AWHi

ADVANCED WATER HEATING INITIATIVE™

Progress Report

Creating a National Advanced Water Heater Movement

May 2022

Credit: Northwest Energy Efficiency Alliance

Acknowledgements

This report provides an overview of the progress made by the Advanced Water Heating Initiative (AWHI) in 2021. The report was led by the AWHI team at New Buildings Institute (NBI) in close collaboration with key partner organizations and their representatives. It serves as a compilation of efforts and reflects the perspectives shared by AWHI participants and stakeholders, who are helping transform the market with more advanced water heaters in all applications.

Key Contributors

The following individuals provided the core content for this report in the various roles they serve as part of the Initiative.

- Amruta Khanolkar, Senior Project Manager, New Buildings Institute
- Mischa Egolf, Project Analyst, New Buildings Institute
- Smita Gupta, Program Director, New Buildings Institute
- Joe Wachunas, Project Manager, New Buildings Institute
- Owen Howlett, Research Project Manager, Sacramento Municipal Utility District, and AWHI Residential Working Group Co-Lead
- Paul Campbell, ENERGY STAR Program Implementer, and AWHI Residential Working Group Co-Lead
- Keshmira McVey, Program Manager, Emerging Technologies, Bonneville Power Administration, and AWHI Commercial Working Group Lead
- Lois Gordon, Vice President, D+R International, and AWHI Commercial Market Lead
- Jonathan Heller, President, Ecotope, and AWHI Commercial Technology Lead
- Geoff Wickes, Senior Product Manager Emerging Technologies, Northwest Energy Efficiency Alliance, and AWHI Connectivity Working Group Lead

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Key Partners and Collaborators

The team would also like to acknowledge the substantive financial and in-kind support from the following organizations, who contribute support and leadership to the Initiative.

- Bonneville Power Administration (BPA)
- Northwest Energy Efficiency Alliance (NEEA)
- Sacramento Municipal Utility District (SMUD)
- Environmental Protection Agency (EPA), ENERGY STAR
- Department of Energy (DOE)
- Southern California Edison (SCE)
- Pacific Gas & Electric (PG&E)
- New Buildings Institute (NBI)
- Pacific Northwest National Laboratory (PNNL)
- Midwest Building Decarbonization Coalition (MWBDC)
- McKnight Foundation
- RMI

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Executive Summary

The Advanced Water Heating Initiative (AWHI) is a market transformation program that convenes and facilitates key market actors to scale the production and adoption of heat pump water heaters (HPWHs). This collaborative effort can achieve what one region, entity, or state cannot do alone. Launched in 2019 in California and the Northwest, today over 400 organizations and more than a thousand individuals are working along with AWHI to catalyze a rapid transition to high-efficiency, grid-connected HPWHs. AWHI, coordinated by New Buildings Institute (NBI) in partnership with key partners, has expanded into a national program, with regional deployment, to catalyze the market and accelerate HPWH adoption across the United States.

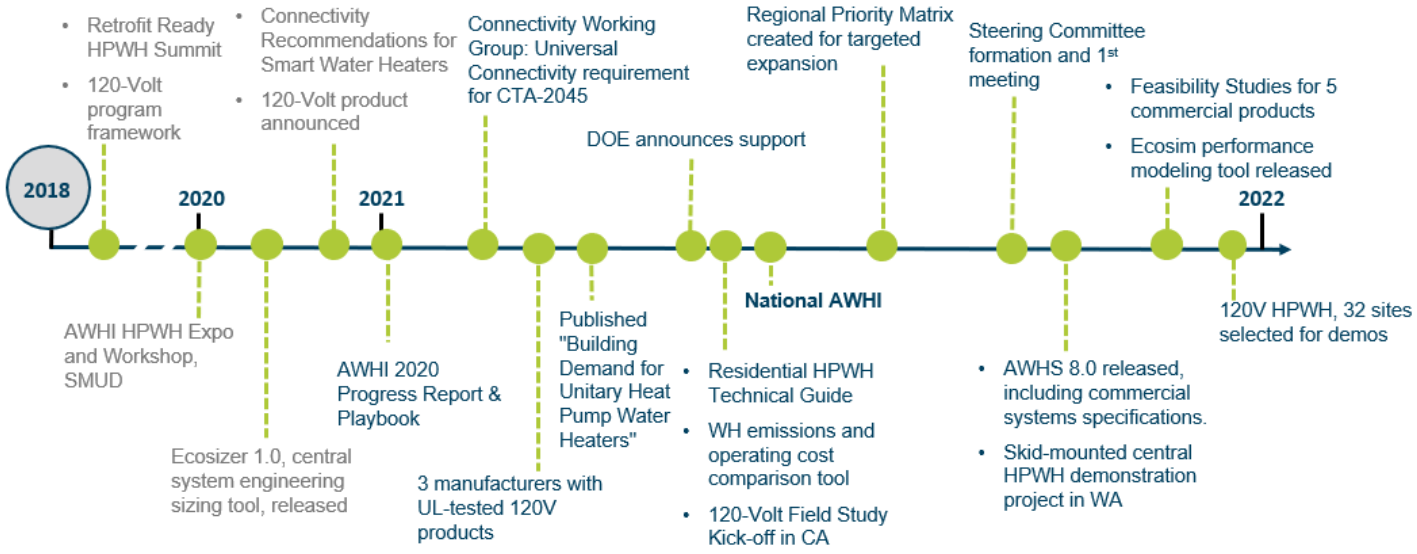
WHY HEAT PUMP WATER HEATERS?

Water heating accounts for up to 17% of total energy consumption in single-family and 32% in multifamily homes in the U.S. With water heating in commercial, residential, and industrial sectors representing 10% of carbon emissions, momentum is growing for energy-efficient technologies such as HPWHs, which are three to five times more efficient than most conventional water heating products. HPWHs are attractive because they not only reduce energy use and carbon emissions, they can also store hot water for later use allowing energy demand to be shifted to times when the carbon impacts of energy production on the electric grid are lower. This capability will become even more important to utilities and grid managers as we shift to a clean energy grid that requires more flexible load management.

PROGRESS IN 2021

AWHI has made notable progress growing into a nationwide program, expanding from its West Coast focus, and developing its first major deliverables in 2021. The Initiative's vision, goals, and strategy focused on funding, infrastructure development, and geographic expansion into U.S. regions. As a result, AWHI has partnered with RMI and the Midwest Building Decarbonization Coalition to launch AWHI in eight Midwest states. Leveraging the work of the national Initiative, the Midwest AWHI is utilizing a unique equity-first lens to identify community priorities and provide resources, such as those in the 2020 Playbook. In 2022, a similar expansion is planned for Northeast and Southeast states. AWHI partners also made significant progress on creating standards and guides related to the grid connectivity potential in heat pump water heaters. See timeline of accomplishments in Figure 1 below.

FIGURE 1: AWHI MILESTONES TIMELINE



PRIORITIES IN 2021, 2022, AND BEYOND

The Initiative, with input directly from manufacturers and other key stakeholders, has established a set of priorities that are evolving. In the 2021 calendar year, priorities included supporting new products as they came to market and pushing market development. In 2022, the focus is on rapid deployment of HPWHs through proactive sales of products in both new construction and replacement markets and building demand with homeowners and builders.

No single region can move the water heating market on its own; with the formation of key partnerships, the coming years will focus on increasing the cumulative impact of efforts through targeted regional deployment activities. Additional 2022 priority areas are summarized below and reflected in Section 5: "Moving Forward, Increasing National Demand." Priorities were also highlighted in the Building Demand for Unitary HPWHs report published in 2021.

OVERARCHING PRIORITIES

- Continued growth and expansion of the Midwest and National Advanced Water Heating Initiative
- Formation of the Northeast AWHI and Southeast AWHI
- Exploration of opportunities and partnerships for expansion into other regions of the U.S.
- Development of 2030 Roadmap to highlight the regions and markets that will be targeted to meet the adoption curve and unlock federal standards
- Conducting supply chain and contractor training
- Increasing equitable access to HPWHs by compiling best practices for programs in low- to moderate-income (LMI) communities and launching a pilot program

COMMERCIAL WORKING GROUP

- Complete Qualified Products List (QPL) for commercial systems in the Advanced Water Heater Specification
- Develop model prescriptive program measures for commercial heat pump water heater (CHPWH) systems based on QPL
- Expand commercial system tools (Ecosizer and Ecosim) and demonstrations to cover applications beyond multifamily
- Engage three new commercial product manufacturers in Technology Innovation Model (TIM)

RESIDENTIAL WORKING GROUP

- Focus on five task groups:
  - Emergency Replacement: develop emergency water heater replacement pilot in CA
  - New Construction: address new construction market through major home builder engagement
  - 240V Expansion: conduct 240-Volt (240V) installer education, accreditation, and licensing
  - Marketing and Education: create direct to consumer marketing, sales, and educational campaign
  - Data Management and Analysis: develop standardized program data collection and use cases
- Commence a California field study of the 120-Volt (120V) HPWH product to support commercialization and program eligibility with initial results in Q1 2023 and completion expected Q4 2023

CONNECTIVITY WORKING GROUP

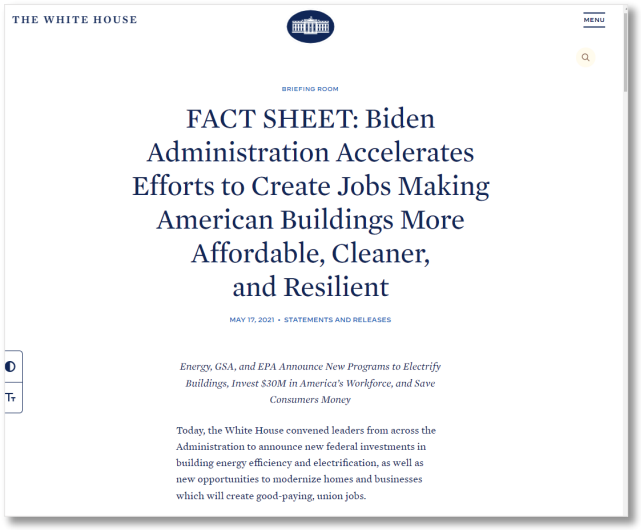
- Support universal grid connectivity adoption in residential and commercial systems including:
  - Connectivity recommendations
  - CTA-2045 branding (EcoPort)
  - Testing procedures and qualified products listing (QPL)
  - Security whitepaper

1. National AWHI

The Advanced Water Heating Initiative (AWHI) is a collaborative, market transformation program that has grown from 50 representatives to over 400 stakeholder organizations and seeks to catalyze a rapid transition to high-efficiency, grid-connected heat pump water heaters (HPWHs). These entities include building industry entities such as utilities, state and local governments, program administrators, manufacturers, wholesalers, retailers, installers, and building industry professionals.

The effort was recognized by the U.S. Department of Energy (DOE) in May 2021 as a key partner for transforming the water heating market in a national announcement under the agency's Energy, Emissions and Equity (E3) Initiative. Through this partnership, DOE is supporting manufacturers and utilities on best practice programs and working closely with stakeholders to develop regional solutions that support both technology innovations and accelerate deployment.

FIGURE 2: MEDIA COVERAGE OF WHITE HOUSE AND DOE PARTNERSHIP WITH AWHI (Learn more about this partnership and other news on the AWHI website.)


