Pacific Northwest
NATIONAL LABORATORY

PNNL-38750

Scaling Up: Demonstrating Risk Reduction and Cost Compression for Commercial Heat Pump Water Heaters (CRADA 625)

December 2025

Cejudo C.

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

NOTICE

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Pacific Northwest National Laboratory
Richland, Washington 99354

Cooperative Research and Development Agreement (CRADA) Final Report

Report Date:

In accordance with Requirements set forth in the terms of the CRADA, this document is the CRADA Final Report, including a list of Subject Inventions, to be provided to PNNL Information Release who will forward to the Department of Energy (DOE) Office of Scientific and Technical Information as part of the commitment to the public to demonstrate results of federally funded research. PNNL acknowledges that the CRADA parties have been involved in the preparation of the report or reviewed the report.

Parties to the Agreement:

D+R International, Ltd. (hereinafter "Participant #1, Prime Recipient"),

Ecotope, Inc. (hereinafter "Participant #2, Subrecipient"), and

Northeast Energy Efficiency Partnerships (NEEP) (hereinafter "Participant #3, Subrecipient"),

CRADA number: PNNL CRADA 625

CRADA Title: Scaling Up: Demonstrating Risk Reduction and Cost Compression for Commercial Heat Pump Water Heaters

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Sponsoring DOE Program Office(s): Building Technologies Office

Joint Work Statement Funding Table showing DOE funding commitment:

	Funding Amounts 4/01/2024 - 11/30/2025			
CRADA Parties	**DOE Funding**	**Funds-In**	***In-kind**	**Total**
D+R International	$ 165,624.14	$0	$0	$165,624.14
Ecotope, Inc.	$0	$ 79,200.00	$0	$ 79,200.00
NEEP	$ 287,923.89	$0	$0	$287,923.89
DOE Funding to PNNL	$520,000.00	N/A	N/A	$520,000
Total of all Contributions	$973,548.03	$79,200.00	$0	$1,052,748.03

Provide a list of publications, conference papers, or other public releases of results, developed under this CRADA:

Cejudo C. 2024. Scaling Up: Demonstrating Risk Reduction and Cost Compression for Commercial Heat Pump Water Heaters - CRADA 625 (Abstract). PNNL-35907. Richland, WA: Pacific Northwest National Laboratory.04/23/2024

Valoria C.R., and T. O'Neill. 2024. Measurement and Verification (M&V) plan: DOE benefit project—Scaling Up. PNNL-37207. Richland, WA: Pacific Northwest National Laboratory.

Provide a detailed list of all subject inventions, to include patent applications, copyrights, and trademarks:

No subject inventions were generated under this CRADA.

Acronyms

AWHS	Advanced Water Heating Specification
BPA	Bonneville Power Administration
BTU	British thermal unit
CBP	Community Benefits Plan
CHPWH	Commercial Heat Pump Water Heater
CO2	carbon dioxide
COP	coefficient of performance
CRADA	Cooperative Research and Development Agreement
DEI	Diversity Equity and Inclusion
DHW	Domestic Hot Water
DOE	Department of Energy
LADWP	Los Angeles Department of Water and Power
M&V	Measurement and Verification
NEEA	Northwest Energy Efficiency Alliance
NEEP	Northeast Energy Efficiency Partnerships
PMP	Project Management Plan
PNNL	Pacific Northwest National Laboratory
QPL	Qualified Products List
SWH	Service Water Heating
SysCOP	System Coefficient of Performance

Executive Summary of CRADA Work

Commercial heat pump water heater (CHPWH) systems can significantly improve the energy efficiency of service water heating (SWH), aka domestic hot water (DHW), in commercial and multifamily buildings but have not yet achieved broad market acceptance due to pricing, complexity, and perceived risk factors. The goal of this project – *Scaling Up: Demonstrating Risk Reduction and Cost Compression for Commercial HPWHs* (Scaling Up) – was to demonstrate and validate a holistic systems approach for CHPWHs that de-risks the technology, creating a reliable, cost-effective, and repeatable approach to CHPWH implementation.

The objectives of the project included the following tasks:

- Recruit and install CHPWH systems in six multifamily sites
- Monitor and gather data with full occupancy through seasonal changes in multiple climate regions
- Compare the actual performance data to the predicted performance from the Northwest Energy Efficiency Alliance (NEEA) Commercial HPWH Qualified Products List (QPL) and the energy simulation tool
- Document the process visually from concept to completion for training

Additionally, market research was to be conducted into existing CHPWH programs and training to identify opportunities for improvement. The primary target regions for demonstration project recruitment and market research were New York/Northeast, California, and the Pacific Northwest.

