

Boring but Efficient: Heat Pump Water Heater Opportunities in Commercial Buildings

Bretnie Eschenbach, Cadeo Group
Geoff Wickes, Northwest Energy Efficiency Alliance
Colleen Collins, Cadeo Group
Sarah Widder, Cadeo Group

ABSTRACT

Utility programs and market transformation efforts have focused heavily on developing the residential heat pump water heater (HPWH) market, but large opportunities also exist for commercial buildings where industry players have greatly advanced the adoption of central and unitary HPWH products. However, the complexity of commercial buildings remains a barrier to adoption because they require more nuanced considerations when selecting, sizing, and installing the right system. While central HPWHs can be a great solution, they are best suited for buildings with specific distribution systems, hot water load and use patterns, and other characteristics. Central HPWHs have many configuration options and design considerations that depend on a building's hot water use. This paper explores the opportunities for HPWH in light commercial applications, which is a gap in existing HPWH initiatives. We will share market research and analysis, manufacturer literature findings, and information from subject matter experts related to the light commercial domestic water heating market.

Introduction

Domestic water heating represents large energy loads in both residential and commercial buildings (NEEA 2018), and many in the energy efficiency industry have been working to increase the use of heat pump water heaters (HPWH) to serve hot water loads. Historically, utility programs and market transformation efforts have focused heavily on developing the residential HPWH market (AWHI 2024), but large opportunities also exist for commercial buildings due to their large hot water loads (NEEA 2018). Industry players have greatly advanced the availability of commercial HPWH products, including a combination of central systems, integrated or unitary systems, and split systems (AWHI 2023). However, the complexity of commercial buildings remains a barrier to adoption because they require more nuanced considerations when selecting, sizing, and installing the right system (Energy Trust of Oregon 2023).

To date, most commercial HPWH product development, research, and resources have focused heavily on central systems (AWHI 2024). While central HPWHs can be a great solution, they are best suited for buildings with specific distribution systems, hot water load and use patterns, and other characteristics (APPA 2022). Central HPWHs have many configuration options and design considerations that depend on a building's hot water use. Simpler light commercial HPWHs, which also come with many sizing and system options, may offer an alternative to complex built-up systems for many commercial buildings with a single, small water heater and lower hot water use requirements.

This paper will summarize a market characterization study the Northwest Energy Efficiency Alliance (NEEA), Bonneville Power Administration (BPA), and Cadeo collaboratively completed in 2023 and 2024 to characterize the residential and commercial water heating market and identify opportunities and gaps for HPWH in the Northwest (Washington, Oregon, Idaho, and Montana).

The market characterization identified different HPWH solutions for different sectors, building types, and applications depending on a number of building characteristics and hot water use patterns (Cadeo 2023).

The market characterization showed that more than 80% of Northwest commercial buildings have a single domestic water heater that is 120 gallons or less, without a recirculation loop, indicating high savings potential for light commercial or residential HPWH (NEEA 2019).

BPA and NEEA, along with others in the HPWH industry, continue to develop the residential HPWH and central HPWH market; however, fewer resources and guidance exist for commercial buildings replacing simple existing water heaters with HPWHs, which includes residential systems in commercial applications. The goal of NEEA, BPA, and Cadeo's research was to investigate and document existing research and market information on opportunities outside of the multifamily, central HPWH market, including market barriers and considerations when selecting, sizing, and installing residential and light commercial HPWH in commercial applications. The market characterization resulted in recommendations for the HPWH industry to pursue as it develops the commercial HPWH market.

This paper will summarize and discuss NEEA, BPA, and Cadeo's 2023 and 2024 market characterization methodologies and the resulting recommendations for future commercial HPWH market development.

Heat Pump Water Heater Terminology

Multiple types of domestic water heating equipment exist in commercial buildings, and terms can mean different things to different people in the industry. For the purposes of this paper, we use the term "central HPWH" to describe a commercial split system or built-up system that would typically replace a central domestic hot water boiler or water heater larger than 120 gallons. The Advanced Water Heating commercial specification says central HPWH products generally have a central plant attached to a circulation system, which is what this paper means when talking about a central system (NEEA 2024a).

When this paper uses the term "light commercial HPWH," it describes either a residential-style water heater less than 120 gallons used in commercial applications or an integrated (or unitary) 120-gallon commercial water heater, typically with a single tank with the heater and storage tank combined. This term could also include 120-gallon split systems that are sold as a single package. A "residential" or light commercial HPWH described in this paper refers to systems that typically do not require extensive design (for both sizing and plumbing distribution) and are selected based on a 1-for-1 replacement of the existing electric or gas water heater.