THE WHITE HOUSE

MENU

BRIEFING ROOM

FACT SHEET: Biden Administration Accelerates Efforts to Create Jobs Making American Buildings More Affordable, Cleaner, and Resilient

MAY 17, 2021 • STATEMENTS AND RELEASES

Energy, GSA, and EPA Announce New Programs to Electrify Buildings, Invest $30M in America's Workforce, and Save Consumers Money

Today, the White House convened leaders from across the Administration to announce new federal investments in building energy efficiency and electrification, as well as new opportunities to modernize homes and businesses which will create good-paying, union jobs.


Sections

The Washington Post
Democracy Dies in Darkness

Try four weeks free

Biden administration announces new Energy Star standards, plans for emissions targets for federal buildings

The plans include the first sustainability benchmarks for federal buildings and programs promoting electric he pumps

By Tik Root

May 17, 2021 at 5:22 p.m. EDT

MOST READ CLIMATE-ENVIRONM

1 1 in 6 Americans live in ar with significant wildfire ri

2 Pollution caused 1 in 6 deaths globally for five years, study says

AWHI is working to facilitate a transformation from conventional electric-resistance and gas-fired water heaters to clean and efficient HPWHs through: 1) policy initiatives, 2) technology guidance, 3) development of appropriate and consistent specifications, and 4) expanded awareness and education efforts for consumers, trades, and supply chain actors. These efforts will create momentum to drive increased manufacturing, sales, installations, and operation of HPWHs across the country.

HPWHs are game-changing products that are three to five times more efficient than conventional options. Water heaters generally last for 12-14 years, which means that by 2035 all water heaters currently in use will likely need to be replaced. By choosing cleaner, more energy efficient HPWHs, America's households would prevent nearly 100 million tons of carbon emissions every year[1]. AWHI is working to realize these savings by growing market share of HPWHs, effectively cutting carbon emissions that are fueling climate change. In addition to carbon savings, transforming the water heater market in favor of heat pumps would save a significant amount of energy—enough to power 25 million

[1] Based on internal New Buildings Institute calculations

homes each year. As part of the national scale up and to confirm its approach, AWHI partners revisited and updated the vision, mission, and goals in close consultation with a national advisory group.

VISION

Efficient heat pumps will be universal in all water heating applications by 2030.

MISSION

- Improve building efficiency and cut emissions by bringing HPWHs to mainstream.
- Engage and support community-based partners with national coordination and expertise.
- Promote equity through regional deployment, workforce training, and investment in local communities.

GOALS

Residential and Commercial Market Sector Goal: 100% market share by 2030

This implies that all residential new construction and all new sales—for new construction and replacements—are HPWHs by 2030. This goal will ensure HPWH installs for new construction and HPWH replacements as aging stock is change out at end of life with proactive replacements thereafter.

VALUE PROPOSITION

AWHI provides value to the market by bringing market actors and stakeholders together to coordinate, collaborate, and align on market transformation strategies, share outreach, facilitate engagement and education efforts, conduct market research, and advance technologies.

See Figures 3 and 4 below for details on AWHI's areas of work and approaches to changing the residential and commercial markets to achieve 100% market share for HPWHs by 2030.

FIGURE 3: AREAS OF WORK UNDER AWHI

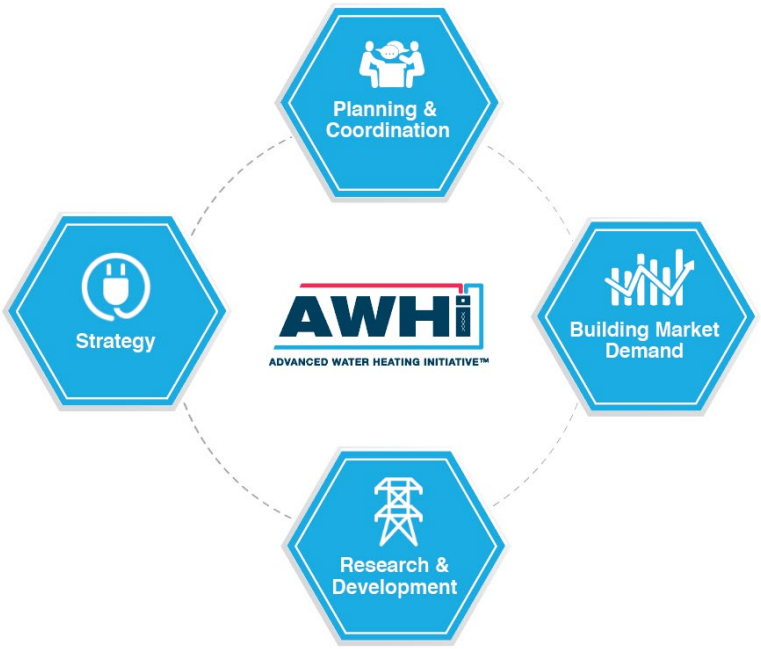
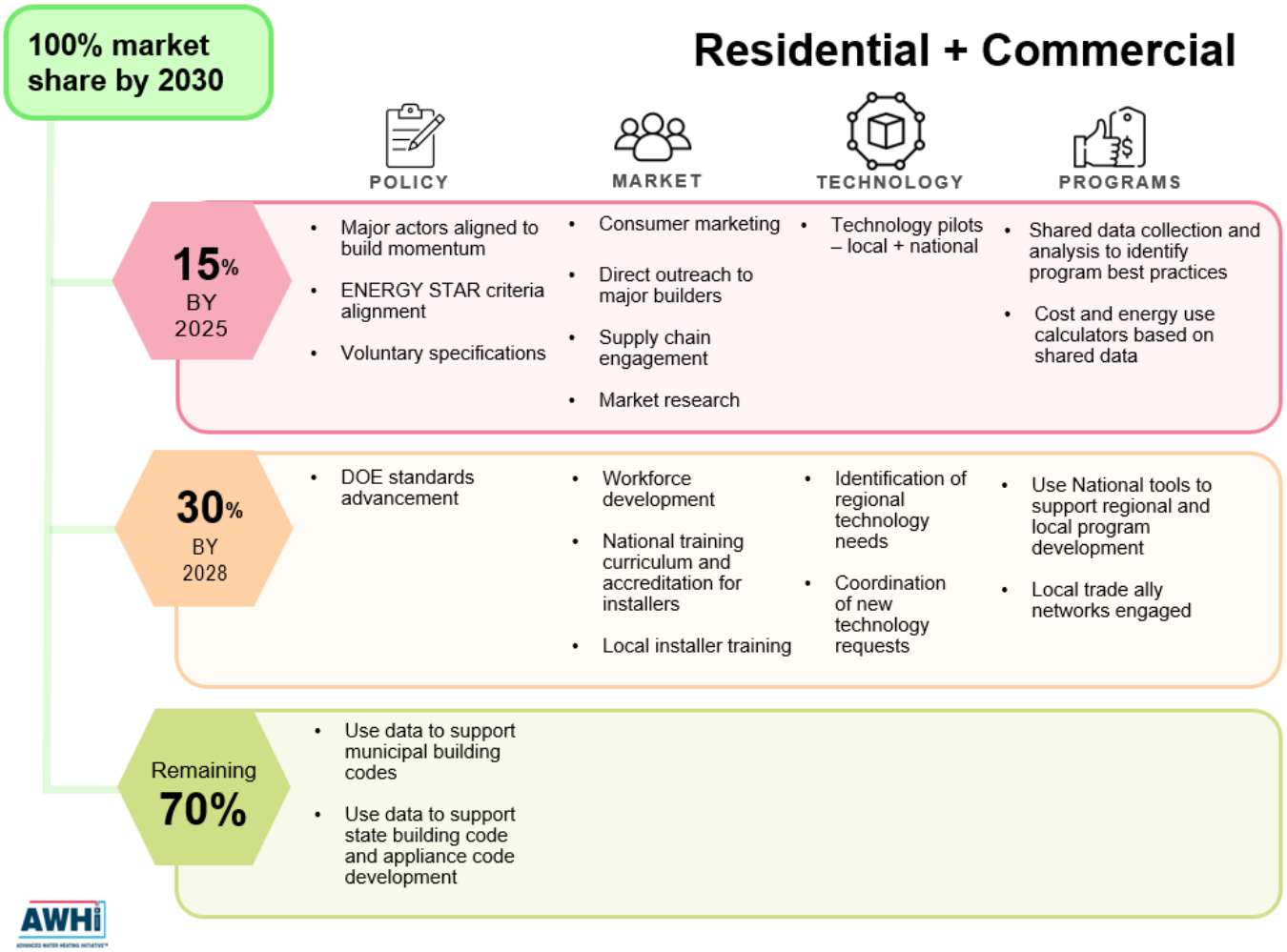


FIGURE 4: AWHI APPROACH TO MARKET CHANGE



Organizational Structure of AWHI

AWHI was launched in 2019 on the West Coast including California and the Northwest states. Four working groups were established to address specific market sectors including: Residential 120-Volt, Residential 240-Volt, Commercial/Multifamily, and Connectivity and Controls. More information about the working groups can be found in the "Working Group Activities" section of this report.

When DOE recognized AWHI as part of its E3 Initiative in May 2021, partners became focused on scaling the West Coast effort to a national concern with the ability to impact and collaborate with a larger footprint. In the subsequent year, the Initiative has brought in collaboration and coordination with an extended set of partners. The national organization of AWHI includes market sector-focused working groups, a national Steering Committee to provide strategic guidance, and the opportunity to establish regional initiatives that can help expand the reach to increase deployments and impact the overall market share for HPWHs.

PARTNERS AND KEY COLLABORATORS

AWHI partners contribute significant funding and leadership to the Initiative. NBI serves as the central convenor and facilitator of partners, key collaborators and stakeholders including:

- Bonneville Power Administration
- Northwest Energy Efficiency Alliance (NEEA)
- Sacramento Municipal Utility District
- U.S. Environmental Protection Agency, ENERGY STAR
- U.S. Department of Energy
- Pacific Northwest National Laboratory (PNNL)