The expected outcomes were twofold: 1) validation of the research team's efficiency prediction, load shapes, thermal storage, and temperature maintenance and 2) validation that the packaged system approach for delivering CHPWH systems supports faster, less expensive, and more reliable field installations.

Although the project was placed on hold in late January 2025, one multifamily site in California was able to continue with the measurement and verification (M&V) equipment installation and commissioning. DOE approved PNNL's participation as part of the CRADA project, which took place with Ecotope's project engineer in April 2025. In early November 2025 PNNL collaborated with Ecotope to analyze the available data to validate the system's performance. A summary of key findings is included in this report. A more detailed technical analysis will be provided in the future under a separate project.

Summary of Research Results

The project was initiated on April 1, 2024, and entered into Budget Period 1 with the following tasks:

1. Project Management and Reporting
2. Demonstration Project Finalization
3. Measurement & Verification Plan
4. Market Research
5. Installation & Commissioning
6. Measurement & Verification
7. Case Studies

On January 27, 2025, D+R International received the *Memorandum for all DOE Funding Agreements or Awards* from Sara Wilson, Acting Head of Contracting Activity, U.S. Department of Energy to "Cease all activities associated with DEI and CBP" as part of the Executive Order entitled *Ending Radical and Wasteful Government DEI Programs and Preferencing*. Due to the possible interpretation that all planned activities on Scaling Up were impacted, D+R International directed their project team and subrecipients to cease all activities until clarification was received from DOE. Contracting Officer. Accordingly, the project work was placed on hold starting January 28, 2025. Repeated requests for clarification were sent to the DOE over several months with no clear guidance as to whether or when project work could resume.

Without a timeline or certainty as to when the project would resume, the Scaling Up project was mutually terminated between the DOE and the Prime, D+R International on November 30, 2025. At the time of notification completed project activities included the following:

- Recruitment of 4 sites
- Development of a Measurement & Verification Plan (M&V), including data pipeline setup and testing
- Development of a Market Research report
- M&V equipment procurement for Site 1: Casa Panorama
- Coordination and site visit to observe Installation and Commissioning of Site 1: Casa Panorama
- Development and testing of M&V data pipeline between Ecotope and PNNL.

Project Team

The project team brought deep experience in CHPWH technology and market development. Ecotope led the engineering and engagement with manufacturers. Pacific Northwest National Laboratory (PNNL) led field validation design; data collection and analysis; and reporting. Northeast Energy Efficiency Partnerships (NEEP) advised on cold climate efficiency. Bonneville Power Administration (BPA) was a strategic advisor to this project, and nationally as commercial lead on the Advanced Water Heating Initiative on market acceleration. Northwest Energy Efficiency Alliance (NEEA) led specification development and QPL development, and market uptake identification. D+R International provided project management, market research, and training expertise.

Project Management and Reporting

General project management included meetings, oversight, and periodic reporting. This continued throughout the project, starting with the project kickoff meeting with the DOE team. An internal work breakdown structure was developed, and an internal communication plan was established with planned quarterly progress meetings with the DOE, quarterly meetings with stakeholders, and at least monthly team meetings with agendas set and managed by D+R. The team implemented a repository for shared documents and collaboration. The ongoing tracking and monitoring of the project included financial management, risk management, change management, and quality control. Quarterly reporting was provided to DOE, and the Project Management Plan (PMP) was submitted and revised as needed.

As demonstration sites came on board, additional documentation was created and managed, including Memoranda of Understanding, Subrecipient Agreements, Cost Share reports, and Interview Release forms.

This Final Technical Report summarizes the work that was completed under the Scaling Up Award, the challenges encountered, lessons learned, and the conclusions.

Demonstration Site Finalization

This task was to recruit, design, and finalize incentive funding for six demonstration sites in affordable housing, including half that would be cold weather sides. Project partner Ecotope led the recruiting effort which included outreach to building owners, housing authorities, manufacturers, distributors, engineering and design build firms. Members of the project team also made announcements to industry groups, in particular the Advanced Water Heating Initiative and the Commercial Manufacturers Action Council, to spread the recruiting message. Project partner NEEP reached out to Northeast regional stakeholders including Boston Housing Authority, National Grid, Maine Governor's Office of Energy, and Office of Energy, Rhode Island about potential cold-weather sites.

