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Dual-Fuel Domestic Hot Water Feasibility Study

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1 Executive Summary

The Northwest Energy Efficiency Alliance (NEEA) commissioned this feasibility study to explore domestic water heating (DHW) systems that integrate electric Commercial Heat Pump Water Heaters (CHPWH) with Gas Water Heaters (GWH). Focused primarily on multifamily buildings, these "dual-fuel" systems offer a strategic pathway to achieve significant regional gas savings and resilient energy efficiency.

While all-electric CHPWH systems are increasingly entering the Northwest market, their widespread adoption is hindered by high capital costs, cold weather performance limitations, design complexity, and the frequent need for expensive electrical infrastructure upgrades. Dual-fuel systems address these challenges by using the heat pump for the majority of the annual hot water load and the gas system for peak demand and cold-weather backup. Key benefits include:

- **Reduced Capital and Infrastructure Costs:** Downsizing the heat pump plant and avoiding major electrical panel upgrades makes fuel diversification more financially viable. Downsizing allows the heat pump plant to cover the hot water load on a majority of days, where the gas equipment can provide trim heating on days with outlier hot water demand or extreme cold temperatures where heat pumps have reduced capacity and operate less efficiently.

- **Optimal Performance for Cold Climates and Resiliency:** Dual-fuel systems allow heat pumps to be used when conditions allow for highest efficiency operations. Gas systems provide reliable capacity during cold weather when heat pump efficiency drops, while offering redundancy during grid outages or equipment maintenance.

- **Space Solutions:** Dual-fuel systems can be designed with a smaller footprint than 100% electric heat pump systems, accommodating space-constrained mechanical rooms.

- **Fuel Flexibility:** Central controls allow buildings to switch between electric and gas heating to optimize for time-of-use pricing and provide grid demand response.

The Northwest Region shows substantial energy and gas savings potential for multifamily dual-fuel DHW systems. Based on regional climate data, census housing data, and a baseline hot water energy use of 86.7 therms per apartment annually, the study estimates:

- **Retrofit Multifamily Market:** ~1.5 million therms of annual gas savings potential.

- **New Construction Multifamily Market:** ~0.5 million therms of annual gas savings potential.

Market adoption of dual-fuel systems is heavily influenced by local regulations and utility program structures:

- **Codes and Standards:** Idaho, Montana, and Oregon energy codes generally accommodate dual-fuel systems. However, Washington State and Seattle impose strict limitations on fossil fuels in new construction. Conversely, Clean Building Performance Standards– like the Washington Clean Buildings Performance Standard (CBPS) and Seattle Building Emissions Performance Standard (BEPS) – are accelerating the retrofit market, as dual-fuel systems offer a highly cost-effective way for existing buildings to meet stringent energy and emissions targets.

- **Incentive Programs:** Dual-fuel systems occupy a regulatory gray area regarding utility fuel-switching rules. To unlock incentives, these systems must be properly classified: as a gas-efficiency measure (reducing gas use by up to 90% while retaining the gas infrastructure) for gas utilities, and as an electric-efficiency measure (relative to electric resistance baselines) for electric utilities.

To facilitate repeatable and reliable installations, four primary standard system configurations were developed and vetted with major equipment manufacturers (referred to as Manufacturer 1, Manufacturer 2, Manufacturer 3, and Manufacturer 4 in this report):

1. Gas Swing Tank
2. Single Pass Return to Primary (RTP) with Gas in Series
3. Single Pass RTP with Gas in Parallel
4. Multi-Pass RTP with Gas in Parallel

Best practice design schematics and controls sequences for the four standard configurations are included in Appendix A. However, successfully deploying these configurations requires specific attention to sizing and controls:

- **Sizing:** The industry-standard Ecosizer tool is currently being updated to support these dual-fuel configurations, allowing design teams to accurately balance heat pump capacity, gas recovery, and thermal storage volume based on local climate data.

- **Controls and Performance Validation:** While simple stand-alone thermostats can operate a dual-fuel system, this controls strategy carries a high risk of reverting to gas-backup operation if setpoints shift. Unified central control systems are strongly recommended for predictable operations. In addition, central controls enable logic-based equipment staging, load shifting, and standardized measurement and verification (M&V) to ensure persistent performance.

Scaling the dual-fuel DHW market requires standardizing system configurations, updating documents like the Advanced Water Heating Specification (AWHS) to include explicit dual-fuel guidelines, and aligning regional utility incentive structures to recognize the gas and electric efficiency benefits these systems provide. We also recommend addressing some energy code barriers in WA State.

2 Background

The Northwest Energy Efficiency Alliance's (NEEA) Advanced Commercial Water Heating (ACWH) program targets central gas water heating system retrofits, historically through more efficient gas-only systems. NEEA is now expanding the ACWH Program to include dual-fuel configurations, a strategy emphasized in its 2026 Operations Plan (NEEA 2026) as a critical pathway for the 2025–2029 business cycle. The plan describes dual-fuel and fuel-neutral measures as essential tools for providing load flexibility and reducing the cost of electrical infrastructure upgrades. NEEA has already begun exploring dual-fuel central air space conditioning systems through its Dual-Fuel Residential HVAC program – conducting field demonstrations and researching market barriers for single-family applications (NEEA 2025) (GTI Energy and NEEA 2025). This report expands NEEA's dual-fuel portfolio by exploring the feasibility of domestic hot water (DHW) systems that integrate Gas Water Heaters (GHW) and Commercial Heat Pump Water Heaters (CHPWH) as an opportunity to provide gas savings as well as provide practical and resiliency benefits to the region[1].

While this report focuses on NEEA's market transformation efforts in multifamily buildings with more than four dwelling units – aligning with the definition of commercial systems in NEEA's Advanced Water Heater Specification (AWHS) (NEEA 2025) – there are also significant commercial DHW dual-fuel opportunities in hotels, food service, grocery, small multifamily, and single-family applications (Ecotope 2022). Additionally, this

[1] While the broader category of CHPWHs includes both electric and gas-powered heat pumps, the terms CHPWH and "heat pump" in this paper refers specifically to electric heat pumps. Additionally, while manufacturers, standards, and codes use both "hybrid" and "dual-fuel" to describe systems that include both gas and electric fuels, this Feasibility Study will refer to them as dual-fuel systems. NEEA may update this standard nomenclature in the future if the industry settles on "hybrid" as the preferred term.

research uses the same basic technologies needed to provide dual-fuel hydronic space heating systems.

Using CHPWHs to supplement GWHs can leverage the advantages of both gas and electric systems. When designed and installed appropriately, dual-fuel systems can address several existing market barriers to CHPWHs while providing significant gas savings in both retrofit and new construction:

- **Optimized Capital Costs and Longevity:** Dual-fuel allows for smaller, less expensive heat pump plants that are right-sized for typical loads rather than worst-case scenarios. This allows the heat pumps to run longer with fewer on/off cycling events, which can increase equipment longevity.
- **Cold Climate Flexibility:** In cold climates, dual-fuel allows for a wider range of CHPWH equipment to be used. The heat pumps can operate when conditions allow for full capacity and high efficiency, and gas can supplement or take over during extreme cold weather conditions. Dual-fuel also has potential to provide freeze protection through pumping controls and lower electrical requirements during power outages.
- **Mitigated Infrastructure Upgrades:** Dual-fuel systems allow for a lower connected electric capacity and lower peak electrical demand. This enables CHPWH adoption in existing buildings with limited electrical capacity without the need for costly electrical system upgrades.
- **Space and Structural Solutions:** Because dual-fuel systems can be designed with a smaller footprint than 100% heat pump systems, they provide a retrofit solution for space-constrained mechanical rooms and buildings with structural load limits.
- **Grid Flexibility:** While NEEA is not currently exploring load shifting between electric and gas technologies as a primary programmatic driver, dual-fuel systems inherently provide cost optimization for building owners by allowing the system to switch to gas heat during high electrical time-of-use pricing or grid emergencies.
- **Resiliency and Risk Reduction:** Dual-fuel systems serve the owner’s needs for performance, redundancy, and flexibility against future fuel price or availability challenges.

To facilitate reliable, cost-effective, and repeatable solutions, this Feasibility Study serves as an engineering due diligence analysis to ready these products for the Northwest Region multifamily market. The report estimates the market potential and regional gas savings potential, describes regulatory barriers and methods to overcome them, and proposes ideas for market transformation alongside justifications for gas savings incentives. After quantifying the market and installation pathways, the report identifies general best practice design guidelines, outlines optimized controls sequences, and explores the necessary measurement and verification (M&V) required to support persistence monitoring. Schematic designs for four primary dual-fuel configurations that have been coordinated and vetted by equipment manufacturers and vendors are included in Appendix A. By identifying technical and regulatory challenges, solutions, and providing justifications, this report supports dual-fuel vendors to develop standard solutions that provide reliable gas savings for utilities.

3 Current Market Landscape

Historically, domestic water heating in the Northwest Region multifamily buildings has followed two primary design paths: electric resistance in-unit systems and gas-fired central plants. According to the Residential Building Stock Assessment (RBSA) most existing multifamily buildings in the region utilize individual, in-unit electric resistance water heaters (Evergreen Economics, Inc. 2024). This approach has traditionally been favored in low- to mid-rise construction due to its low initial capital cost, simplified installation, and the ease of directly billing tenants for their own energy use. Central water heating systems are particularly prevalent in larger mid-rise and high-rise buildings. Developers and design teams typically opt for central plants in these larger facilities to reduce initial capital costs, simplify maintenance, and to save valuable floor area within individual apartments, thereby maximizing rentable space. Historically, most of these central systems have been gas-fired, leveraging the low cost of natural gas and the compact footprint of high-capacity gas boilers to meet large domestic hot water loads.[2]

Recently, commercial heat pump water heaters (CHWPH) have begun to enter the Northwest Region multifamily market. This has been driven by market transformation efforts supported by NEEA such as the Advanced Water Heating Initiative (AWHI), by state and local energy codes which encourage or require these systems in larger multifamily buildings, and most recently by regional Building Performance Standards (BPS). Utility programs are also beginning to support these systems.

In response to market demands for CHPWHs, equipment manufacturers have been launching CHPWH products to capture their growing share of the US market. A 2009 study found only three commercial HPWH products targeted to heating potable water offered by relatively small manufacturers (Ecotope 2009). At the time of this study there are more than a dozen manufacturers offering products of this class in the US with multiple product lines. The big players in US water heating, AO Smith, Rheem, and Bradford White all have introduced CHPWH products. Many manufacturers who were previously known for their gas water heating equipment have recently introduced CHPWH products so as not to be left behind. For example, in 2023 Laars introduced the

[2] Central water systems in many public housing buildings such as those owned by Seattle Housing Authority are electric resistance due to extremely low electricity rates offered to public housing by municipal utilities.

E-Therm and Lochinvar introduced the *Veritus* CHPWH. Noritz, partnered with Nihon Itomic, unveiled their CHPWH planned for the US market at the 2026 AHR Expo.

While the market for CHPWHs is expanding, it has not taken off dramatically due to a few key market barriers.

- **Capital Cost:** CHPWH systems are significantly more expensive to install than gas-fired water heating systems.

1. **Fuel Cost:** On a per-BTU basis, gas is significantly less expensive than electricity. To reduce utility bills in most parts of the Northwest Region, CHPWH systems must deliver average annual system COPs of higher than about 2.5.

- **Complexities:** CHPWH systems have design constraints not found with gas water heating systems. It is not possible to simply replace a gas water heating system with a heat pump in the same type of design configuration.

2. **Reliability:** Due to the added system design complexity, some early CHPWH system installations have had installation and controls issues common for newly emerging technologies. Issues can occur either in the system or in the heat pump equipment. When controls and piping follow those linked to the NEEA CHPWH Qualified Products List (QPL), the systems operate reliably. However, some heat pump manufacturers have not addressed issues within their heat pump equipment – especially around defrost controls and ability to handle higher incoming water temperatures. Monitoring CHPWHs is important to identify root cause and resolve performance issues. Resolving system issues tends to be easier than resolving equipment issues. However, monitoring also allows NEEA to identify equipment that does not perform.

- **Awareness, Risk and Expertise:** CHPWHs are still an emerging technology and awareness and specific expertise with design and installation of these systems is still developing. This increases the perceived risk of these systems for the design and contracting communities.
- **Cold Climate Performance:** Depending on the style, refrigerant, and manufacturer of the heat pump, performance can suffer in cold weather. Efficiency and output capacity drop significantly for some, but not all, CHPWH products at temperatures below about 40°F. Satisfying the hot water load on peak days with current CHPWH products often requires significant up-sizing or the addition of supplemental heating. In addition to efficiency and capacity concerns, many CHPWH systems pipe potable water outside the building envelope, through the heat pump, to heat it. Taking potable water outside creates freeze risk and requires thoughtfully designed freeze protection systems that are resilient to power outages to protect equipment from damage.

Dual-fuel systems directly address many of the above market pressures currently hindering widespread CHPWH adoption. By using CHPWHs as the primary heating stage alongside gas equipment for supplementary or back-up heating, dual-fuel designs allow for smaller, less expensive heat pumps that are optimally sized for typical loads rather than worst-case peak scenarios. Balancing heat pump and gas capacity reduces the initial capital cost and lowers the connected electrical capacity and peak electrical demand. Furthermore, gas backup provides built-in redundancy, which mitigates performance concerns, provides flexibility during maintenance or grid emergencies, and reduces the perceived risk for the design and installation community. In cold climates, a dual-fuel approach allows a wider range of CHPWH equipment to be used; the heat pumps can operate during conditions that allow for high efficiency, while the gas system can seamlessly take over during extreme cold weather when heat pump capacity and efficiency drops or freeze risks become a concern. Operationally, this strategy can yield a high average annual system COP, keeping fuel costs manageable while maximizing equipment longevity through fewer on/off cycling events.

For reference, dual-fuel HVAC solutions are also gaining interest in various markets. The 2025 Draft California Building Energy Action Plan by the CA Energy Commission directly recommend dual-fuel heat pump systems particularly for retrofit applications because they mitigate electrical infrastructure upgrades, support cost effectiveness and feasibility, and have potential to provide grid resiliency and load shifting (California Energy Commission 2025).

4 Regional Multifamily Gas Savings Potential

One of the primary target dual-fuel markets is existing multifamily buildings that need to replace aging gas DHW systems. Compliance with existing energy codes and building performance standards varies by state and makes dual-fuel systems much more difficult to install in Washington, especially Seattle, than other regional jurisdictions. A detailed description of energy codes and building performance standards that impact dual-fuel systems is provided below under *Regulatory Environment*.

Gas savings potential for the Northwest Region is calculated through a per-apartment-served analysis. First, the annual per apartment energy usage for DHW is determined. Then savings from retrofits and new construction are calculated separately.

4.1 Annual DHW Energy Usage Per Apartment

Energy usage per apartment is calculated by adding the usage load, or energy required to heat incoming city water temperature to hot water delivery temperature, to the temperature maintenance load, or energy required to maintain hot water distribution temperature and offset recirculation losses.

1. Cold entering water temperature is estimated using ground water temperatures provided in TMY3 weather data files (National Renewable Energy Laboratory 2026). Although cold water temperatures vary slightly regionally, a population normalized average water temperature of 58°F is used for this analysis. Hot water supply temperature is assumed to be 125°F, which is an industry standard to achieve a hot water delivery temperature of 120°F at the fixtures.
2. Water usage per apartment is determined by estimating the average number of people per apartment as 1.6 from US census data displayed in Table 1 below and weighted using Table 3 (U.S. Census Bureau 2026). Research performed during development of the Ecosizer tool concludes an average of 18 gallons of hot water is used per person per day in apartment buildings. This results in an average of 28.8 gallons used per apartment (Ecotope 2026)[3].

State/City	5-9 Units	10-19 Units	20-49 Units	50+ Units
Idaho	1.81	1.74	1.71	1.63
Montana	1.78	1.7	1.68	1.54
Oregon	1.68	1.62	1.59	1.51
Washington	1.62	1.57	1.55	1.48
Seattle	1.52	1.49	1.45	1.41

Table 1. Average number of people per apartment for apartment buildings in the Northwest Region

3. Recirculation loss rate of 93 watts per apartment is sourced from a 2019 NEEA Study Literature Review of Multifamily Central Domestic Hot Water Distributions Losses (Larson and Oram 2019). The median loss per apartment instead of the average loss per apartment is assumed to reduce the impact of outliers in the study.

Equations 1 and 2 calculate therms per year attributable to Water Usage Per Apartment

Equation 1 $$\frac{BTU}{day} = \frac{gallons}{day} \times 8.34 \left(\frac{BTU}{°\mathrm{F} \times gal}\right) \Delta T$$

Equation 2 $$\frac{therms}{year} = \frac{BTU}{day} \times 365 \times \frac{1\ therm}{100{,}000}$$

Equation 3 calculates the therms per year attributable to Temperature Maintenance or Recirculation Losses.

[3] 18 gallons per apartment is derived from monitoring of new construction DHW systems. In retrofits, high flow fixtures could drive higher water usage, making these calculations conservative in retrofit applications.

$$\text{Equation 3} \quad \frac{therms}{year} = \frac{watts \times 24\ hours/day \times 365\ days/year}{29{,}300\ watts/therm}$$

Calculations from assumptions and equations provided above result in an **average of 86.7 therms per year per apartment of thermal energy usage**. Gas savings potential calculated in Table 2 below includes assumed thermal efficiencies for gas equipment.

4.2 Retrofit Gas Savings Potential

To calculate regional savings, the Northwest Region is broken into seven regions: WA-East, WA-West, WA-Seattle[4], OR-East, OR-West, ID, and MT. TMY3 weather data is used to estimate the percentage of load that is covered by gas heating v. heat pump heating. The number of available dwelling units (apartments) is calculated using census data and the number of units served by central gas systems is estimated using building stock assessment data. Local energy codes and laws are used to estimate the number of retrofit opportunities where dual-fuel systems can be installed in each region.

1. TMY 3 outdoor air temperature data is binned by hours above 45°F, hours between 30°F and 44°F, hours between 15°F and 34°F, and hours below 15°F. As the air temperature is lower, less heating is assumed to be covered by the CHPWH. Table 2 shows the binned hours for each region, a conservative percentage of heating assumed by the CHPWH for each bin, and an estimated gas savings per apartment. The gas savings are determined by the gas offset by CHPWH in each region.