CA/West Coast Region

- Southern California Edison
- Pacific Gas & Electric

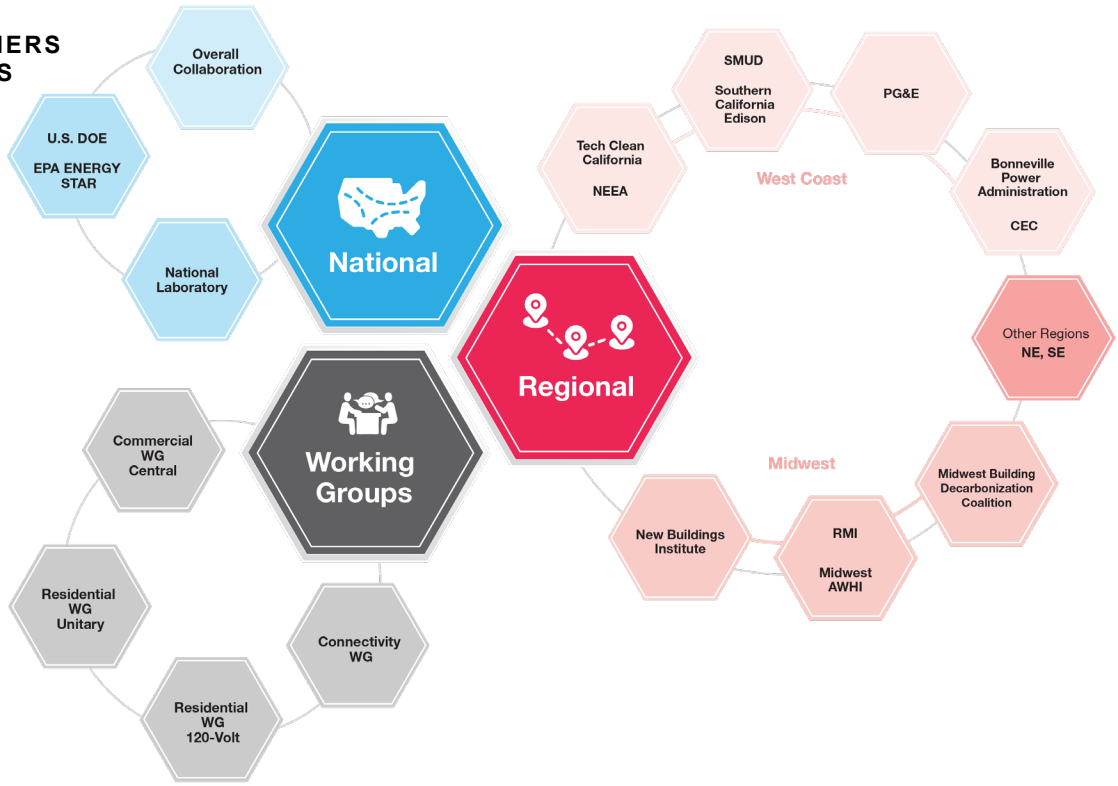
Midwest Region

- Midwest Building Decarbonization Coalition
- McKnight Foundation
- RMI
- NBI

Key Collaborators

- U.S. DOE Office of Energy Efficiency & Renewable Energy: Buildings Technology Office (BTO)
- U.S. Environmental Protection Agency, ENERGY STAR

FIGURE 5: KEY PARTNERS AND COLLABORATORS



WORKING GROUPS

The working groups (WG) are critical in providing hands-on market development, identifying gaps, and implementing on the direction provided by the Steering Committee. The WG workplans and activities associated with programs, policy, market, and technology channels aim to achieve market transformation. The key working groups of AWHI:

- Residential:
  - The residential working group (WG) primarily tackles residential markets and systems that serve single-family housing, up to four dwelling units (apartments), and small commercial applications such as a preschool kitchen or showers in an office building. The objective is to activate the different market transformation levers to build demand for residential HPWHs[2].
- Commercial/Multifamily:
  - This working group serves the commercial sector with a focus on multifamily buildings. The commercial systems are larger systems serving more than four dwelling units or larger commercial loads needing more than a total of 119 gallons of storage volume.
- Connectivity and Controls:
  - This working group crosses all market sectors and technologies. Its focus is on standardizing the grid connectivity aspects for water heating equipment.

STEERING COMMITTEE

The Steering Committee provides strategic guidance to the Initiative with representation from a broad and diverse perspective. Members include representatives from Federal, State and regional energy agencies, utilities, non-governmental organizations (NGOs), technical experts, manufacturers, and stakeholders from the building industry. Members can impact and influence deployment of HPWHs through their own activities, mandates, and partner networks. The Steering Committee was convened as part of the national Initiative launch and is co-chaired by David Nemtzow, Director at Building Technologies Office, DOE; Andrew McAllister, Commissioner at California Energy Commission; and Ralph DiNola, CEO at NBI. The Steering Committee met three times in 2021 to adopt goals for the national Initiative and will convene quarterly in 2022 to provide ongoing guidance on priorities and activities.

STAKEHOLDERS

Stakeholders are an important aspect of AWHI's market transformation efforts and offer a broad representation of the market actors, agencies, researchers, etc. with a stake and role to play in the national working groups and regional initiatives. AWHI hosts a quarterly stakeholder meeting to engage on various topics relevant to increased HPWH deployment. In the last year, AWHI has grown to over 400 stakeholder organizations represented by over 1,000 individuals in the U.S. and globally.

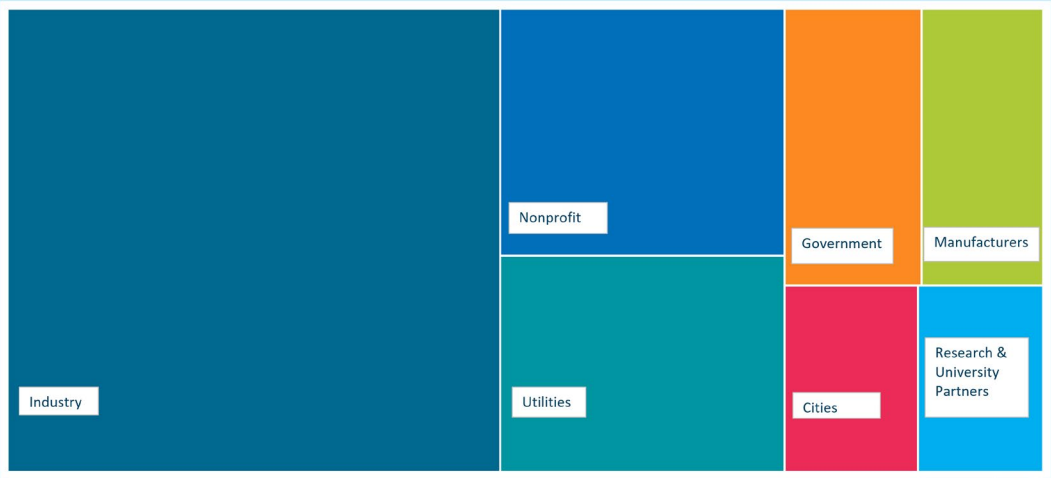


FIGURE 6: STAKEHOLDER REPRESENTATION

[2] HPWHs have just 2.2% of market share among water heating technologies today

2. Regional Initiatives

While AWHI is a national effort, it is also focused on tapping into the power of regional markets. As "boots on the ground," regional partners implement AWHI at the regional, state, and local level, providing critical knowledge and expertise related to market readiness, technology implementation challenges, regional policy and programs, climate implications, and other local adoption factors. They are also a critical voice in the national conversation.

The benefits of participating in AWHI as a regional partner include national backing of regional HPWH deployment goals, helping to create good paying jobs, demonstrating market leadership in addressing one of the largest sources of emissions in buildings, and lowering energy demand while increasing load flexibility to support a more resilient electric grid. National AWHI provides a foundation and resources for regional partners to launch local deployment strategies and leverage the collective market power of the national group.

The value of working together

By collaborating under a national umbrella, regional partners with energy efficiency and decarbonization goals have greater opportunities to drive market change. Through the AWHI collaboration, partners gain:

Speed of change, which increases when national, regional, and local actors align on goals and approaches sending clear signals to the market ultimately accelerating adoption.

Influence direction of national efforts through opportunities for input and participation in steering committee, advisory, and working groups that are part of the AWHI organizational structure.

Leverage funding with partners from other regions of the country and the federal government to make marketing dollars go further and provide consistency for policies governing equipment specifications.

Lower risk associated with investment in programs by increasing market power that ensures manufacturers will make products available and a trained workforce will be prepared for quality installations.

Facilitate collaborations through connections available within the network of national AWHI partners and experts, as well as community-based groups working on equitable distribution of efficiency benefits.

Gain access to customized resources and support, including cutting-edge research on important topics such as improving cold climate performance and insights from manufacturers and policy makers.

REGIONAL INITIATIVES UNDERWAY OR PLANNED

- **West:** Exploring a partnership with California Public Utilities Commission, led by statewide third-party electrification program implementer (TECH)
- **Northwest:** Northwest Energy Efficiency Alliance, Bonneville Power Authority, and Energy Trust of Oregon are active in the Hot Water Solutions program and central heat pump market development

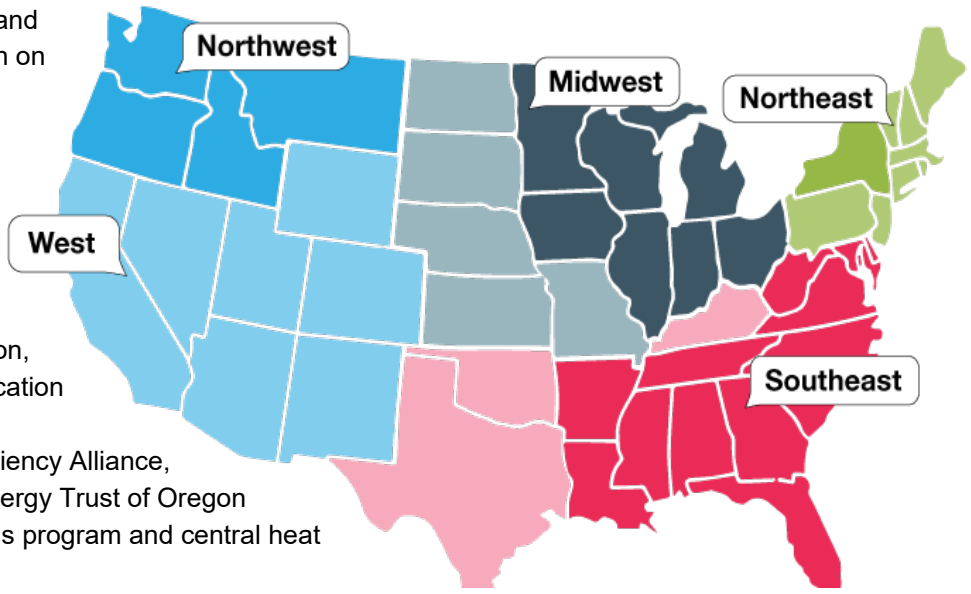


FIGURE 7: REGIONAL SEGMENTS

- **Midwest**: Midwest Building Decarbonization Coalition and NBI, in in partnership with Fresh Energy and RMI, are developing an equity-centered program
- **Northeast:** Investigating a New York and NE regional initiative with Northeast Energy Efficiency Partnerships and New York State Energy Research and Development Authority

3. Activities and Updates

This section is divided by overarching activities that support national scale up and working group efforts targeting residential and commercial market sectors.

Overarching Activities

- **National Scale-Up:** The national scaling of the Initiative in 2021 meant collaboration and coordination with an extended set of partners. Developing the organizational structure for a national AWHI was one of the key activities last year. This included reorganizing the working groups to address specific market sectors, forming a national Steering Committee, and establishing the regional initiative framework.
- **Website launch:** In conjunction with DOE and the White House announcement and support for AWHI, an Advanced Water Heating Initiative website was launched in May 2021. It provides a platform to share the mission, vision, and goals; provide updates on Initiative activities; and a sign-up form for interested individuals and organizations to engage or get more information about HPWHs.
- **Newsletters:** In 2021, a quarterly newsletter was initiated with key updates and HPWH-related news. Three newsletters were published through March 2022 with the next one to be issued in June.
- **Quarterly stakeholder calls:** Five all-stakeholder calls were organized by AWHI in 2021 with robust representation across manufacturers, utilities, and industry partners. These meetings are for all members and individuals involved in any capacity or associated with other industry stakeholders. This group meets on AWHI's key activities and Roadmap. In 2021, guest presenters included the Building Electrification Institute to discuss equitable electrification of multifamily buildings and DNV GL, to present their impact evaluation of residential water heating for the CPUC. Meeting notes, which include the attendee list and agenda, are sent to all stakeholders following each call and are available on the AWHI Google Drive.
- **Regional prioritization:** AWHI undertook an assessment of regions and states to prioritize activities in areas which have the highest potential for rapid deployment—primarily focused on the residential market sector for the 240V products.
- **Engagement with California programs:** The TECH Clean California program provided Quick Start Grants to fund high-impact opportunities to accelerate deployment of heat pump space and water heating technologies. NBI secured a Quick Start Grant to support implementation of the 120V HPWH field study with product installations. The TECH team has also engaged with the Residential working group and sits on the 120V heat pump water heater Technical Advisory Committee.
- **Midwest regional engagement:** AWHI completed preliminary engagement efforts with the Midwest Building Decarbonization Coalition on a Midwest Advanced Water Heating Initiative. This nationally supported, locally run effort aims to remove barriers that hinder HPWH adoption in the Midwest, specifically those barriers identified by Black, Indigenous, and people of color (BIPOC), low-income and under-resourced community members.

