SCA DOMESTIC HOT WATER HEAT PUMP PROJECT COMPARISON AND OPTIMIZATION STUDY

NYC SCHOOL CONSTRUCTION AUTHORITY

Public Report Date: January 29, 2024

TABLE OF CONTENTS

1.0 Executive Summary

OLA Consulting Engineers (OLA) was tasked with providing a domestic hot water (DHW) air-source heat pump system comparison study for the New York City School Construction Authority (SCA). The system types to be compared were packaged DHW heat pumps and split type system DHW heat pumps. To support this investigation, SCA provided design drawings, energy models and reports, and cost estimates for six (6) capacity projects.

As part of this project, OLA reviewed the system designs and energy models provided, and reviewed against the SCA's current Design Requirements for DHW systems, eQuest Input Summaries for Energy Models, and past SCA DHW studies. This effort also included performing spreadsheet-based energy calculations for the two (2) DHW configurations and analyzing their impact on space conditioning.

The following is a summary of the key findings of this study, with additional details provided throughout the report:

- Cost Comparison
    - Based on the cost estimates provided, split type systems cost approximately 20% to 25% more than packaged systems. This is assuming all distribution piping, recirculation pumps, and controls are equal. The cost data was limited to the schools studied, and large ranges of prices were found in packaged type systems. Design and costs are expected to be optimized as more systems are installed by SCA. Additional notes are provided in Table 4.
- Efficiency and Capacity Comparison
    - Coefficient of performance (COP) in the six (6) projects ranged from 2.8 to 4.2 COP. Split type system heat pumps were noted as having lower COP (according to Design Documents provided), however, the packaged equipment operating mode (i.e. hybrid or heat pump only) and location greatly impact the system efficiency.
- Equipment Location and Configuration Review
    - The DHW system equipment locations for all six (6) schools, which include two (2) split type system and four (4) packaged HPWHs, were all indoor mechanical rooms. Many of the rooms reviewed do not have substantial amounts of "free heat" and will require supplemental space-heating to operate the heat pumps.
        - The energy penalty associated with locating the HPWHs indoors was estimated to increase the site Energy Use Intensity by 2-3%. Additional details are provided in Table 5.
- DHW Load and Energy Consumption Comparison
    - Estimated domestic hot water consumption rates greatly impact system sizing and energy use.
    - Variations in estimated hot water consumption (gallons per day per student) were found in the energy models and system designs, ranging from 0.6 – 1.0 gpd/student.

2.0 Project Approach

New York City School Construction Authority (SCA) provided OLA with design drawings, energy models and reports, and cost information for six (6) capacity projects that were recently designed. A summary of the analysis and comparisons conducted on the DHW systems is provided in this report, and includes details on the impact of each DHW system configuration on the following parameters:

- Cost of DHW systems
- Energy efficiency impacts
- Equipment location and configuration
- System sizing differences

OLA reviewed the DHW system designs and energy models of each of the six (6) selected capacity projects. The review consisted of comparing the modeled buildings' DHW systems and loads against the design drawings and specifications, as well as the SCA's current Design Requirements for domestic hot water systems. OLA also performed spreadsheet-based energy calculations for the two (2) DHW configurations to be studied. The system types compared are the packaged DHW heat pump and split type system DHW configurations, and a supplemental review of CO_2-based heat pumps.

The first heat pump water heater (HPWH) system configuration is called a packaged system because the heat pump and storage tank are combined, typically with the heat pump section mounted directly on top or side of the tank (see Figure 1 below). Packaged systems are typically installed indoors and have become increasingly popular in single-family home applications.

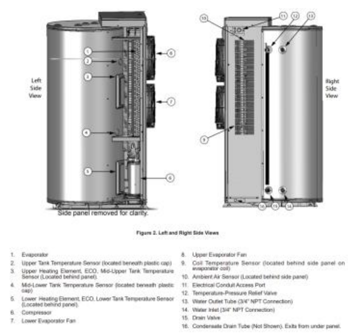


Figure 1: Example of Packaged Type System (*image credit: Lochinvar*)

The second HPWH configuration is a split type system, where the heat pump section (typically an air-to-water heat pump) and storage tank are two separate pieces of equipment, typically connected by hot water piping. The heat pump section is typically installed outdoors (see Figure 2 below), while the storage tank is installed indoors.

Figure 2: Example of Split Type System (*image credit: Colmac*)

3.0 DHW Split Type System vs. Packaged Heat Pump Configuration Pro and Cons

Table 1 below provides high level pros and cons for packaged heat pump and split type system (non-CO_2-based refrigerant system) DHW Heat pumps. The table assumes that typical placement of the packaged heat pumps is in indoor mechanical rooms, while split type system heat pumps are outdoors.

Table 1. DHW Equipment Pro and Cons

	Packaged Heat Pump	Split Type System Heat Pump (non-CO_2)
Pro	• Relatively simple equipment. • Lower cost compared to split type system. • Commercial-grade equipment is becoming more commonly available.	• Estimated to have higher performance in buildings with minimal internal equipment heat gain. • Pre-constructed equipment skids, which include all associated equipment (i.e. swing tank) are coming to market. Allows for potential easier installations.
Con	• Requires ambient air to be warm enough to operate (above minimum ambient operating temperatures, typically above 40°F). • System energy efficiency greatly depends on equipment location, heat source, and available “free heat”.	• Typically, more expensive installation (20%-25% more than packaged heat pump). • Limited available equipment capable of producing 140°F hot water at winter design outdoor temperatures 13°F. • Outdoor equipment has higher risk of freeze damage and requires freeze-protection (i.e. glycol, heat trace, and/or drainback system). • Several configurations are available, adding slight complexity to designs.