An opportunity assessment was conducted for each potential site. Time was spent coordinating, reviewing, assessing, and determining whether the sites were a good fit for the project in terms of meeting the criteria for building type, system, and product, as well as the construction timeline meshing with the Scaling Up schedule which would require a year of metering.

Project Recruitment

Starting in April 2024, 28 potential sites were considered for inclusion in the study, both retrofit and new construction, across 8 states: WA, OR, CA, MA, NY, WI, IL, and AR. The criteria were: Multifamily affordable housing

- Systems designed in accordance with the Advanced Water Heating Specification
- Products listed on the NEEA Qualified Products List (QPL)
- Four multifamily projects were recruited, and a memorandum of understanding was executed with the building owner for each of the following sites:

Site	Name	Owner	Location	Type	CHPWH System
1	Casa Panorama	Rose Companies	Panorama City, CA	Retrofit	WaterDroplet-9
2	Views at Madison	Bellwether Housing	Seattle, WA	Retrofit	Lochinvar Veritus
3	Bakerview Apartments	Everett Housing Authority	Everett, WA	Retrofit	Mitsubishi HEAT 20
4	First Street Flats	Specialized Real Estate	Rogers, AR	New	Teal

Sites 1, 2, and 3 were warm-weather sites, while Site 4 was a cold-weather site. Additional cold-weather sites were pursued but not confirmed prior to project closure. Onboarding of potential demonstration sites moved more slowly than the team had anticipated, especially with uncertainty surrounding the status of the DOE contract and when/if the project work could resume. To mitigate low recruitment, the team expanded outreach to mixed affordable sites and considered the potential of monitoring previously installed sites. Ultimately, Site 2 withdrew from the study in June 2025, citing DOE uncertainty and delays.

Design Support and 3rd Party Review

The project team conducted third-party reviews for Sites 1, 2, and 3.

Site 1 Casa Panorama was built in 1978 and with 154 affordable senior apartments. Its centralized DHW baseline system was installed in 2018 on the roof with a Colmac heat pump water heater as primary stage, feeding two central storage tanks, and gas boiler backup. The retrofit system consisted of a Droplet 9 heat pump water heater assembly installed in a swing tank configuration. The Droplet 9 is made up of nine SanCO2 heat pumps installed in a pre-manufactured skid assembly. Two AO Smith CHP-120 heat pump water heaters are used in parallel as the “swing tank” to satisfy the recirculation load. Both the Droplet 9 and the AO Smith CHP-120 units use R-744 (carbon dioxide, CO_2) as the refrigerant.

Figure 1. Crane for lifting the CHPWH Equipment onto Casa Panorama roof

Site 2 Views at Madison was built in 2003 with 96 affordable apartments. It had a gas baseline system located in the underground parking garage. The retrofit design included the decommissioning and removal of the existing DHW plant equipment, to be replaced by the electric Lochinvar Veritus CHPWH system.

Site 3 Bakerview Apartments was built in 1968 and had 151 affordable apartments for seniors and people with disabilities. The baseline system with gas boilers was to be demolished and removed, a new was a Mitsubishi HEAT 20 CHPWH system was to be installed.
Site 4 First Street Flats was new construction, market-rate with 121 units completed in 2025. The Teal CHPWH system, which delivered hot water as a service, was located in an amenity building. This site did not receive design support or third party review from the Scaling Up project.

Utility Incentive Funding

Site 1 received incentive funding from the Los Angeles Department of Water and Power Comprehensive Affordable Multifamily Retrofits Program (LADWP CAMR Program). Site 2 received funds from Seattle Office of Housing and Washington Department of Commerce. Snohomish County Public Utility District (SnoPUD) committed funds to Site 3 to support M&V and load shifting. New York State Energy Research and Development Authority (NYSERDA) funding was available for load shifting for potential cold weather sites in New York City, but those sites were not secured prior to project hold.

Measurement & Verification Plan

Project partners from Ecotope and PNNL collaborated and coordinated on the Measurement and Verification Plan, and the development of a data pipeline and data visualization tool.

Design M&V Plan

The Scaling Up M&V Plan described the means and methods for collecting and analyzing Measurement and Verification (M&V) data from the six commercial HPWH demonstration sites that would be associated with the project. The M&V approach had three main objectives:

1. Validate Northwest Energy Efficiency Alliance’s (NEEA) Qualified Products List (QPL) System Coefficient of Performance (SysCOP) calculator – Ecosim using field data from six CHPWH demonstration projects.

