Better Buildings
U.S. DEPARTMENT OF ENERGY

Better Buildings Residential Network
Peer Exchange Call Series

In Hot Water? Residential Efficiency, Affordability & Technology

July 8, 2021

U.S. DEPARTMENT OF ENERGY

Agenda and Ground Rules

- Agenda Review and Ground Rules
- Opening Poll
- Residential Network Overview and Upcoming Call Schedule
- Featured Speakers
  - **Jennifer Amann,** ACEEE
  - **Josh Butzbaugh,** Pacific Northwest National Laboratory
  - **Joshua Greene**, A.O. Smith
- Open Discussion
- Closing Poll and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

The views expressed by speakers are their own, and do not reflect those of the Dept. of Energy.

Better Buildings Residential Network

Join the Network

Member Benefits:

- Recognition in media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- One-on-One brainstorming conversations

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year, or equivalent.

Upcoming Calls (2nd & 4th Thursdays):

- *7/22: Like a Heat Wave: Summer Healthy, Efficient Housing Challenges*
- *8/12: The Cost of Cooling: Air Conditioning, Climate and Health Solutions*
- *9/12: Behavior Change, Efficiency and Climate: What Really Happens vs. Models & Assumptions*

Peer Exchange Call summaries are posted on the Better Buildings website a few weeks after the call

For more information or to join, for no cost, email bbresidentialnetwork@ee.doe.gov*, or go to* energy.gov/eere/bbrn *& click Join*

Jennifer Amann

American Council for an Energy Efficient Economy

U.S. DEPARTMENT OF ENERGY

Savings on Tap
Supplemental Measures for Enhanced Energy and Water Savings

Better Buildings Residential Network Webinar

In Hot Water? Residential Energy Efficiency, Affordability & Technology

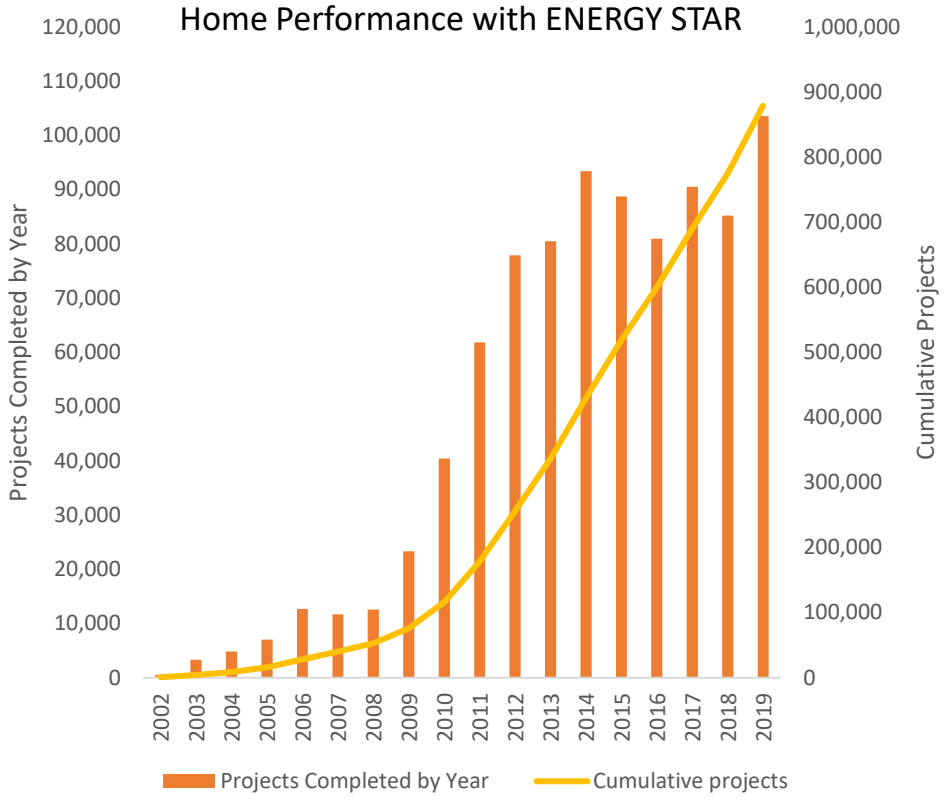
July 8, 2021

Jennifer Amann

American Council for an Energy-Efficient Economy

Exploring retrofit packages and approaches to expand the depth and breadth of home retrofits

- Existing programs and approaches fall short of what's needed
  - Relatively high project and program delivery costs
  - Average 25% savings project
  - Limited consumer demand
- New approaches would
  - Leverage non-energy benefits and behavioral strategies
  - Include electrification as appropriate
  - Maximize near-term savings while advanced approaches are in development
  - Increase consumer appeal



ACEEE
American Council for an Energy-Efficient Economy

Technology packages for water heating and distribution

- Heat pump water heaters
    - Including 120V models where appropriate
    - In staged retrofit scenarios, HPWH replacement may be delayed to later stage
- Low-flow fixtures
- Tub spout diverter replacement
- Thermostatic restrictor valves
- Drain water heat recovery
- On-demand recirculation systems

Technology packages for water heating and distribution

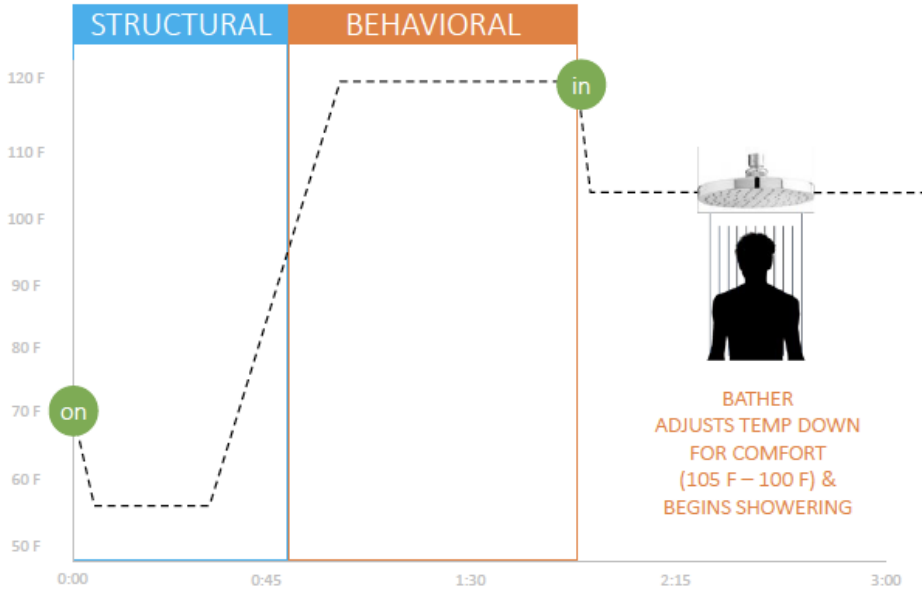
- Heat pump water heaters
    - Including 120V models where appropriate
    - In staged retrofit scenarios, HPWH replacement may be delayed to later stage
- Low-flow fixtures
- Tub spout diverter replacement
- Thermostatic restrictor valves
- Drain water heat recovery
- On-demand recirculation systems

Tub spout diverter (TSD)