Region	Hours Above 45°F	Hours 30°F to 45°F	Hours 15°F to 30°F	Hours Below 15°F	Gas Savings Per Apartment [therms]
WA – Seattle	6,584	1,931	232	12	68.9
WA – West	5,912	2,345	458	34	67.0
WA – East	5,231	2,214	1,023	292	63.4
OR – West	6,695	1,842	208	15	69.1
OR – East	5,340	2,321	920	179	64.3
ID	5,820	1,915	845	180	65.4
MT	5,090	1,745	1,220	705	60.9
Heating Assumed by Heat Pump	85%	65%	45%	20%	

Table 2. Binned outdoor air temperatures for each region and average gas savings per apartment

2. US Census data is used to estimate the number of housing units in each region. Counties were categorized into "Western" or "Eastern" regions based on their

[4] Seattle is broken out differently because the Seattle Energy Code and Building Energy Performance Standard put stricter limitations on dual-fuel installations

geographic location relative to the Cascade Mountains. The Western Washington region includes high-density areas such as King, Pierce, Snohomish, Kitsap, Thurston, and Clark counties, while Eastern Washington is represented by centers like Spokane, Benton, Yakima, Franklin, and Walla Walla. In Oregon, the Western grouping comprises Multnomah, Washington, Clackamas, Lane, and Marion counties, with the Eastern grouping including Deschutes, Umatilla, Klamath, and Wasco counties. Table 3 shows number of units for each region.

Region	5-9 Units	10-19 Units	20-49 units	50+ Units	Total Units
WA – Seattle	12,504	18,211	35,843	119,531	186,089
WA – West	111,608	124,989	115,968	193,673	546,238
WA – East	23,628	27,127	19,530	19,820	90,105
OR – West	73,436	72,100	67,295	106,400	319,231
OR – East	5,750	5,647	4,343	5,303	21,043
ID	28,078	15,860	17,462	25,813	87,213
MT	17,195	15,461	16,196	13,561	62,413

Table 3. Total number of dwelling units by multifamily building size

3. According to the 2022 Residential Building Stock Assessment (RBSA), about 40% of multifamily apartments in the region are served by a central water heating system. Central systems are particularly prevalent in larger mid-rise and high-rise buildings, and of these central systems, about 80%, are gas-fired (Ecotope 2022). (Evergreen Economics, Inc. 2024) Table 4 shows estimations for how many structures in each US census bin have central gas DHW systems.

	5-9 Units	10-19 Units	20-49 units	50+ Units
Total Buildings	38,884	18,626	7,904	5,978
Percentage with Central	10%	65%	90%	90%
Structures with Central	3,888	12,107	7,114	5,380
Overall Percentage Central	40% (across all according to RBSA)			
Structures with Central Gas	3,111	9,686	5,691	4,304
Percentage with Central Gas	8%	52%	72%	72%
Overall Percentage Central Gas	32%			

Table 4. Number of buildings by size and estimation of percentage of structures which include gas central systems

4. The number of housing units in each type of structure from Table 3 is then multiplied by the percentage of structures served by central gas systems from Table 4 to estimate the total units served by central gas DHW systems; this result is shown in Table 5. Table 5 also shows the total potential gas savings if all central DHW systems were to be converted to dual-fuel systems.

Region	5-9 Units	10-19 Units	20-49 units	50+ Units	Total Units	Savings Potential [therms/year]
WA – Seattle	1,000	9,470	25,807	86,062	122,339	8,425,580
WA – West	8,929	64,994	83,497	139,445	296,864	19,875,226
WA – East	1,890	14,106	14,062	14,270	44,328	2,809,705
OR – West	5,875	37,492	48,452	76,608	168,427	11,643,192
OR – East	460	2,936	3,127	3,818	10,342	665,034
ID	2,246	8,247	12,573	18,585	41,651	2,724,050
MT	1,376	8,040	11,661	9,764	30,840	1,877,425

Table 5. Estimated number of units which include gas central systems

5. The final step is to include market penetration, equipment life, and assumed gas efficiency. Factors which influence market penetration, or the percentage of central gas DHW systems converted to dual-fuel systems, include energy codes, building performance standards, and other market forces that are discussed in more detail under Regulatory Environment. Equipment life is assumed to be 20 years for all central gas systems. Retrofit gas efficiency is assumed to be 80% - common for non-condensing gas boilers. At a retrofit rate of 5% of dwelling units per year, the dual-fuel systems can achieve an annual savings of 1.5 million therms for each year of implementation. By the end of the 20-year period, the total fleet-wide savings will reach 30 million therms of annual gas reduction.

Region	Dwelling Units Served by Central Gas	Market Penetration	Annual Savings Potential [therms/year]
WA – Seattle	122,339	10%	52,660
WA – West	296,864	50%	621,101
WA – East	44,328	80%	140,485
OR – West	168,427	80%	582,160
OR – East	10,342	80%	33,252
ID	41,651	25%	42,563

MT	30,840	25%	29,335
Total			1,501,555

Table 6. Retrofit market penetration estimations by region and annual available new gas savings when 20-year equipment life is applied

4.3 New Construction Savings Potential

New construction savings are estimated using the same per-apartment analysis as retrofit. Several factors influence the number of new multifamily construction units built in the Northwest Region. Primary demand drivers include significant regional population growth and a persistent, unmet need for housing, particularly for low-income and affordable households. However, recent downturns in new project initiations are heavily influenced by restrictive economic conditions, such as tighter credit availability for developers, elevated interest rates that increase the cost of capital, ongoing labor shortages, and rising material expenses. While the number of apartments built over the next few years may be lower because of market factors, the average market over the next decade is assumed to be similar to 2020 through 2023.

1. The number of multifamily new construction housing units starts is estimated based on permit data from each state and is shown in Table 7 (National Association of Home Builders 2026). The average number of new permit starts from 2020 through 2023 is assumed to be the average number of new construction units for each state.

State/City	2020	2021	2022	2023	Average
Idaho	2,800	4,500	4,200	2,500	3,500
Montana	1,100	1,800	2,000	500	1,350
Oregon	7,500	10,500	11,000	6,500	8,875
Washington	21,000	30,000	28,000	20,000	24,750

Table 7. Multifamily permit data for new construction to obtain estimated annual market size

2. Population weighting by region is then used to estimate the number of new housing units in each region. A market penetration factor and assumed 97% condensing boiler efficiency is applied, and the annual savings are calculated in Table 8. Market penetration factors for new construction are assumed lower than those for retrofit because many new construction buildings will choose to go all electric to provide resilience to future decarbonization regulations. The colder climates of Oregon and Washington have the highest market penetration due to energy codes that require some heat pump heating, while gas provides benefits in colder climates. Idaho and Montana are assumed to have low uptake due to fewer driving forces – including codes and building performance standards described in

subsequent sections – for CHPWHs. The annual regional gas savings in the new construction multi-family market is approximately half a million therms.

Region	Population Weighting	New Housing Units	Market Penetration	Annual Savings Potential [therms/year]
WA – Seattle	10%	2,475	0%	-
WA – West	69%	17,078	15%	176,806
WA – East	21%	5,198	50%	169,814
OR – West	87%	7,721	15%	82,540
OR – East	13%	3,500	75%	57,367
ID	100%	3,500	15%	35,398
MT	100%	1,350	15%	12,709
Total				534,633

Table 8. New construction market penetration estimations by region and annual new gas savings

Details on regulatory environment in the next section give insights into the assumed market penetration factors used in this analysis. However, climate also influences market penetration. At a high level:

- A higher percentage of retrofits are assumed to support compliance while avoiding electric infrastructure upgrades.
- Dual-fuel systems will have the highest penetration in cold climates east of the Cascade mountains.
- New construction in regions west of the Cascades will default to a higher percentage of all electric buildings and therefore less penetration.
- Many buildings in Idaho and Montana will continue to be built with gas only due to permissive energy codes and low cost of gas.
- Energy codes favor dual-fuel systems in Oregon more than in Washington – where all electric buildings are more heavily encouraged.

5 Regulatory Environment

All installed equipment to handle potable water is required to meet basic federal water quality law, and mechanical, electrical, and plumbing codes. These codes present no barriers to dual-fuel systems since manufacturers already meet these requirements for equipment sold in the US.

However, energy codes are beginning to introduce barriers to dual-fuel systems as they move towards electrification requirements in some jurisdictions (most notably WA State and Seattle), and plumbing and mechanical codes reference AHRI and ANSI standards and UL certification as requirements. These standards are still in development for CHPWH systems and have not addressed dual-fuel systems, so they should be watched to ensure that no significant barriers develop there.

While energy codes can present a barrier, Building Performance Standards present a strong incentive to deploy either all-electric or dual-fuel systems. Clean Building Performance Standards (CBPS) are in place in WA and OR which regulate the energy use (EUI) of existing buildings. Seattle has its own version of a CBPS which targets emissions instead of energy use. For existing buildings with high DHW usage served by existing gas equipment, a CHPWH system is often the easiest way to meet compliance with the CBPS targets. These same existing buildings often are constrained by space, electrical capacity, and capital budget. This makes existing building renovations throughout the Northwest Region a good target niche for dual-fuel systems.

5.1 Energy Codes

WA State is shifting its energy code to focus on site energy use reduction. As such, the code is imposing more limitations on fossil fuel systems. In WA State, all multifamily buildings greater than three stories – as well as all multifamily buildings with units accessed from enclosed interior spaces – fall under the commercial energy code. While the commercial WA State Energy Code (WSEC) heavily promotes heat pump water heating, dual-fuel systems are explicitly allowed. This is due in part to the anticipated potential need for dual-fuel systems to meet peak demand requirements. The relevant excerpts from the 2021 WSEC's Prescriptive compliance path for new construction are shown below (these sections are not required for projects that use the energy modeling-based Performance Path):

C404.2.1.1 Primary heat pump system sizing. *The primary heat pump service water heating system shall be sized to deliver no less than 50 percent of the calculated demand for service hot water production during the peak demand period. […] The remaining primary service output may be met by fossil fuel, electric resistance, or heat pump water heating systems.*

C404.2.1.4 Supplemental water heating. *Total supplemental water heating equipment shall not have an output capacity greater than the total summed capacity of all primary water heating equipment. […] Supplemental heating is permitted for the following uses:*

1. Temperature maintenance of heated-water circulation systems, physically separate from the primary service water heating system.

2. Defrost of compressor coils.

3. Heat tracing of piping for freeze protection or for temperature maintenance in lieu of recirculation of hot water.

4. Backup or low ambient temperature conditions [...]

This code wording restricts the sizing of the gas component in dual-fuel systems by requiring it to be less than or equal to the primary service heat pump capacity at 40°F. This can prevent a "hybrid" approach where a heat pump handles the full load down to 40°F and a gas backup provides 100% redundancy. A significant barrier arises because in most dual-fuel configurations the primary storage tanks are heated by heat pumps, with gas heaters providing heat to tanks downstream. These in-series tanks could be smaller, and therefore cost less, than the primary storage tanks – because gas heating capacity is less expensive than heat pump capacity – if energy codes allow for sufficient gas capacity to be installed. Because code caps gas heating capacity, full redundancy cannot be achieved without increasing the downstream, gas-heated storage volume to equal the primary storage volume, eliminating the cost advantage.

While the code nominally allows dual-fuel water heating systems, the WSEC also requires additional energy efficiency credits under section C406. The simplest pathway for most new multifamily buildings to gain the required credits is to size a CHPWH system to meet 100% of the water heating load without the use of fossil fuel supplemental heating. If this credit pathway is not taken, then the project must implement several other credits associated with mechanical, envelope, lighting, or other systems to accumulate enough credits to meet the requirements. So, while there are explicit pathways for dual-fuel systems in the WSEC, they are not as simple as 100% electric heat pump systems. The 2021 Seattle Energy Code, on the other hand, does not allow fossil fuel water heating equipment in new commercial construction projects complying via its Prescriptive path; the Performance path does not have this limitation.[5]

The impact of the WSEC is less clear-cut for existing building system replacements or upgrades.

C503.5 Service water heating equipment. *All new service water heating systems, equipment, and components of existing systems that are altered or replaced shall comply with Section C404. [sic], C408.3, C409.5, and C501.6. Additions or alterations shall not be made to an existing service water heating system that will cause the existing system to become out of compliance.*

Exception: *The following equipment is not required to comply with Section C404.2.1:*

1. Replacement of a single electric resistance or fuel-fired service water heating appliance with a unit that is the same type and has the same or higher efficiency and the same or lower capacity, provided there are no other alterations made to the existing service water heating system size or configuration.

2. Replacement of any of the following water heater appliances:

2.1. Electric water heaters with an input of 12 kW or less.

2.2. Gas storage water heaters with an input of 75,000 Btu/h or less.

2.3. Gas instantaneous water heaters with an input of 200,000 Btu/h or less and 2 gallons or less of storage.

3. Where it has been determined by the code official that existing building constraints including, but not limited to, available floor space or ceiling height, limitations of the existing structure, or electrical service capacity, make compliance technically infeasible.

Without the exceptions, the main section indicates that all new water heating equipment in existing buildings would need to comply with the new code requirements. The first exception listed indicates that it is permissible to replace a gas system with another gas system of the same or better efficiency and the same or smaller capacity, but that if alterations are "*made to the existing service water heating system size or configuration*" then the entire system must meet the new code requirements.

For existing buildings, interpretation and enforcement of service water heating upgrade requirements can vary by jurisdiction. While like-for-like replacements are clearly permitted, more complex system modifications may trigger additional compliance review. In practice, equipment service, replacement, and improvements are often not brought to the attention of the energy code reviewers, and plumbing, mechanical, and electrical permit officials will often not engage the officials responsible for enforcing the energy code. It is unlikely that a code official would tell someone that they could not install a HPWH to "preheat" water upstream from an existing gas water heater, so it is not clear that the current code is actually a significant barrier to dual-fuel system retrofits in most WA jurisdictions. However, industry stakeholders are encouraged to engage with the WA State Energy Code and Seattle Energy Code development process to share the advantages of allowing dual-fuel systems in existing buildings.

Another barrier in the WA and Seattle codes is requirements for system design. The section excerpted below eliminates one of the standard dual-fuel configurations that was developed with our manufacturing partners: single-pass return-to-primary.

C404.2.1.3 System design. *The service water heating system shall be configured to conform to one of the following provisions [emphasis added]:*

> *1. For <u>single-pass</u> heat pump water heaters, temperature maintenance heating provided for reheating return water from the building's heated water circulation system shall be physically decoupled from the primary service water heating system storage tank(s) in a manner that prevents destratification of the primary system storage tanks. Temperature maintenance heating is permitted to be provided by electric resistance, fossil fuel, or a separate dedicated heat pump system.*
>
> *2. For <u>multi-pass</u> heat pump water heaters, recirculated temperature maintenance water is permitted to be returned to the primary water storage tanks for reheating. [...]*

It is unlikely that most designers, contractors, and building code jurisdictions will limit their designs based on this section. The language in the WSEC appears to have been written at a time when commercially available CHPWH design practices were less mature, resulting in constraints that do not fully reflect current system capabilities. Engagement with the code development process in WA State may help to remove some of these barriers in both the new construction and existing buildings sections of the code.

The Oregon energy code follows ASHRAE 90.1 which has explicit allowances for dual-fuel systems. The additional energy credit requirements of ASHRAE 90.1 are not as restrictive as WSEC's for dual-fuel systems with other available pathways for code compliance. Therefore, we do not see any significant code-related barriers to dual-fuel systems in Oregon.

Neither Idaho (2018 IECC with amendments) nor Montana (2021 IECC with amendments) has a mandatory statewide requirement for heat pump water heaters (HPWH) in their current commercial energy codes. While both offer heat pumps as a compliance path for "Additional Efficiency" credits, the lowest cost option in these jurisdictions will likely be to continue to use all gas systems.

5.2 Clean Building Performance Standards

Clean Building Performance Standards adopted in WA and OR present a market opportunity for dual-fuel DHW systems for buildings with high DHW usage and existing gas-fired systems. The state-level standards are based on building Energy Use Intensity (EUI) which is defined as energy use per square foot per year. For buildings with high DHW usage with existing gas equipment, one of the simplest ways to reduce the EUI is to replace most of the DHW load with an efficient CHPWH.

Seattle has adopted a Building Emission Performance Standard (BEPS) which is emissions-based rather than energy-based. Dual-fuel systems can also help buildings reduce on-site carbon emissions by using heat pump water heaters to satisfy the majority of the DHW load. However, note that the BEPS is designed to reduce allowable on-site emissions to zero eventually, so any dual-fuel solutions in Seattle should be planned as initial partial steps towards full electrification.

6 Market Transformation Strategy

In order to bring dual-fuel DHW solutions to market it will be important to have the support of the key mechanical equipment sales representatives in the region. These are the market actors who educate the engineers and contractors and who sell and support the equipment needed. In terms of market delivery, there are a few different types of supply chain partners who could support bringing integrated dual-fuel systems to market. In all cases, the integration of system controls will be critical to produce reliable systems.

- <u>Gas Equipment Manufacturers</u>: Several manufacturers of gas water heating equipment are responding to the market shift toward heat pumps by purchasing, rebranding, or developing their own heat pump offerings. For these manufacturers, dual-fuel system packages could benefit both their gas and new heat pump product lines. These manufacturers are also well positioned to develop fully integrated solutions with a standard unified control system.

3. <u>HVAC Equipment Reps</u>: Many of the large regional HVAC product representatives and distributors represent both heat pump manufacturers as well as gas equipment manufacturers and tank manufacturers. These supply chain partners could develop standard dual-fuel equipment packages, pre-tested to ensure product compatibility. They may also be able to provide a third-party controls overlay which would do the work of staging and shifting load from the heat pumps to the gas system under specified conditions.

- <u>Heat Pump Manufacturers</u>: Manufacturers with only a heat pump product may be open to including dual-fuel configuration options for back-up or supplementary heating in their standard manufacturer's design guidelines. This might include standard design schematics, recommended setpoints, sizing guidelines, and specification requirements for the gas systems. Control systems for CHPWH could be made to include logic and signals to control supplementary gas-fired equipment.

Engagement with the key supply chain partners in the region who are positioned to support the major CHPWH market actors is recommended. The development of dual-fuel package solutions which include controls which can integrate control over the gas systems, CTA2045 load flex commands or time-of-use scheduling, and a connected M&V package for performance feedback would aid in market advancement.

6.1 Programs

Dual-fuel systems present a new challenge for utility incentive programs in the Northwest Region. These systems can deliver significant gas savings while reducing electric peak impacts and maintaining service reliability in cold weather. However, their hybrid nature raises questions about compliance with state utility regulations governing fuel-switching, allowable uses of public purpose funds, and coordination between gas and electric utilities.

