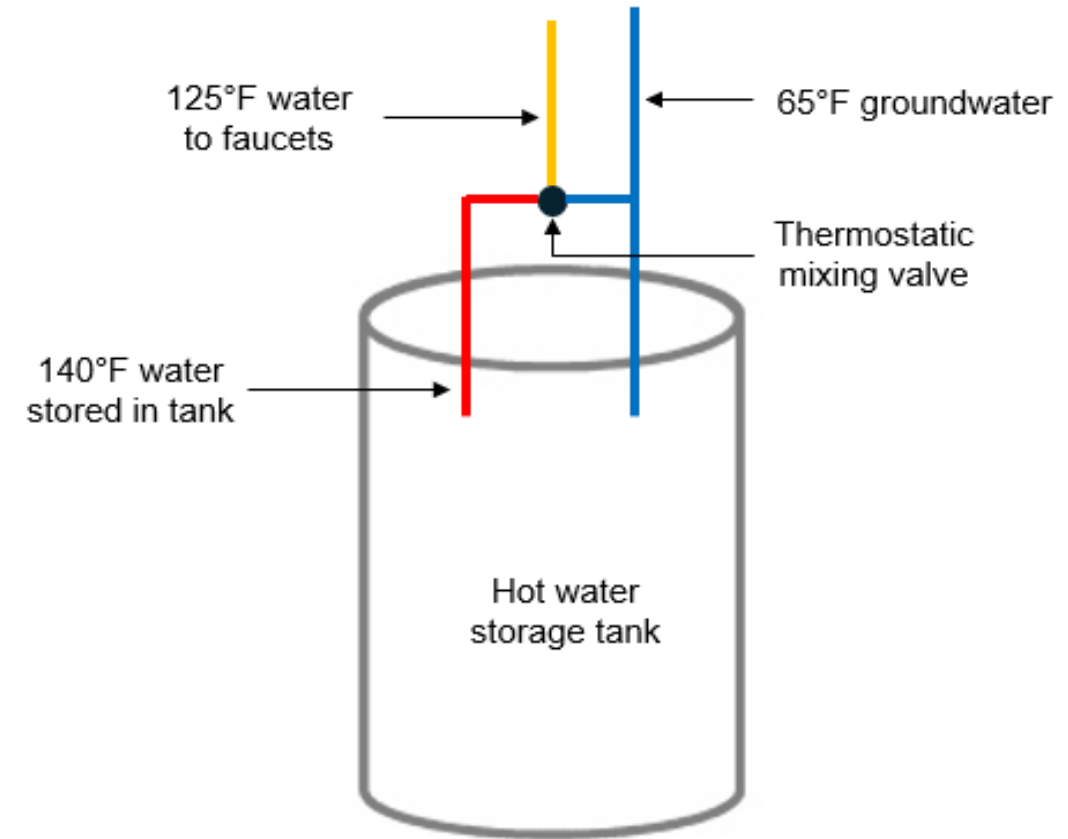
Strategies for increasing first hour delivery

- Thermostatic mixing valve

- Decouples temperature at storage tank and faucet
- Increases storage tank storage capacity
- Comes standard on most models

- Larger storage tanks

- First hour ratings drive larger tanks
- Larger tanks are more expensive and may not fit
- Certain customer may have more space than others



Model demonstrating mixing valve functionality

Product Characteristics

	AO Smith	GE	Nyle	Rheem
Product Line	TBD	Geospring	e8	Proterra
Availability	Early 2023	Mid 2023	Early 2023	Available since July 2022
Small Electric Resistance Backup	Yes	Yes	Yes	No
Compressor Location	On storage tank	On storage tank	Separate compressor box	On storage tank
Thermostatic mixing valve	On standard product	On standard product	Available as add-on	Shared circuit: standard Dedicated circuit: add-on
Grid connectivity	Yes	Yes	Yes	Yes
Years under warranty	Not available	Not available	Not available	10 years



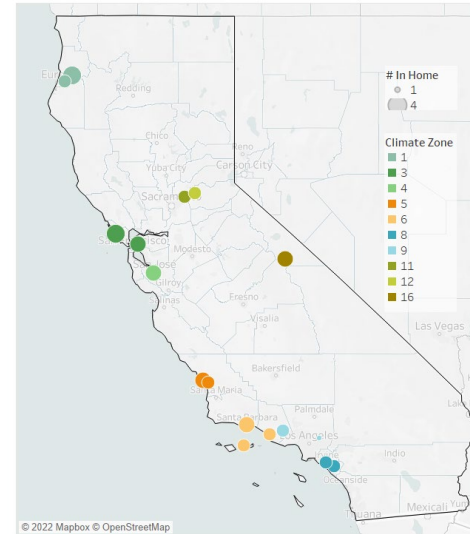
Nyle e8

Must be on 15-amp dedicated circuit due to bigger compressor, but ~3x faster recovery