- Faulty TSDs are a common source of energy and water waste in combination bathtub-showers
- Leaky units waste an average of 0.8 gallons of hot water per shower and reduce shower pressure
- Energy savings per fixture replaced:
  - Electric resistance WH: 100 to 400 kWh/year
  - HPWH: 50 to 115 kWh/year
  - Gas WH: 5 to 15 therms/year
- Cost: ~$100 installed
- Direct install opportunity for single- and multi-family

Thermostatic restrictor valve (TSV)

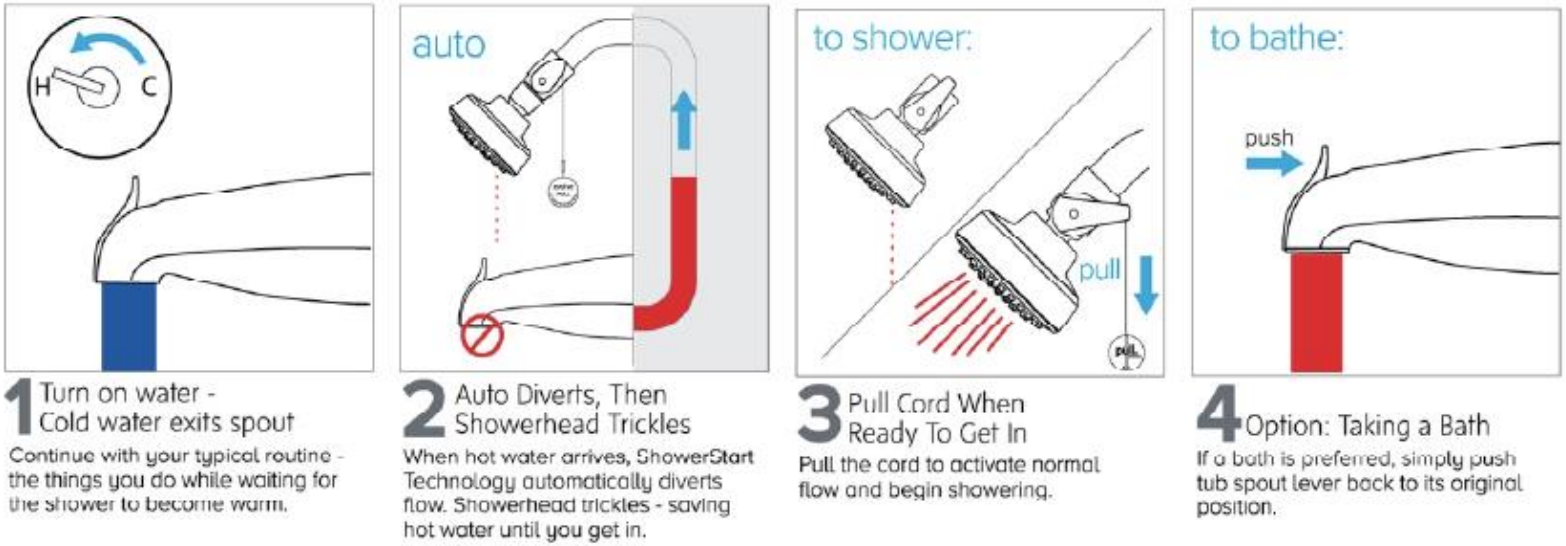
- TSVs eliminate the energy and water wasted in the lag time between hot water reaching the fixture and the user beginning to shower
- Available for stand-alone showers and tub/shower combinations
- Basic models can be installed with an existing showerhead
- Newer designs:
  - couple the TSV with a high-efficiency, low-flow showerhead or improved tub spout diverter design
  - for shower only, may include mechanism to purge cold water from the hot water line to significantly reduce lag time and increase water savings



ACEEE
American Council for an Energy-Efficient Economy

Auto Diverting Tub Spout with TSV

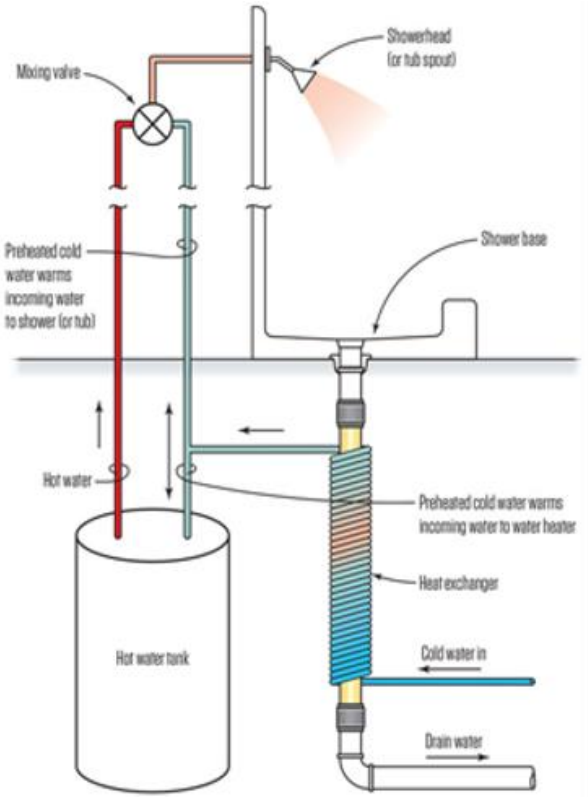
- Energy savings
  - Gas WH: 10 to 22 therms/year
  - HPWH: 50 to 165 kWh/yr
- Cost: $60 to $150 installed
- Significant water savings: 1800 to 2500 gallons/year
- Other benefits
  - Convenience and time savings
  - Improved showerhead water pressure



ACEEE
American Council for an Energy-Efficient Economy

Drain water heat recovery

- Reclaims waste heat from the shower drain line to preheat water delivered to the showerhead and/or water heater
- Horizontal and vertical configurations available
- Best applications:
  - New construction
  - Retrofits in homes with drainpipes easily accessible
  - Time of larger remodel or fixture replacement
  - Large households
  - Multifamily
- Growing interest as code measure; some limited rebate programs