The Washington Utilities and Transportation Commission (UTC), Oregon Public Utility Commission (OPUC), Idaho PUC, and Montana PSC each regulate how ratepayer funding may support energy efficiency. Washington and Oregon have historically constrained the use of electric ratepayer funds for customer fuel-switching incentives — primarily through statutory definitions of 'conservation' that exclude measures increasing electric load, and through program administration policies that separate electric and gas public purpose funds. These frameworks were designed to prevent cross-subsidization between regulated fuels; inhibiting energy efficiency from dual-fuel systems that could be defined as gas efficiency. Dual-fuel HPWH systems occupy a regulatory gray area where neither the electric nor the gas utility is clearly precluded from offering incentives, provided the measure is correctly classified.

Most Northwest Region utility commissions distinguish **fuel substitution** (a regulated prohibition) from **efficiency improvements** (a regulated obligation). Washington's 2019 Clean Energy Transformation Act (CETA), the Washington State Energy Independence Act (I-937), and various Washington Administrative Code (WAC) rules collectively bar electric Independently Owned Utilities (IOUs) from using ratepayer funds to induce customers to disconnect from gas service. In Oregon, the OPUC has similar restrictions.

Washington's Clean Energy Transformation Act (CETA), the Climate Commitment Act (CCA), and the 2021 WA State Energy Strategy all instruct utilities to reduce emissions. The Washington Utilities and Transportation Commission (UTC) has explicitly encouraged exploration of **demand-side pathways** to reduce gas use, including dual fuel systems that maintain customer relationships while reducing annual gas load.

This broader policy direction strengthens the case that dual-fuel HPWH systems could qualify as gas-efficiency measures.

Gas utilities traditionally invest in high-efficiency combustion equipment—condensing water heaters, high-turndown boilers, gas heat pumps, or modulating burners. These systems rely on small additional electrical loads for fans, valves, and controls. Regulators accept these modest electrical inputs as part of normal efficient gas operation.

A dual-fuel HPWH system extends this logic by:

1. Reducing annual gas use by ~70% in the colder climates east of the cascades and ~80% in warmer coastal climates[6].
2. Retaining the gas service connection and backup capacity, ensuring reliability and preserving the gas customer relationship.
3. Shifting the primary heating load to a highly efficient electric heat pump, without eliminating the gas system.

6.2 Specifications

The Advanced Water Heater Specification (AWHS) v8.1 is the most comprehensive specification for CHPWH systems. Most CHPWH manufacturers have systems meeting the requirements of the specification and have listed their systems on the Qualified Products List. While it does not explicitly disallow dual-fuel systems, the specification was designed around CHPWH systems with minimal electric resistance back-up or supplementary heat. Energy Star and CEE are both developing specifications that take the same basic approach as the AWHS and were also designed around all-electric systems at this time.

The AWHS should be expanded to explicitly address dual-fuel systems by adding content to the existing specification or creating a parallel document. This new content should address such issues as sizing of the HPWH vs. gas components, standard design configurations, controls settings and alarming, standard M&V, standard approach to load shifting, and sequence of operations.

7 Technical Framework for Market Transformation

To facilitate reliable, cost-effective, and repeatable solutions that support rapid market transformation, the industry must establish clear, standardized design methodologies. The following sections provide descriptions of system components, sizing strategies, performance metrics, and control sequences required to successfully deploy dual-fuel DHW systems.

[6] These percentage estimations are based on the assumptions in Table 2. However, actual savings will be determined on a per site basis and depend on the controls strategy and sizing of equipment.

7.1 Manufacturer Collaboration

Best practice schematic designs which include controls sequences for four dual-fuel configurations can be found in Appendix A. The project team collaborated with four manufacturers of GWH and CHPWH equipment to decide which standard configurations would provide the broadest market coverage and to detail out the schematics and controls sequences. The following configurations were deemed as the most appropriate starting point for multifamily DHW dual-fuel systems:

1. Gas Swing Tank
2. Single Pass Return to Primary with Gas in Series
3. Multi Pass Return to Primary with Gas in Series
4. Single Pass Return to Primary with Gas in Parallel

The project team created a range of conceptual designs for representative dual-fuel CHPWH configurations. These diagrams were developed to explore integration between electric heat pumps and gas-fired equipment while maintaining reliable hot-water delivery and compatibility with the Advanced Water Heating Specification (AWHS). The designs integrated single-pass and multipass heat pumps with instantaneous and multipass gas systems and investigated potential configurations utilizing unpressurized storage. These system diagrams were sent to three manufacturer partners who agreed to review, comment on, and provide feedback regarding how their company may respond to the potential dual-fuel market. Coordination meetings were held in October 2025 with Manufacturers 1, 2, 3, and 4 to review the draft configurations and gather product-specific input.

After these conversations and feedback, the various options were condensed down to four basic configurations. All standard configurations can be controlled to provide operational flexibility, enabling load shifting/sharing and efficient response to variable demand or grid-interactive control signals. The standard configurations are intended to provide enough detail to enable development of standard methods to enable system sizing and energy use predictions for the range of dual-fuel systems:

1. **Single Pass Heat Pump with Gas Swing Tank**

   This is perhaps the easiest configuration of dual-fuel systems to get rapidly into the market. It is a direct duplication of the swing tank configuration used by many of the CHPWH manufacturers today, though the electric resistance swing tank is replaced with a gas water heater. In a swing tank design a single pass HPWH provides heating to fully stratified primary storage tanks (typically stored at temperatures above ~150°F). This water flows through a temperature maintenance tank piped in series and maintained by the back-up heat at 120°-125°F before going to the thermostatic mixing valve supplying the building. The recirculation loop returns to the swing tank to avoid de-stratifying the primary storage. As long as temperature maintenance losses are low compared to hot water usage, the swing tank is only needed during periods of low water usage such as overnight. In a dual-fuel system, the gas swing tank can be over-sized to provide supplemental heating as well as temperature maintenance, and no other design changes are needed.

2. **Return to Primary (RTP) with Gas in Series**

   This design configuration returns the temperature maintenance loop to the primary storage tanks which are served by the heat pump system. Gas-fired water heaters are piped in series with the primary storage and act as "trim" heaters (if the water entering the trim tank is not up to setpoint the gas system comes on to supplement). This arrangement allows the HPWH to serve the primary and recirculation loads, with gas providing supplemental heating during peak hot water usage periods, low-ambient conditions, load shift periods, or heat pump maintenance. Return-to-primary sizing methods currently being developed for Ecosizer will support this design configuration and modeling algorithms can be adjusted to estimate load fractions given heat pump sizing. This configuration can use either single-pass or multi-pass heat pumps.

3. **Single Pass RTP – Gas in Parallel**

   HPWHs and gas water heaters are connected to the same storage system and are piped in parallel so that both systems can serve the same primary storage volume. The temperature maintenance loop is returned to the primary storage tank; eliminating the need for secondary tanks. The gas circuit draws water from the lower portion of the storage tank and returns heated water to the upper section when the upper tank temperature falls below setpoint, maintaining stratification and supplementing the HPWH system only when the HPWH system falls behind. Some work is needed to develop sizing and modeling tools to support this design configuration.

4. **Multi-Pass RTP – Gas in Parallel**

   Similar to Single Pass RTP, HPWHs and gas water heaters are connected to the same storage system and are piped in parallel so that both systems can serve the same primary storage volume. With parallel systems controlled as multi-pass the controls can be relatively simple with the heat pump system set to maintain a higher setpoint in the storage than the gas system. This will hold off the gas system until the heat pump is no longer able to achieve setpoint for whatever reason (e.g., high load, low ambient performance, load shifting, maintenance, etc…). Higher storage volumes are needed with multipass systems. Some work is needed to develop sizing and modeling tools to support this design configuration.

The project team developed example best practice design guidelines for each of the above design configurations. These design guidelines were sent to the three partner manufacturers who were initially interviewed plus Manufacturer 4 for feedback in February 2026. Other than minor comments, all manufacturers agreed that these guidelines represent system designs which, if followed, will result in high performing systems with the heat pumps providing primary heating and the gas systems backing them up. The load shifting logic and sequences described in these diagrams are expected to deliver significant peak savings. None of the manufacturers expressed concerns that longer CHPWH runtimes – because of under sizing the CHPWH and letting the boiler trim heat – would impact equipment life. The example best practices design guidelines are included in Appendix A.

1. **Manufacturer 1**
   Discussion with Manufacturer 1 centered on the RTP – Gas in Series and Gas in Parallel configurations. Manufacturer 1 confirmed that this layout aligns with their current product capabilities and represents a practical baseline for early deployment. The team was engaged and open to collaboration, noting that Manufacturer 1 already offers a broad range of gas boilers and water heaters in their portfolio and is eager to explore this dual-fuel application. They also shared unique configuration and control preferences that were reconciled with the project team's standardized design framework and impacted the final diagrams.

2. **Manufacturer 2**
   Manufacturer 2 does not offer a gas water heating line in the US. However, they have distribution partnerships that may bring additional parties into dual-fuel system development. Integration options were reviewed for their non-potable-rated CO_2 heat pump. Their team confirmed that current products require a secondary heat exchanger for potable applications and highlighted a forthcoming product as another potential option for dual-fuel integration. Manufacturer 2 was receptive to the concepts discussed and found the proposed configurations technically feasible. Several dual-fuel arrangements align well with their CO_2 product line, and the team acknowledged the importance of maintaining multi-vendor compatibility to support market transformation and future field demonstrations. Manufacturer 2 is interested in investigating unpressurized or low-pressure non-potable glycol storage with a temperature

controlled buffer tank configuration. An existing dual-fuel installation using a gas swing tank was also identified during this engagement.

3. **Manufacturer 3**
   There was strong engagement from the Manufacturer 3 team who are developing their own parallel design details for dual-fuel systems and appreciated the collaboration afforded by this project. Manufacturer 3 noted risks in configurations where the gas boiler and heat pump are designed to heat the same storage volume. With multipass equipment, it is important that configurations be designed so that gas and heat pump equipment heats separate tanks or are controlled to avoid operating simultaneously. Both teams agreed that the dual-fuel arrangement where the gas boiler and heat pump heat separate tanks (or are sequenced to avoid simultaneous operation) represent a promising pathway for dual-fuel integration that balances resiliency, redundancy, and simplicity. The multi pass and single pass return to primary with gas in-series and gas swing tank diagrams fit products offered by Manufacturer 3.

4. **Manufacturer 4**
   Manufacturer 4 offers several commercial gas boilers, a tank style gas water heater, and a CO_2 refrigerant CHPWH. Manufacturer 4 currently offers a packaged system which includes the CHPWH, electric swing tank, and controller. Replacing the electric swing tank with one of the many gas water heater options available by Manufacturer 4 would allow for a plug and play dual-fuel system. The controller developed by Manufacturer 4 includes the capability to provide all suggested controls outlined in Appendix A.

7.2 System Components

Dual-fuel DHW systems include a combination of components common in electric CHPWH systems and in gas water heating systems.

7.2.1 Air to Water Heat Pumps

Air-to-water heat pumps serve as the electric heating source for the DHW system. These units are typically configured to include double-wall heat exchangers designed directly for potable water applications, or as hydronic air-to-water heat pumps paired with a secondary heat exchanger. Some system designs require these secondary heat exchangers to separate potable water from the internal heat exchangers in the heating equipment or from a glycol loop used for freeze protection. These heat exchangers must be paired with pumping controls to optimize equipment operations and will have different configurations depending on the particulars of the heat pump product and storage design configuration.

Depending on the specific equipment, heat pumps operate as either single-pass systems (which modulate flow to target a specific high outlet temperature) or multi-pass systems (which use constant flow, requiring multiple passes through the unit to gradually reach the storage setpoint). It is critical to note that a single-pass heat pump may require a separate temperature maintenance system if the heat pump is unable to heat, or has significant capacity derates, at the higher inlet water temperatures expected from the recirculation return (which can reach up to 125°F in multifamily buildings).

While manufacturers provide detailed guidance for appropriately applying their specific products, proper placement of these heat pumps is critical to system performance. They must be installed outdoors or in a sufficient buffer space, such as a large parking garage, to ensure adequate access to fresh air and prevent the recirculation of discharged cold air. Designers must also account for environmental and acoustic factors: units should be elevated above the local snow line to ensure unimpeded airflow during winter and placed away from tenant windows to mitigate noise impacts. They also need to be designed to manage defrost and condensation (Energy Trust of Oregon 2023).

Equipment will use one of several refrigerant classes:

1. **Natural Refrigerants:** R744 (CO_2) is a common natural refrigerant option well-suited for high-temperature DHW. R290 (propane) possesses superior thermodynamic properties and is widely used in Europe, though it currently faces regulatory barriers that limit its use in the United States (Spielman and Ecotope 2024).
2. **Low-GWP Alternatives:** R513A, R32, and R454B represent emerging lower Global Warming Potential (GWP) options which are aligned with current lower GWP regulations.
3. **Legacy HFCs**: R410A and R134a are high-GWP hydrofluorocarbons that are actively being phased out, though they remain available on the market for DHW applications.

7.2.2 Temperature Maintenance

In a typical large multifamily building, hot water must be circulated continuously throughout the primary distribution risers. This ensures that any occupant, anywhere in the building, has quick access to hot water at the tap without a long wait time to clear cold, stagnant water from the piping. Reheating this circulated water—referred to as "temperature maintenance"—consumes about 25-50% of the total heat energy required for a typical multifamily domestic hot water system.

The design and integration of this temperature maintenance system has a profound impact on overall system performance. In fact, the handling of this recirculation loop defines the primary classification for CHPWH system designs according to NEEA's

Advanced Water Heating Specification (AWHS). These classifications, and how they adapt to dual-fuel applications, are detailed below:

- **Return-to-Primary:** In this configuration, the recirculated water mixes directly back into the primary storage volume. While almost all traditional gas systems are designed this way, it has the disadvantage of negatively impacting thermal stratification in heat pump systems. Hot incoming water from the recirculation loop can raise refrigerant pressures and significantly reduce heat pump efficiency. Therefore, dual-fuel return-to-primary designs must be carefully engineered to account for the specific incoming water temperature limitations of the selected heat pumps.

- **Swing Tank:** This design routes the recirculated water to a separate tank located downstream of the primary storage. By isolating the return water, the primary storage can remain fully stratified. If the primary storage is kept at a high enough temperature, it can actually offset much of the temperature maintenance load. While historically standard CHPWH designs use an electric resistance heater for the swing tank, a dual-fuel system can easily utilize a gas water heater as the swing tank with minimal impact on current standard design layouts.

- While **Parallel Loop Tank** is another configuration described in the Advanced Water Heating Specification, it is specific to all-electric systems because it is specifically designed so that the recirculation load can be handled by a separate heat pump with a primary, single pass heat pump, heating only incoming city water.

7.2.3 Gas Water Heater

Gas water heating equipment is generally categorized as either non-condensing (typically ~80% thermal efficiency) or condensing (up to 95-98% thermal efficiency, utilizing a heat exchanger to capture latent heat from the exhaust gases). Condensing equipment requires lower entering water temperatures to achieve higher efficiencies – typically below 130°F with significant efficiency gains realized below 120°F. This cooler water is necessary to drop the exhaust gases below their dew point, forcing the vapor to condense and release latent heat. If a condensing boiler is placed downstream of the heat pumps where it receives pre-heated 140°F water, it will fail to condense and its efficiency will drop significantly. Conversely, non-condensing equipment requires higher entering water temperatures, typically between 130°F and 140°F. Because their internal components are not designed to withstand acidic condensate, operating non-condensing boilers with cold entering water causes condensation that rapidly corrodes and destroys the equipment.

When heating domestic hot water, it is critical to account for the continuous introduction of fresh, oxygenated city water. Standard cast-iron or carbon steel boilers – commonly used for closed-loop hydronic space heating – will rapidly corrode and fail if exposed directly to open potable water. Therefore, equipment used for direct potable water heating utilizes corrosion-resistant heat exchangers rated for potable water, most commonly copper water-tube or stainless steel. If standard closed-loop boilers are utilized in a dual-fuel design, they must be isolated from the potable water supply via an indirect heat exchanger.

Gas water heating equipment generally falls into three primary configuration categories. Each style integrates into a dual-fuel system in slightly different ways, as illustrated in the schematic diagrams in Appendix A:

- **Gas Storage Water Heaters:** These are traditional, self-contained units where the gas burner and heating elements are integrated directly into the bottom or center of a pressurized potable water storage tank.
- **Hot Water Supply Boilers (Volume Water Heaters):** In this configuration, the gas heating plant (the boiler) is separated from the storage volume. A dedicated circulation pump draws cooler water from the bottom of a separate, standalone storage tank, pushes it through the boiler for heating, and returns the hot water to the tank.
- **Tankless (Instantaneous) Water Heaters:** These units do not utilize storage tanks. Instead, they provide instantaneous heating by firing a variable speed high-capacity burner to rapidly heat water to the target setpoint in a single pass as it flows through the unit.

Gas-fired equipment offers several distinct advantages that complement heat pump technology in a dual-fuel design. Gas water heaters can achieve much higher heating capacities within a significantly more compact footprint. Furthermore, because gas combustion relies on fuel rather than extracting heat from the ambient air, the equipment is typically installed indoors (eliminating freeze protection concerns) and its heating capacity does not degrade during extreme cold weather events.

7.2.4 Thermal Storage Tanks

While both gas and heat pump systems typically utilize thermal storage (with the exception of instantaneous gas tankless units), their design approaches, sizing methodologies, and internal tank dynamics differ fundamentally. Dual-fuel systems must carefully balance these differing requirements depending on the selected configuration and the operational goals of the design.

CHPWH systems typically rely on large thermal storage volumes to provide for peak demand periods lasting three or more hours. This thermal battery approach is particularly important for load shifting; it allows the electric heat pumps to be sized smaller (reducing capital costs and electrical infrastructure) and enables them to run for longer, more efficient cycles to slowly recover the tank. Conversely, gas fire systems typically do not require as much thermal storage capacity because they rely on much larger heating capacities to rapidly recover the tanks.

Traditional gas fire storage tanks are specifically designed to mix the water to provide a uniform temperature and prevent stratification.

However, thermal stratification is essential for single-pass heat pump systems because mixing creates two critical performance issues. First, drawing mixed, warmer water instead of cold city water directly reduces the heat pump's heating capacity and efficiency. Second, if the entering water is mixed down below the required supply temperature, the available storage may no longer be adequate to meet the building's peak load. Sizing tools like the Ecosizer rely on both continuous heat pump generation and the full volume of stratified storage to satisfy peak demand periods. Drawing the coldest possible water from the bottom of the tank ensures the system operates at the design parameters required to meet the building's hot water needs.