4.0 DHW Equipment Expanded Review and Comparison Findings

Table 2 summarizes key considerations of the domestic hot water (DHW) heat pump configurations included in the six (6) schools, as well as a supplemental comparison with CO_2 systems.

Table 2. DHW Equipment Expanded Review and Comparison Findings Summary Table

Category	Packaged Heat Pump	Split type system Heat Pump	CO_2 Heat Pump
Cost[1]	$$	$$$	$$$$
Design and Equipment Configuration Considerations	• Kitchens are typically a school's largest DHW load, kitchen specific HPWHs located in/or beside the kitchen, to capture "free heat" from the kitchen, should be considered. See further details Recommendations and Opportunities for Further Study section.	• Outdoor equipment requires freeze-protection (i.e. glycol, heat trace, and/or drain-back system) • Hot water storage capacity and equipment capacity should be optimized for energy efficiency and system sizing. • Typically, multi-pass configuration.[2]	• Outdoor equipment requires freeze-protection (i.e. glycol, heat trace, and/or drain-back system) • Typically, single-pass configuration.[2]
Energy Efficiency Considerations[3]	• Medium, depends on equipment location, heat source, and available "free heat". • System efficiency decreases if significant space-heating is used to provide heat ambient air around the HPWH.	• Medium, equipment performance and capacity decrease with ambient temperature. • Systems with heat pumps in series (e.g. with outdoor and indoor heat pump to boost temperature), should be carefully evaluated for total system efficiency.[4]	• High, performance and capacity does not decrease ambient temperatures as much as non-CO_2 refrigerant heat pumps.
Modeling Considerations	• Should account for heat absorbed by HPWH, and heat source (e.g., "free heat" or heat from space-heating equipment). • eQuest Input Summary document requires heat pump water heaters to be modeled "outdoors", despite actual location of HPWH. The net COP should be adjusted to account for the additional space-heating required. • Heat pump mode should be carefully evaluated (if equipment is likely to be in "efficiency" (heat pump-only) or in "hybrid" (heat pump plus electric resistance) mode)	• Energy models should include performance curves of equipment. • Electric resistance heaters are often required for cold weather operation to maintain legionella safe storage tank temperatures. Energy models should account for electric resistance back-up or supplemental storage tank heaters where used.	• Energy models should include performance curves of equipment.
Typical Equipment Locations	• Indoors, should be located to capture "free heat".	• Outdoor unit on rooftop or courtyard, storage tank indoors, indoor unit[4] (where applicable) indoors. • Note, all buildings evaluated in this study had equipment located in indoor mechanical rooms.	• Outdoor unit on rooftop or courtyard, storage tank indoors.

[1] Cost data primarily from SCA-provided project cost estimates.
[2] Single-pass heat pumps increase the temperature of the water in a single-pass, meanwhile multi-pass heat pumps increase the temperature of the water over multiple passes through the heat exchanger. Note, single pass heat pumps do not operate efficiently in low load conditions. Hot water distribution and recirculation system should be designed to minimize distribution heat loss (caused by unused hot water losing heat in the distribution piping). Multi-pass HPWHs tend to be less efficient than single-pass HPWHs because of increased pumping energy and longer operating times, but depend on system design.
[3] Split type system and CO_2-based heat pumps do not have significant field-measured performance data publicly available. Field-measured data is available for packaged heat pump, however, total energy efficiency is significantly dependent on the equipment location and available heat source.
[4] Some split-system heat pumps use a cascade type system, with an outdoor and indoor unit and refrigerant connecting the two pieces of equipment.

5.0 Domestic Hot Water System Detailed Comparisons

The following section provides comparisons of various metrics conducted as part of this study. Table 3 provides an overall summary of the domestic hot water systems in the six (6) schools evaluated. The summary information includes school area, students served, heat pump make and model, system type and quantity, and capacity, with additional details provided in subsequent sections. (Note that for the purposes of this report, the schools evaluated are referred to generically as PS School 1 thru 6.)

Table 3. DHW Equipment Summary

School	Area (SF)	Students Served	Heat Pump Make / Model	System Type (Packaged or Split)	Quantity of Heat Pumps	DHW System Heat Pump Mode Capacity (MBH)	DHW Total Capacity (Heat Pump and Electric Resistance, MBH)
PS School 1	77,001	560	Lochinvar CHPA120PD	Packaged	3	113.7	236.7
PS School 2	92,022	487	Colmac CxA-10	Split	1	186.0	186.0
PS School 3	53,638	1050	Nyle C60	Split	2	200.9	200.9
PS School 4	81,027	684	AO Smith CHP120	Packaged	2	67.4	149.3
PS School 5	61,198	520	AO Smith CHP120	Packaged	2	67.4	149.3
PS School 6	50,742	1100	Lochinvar CHPA120PD	Packaged	2	75.8	157.7

Cost Comparison

Project cost estimates were provided by SCA, for OLA's review. According to the estimates, the material and labor cost of the split type system was 24% more than the packaged type system when compared on a dollar per square foot basis. Costs do not always scale linearly with building area, however, the split type system was found to cost approximately 21% more than the packaged DHW heat pump when comparing the cost per output capacity. Based on the cost estimates provided, it's reasonable to expect split type systems to cost approximately 20% to 25% more than packaged systems.