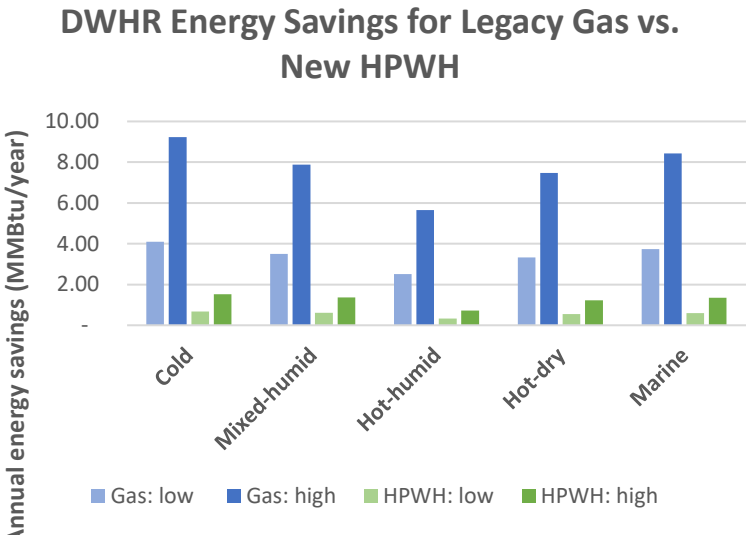


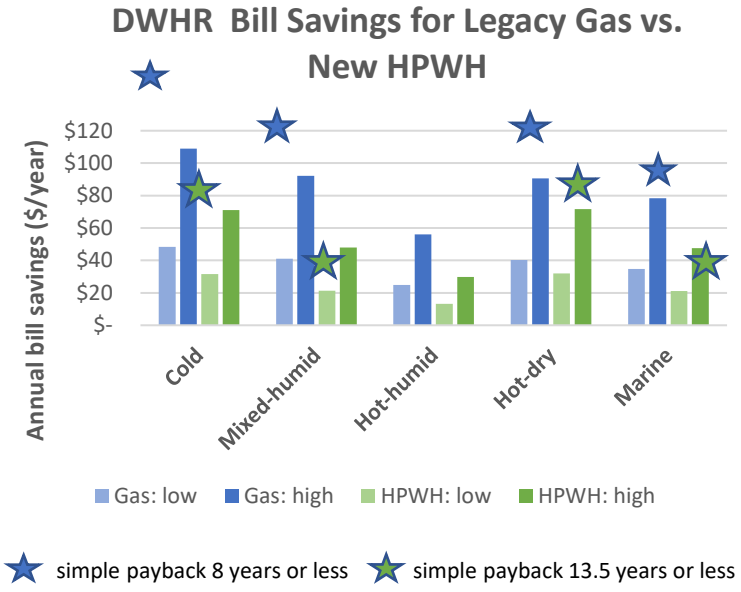
Source: Journal of Light Construction, September 2016

DWHR

- 20% to 45% reduction in WH energy use
  - Inlet water temp
  - # of fixtures
  - DWHR unit efficiency
  - Flow configuration
- Installed cost: $650 to $1000

- Lifetime: 30-50 years
- Simple payback: 6 to 30+ years
- Other benefits
  - Faster WH recovery time
  - Extended WH lifetime





ACEEE
American Council for an Energy-Efficient Economy

Supplemental hot water measures

- Yield significant near-term and long-term savings
- Packages should be tailored to market/region
- Complement staged retrofit approaches
  - **Envelope then equipment**
  - **Priority measures based on equipment replacement schedule**
- Support electrification
- Integration of contractor-led retrofits with direct install, utility marketplace, and retail program offerings

Thanks for tuning in!

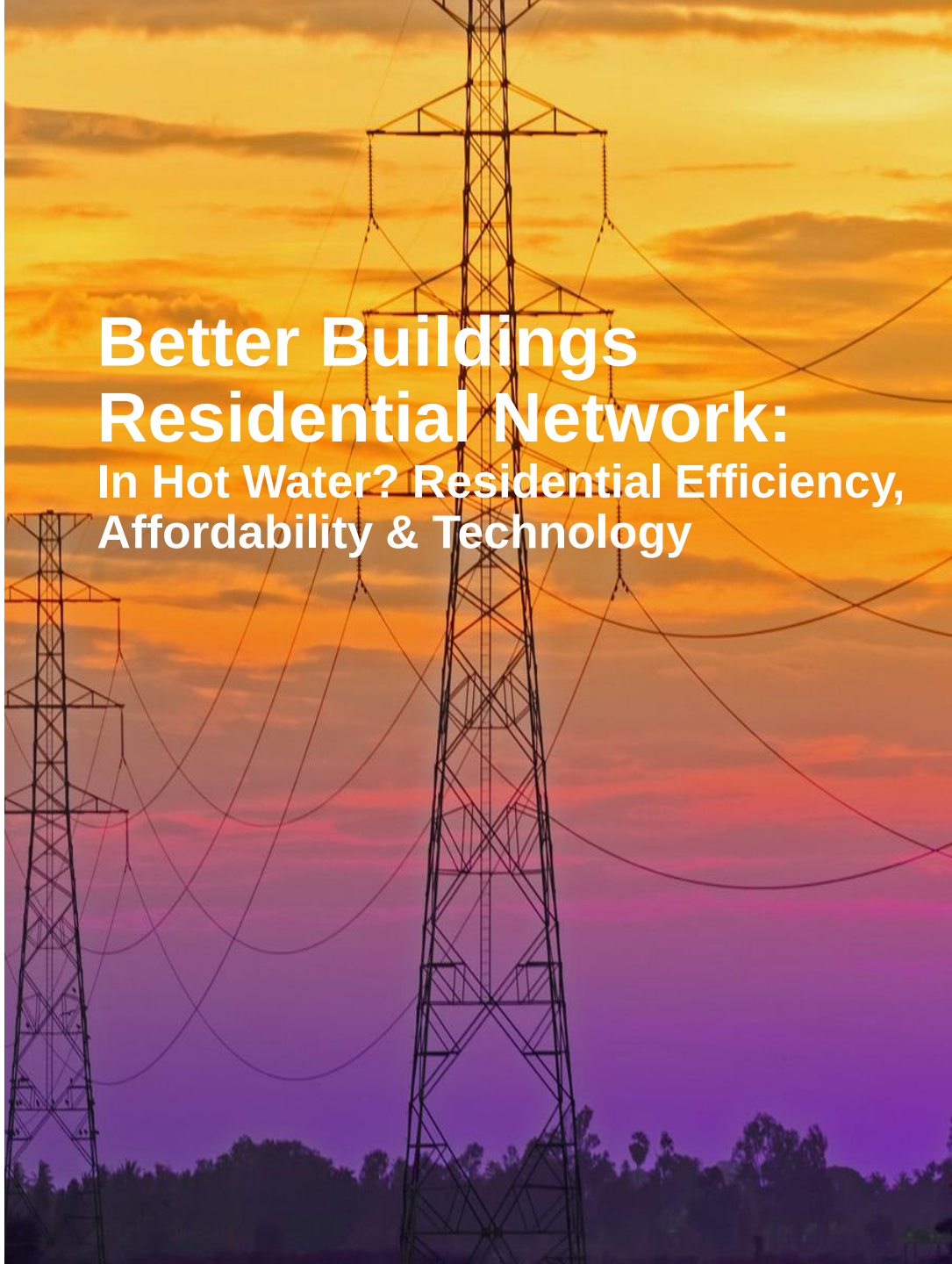
Jennifer Amann
jamann@aceee.org

ACEEE
American Council for an Energy-Efficient Economy

Josh Butzbaugh
Pacific Northwest National Laboratory (PNNL)

U.S. DEPARTMENT OF ENERGY

Pacific Northwest
NATIONAL LABORATORY



Better Buildings Residential Network:

In Hot Water? Residential Efficiency, Affordability & Technology

Heat Pump Water Heaters: Max Tech and Grid-connected Research

Presenter: Josh Butzbaugh

Authors: Josh Butzbaugh
Walt Hunt
Ebony Mayhorn

July 8, 2021

U.S. DEPARTMENT OF ENERGY BATTELLE

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

Agenda

- Background
- Pacific Northwest National Lab Research
  - Max Tech HPWH
  - Pacific Northwest Grid-connected HPWH Study
  - Southeast Grid-connected HPWH Study
- Advanced Water Heating Initiative
- Questions/Answers

Background

- Water heating is the second largest energy use in U.S. residences
- Heat pump water heaters (HPWHs) can save 60%+ of electric water heating energy
  - Provide ample storage of hot water during grid emergencies: 50, 65, 80-gallon capacities
  - Permanent peak load reduction through improved energy efficiency
  - Energy efficiency improvement means downsized back-up generators or more capacity for other electric appliances/equipment on back-up generators

Grid Emergency Attribute	HPWH	ERWH	Tankless
Provides hot water during power outage?	Yes	Yes	No
Accommodating for back-up power?	Yes	No	No
Saves energy under normal grid operation?	Yes	No	No
Easy and dependable for shifting load?	Yes	Yes	No

- PNNL research is addressing two key issues
  - Performance of HPWHs with low global warming potential (GWP) refrigerants
  - Ability of HPWHs to shift load using “EcoPort” and CTA-2045 commands in two regions
    - Pacific Northwest
    - Southeast

Max Tech HPWH

What's the meaning of "Max Tech"?