Existing research on 120V HPWH

California field study

- 32 planned monitoring sites across CA
- Installations currently underway
- NBI administering project



nbi new buildings institute

SOUTHERN CALIFORNIA EDISON
Energy for What's Ahead®

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Louisiana field study

- Sites are currently being identified for monitoring
- Pacific Northwest National Lab administering project

Midwest market research

- ComEd, Focus on Energy, Consumers Energy, and Xcel



Pacific Gas and Electric Company





Economics

Equipment costs

Water heater type	Average equipment cost	
	50-gallon	65-gallon
120V HPWH with mixing valve	\$1,950	\$2,100
240V HPWH	\$1,700	\$1,850
Natural gas water heater	\$650	-
Propane water heater	\$850	-

Sources: Equipment cost estimates considered prices from Home Depot retailers in Wisconsin, manufacturer guidance, the National Residential Efficiency Measure Database, and Slipstream's HVAC installation expert.

Operating costs

Water heater type	Annual operating cost	
	Typical	Range
240V HPWH	\$150	\$114 to \$182
120V HPWH	\$167	\$127 to \$202
Natural Gas Water Heater	\$227	\$203 to \$250
Propane Water Heater	\$411	\$355 to \$467
Electric Resistance Water Heater	\$471	\$359 to \$571

- Propane and natural gas prices have 2022 avg prices as high end and 2017-2022 avg price as low range
- Rates for electricity are based on weighted averages of residential rates for Focus on Energy utilities

Home electric upgrade costs

If no outlet
within 10 ft of
the water heater

Intervention	Likelihood of upgrade needed		Cost per housing unit	
	120V HPWH	240V HPWH	Single family	Multifamily
Electric permit	40-60%	100%	\$75-250 (\$150)	\$75-250 (\$150)
Extension of shared circuit	40-60%	0%	\$150-400 (\$300)	\$150-400 (\$300)
New dedicated circuit	0%	100%	\$150-1000 (\$400)	\$150-1000 (\$400)
Replacement panel or subpanel	0%	13-38%	\$500-2000 (\$1,000)	\$500-3000 (\$1,000)
Amperage service upgrade	0%	23%	\$1,300-15,000 (\$4,000)	\$900-9,000 (\$5,500)