The following products are included when we use the term light commercial HPWH in this paper:

- Residential HPWHs <120 gallons on NEEA's residential Qualified Products List (QPL) that could be used in commercial applications (NEEA 2024b).
- 120-gallon integrated HPWHs.

- Light duty commercial 40-80-gallon HPWHs.
- Residential or commercial tankless HPWHs in commercial applications.

These terms and their definitions are debatable and potentially confusing because integrated tanks can be banked to create a built-up system, 120 gallons is not always a clear differentiator, and central systems can be integrated; thus, these terms are not mutually exclusive. A range of HPWH types and configurations could be used in commercial applications, including any of the systems shown in Figure 1 (RTF 2022).



Figure 1. HPWH system types.

Methodology

The NEEA, BPA, and Cadeo 2023 and 2024 market characterization included analyzing the Northwest existing water heater market, conducting a market literature review, and holding discussions with HPWH subject matter experts. This section describes the details of these activities.

Market Characterization

We first analyzed NEEA’s Commercial Building Stock Assessment (NEEA 2019), the Energy Information Administration’s Commercial Buildings Energy Consumption Survey (EIA 2018), and DOE’s commercial water heating Technical Support Document (DOE 2022). We used the data to estimate the number of buildings and water heaters in the Northwest, their energy consumption, and the potential energy savings from converting to HPWH by building type or application. The analysis included building type characteristics to help identify

opportunities for different HPWH types in Northwest buildings. The characterization helped identify opportunities and gaps in the commercial sector.

Market Literature Review

We next reviewed commercial HPWH studies, guidance, best practices, and lessons learned focusing on the following information where available:

- How building characteristics, hot water-use patterns, and existing water heater systems inform what type of HPWH is the best solution for a building.
- Sizing guidance and considerations for light commercial systems in commercial buildings.
- Installation recommendations unique to commercial buildings.
- Hot water usage breakdowns by building type.

Subject Matter Expert Discussions

To supplement the market characterization and market literature review, Cadeo held a commercial HPWH focus group and spoke with three additional subject matter experts to review findings, better understand market barriers and gaps, and refine recommendations. The goal of the focus group was to understand the commercial building characteristics best suited for a central HPWH. The focus group also explored the remaining gaps and opportunities for commercial buildings where a central HPWH is not the best solution. The goal of the subject matter expert discussions was to understand commercial building hot water load patterns, sizing practices, and opportunities for light commercial HPWH.

Findings and Recommendations

The market characterization's findings support this paper's following recommendations for the HPWH industry to develop more resources and guidance targeting smaller, simpler commercial water heating systems more appropriate for a single, simple HPWH. The research yielded the following specific recommendations to develop the light commercial HPWH market, described in depth in subsequent sections:

1. The industry should pursue low-hanging opportunities in the commercial sector by developing a targeted strategy for applications best suited for residential and light commercial HPWH.
2. The targeted strategy should include updating existing commercial documents and tools to include light commercial HPWH in literature, updating residential literature to create commercial-specific guidance, and updating commercial system selection tools to include pathways to light commercial products.
3. In parallel with updating existing resources, the industry should pursue additional field and case studies with light commercial HPWH, which include residential products in commercial applications, to demonstrate performance and increase knowledge of commercial hot water loads.

Recommendation: Pursue low-hanging light commercial HPWH opportunities.

The commercial sector offers many opportunities for relatively simple HPWH replacement solutions, identified by targeting commercial buildings equipped with a single, existing water heater (120 gallons or less) without recirculation. Buildings with these characteristics typically do not require extensive design to replace the existing water heater with an HPWH. These units are often packaged solutions that could be sized based on a 1-for-1 replacement and do not require the complex configurations (swing tanks, recirculation, etc.) that a larger central system requires.

Supporting Finding: More than 80% of the existing commercial water heaters in the Northwest could be replaced with a relatively simple residential or light commercial HPWH.