Max Tech refers to enhancing Residential HPWHs with:

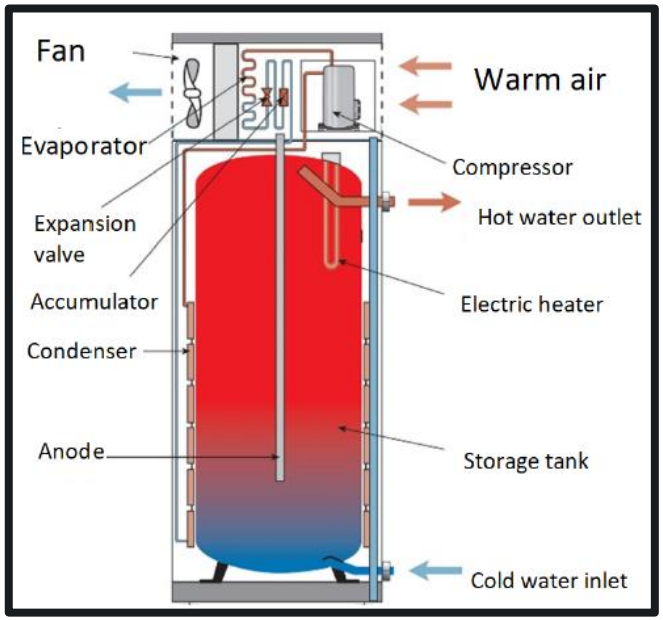
- Low-GWP (Global Warming Potential) refrigerant
- Maintaining energy efficiency with refrigerant change-out
- *Increased efficiency through optimizing components (results not yet available)*

Refrigerant Selection

- Existing HPWHs: **R-134a (GWP of ~1,300)**
- Max Tech: **R-1234yf (GWP of ~1)**

System Efficiency

- Existing HPWHs: **COPs from ~2.0 to ~3.0 in the field**
- Refrigerant change-out **(maintain COP)**
- Efficiency optimization (*results not yet available*)



Max Tech HPWH

PNNL Lab Homes Evaluation - Overview

Baseline Comparison

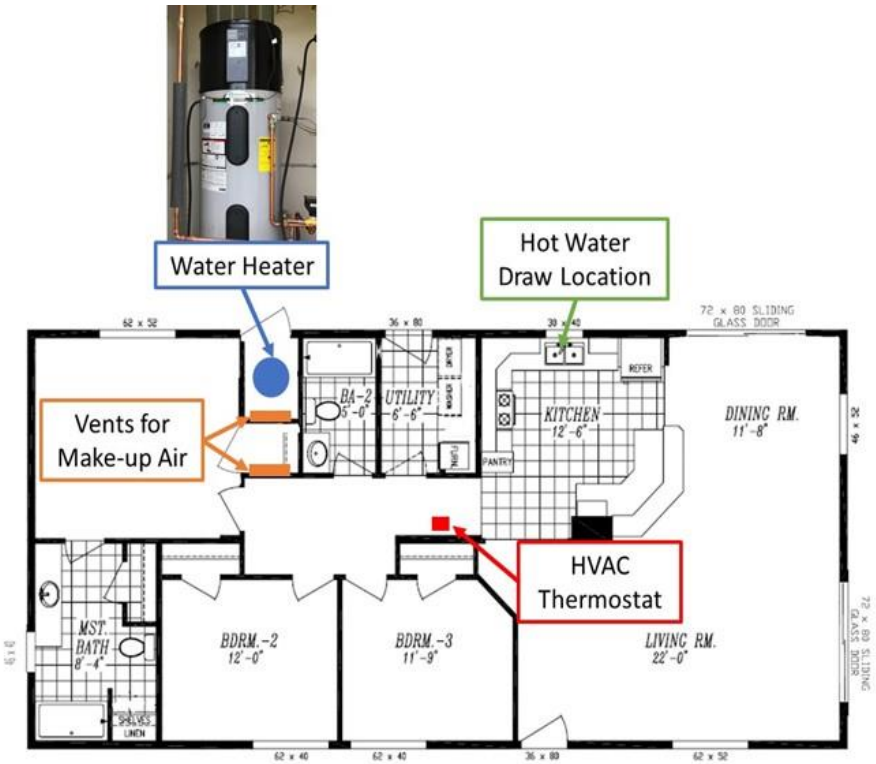
- Side-by-side R-134a and R-1234yf HPWH evaluated under identical conditions

Hot Water Draw Profiles

- Field-based 47-, 57-, and 69-gallon daily draw profiles adapted from industry

HPWH Specifications

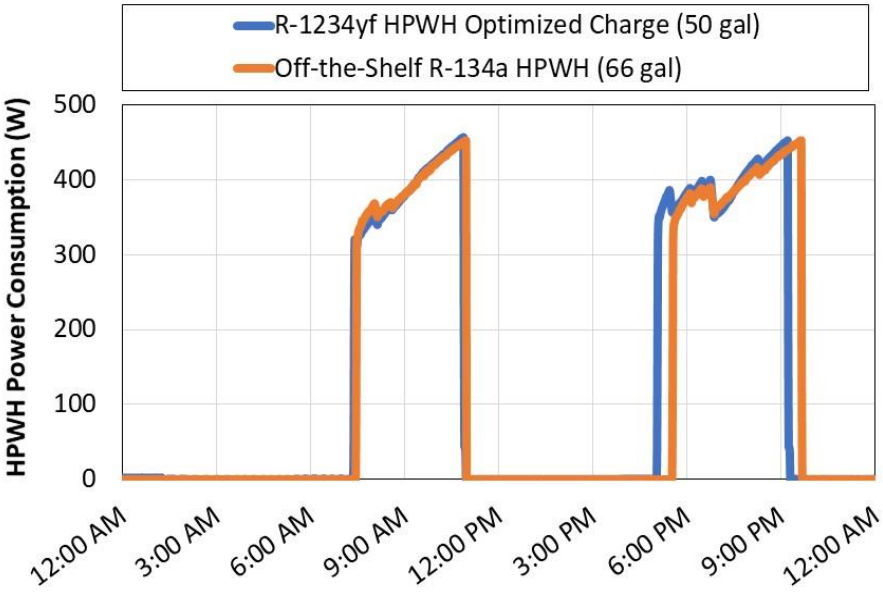
- 125°F hot water setpoint
- Hybrid mode (heat pump with backup electric)
- 50-gallon hot water tank for R-1234yf HPWH