- **Collaboration on ENERGY STAR Residential Water Heater Draft Specification 5.0 Comment:** In 2021, the EPA released the first draft of the ENERGY STAR Version 5.0 Residential Water Heaters specification. The proposed revisions create more stringent criteria for gas-fired storage and instantaneous water heaters. NBI coordinated the development of a comment letter in support of the proposed changes, with additional recommendations. The comment letter was co-signed by four AWHI partners in addition to NBI.

Working Group Activities

AWHI Working Groups (WG) are actively engaged toward outcomes that both advance their topic area and bring benefits to efforts working to increase the adoption of HPWHs. In 2021, AWHI working groups reorganized as shown in Table 1 below. In addition to the residential and commercial working groups, a policy working group will begin meeting in 2022 to focus on national and regional policy advancement in the residential and commercial sectors.

TABLE 1: AWHI WORKING GROUP STRUCTURE

2019-2020 Working Groups	2021 Working Groups
120-volt working group 240-volt working group	Residential working group
Commercial working group	Commercial/Multifamily working group
Connectivity and Controls working group	Connectivity and Controls working group

RESIDENTIAL WORKING GROUP

The focus of the Residential WG is to swiftly increase the market share of unitary 240-volt HPWH, which are readily available in the market, and aid in the development of 120-volt HPWHs, which are an emerging technology. The group also promotes market awareness of HPWHs and increased efficiency program activity supporting all unitary HPWHs (both 240V and 120V). The most significant areas of progress are provided below.

- **Engagement of Co-Lead.** As part of the expansion to a more national scope, the Residential Working Group added a co-lead position in August 2021. This ensures a diversity of ideas and uniform coverage should one of the leads be unable to facilitate a monthly call and will aid in maintaining the group's momentum toward market transformation.
- **Building Demand for Unitary Heat Pump Water Heaters Report.** In May 2021, the "Building Demand for Unitary Heat Pump Water Heaters" report was published, providing an overview of best practices to promote rapid scale-up of unitary water heaters and market transformation in both the new construction and retrofit markets. The report builds upon the working group's progress in 2020 to identify and document characteristics of successful heat pump water heater programs in the U.S., develop innovative methods to rapidly reach more customers, and identify emerging trends that could be leveraged. The document is a result of engagement and input received at three working group meetings, which included 92 members and invited guest speakers.
- **Market Transformation Strategy.** A comprehensive market transformation strategy was developed in partnership with the residential working group leads. This includes engagement with the California's statewide TECH program and PNNL to develop a plan for standardized data collection and sharing, and the development of market transformation incentives.
- **Residential Marketing and Communications Plan.** This plan describes sector-specific marketing and communications strategies needed to catalyze market transformation toward heat pump water heaters. The plan also describes the marketing and communications elements of AWHI's National Infrastructure that are needed to expand into new regional markets across the U.S. The plan was developed by D+R International

with DOE support and engagement with an ad hoc Market Advisory Group including representatives from key stakeholders, NBI, and Residential Working Group Leads.

- **Residential Education and Engagement Plan for 240V HPWH.** This plan proposes a targeted, multi-faceted approach to education and engagement with entities on both the supply and demand side of the residential heat pump water heating market. It expands on the "Building Demand for Unitary Heat Pump Water Heaters" report (see above) centering on training the contractor and installer base. The plan also outlines outreach to and education of diverse trade associations, community organizations, home builders, developers, and consumers in a coordinated campaign to increase awareness, demand, and supply chain readiness. It was developed by D+R International with DOE support and in collaboration with the Residential Working Group Leads and ENERGY STAR.
- **Sustained Market Research Plan.** This plan sets out a phased approach to conduct continuous market research that supports AWHI's national market transformation goals. It was developed by D+R International with support from DOE.
- **Marketing Toolkit Catalog.** A framework to collect and create a searchable repository of HPWH resources, segmented by audience type, asset type (e.g., video, print resource, web resource), and source, with links to quickly access each resource.
- **HPWH Technical Guide.** The Heat Pump Water Heater Technical Guide, released by NBI in June 2021, was developed as a tool for installers. The guide provides a flowchart to guide installation decisions, key design considerations, and a summary of installation best practices.
- **Operating Cost and Emissions Tool.** NBI developed a scalable tool for Southern California Edison comparing operating cost, energy, and emissions of all the conventional water heating technologies with HPWHs. This tool helps customers and installers understand the environmental and financial aspects of switching to HPWHs.
- **120-Volt (120V) HPWH Field Validation Study in California**. The retrofit ready, plug-in 120V HPWH is an emerging technology. The low-power 120V design can plug in to existing wall outlets without requiring expensive panel upgrades and/or home rewiring that can be required for traditional 240V units. This technology represents an ideal solution for retrofit applications to replace existing gas-fired tank type water heaters and is expected to be well suited to smaller homes with lower hot water demand. The NBI-led field study for the 120V HPWH was launched in 2021 with support from Pacific Gas & Electric, Southern California Edison and Sacramento Municipal Utility District in California as well as a quick start grant through the State's TECH program.

  The work commenced with finalizing a research plan, engaging with site coordination and monitoring partners, and convening a technical advisory committee (TAC) with representatives from utility sponsors, participating manufacturers, and researchers. The team engaged in active outreach to recruit potential host sites with a view to assessing suitability, and diverse representation across building type, hot water demand, climate zones, vintage of construction, and location of water heater. There was overwhelming response from over 70 volunteers towards selecting 32 eventual sites. The installs commencing in May 2022, with a study period of 12 months. Updates will be forthcoming at www.advancedwaterheatinginitiative.org/120v-field-study

- **Accelerating HPWH Deployment and Expanding Market Share:** In September 2021, the Residential WG established a standing monthly call to report on progress toward workplan goals and identified eight priority activities and corresponding goals to tackle in 2022. It began recruitment of task group leaders and volunteers. ENERGY STAR committed to leadership of select task groups. A table summarizing the tasks is shown below.

- **TABLE 2: RESIDENTIAL WORKING GROUP PRIORITIES**

Task	2022 Priority	Goal Statement
Emergency water heater replacement pilot in CA	Very high	Develop and test a method of achieving same-day replacement of gas or electric water heaters
Addressing new construction through Home Builder engagement	Very high	A heat pump water heater is installed in every newly constructed home
White label "Program in a Box" RFP Templates	High	Develop RFP templates that include all of the key items to more easily roll out a program
Strategy for 240V installer education, accreditation and licensing	High	Develop an education and deployment plan for installer education, accreditation, and licensing.
Direct-to-consumer and installer-led marketing, sales, and education materials--data collection	High	Create and deploy regionally focused campaigns, summarizing marketing and education materials currently available, and best practices
Northeast Regional Initiative	High	Setup of a Northeast-region AWHI to achieve increased deployment and market share in the Northeast
Standardized program data collection and use cases	High	Develop standardized data collection methods for utility programs, develop data use cases and a public data structure for program level information
Midwest 120-volt field study	Medium	Adapt the research methodology developed in CA for applicability in the MW region

COMMERCIAL/MULTIFAMILY WORKING GROUP

The AWHI commercial working group's goal is to shift the standard water heating practice in multifamily and commercial buildings from reliance on fossil fuel-based equipment to efficient, low-Global Warming Potential (GWP) commercial heat pump water heating systems. The Work Group has three parallel tracks, as follows:

1. **Standards, Specifications, Programs and Codes**. The development of specifications, standards, and simplified model programs help standardize and steer the market. The approach centers on HPWH systems and includes all system components and energy used in heating the building's water. The Advanced Water Heating Specification (AWHS) provides a mechanism for a Qualified Products List (QPL) in order to deliver reliable, repeatable results for water heating energy use predictions, which can form the basis for utility programs and codes.

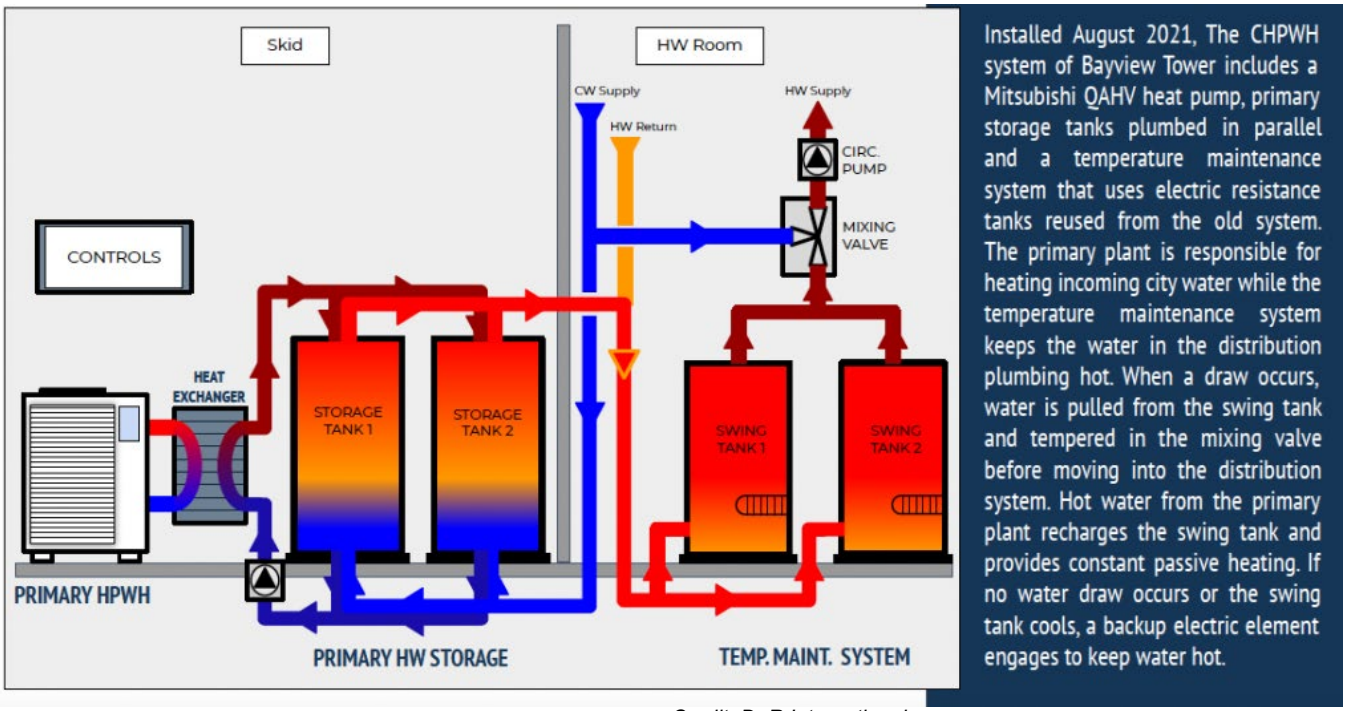
2. **Market Development and Engagement.** By providing training, educational materials, and market engagement, AWHI works to shift the wide range of stakeholders in this market towards awareness, understanding, and desire for these systems.