Table 4 provides a summary of the cost estimations, provided by SCA, for each school's domestic hot water system. Relative material and labor costs are shown, per heat pump, where the lowest cost shown is 1.00 (for one (1) packaged heat pump) and the highest cost is 4.53 (for one (1) larger split heat pump). Relative total costs are also shown, where the lowest cost is 1.00 and the highest is 2.56. Cost data was limited to the six schools analyzed, and large ranges of prices were found in packaged type systems where the material cost varied by 74%. Furthermore, commercial equipment costs may vary depending on the vendor or data source used by the cost estimator at the time of the cost estimation. In general, cost estimates were typically only provided for the water heater, and did not include specific components such as circulator pumps, expansion tanks, controls, freeze protection, supplemental heat, and other ancillary equipment. The costs shown in Table 4 are for the heat pump units only, and do not include piping which would be assumed to be approximately equal between the systems.

Table 4: Cost Estimate Summary Comparison

School	Area (SF)	Quantity	Make/Model	DHW System Type	Relative Material Unit Cost	Relative Labor Unit Cost	Relative Total Cost
PS School 1	77,001	3	Lochinvar CHPA120PD	Packaged	1.74	1.00	2.04
PS School 2	92,022	2	Lochinvar CHPA120PD[1]	Packaged[1]	1.10	1.95	1.07
PS School 3	53,638	2	Lochinvar CHPA120PD[1]	Packaged[1]	1.00	1.94	1.00
PS School 4	81,027	2	Lochinvar CHPA120PD[1]	Packaged	1.00	1.94	1.00
PS School 5	61,198	2	AO Smith CHP-120	Packaged	1.22	1.00	1.01
PS School 6	50,742	2	Lochinvar CHPA120PD	Packaged	1.74	1.00	1.36
PS School 7[2]	103,158	1	Colmac CxA15 (181GPH)	Split	3.07	1.42	2.88
		1	Colmac CxA15 (267 GPH)	Split	4.53	1.69	

[1] As noted in cost estimate report.
[2] PS School 7 Cost Report was provided by SCA as Split System cost data point

Efficiency and Capacity Comparison

OLA reviewed the DHW system designs and eQuest energy models of the six (6) selected capacity projects and reviewed the DHW loads in each energy model against the design drawings and specifications.

The DHW heat pump coefficient of performance (COP) in the six (6) projects, ranged from 2.8 to 4.2 COP, based on the mechanical schedules. The split type system heat pumps were noted as having lower COP, however, mechanical schedules often do not provide enough detail on variables affecting performance to compare equally. These variables include ambient temperature assumed, system mode (e.g. if packaged heat pump efficiency includes electric resistance energy). Upon further evaluation, the COPs of the different manufacturers are comparable (closer than the 2.8 to 4.2 COP range suggests) when all factors are equal. In general the split type system heat pumps can operate at lower outdoor temperatures, therefore are able to be installed outdoors, unlike packaged systems which typically do not operate lower than approximately 20°F.

The packaged heat pumps studied in this project all include factory electric resistance heat (COP of ~1). The default setting of these units is called a “hybrid mode”, where the heat pump is the primary heating source, but electric resistance is activated if demand exceeds a predetermined level so that the setpoint temperature can be recovered more quickly. The hybrid mode cannot be compared equally to a split type system heat pump that does not use electric resistance. The default mode should be updated to “efficiency” (heat pump only) mode for each school unless approved otherwise.

The DHW equipment is sized based on standardized guidelines by SCA. The capacities for the packaged heat pump systems, used in mechanical schedules, are typically based on the “hybrid mode” capacity and includes the full capacity of the heat pump and electric resistance heat output. This should be carefully evaluated when comparing different systems and manufacturer/models.

Equipment Location and Configuration Review

Equipment location has a significant effect on heat pump operation. DHW heat pumps transfer heat from ambient air (either inside or outside of a building) to the domestic water, therefore, require a heat source. If a heat pump is placed in a room with highly insulated walls and no additional heat source, then it can cool the space until the indoor temperature falls below the heat pump’s minimum ambient operating air temperature. On the other hand, the benefit of the ambient air heat transfer is if there is heat generated from other equipment while the heat pump is operating, such as pumps, then the heat pump will recover any waste heat.

Note, several manufacturers have minimum space requirements when equipment is located indoors. These space requirements should be noted in design drawings, to ensure adequate space is provided. Example of Lochinvar Commercial Heat Pump Electric Water Heater space requirements provided below.

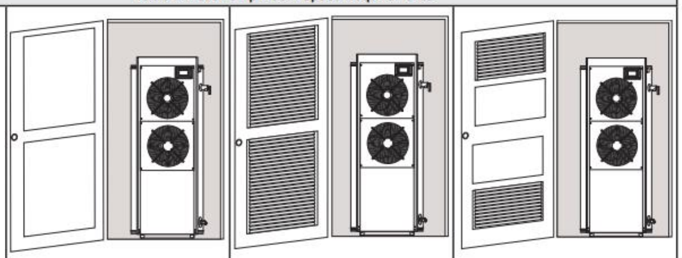
ROOM SIZE REQUIREMENT

The water heater should have adequate space (clearances) for periodic servicing. For optimal water heater efficiency and performance, the water heater must have unrestricted airflow and is recommended to have a minimum installation space of approximately 3200 cubic feet. Installation spaces less than the recommended could result in reduced water heater efficiency and performance.