2. Collect field data during CHPWH load shift demonstrations. Then use the data to confirm load shifting does not impact hot water delivery and calculated load shift metrics.
3. Confirm correct sizing of installed systems and inform updates to online sizing tool, Ecosizer, as appropriate.

The M&V Plan identified the SysCOP calculation method, required data points, M&V instrumentation, equipment requirements, data acquisition requirements, data pipeline process (including roles and responsibilities), and reporting requirements.

M&V Testing Plan, Construction Documents & Bids

The test plan was written for Site 1 Casa Panorama, though the load shift portion could not be executed due to issues with communication of load shift signals to the system. Funding was not available to support running this effort to ground so load shift testing was not pursued further. M&V system construction documents were produced for Site 1. An installation bid was received, and the equipment was ordered and delivered to the site.

Market Research

The Scaling Up team delivered a report based on market research that identified and investigated gaps in two key areas that pose barriers to CHPWH market acceptance.

Methodology

The team engaged with key market actors to examine the effectiveness of currently implemented programs and training resources through two live surveys and 33 formal interviews conducted between September 2024 and January 2025. Survey and interview participants included manufacturers, distributors and product representatives, tradespeople, energy efficiency program administrators from utilities and state energy offices, specifiers, and property owners. All activities were conducted with the following objectives in mind:

1. Investigate the components of successful CHPWH program design.
2. Assess needs for training materials.

Findings and Recommendations

The research team identified the four main findings and associated recommendations below by analyzing survey and interview results with consideration for the research objectives.

Complex application processes and unclear requirements reduce program engagement

Those involved in the application process often find it difficult to understand data requirements and performance evaluation criteria, and system operation and performance information provided by manufacturers and specifiers is sometimes inconsistent. The lack of a streamlined approach to evaluation of CHPWH performance often results in applicants using custom project pathways to get project funding.

Recommendations to simplify the application process and increase awareness:

- Build off existing research to establish a general baseline that helps streamline the approach for evaluating CHPWH performance among utilities.
- Facilitate coordination between manufacturers and specifiers to ensure consistent information regarding system operation.
- Create a centralized source for program information, segmented by region or state.

Utility dollars are considered most effective when directed at contractors and end-users

Contractors are deterred from bidding on CHPWH projects due to a lack of knowledge of the systems. Shifting focus to midstream incentives for contractors or distributors could encourage contractors to develop the skills to work on these systems, while also lowering end-user costs, as these market actors typically pass savings downstream. Additionally, programs that include commissioning and maintenance would help ensure system reliability by providing access to trained contractors and alleviating these costs.

Recommendations to incentivize contractors and end-users:

- Seek additional research opportunities to implement midstream incentives to increase contractor bidding on CHPWH projects and reduce costs for end-users.
- Smaller utilities with finite resources should identify and engage with property owners with known cost reduction goals.
- Investigate ways to incorporate commissioning and maintenance into program design to assure property owners of long-term operational success.

Training approaches are strong at top of supply chain, but gaps appear as training flows downstream

More technical training is needed among engineers and contractors, with untrained and unconfident contractors and specifiers cited as one of the biggest barriers to sales after cost. Training gaps among these groups are widened by incomplete or outdated manufacturer materials. Further downstream, market actors agreed that building owners would benefit from easily digestible, shorter training modules on the basics of a CHPWH system compared to a traditional system. Beyond installation, knowledge of CHPWH technology is highly variable among operations and maintenance personnel, and there is no streamlined process for knowledge transfer to maintenance staff.

Recommendations to strengthen downstream training approaches:

- Seek further opportunities to investigate how to better engage and incentivize engineers and installers to increase their participation in technical training.
- Encourage manufacturers to establish a regular cadence to update their technical content with new or previously missing information and offer support to do so.
- Create straightforward virtual training materials on the key differences between CHPWHs and traditional systems.
- Conduct further research on how to best streamline knowledge transfer to operation and maintenance staff. Engage with manufacturers to develop advanced best practices.

Training in all formats helps fill gaps, though in-person and virtual training serve different purposes

While in-person training is highly preferred among interview participants for increasing technical knowledge, most market actors would take advantage of virtual training to supplement their hands-on learning. However, manufacturers need support in developing effective virtual training. Meanwhile, in-person technical training is less helpful downstream, where training approaches weaken. Virtual learning opportunities can supplement longer technical training, especially for market actors with less demand for technical knowledge like building managers, property owners, and developers.

Recommendations to further develop a multi-prong training approach:

- Continue offering highly technical training in-person for midstream market actors but encourage manufacturers to segment this training into smaller, more engaging groups.