Our analysis of NEEA’s 2019 Commercial Building Stock Assessment (CBSA) indicates that buildings with an existing water heater 120 gallons or less without recirculation represent more than 80% of existing water heaters (NEEA 2019). We have grouped the commercial water heating market into three HPWH solutions:

- **Light Commercial HPWH**, which are best suited for buildings with a single water heater 120 gallons or less without recirculation. It is noteworthy that 76% of water heaters in this category in the Northwest are electric resistance, which presents ideal HPWH opportunities (NEEA 2019).
- **“Grey Areas,”** which could include a combination of characteristics like multiple water heaters or larger single water heaters with or without recirculation. These buildings could utilize either a more complex integrated HPWH (e.g., multiple staged units, etc.) or a less complex central system, but would vary building by building.
- **Central HPWH**, which are best suited for buildings with larger existing water heaters, often multiple water heaters, and typically include a recirculation loop.

These groups are not mutually exclusive; both light commercial and central systems could be used in any building depending on the individual building characteristics and hot water use, but they provide a useful framework for identifying potential target markets.

We recommend the HPWH industry targets buildings with single, ≤120-gallon water heaters that could be suitable for a residential or light commercial HPWH. The industry has had success with the residential HPWH market, targeting simple buildings first and addressing the “grey area” buildings later (NEEA 2024c).

Of the existing water heaters that fall into the light commercial HPWH category, 53% of these units are residential-sized, between 35 and 120 gallons and less than or equal to 12 kW or 75 kBtu, meaning they could be replaced with a residential-style HPWH. These data indicate offices, retail, and mixed commercial, which have a high quantity of existing electric resistance and gas water heaters that could be replaced with a simple residential or light commercial HPWH. These building types also predominantly have small, single tanks, suggesting that a targeted strategy could be successful with limited market confusion.

Supporting Finding: More than 60% of the Northwest commercial water heating load could be met with a simple residential or light commercial HPWH.

Hot water loads are a critical component when identifying target markets. Many of the building types that could utilize a residential or light commercial HPWH have medium-to-low

hot water use (RTF 2023). For example, offices and retail make up the largest number of existing water heaters, but their use per square foot is among the lowest compared to other building types.

Using the 2019 CBSA (NEEA 2019) and the Northwest Power and Conservation Council Regional Technical Forum's (RTF) commercial building hot water use assumptions (RTF 2023), we developed an end-use breakdown of hot water use by building type, shown in Figure 2. The analysis confirms more than 60% of Northwest commercial water usage could be met with a light commercial HPWH.

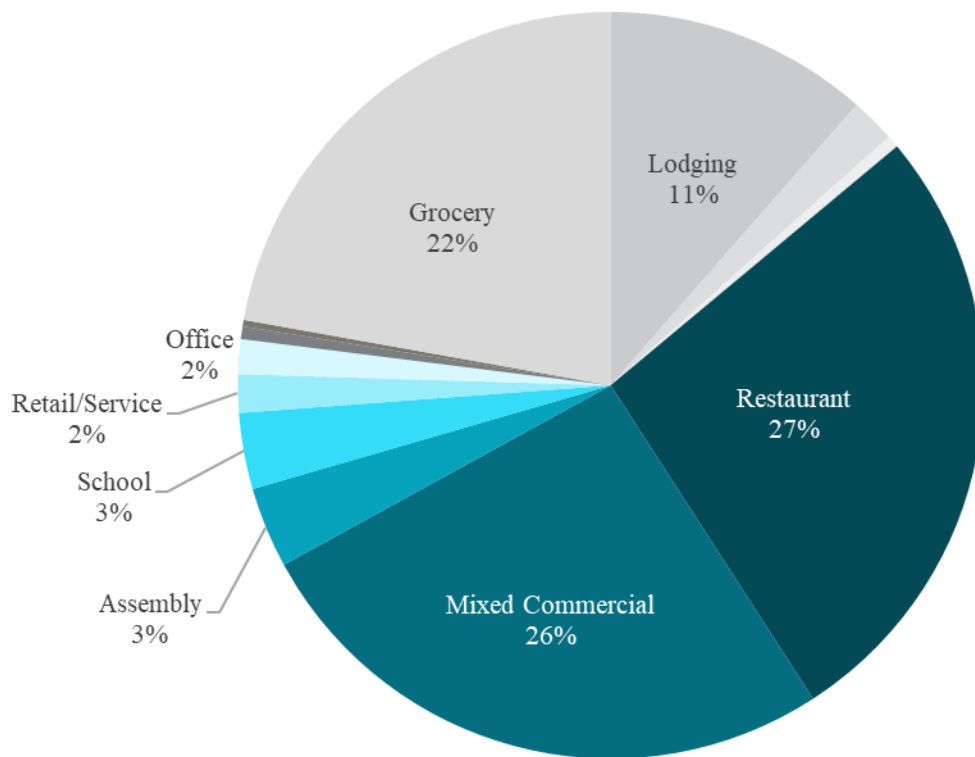


Figure 2: Total regional hot water use (gallons per year) (Cadeo 2023)

Supporting Finding: Few resources exist for installing residential or light commercial HPWH in commercial buildings.