120V HPWH Economics: Takeaways

The 120V HPWH will save significant costs in homes needing electric upgrades

Amperage service upgrades

Electric panel replacements or subpanels

HPWHs have higher equipment costs than gas or propane water heaters

Incremental cost can range from \$850 - \$1,300

Rebates can help

Both 120V and 240V HPWHs will save on operating costs under current prices

The sales pitch will depend on the home's energy rates



Modeled Performance

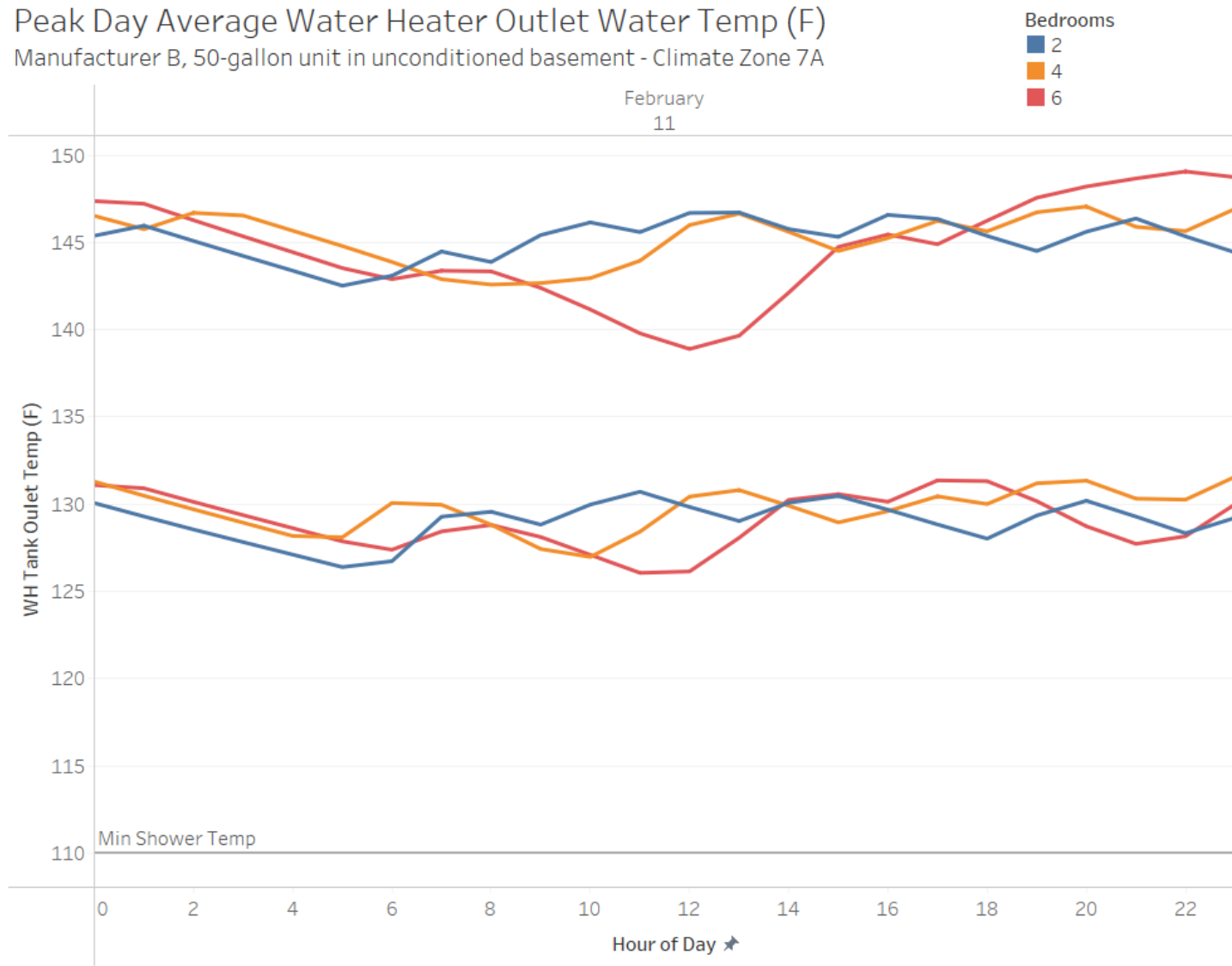
Annual Operating Cost

- Energy use is heavily dependent on occupancy
- Higher setpoint increases energy use by ~15%
- Energy use is around 6% higher in unconditioned spaces

Bedrooms	Annual Energy Usage (kWh)	
	50-gallon tank	80-gallon tank
2	973	1,034
4	1,367	1,422
6	1,746	1,800