- Develop supplemental virtual training resources for contractors and decision-makers. Compile these into a centralized, accessible repository of shared virtual resources.
- Connect manufacturers and distributors to external training providers or other market actors to support the conversion or development of virtual training modules.

Installation and Commissioning

The CHPWH system at Site 1 Casa Panorama was installed and commissioned in April 2025. Project members from PNNL and Ecotope were on site to provide these services:

1. Commission monitoring equipment to ensure monitoring data accurately represents system operation. This includes verifying temperature and current readings and confirming data flow from the site to Ecotope servers.
2. Validate HPWH plant installation is in alignment with construction documents and controls are functioning as intended. This step helps verify any shortcomings in system efficiency or reliability is a function of installer error. This service is typically provided by a 3rd-party commissioning agent.
3. Witness equipment start-up to ensure equipment is operating as intended by the manufacturer. This includes testing hot water delivery temperature, control setpoints, and alarms.

CHPWH System

The project members reported the following after the site visit. The water heating equipment was installed and started by end of day on April 1, 2025, and no alarms were present. The mixing valve temperature was raised from the minimum setting (~ 95°F) to 128°F on April 2, 2025 after observing low supply water temperature. Trending data shows hot water supply temperature between 123°F and 132°F. The system plumbing installation was generally correct, with minor deviations noted from the drawings. The pipe stands for the system were uninsulated, which could be addressed in the future.

CHPWH system installation issues encountered included the late arrival of the storage tanks, which shifted the schedule back. The switchover also took much longer than expected, and the gas backup system did not work so residents were without hot water for more than 24 hours. Additionally, air was trapped in the piping, with no good way of venting, therefore additional time to address this issue was required. Addressing venting of existing piping in retrofits should be included in future design considerations.

Figure 2. Mechanical Engineer inspecting the front of the Droplet-9 at Casa Panorama

M&V Monitoring System

M&V equipment was installed successfully by an authorized contractor (Carbon Zero) and EcoDash (a monitoring dashboard developed by Ecotope) was configured to accept the data. The compressors were running consistently on SWT-01 and SWT-02, with additional electric resistance engaging when there was usage from the building. When there was no building usage, temperature maintenance heaters were maintaining the load without additional electric resistance. Temperature maintenance heat loss was close to measured heat loss pre-retrofit but increased significantly when the building used hot water. This indicated significant cross-over due to the existing distribution piping. T05 (HPWH outlet temperature) was not present on the Droplet skid. Ecotope mounted sensor 4 (unused, native to Droplet skid) in an empty thermowell on Droplet outlet.

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The project team did a walkthrough of the piping system and confirmed that all correct sensors were installed. There were some issues with the demand response system, which was not communicating and could not send load up or shed signals, so this could not be tested. Additional coordination between the controls manufacturer and the CHPWH manufacturer would be required to address this.

Figure 3. M&V panels at Casa Panorama

Figure 4. Back view of WaterDroplet-9

Measurement & Verification

PNNL and Ecotope collaborated to implement the M&V plan to build a data pipeline tool, which was completed in January 2025 and tested with sample data. The equipment installed at Site 1: Casa Panorama is flowing data to Ecotope's servers and will be transferred to PNNL as part of the project closeout for final analysis. The data pipeline will be discontinued after the final data transfer. However, the data that was collected at Casa Panorama will be imported into the existing Field Validation Partnership database for future analysis.

Key Findings of Casa Panorama M&V Data

Ecotope provided access to the available EcoDash data, which PNNL analyzed for the period of November 1 – 14 2025. PNNL's analysis focused on validating the dataset, reviewing calculation methods, and addressing discrepancies in system measurements. Critical issues identified include the need for minute-level data of the recirculating loop to accurately reflect temperature differences and energy usage, as hourly averages were deemed insufficient for comparison with non-recirculating systems. COP (Coefficient of Performance) validations revealed inconsistencies stemming from improper temperature usage in calculations and database design intended for air-source systems rather than water systems. Discrepancies in temperature readings (e.g., BTU meter measurements consistently being 2°F lower than the thermal well measurements) impacted load calculations and overall accuracy. Collaboration with third-party organizations and refined documentation practices were suggested as necessary next steps to resolve these discrepancies and support further research.

Preliminary analysis attributed these temperature anomalies to "hot water crossover," a common issue in retrofitted multifamily buildings. Crossover occurs when pressure differences between hot and cold-water lines allow leaking mixing valves to channel hot water into cold water lines. While crossover was confirmed to have no significant impact on the COP of the system, it contributed to an increased load on the swing tanks.