If the water heater is installed in a confined space with less than 3200 cubic feet, provisions should be made to ensure sufficient airflow, such as installing louvered grills or fully louvered doors to ensure the most efficient operation of the water heater. See ***Table 4.*** Failure to do so could result in reduced heater efficiency and performance.

If the ambient air temperature in the installed location drops more than 15°F (8°C) during heating, air circulation is insufficient and could result in reduced water heater efficiency and performance. The side opposite to the fans should normally be left open with a minimum clearance of 36" (91 cm) to any obstacles.

Table 4. Heat Pump Room Space Requirements



Configuration (See Note 1)	Enclosed Room (No louvers)	Fully Louvered Door or Wall Opening	Double Louvers in Wall or Door
Minimum Space (FT^3)	3200	1600	1600
Space Example H x L x W (FT)	18 x 18 x 10	13 x 13 x 10	13 x 13 x 10

1. Total minimum louver open area is 4 ft^2 or 576 in^2.
2. Installations less than the recommended room size could result in reduced water heater efficiency and performance.
3. When two louvers are installed, install one louver at or near the top of the heater and the other one close to the bottom of the heater.
4. Maintaining a room temperature above 50°F(10°C) helps to avoid the defrost cycle being activated and provides for better heater efficiency and performance.

Figure 3: Example of Lochinvar Space Requirements as Noted in Manual (*image credit: Lochinvar*)

For DHW heat pumps located indoors, during cold outdoor temperatures, the energy required to heat the DHW includes both the energy to operate the DHW heat pump and the energy to heat the space to cover heat loss from the envelope (walls, window, doors, etc.). The following equation shows the energy absorbed by the DHW heat pump. Where Q_a is the energy absorbed by the HPWH, and Q_d is the energy required to heat the water. The equation is independent of time scale, however daily time scales were used for this study.

$$Q_a = Q_d \times (1 - \frac{1}{COP})$$

The heat source to satisfy the energy required for Q_a greatly impacts the DHW system's overall efficiency. If an electric resistance unit heater is used to generate heat for Q_a, then the DHW system's overall efficiency is greatly diminished, and would likely be more efficient if placed outdoors so long as it is capable of operating under the outdoor conditions.

OLA evaluated three (3) scenarios to determine what general conditions would cause a DHW heat pump water heater, located indoors, to require additional space-heating. Results of this analysis and background information is provided in the following Table 5.

Table 5. DHW Heat Absorbed Evaluation Summary

School	HPWH Location	Adjacent Rooms	Equipment in Mechanical Room	Results
PS School 1	Rooftop Mechanical Room	• Gymnasium and stairwell	• 2 gas-fired condensing Viessmann Vitocrossal 200 boilers, • 3 primary hot water loop pumps, • 2 perimeter heating secondary hot water pumps • 2 chilled water loop pumps	• Negligible additional space-heating required.
PS School 5	Rooftop Mechanical Room	• Stairwell and storage room	• 2 hot water Bell & Gossett circulation pumps	• Significant additional space-heating required. Increase of site EUI of 0.5 kBtu/SF (potentially 2-3% of whole building EUI).
Hypothetical cellar - based on PS School 5, but Cellar HPWH	Cellar Mechanical Room			• Additional space-heating required. Increase of site EUI of 0.3 kBtu/SF. • Room area would need to increase by 50% to eliminate additional space heating required.

DHW Load and Energy Consumption Comparison

The DHW consumption has a direct relationship to the DHW system energy consumption. The energy models and supporting documentation provided for this study included SCA Appendix A domestic hot water calculator spreadsheets. The project designs occurred at different times, and several SCA Appendix A spreadsheet versions were used in the different projects. In general, the SCA Appendix A spreadsheet provides a Peak Hot Water Demand (gpm) output, which is used in the eQuest model. The (eQuest) energy model uses a fractional schedule to create an hourly DHW consumption profile by assigning a fraction of the peak hot water demand to each hour of the day.

OLA evaluated each energy model's peak hot water demand and fractional schedule to calculate the estimated daily hot water usage (in gallons per day). The daily hot water usage was then normalized between schools, by dividing by number of students. A large variation (~40%) was found in the estimated gallons per day per student. These values were also higher than expected, with values approaching 1.0 gallon/student/day.

The relationship between the domestic hot water consumption and its impact on energy usage is also shown in the following spreadsheet-based energy calculation results, for the two (2) different DHW configurations (split type system and packaged heat pumps). For this analysis, the schools were grouped into two (2) groups, one based on the average DHW consumption (gal/day) of the two (2) split type system heat pump schools, and one based on the average DHW consumption of the four (4) packaged heat pump schools. Table 6 summarizes the results of this analysis.