While the HPWH industry has made much progress in developing the central HPWH market, which targets high hot water users, many buildings do not require a large, built-up system and could utilize a smaller, simpler HPWH solution. However, fewer resources exist for these opportunities (AWHI 2024; NEEA 2024c; EPRI 2011; Energy Star 2023).

Our market literature review found extensive studies, tools, and literature specific to residential HPWH and central systems but very few resources for light commercial HPWH (AWHI 2024; NEEA 2024c; EPRI 2011; Energy Star 2023). Guidance that does exist came from manufacturer literature published on their websites, for example:

- AO Smith resources include installation guidance, a sizing tool, and training videos, with a commercial technology system selection tool under development. (AO Smith 2024),
- Rheem's website includes a sizing tool and marketing materials (both for their 120-gallon split system and <120-gallon commercial integrated HPWH) (Rheem 2024),

- Intellihot’s resources include a buying guide (Intellihot 2024a) and a calculator (Intellihot 2024b).

The team did not research manufacturers that make residential HPWH to identify if they market their products for the commercial market; however, this is something that could be explored more in future research.

These manufacturers provide sizing and installation guidance very similar to a residential system or a standard commercial electric water heater. They note design and sizing are similar to a standard tank (i.e., a 120-gallon water heater could be replaced with a 120-gallon HPWH) and can be paired or used modularly with multiple units for larger hot water loads.

Guidance specific to commercial HPWH recommends systems should be located indoors, require a drain for condensate, and must have unrestricted airflow (each manufacturer has specific air space requirements).

These findings support the recommendation to develop a strategy targeting ≤ 120 -gallon residential or light commercial water heaters as a simple HPWH solution for many commercial applications. The next recommendations provide additional detail on what that strategy should include and how to fill the current gaps in the light commercial HPWH market.

Recommendation: Update existing resources to differentiate light commercial HPWH.

One of the barriers noted in commercial HPWH literature was the limited number of unitary products; however, this barrier is specific to 120-gallon units, which AO Smith and Rheem target for restaurants and groceries. Residential-style HPWH can be used in many commercial applications, and NEEA’s QPL includes a range of sizes and manufacturers consumers can choose from (NEEA 2024b). As described in the previous finding, one of the barriers to increasing residential and light commercial HPWH in commercial buildings is the lack of resources specific to these products.

We recommend a commercial HPWH strategy should include updating existing HPWH resources and tools to differentiate light commercial products, including:

- Where residential HPWH resources exist, updating those resources to include the use of residential HPWH in commercial applications. This could include updating buying guidance, sizing recommendations, and installation requirements in residential literature to include commercial-specific information,
- Where commercial HPWH resources exist, including information on light commercial products, in addition to central system resources, to communicate a HPWH solution for the light commercial market. Information could include links to light commercial products, manufacturer sizing and installation guidance, and case studies,
- Differentiating commercial products,
- Updating existing system selection tools to include pathways that lead to both central and non-central HPWH solutions in commercial applications.

Supporting Finding: HPWH resources have opportunities to increase awareness of light commercial HPWH.

The HPWH industry has an opportunity to highlight light commercial HPWH anywhere where HPWHs are discussed, which includes, but is not limited to, the following sites:

- HotWaterSolutionsNW.org
- CHPWH.org
- Advancedwaterheatinginitiative.org
- EnergyStar.gov

Many of these websites focus solely on residential HPWH resources or resources specific to central HPWH. This leaves a gap in where to house information specific to light commercial HPWH, or residential-style HPWH in commercial applications. Websites have an opportunity to include resources on light commercial HPWH, which could include the following resources:

- Program resources, identifying utilities offering incentives on light commercial HPWH (and residential-style HPWH in commercial applications),
- Case studies of light commercial HPWH used in commercial applications to demonstrate performance and increase awareness of how HPWH can meet commercial hot water loads,
- A commercial buyer's guide, leveraging the resources in residential guides but made specific for the commercial sector,
- Links to manufacturer resources, similar to the residential resources that include system selection and sizing tools, sales and marketing information, training, and product spec sheets.