Moving forward, focusing on mitigating crossover issues is essential to optimize system performance and energy consumption. Recommendations include investigating methods to modulate return pump flow based on pressure, addressing leaking mixing valves, and exploring heat losses into cold water lines. Advanced monitoring and metering tools could provide better detection and management of inefficiencies caused by crossover, ensuring long-term system sustainability and functionality.

Recommendations

The team provided the following recommendations to optimize the system.
Parallel piping for the storage tanks was installed in reverse return configuration, though caps were not installed at piping manifolds as required by the drawings. This condition could result in uneven water flow through the parallel tanks. The team suggested installing caps per the contract documents.

Insulated pipe hangers were installed on the hydronic plant but not the DHW plant. The team recommended reviewing contract scope to determine whether insulated pipe hangers were specified, and to insulate all DHW piping.

Control sensors were installed in tanks temporarily, it was recommended to install tank temperature sensor installation with properly sized thermowells and conduit.

There were no major leaks, but there was a small drip on the union for the DCW flow meter and a small drip on the isolation ball valve connecting the expansion tank. The team suggested addressing these leaks before pipes were insulated.

Excessive temperature maintenance heat loss and low return water temperature was observed during high building usage, which may be caused by cross-over of cold water into the hot water distribution loop. The team suggested addressing these issues causing excessive electric resistance usage from the temperature maintenance heaters (though noted that this may be outside of current project scope).

The anchor bolts on hot water storage tanks may be smaller than specified; the team suggested to check and verify anchor bolts on primary storage tank are sufficient.

Condensate pipes from SWT-01 and SWT-02 were not piped to drain. Rubber condensate hoses were tucked under SWT-01 and SWT-02. The team suggested routing condensate hoses away from SWT-01 and SWT-02, ideally off the housekeeping pad.

The team noted some deviations from the design drawings, and recommended reviewing those deviations.

The Droplet controls were sufficient to deliver hot water but were not successful in receiving load shift commands. The team recommended working with the manufacturer Small Planet Supply to troubleshoot load shift communication.

Additional Case Studies

To facilitate knowledge transfer from the learnings and key takeaways of the demonstration sites, the Scaling Up team planned to develop concise illustrated two-page case studies and interactive virtual tours for each site. The case study deliverables would summarize the installation, provide a project overview, describe the CHPWH system design, and highlight key findings.

The virtual tours were envisioned as immersive, click-through experiences featuring stakeholder and installer interviews, annotated 360° images of the project site, and embedded interactive views of the CHPWH system equipment, components, and installation site, as shown by the schematic below. Planned activities included interviewing key stakeholders, capturing multimedia assets to help demystify CHPWH systems, and showing data that compared performance before and after the installation of the new system. To support these efforts, detailed asset-capture planners were created to outline the full itinerary for travel to and from site, onsite information gathering, multimedia shot lists, as well as interview schedules and question guides.

Before work ceased, D+R completed only partial asset capture for Site 1. This included five virtual interviews with key stakeholders: the Casa Panorama project manager, the CHPWH manufacturer, a mechanical engineer from Ecotope, the principal from the design build firm, and the project electrician. D+R also received supplemental multimedia assets provided by on-site partners. However, due to the project going on hold, D+R was unable to develop the planned case study or virtual tour for Site 1.

Despite the early termination of the Scaling Up study, valuable information was gained. To maximize the potential for successful CHPWH system installations, providing clear guidance would be very important. The QPL helps guide the delivery process for CHPWH systems, though our observations are that most systems are still being custom engineered (as opposed to fully specified built-up or skid-mounted systems). Utility incentives could be used as a tool to drive designers and building owners towards the latter two delivery methods. Simplified and streamlined incentive application processes would also be important.

There also needs to be more common approaches to system designs, as is suggested in the NEEA AWHS and further emphasized by the system diagrams provided by the QPL.

Contractors need more experience. Their sense is that they are incorporating the risk of the new technologies into their bids, inflating the initial cost of these systems. Expanding training opportunities, especially geared toward engineers and contractors, would help bridge the gap and build confidence in bidding projects realistically.

The one installed site, Casa Panorama, reported considerable value from the engineering oversight that ensured the CHPWH system design was well done, and being able to leverage data from the data acquisition system that allowed the system to be optimized. The study was terminated before validation of efficiency prediction, load shapes, thermal storage, or temperature maintenance could be performed.

Figure 5. Full CHPWH system at Casa Panorama with M&V panels at left

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