These estimates use a 140°F setpoint and a semi-conditioned install location

Cold water events didn't occur on the peak demand day



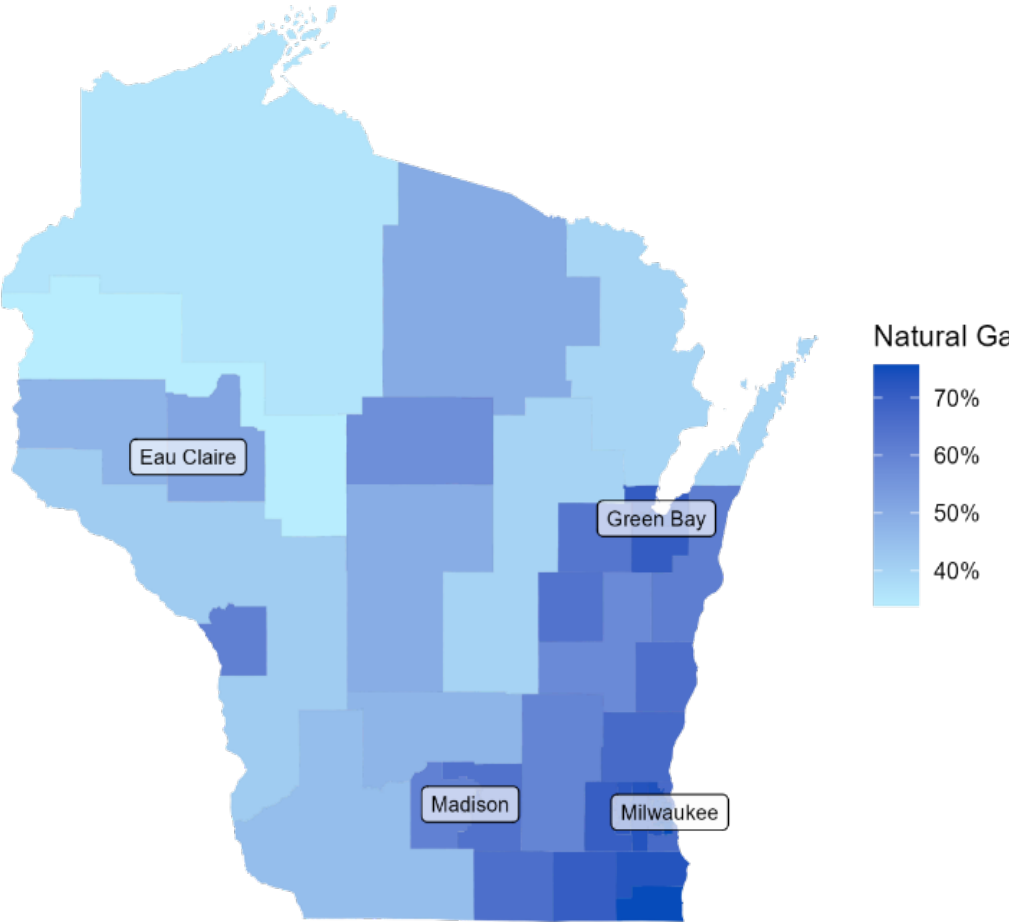


Market Potential

Water heater fuel types

Fuel type	Single Family	Low Rise Multifamily	High Rise Multifamily	All Residential
Natural Gas	60%	60%	59%	60%
Electricity	32%	37%	37%	33%
Propane	8%	3%	4%*	7%

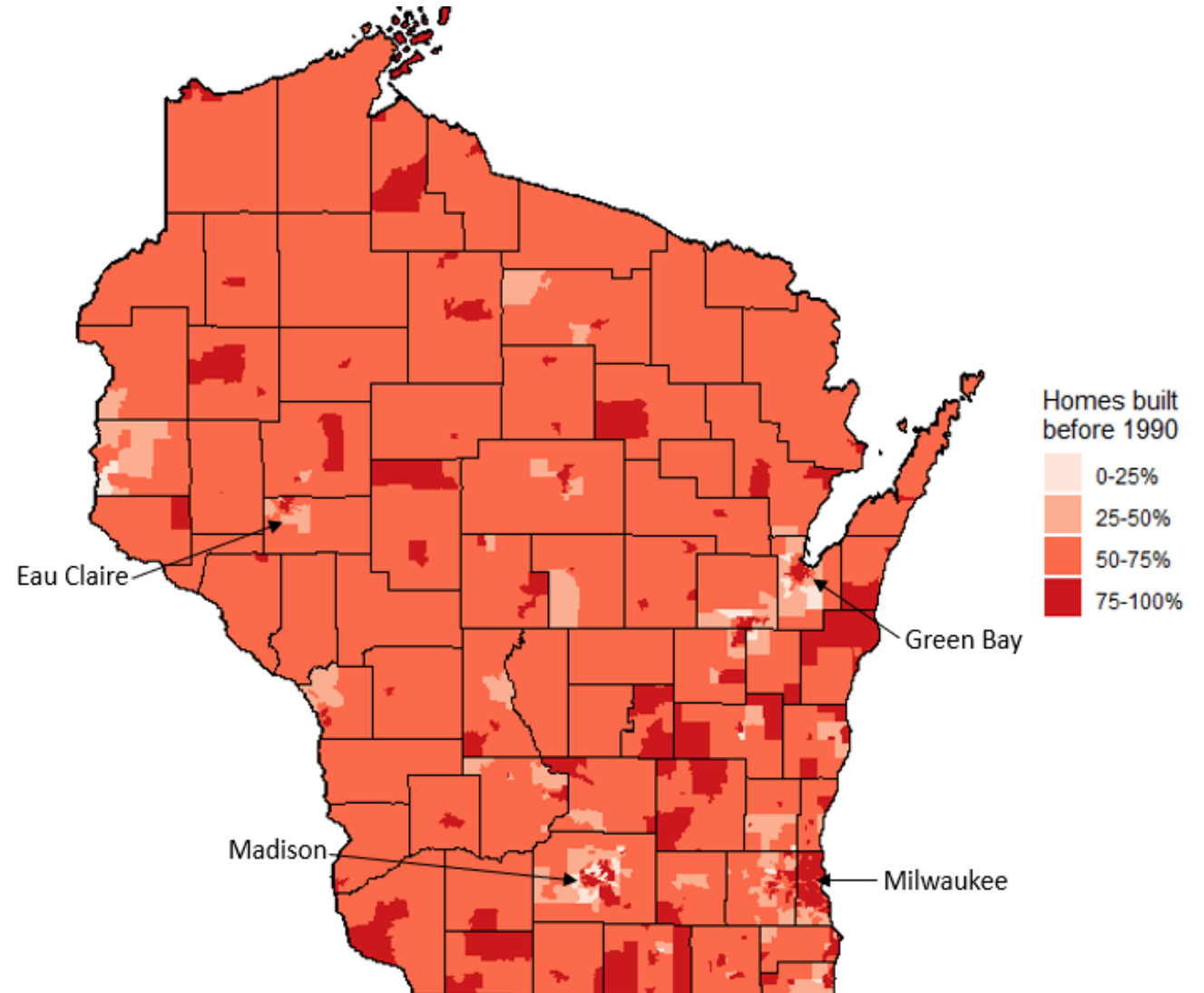
*This seems high to us. We reached out to NREL for more information and are awaiting a response