Max Tech HPWH

PNNL Lab Homes Evaluation - Results

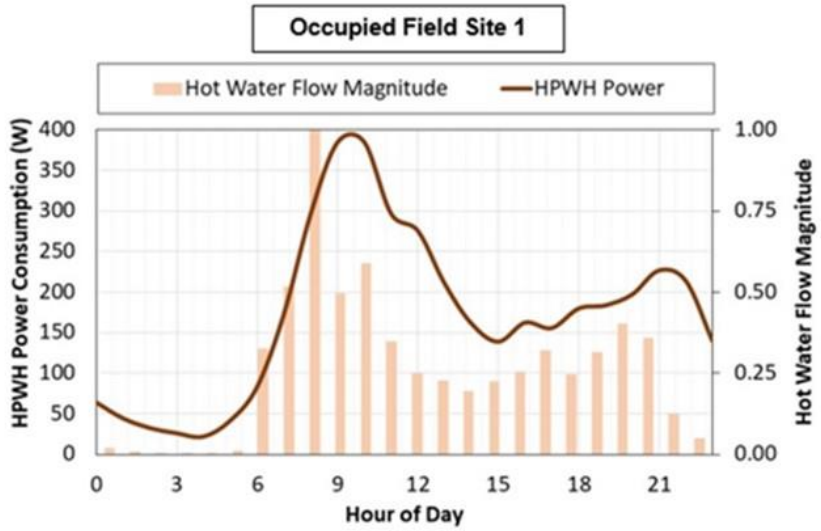
- **Summer evaluation:** R-1234yf HPWH was 0.9% more efficient
- **Winter evaluation:** R-1234yf HPWH was 2.2% more efficient
- **HPWH operation:** Side-by-side HPWHs (R-134a and R-1234yf) demonstrated near identical operating profiles

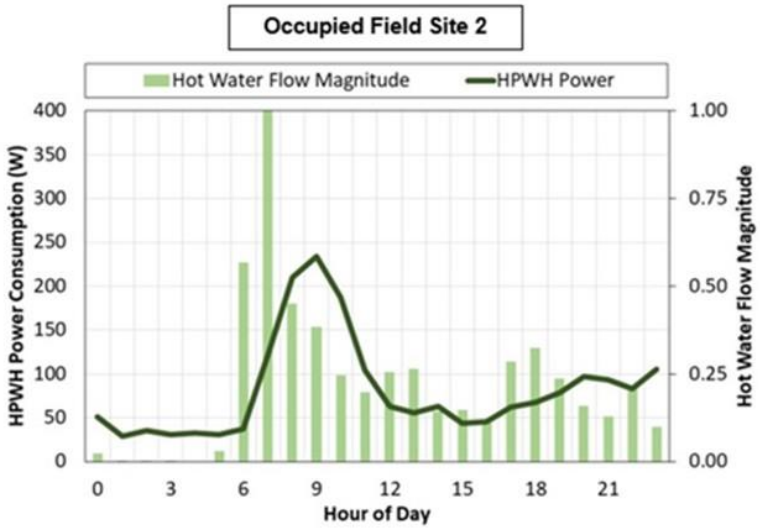


Max Tech HPWH

Occupied Field Site Evaluations - Overview

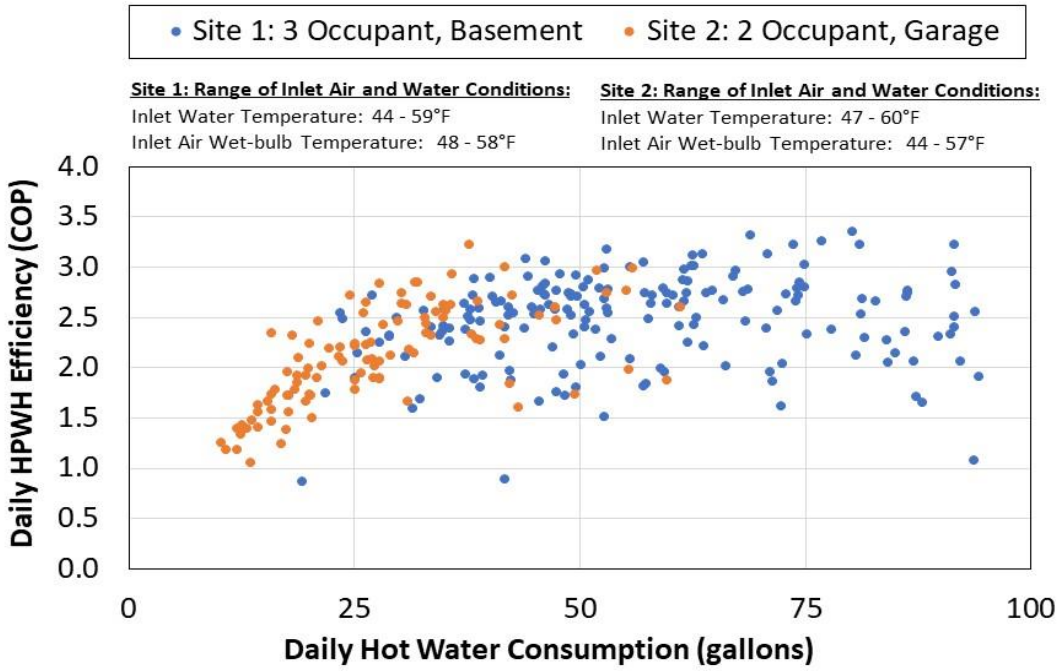
	Field Site 1	Field Site 2
Home Occupants	3 Occupants	2 Occupants
HPWH Location	Unconditioned Basement	Garage
Site Location	Portland, OR	Portland, OR
At least 1 adult Home during weekdays, 8AM – 5PM?	Yes	Yes





Max Tech HPWH

Occupied Field Site Evaluations - Results



Average daily HPWH efficiency:

- Field Site 1 = 2.5 COP
- Field Site 2 = 2.1 COP

Operational and Homeowner View:

- ~16 months of issue-free operation
- Positive homeowner survey

Grid-connected HPWH
Pacific Northwest Study

- Pacific Northwest
  - Active and committed region to energy efficiency and demand response
  - Extensive HPWH programs featuring instant rebates, tax credits, installer bonuses, etc.
- In 2017-2018, the BPA, Portland General Electric, NEEA, and PNNL collaborated on the first large-scale, grid-connected HPWH demonstration in the Pacific Northwest
  - Demonstrated grid-connected HPWHs as an effective resource to shift load
  - Studied the CTA-2045 standard for straight forward load shifting strategies, using the “load up”, “shed”, and “grid emergency” commands
- PNNL continued the grid-connected HPWH field study in 2019-2021 to determine whether additional load is shifted through more sophisticated strategies

Grid-connected HPWH
Pacific Northwest Study

- **Field study**
  - 147 HPWHs included with CTA-2045 communication module
  - Located in Portland, OR
- **Load shift commands:** load up, shed, critical peak, grid emergency
- **Load shifting strategies**
  - **Non-targeted =** same load curtailment signal is sent to the entire population of water heaters
  - **Targeted =** water heaters grouped into low/high, morning/afternoon hot water users; each group receives customized schedules
  - **Smart =** individualized control (*based on direct commands)* that uses the two-way communication to incorporate status of thermal storage, enabling it to proactively adapt control commands

Grid-connected HPWH
Pacific Northwest Study

Direct Strategies: Morning Results

Smart strategy results in greater load shifting, especially when paired with aggressive event commands

Strategy Type	Event Duration	Event Time Range	Number of Weeks Averaged	Average Total Wh Shifted
Non-targeted (Shed) N = ~150	3 h	6–11 am*	6	620
Targeted (Shed) N = ~150	High am user 3 h Low am user 5 h	7–10 am 6–11 am	4	596 (6-11 a.m.)
Smart (Shed) N = ~60	5 h	6–11 am	2	608
Smart (Critical Peak) N = ~60	5 h	6–11 am	2	736
Smart (Grid Emergency) N = ~60	5 h	6–11 am	2	863

* Each event only lasted three hours, although, over the course of the six weeks, the events were shifted within this five-hour time interval.