While the vast majority of stock storage tanks available on the market today are still designed around gas water heating usage (mixing), manufacturers are beginning to develop tanks with specialized inlet diffusers and port configurations specifically engineered to protect stratification for heat pump applications (Spielman and Ecotope 2024).

Most standard stand-alone storage tanks include a single thermowell location to insert a thermostat to control the water heater (gas or electric). To optimally implement load flexibility, it is preferable to use storage tanks which include at least three thermowells distributed up and down the storage tank.

7.2.5 Pressurized vs. Unpressurized Tanks

Primary thermal storage in larger multifamily buildings is most commonly provided via ASME-rated, potable pressurized tanks. Recently, system manufacturers have begun experimenting with unpressurized thermal storage. In these systems, the unpressurized tank holds a stagnant volume of water that acts as a thermal battery, while the potable water is heated as it flows through internal heat exchange coils or an external heat exchanger. This configuration offers several significant advantages for dual-fuel systems, including:

- **Lower Capital Costs:** Unpressurized tanks avoid expensive ASME pressure-vessel requirements.
- **Superior Insulation:** They are easier to wrap in high-R-value insulation, reducing standby losses.
- **Retrofit Feasibility:** They often require less space and can be assembled on-site, making them much easier to maneuver into existing, space-constrained mechanical rooms.
- **Pressure Isolation:** They separate the primary heating equipment from the high-pressure conditions typically required in high-rise buildings.
- **Freeze Protection:** The tank water can be easily treated or managed for freeze protection.

7.2.6 Control System

The control system uses sensors and logic to govern the operation of various components, acting as the critical element necessary to create a reliable and fully integrated dual-fuel system. Detailed control sequences for dual-fuel configurations are provided in Appendix A. While common stand-alone controls can be utilized to achieve the Normal Operation sequences shown in the appendix, they often limit the system to a single operational state and do not provide the level of monitoring required to guarantee continued performance. At the time of writing, at least one manufacturer offers a standard unified central control system which can integrate dual-fuel equipment, provide for load flexibility, and manage actionable M&V . Though originally designed for electric swing tanks, such a controller can also manage a gas swing tank in the flexible manner required for dual-fuel.

Significant benefits are provided by central control systems, which offer robust reliability and logic-based equipment staging. These controllers can actively switch operations to take advantage of time-of-use pricing and reduce overall utility costs. Furthermore, central controllers can incorporate low-cost, standardized monitoring and measurement and verification (M&V) protocols. This integrated monitoring provides the actionable performance feedback necessary to ensure continued system performance and to diagnose potential problems before they lead to system failure.

Regardless of whether stand alone or central controls are used, it is essential that manufacturers provide clear and transparent documentation to practitioners. Installers and commissioning professionals must be able to easily identify which specific temperature sensor is used to control the start and stop of each device, the precise temperatures that trigger a device to turn on or off, and exactly how the various pieces of equipment are staged. More complex control strategies should only be implemented if the sequence of operations is documented with precision. This level of detail is necessary to allow commissioning professionals to write functional test plans that confirm correct operation in the field. Some of the most common issues in the current commercial heat pump water heater market are directly related to control sequences that are either incorrectly implemented or not clearly communicated by manufacturers to the professionals responsible for their installation and maintenance.

7.2.7 Load Shifting

Standard system configuration diagrams available through industry Qualified Products Lists provide examples of best practices for load shift sensors, controls, and operation for all-electric systems (NEEA 2026). For these systems to accomplish load shedding they must rely on adequate thermal storage to carry through any peak periods without the need to operate the heat pumps or back-up equipment. Generally, this is done by using multiple temperature sensors arrayed in the thermal storage tanks and shifting the location of the ON sensor higher in the tank during load shed events.

Dual-fuel systems have the advantage of potentially being able to shift from electric to gas operations in time-of-use fuel pricing or signals from a utility. Appendix A of this report includes recommended best practices for load shift controls for dual-fuel systems.

7.2.8 Temperature Control

Any system which stores hot water above an acceptable delivery temperature must temper the water leaving the DHW system before delivery to the distribution piping to prevent scalding water temperatures delivered to residential fixtures. The choice of tempering technology depends on the system configuration. While traditional non-electric tempering valves are common, they are generally only appropriate for systems with relatively consistent storage temperatures. In many dual-fuel designs, electronic mixing valves are recommended because they can accurately maintain a fixed output temperature even when input temperatures from the heat pump or gas plants vary. However, in return-to-primary systems, the consistent and slow-moving temperatures at the top of the primary storage may allow for the use of standard TMVs. Additionally, some system configurations may use heat exchangers as a primary means to control and isolate temperatures within the various heating loops.

8 Dual-fuel System Sizing

Sizing a standard all-electric CHPWH system requires designing for the design conditions of the highest peak water demand periods combined with the coldest expected ambient air temperatures. Dual-fuel sizing fundamentally shifts this paradigm.

By relying on gas for supplementary heating, the heat pump—typically the most expensive component of the central plant—can be optimally sized for *typical* daily loads and typical milder weather, significantly reducing capital costs.

8.1 Balancing Heat Pump and Gas Capacity

In a dual-fuel configuration, the heat pump can be deliberately "undersized" to handle the baseline hot water demand. For example, an all-electric design for a 100-unit apartment building might require a 165 KBH heat pump plant designed to run 16 hours a day. In a dual-fuel system, that heat pump could be downsized to 67 KBH (a 60% reduction in capacity) by designing it to run continuously for 24 hours on a typical day[7]. A supplementary 100 KBH gas boiler can trim during peak hot water usage periods. Alternatively, the gas equipment can be upsized to cover the entire building load (e.g., 150 KBH), serving as full redundancy during heat pump maintenance, grid emergencies, or to optimize fuel selection based on time-of-use pricing.

8.2 Cold Weather Optimization

The amount of heat a heat pump can produce is directly related to the temperature of the incoming ambient air. Most heat pumps experience a capacity derate in colder temperatures; a unit that outputs 192 KBH at 50°F might only produce 81 KBH at 10°F. Sizing an all-electric system to meet peak demand on that 10°F day is not cost effective since much of the system capacity will not be utilized throughout the year. A dual-fuel approach allows a smaller heat pump to handle 100% of the load most of the year, only requiring the gas system to fire when high usage days coincide with the coldest days of the year.

8.3 Storage and Temperature Strategies

All-electric systems rely on large thermal storage volumes to coast through peak periods, whereas gas systems use large burners for rapid tank recovery. Dual-fuel storage sizing optimizes this balance—leveraging enough storage to maximize the heat pump's operational hours while relying on the rapid recovery of the gas system to reduce the overall required tank footprint. Furthermore, dual-fuel enables specialized approaches like in-series gas "trim tank" configurations. This allows the heat pump to target a lower, more efficient primary storage temperature for better cold-weather performance, while the gas system provides the final temperature boost to the required distribution setpoint.

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[7] Although all manufacturers interviewed have no issues with heat pumps running 24/7, and prefer the longer run cycles, Ecotope is aware of some manufacturers who lock out heat pumps after a certain number of hours per day to meet warranty requirements. Designers should confirm runtime requirements with the equipment manufacturer and adjust controls sequences accordingly.

8.4 The Ecosizer Update

Because dual-fuel sizing requires analyzing complex trade-offs between heat pump capacity, gas recovery, storage volume, and local climate data, the industry will need to rely on sophisticated modeling to estimate what fraction of the annual load will be supplied by each fuel source. To support this need, the industry-standard Ecosizer tool[8] is currently being updated to explicitly include the four primary dual-fuel configurations. This update will allow design teams to more easily explore cost, space, and electrical capacity trade-offs options, making it simple to accurately size reliable, cost-effective dual-fuel systems.

9 Performance Validation

There are a range of system performance metrics which are relevant with respect to dual-fuel systems.

- **System COP (SysCOP):** SysCOP represents the overall efficiency of the combined system in delivering heat to the building. It is defined by the AWHS as the total heat energy output divided by the total site energy (electricity plus gas) consumed. While gas systems typically have SysCOPs of 0.8–0.9 and all-electric CHPWH systems range from 2.0 to 3.5, dual-fuel systems fall between these ranges depending on the fuel balance. For all-electric systems, SysCOP is a primary metric for determining savings against a baseline; however, it is less useful for dual-fuel comparative analysis because it aggregates two different energy inputs. While SysCOP can confirm if a dual-fuel system is operating as intended, the individual efficiencies of the gas and electric components may provide more value for baseline comparisons and for calculating specific energy savings.

- **Equipment Efficiency:** It is relevant to understand the relative efficiency of the equipment selected for a dual-fuel system – including heat pump equipment COP and gas boiler efficiency. Equipment efficiency is typically determined at a standard reference condition and reported by the manufacturer. This could be relevant to utility programs to incentivize better-than-minimum equipment selection on either the gas or electric side.

- **Energy Savings:** Gas savings could be a relevant metric for gas efficiency programs. This would be the fraction of the gas load offset by the heat pump system and any higher-than-baseline gas equipment efficiency. Gas savings could be calculated based on bills for an existing gas-fired system or based on

[8] See https://ecosizer.ecotope.com/sizer/.

modeling with an assumed code-minimum gas fired system. Electric savings could be calculated based on the electric component of the SysCOP compared to an electric resistance or a NEEA QPL tier 1 CHPWH.

- **Carbon Reduction:** Similar to gas savings, carbon reductions could be calculated based on the fraction of the load offset by heat pumps, the relative efficiency of the gas equipment compared to baseline, and the assumed carbon content of the electricity.
- **Electric Load Factor:** This metric is the ratio of average load to peak load. It gives a measure of how well the electric demand is spread across the day. Smaller heat pumps with supplemental gas will have much more grid-friendly load factors than systems sized to meet peak loads.
- **Peak Demand Reduction (KW or %):** This is a measure of how well a given electrical load can be shifted away from a given peak utility period. Depending on the given utility rate structure and system control package, dual-fuel systems could be operated to avoid electric utility peaks completely.

9.1 Measurement and Verification

Based on field experience monitoring dozens of commercial heat pump water heating systems, it is evident that without monitoring, it is difficult to maintain system performance over time. Without proper measurement and verification (M&V) and system alarms, it is highly likely that malfunctioning dual-fuel systems will go unnoticed, silently reverting to operate primarily as gas-fired systems.

NEEA's Advanced Water Heater Specification (AWHS) currently includes minimum requirements for system failure alarms and outlines best practices for M&V (Appendix H) to provide the data points necessary to diagnose potential problems. While the AWHS does not explicitly exclude dual-fuel systems, it was written primarily with all-electric systems in mind. To ensure dual-fuel systems operate reliably and efficiently, this feasibility study recommends that the next version of the AWHS be expanded to include dual-fuel systems and provide M&V guidance.

- **Expanded Measurement & Verification:** The M&V guidelines in the AWHS must be expanded to monitor the gas system. Ideally, this would include a dedicated gas meter to accurately measure the gas system's energy use. Because commercial gas meters can be expensive, future research should be devoted to validating alternative, cost-effective methods for estimating gas energy use—such as measuring water flow and temperature differentials and applying an assumed equipment efficiency based on the specific configuration and average water temperatures.

- **System COP Definition:** System COP for dual-fuel systems is inherently complex and must be explicitly defined within the specification. It is recommended that the dual-fuel System COP calculation combine the energy content of the gas consumed with the electrical energy used to establish the "Total Energy Usage" in the denominator. Additionally, the specification must account for how system sizing impacts this metric, as the ratio of heat pump capacity to gas capacity will have a massive impact on the overall System COP if the heat pump is sized to carry only a specific portion of the annual load.

- **Gas Savings Calculations:** The AWHS should outline standardized calculation methodologies that use the data from the recommended dual-fuel monitoring options. Establishing these standard calculations will allow practitioners and utility programs to accurately estimate and verify ongoing gas savings in the field.

10 Conclusions, Recommendations, and Future Research

When designed properly, dual-fuel domestic hot water systems present clear advantages over all-electric systems, particularly for retrofitting existing buildings currently served by gas appliances. They offer a practical pathway to significant energy and carbon reduction while avoiding costly electrical infrastructure upgrades and space constraints.

To realize these benefits, the industry must draw on lessons learned from the Advanced Water Heating Initiative (AWHI) regarding all-electric systems: dual-fuel plants must be treated and designed as unified, single systems rather than disparate parts. Furthermore, the success of these systems relies on consistent control strategies and measurement and verification (M&V). Without reliable controls and ongoing M&V, dual-fuel systems risk reverting to gas-dominant operation, negating their efficiency and gas savings benefits.

To facilitate market transformation and support the reliable deployment of dual-fuel systems, the following actions are recommended:

- **Apply Best Practice Designs:** Design teams and sales engineers should use the schematic design documents, control sequences, and M&V plans developed in this Feasibility Study. These materials serve as foundational training content and best practice design guidance. As dual-fuel systems gain traction, increasing numbers of installed systems will lead to feedback on the best practice designs provided in this study. Program administrators and industry stakeholders should plan to gather feedback and support iteration of the best practice material based on findings as installation numbers grow. These best practices should be integrated into future versions of the Advanced Water Heater Specification.

- **Engage in Code Development:** Current energy codes generally allow dual-fuel water heating systems. However, some provisions—particularly capacity-based requirements and prescriptive compliance pathways—can increase design complexity or limit flexibility relative to all-electric heat pump systems. Engagement with the Washington and Seattle code development process is encouraged to integrate explicit, simplified compliance pathways for dual-fuel systems in existing building retrofits to encourage partial step-wise decarbonization.

- **Expand the AWHS:** Update NEEA's Advanced Water Heating Specification (AWHS) to explicitly include dual-fuel configurations. This expansion should establish standards for gas and electric component sizing, required control settings, alarming, M&V, and sequence of operations.

- **Expand the Ecosizer Tool:** Update the Ecosizer design tool to address dual-fuel configurations and multi-pass heat pump systems, allowing designers to accurately balance heat pump capacity, gas recovery, and storage volume.

To further develop the dual-fuel market, future research and program efforts should focus on the following areas:

- **Field Monitoring:** Monitor the performance of early dual-fuel demonstration projects and case studies to validate design assumptions, control sequences, and predicted gas savings.

- **Cost-Effective M&V:** Engage with vendors through funded research collaboration, incentive design, and regulatory frameworks to define the minimum viable M&V requirements necessary to ensure long-term performance and encourage its inclusion in vendors standard central control systems.

- **Best Practice Iteration:** Use data collected from field monitoring and vendor collaboration to iterate on the provided best practice diagrams and controls.

- **Sizing Trade-offs:** Investigate the specific cost, space, and electrical capacity impacts associated with different dual-fuel sizing approaches (e.g., sizing the heat pump for average load vs. mild-weather load).

- **Dual-fuel Program development:** The sharing of opportunities and advantages available through dual-fuel systems with utilities and utility regulators can help advance the development of dual-fuel program incentives to help incentivize the market toward these solutions.

Finally, while this feasibility study primarily addresses domestic hot water (DHW) in multifamily buildings, the strategies and system configurations explored here have broad applicability across the commercial sector. Extending this work through future research and program initiatives in the following areas is recommended:

- **Commercial Hydronic Space Heating and Combi Systems:** The dual-fuel strategies and equipment detailed in this report can be closely adapted for commercial hydronic space heating. This technical overlap presents a significant opportunity to investigate "combi" systems, which utilize a single outdoor air-to-water heat pump plant to supplement a hydronic gas heating system and simultaneously provide both space conditioning and DHW. Future research should evaluate how the sizing methodologies, control logic, and M&V findings from this initiative can be applied to develop this new market segment and provide additional gas savings opportunities.

- **High-use DHW Commercial Applications:** There is substantial natural gas consumption associated with DHW in other commercial sectors, most notably in hotels, food service, restaurants, natatoriums, and grocery applications. Because this study focused strictly on the multifamily sector, further research is recommended to determine how standard dual-fuel heat pump configurations can be effectively integrated into the specific plumbing, mechanical, and operational demands of these high-usage commercial facilities.

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Appendix A – Dual-fuel Piping Configurations and Controls

LOAD SHIFT SCHEDULE AND SIGNALING

THE CHPWH SHALL BE CAPABLE OF ADJUSTING ITS CONTROL SETPOINTS BASED ON LOAD SHIFT OPERATING STATE (NORMAL, SHED, CRITICAL PEAK, GRID EMERGENCY, LOAD UP, ADVANCED LOAD UP) PER THE "PRIMARY AND SWING TANK SETPOINTS" TABLE. THE CHPWH SYSTEM SHALL BE CAPABLE OF ADJUSTING ITS LOAD SHIFT OPERATING STATE IN RESPONSE TO:

1. LOAD SHIFT SIGNAL IS RECEIVED THROUGH CTA-2045B PROTOCOL.
2. PRE-PROGRAMMED LOAD SHIFT SCHEDULES.

THE CHPWH SHALL BE CAPABLE OF STORING A MINIMUM OF TWO "HOUR OF DAY" LOAD SHIFT SCHEDULES AND ONE "DAY OF THE WEEK" SCHEDULE. THE HOUR OF DAY SCHEDULES SHALL DICTATE WHICH LOAD SHIFT OPERATING STATE TO RUN IN FOR EACH HOUR. THE DAY OF THE WEEK SCHEDULE TELLS WHICH SCHEDULE TO OPERATE IN ON EACH DAY OF THE WEEK. NOTE: REFERENCE LOCAL UTILITY RATE STRUCTURE TO OPTIMIZE THIS SCHEDULE.