3. **Product Development.** Through the engagement of manufacturers and the supply chain in the Technology Innovation Model (TIM), AWHI works to accelerate the shift from selling heat pumps for custom-engineered solutions to selling fully integrated, tested, and proven plug-and-play commercial water heating systems that reduce cost and risk and rapidly scale adoption. Work also includes the development of sizing and modeling design tools to support industry.

A summary of the key progress made by this group in 2021 is provided below.

- **Milestone Demonstration Project.** A retrofit of the water heating system at an affordable housing project in Seattle at Bayview Towers represents a new class of CHPWH system. This system was fully pre-assembled, delivered to the site on a truck, lifted into place, connected, and commissioned. This allowed a non-specialized contractor to provide a low-risk CHPWH solution with minimal hot water disruption in this fully occupied building. This is also the first demonstration in the U.S. of a large-scale commercial CO2 HPWH designed specifically for potable water heating and the first to incorporate load shifting capabilities.

FIGURE 8: BAYVIEW COMMERCIAL HEAT PUMP WATER HEATING SYSTEM



Credit: D+R International

This demonstration project of a Mitsubishi Commercial Heat Pump Water Heater (CHPWH) system includes a one-year field study during which the load shifting capabilities will be tested and optimized. The system is expected to supply hot water using about one-third of the energy of a conventional system–a 59% reduction, from 230,000 kWh/year to 95,000 kWh/year—and provide demand flexibility for grid operations.

- **Specifications Development.** The Commercial/Multifamily working group developed a set of specifications for central HPWH for inclusion in NEEA's Advanced Water Heating Specification (AWHS), version 8.0. This specification supports system efficiency, installation best practices, performance, and system configuration to ensure energy efficient design and operation, providing best practice strategies to the industry for optimal performance of central systems. This will support development of a QPL which can form the basis for utility program development.

- **Application Guidance and Outreach.**
    - Release of the free, online Ecosizer tool for sizing central water heating systems. The tool is designed to support the building industry to adopt HPWHs to improve energy efficiency and reduce greenhouse gas emissions. The Ecosizer is also intended to provide educational information on central HPWH system designs.
    - Release of the free Ecosim research tool for performance modeling of CHPWH systems. This tool will be used by researchers to predict performance of systems on the QPL and to investigate impacts on performance of a wide range of system variables.
    - D+R LEARN, in collaboration with Ecotope, Inc., developed an in-depth library of CHPWH educational resources, released through San Diego Gas & Electric (SDG&E). Courses include:
        - CHPWH System Components, Sizing, and Design
        - Measurement and Verification: A Unified Approach to CHPWH Performance Data
        - CHPWH: Manufacturer Training and Resources
        - CHPWH: Maintenance and Operations
        - Installation of CHPWHs in New Construction
- **Market Deployment**. Through partnerships with multiple HPWH manufacturers, the group has worked to deliver to new fully developed, tested, plug-and-play CHPWH systems to the market including systems using low-GWP refrigerants. in 2021 this work included:
    - Applications testing, demonstration, M&V, and Design Guidelines for Mitsubishi HEAT2O CO2 HPWH
    - Feasibility study for small-scale imported CO2 HPWH
    - Feasibility study for new U.S.-manufactured CO2 CHPWH
    - Demonstration and M&V of new generation of Colmac CHPWHs
    - Feasibility study for Nyle's new U.S.-made low-GWP E-series heat pump
    - Feasibility study for the WaterDrop fully packaged skid-mounted commercial product built up with small-scale SanCO2 HPWHs
    - Feasibility study and applications testing of new advanced controller for SanCO2 commercial systems

CONNECTIVITY AND CONTROLS WORKING GROUP

The Connectivity and Controls working group's focus is on water heater communications to enable grid connectivity and load shifting capabilities, including the development of connectivity security requirements and standards and a QPL. A summary of the key progress made by this group in 2021 is provided below.

- **Connectivity Recommendations:** The working group has updated the "AWHI Connectivity Overview," which provides connectivity guidance to the 120V, 240V, and central water heating group working groups. The document summarizes key attributes, reference documents and rationale, and describes the working group's efforts. The working group made progress to integrate CTA-2045 recommendations for Commercial Products in the Advanced Water Heating Specification version 8.0 draft.

FIGURE 9: ECOPORT LOGO

- **CTA-2045 Branding**: In 2021, the working group engaged in an effort to develop a branding package for CTA-2045, including a name, logo design, and logo colors. The group voted to approve EcoPort™ and has filed for a trademark and developed a style guide for proper use.

- **Testing and Qualified Product Listing:** Working with OpenADR Alliance to launch a QPL. The first posting is expected in August 2022, and the list will be mirrored on CTA and NEEA sites. Concurrently, testing methodology has been developed and is available to manufacturers. Third-party testing organizations (UL and Intertek) are offering testing in 2022. The QPL will be available here: http://ecoport.openadr.org/
- **AHRI 1430:** WG members have engaged in the process to publish AHRI 1430 (Standard for Demand Response for Electric Water Heaters). The goal is to create an ANSI Standard for electric water heater application definitions; test requirements; operating and physical requirements; minimum data requirements for published ratings, marking and nameplate; and data and conformance conditions. This effort seeks to gain alignment between AHRI 1430 and CTA-2045 B, to cover all water heating up to 12kW and 119 gallons.
- **Security Whitepaper**: Development of a whitepaper is underway that provides guidance to utilities, aggregators, device manufacturers and other smart grid stakeholders on recommended communication security levels for individual distributed energy resources (DERs) and the systems used to monitor and change the behaviors of individual DERs or groups of DERs. Recommendations will point to established standards such as those developed by the National Institute of Standards and Technology (NIST) and the CEC.

Policy Updates

The codes and policy landscape for HPWH has seen some significant progress in 2021, which would impact the adoption rates and market share. Past policy highlights and future potential areas of focus are described below. See additional specific policy updates in Appendix B.

- **Efficiency and Performance**: Code stringency improvements incentivize utilization of above-code efficiency equipment in high hot water usage buildings. Particularly in modeled performance code compliance and package or credits-based codes (C406 and R408 in IECC).
- **Building Performance Standards (BPS):** By the end of 2021, there were eight BPS policies in place, and additional states and cities looking at the role BPS could play to achieve climate goals through efficiency and decarbonization in existing buildings. Particularly when BPS is site energy or carbon based, HPWH can help achieve those goals with higher efficiency and transitioning buildings away from fossil fuel combustion. An increased interest in considerations for grid connectivity in BPS may place additional value on HPWH in the coming year.
- **Grid Connectivity**: States are adopting and considering grid integration requirements for water heaters in their energy codes (particularly CTA-2045). As the market for CTA-2045 compliant water heaters are currently mainly HPWHs, this is effectively a requirement for HPWHs. The state of Washington already had an appliance standard requiring CTA-2045-A and is currently in the process of approving an energy code requirement moving to “near”-B. California has seen a lot of movement in grid integration generally. Primarily driven by Renewable Portfolio Standards and Grid Decarbonization requirements, many utilities are looking to water heating loads for grid demand management (see: WatterSaver program). As a result, there has been greater interest and activity in HPWH incentive programs and policies.
- **Electrification**: Dozens of cities and states are considering code provisions that require or heavily incentivize electrification of water heating loads. This decreases barriers for HPWH installations, particularly when combined with increased code stringency. For new construction, variations include mandatory electrification, electrification readiness, and HPWH readiness requirements (with electric panel capacity and wiring upgrades in place).
- **Emissions:** Increasingly, appliance and building emission standards and requirements, enforced by air quality districts and air resource boards, are driving towards the use of appliances that emit low- to no-direct

emissions. These policies focus on NOx and SOx emissions instead of carbon but have a similar impact on transitioning to electric appliances, including HPWHs.

Technology Landscape

As part the work supported by California utilities, NBI collected information and summarized the status of HPWHs available in the market as well as products that are in development or available internationally. In addition to investigating residential and commercial HPWH technologies, the market scan focused on key features like grid connectivity and refrigerant use of the available HPWHs. It provided quantitative data on the scale of the market. For additional information on the technologies and state of the market please refer to Appendix C.

4. Connections and Collaborations

Water heating interests cover a wide-ranging territory. AWHI connects with a broad spectrum of companies, organizations, and individuals to exchange information and perspectives on technology, market, program, and policy approaches. This section highlights the AWHI connections made in 2021.

Manufacturer Engagement

A core element of the success of AWHI is the engagement of and coordination with water heater manufacturers. Manufacturers are both AWHI participants and core partners, bringing their product development, business needs, and expertise to the group. They are active participants in all AWHI working groups, representing both the residential and commercial sectors.

The list in Table 3 below shows the 12 manufacturers with heat pump water heater offerings that have been engaged with AWHI and the sectors they serve with their products.

TABLE 3: AWHI MANUFACTURER BASE

Manufacturers	Sector Served
A.O. Smith	Residential & Commercial
Ariston Thermo USA	Residential & Commercial
Bradford White	Residential
Colmac	Commercial
GE	Residential
HTP Comfort Solutions	Residential
Lochinvar	Residential
LG	Residential
Mitsubishi	Commercial
Nyle	Residential & Commercial
Rheem	Residential & Commercial
Sanden/ Eco2 Systems	Residential & Commercial

In 2021, the Commercial working group engaged directly with two distributors, Steffes and Small Planet Supply, as part of their work to promote the development of skid-mounted “plug and play” systems. These distributors and their skid-mounted product offerings are shown Table 4.

TABLE 4: DISTRIBUTORS OFFERING SKID-MOUNTED SOLUTIONS

Distributor Name	Skid-Mounted Product
Steffes	Origin
Small Planet Supply	WaterDrop

One of the key manufacturer-focused activities AWHI undertook in 2021 was engaging through the ENERGY STAR Manufacturer Action Council (ESMAC) and developing a framework for more consistent communication with manufacturers to ensure that AWHI is supporting this key market group. AWHI will continue to engage with manufacturers in 2022 and will connect with key personnel from multiple departments to ensure consistent messaging and understanding of mutual goals. To date, manufacturers have shared feedback on their priorities for AWHI. Below are the top five takeaways:

1. **Target new construction for rapid increase in market share.** Assure new construction prioritized out of the gate by getting universal program adoption and policy performance requirements that support HPWHs.
2. **Pursue critical policies that enable scaling HPWH installations.** Targeting policy and program levers is key. It includes local, state, and federal codes and policy for building and appliance standards, and also the regulations of emission by air quality districts.
3. **Build awareness to accelerate consumer demand.** Build an HPWH campaign customized to various audiences to provide inspiration, awareness, confidence, and education.
4. **Create uniform programs and incentives.** Create a consistent statewide approach with uniform program design and incentive amounts that include direct-to-consumer rebates and supply chain incentives (distributors and retailers).
5. **Focus on replacements through increasing installer confidence and awareness.** Provide training and tools to distributors, contractors, and installers.