Table 6. DHW Spreadsheet Calculation Comparing Impact of DHW Consumption on Results

System Type	Calculation Criteria	Modeled (unmixed) DHW Gal/Day	Installed Equipment COP[1]	Annual DHW Site EUI (kBtu/SF)
Split Type System Heat Pump	Based on Average Energy Model DHW Consumption	666	2.6	0.96
	Based on OLA DHW Consumption Metering (0.44 gal/day/student)	220		0.32
Packaged Heat Pump	Based on Average Energy Model DHW Consumption	690	2.0	1.32
	Based on OLA DHW Consumption Metering (0.44 gal/day/student)	220		0.89

[1] Split Type System heat pump COP based on weighted average (based on hourly bin data) and an OAT-based performance curve, based on manufacturer's data. Packaged heat pump COP based on field observed operation (Field Performance of Heat Pump Water Heaters in the Northeast, 2016, US Department of Energy.

6.0 Review of CO_2-Based Heat Pumps

Carbon dioxide (CO_2) based heat pumps use CO_2 as the refrigerant fluid, (as opposed to HFC refrigerants). CO_2 based heat pumps are increasing in availability as manufacturers design and develop new equipment, and expand production, to meet market demand for energy efficient heat pumps with low global warming potential refrigerants. Equipment offered on the market today is of the split type system configuration, with the heat pump typically located outdoors and storage tank located indoors.

In addition to having a global warming potential (GWP) of one (1) (see table below for additional GWPs of common refrigerants), CO_2 heat pumps offer benefits in domestic hot water applications such as being able to produce hot water temperatures above 140°F (above the minimum recommended storage tank temperature to eliminate legionella growth) even in cold ambient air environments. Many non-CO_2 heat pumps cannot produce hot water temperatures during the same conditions, and therefore need supplemental electric resistance heaters to reach adequate supply temperatures. Another benefit of CO_2 heat pumps, over its competition, is that performance (COP) and capacity (MBH) does not degrade during lower temperatures as much as non-CO_2 heat pumps.

Table 7. Common Refrigerant Global Warming Potentials

Refrigerant	Global Warming Potential
R410a	2,088
R134a	1,430
R32	675
R454B	466
R290 (propane)	3.3
R744 (CO_2)	1

CO_2-based heat pumps come with a few technical challenges as well. Many of these challenges have solutions in design or in production for some manufacturers. CO_2 heat pumps on the market today are primarily single-pass heat pumps, meaning they heat the water in a single pass through the heat exchanger, and requires a large temperature differential between the inlet and outlet water in the heat exchanger to operate. This temperature differential is often referred to as “lift”. Some models require a “lift” of at least 45°F. The main challenge with this large “lift” is that during low DHW loads, the only heat loss of the system is through distribution pipes and recirculation system, and this heat loss doesn’t create a large temperature differential (could be less than 5°F). The solution is to use a separate small DHW heater, specific to maintaining the low distribution loss. These tanks are often called “swing tanks” and are designed to handle low load conditions distribution loss. Manufacturers such as Mitsubishi have designed skids (prefabricated assemblies of components) to include all the necessary components to operate and install these units. These components include a storage tank designed to optimize tank temperature stratification and inlet and outlet temperature differential, the swing tank, and framing.

Another challenge with CO_2 heat pumps is their high operating pressure. These heat pumps are required to operate at pressures of around 1,500 psi (as opposed to typical non-CO_2 heat pumps that operate at closer to 500 psi.) These higher pressures require specific components, which are not as common as non-CO_2 heat pump components. However, as more equipment and manufacturers enter the market, it is expected that parts will become more readily available.

Another challenge with any split type system heat pump, is ensuring the equipment is protected against damage caused by water freezing during building-wide power outages, or unforeseen shutdown of heat pumps. Solutions to this challenge range from using an intermediate anti-freeze such as glycol instead of water to lower the freezing point of the water circulated outdoors, using heat trace, and/ or designing the system with a drain back system (drains the system in the event of a shutdown).

The final challenge is product availability and cost. CO_2-based heat pumps are newer to the market; therefore the options are limited compared to other non-CO_2 heat pumps. This limited supply and unique equipment componentry causes the price of CO_2 to be higher than its non-CO_2 competition.

The following is a list of CO_2-based domestic hot water heat pumps. This list may not include all options since new equipment enters the market frequently, including manufacturers starting to offer equipment previously only available overseas, and model names change.

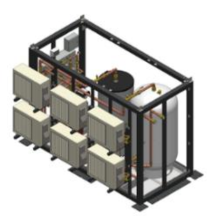
- Mitsubishi - Heat2O/QAHV

(*image credit: Mitsubishi*)

- Lync - Aegis A, CO_2 Heat Pump

(*image credit: Lync*)

- WaterDrop – Powered By SanCO$_2$



(*image credit: WaterDrop Systems*)

- Mayekawa – Unimo

(*image credit: Mayekawa*)

7.0 Appendices

A. Detailed School to School Comparisons
B. School Domestic Hot Water Background Summaries
C. Manufacturer Cutsheets

Appendix A: Detailed School to School Comparisons

Design Comparisons

Table 8 provides a summary of key information related to DHW loads in the studied schools. All schools analyzed in this study contain full kitchens. SCA provides DHW hot water consumption rate guidance in their Design Guidelines, which design teams utilize for system. Mechanical engineer DHW equipment sizing calculations were not provided, however the design drawings, equipment schedules, Appendix A calculations, and energy models were used to evaluate each school's DHW system sizing. Additional details are provided in Table 10.