EXAMPLE HOUR OF DAY SCHEDULES

HOUR	LOAD SHIFT REQUEST SCHEDULE 1	LOAD SHIFT REQUEST SCHEDULE 2
1:00 AM	NORMAL	NORMAL
2:00 AM	NORMAL	NORMAL
3:00 AM	NORMAL	NORMAL
4:00 AM	NORMAL	NORMAL
5:00 AM	NORMAL	NORMAL
6:00 AM	NORMAL	NORMAL
7:00 AM	NORMAL	NORMAL
8:00 AM	NORMAL	NORMAL
9:00 AM	NORMAL	NORMAL
10:00 AM	NORMAL	NORMAL
11:00 AM	NORMAL	NORMAL
12:00 PM	LOAD UP	NORMAL
1:00 PM	LOAD UP	NORMAL
2:00 PM	LOAD UP	NORMAL
3:00 PM	LOAD UP	NORMAL
4:00 PM	SHED	NORMAL
5:00 PM	SHED	NORMAL
6:00 PM	SHED	NORMAL
7:00 PM	SHED	NORMAL
8:00 PM	SHED	NORMAL
9:00 PM	SHED	NORMAL
10:00 PM	SHED	NORMAL
11:00 PM	SHED	NORMAL
12:00 AM	NORMAL	NORMAL

EXAMPLE DAY OF WEEK SCHEDULE

MONDAY	SCHEDULE 1
TUESDAY	SCHEDULE 1
WEDNESDAY	SCHEDULE 1
THURSDAY	SCHEDULE 1
FRIDAY	SCHEDULE 1
SATURDAY	SCHEDULE 2
SUNDAY	SCHEDULE 2

SEQUENCE OF OPERATIONS

1. SINGLE PASS CHPWH(S)
   1.1. ENABLE FIRST CHPWH WHEN "ON SENSOR" IS COOLER THAN "ON TEMPERATURE". STAGE ADDITIONAL CHPWHS PER MANUFACTURER GUIDANCE OR FOLLOW TEMPERATURE STAGING APPROACH OUTLINED BELOW:
   1.2. IF MULTIPLE STAGES OF CHPWH ARE INSTALLED INITIATE ADDITIONAL CHPWH STAGE FOR EVERY 2°F BELOW "ON TEMPERATURE" OR IF "ON SENSOR" REMAINS COOLER THAN "ON TEMPERATURE" AFTER 30 MINUTES, WHICHEVER HAPPENS FIRST.
      1.2.1. CHPWHS WITH THE LOWEST ACCUMULATED RUN TIME SHALL BE CALLED TO RUN FIRST.
      1.2.2. IF MORE THAN 3 CHPWH STAGES ARE USED, INITIATE STAGES AT 1°F INCREMENTS AND ADJUST TIME CRITERIA TO 15 MINUTES. DO NOT USE MORE THAN 6 STAGES.
   1.3. DISABLE ALL HEATERS WHEN "OFF SENSOR" IS WARMER THAN "OFF TEMPERATURE".
   1.4. UPON CHANGE OF LOAD SHIFT OPERATION, DISABLE ALL HEATERS IF "ON SENSOR" IS WARMER THAN "ON TEMPERATURE".
2. GAS SWING TANK(S):
   2.1. ENABLE GAS SWING TANK HEATER WHEN REFERENCE TEMPERATURE SENSOR IS COOLER THAN ("SETPOINT" - "DEADBAND").
   2.2. DISABLE SWING TANK HEATER WHEN REFERENCE TEMPERATURE SENSOR IS WARMER THAN "SETPOINT".
3. GAS BACK-UP MODE:
   3.1. BACK-UP MODE SHALL BE ENABLED MANUALLY BY OPERATOR AND LAST 48 HOURS OR UNTIL MANUALLY DISABLED - WHICHEVER OCCURS FIRST.
   3.2. USE TE-07 INSTEAD OF TE-06 TO ENABLE/DISABLE GAS SWING TANK. INCREASE SETPOINT TO 150°F.
4. MIXING VALVE SHALL MAINTAIN A HOT WATER SUPPLY TEMPERATURE (TE-05) SETPOINT AT OR ABOVE 125°F.
5. HOT WATER CIRCULATION PUMP:
   5.1. MAINTAIN THE MINIMUM FLOW REQUIRED BY THE MIXING VALVE MANUFACTURER AT ALL TIMES.
   5.2. PROVIDE THE MINIMUM FLOW POSSIBLE THAT DELIVERS 122°F HOT WATER RETURN TEMPERATURE.
   5.3. DISTRIBUTION LOOPS WITH MULTIPLE BALANCED BRANCHES:
      5.3.1. SET PUMP TO CONSTANT OR PROPORTIONAL PRESSURE IF SERVING THERMOSTATIC BALANCING VALVES. ENSURE VALVE DIALS ARE SET TO DESIGN RETURN TEMPERATURE.
      5.3.1. SET PUMP TO CONSTANT PRESSURE IF SERVING PRESSURE INDEPENDENT BALANCING VALVES OR MANUAL BALANCING VALVES. MANUALLY ADJUST VALVES TO CALCULATED GPMS.
      5.3.1. IF USING A CONSTANT SPEED PUMP, MANUALLY ADJUST VALVES TO CALCULATED GPMS. USE BALANCING VALVE AT RECIRCULATION PUMP IF REQUIRED TO FURTHER REDUCE FLOW.
   5.4. DISTRIBUTION LOOPS WITH SINGLE PIPE RUNS (WITHOUT MULTIPLE BRANCHES) AND VARIABLE SPEED RECIRCULATION PUMP(S): SET PUMP TO CONSTANT TEMPERATURE.
   5.5. DISTRIBUTION LOOPS WITH SINGLE PIPE RUNS (WITHOUT MULTIPLE BRANCHES) AND CONSTANT SPEED RECIRCULATION PUMP(S): ADJUST BALANCING VALVE AT PUMP TO TARGET RETURN TEMPERATURE.
6. ALARMS SHALL BE INITIATED IN THE FOLLOWING CONDITIONS AT A MINIMUM:
   6.1. HPWH EXPERIENCES A FAULT CONDITION.
   6.2. GAS SWING TANK EXPERIENCES A FAULT CONDITION.
   6.3. MIXING VALVE OUTLET TEMPERATURE DROPS BELOW SETPOINT BY 5°F FOR MORE THAN 15 MINUTES.
   6.4. MIXING VALVE OUTLET TEMPERATURE RISES ABOVE SETPOINT BY 10°F FOR MORE THAN 5 MINUTES.

CONTROLS POINTS LIST

TAG	LOCATION
TEMPERATURE SENSORS	
TE-01	PRIMARY STORAGE LOW (10-25% AQUASTAT FRACTION)
TE-02	PRIMARY STORAGE MID (30-45% AQUASTAT FRACTION)
TE-03	PRIMARY STORAGE HIGH (65-85% AQUASTAT FRACTION)
TE-04	HPWH INLET(S)
TE-05	HOT WATER SUPPLY
TE-06	SWING TANK LOW (20-45% AQUASTAT FRACTION)
TE-07	SWING TANK HIGH (65-85% AQUASTAT FRACTION)
CHPWH INTERNAL POINTS	
HPWH INTERNAL FAULT	HPWH(S) (INTERNAL)
HPWH ENABLE/DISABLE	HPWH(S) (INTERNAL)
HPWH OUTLET TEMP SETPOINT	HPWH(S) (INTERNAL)

WATER HEATER SETPOINTS

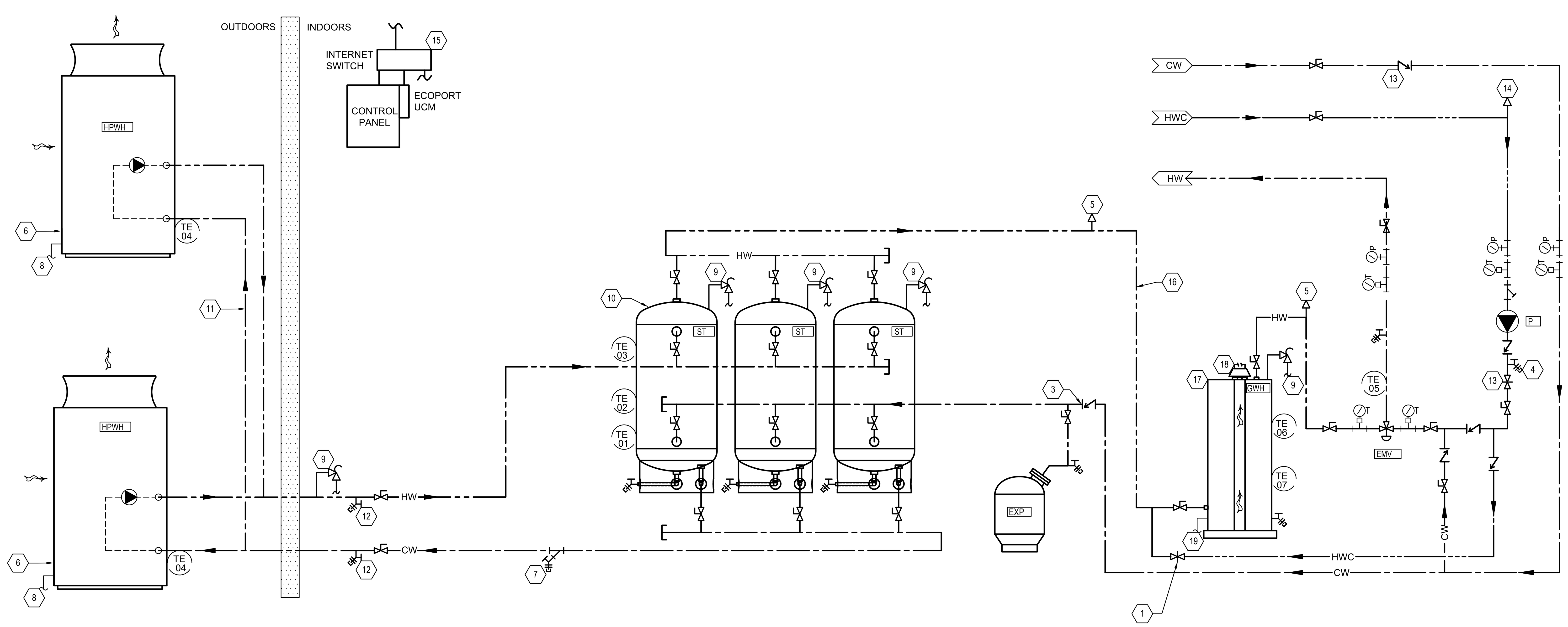
LOAD SHIFT MODE	NORMAL OPERATION	SHED	CRITICAL PEAK EVENT	GRID EMERGENCY	LOAD UP	ADV. LOAD UP
SINGLE PASS CHPWH SETPOINTS						
OUTLET TEMPERATURE	160°F	150°F	140°F	DISABLED	160°F	180°F
ON SENSOR	TE-02	TE-03	TE-03	DISABLED	TE-01	TE-01
ON TEMPERATURE	120°F	120°F	120°F	DISABLED	120°F	120°F
OFF SENSOR	TE-01	TE-02	TE-02	DISABLED	TE-04 (HPWH INLET TEMP)	TE-04 (HPWH INLET TEMP)
OFF TEMPERATURE	140°F	140°F	140°F	DISABLED	125°F	125°F
GAS WATER HEATER SETPOINTS						
SETPOINT (DEADBAND)	130°F (5°F)	140°F (5°F)	140°F (5°F)	150°F (5°F)	130°F (5°F)	130°F (5°F)
SENSOR	TE-06	TE-06	TE-07	TE-07	TE-06	TE-06

GENERAL NOTES

A. THIS SHEET PROVIDES A DETAILED GENERIC REPRESENTATION OF A SINGLE PASS CHPWH WITH A GAS SWING TANK. NOTE THAT THE QUANTITY OF CHPWHS, GAS WATER HEATERS, AND STORAGE TANKS IS SIMPLY REPRESENTATIVE AND CAN BE ADJUSTED FOR THE INDIVIDUAL DESIGN.
B. THE DIAGRAM AND CONTROLS SHOWN ARE SUGGESTED WITH REQUIREMENTS FOR NORTHWEST ENERGY EFFICIENCY ALLIANCE LISTING CALLED OUT IN THE ADVANCED WATER HEATING SPECIFICATION.
C. SIZE SYSTEM WITH MANUFACTURER APPROVED SIZING TOOL. REFERENCE MANUFACTURER DOCUMENTATION TO DETERMINE CAPACITY AT VARIABLE OUTDOOR AIR TEMPERATURES. IF NO DEFROST DERATE IS PROVIDED BY MANUFACTURER, A MINIMUM 20% DERATE IS RECOMMENDED.
D. FOLLOW MANUFACTURERS PRODUCT SPECIFIC GUIDANCE FOR EQUIPMENT CONNECTIONS - PLUMBING, ELECTRICAL, GAS, STRUCTURAL, CONDENSATE, AND COMMUNICATION - INCLUDING MAXIMUM DISTANCE BETWEEN EQUIPMENT AND STORAGE TANK(S) AND PIPING OF MULTIPLE HEATERS SERVING A SINGLE LOAD.
E. INSTALL PER LOCAL BUILDING CODES. CONSULT STRUCTURAL ENGINEER IF NEEDED. PROVIDE SEISMIC STRAP AS REQUIRED BY LOCAL CODE.
F. REFER TO AWHS APPENDIX H FOR MINIMUM M&V INSTALLATION GUIDELINES.

SHEET NOTES

1. BALANCING VALVE REQUIRED TO FORCE AS MUCH RECIRCULATION AS POSSIBLE TO THE MIXING VALVE COLD INLET. SET BALANCING VALVE TO MINIMUM POSSIBLE FLOW THAT MAINTAINS STABLE MIXING VALVE OPERATION WHEN SYSTEM HAS NO HW DRAW.
2. BALANCING VALVE ONLY REQUIRED WHEN CONSTANT SPEED RECIRCULATION PUMP IS USED.
3. SPRING CHECK VALVE OR HEAT TRAP REQUIRED ON STORAGE TANK INLET. EXPANSION TANK MAY BE MOVED TO COLD WATER OUTLET TO HEAT PUMPS.
4. DRAIN VALVE AFTER RECIRCULATION PUMP IS REQUIRED FOR MAINTENANCE AND STARTUP TESTING. USE DRAIN VALVE TO PURGE AIR AND DRAW WATER DURING STARTUP AND COMMISSIONING.
5. AUTOMATIC AIR VENTS WITH SERVICE CHECK VALVES REQUIRED AT ALL HIGH POINTS. PROVIDE CLEARANCE ABOVE AIR VENT SUFFICIENT TO REPLACE DEVICE.
6. INCLUDE A CHECK VALVE ON EACH HEAT PUMP IF THERE IS NO INTERNAL VALVE (EITHER CONTROL VALVE OR CHECK VALVE) TO PREVENT BACKFLOW WHEN NOT OPERATING.
7. STRAINER MAY BE LOCATED AT EACH HEAT PUMP, INTERNAL TO THE HEAT PUMP OR, AS DEPICTED, ON THE COMMON PIPE SERVING ALL HEAT PUMPS.
8. ROUTE CONDENSATE OUTLET TO ACCEPTABLE DRAIN PER LOCAL REQUIREMENTS. PROVIDE HEAT TRACE OR HEATING PAD ON BOTTOM OF CONDENSATE PAN AND DRAIN LINE FOR FREEZE PROTECTION IN CLIMATES WHERE FREEZING IS POSSIBLE. INSULATE CONDENSATE DRAIN LINE OVER HEAT TRACE IS INSTALLED. CONDENSATE WILL NOT BE PRODUCED IS HEAT PUMP IS NOT OPERATIONAL SO CONDENSATE FREEZE PROTECTION IS ONLY REQUIRED WHEN HEAT PUMP IS POWERED.
9. ROUTE ALL T&P VALVES TO ACCEPTABLE DRAIN PER LOCAL REQUIREMENTS.
10. THERMAL STORAGE TANKS MAY BE PIPED IN PARALLEL OR SERIES BUT NOT A COMBINATION OF PARALLEL AND SERIES. UNPRESSURIZED STORAGE MAY ALSO BE USED WHEN HEAT EXCHANGER SYSTEM IS APPROPRIATELY DESIGNED BY A PROFESSIONAL ENGINEER. WHEN PIPED IN PARALLEL, CLOSE TO EQUAL PIPE LENGTHS ARE REQUIRED TO CREATE EQUAL PRESSURE DROP. PARALLEL SYSTEMS WITH THREE OR MORE TANKS MUST BE PIPED IN REVERSE RETURN. CAPPED HEADERS ARE RECOMMENDED ON REVERSE RETURN PIPING TO SUPPORT EQUAL FLOW. STORAGE SYSTEMS ARE RECOMMENDED TO HAVE NO MORE THAN 3 TANKS AND STRONGLY RECOMMENDED TO HAVE NO MORE THAN 5 TANKS. PROVIDE CLEARANCE IN FRONT OF STORAGE TANKS TO REPLACE ANODES. PROVIDE CLEARANCE AND EGRESS TO REMOVE AND REPLACE STORAGE TANK IN CASE OF FAILURE.
11. FREEZE PROTECTION REQUIRED ON ALL WATER PIPING AND EQUIPMENT COMPONENTS AT RISK OF FREEZING. INCLUDE PROVISIONS TO ENSURE FREEZE PROTECTION FUNCTIONAL DURING POWER OUTAGE. FREEZE PROTECTION METHODS MAY INCLUDE HEAT TRACE ON BACKUP POWER, GLYCOL, AUTOMATIC ISOLATION AND DRAIN VALVES, OR OTHER METHOD ACCEPTABLE FOR CLIMATE AND SYSTEM OWNER.
12. ISOLATION AND DRAIN VALVES STRONGLY RECOMMENDED AT LOW POINT INDOORS OR OUTDOORS TO ALLOW HEAT PUMPS TO BE DRAINED OF WATER.
13. IN SOME JURISDICTIONS A CHECK VALVE IS REQUIRED ON THE COLD WATER SUPPLY SIDE FOR BACKFLOW PREVENTION.
14. IN SOME JURISDICTIONS AN AUTOMATIC AIR RELEASE VALVE IS REQUIRED AT THE TOP OF A VERTICAL SECTION OF RECIRCULATION RETURN PIPE (12" MINIMUM) BEFORE THE INLET TO THE RECIRCULATION PUMP AND NO MORE THAN 4 FEET FROM THE PUMP. THE VALVE SHALL BE ACCESSIBLE FOR REPLACEMENT AND REPAIR.
15. HARDWIRED NETWORK CONNECTION INFRASTRUCTURE TO ENABLE CURRENT OR FUTURE INTERNET CONNECTIVITY IS REQUIRED FOR LOAD SHIFT AND/OR M&V CAPABLE SYSTEMS. CONNECT TO BUILDING INTERNET PROVIDER IF APPROVED. OTHERWISE, ROUTE CABLING TO A LOCATION SUITABLE FOR FUTURE CELLULAR MODEM INSTALLATION.
16. HEAT TRAP REQUIRED WITHIN IN 30 FEET OF PRIMARY WATER OUTLET. HEAT TRAP INSTALLED BY DROPPING PIPE A MINIMUM OF 12" BELOW STORAGE TANK CONNECTION.
17. SEPARATE TANK AND GAS BOILER MAY ALSO BE USED INSTEAD OF INTEGRATED GAS TANK.
18. FLUE CONNECTION REQUIRED FOR GAS WATER HEATER. FOLLOW MANUFACTURERS GUIDELINES AND LOCAL CODES FOR INSTALLATION. ROUTE TO APPROPRIATE EXHAUST LOCATION. PROVIDE ADEQUATE PATH FOR MAKEUP COMBUSTION AIR.
19. FOR CONDENSING GAS EQUIPMENT, CONDENSATE DRAIN REQUIRED WITH CONDENSATE NEUTRALIZER KIT.