Federal and State Agencies

Active collaborations and leveraging existing HPWH efforts are key focus areas of the Initiative. Some of the key collaborations and connections in 2021 included the Department of Energy (DOE), Environmental Protection Agency (EPA), ENERGY STAR, California Energy Commission (CEC), California Public Utilities Commission (CPUC), Northwest Energy Efficiency Alliance (NEEA). Details of some of those engagements are described below:

- **U.S. Department of Energy.** In May 2021, DOE announced its partnership with AWHI to increase market adoption of high-efficiency, grid-connected HPWHs in residential and commercial buildings. The DOE is represented on the AWHI Steering Committee and actively participating in WG calls.
- **U.S. EPA ENERGY STAR.** While leveraging ENERGY STAR's national partnership network, the Initiative is collaborating with ENERGY STAR on task group leadership through the Residential WG.
    - **ENERGY STAR Manufacturers Action Council (ESMAC).** ESMAC is unique forum for product advocates to come together and identify common challenges and solutions for the advancement of HPWHs. AWHI regularly collaborates with ESMAC on building market demand and acting on manufacturer feedback (as described above). In 2021, ESMAC membership increased from five to eight leading manufacturers. Contributions included: 15 joint training sessions for utilities, contractors, distributors, and home builders across the country, as well as input on ENERGY STAR website tools including certified product and qualified installer finders.

- **California Directive and Regulatory.** CEC and CPUC have been represented in the Initiative since inception. California has made several directives, including the SB1477 BUILD & TECH programs and the Self Generation Incentive Program (SGIP). As described above, the Initiative has been actively engaged with the TECH program.

5. Moving Forward in 2022

Rapid and sustained climate action is needed to curtail greenhouse gas emissions and accelerate the transformation to a clean energy economy in the next decade. AWHI is dedicated to accelerating the adoption of heat pump water heater technologies through a collective impact approach to market transformation to advance the highest efficiency technology for water heating and dramatically reduce related carbon emissions.

In 2020, AWHI focused on technology development, program advancement, and market confidence building measures. The focus of 2021 was on bringing national momentum to activities that will result in rapid scaling of program reach and investments. In 2022, AWHI will target rapid deployment of HPWH through proactive sales in both new construction and replacement markets and building demand with homeowners and builders. This includes widespread installation of products in coordination with existing and emerging programs, and collaboration on the development of awareness-building and training activities.

Plan of Action for 2022

The AWHI Steering Committee will guide the implementation of work to address the focus areas listed below. AWHI also will develop a 2030 Roadmap and three-year workplans highlighting priority regions and markets to meet the adoption curve and unlock federal standards. The 2022 focus areas for AWHI can be found below. Additional work streams in process or planned are described in Appendix A of this report.

- Continue the work of regional initiatives already underway along with the national AWHI
- Continue Residential and Commercial WGs to engage with stakeholders towards building demand and increasing deployments
- Setup initiatives in the Northeast and Southeast in collaboration with regional partners
- Continue activities to increase awareness and build demand for HPWHs
- Develop 2030 Roadmap to achieve the market share goals
- Develop and conduct supply chain and contractor training
- Accelerate 240V HPWH installation in new construction and electric resistance unit replacements
- Complete 120V HPWH field study to support commercialization and program eligibility
- Complete commercial system Advanced Water Heater Specification and Qualified Products List
- Increase equitable access to HPWH by compiling best practices for programs in LMI communities and launching at least one pilot program
- Expand commercial system tools and demonstrations to cover other applications beyond multifamily
- Support universal grid connectivity adoption in residential and commercial systems
- Engage with California TECH, BUILD, SGIP programs; New York NYSERDA programs, others
- Showcase program and regulatory integration with ENERGY STAR and others

Path to Market Transformation

HPWHs currently represent only 2.2%[3] of the U.S. water heating market, and less than half of those are grid-connected, according to a 2018 RMI report. Reaching AWHI's moonshot goal of 100% market share for HPWH by 2030 can bring many benefits—less pollution from fossil fuel combustion appliances, lowered climate risks, and workforce development opportunities with higher wage job creation for installers and other workers along the supply

[3] 2020 Energy Star Shipment Report

chain. While we recognize the small market share for HPWHs today, we also know that all water heaters currently in use will need to be replaced by 2035 (based on the current lifespan of conventional technologies), which presents a tremendous and time urgent opportunity to shift the market toward cleaner, more energy efficient HPWHs.

Appendix A: Key Activities Looking for Broader Collaboration, Coordination and Support

In 2021, AWHI identified several potential collaboration and funding opportunities that provide specific benefits at the regional, state, city, and utility level and present solutions to addressing upcoming emissions reductions mandates. Starting in 2024-2025, several jurisdictions will face potential fines for not meeting efficiency/emissions requirements/standards. Through partnership, AWHI can support regional efforts by working in the following areas immediately. The priority projects below were scoped and are awaiting funding in 2022 or are in operation and can be easily customized for use in other markets. Partnership and support are actively being sought include:

Residential Market Engagement and Workforce Development

HOMEBUILDER ENGAGEMENT

Engage with homebuilders to encourage HPWH adoption as a standard solution for new construction and pilot approaches to persuade more builders to include HPWHs in their standard home designs.

INSTALLER EDUCATION AND LICENSING

Develop clear, concise, and repeatable standards and guides for installation and operation of residential HPWHs, serving as a Roadmap for the majority of installation scenarios. The project will comprise a variety of training assets developed by manufacturers and other industry experts, as well as a process to select, train, and retain installation contractors. It will be complete in 2022 and deliver first draft consensus-based training materials for installers.

CONSUMER MARKETING AND EDUCATIONAL CAMPAIGN

Increase HPWH sales and installations by applying a local, customized education and marketing approach to consumers, in coordination with key market actors, to address barriers and facilitate consumer demand and adoption. By summer 2022 the project aims to deliver a marketing toolkit to include consumer research, best practices for marketing/media mix and templated marketing/media materials. These will be developed by ENERGY STAR based on learnings from the field. Regions targeted for pilot deployment include NE, SE, and MW.

Residential Programs and Research Projects

PROGRAM-IN-A-BOX OR PLAYBOOK FOR PROGRAMS

Create package, focused on midstream incentive program design, the provides consistency in approach and procurement. It is intended to combine multiple deliverables needed for residential deployment—RFP templates, data collection tools, and other needed documents—into one package that is 80% standardized and 20% customizable to meet unique market needs of a range of utilities.

240V EMERGENCY REPLACEMENT PILOT

Make HPWHs the first choice offering of plumbers for customers who need emergency replacement of their electric or gas water heater. AWHI is scoping a comprehensive proposal for an emergency replacement pilot program that can be replicated across the country that could be adopted by one or more utilities.

STANDARDIZED PROGRAM DATA COLLECTION AND USE CASES

Develop data use cases and guidance documents that will allow utilities and others to collect standardized technical and customer data from their programs that can then be shared and analyzed to gain insights into which program approaches and devices are working best, and why. By August 2022, the project aims to create a consensus document that describes use cases, a data dictionary, data collection, and QC protocols.

120V FIELD STUDY

The 120-volt HPWH represents an ideal solution for retrofit applications to replace existing gas-fired tank type water heaters and is expected to be well suited to smaller homes or manufactured homes with lower hot water demand. The 120V HPWH is also ideal for applications where overall amp usage may be a concern, as this product is associated with a lower “amp diet”. The first field study of this emerging technology has been launched in California: https://www.advancedwaterheatinginitiative.org/120v-field-study. We are looking to launch 120V field study and market readiness effort for cold climate applications in Midwest starting 2023.

RESIDENTIAL WATER HEATER COMPARISON TOOL

Adopt an existing consumer- and installer-facing calculation tool to compare HPWHs with other traditional water heater types (gas tank and tankless, electric resistance and propane/fuel oil), on criteria of emissions, energy and operational cost, and utility rate structures (tiered and time-of-use). The calculator framework has been created for Southern California Edison and can be leveraged to expand to other regions, including customization for consumers with relevant demand and draw profiles, emission savings and rate structures.

Commercial/Multifamily Research Development and Deployment

PACKAGED SOLUTIONS FOR HIGH-RISE BUILDINGS AND RETROFITS

Develop a central HPWH system with capabilities to meet high-rise building stock requirements. It will produce a design with integrated controls that allow for redundancy while minimizing electrical service requirements and mitigating the need to upsize electrical feeders. It will develop small form-factor options for retrofitting existing buildings that require equipment to fit through tight spaces and use a Technology Innovation Model to ensure hot-water solutions meet the AWHS 8.0 requirements and will be ready for inclusion on the QPL.

ECOSIZER AND ECOSIM UPDATES

Ecosizer and Ecosim are open-source system sizing and energy modeling tools. These tools are the basis for a simplified utility uniform energy savings measure and incentive offerings. Currently, the tools only size and model single-pass central HPWH systems in multifamily applications. As new configurations are developed for additional building stock, these two tools will require upgrades. The tools will provide right-sized reliable and repeatable systems with predictable performance results. The standardized sizing and modeling will allow for faster, more affordable, and less risky adoption in the marketplace.

COMMERCIAL ADVANCED WATER HEATER SPECIFICATION AND QUALIFIED PRODUCTS LIST

Development and maintenance of a Commercial Advanced Water Heater Specification and Qualified Products List including complete AWHS, manufacturer interface, and modeling framework to create QPL that can be the basis for prescriptive utility program support for CHPWH systems.

FIELD VALIDATION

Support for demonstration and M&V of products on the Commercial QPL to validate predicted performance and provide feedback for product improvements, AWHS adjustments and validation of modeling assumptions.

DEMAND RESPONSE/LOAD SHIFTING

Support for testing, demonstration, optimization, and standardization of demand response and load shifting capabilities for commercial systems. Development of test method and modeling methodology to predict available load shift resource depending on heat pump and storage sizing, piping configuration, control capabilities, and back-up system operations.

Commercial/Multifamily Market Engagement and Workforce Development

RETURN-ON-INVESTMENT (ROI) CALCULATOR FOR PROPERTY OWNERS

New York City's forthcoming GHG emissions regulations present a unique challenge for property owners. AWHI is developing a set of resources to help property owners and developers calculate costs and benefits for their projects and understand the impact on their investments. These resources, including an interactive calculator, communication materials, and training, can be customized for regional markets.

NEW YORK/NORTHEAST COMMERCIAL MARKET ENGAGEMENT AND DEVELOPMENT

This effort involves engaging market actors in the commercial/multifamily market to build awareness, capability, and partnerships necessary to rapidly scale commercial HPWH technology. Beginning with identifying and connecting with select manufacturer representatives, distributors, property owners, developers, engineers, and contractors, AWHI will gather intelligence on local market barriers and perceptions, develop market-specific messaging and communications materials. This material will be used to recruit partners for demonstration projects and connect professionals with educational resources. As products become more widely available, engagement will broaden with goals for increasing demand among property owners and expanding workforce education and accreditation for engineers and contractors.

CENTRAL HPWH SYSTEM INTERACTIVE TOUR

Virtual, interactive tours are an innovative way to engage modern learners. These resources allow engineers, code officials, and contractors to see CHPWH systems installed in real applications, watch interviews with experts involved in the project, and study site plans and other materials for the site. AWHI has developed these resources for low-rise multifamily buildings and similar commercial applications and can improve the effectiveness of engagement and education in the New York market with virtual tours that address the unique challenges of high-rise buildings.

TRAINING PLAYBOOKS

Develop regional training curricula and resources based on unique regional challenges and solutions. These playbooks will cover installations in new buildings and retrofits and focus on multiple audiences including code officials, installers, and trainers. These resources will be developed working with local partners on demonstration projects from concept to completion, documenting the process, and continuing to collect project data through the validation period.