Table 8. DHW Load Factor Comparison

School	Area (SF)	# of Students	# of Students Served by Kitchen[1]	# of Lavatory/ Classroom Faucets	# of Janitor Faucets	# of Kitchen Faucets
PS School 1	77,001	560	-	70	6	9
PS School 2	92,022	487	-	73	4	8
PS School 3	53,638	394	1050	67	4	11
PS School 4	81,027	684	-	105	3	8
PS School 5	61,198	540	520	69	5	10
PS School 6	50,742	344	1100	62	3	7

[1] PS School 3, PS School 6, and PS School 5 projects are additions to existing schools. Number of students served by the kitchen is provided by the Appendix A calculator for each project. The kitchen in PS School 3 and PS School 6 is sized to serve the addition and existing school, but only the addition for PS School 5.

Energy and System Sizing Comparisons

Table 9 provides a summary of each school's proposed DHW heat pump equipment efficiency, noted as a coefficient of performance (COP). Table 10 provides a summary of the equipment capacity noted in the energy model and design drawings.

Table 9. DHW Equipment Energy Efficiency

School	Heat Pump Make / Model	Mechanical Schedule COP
PS School 1	Lochinvar CHPA120PD	4.2
PS School 2	Colmac CxA-10	2.8
PS School 3	Nyle C60	4.2
PS School 4	AO Smith CHP120	4.2
PS School 5	AO Smith CHP120	4.2
PS School 6	Lochinvar CHPA120PD	4.2

Table 10. Energy Model Capacity and Design Comparison					
School	Heat Pump Make / Model	Modeled Capacity (Btu/hr)	DHW Total Capacity (Heat Pump and Electric Resistance, Btu/hr)	Heat Pump Output Capacity (Btu/hr)	Electric Resistance Output Capacity (Btu/hr)
PS School 1	Lochinvar CHPA120PD	Auto-sized by energy model (41,000 noted in Energy Modeling Report)	236,700	113,900	122,800
PS School 2	Colmac CxA-10	Auto-sized by energy model (132,200 noted in Energy Modeling Report)	186,000	186,000	n/a
PS School 3	Nyle C60	100,000	200,900	200,900	n/a
PS School 4	AO Smith CHP120	38,000	149,300	67,400	81,900
PS School 5	AO Smith CHP120	77,000	149,300	67,400	81,900
PS School 6	Lochinvar CHPA120PD	200,000	157,700	75,800	81,900

DHW Load and Energy Use Comparison (Energy Model)

Table 11 provides a summary of the DHW gallons per day (based on Peak Hot Water Demand and usage schedules) in each school's energy model, and shown per student for comparison. The table summarizes the DHW annual end use energy model results and is also shown per square foot for comparison.

School PS School 6 and PS School 3 have the highest modeled gallon per day per student rates and energy consumption per square foot. PS School 6 and PS School 3 are additions to existing schools, with kitchens and DHW systems sized to serve a larger student population than the addition.

Table 11. DHW Energy Model Comparison						
School	Peak Hot Water Demand (gpm)	Modeled (unmixed) DHW Gal/Day	Modeled Gal/Day/ Student	Modeled Gal/Day/ Students-served-by-Kitchen[1]	Modeled Annual DHW End Use (kWh)	Modeled Annual DHW Site End Use (kBtu/SF)
PS School 1	2.06	368	0.64	-	23,483	1.04
PS School 2 (split-system)	3.09	436	0.90	-	17,520	0.65
PS School 3 (split-system)	6.53	897	2.28	0.85	53,394	3.40
PS School 4	5.31	753	1.10	-	17,711	0.75
PS School 5	3.85	542	1.00	0.73	29,099	1.62
PS School 6	7.94	1,098	3.19	1.00	3,513 (therms[2])	6.92

[1]As noted in Table 8, the kitchen in PS School 3 and PS School 6 is sized to serve the addition and existing school, but only the addition for PS School 5..
[2]PS School 6 was modeled as gas-fired domestic hot water system.

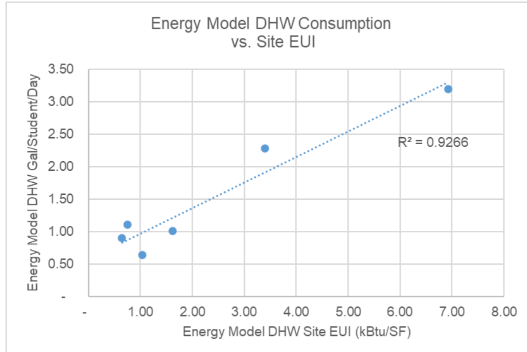


Figure 4: Energy Model DHW Consumption vs. DHW Site End Use

Table 12 provides a summary of other DHW energy model inputs that impact energy efficiency.

Table 12. Other DHW Energy Model Input Factors

School	Modeled "MAX-HP-TANK-T" Temp. (°F)	Tank Volume (gallons)	Loop Differential Temperature (Deg F)
PS School 1	100	Auto-sized	95
PS School 2	100	249	45
PS School 3	100	119	45
PS School 4	140	111	80
PS School 5	100	120	80
PS School 6	N/A	200	45

For hand washing and lavatory usage, all energy models used the same DHW usage schedule, "DHWSCH", except school PS School 1, which used the "TOTHW-SCH" schedule for weekends and holidays. All other school models used a 1% fraction for the weekend and holidays. For the kitchen hot water consumption, all schools' energy models used the same schedule, "KITHW-SCH". Table 13 provides a summary of the total gallons per day per usage category.