1 WATER HEATING PLANT P&ID

Scale: NTS

LEGEND

PIPING COMPONENTS AND VALVES

- MIXING VALVE
- SHUT-OFF VALVE (BALL, GATE, OR BUTTERFLY)
- CHECK VALVE
- BALANCING VALVE
- DRAIN VALVE
- AUTOMATIC AIR VENT
- STRAINER
- PRESSURE GAUGE
- TEMPERATURE GAUGE
- PRESSURE RELIEF VALVE
- PUMP
- STRAINER

INSTRUMENTS

- FM XX — FLOW METER
- TE XX — TEMPERATURE SENSOR

GENERAL SHEET SYMBOLS

- # — PLAN NOTE REFERENCE SYMBOL

ABBREVIATIONS

CW	COLD WATER
HW	HOT WATER
HWC	HOT WATER RECIRCULATION
ST	STORAGE TANK
P	PUMP
GWH	GAS WATER HEATER
CHPWH, HPWH, OR HEAT PUMP	COMMERCIAL HEAT PUMP WATER HEATER
EXP	EXPANSION TANK
EMV	ELECTRONIC MIXING VALVE

ECOTOPE

neea

PROJECT

COMMERCIAL HPWH - GAS SWING TANK

NORTHWEST ENERGY EFFICIENCY ALLIANCE

ADVANCED WATER HEATING SPECIFICATION

DATE 01/22/2026

REVISIONS

LOAD SHIFT SCHEDULE AND SIGNALING

THE CHPWH SHALL BE CAPABLE OF ADJUSTING ITS CONTROL SETPOINTS BASED ON LOAD SHIFT OPERATING STATE (NORMAL, SHED, CRITICAL PEAK, GRID EMERGENCY, LOAD UP, ADVANCED LOAD UP) PER THE "PRIMARY WATER HEATER SETPOINTS" TABLE. THE CHPWH SYSTEM SHALL BE CAPABLE OF ADJUSTING ITS LOAD SHIFT OPERATING STATE IN RESPONSE TO:

1. LOAD SHIFT SIGNAL IS RECEIVED THROUGH CTA-2045B PROTOCOL.
2. PRE-PROGRAMMED LOAD SHIFT SCHEDULES.

THE CHPWH SHALL BE CAPABLE OF STORING A MINIMUM OF TWO "HOUR OF DAY" LOAD SHIFT SCHEDULES AND ONE, "DAY OF THE WEEK" SCHEDULE. THE HOUR OF DAY SCHEDULES SHALL DICTATE WHICH LOAD SHIFT OPERATING STATE TO RUN IN FOR EACH HOUR. THE DAY OF THE WEEK SCHEDULE TELLS WHICH SCHEDULE TO OPERATE IN ON EACH DAY OF THE WEEK. NOTE: REFERENCE LOCAL UTILITY RATE STRUCTURE TO OPTIMIZE THIS SCHEDULE.

EXAMPLE HOUR OF DAY SCHEDULES

HOUR	LOAD SHIFT REQUEST SCHEDULE 1	LOAD SHIFT REQUEST SCHEDULE 2
1:00 AM	NORMAL	NORMAL
2:00 AM	NORMAL	NORMAL
3:00 AM	NORMAL	NORMAL
4:00 AM	NORMAL	NORMAL
5:00 AM	NORMAL	NORMAL
6:00 AM	NORMAL	NORMAL
7:00 AM	NORMAL	NORMAL
8:00 AM	NORMAL	NORMAL
9:00 AM	NORMAL	NORMAL
10:00 AM	NORMAL	NORMAL
11:00 AM	NORMAL	NORMAL
12:00 PM	LOAD UP	NORMAL
1:00 PM	LOAD UP	NORMAL
2:00 PM	LOAD UP	NORMAL
3:00 PM	LOAD UP	NORMAL
4:00 PM	SHED	NORMAL
5:00 PM	SHED	NORMAL
6:00 PM	SHED	NORMAL
7:00 PM	SHED	NORMAL
8:00 PM	SHED	NORMAL
9:00 PM	SHED	NORMAL
10:00 PM	SHED	NORMAL
11:00 PM	SHED	NORMAL
12:00 AM	NORMAL	NORMAL

EXAMPLE DAY OF WEEK SCHEDULE

MONDAY	SCHEDULE 1
TUESDAY	SCHEDULE 1
WEDNESDAY	SCHEDULE 1
THURSDAY	SCHEDULE 1
FRIDAY	SCHEDULE 1
SATURDAY	SCHEDULE 2
SUNDAY	SCHEDULE 2

SEQUENCE OF OPERATIONS

1. SINGLE PASS WATER HEATERS
   - 1.1. ENABLE AND DISABLE CHPWH(S) AND GAS WATER HEATER(S) AS INDICATED IN THE "WATER HEATER SETPOINTS" TABLE. ADJUSTED CHPWH SETPOINTS BASED ON LOAD SHIFT MODE.
   - 1.2. ENABLE THE FIRST STAGE OF CHPWH OR GAS WATER HEATER WHEN THE "ON SENSOR" IS COOLER THAN THE "ON TEMPERATURE". STAGE ADDITIONAL CHPWHS PER MANUFACTURERS GUIDANCE OR FOLLOW TEMPERATURE STAGING APPROACH OUTLINED BELOW:
   - 1.3. IF MULTIPLE STAGES ARE INSTALLED INITIATE ADDITIONAL STAGE FOR EVERY 2°F BELOW "ON TEMPERATURE" OR IF "ON SENSOR" REMAINS COOLER THAN "ON TEMPERATURE" AFTER 30 MINUTES, WHICHEVER HAPPENS FIRST.
     - 1.3.1. WATER HEATERS WITH THE LOWEST ACCUMULATED RUN TIME SHALL BE CALLED TO RUN FIRST.
     - 1.3.2. IF MORE THAN 3 STAGES ARE USED, INITIATE STAGES AT 1°F INCREMENTS AND ADJUST TIME CRITERIA TO 15 MINUTES. MORE THAN 6 STAGES IS NOT RECCOMMENDED.
   - 1.4. DISABLE ALL HEATERS WHEN "OFF SENSOR" IS WARMER THAN "OFF TEMPERATURE".
   - 1.5. UPON CHANGE OF LOAD SHIFT OPERATION, DISABLE ALL HEATERS IF "ON SENSOR" IS WARMER THAN "ON TEMPERATURE".
2. GAS BACK-UP MODE:
   - 2.1. BACK-UP MODE SHALL BE ENABLED MANUALLY BY OPERATOR AND LAST 48 HOURS OR UNTIL MANUALLY DISABLED - WHICHEVER OCCURS FIRST.
   - 2.2. OPERATE GAS WATER HEATERS AS INDICATED UNDER "GRID EMERGENCY" WHILE MANTAINING HEAT PUMP OPERATION PER CURRENT STATE.
3. INCREASE GAS HEATER SETPOINT TO 150°F.
4. MIXING VALVE SHALL MAINTAIN A SUPPLY WATER TEMPERATURE SETPOINT AT OR ABOVE 125°F.
5. HOT WATER CIRCULATION PUMP:
   - 5.1. MAINTAIN THE MINIMUM FLOW REQUIRED BY THE MIXING VALVE MANUFACTURER AT ALL TIMES.
   - 5.2. PROVIDE THE MINIMUM FLOW POSSIBLE THAT DELIVERS 122°F HOT WATER RETURN TEMPERATURE.
   - 5.3. DISTRIBUTION LOOPS WITH MULTIPLE BALANCED BRANCHES:
     - 5.3.1. SET PUMP TO CONSTANT OR PROPORTIONAL PRESSURE IF SERVING THERMOSTATIC BALANCING VALVES. ENSURE VALVE DIALS ARE SET TO DESIGN RETURN TEMPERATURE.
     - 5.3.2. SET PUMP TO CONSTANT PRESSURE IF SERVING PRESSURE INDEPENDENT BALANCING VALVES OR MANUAL BALANCING VALVES. MANUALLY ADJUST VALVES TO CALCULATED GPMS.
     - 5.3.3. IF USING A CONSTANT SPEED PUMP, MANUALLY ADJUST VALVES TO CALCULATED GPMS. USE BALANCING VALVE AT RECIRCULATION PUMP IF REQUIRED TO FURTHER REDUCE FLOW.
   - 5.4. DISTRIBUTION LOOPS WITH SINGLE PIPE RUNS (WITHOUT MULTIPLE BRANCHES) AND VARIABLE SPEED RECIRCULATION PUMP(S): SET PUMP TO CONSTANT TEMPERATURE.
6. ALARMS SHALL BE INITIATED IN THE FOLLOWING CONDITIONS AT A MINIMUM:
   - 6.1. HPWH EXPERIENCES A FAULT CONDITION.
   - 6.2. GAS WATER HEATER EXPERIENCES A FAULT CONDITION.
   - 6.3. MIXING VALVE OUTLET TEMPERATURE DROPS BELOW SETPOINT BY 5°F FOR MORE THAN 15 MINUTES.
   - 6.4. MIXING VALVE OUTLET TEMPERATURE RISES ABOVE SETPOINT BY 10°F FOR MORE THAN 5 MINUTES.

CONTROLS POINTS LIST

TAG	LOCATION
TEMPERATURE SENSORS	
TE-01	STORAGE LOW (10-25% AQUASTAT FRACTION)
TE-02	STORAGE MID (30-45% AQUASTAT FRACTION)
TE-03	STORAGE HIGH (65-85% AQUASTAT FRACTION)
TE-04	HPWH INLET(S)
TE-05	HOT WATER SUPPLY
CHPWH INTERNAL POINTS	
HPWH INTERNAL FAULT	HPWH(S) (INTERNAL)
HPWH ENABLE/DISABLE	HPWH(S) (INTERNAL)
HPWH OUTLET TEMP SETPOINT	HPWH(S) (INTERNAL)

WATER HEATER SETPOINTS

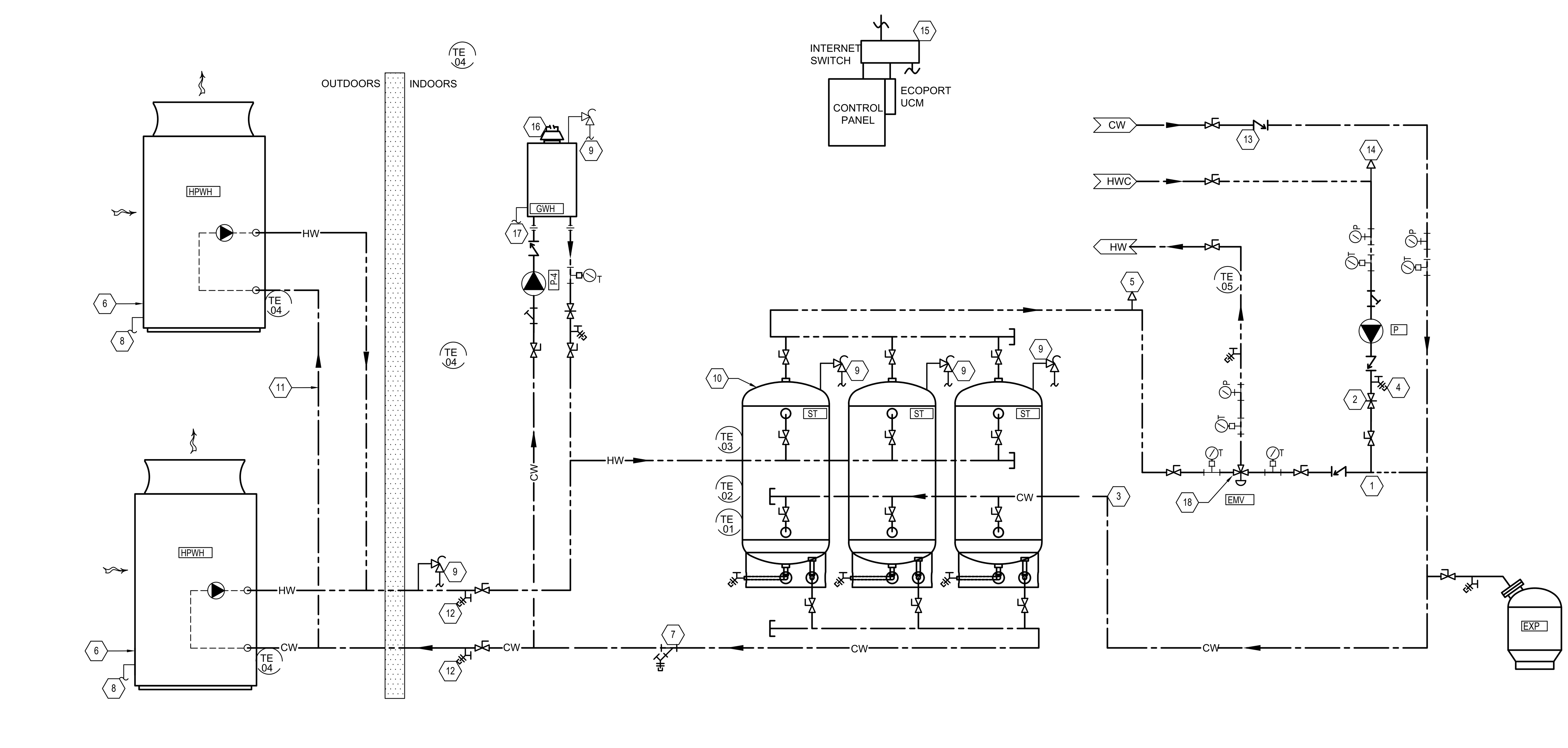
LOAD SHIFT MODE	NORMAL OPERATION	SHED	CRITICAL PEAK EVENT	GRID EMERGENCY	LOAD UP	ADV. LOAD UP
COMMERCIAL HEAT PUMP WATER HEATER STAGING						
OUTLET TEMPERATURE	140°F	140°F	140°F	DISABLED	140°F	160°F
ON SENSOR	TE-02	TE-03	TE-03	DISABLED	TE-01	TE-01
ON TEMPERATURE	125°F	120°F	105°F	DISABLED	125°F	125°F
OFF SENSOR	TE-01	TE-02	TE-02	DISABLED	TE-04	TE-04
OFF TEMPERATURE	130°F	125°F	115°F	DISABLED	130°F	130°F
GAS WATER HEATER STAGING						
OUTLET TEMPERATURE	140°F	140°F	140°F	140°F	140°F	140°F
ON SENSOR	TE-03	TE-02	TE-02	TE-02	TE-03	TE-03
ON TEMPERATURE	120°F	120°F	125°F	125°F	120°F	120°F
OFF SENSOR	TE-02	TE-01	TE-01	TE-01	TE-02	TE-02
OFF TEMPERATURE	125°F	130°F	130°F	130°F	125°F	125°F

GENERAL NOTES

- A. THIS SHEET PROVIDES A DETAILED GENERIC REPRESENTATION OF A SINGLE PASS CHPWH WITH A SINGLE PASS GAS WATER HEATER IN PARALLEL. NOTE THAT THE QUANTITY OF CHPWHS, GAS WATER HEATERS, AND STORAGE TANKS IS SIMPLY REPRESENTATIVE AND CAN BE ADJUSTED FOR THE INDIVIDUAL DESIGN.
- B. THE DIAGRAM AND CONTROLS SHOWN ARE SUGGESTED WITH REQUIREMENTS FOR NORTHWEST ENERGY EFFICIENCY ALLIANCE LISTING CALLED OUT IN THE ADVANCED WATER HEATING SPECIFICATION.
- C. SIZE SYSTEM WITH MANUFACTURER APPROVED SIZING TOOL. REFERENCE MANUFACTURER DOCUMENTATION TO DETERMINE CAPACITY AT VARIABLE OUTDOOR AIR TEMPERATURES. IF NO DEFROST DERATE IS PROVIDED BY MANUFACTURER, A MINIMUM 20% DERATE IS RECOMMENDED.
- E. FOLLOW MANUFACTURERS PRODUCT SPECIFIC GUIDANCE FOR EQUIPMENT CONNECTIONS - PLUMBING, ELECTRICAL, GAS, STRUCTURAL, CONDENSATE, AND COMMUNICATION - INCLUDING MAXIMUM DISTANCE BETWEEN EQUIPMENT AND STORAGE TANK(S) AND PIPING OF MULTIPLE HEATERS SERVING A SINGLE LOAD.
- F. INSTALL PER LOCAL BUILDING CODES. CONSULT STRUCTURAL ENGINEER IF NEEDED. PROVIDE SEISMIC STRAP AS REQUIRED BY LOCAL CODE.
- G. REFER TO AWHS APPENDIX H FOR MINIMUM M&V INSTALLATION GUIDELINES.