Appendix B: Additional Policy Updates

A scan of policy updates that impact the market and requirements for HPWHs from across the country.

NATIONAL

- In 2021, DOE launched the E3 Initiative which is focused on better energy, emissions and equity outcomes and seeks to engage stakeholders on increasing heat pump adoption, including HPWHs.
- The EPA ENERGY STAR Residential Water Heaters Specification DRAFT Version 5.0 proposes to set a high bar for efficiency, making HPWH more attractive to market adoption.
- In December 2021, President Biden signed an Executive Order for Decarbonizing Federal Buildings to lead by example. The federal government will work across existing real property and during new building construction and major renovations to increase water and energy efficiency, reduce waste, electrify systems, and promote sustainable locations for federal facilities to strengthen the vitality and livability of the communities where federal facilities are located.

CALIFORNIA

- 2022 CA Title 24 (part 6)
    - Established code to use HPWH as baseline prescriptive systems for new multifamily construction.
    - Established modifications to TDV that make gas less favorable.
    - Required solar thermal for gas systems.
- California Public Utilities Commission (CPUC)
    - Self-generation Incentive Program (SGIP) Staff proposal.
    - Decision 21-11-002 November 4, 2021: Allows layering of incentives from various programs SGIP, TECH, and wildfire rebuild. Asks IOUs to propose rates for adoption of HPWH and to eliminate any financial disincentive for fuel switching.
- SB1744 Programs in CA becomes operational
    - TECH program primarily focused on retrofits, is offering $1500/apartment for HPWH installations.
    - BUILD program is focused on design assistance and incentives for affordable housing new construction.
- Cities with electrification mandates: https://www.sierraclub.org/articles/2021/07/californias-cities-lead-way-gas-free-future

PACIFIC NORTHWEST

- Seattle requires HPWH in all new commercial construction.
- WA State Building Code Council to require HPWH for 50% of water heating in new commercial buildings by July 2023.

MIDWEST

- In Illinois, the Capitol Development Board released the administrative rules to adopt the 2021 International Energy Conservation Code for commercial and residential buildings in May 2022. The rules will include an amendment to the code that incentivizes commercial buildings to implement grid integrated features such as controls like CTA-2045B which are primarily installed on HPWHs.

NEW YORK

- Climate Leadership and Community Protection Act (Climate Act) sets statewide targets in statute for carbon emission reductions, including sector wide targets for buildings. Subsequent draft of Climate Action Council Scoping Plan includes recommendations for mandates to upgrade and convert to zero emissions heating and hot water systems using residential-sized GSHPs or ASHPs and commercial equipment.
- NY Public Service Commission directed three major gas utilities to discontinue natural gas marketing efforts and promotional programs and provide educational information to customers about alternative heating options and the emission reduction requirements of the Climate Act.
- New York City Intro 1237-a phases in over five years a prohibition on gas-burning equipment for heating and hot water in new construction.
- Ithaca, New York, City Council voted to decarbonize all buildings through electrification by 2030.

Appendix C: Technology Landscape and Industry Status

This appendix summarizes the findings of a market scan for HPWs available in the market well as products that are in development as of February 2022. These include some international products not yet available in North America. Before reviewing the traditional product specifications, it is important to understand two additional aspects of HPWHs: grid connectivity/controls and refrigerants used. Context on these aspects of the equipment is below.

Grid Connectivity and Controls

HPWHs that have demand management controls are rapidly becoming more available. Demand management standards (JA13 in T24) and regulations throughout the West Coast require universal CTA-2045 communications port (hardware) on the water heaters. ANSI standard CTA-2045 specifies a standard socket (port) and communications protocol that water heater manufacturers can include on their products. In 2021, the AWHI Connectivity and Controls WG developed the EcoPort brand for easier communication to customers and installers who seek to purchase appliances that comply with the CTA-2045 standard.

Refrigerant Status

HPWHs rely on refrigerants to transfer heat and achieve their high energy efficiencies. Hydrofluorocarbons (HFCs), today's "third-generation" refrigerants, are the predominant type in HPWHs. Unlike first- and second-generation chlorofluorocarbon (CFC and HCFC) refrigerants, HFCs do not deplete the ozone. Yet they remain a potent greenhouse gas, if released. Refrigerants are measured by their GWP, and the emergence of natural refrigerants with little to no GWP is a critical path for heat pumps of all kinds. Relevant factors regarding refrigerants are noted below.

- Refrigerants with a GWP value of less than 150 GWP have a 'low-GWP' rating whereas refrigerants with a GWP value >150 but <750 GWP are considered 'mid-GWP.' Natural refrigerants such as propane, CO_2, and ammonia (NH3), fall into the low-GWP category.
- Currently most HPWHs that are on the market are using high GWP (>750) to mid-GWP (750-150) refrigerants in their systems with few exceptions. The common refrigerant 134A has a very high GWP of 1430, while refrigerant 513a has a GWP of 631.

The table at right summarizes the GWP category for the refrigerants used by the HPWH models described in this report.

Refrigerant	GWP Category
CO_2	Low
NH_3	Low
513A	Mid
134A	High
410A	High

TABLE C-1 GWP CATEGORIES FOR REFRIGERANTS

Residential HPWHs

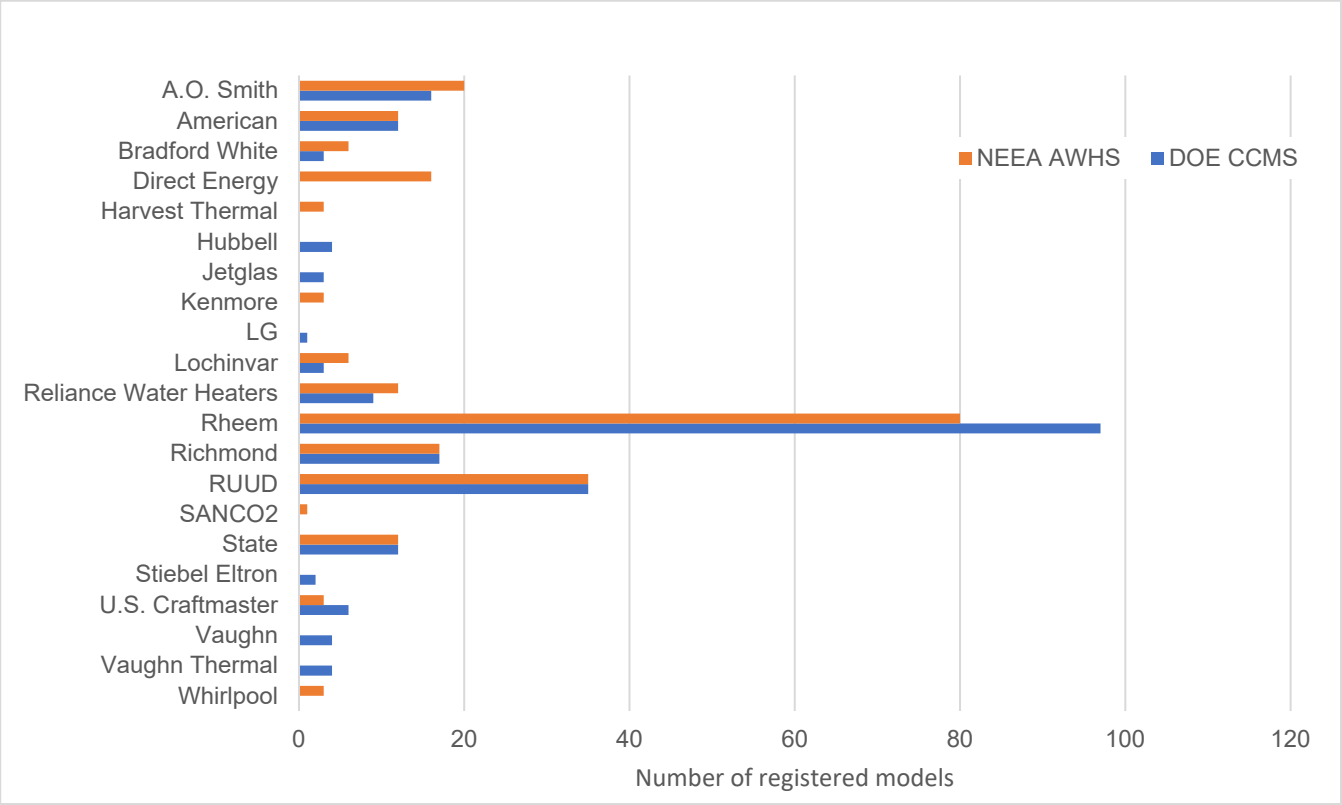
As defined by DOE, an air-source heat pump water heater uses electricity to pull heat from the surrounding air and transfers it—at a higher temperature—to heat water in a storage tank[4]. For the purposes of this document, residential HPWH are defined as water heaters with a storage volume less than 119 gallons and less than 6 kW. Residential HPWHs can be either packaged units or split systems. Packaged HPWHs are stand-alone systems that are integrated with built-in elements like water storage tank, condenser, and back-up resistance heating elements (where applicable). These HPWHs can be purchased at home improvement retail establishments or from distribution channels. Split systems have an outside compressor unit and interior storage tank, and it takes its heat from outdoor air rather than indoor air. Split heat pumps are typically installed by skilled construction trades.

[4] Heat Pump Water Heaters | Department of Energy

240V TECHNOLOGY

240V heat pump water heaters are a decades old technology and are widely available and accepted in the market today. Between the DOE Compliance Certification Management System (CCMS) and NEEA's Advanced Water Heater Specification Qualified Products List, there are 21 unique brands of HPWHs with more than 225 models available in the market currently. The chart below shows the number of models registered on each list.

FIGURE C-1: NUMBER OF HPWHS INCLUDED WITH NEEA QPL AND DOE DATABASE



NEEA's Qualified Products List tracks the qualification date of each model. The chart below shows the growth since 2016, broken into Uniform Energy Factor (UEF) ranges. The Qualified Product List started with 49 products in 2016 and has over 225 products listed today.

FIGURE C-2: CUMULATIVE GROWTH OF QUALIFIED PRODUCTS (SOURCE: NEEA)

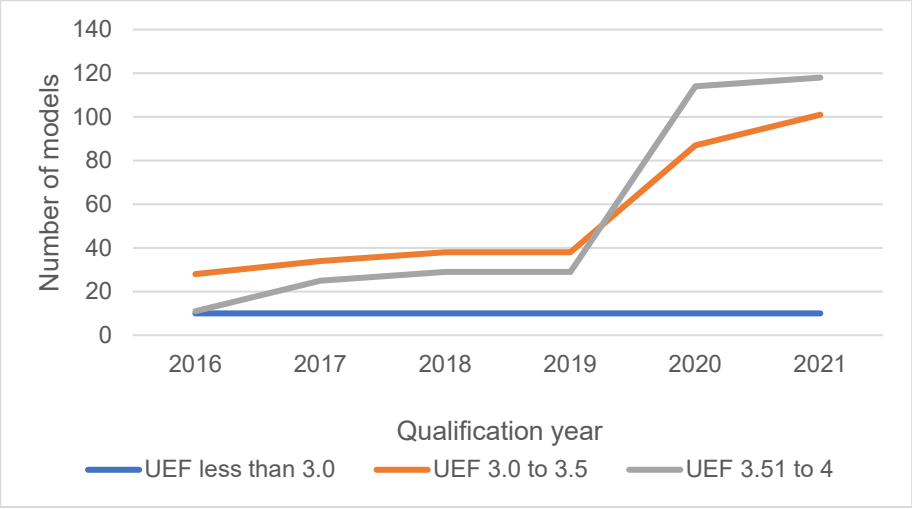


TABLE C-2: SUMMARY OF 240V HPWH FROM MAJOR MANUFACTURERS AVAILABLE IN THE U.S.