Supporting Finding: Current system selection tools are limited to central HPWH applications (Ecotope 2020; APPA 2022).

Existing system selection tools have limited pathways for HPWH solutions in commercial applications and are not always publicly available. The American Public Power Association developed a tool called the “Existing Multifamily Building Screening Tool,” which provides valuable screening questions to help users identify the best central HPWH configuration for their building, depending on their building's characteristics, but could be expanded in the following ways (APPA 2022):

- Expand beyond multifamily to include all commercial buildings,
- Include additional screening criteria, such as existing tank size and quantity, existing distribution system, temperature requirements, and climate zone,
- Add a pathway that leads to light commercial HPWH. The initial yes/no question currently leads to “no” responses to “challenging install” when it could lead users to a residential or light commercial HPWH,
- Make it public since the existing tool is not available publicly.

Creating this tool could require additional research in order to refine the criteria used in selecting HPWH systems and configurations, which the next recommendation addresses.

Additionally, Ecotope has developed a commercial HPWH sizing tool, EcoSizer, which currently focuses central HPWH, but could be expanded to include light commercial HPWH options (Ecotope 2020).

Recommendation: Engage with HPWH manufacturers to demonstrate commercial HPWH performance.

One of the primary barriers identified to increasing light commercial HPWH is the perception that these products are less proven in commercial applications. Market literature and subject matter experts indicate consumers and contractors have concerns about HPWH being able to meet commercial hot water loads.

The following market engagement activities would help demonstrate HPWH performance and contribute to commercial HPWH tools and resources:

- Conducting field studies with 120-gallon products and with residential HPWH manufacturers to demonstrate residential and light commercial HPWH performance in commercial applications. This research would help prove that HPWHs can meet commercial hot water loads and improve the industry's understanding of commercial hot water use.
- Conducting outreach to residential HPWH manufacturers to discuss their perspective on using residential products in commercial applications. These conversations could help map this market and the major market actors that utilities would need to target in their commercial strategy.
- Creating commercial case studies highlighting residential and light commercial HPWH and featuring these case studies on HPWH websites.

Supporting Finding: Most existing commercial water heating systems are oversized.

The subject matter experts we spoke to said residential and light commercial HPWH could be used in many commercial applications with low concern about meeting hot water loads because most existing commercial water heating systems are oversized. The subject matter experts interviewed said past and current industry design practices and sizing guidance use older hot water use assumptions (higher gallons per minute fixture use than current standards) (IAPMO 2024). This means existing water heaters are oversized for their needs and many simple water heaters (120 gallons or less) could be replaced 1-for-1 with a light commercial HPWH. However, HPWHs inherently have a different capacity than their electric and gas counterparts, so a better, more updated understanding of commercial water heating load profiles is important to understand how to effectively size HPWHs for different applications, considering capacity as well as storage volume.

The subject matter experts thought most commercial applications that currently have a single 120-gallon unit without recirculation would not require this type of design. However, other more complex buildings may require design and sizing considerations beyond a 1-for-1 replacement, like oversizing the storage tank on a split system, installing paired units for higher capacity, or designing for a recirculation loop.

Pursuing the recommended field studies and manufacturer outreach could help demonstrate light commercial HPWHs can meet many commercial loads without complex design and provide valuable evidence for both consumers and contractors.

Supporting Finding: Barriers do exist for light commercial HPWH, primarily space constraints.

Residential and light commercial HPWHs appear to be a good solution for many commercial applications; however, other barriers exist that additional research and outreach

could address. The two primary barriers identified during the market literature review and subject matter expert discussions were commercial space constraints and electrical capacity.

Integrated HPWHs require adequate airflow surrounding the unit to achieve efficiency and capacity performance. Manufacturers include air space requirements in their product literature, and subject matter experts indicate these could be limitations for many commercial buildings (AO Smith 2024; Rheem 2024).

The recommended field studies could help identify how common this barrier is and improve guidance around airflow and space requirements, similar to the work the industry has done regarding easy and challenging installs in the residential market.

Additionally, many commercial buildings have limited electrical panel space for additional loads, so if the HPWH is replacing a gas water heater, electrical capacity could be a barrier. However, analysis of the 2019 CBSA showed 77% of the water heaters ≤ 120 gallons in existing Northwest buildings are electric, which would likely not require an electrical upgrade and present large opportunities for HPWH. Buildings outside of the Northwest may not have these characteristics, so electrical capacity may be a larger barrier in other regions.