SHEET NOTES

1. CONFIRM RECIRCULATION AND MIXING VALVE PIPING WITH MIXING VALVE MANUFACTURER. IF ASSEMBLY SHOWN IN SWING TANK SCHEMATIC IS USED, PROVIDE BALANCING VALVE AND BALANCE PER SHEET NOTE #1 IN THE SWING TANK DIAGRAM.
2. BALANCING VALVE ONLY REQUIRED WHEN CONSTANT SPEED RECIRCULATION PUMP IS USED.
3. NO HEAT TRAP OR CHECK VALVE REQUIRED TO PREVENT THERMOSYPHONING WHEN CONSTANT RECIRCULATION INSTALLED.
4. DRAIN VALVE AFTER RECIRCULATION PUMP IS REQUIRED FOR MAINTENANCE AND STARTUP TESTING. USE DRAIN VALVE TO PURGE AIR AND DRAW WATER DURING STARTUP AND COMMISSIONING.
5. AUTOMATIC AIR VENTS WITH SERVICE CHECK VALVES REQUIRED AT ALL HIGH POINTS. PROVIDE CLEARANCE ABOVE AIR VENT SUFFICIENT TO REPLACE DEVICE.
6. INCLUDE A CHECK VALVE ON EACH HEAT PUMP IF THERE IS NO INTERNAL VALVE (EITHER CONTROL VALVE OR CHECK VALVE) TO PREVENT BACKFLOW WHEN NOT OPERATING.
7. STRAINER MAY BE LOCATED AT EACH HEAT PUMP, INTERNAL TO THE HEAT PUMP OR, AS DEPICTED, ON THE COMMON PIPE SERVING ALL HEAT PUMPS.
8. ROUTE CONDENSATE OUTLET TO ACCEPTABLE DRAIN PER LOCAL REQUIREMENTS. PROVIDE HEAT TRACE OR HEATING PAD ON BOTTOM OF CONDENSATE PAN AND DRAIN LINE FOR FREEZE PROTECTION IN CLIMATES WHERE FREEZING IS POSSIBLE. INSULATE CONDENSATE DRAIN LINE OVER HEAT TRACE IS INSTALLED. CONDENSATE WILL NOT BE PRODUCED IS HEAT PUMP IS NOT OPERATIONAL SO CONDENSATE FREEZE PROTECTION IS ONLY REQUIRED WHEN HEAT PUMP IS POWERED.
9. ROUTE ALL T&P VALVES TO ACCEPTABLE DRAIN PER LOCAL REQUIREMENTS.
10. THERMAL STORAGE TANKS MAY BE PIPED IN PARALLEL OR SERIES BUT NOT A COMBINATION OF PARALLEL AND SERIES. UNPRESSURIZED STORAGE MAY ALSO BE USED WHEN HEAT EXCHANGER SYSTEM IS APPROPRIATELY DESIGNED BY A PROFESSIONAL ENGINEER. WHEN PIPED IN PARALLEL, CLOSE TO EQUAL PIPE LENGTHS ARE REQUIRED TO CREATE EQUAL PRESSURE DROP. PARALLEL SYSTEMS WITH THREE OR MORE TANKS MUST BE PIPED IN REVERSE RETURN. CAPPED HEADERS ARE RECOMMENDED ON REVERSE RETURN PIPING TO SUPPORT EQUAL FLOW. STORAGE SYSTEMS ARE RECOMMENDED TO HAVE NO MORE THAN 3 TANKS AND STRONGLY RECOMMENDED TO HAVE NO MORE THAN 5 TANKS. PROVIDE CLEARANCE IN FRONT OF STORAGE TANKS TO REPLACE ANODES. PROVIDE CLEARANCE AND EGRESS TO REMOVE AND REPLACE STORAGE TANK IN CASE OF FAILURE.
11. FREEZE PROTECTION REQUIRED ON ALL WATER PIPING AND EQUIPMENT COMPONENTS AT RISK OF FREEZING. INCLUDE PROVISIONS TO ENSURE FREEZE PROTECTION FUNCTIONAL DURING POWER OUTAGE. FREEZE PROTECTION METHODS MAY INCLUDE HEAT TRACE ON BACKUP POWER, GLYCOL, AUTOMATIC ISOLATION AND DRAIN VALVES, OR OTHER METHOD ACCEPTABLE FOR CLIMATE AND SYSTEM OWNER.
12. ISOLATION AND DRAIN VALVES STRONGLY RECOMMENDED AT LOW POINT INDOORS OR OUTDOORS TO ALLOW HEAT PUMPS TO BE DRAINED OF WATER.
13. IN SOME JURISDICTIONS A CHECK VALVE IS REQUIRED ON THE COLD WATER SUPPLY SIDE FOR BACKFLOW PREVENTION.
14. IN SOME JURISDICTIONS AN AUTOMATIC AIR RELEASE VALVE IS REQUIRED AT THE TOP OF A VERTICAL SECTION OF RECIRCULATION RETURN PIPE (12" MINIMUM) BEFORE THE INLET TO THE RECIRCULATION PUMP AND NO MORE THAN 4 FEET FROM THE PUMP. THE VALVE SHALL BE ACCESSIBLE FOR REPLACEMENT AND REPAIR.
15. HARDWIRED NETWORK CONNECTION INFRASTRUCTURE TO ENABLE CURRENT OR FUTURE INTERNET CONNECTIVITY IS REQUIRED FOR LOAD SHIFT AND/OR M&V CAPABLE SYSTEMS. CONNECT TO BUILDING INTERNET PROVIDER IF APPROVED. OTHERWISE, ROUTE CABLING TO A LOCATION SUITABLE FOR FUTURE CELLULAR MODEM INSTALLATION.
16. FLUE CONNECTION REQUIRED FOR GAS WATER HEATER. FOLLOW MANUFACTURERS GUIDELINES AND LOCAL CODES FOR INSTALLATION. ROUTE TO APPROPRIATE EXHAUST LOCATION. PROVIDE ADEQUATE PATH FOR MAKEUP COMBUSTION AIR.
17. FOR CONDENSING GAS EQUIPMENT, CONDENSATE DRAIN REQUIRED WITH CONDENSATE NEUTRALIZER KIT.
18. A HEAT EXCHANGER OR INSTANTANEOUS GAS WATER HEATER MAY ALSO BE USED TO TARGET LEAVING WATER TEMPERATURE. WHEN A HEAT EXCHANGER OR GAS WATER HEATER IS USED, ALL STORAGE WATER MUST BE NON-POTABLE AND THE PLANT MUST OPERATE AS AN INSTANTANEOUS WATER HEATER.



1 WATER HEATING PLANT P&ID

Scale: NTS

LEGEND

PIPING COMPONENTS AND VALVES

- MIXING VALVE
- SHUT-OFF VALVE (BALL, GATE, OR BUTTERFLY)
- CHECK VALVE
- BALANCING VALVE
- DRAIN VALVE
- AUTOMATIC AIR VENT
- STRAINER
- PRESSURE GAUGE
- TEMPERATURE GAUGE
- PRESSURE RELIEF VALVE
- PUMP
- STRAINER

INSTRUMENTS

- FM XX — FLOW METER
- TE XX — TEMPERATURE SENSOR

GENERAL SHEET SYMBOLS

- # — PLAN NOTE REFERENCE SYMBOL

ABBREVIATIONS

CW	COLD WATER
HW	HOT WATER
HWC	HOT WATER RECIRCULATION
ST	STORAGE TANK
P	PUMP
GWH	GAS WATER HEATER
CHPWH, HPWH, OR HEAT PUMP	COMMERCIAL HEAT PUMP WATER HEATER
EXP	EXPANSION TANK
EMV	ELECTRONIC MIXING VALVE

PROJECT

COMMERCIAL HPWH - SINGLE PASS WITH GAS IN PARALLEL

NORTHWEST ENERGY EFFICIENCY ALLIANCE

ADVANCED WATER HEATING SPECIFICATION

DATE 01/22/2026

REVISIONS

LOAD SHIFT SCHEDULE AND SIGNALING

THE CHPWH SHALL BE CAPABLE OF ADJUSTING ITS CONTROL SETPOINTS BASED ON LOAD SHIFT OPERATING STATE (NORMAL, SHED, CRITICAL PEAK, GRID EMERGENCY, LOAD UP, ADVANCED LOAD UP) PER THE "PRIMARY WATER HEATER SETPOINTS" TABLE. THE CHPWH SYSTEM SHALL BE CAPABLE OF ADJUSTING ITS LOAD SHIFT OPERATING STATE IN RESPONSE TO:

1. LOAD SHIFT SIGNAL IS RECEIVED THROUGH CTA-2045B PROTOCOL.
2. PRE-PROGRAMMED LOAD SHIFT SCHEDULES.

THE CHPWH SHALL BE CAPABLE OF STORING A MINIMUM OF TWO "HOUR OF DAY" LOAD SHIFT SCHEDULES AND ONE "DAY OF THE WEEK" SCHEDULE. THE HOUR OF DAY SCHEDULES SHALL DICTATE WHICH LOAD SHIFT OPERATING STATE TO RUN IN FOR EACH HOUR. THE DAY OF THE WEEK SCHEDULE TELLS WHICH SCHEDULE TO OPERATE IN ON EACH DAY OF THE WEEK. NOTE: REFERENCE LOCAL UTILITY RATE STRUCTURE TO OPTIMIZE THIS SCHEDULE.

EXAMPLE HOUR OF DAY SCHEDULES

HOUR	LOAD SHIFT REQUEST SCHEDULE 1	LOAD SHIFT REQUEST SCHEDULE 2
1:00 AM	NORMAL	NORMAL
2:00 AM	NORMAL	NORMAL
3:00 AM	NORMAL	NORMAL
4:00 AM	NORMAL	NORMAL
5:00 AM	NORMAL	NORMAL
6:00 AM	NORMAL	NORMAL
7:00 AM	NORMAL	NORMAL
8:00 AM	NORMAL	NORMAL
9:00 AM	NORMAL	NORMAL
10:00 AM	NORMAL	NORMAL
11:00 AM	NORMAL	NORMAL
12:00 PM	LOAD UP	NORMAL
1:00 PM	LOAD UP	NORMAL
2:00 PM	LOAD UP	NORMAL
3:00 PM	LOAD UP	NORMAL
4:00 PM	SHED	NORMAL
5:00 PM	SHED	NORMAL
6:00 PM	SHED	NORMAL
7:00 PM	SHED	NORMAL
8:00 PM	SHED	NORMAL
9:00 PM	SHED	NORMAL
10:00 PM	SHED	NORMAL
11:00 PM	SHED	NORMAL
12:00 AM	NORMAL	NORMAL

EXAMPLE DAY OF WEEK SCHEDULE

MONDAY	SCHEDULE 1
TUESDAY	SCHEDULE 1
WEDNESDAY	SCHEDULE 1
THURSDAY	SCHEDULE 1
FRIDAY	SCHEDULE 1
SATURDAY	SCHEDULE 2
SUNDAY	SCHEDULE 2

SEQUENCE OF OPERATIONS

1. SINGLE PASS CHPWH(S)
  1.1. ENABLE FIRST CHPWH WHEN "ON SENSOR" IS COOLER THAN "ON TEMPERATURE". STAGE ADDITIONAL CHPWHS PER MANUFACTURER GUIDANCE OR FOLLOW TEMPERATURE STAGING APPROACH OUTLINED BELOW:
  1.2. IF MULTIPLE STAGES OF CHPWH ARE INSTALLED INITIATE ADDITIONAL CHPWH STAGE FOR EVERY 2°F BELOW "ON TEMPERATURE" OR IF "ON SENSOR" REMAINS COOLER THAN "ON TEMPERATURE" AFTER 30 MINUTES, WHICHEVER HAPPENS FIRST.
    1.2.1. CHPWHS WITH THE LOWEST ACCUMULATED RUN TIME SHALL BE CALLED TO RUN FIRST.
    1.2.2. IF MORE THAN 3 CHPWH STAGES ARE USED, INITIATE STAGES AT 1°F INCREMENTS AND ADJUST TIME CRITERIA TO 15 MINUTES. DO NOT USE MORE THAN 6 STAGES.
  1.3. DISABLE ALL HEATERS WHEN "OFF SENSOR" IS WARMER THAN "OFF TEMPERATURE".
  1.4. UPON CHANGE OF LOAD SHIFT OPERATION, DISABLE ALL HEATERS IF "ON SENSOR" IS WARMER THAN "ON TEMPERATURE".
2. GAS WATER HEATERS(S):
  2.1. ENABLE GAS HEATER WHEN TE-06 IS COOLER THAN ("SETPOINT" - "DEADBAND").
  2.2. DISABLE GAS HEATER WHEN TE-06 IS WARMER THAN "SETPOINT".
3. GAS BACK-UP MODE:
  3.1. BACK-UP MODE SHALL BE ENABLED MANUALLY BY OPERATOR AND LAST 48 HOURS OR UNTIL MANUALLY DISABLED - WHICHEVER OCCURS FIRST.
  3.2. INCREASE GAS HEATER SETPOINT TO 150°F.
4. MIXING VALVE SHALL MAINTAIN A SUPPLY WATER TEMPERATURE SETPOINT AT OR ABOVE 125°F.
5. HOT WATER CIRCULATION PUMP:
  5.1. MAINTAIN THE MINIMUM FLOW REQUIRED BY THE MIXING VALVE MANUFACTURER AT ALL TIMES.
  5.2. PROVIDE THE MINIMUM FLOW POSSIBLE THAT DELIVERS 122°F HOT WATER RETURN TEMPERATURE.
  5.3. DISTRIBUTION LOOPS WITH MULTIPLE BALANCED BRANCHES:
    5.3.1. SET PUMP TO CONSTANT OR PROPORTIONAL PRESSURE IF SERVING THERMOSTATIC BALANCING VALVES. ENSURE VALVE DIALS ARE SET TO DESIGN RETURN TEMPERATURE.
    5.3.1. SET PUMP TO CONSTANT PRESSURE IF SERVING PRESSURE INDEPENDENT BALANCING VALVES OR MANUAL BALANCING VALVES. MANUALLY ADJUST VALVES TO CALCULATED GPMS.
    5.3.1. IF USING A CONSTANT SPEED PUMP, MANUALLY ADJUST VALVES TO CALCULATED GPMS. USE BALANCING VALVE AT RECIRCULATION PUMP IF REQUIRED TO FURTHER REDUCE FLOW.
  5.4. DISTRIBUTION LOOPS WITH SINGLE PIPE RUNS (WITHOUT MULTIPLE BRANCHES) AND VARIABLE SPEED RECIRCULATION PUMP(S): SET PUMP TO CONSTANT TEMPERATURE.
6. DISTRIBUTION LOOPS WITH SINGLE PIPE RUNS (WITHOUT MULTIPLE BRANCHES) AND CONSTANT SPEED RECIRCULATION PUMP(S): ADJUST BALANCING VALVE AT PUMP TO TARGET RETURN TEMPERATURE.
7. ALARMS SHALL BE INITIATED IN THE FOLLOWING CONDITIONS AT A MINIMUM:
  7.1. HPWH EXPERIENCES A FAULT CONDITION.
  7.2. THE GAS WATER HEATER EXPERIENCES A FAULT CONDITION.
  7.3. BACKUP WATER HEATER(S) ARE ENGAGED.
  7.4. MIXING VALVE OUTLET TEMPERATURE DROPS BELOW SETPOINT MINUS 5°F FOR MORE THAN 15 MINUTES.

CONTROLS POINTS LIST

TAG	LOCATION
TEMPERATURE SENSORS	
TE-01	STORAGE LOW (10-25% AQUASTAT FRACTION)
TE-02	STORAGE MID (30-45% AQUASTAT FRACTION)
TE-03	STORAGE HIGH (65-85% AQUASTAT FRACTION)
TE-04	HPWH INLET(S)
TE-05	EMV-1 OUTLET
TE-06	GWH TANK(S)
CHPWH INTERNAL POINTS	
HPWH INTERNAL FAULT	HPWH(S) (INTERNAL)
HPWH ENABLE/DISABLE	HPWH(S) (INTERNAL)
HPWH OUTLET TEMP SETPOINT	HPWH(S) (INTERNAL)

PRIMARY WATER HEATER SETPOINTS

LOAD SHIFT MODE	NORMAL OPERATION	SHED	CRITICAL PEAK EVENT	GRID EMERGENCY	LOAD UP	ADV. LOAD UP
PRIMARY WATER HEATER SETPOINTS						
OUTLET TEMPERATURE	140°F	140°F	140°F	DISABLED	140°F	160°F
ON SENSOR	TE-02	TE-03	TE-03	DISABLED	TE-01	TE-01
ON TEMPERATURE	125°F	120°F	105°F	DISABLED	125°F	125°F
OFF SENSOR	TE-01	TE-02	TE-02	DISABLED	TE-04 (CHPWH INLET)	TE-04 (CHPWH INLET)
OFF TEMPERATURE	130°F	125°F	115°F	DISABLED	130°F	130°F
GAS WATER HEATER SETPOINTS						
SETPOINT (DEADBAND)	130°F (5°F)	140°F (5°F)	140°F (5°F)	150°F (5°F)	130°F (5°F)	130°F (5°F)

GENERAL NOTES

A. THIS SHEET PROVIDES A DETAILED GENERIC REPRESENTATION OF A SINGLE PASS CHPWH WITH GAS WATER HEATING IN SERIES. NOTE THAT THE QUANTITY OF CHPWHS, GAS WATER HEATERS, AND STORAGE TANKS IS SIMPLY REPRESENTATIVE AND CAN BE ADJUSTED FOR THE INDIVIDUAL DESIGN.
B. THE DIAGRAM AND CONTROLS SHOWN ARE SUGGESTED WITH REQUIREMENTS FOR NORTHWEST ENERGY EFFICIENCY ALLIANCE LISTING CALLED OUT IN THE ADVANCED WATER HEATING SPECIFICATION.
C. THIS CONFIGURATION MAY ALSO BE APPLIED WITH LOWER SETPOINTS AND NO MIXING VALVE IN APPROPRIATE APPLICATIONS WHEN APPROVED BY THE BUILDING OWNER.
D. SIZE SYSTEM WITH MANUFACTURER APPROVED SIZING TOOL. REFERENCE MANUFACTURER DOCUMENTATION TO DETERMINE CAPACITY AT VARIABLE OUTDOOR AIR TEMPERATURES. IF NO DEFROST DERATE IS PROVIDED BY MANUFACTURER, A MINIMUM 20% DERATE IS RECOMMENDED.
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F. INSTALL PER LOCAL BUILDING CODES. CONSULT STRUCTURAL ENGINEER IF NEEDED. PROVIDE SEISMIC STRAP AS REQUIRED BY LOCAL CODE.
G. REFER TO AWHS APPENDIX H FOR MINIMUM M&V INSTALLATION GUIDELINES.