Grid-connected HPWH
Pacific Northwest Study

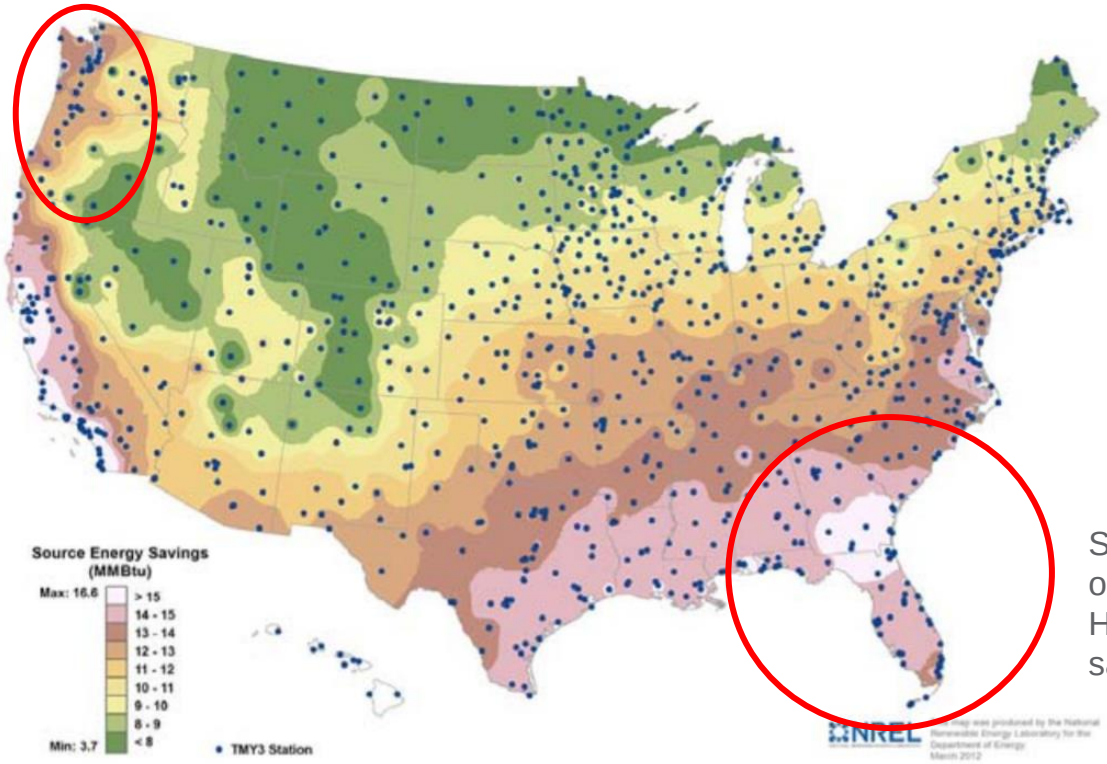
Direct Strategies: Afternoon Results

Targeted strategy was effective. This strategy could shift more load if the shed event for high hot water users began earlier than 7 pm, but beginning earlier risks a hot water run out or activation of electric-resistance back-up

Strategy Type	Event Duration	Event Time Range	Number of Weeks Averaged	Average Total Wh Shifted
Non-targeted (Shed) N = ~150	3 h	6–9 p.m.	2	622 (5-10 p.m.)
Targeted (shed) N = ~150	High pm user 3 h Low pm user 5 h	7–10 p.m. 5–10 p.m.	4	740 (5-10 p.m.)
Smart (Shed) N = ~60	5 h	5–10 p.m.	2	607
Smart (Critical Peak) N = ~60	5 h	5–10 p.m.	2	731
Smart (Grid Emergency) N = ~60	5 h	5–10 p.m.	2	819

Grid-connected HPWH
Southeast Study

PNW
Field
Validation



Southeast is a large opportunity for HPWH energy savings

NREL Highlight: NREL Develops Heat Pump Water Heater Simulation Model, 2012. Based on research performed by Jeff Maguire.

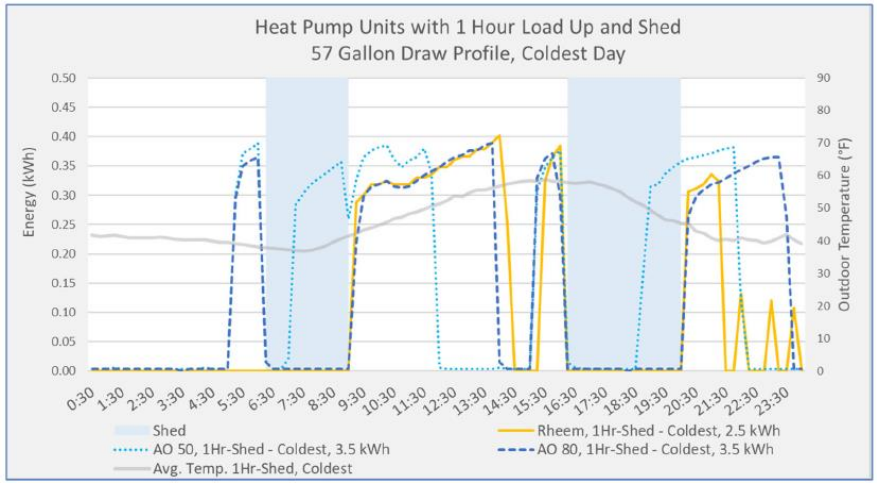
This map shows the source energy savings potential of heat pump water heaters (3.37 site-to-source ratio), including effects from climate and space conditioning interactions. The white and pink areas represent the most savings.