Manufacturer	Gallons	Grid Connectivity/ CTA2045 Port	Refrigerant	Type
A.O. Smith	50, 66, 80	Available on certain models	134A	Packaged system, Hybrid (electric resistance backup)
Bradford White	50, 65, 80	Available on certain models	134A	Packaged system, Hybrid (electric resistance backup)
ECO_2 Systems (split system)	43, 83, 119	Available on certain models	CO_2	Split system, Hybrid (electric resistance backup)
Rheem	50, 65, 80	Available on certain models	134A	Packaged system, Hybrid (electric resistance backup)
Stiebel Eltron	58, 80	Available on certain models	134A	Heat pump

120V HPWH TECHNOLOGY

The plug-in 120V unitary HPWH is an emerging technology in development by four manufacturers. These products would eliminate expensive panel upgrades and/or home rewiring and offers an ideal solution for retrofit applications to replace existing gas-fired tank type water heaters and well-suited for smaller homes with lower hot water demand.

NBI is facilitating a 120V HPWH Field Study to independently verify the field performance of this emerging technology. The study will gauge energy performance, installer acceptance, and user satisfaction to advance market commercialization, policy adoption, and program promotion. Manufacturers working to develop 120V units are actively participating in the study. While most of the models are 15-amp shared circuit models, Rheem is also offering a dedicated circuit model designed for houses built in last 15-20 years, which typically have better wiring and panel capacity to accommodate these units. All units will have a CTA2045 Port (branded as Eco-Port) to enable connectivity, and one manufacturer is developing a low-GWP offering as shown in the table below.

TABLE C-3: SUMMARY OF MANUFACTURES AND MODELS DEVELOPING 120V HPWH FOR THE U.S.

Manufacturer	Gallons	Electrical Features	CTA2045 Port	Refrigerant	Market Availability Status	Type
A.O. Smith	40, 50, 66, 80	Shared circuit-120V/ 1 PH, 15A breaker size	Y	TBD	Expected 2022	Unitary
GE	50, 65, 80	Shared circuit-120/110VAC 15A, 60 Hz	Y	134A	Expected 2023	Unitary
Nyle E8 (split system)	50, 80	Shared circuit-120V/ 1 PH, 15A breaker size	Y	R513A (Low-GWP)	Available	Split, packaged
Rheem	40, 50	Dedicated circuit-120V/ 1 PH, 15A breaker size	Y	134A	Dedicated circuit model: expected early 2022	Unitary
	40, 50, 65, 80	Shared circuit-120V/ 1 PH, 15 Amp breaker size	Y	134A	Shared circuit model: expected early 2022	Unitary

Commercial HPWHs

Central heat pump water heater systems designed to serve a multifamily or commercial load (typically with more than 120 gallons of storage volume) are available in the market. The table below provides a summary of available equipment. In 2021, the AWHI Commercial WG worked to promote packaged, skid-mounted, "plug-and-play" solutions to increase the ease of market adoption. These solutions streamline the design process by housing all the key components of the system in one package, thus decreasing complexity and cost. Key forthcoming "plug-and-play" packaged products that utilize heat pump water heaters are noted in the table below.

TABLE C-4: CENTRAL HEAT PUMP WATER SYSTEMS AVAILABLE IN THE MARKET

Manufacturer	Grid Connectivity/ CTA2045 Port	Refrigerant	Market Availability Status	Packaged (skid mounted) option?
Small Planet Supply SANCO2	Y	CO_2	Available now	Water Drop; under development
Nyle E60, E360	Y	R513A	Expected Q2 2022	-
Colmac CxV, CxA **Series**	-	134A, 410A	Available now	-
Mitsubishi Heat2o	Y	CO_2	Available now	Origin by Steffes; Expected 2022

International Technologies Profile

In addition to the U.S. manufacturers, there are several international HPWH manufacturers that are planning to enter the U.S. market. The interested international manufacturers are including but not limited to Ariston Thermo (recognized as HTP in international market), Daikin (recognized as Altherma in the international market), and LG. The table below lists the international products and the countries where they are offered.

TABLE C-5: INTERNATIONAL MANUFACTURERS AND AREAS OF PRODUCT AVAILABILITY

Technology Type	Manufacturers (Region Served)
240V CO2 heat pump water heater (Sanden Ecocute products)	Daikin, Mayekawa, Hitachi, Mitsubishi, Sanyo, Panasonic (Japan)
120V split system HPWH	Nulite, OSB (China)
120V unitary HPWH	Ariston (Italy), Nyle (USA), Haier (China)
240V wall mounted heat pump water heater	LG (Korea), AO Smith (USA)
Large compressor/small tank HPWH	Mitsubishi, Panasonic (Japan), Danfoss (Denmark)
Central HPWH	Sanden (USA), Mitsubishi (Japan)
Combined space and water heat pump	LG (Korea), Clivet (Italy), Factory Zero (Netherlands)
Combine space and water heating, Natural refrigerant (propane, CO2, etc.) HPWH	Alpha Innotec, Heliotherm, NIBE, Roth GmbH, Wolf GmbH, Vaillant (Germany), Denso (Netherlands), Hotjet (Czech), Enex, Enerblue (Italy), Daikin (Japan)

Additional Product Details

The tables below provide additional details about the HPWHs currently available in the market from AWHI manufacturing partners.

240V TECHNOLOGY

These unitary HPWHs are a factory-made assembly with all major components housed in one package. This typically includes an evaporator or cooling coil, compressor(s), and condenser. The units in the table below are designed for 240V electrical service.

TABLE C-6: AVAILABLE 240V HPWH PRODUCTS

Manufacturer	**A.O. Smith**	**Bradford White**	**Rheem**
Product Image			
U.S / International	U.S.	U.S.	U.S.
Model Line	Voltex Hybrid	AeroTherm	Prestige ProTerra Hybrid
Type (HPWH vs. Hybrid)	Hybrid	Hybrid	Hybrid
Sector (SF/MF)	SF/MF in-unit	SF/MF in-unit	SF/MF in-unit
Gallons	50, 66, 80	50, 65, 80	50, 65, 80
Uniform Energy Factor (UEF)	3.35 (FPTU) 3.45 (HPTU)	3.39-3.48	3.55-3.70
Grid Connectivity	Y	Y	Y
Voltage (V)	208/240	208/240	208/240
Max Amps (A)	30	30	30
Power (W)	4500	4500	4500
Refrigerant	R134A	R134A	R134A
Ambient Operating Range (° F)	45 to 109° F	35 to 120° F	37 to 145° F
Notes	Subsidiaries of A.O. Smith, including Lochinvar, offer HPWH models under a different name	Other brand names on the market may include Jetglas	Other brand names on the market may include Ruud

120V TECHNOLOGY

These unitary HPWHs are a factory-made assembly with all major components housed in one package. This typically includes an evaporator or cooling coil, compressor(s), and condenser. The units in the table below are specifically designed to plug into a standard 120V wall outlet.

TABLE C-7: AVAILABLE 120V HPWH PRODUCTS

Manufacturer	A.O. Smith	GE	Nyle	Rheem
Product Image				
U.S / International	U.S.	U.S.	U.S.	U.S.
Model Line	TBD	GeoSpring	E8	ProTerra Plugin
Type (HPWH vs. Hybrid)	HPWH	HPWH with hybrid backup	HPWH	HPWH
Sector (SF/MF)	SF/MF in-unit	SF/MF in-unit	SF/MF in-unit	SF/MF in-unit
Gallons	40, 50, 66, 80	50, 65, 80	50, 80, 119	40, 50, 65, 80
Grid Connectivity	Y	Y	Y	Y
Voltage (V)	120V (shared circuit)	120V (shared circuit)	120V (shared circuit)	120V (shared circuit and dedicated circuit)
Max Amps (A)	15	15	15	15
Power (W)	900	850	900	900
Refrigerant	TBD	R134A	R513A	R134A
Ambient Operating Range (°F)	TBD	35 to 120° F	38 to 120° F	Dedicated circuit: 45 to 140° F Shared circuit: 37 to 145° F
Notes	Market launch anticipated in 2022	Market launch anticipated in 2023	Currently available in market	Market launch anticipated in Q1 2022

CENTRAL/COMMERCIAL TECHNOLOGY

These systems include one large (commercial) unit, such as an air-to-water heat pump (also called a reverse-cycle chiller) that serves multiple loads (e.g., apartments) through a hot water distribution system. For these systems, the heat pump component and storage tank are provided in separate assemblies.

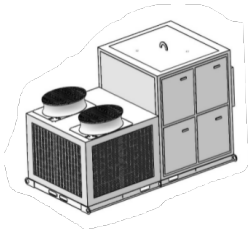
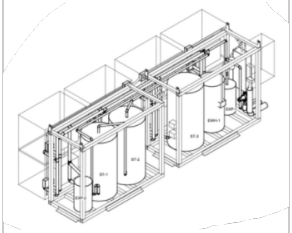
TABLE C-8: AVAILABLE CENTRAL/COMMERCIAL SYSTEMS

Manufacturer	A.O. Smith	Colmac	Mitsubishi	Nyle	Rheem	ECO2 Systems (Sanden)
Product Image						
U.S / International	U.S.	U.S.	U.S., International	U.S.	U.S.	U.S.
Model Line	CAHP	CxA Series	Heat2o	C-Series	HPHD	$SANCO_2$
Type	Commercial HPWH	Air-source heat pump (combo space heating and DHW)	Commercial HPWH	Commercial HPWH	Commercial HPWH	Split HPWH
Sector (SF/MF)	MF	MF	MF	MF	MF	SF/MF
Accompanying tank (gallons)	119	N/A	N/A	Up to 2,500	Up to 940	43, 83, 119
COP	Up to 4.2	Varies by size	Up to 4.11	Varies by size	Varies by size	Up to 5.5
Grid Connectivity	N	Y	Y	BACnet add-on	BACnet add-on	Y
Voltage (V)	208/240	208/230	208/230	208/230	208/240	208/230
Refrigerant	R134A	R134A	CO_2	R134A	R134A	CO_2
Ambient Operating Range (° F)	40 to 110° F	23 to 110° F	-13 to 110° F	25 to 110° F	40 to 104° F	-20 to 110° F
Notes		CxV low-temp model also available, as well as CxW waster-source line		Launch of new E-Series (low GWP refrigerant) expected in Q2 2022		

SKID-MOUNTED "PLUG-AND-PLAY" CENTRAL/COMMERCIAL

Two systems currently off multi-component assembly mounted on a skid for delivery and installation.

TABLE C-9: AVAILABLE SKID-MOUNTED CENTRAL/COMMERCIAL SYSTEMS

Manufacturer	Steffes	Small Planet Supply
Product Image		
U.S / International	U.S.	U.S.
Model Line	Origin	Water Drop
Heat Pump Used	Mitsubishi Heat2o	ECO2 Systems SANCO$_2$
Type	Skid-mounted HPWH	Skid-mounted HPWH
Sector (SF/MF)	MF	MF
Refrigerant	CO_2	CO_2

All product images courtesy of manufacturers websites and specification sheets.

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