SHEET NOTES

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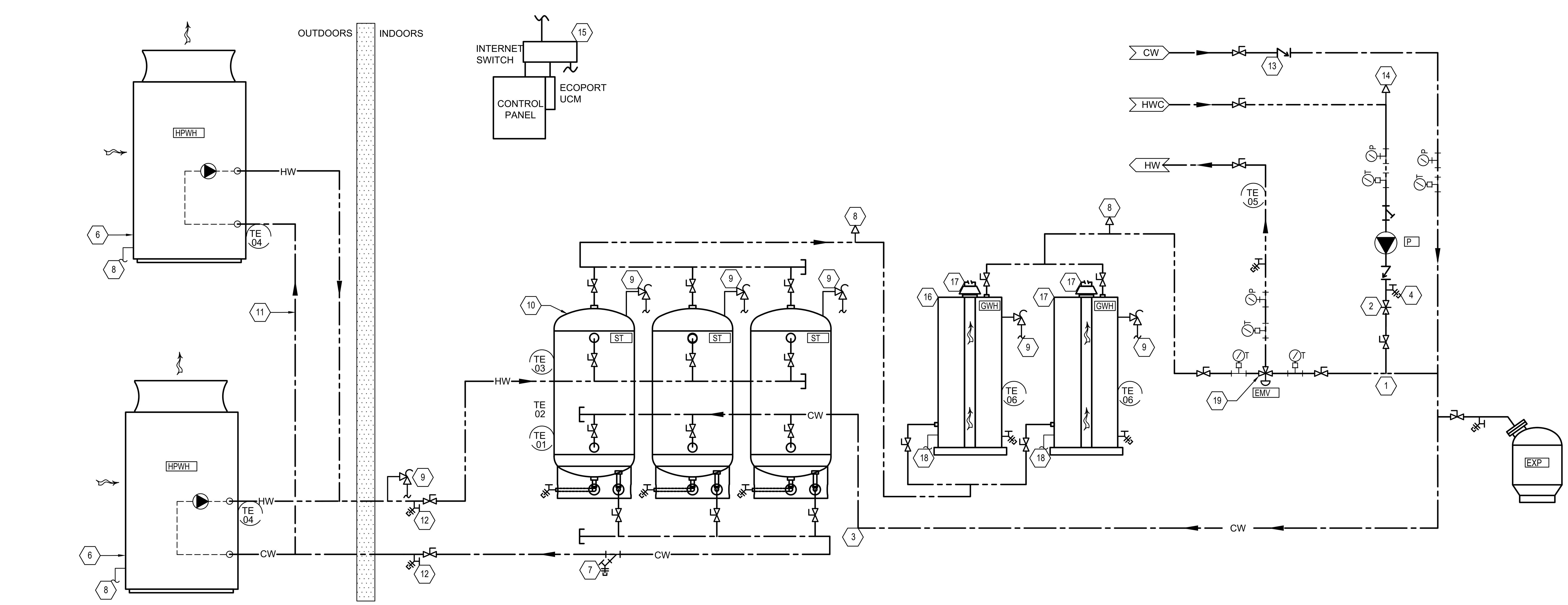
15. HARDWIRED NETWORK CONNECTION INFRASTRUCTURE TO ENABLE CURRENT OR FUTURE INTERNET CONNECTIVITY IS REQUIRED FOR LOAD SHIFT AND/OR M&V CAPABLE SYSTEMS. CONNECT TO BUILDING INTERNET PROVIDER IF APPROVED. OTHERWISE, ROUTE CABLING TO A LOCATION SUITABLE FOR FUTURE CELLULAR MODEM INSTALLATION.
16. SEPARATE TANK AND GAS BOILER MAY ALSO BE USED INSTEAD OF INTEGRATED GAS TANK. TANKLESS GAS WATER HEATERS MAY BE USED IN LEU OF TANK STYLE WATER HEATERS WHEN APPRIOPRIATELY DESIGNED BY ENGINEER OF RECORD.
17. FLUE CONNECTION REQUIRED FOR GAS WATER HEATER. FOLLOW MANUFACTURERS GUIDELINES AND LOCAL CODES FOR INSTALLATION. ROUTE TO APPROPRIATE EXHAUST LOCATION. PROVIDE ADEQUATE PATH FOR MAKEUP COMBUSTION AIR.
18. FOR CONDENSING GAS EQUIPMENT, CONDENSATE DRAIN REQUIRED WITH CONDENSATE NEUTRALIZER KIT.
19. A HEAT EXCHANGER OR INSTANTANEOUS GAS WATER HEATER MAY ALSO BE USED TO TARGET LEAVING WATER TEMPERATURE. WHEN A HEAT EXCHANGER OR GAS WATER HEATER IS USED, ALL STORAGE WATER MUST BE NON-POTABLE AND THE PLANT MUST OPERATE AS AN INSTANTANEOUS WATER HEATER.



1 WATER HEATING PLANT P&ID

Scale: NTS

LEGEND

PIPING COMPONENTS AND VALVES

MIXING VALVE
SHUT-OFF VALVE (BALL, GATE, OR BUTTERFLY)
CHECK VALVE
BALANCING VALVE
DRAIN VALVE
AUTOMATIC AIR VENT
STRAINER
PRESSURE GAUGE
TEMPERATURE GAUGE
PRESSURE RELIEF VALVE
PUMP
STRAINER

INSTRUMENTS

FM XX — FLOW METER
TE XX — TEMPERATURE SENSOR

GENERAL SHEET SYMBOLS

— PLAN NOTE REFERENCE SYMBOL

ABBREVIATIONS

CW	COLD WATER
HW	HOT WATER
HWC	HOT WATER RECIRCULATION
ST	STORAGE TANK
P	PUMP
GWH	GAS WATER HEATER
CHPWH, HPWH, OR HEAT PUMP	COMMERCIAL HEAT PUMP WATER HEATER
EXP	EXPANSION TANK
EMV	ELECTRONIC MIXING VALVE

ECOTOPE

PROJECT
COMMERCIAL HPWH - SINGLE PASS WITH GAS IN SERIES
NORTHWEST ENERGY EFFICIENCY ALLIANCE
ADVANCED WATER HEATING SPECIFICATION

DATE
01/22/2026

REVISIONS

LOAD SHIFT SCHEDULE AND SIGNALING

THE CHPWH SHALL BE CAPABLE OF ADJUSTING ITS CONTROL SETPOINTS BASED ON LOAD SHIFT OPERATING STATE (NORMAL, SHED, CRITICAL PEAK, GRID EMERGENCY, LOAD UP, ADVANCED LOAD UP) PER THE "PRIMARY WATER HEATER SETPOINTS" TABLE. THE CHPWH SYSTEM SHALL BE CAPABLE OF ADJUSTING ITS LOAD SHIFT OPERATING STATE IN RESPONSE TO:
1. LOAD SHIFT SIGNAL IS RECEIVED THROUGH CTA-2045B PROTOCOL.
2. PRE-PROGRAMMED LOAD SHIFT SCHEDULES.

THE CHPWH SHALL BE CAPABLE OF STORING A MINIMUM OF TWO "HOUR OF DAY" LOAD SHIFT SCHEDULES AND ONE "DAY OF THE WEEK" SCHEDULE. THE HOUR OF DAY SCHEDULES SHALL DICTATE WHICH LOAD SHIFT OPERATING STATE TO RUN IN FOR EACH HOUR. THE DAY OF THE WEEK SCHEDULE TELLS WHICH SCHEDULE TO OPERATE IN ON EACH DAY OF THE WEEK. NOTE: REFERENCE LOCAL UTILITY RATE STRUCTURE TO OPTIMIZE THIS SCHEDULE.

EXAMPLE HOUR OF DAY SCHEDULES

HOUR	LOAD SHIFT REQUEST SCHEDULE 1	LOAD SHIFT REQUEST SCHEDULE 2
1:00 AM	NORMAL	NORMAL
2:00 AM	NORMAL	NORMAL
3:00 AM	NORMAL	NORMAL
4:00 AM	NORMAL	NORMAL
5:00 AM	NORMAL	NORMAL
6:00 AM	NORMAL	NORMAL
7:00 AM	NORMAL	NORMAL
8:00 AM	NORMAL	NORMAL
9:00 AM	NORMAL	NORMAL
10:00 AM	NORMAL	NORMAL
11:00 AM	NORMAL	NORMAL
12:00 PM	LOAD UP	NORMAL
1:00 PM	LOAD UP	NORMAL
2:00 PM	LOAD UP	NORMAL
3:00 PM	LOAD UP	NORMAL
4:00 PM	SHED	NORMAL
5:00 PM	SHED	NORMAL
6:00 PM	SHED	NORMAL
7:00 PM	SHED	NORMAL
8:00 PM	SHED	NORMAL
9:00 PM	SHED	NORMAL
10:00 PM	SHED	NORMAL
11:00 PM	SHED	NORMAL
12:00 AM	NORMAL	NORMAL

EXAMPLE DAY OF WEEK SCHEDULE

MONDAY	SCHEDULE 1
TUESDAY	SCHEDULE 1
WEDNESDAY	SCHEDULE 1
THURSDAY	SCHEDULE 1
FRIDAY	SCHEDULE 1
SATURDAY	SCHEDULE 2
SUNDAY	SCHEDULE 2

SEQUENCE OF OPERATIONS

1. MULTI PASS CHPWH(S):
 1.1. ENABLE FIRST CHPWH WHEN "ON SENSOR" IS COOLER THAN "ON TEMPERATURE". STAGE ADDITIONAL CHPWH PER MANUFACTURER GUIDANCE OR FOLLOW TEMPERATURE STAGING APPROACH OUTLINED BELOW:
 1.2. IF MULTIPLE STAGES OF CHPWH ARE INSTALLED INITIATE ADDITIONAL CHPWH STAGE FOR EVERY 2°F BELOW "ON TEMPERATURE" OR IF "ON SENSOR" REMAINS COOLER THAN "ON TEMPERATURE" AFTER 30 MINUTES, WHICHEVER HAPPENS FIRST.
 1.2.1. CHPWHS WITH THE LOWEST ACCUMULATED RUN TIME SHALL BE CALLED TO RUN FIRST.
 1.2.2. IF MORE THAN 3 CHPWH STAGES ARE USED, INITIATE STAGES AT 1°F INCREMENTS AND ADJUST TIME CRITERIA TO 15 MINUTES. DO NOT USE MORE THAN 6 STAGES.
 1.3. DISABLE ALL WATER HEATERS WHEN "OFF SENSOR" IS WARMER THAN "OFF TEMPERATURE".
 1.4. UPON CHANGE OF LOAD SHIFT OPERATION, DISABLE ALL HEATERS IF "ON SENSOR" IS WARMER THAN "ON TEMPERATURE".
2. GAS WATER HEATER(S):
 2.1. ENABLE SWING TANK HEATER WHEN SWING TANK TEMPERATURE IS COOLER THAN ("SWING TANK SETPOINT" - "DEADBAND").
 2.2. DISABLE SWING TANK HEATER WHEN SWING TANK TEMPERATURE IS WARMER THAN SWING TANK SETPOINT.
3. GAS BACK-UP MODE:
 3.1. BACK-UP MODE SHALL BE ENABLED MANUALLY BY OPERATOR AND LAST 48 HOURS OR UNTIL MANUALLY DISABLED - WHICHEVER OCCURS FIRST.
4. INCREASE GAS HEATER SETPOINT TO 150°F.
5. MIXING VALVE SHALL MAINTAIN A SUPPLY WATER TEMPERATURE SETPOINT AT OR ABOVE 125°F.
6. HOT WATER CIRCULATION PUMP:
 6.1. MAINTAIN THE MINIMUM FLOW REQUIRED BY THE MIXING VALVE MANUFACTURER AT ALL TIMES.
 6.2. PROVIDE THE MINIMUM FLOW POSSIBLE THAT DELIVERS 122°F HOT WATER RETURN TEMPERATURE.
 6.3. DISTRIBUTION LOOPS WITH MULTIPLE BALANCED BRANCHES:
 6.3.1. SET PUMP TO CONSTANT OR PROPORTIONAL PRESSURE IF SERVING THERMOSTATIC BALANCING VALVES. ENSURE VALVE DIALS ARE SET TO DESIGN RETURN TEMPERATURE.
 6.3.2. SET PUMP TO CONSTANT PRESSURE IF SERVING PRESSURE INDEPENDENT BALANCING VALVES OR MANUAL BALANCING VALVES. MANUALLY ADJUST VALVES TO CALCULATED GPMS.
 6.3.3. IF USING A CONSTANT SPEED PUMP, MANUALLY ADJUST VALVES TO CALCULATED GPMS. USE BALANCING VALVE AT RECIRCULATION PUMP IF REQUIRED TO FURTHER REDUCE FLOW.
7. DISTRIBUTION LOOPS WITH SINGLE PIPE RUNS (WITHOUT MULTIPLE BRANCHES) AND VARIABLE SPEED RECIRCULATION PUMP(S): SET PUMP TO CONSTANT TEMPERATURE.
8. THE CHPWH SYSTEM ALARMS SHALL BE AUDIBLE, TEXT, OR EMAIL. AN ALARM HISTORY SHALL STORE LIST OF ALARMS THAT OCCURRED ON CONTROLLER UNTIL CLEARED BY USER. ALARMS SHALL BE INITIATED IN THE FOLLOWING CONDITIONS AT A MINIMUM:
 8.1. CHPWH EXPERIENCES A FAULT CONDITION.
 8.2. GAS WATER HEATER EXPERIENCES A FAULT CONDITION.
 8.3. MIXING VALVE OUTLET TEMPERATURE DROPS BELOW SETPOINT BY 5°F FOR MORE THAN 15 MINUTES.
 8.4. MIXING VALVE OUTLET TEMPERATURE RISES ABOVE SETPOINT BY 10°F FOR MORE THAN 5 MINUTES.

CONTROLS POINTS LIST

TAG	LOCATION
TEMPERATURE SENSORS	
TE-01	PRIMARY STORAGE (10-40% AQUASTAT FRACTION)
TE-02	HPWH INLET(S)
TE-03	HOT WATER SUPPLY
TE-04	GAS WATER HEATER(S)
CHPWH INTERNAL POINTS	
HPWH INTERNAL FAULT	HPWH(S) (INTERNAL)
HPWH ENABLE/DISABLE	HPWH(S) (INTERNAL)

WATER HEATER SETPOINTS

LOAD SHIFT MODE	NORMAL OPERATION	SHED	CRITICAL PEAK EVENT	GRID EMERGENCY	LOAD UP	ADV. LOAD UP
COMMERCIAL HEAT PUMP WATER HEATER STAGING						
ON SENSOR	TE-01	TE-01	TE-01	DISABLED	TE-01	TE-01
ON TEMPERATURE	125°F	100°F	80°F	DISABLED	130°F	135°F
OFF SENSOR	TE-02	TE-02	TE-02	DISABLED	TE-02	TE-02
OFF TEMPERATURE	140°F	115°F	105°F	DISABLED	140°F	150°F
GAS WATER HEATER SETPOINTS						
SETPOINT (DEADBAND)	130°F (5°F)	140°F (5°F)	160°F (5°F)	160°F (5°F)	130°F (5°F)	130°F (5°F)

GENERAL NOTES

A. THIS SHEET PROVIDES A DETAILED GENERIC REPRESENTATION OF A MULTI PASS CHPWH WITH GAS WATER HEATING IN SERIES. NOTE THAT THE QUANTITY OF CHPWHS, GAS WATER HEATERS, AND STORAGE TANKS IS SIMPLY REPRESENTATIVE AND CAN BE ADJUSTED FOR THE INDIVIDUAL DESIGN.
B. THE DIAGRAM AND CONTROLS SHOWN ARE SUGGESTED WITH REQUIREMENTS FOR NORTHWEST ENERGY EFFICIENCY ALLIANCE LISTING CALLED OUT IN THE ADVANCED WATER HEATING SPECIFICATION.
C. THIS CONFIGURATION MAY ALSO BE APPLIED WITH LOWER SETPOINTS AND NO MIXING VALVE IN APPROPRIATE APPLICATIONS WHEN APPROVED BY THE BUILDING OWNER.
D. SIZE SYSTEM WITH MANUFACTURER APPROVED SIZING TOOL. REFERENCE MANUFACTURER DOCUMENTATION TO DETERMINE CAPACITY AT VARIABLE OUTDOOR AIR TEMPERATURES. IF NO DEFROST DERATE IS PROVIDED BY MANUFACTURER, A MINIMUM 20% DERATE IS RECOMMENDED.
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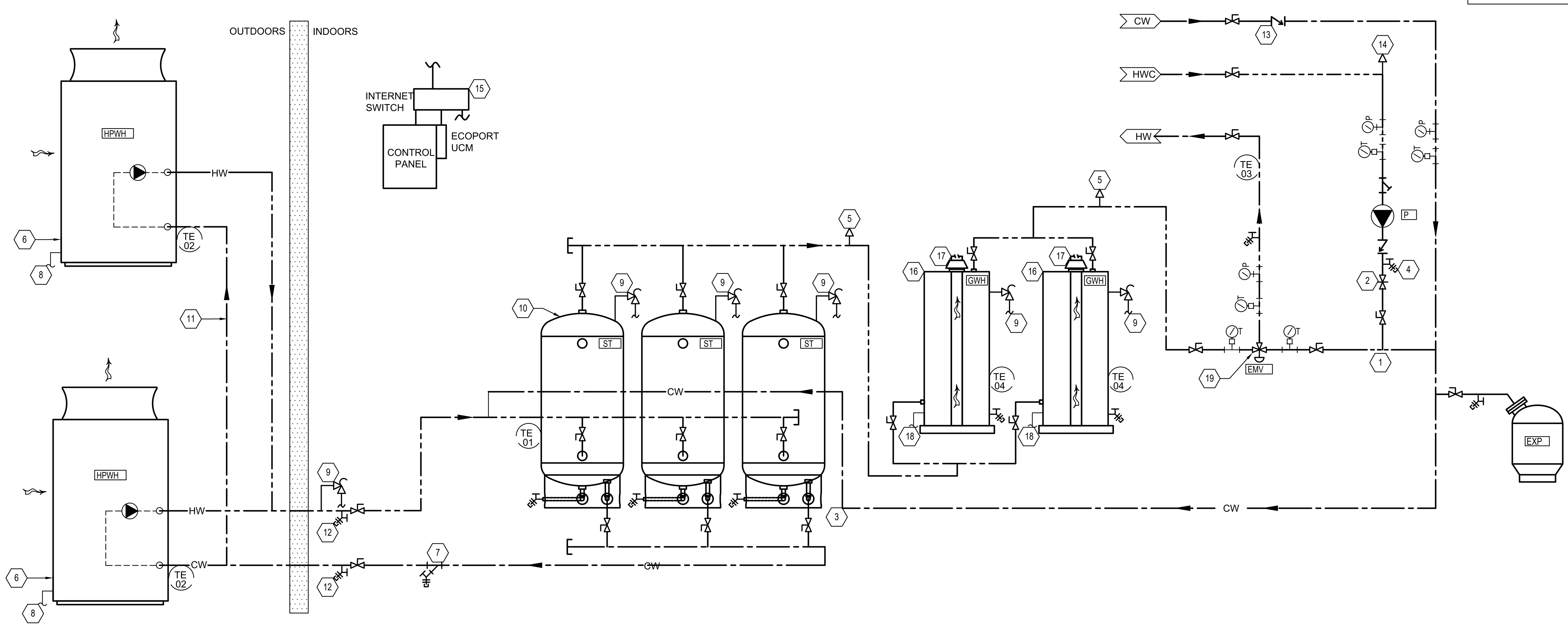

1 WATER HEATING PLANT P&ID

Scale: NTS

LEGEND

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