Conclusion

As the HPWH industry continues to expand product applications, it will be worth thinking about the commercial market holistically in order to capture the full range of opportunities for HPWH and improved water heating efficiency. Commercial buildings can utilize central HPWH or light commercial HPWH products depending on their hot water use patterns, existing water heaters, and existing distribution systems. The industry should continue to develop central HPWH technology and programs, but also increase the resources available for opportunities best served by less complex light commercial HPWHs.

References

- Advanced Water Heating Initiative. 2023. *Commercial Working Group*.
www.advancedwaterheatinginitiative.org/commercial-working-group.
- Advanced Water Heating Initiative. 2024. *AWHI Resources*.
www.advancedwaterheatinginitiative.org/resources.
- American Public Power Administration. 2022. “APPA-funded study provides heat pump water heater guidebook and calculator tool for public power utilities.”
www.publicpower.org/periodical/article/appa-funded-study-provides-heat-pump-water-heater-guidebook-and-calculator-tool-public-power.
- AO Smith. 2024. www.hotwater.com/products/commercial-heat-pump-heat-pump-integrated-product-line-sg100/cahp-120-100/cahp-120-100.html.
- Cadeo. 2023. “HPWH Market Characterization.” Bonneville Power Administration and Northwest Energy Efficiency Alliance.
- Ecotope, Inc. 2020. “EcoSizer Documentation.” <https://ecosizer.ecotope.com/sizer/docs/>
- Electric Power Research Institute. 2011. *HPWH for Commercial Buildings*.
www.epri.com/research/products/1021970.
- Energy Star. 2023. *Energy Star Commercial Water Heaters*.
www.energystar.gov/products/commercial_water_heaters.
- Energy Trust of Oregon. 2023. *Central Heat Pump Water Heater Design Guide*. Ecotope.
www.energytrust.org/wp-content/uploads/2023/04/New-Buildings_Design-Guide-for-Central-Heat-Pump-Water-Heaters.pdf
- International Association of Plumbing and Mechanical Officials. 2024. *Water Demand Calculator*. www.iapmo.org/water-demand-calculator/
- Intellihot. 2024a. www.intellihot.com/electron-ie1/?campaignid=19934364887&adgroupid=&adid=&gad_source=1&gclid=EAIaIQobChMI2Jmy8cnvggMVYwCtBh1t6wByEAAYASAAEgJ9xvD_BwE.
- Intellihot. 2024b.
www.intellihot.com/calculator/?campaignid=19934364887&adgroupid=&adid=&gad_source=1&gclid=EAIaIQobChMI2Jmy8cnvggMVYwCtBh1t6wByEAAYASAEgKuZPD_BwE.
- Northwest Energy Efficiency Alliance. 2018. *Water Heater Market Characterization Report*.
<https://neea.org/img/documents/water-heater-market-characterization-report.pdf>.
- Northwest Energy Efficiency Alliance. 2019. *Commercial Building Stock Assessment*.
<https://neea.org/data/commercial-building-stock-assessments>.

- Northwest Energy Efficiency Alliance. 2024a. *Advanced Water Heating Specification*.
<https://neea.org/our-work/advanced-water-heating-specification>.
- Northwest Energy Efficiency Alliance. 2024b. *Residential Heat Pump Water Heater Qualified Products List*. <https://neea.org/resources/residential-hpwh-qualified-products-list>.
- Northwest Energy Efficiency Alliance. 2024c. *Hot Water Solutions*.
<https://hotwatersolutionsnw.org/partners>.
- Regional Technical Forum. 2022. *Commercial Unitary HPWH*.
<https://nwcouncil.app.box.com/v/20220322ComUnHPWHRTFPres>.
- Energy Information Administration. 2018. *Commercial Buildings Energy Consumption Survey*.
www.eia.gov/consumption/commercial/.
- Regional Technical Forum. 2022. *Commercial Unitary HPWH*.
<https://rtf.nwcouncil.org/calendar/rtf-meeting-march-22-23-2022/>
- Regional Technical Forum. 2023. *Commercial Unitary HPWH v1.2*.
<https://rtf.nwcouncil.org/measure/commercial-unitary-heat-pump-water-heaters/>
- Rheem. 2024. www.rheem.com/commercialheatpumpwaterheater/.
- US Department of Energy. 2022. “Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Water Heating Equipment.” www.regulations.gov/document/EERE-2021-BT-STD-0027-0001.