Table 13. Energy Model DHW Water Consumption Breakdown

School	Lavatory DHW Usage Schedule	Kitchen DHW Usage Schedule	Hand washing and lavatory hot water usage (gal/day)	Kitchen hot water usage (gal/day)	Sub-total (gal/day)
PS School 1	TOTHW-SCH	KITHW-SCH	118	240	358
PS School 2	DHWSCH	KITHW-SCH	54	382	436
PS School 3	DHWSCH	KITHW-SCH	29	868	897
PS School 4	DHWSCH	KITHW-SCH	104	649	753
PS School 5	DHWSCH	KITHW-SCH	60	481	542
PS School 6	DHWSCH	KITHW-SCH	62	1,036	1,098

Cost Comparison

Table 14 and Table 15 provides a summary of the cost estimations, provided by SCA, for each school's domestic hot water system. Relative total costs are also shown, where the lowest cost is 1.00 and the highest is 2.56. The cost per square foot of school area and system capacity was also calculated for comparison. HPWH material cost range differed by 74%. Relative material and labor costs are shown, per heat pump, where the lowest cost shown is 1.00 (for one (1) packaged heat pump) and the highest cost is 4.53 (for one (1) larger split heat pump).

In general, cost estimates were typically only provided for the water heaters for the schools, and lacked cost data on circulator pumps, expansion tanks, controls, freeze protection, supplemental heat, and other ancillary equipment.

Table 14. DHW Equipment Cost Comparison Summary					
School	Area (SF)	System Capacity (MBH)	Relative Total Cost of DHW System	Relative Cost of DHW System Cost per SF	Relative Cost of DHW System Cost per MBH
PS School 1	77,001	236.7	2.04	2.56	1.95
PS School 2	92,022	186	1.07	1.00	1.16
PS School 3	53,638	200.9	1.00	1.60	1.00
PS School 4	81,027	149.3	1.00	1.15	1.45
PS School 5	61,198	149.3	1.01	1.45	1.39
PS School 6	50,742	157.7	1.36	2.31	1.74

Table 15. DHW Equipment Cost Comparison					
School	Qty	Make/Model	System	Relative Material Unit Cost	Relative Labor Unit Cost
PS School 1	3	Lochinvar CHPA120PD	Packaged	1.74	1.00
PS School 2	2	Lochinvar CHPA120PD[1]	Packaged[1]	1.10	1.95
PS School 3	2	Lochinvar CHPA120PD[1]	Packaged[1]	1.00	1.94
PS School 4	2	Lochinvar CHPA120PD[1]	Packaged	1.00	1.94
PS School 5	2	AO Smith CHP-120	Packaged	1.22	1.00
PS School 6	2	Lochinvar CHPA120PD	Packaged	1.74	1.00
PS School 7[2]	1	Colmac CxA15 (181GPH)	Split	3.07	1.42
PS School 7[2]	1	Colmac CxA15 (267 GPH)	Split	4.53	1.69

[1] As noted in cost estimate.
[2] Due to a lack of split type system cost data, PS School 7 Cost Report was provided by SCA, however was not evaluated in detail for other sections of this report.

Appendix B. School Domestic Hot Water Background Summaries

PS School 1:

The first school reviewed in this study was PS School 1. This is a five story (plus cellar), 77,001 square foot middle school. This school is expected to complete construction in 2023.

The domestic hot water loads are served by three (3) heat pump water heaters (HPWHs). The heat pumps are Lochinvar CHPA120PD models and are packaged systems. The school will contain 560 students and has a total of 85 faucets (see table below for breakdown). The modeled average number of gallons of water per day per student is 0.64. The modeled DHW site energy use per square foot is 1.04 kBtu/SF, see table below for more details.

Table 16. PS School 1 Domestic Hot Water (DHW) Equipment Summary

Area (SF)	Heat Pump Make / Model	System Type (Packaged or Split)	DHW System Heat Pump Mode Capacity (MBH)	DHW Total System Capacity (MBH)
77,001	Lochinvar CHPA120PD	Packaged	113.7	236.7

Table 17. PS School 1 Domestic Hot Water Service Summary

# of Students	# of Lavatory/Classroom Faucets	# of Janitor Faucets	# of Kitchen Faucets
560	70	6	9

Table 18. PS School 1 Domestic Hot Water Energy Summary

Modeled (unmixed) DHW Gal/Day	Modeled Gal/Day/Student	Modeled DHW End Use (kWh)	Modeled DHW End Use (kBtu/SF)
368	0.64	23,483	1.04

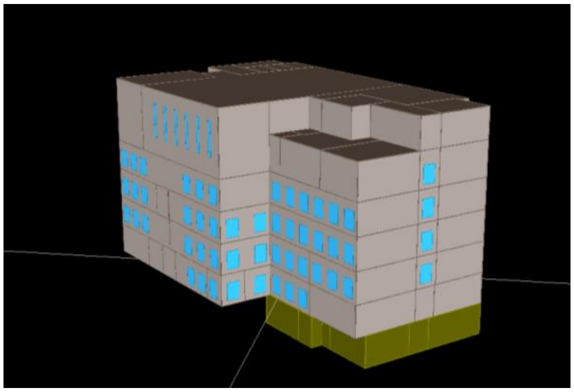


Figure 5: Energy Model Rendering of PS School 1

Figure 6: Lochinvar's Commercial Heat Pump (Image credit: Lochinvar)