Amperage service level in Wisconsin

Electrical service size (100A, 200A) can determine need for home electric upgrades

- Age of home as proxy for electrical service level
 - Pre-1990 more likely to have 100A or smaller service
- We estimate approximately 66% of Wisconsin homes likely to have 100A or smaller service



Supply chain feedback

Manufacturers

- Targeting areas with fuel-switching incentives
- Suggest midstream incentives of around \$700
- Want field validation in cold climates

Distributors and Retailers

- Generally unaware of 120V HPWHs
- 240V HPWHs are still uncommon
- Communicate aggressive program incentives to ensure sufficient stocking
- Consumer education around HPWHs needed to build demand
- Want field validation in cold climates

Plumbers

- Plug in water heaters would simplify fuel-switching retrofits
- View home electric upgrades as a significant cost barrier
- 240V HPWH champions tend to be more receptive to 120V HPWHs
- Want field validation in cold climates

Code enforcement officials

- Unaware of 120V HPWHs
- Reluctantly accept 120V HPWHs
- “Its non-traditional, and its non-traditional for a reason. That being said, I would allow it”

Installation and maintenance

The 120V HPWH may be larger than the gas or propane water heaters they replace

More spacious installation locations will be easier retrofits

Bigger issue if higher gallon tank selected

Proper installation more important without backup

120V HPWHs more reliant on compressor performance

Ample air supply for the compressor is increasingly important

Maintenance is more important without backup

Customers will need to clean filter and keep location near water heater clear

Poor maintenance practices will have an impact on hot water delivery



Field Study Proposal

Why we think its important?

The 120V HPWH can save on energy and costs

The 120V HPWH can save on electric upgrade costs, which can be significant

Under typical draw profiles, homes didn't have hot water shortages

The supply chain consistently requested field validation

Study Design

- **Participants**

- Each funder would contribute 6-8 sites → goal of 24 sites total across Midwest
- Coordinated with monitoring studies in CA and Louisiana

- **Monitored data**

- Power, delivered hot water temperatures, flow, condensate pump (for humidity)
- Analysis covers energy impacts, economics, comfort (e.g. hot water shortages), and load shifting capability

- **Surveys**

- Customer and installer experience

- **Leverages relationships from phase 1**

- Manufacturers for troubleshooting and installation advice
- Distributors and plumbers for recruitment

Timeline

Tasks	2023				2024			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Kickoff								
Recruitment								
Site installations								
Data collection								
Monitoring equipment removal								
Analyze final data and surveys								
Final report and presentations								

Budget

Task	Costs per funder	
	3 Funders	4 Funders
Planning and program investigation	\$24,749	\$18,562
Field demonstration	\$128,030	\$96,023
Analysis	\$68,794	\$51,595
Energy modeling	\$12,000	\$9,000
Reporting	\$14,563	\$10,922
Project management	\$18,995	\$14,247
	\$266,498	\$199,873

Questions?