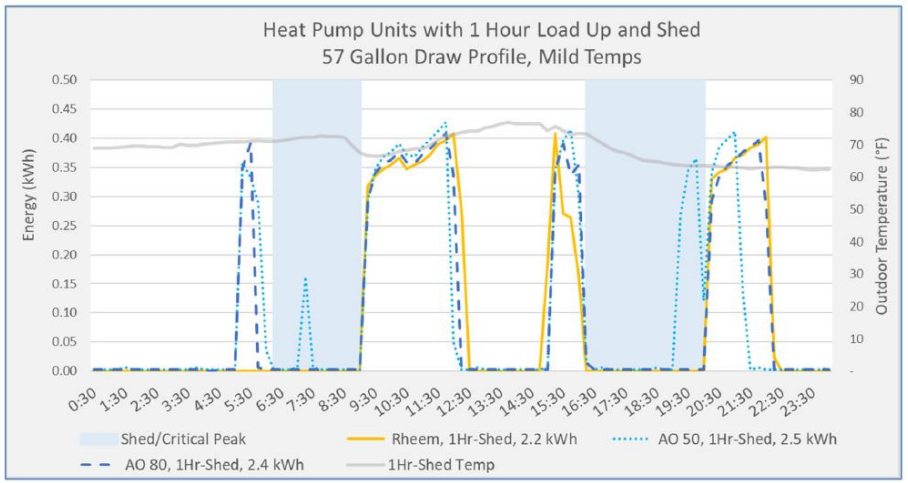
Grid-connected HPWH
Southeast Study

- Southeast region is an ideal candidate for applying lessons learned from the PNW
  - Highest stock penetration of residential electric water heaters
  - High potential for energy savings through HPWH market uptake
  - Utility incentives for HPWHs are relatively sparse
  - Utility load shifting programs are relatively common due to peak load and grid constraints
- PNNL partnered with the Florida Solar Energy Center (FSEC) to conduct a two-track study
  - Field study of grid-connected HPWHs in the Orlando, FL area
    - Recruitment began in March 2020, negatively impacted by COVID-19 pandemic
    - Load shifting research began in November 2020, now includes over 40 homes
  - Lab tests for four grid-connected HPWHs and one grid-connected electric-resistance water heater (ERWH) in the FSEC water heater lab
    - Comparison by manufacturer, capacity (50- and 80-gallon), load shifting strategy, and season/temperature across three draw patterns (47, 57, and 69 GPD)
    - Includes a HPWH prototype with an integrated, electronic mixing valve to load up the water heater storage temperature above and beyond setpoint (e.g., 140 ºF)

Grid-connected HPWH
Southeast Study

- Field study research is ongoing through the summer season
- Results of winter season lab tests are published in an FSEC report:
  Fenaughty, K., D. S. Parker, C. Colon, R. Vieira. June 30, 2021.
  "Connected Water Heater Load Shifting and Energy Efficiency Evaluation for the Southeast: Winter Laboratory Assessment, Final Report." FSEC-CR-2114-21.
  https://publications.energyresearch.ucf.edu/wp-content/uploads/2021/06/FSEC-CR-2114-21.pdf
- Conclusion: grid-connected HPWHs can provide large and dependable load shifting relative to ERWHs
- Example of research: two graphs of HPWH load shifting performance using one-hour load up and shed during coldest day and typical day during winter testing





Advanced Water Heating Initiative

- Advanced Water Heating Initiative (AWHI) is a collaboration of HPWH stakeholders with a goal of accelerating HPWH market transformation
  - Technology development: 240v, 120v, and commercial HPWHs
  - Market- and policy-focused strategies to increase HPWH uptake
- U.S. Department of Energy announced support of AWHI on May 17, 2021 through a web summit with Secretary Granholm
- Over 60 organizations are involved, and participation is growing
- Learn more at: https://www.advancedwaterheatinginitiative.org/

Pacific Northwest
NATIONAL LABORATORY

Thank you

Josh Butzbaugh
joshua.butzbaugh@pnnl.gov
Ph: (971) 940-7092

Josh Greene
A.O. Smith

U.S. DEPARTMENT OF ENERGY

Better Buildings Residential Network Peer Exchange Call "In Hot Water? Residential Energy Efficiency Affordability & Technology"

Joshua C. Greene
July 8, 2021

Overview

- A. O. Smith
- Products
- Go to Market
- Challenges/Opportunities
- Thank You

A. O. Smith

- Global water technology manufacturing company doing business in over 60 countries.
- Headquartered in Milwaukee, Wisconsin since 1874, ~ 14,000 employees globally.
- A leader in applying innovative technology and energy-efficient solutions to products marketed worldwide.
- One of the world's largest manufacturers of residential and commercial water heaters and boilers with as well as a leading global manufacturer and marketer of water treatment equipment for residential and light commercial applications.
- Operations in the U.S., Canada, China, India, Mexico, the Netherlands, Turkey, and the UK.
- (NYSE:AOS) S&P 500

A. O. Smith - Vision

Vision

To be a leading provider of **innovative** and energy-efficient products used to **heat, treat and conserve water**, providing value to our residential and commercial customers**.**

We will **create long-term value** for our stakeholders in a socially responsible manner and drive profitable growth by:

- Living our values
- Taking care of our customers
- Leading through innovation
- Investing in people
- Supplementing organic growth with strategic acquisitions

A. O. Smith - Values

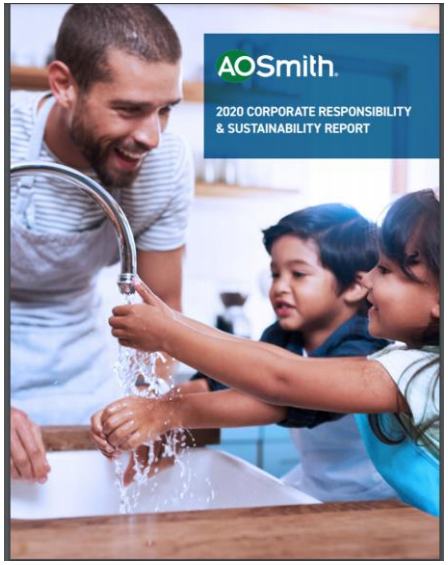
Handed down from founding Smith family and embraced by all employees worldwide

We do business with uncompromising honesty and integrity

- A. O. Smith will achieve profitable growth
- A. O. Smith will emphasize innovation
- A. O. Smith will preserve its good name
- A. O. Smith will be a good place to work
- A. O. Smith will be a good citizen

A. O. Smith – Corporate Responsibility & Sustainability

- Water is one of our most precious resources — and the world's growing population is creating greater urgency to access, heat, treat, conserve and distribute water efficiently, safely, equitably and environmentally thoughtfully.
- Have aligned our disclosures SASB criteria material to our company, including product lifecycle and safety, energy management, materials sourcing and business ethics.
- Greenhouse Gas Emissions footprint reduction goal of 10% by 2025
- https://www.aosmith.com/Sustainability/



A. O. Smith Family of Products

- Proven innovative technology
- ENERGY STAR® qualified
- High Efficiency (Thermal, Standby, UEF, COP)
- Qualify for rebates and tax incentives
- A proven leader and brand name for 145 years

Market Ready Technologies - Heat Pump Water Heaters

Standard Residential – 240V

- **High Efficiency – 3.45 UEF**
  - Reduce water heating costs up to 73% compared to a standard electric
  - Reduce CO_2 emissions by more than 50% compared to a standard gas
- **50, 66, and 80 gallon models**
- **NEEA Tier 3 qualified**
- **Quiet Operation – 51 dBA**
- **Confined Space Capable** – Accessory ducting kit

JA13 Certified Residential – 240V

- Wi-Fi and Bluetooth connectivity
- Connect through free A. O. Smith app
- Time-of-use Schedules
  - Easily find your utility and push rate schedule to water heater in the app
  - Reduces operating costs by heating during low-cost periods and limiting operating during peak rate periods
- Demand Response Capable
  - OpenADR 2.0b VEN certified

Residential – 120V Plug-In Applications

- Designed for homes that currently have a gas water heater
- Common challenges
  - Limited space
  - Home's electric panel may not have 30A available for a water heater
  - Expensive to hire an electrician to run a 240V dedicated circuit for a water heater and upgrade electric panel if necessary
- Homes upgrading from a standard electric water heater should use the standard 240V heat pump models

Residential – 120V Plug-In HPWH

- Designed to meet NEEA AWHS v7.0 Plug-In specification
- Plugs into standard residential outlet (120 volt 15 amp shared circuit)
  - Work within a home's existing electrical system
  - One-trade or DIY instantiation
- 40-80 gallon model sizes
  - Options to fit within existing gas water heater installation footprints
- First Hour Ratings in line with UPC sizing requirements
- JA13 and CTA-2045 Capable
  - Time-of-use Rate Scheduling
  - Utility Demand Response ready

Unitary Commercial

- ENERGY STAR® Qualified
- High Efficiency – 4.2 COP
- Integrated design for easy installation
  - 119-gallon tank enables heat pump to operate more frequently than backup electric elements to improve system efficiency
- 150 gallon First Hour Delivery
- HP + 12kW backup elements = 20 kW total heating capacity
- Multiple operating modes to balance efficiency and hot water delivery

Commercial Split Systems

- Packaged system solutions
- Air and Water Source Split System Heat Pumps
- Sized for Commercial and Multifamily Applications
  - 25,000 to more than 2,000,000 BTU/h heating capacities
  - Modular design
- Suitable for indoor and outdoor applications
- Double wall stainless steel condenser for potable water applications
- Compatible with Single-Pass or Multi-Pass systems

Heat Pump

Storage Tank

Go to Market

Industry Leading Partners in both the U.S. Residential Water Heater Channels[1]

Wholesale Channel	Retail Channel
FERGUSON, Winsupply, HAJOCA	LOWE'S, True Value, ACE Hardware, Do it Best
Large Regional Distributors	

A. O. Smith Customers

WHOLESALE CHANNEL
53% of the market

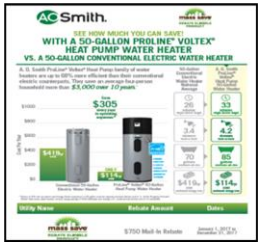
RETAIL CHANNEL
47% of the market

- Manufacturers Reps
- Specifying Engineering Firms
- Residential and Commercial Builders
- Utilities

[1] Residential tank type water heaters only, excludes gas tankless

Go to Market

Counter Display



Consumer Brochure/Tearpads

Contractor Rewards

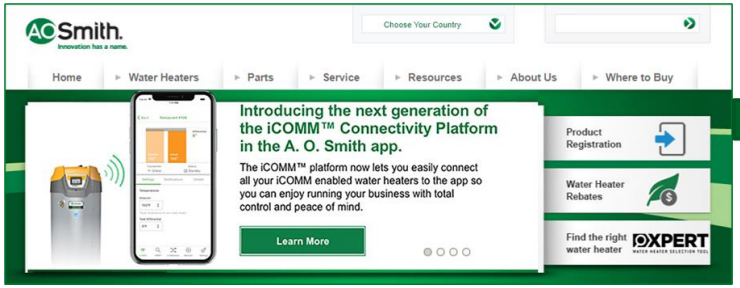
Digital Ads

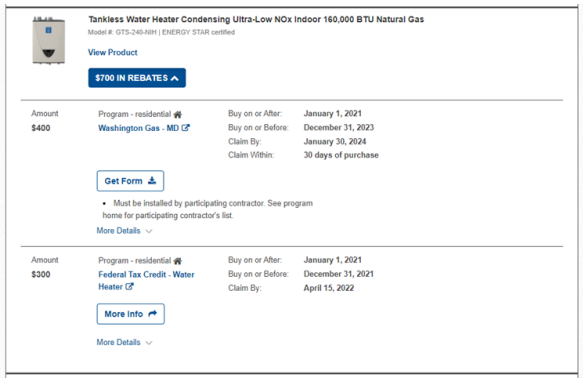
Product Training

Consumer Advertising

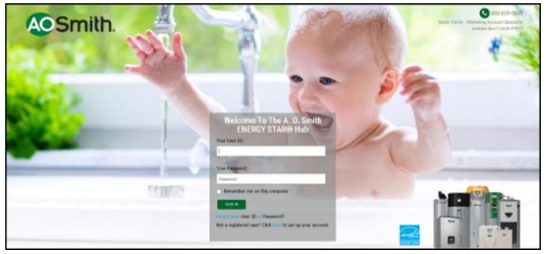
Go to Market

- Zip Code Rebate Finder





- ENERGY STAR® Hub

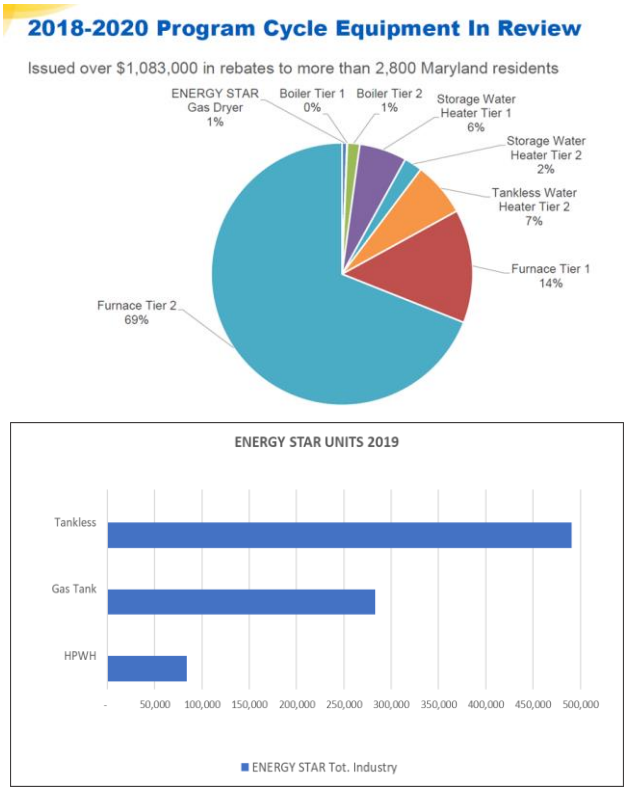


https://aosmith.mymarketingbench.com/

- Dedicated to ENERGY STAR certified products
- Resources for Distributors and Contractors
- Central repository of spec. sheets, brochures, videos, web banners, advertising material

Challenges & Opportunities

- Building Decarbonization / Electrification Programs
- New Construction Programs
  - Easiest time to install high efficiency product (e.g. HPWH)
  - Products already commercially available
- Instant Rebate Programs
  - Up-front cost is largest barrier for many customers
  - Downstream mail-in rebates have shown that they do not influence the purchase decision
  - Upstream or midstream programs for BOTH wholesale and retail channels to reach all potential customers
- Consumer Awareness
  - Drive proactive replacements when consumers can understand the value prop before an emergency
- Contractor Training
  - Stakeholder engagement with installer network, industry best practices



THANK YOU

Josh Greene

Corporate Vice President, Government & Industry Affairs

- jcgreene@aosmith.com


STEM
RISING
U.S. DEPARTMENT OF ENERGY
ENERGY.GOV/STEMRISING

Explore the Residential Program Solution Center

Resources to help improve your program and reach energy efficiency targets:

- Handbooks - explain *why* and *how* to implement specific stages of a program.
- Quick Answers - provide answers and resources for common questions.
- Proven Practices posts - include lessons learned, examples, and helpful tips from successful programs.
- Technology Solutions NEW! - present resources on advanced technologies, **HVAC** & **Heat Pump Water Heaters**, including installation guidance, marketing strategies, & potential savings.

https://rpsc.energy.gov

Thank You!

Follow us to plug into the latest Better Buildings news and updates!

Better Buildings Twitter with #BBResNet

Better Buildings LinkedIn

Office of Energy Efficiency and Renewable Energy Facebook

Please send any follow-up questions or future call topic ideas to:
bbresidentialnetwork@ee.doe.gov