The three (3) heat pumps are located in the lower boiler room. The boiler room is located next to an elevator machine room and stairwell. The boiler room also contains three (3) primary hot water loop pumps, two (2) perimeter heating secondary hot water pumps, and two (2) chilled water loop pumps. The boiler room also includes two (2) gas-fired condensing Viessmann Vitocrossal 200 boilers. An air intake is located directly above the packaged HPWHs.

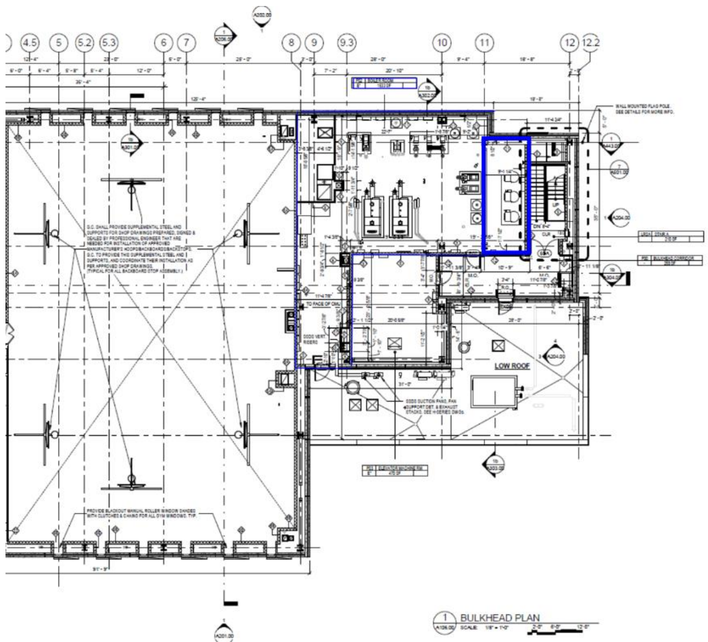


Figure 7: DHW System Location

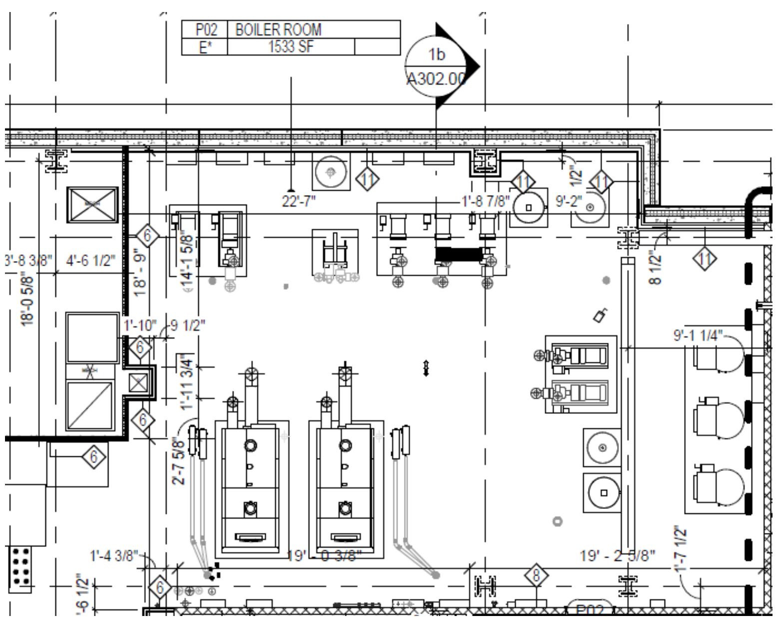


Figure 8: DHW Location Detail

PS School 2:

The next school examined was the PS School 2. It is a four story, 92,000 square foot school serving K through 8th grade. This school is expected to complete construction in 2026.

The school is served by one (1) HPWH in the cellar and is a split type system. The heat pump's model is a Colmac CxA-10 and has a separate 150 gallon Niles storage tank. The school will contain 487 students and has a total of 85 faucets (see table below for breakdown). The modeled average of gallons of water per day per student is 0.90. The modeled DHW site energy use per square foot is 0.65 kBtu/SF, see table below for more details.

Table 19. PS School 2 Domestic Hot Water (DHW) Equipment Summary

Area (SF)	Heat Pump Make / Model	System Type (Packaged or Split)	DHW System Heat Pump Mode Capacity (MBH)	DHW Total System Capacity (MBH)
92,022	Colmac CxA-10	Split	186.0	186.0

Table 20. PS School 2 Domestic Hot Water Service Summary

# of Students	# of Lavatory/Classroom Faucets	# of Janitor Faucets	# of Kitchen Faucets
487	73	4	8

Table 21. PS School 2 Domestic Hot Water Energy Summary

Modeled (unmixed) DHW Gal/Day	Modeled Gal/Day/Student	Modeled DHW End Use (kWh)	Modeled DHW End Use (kBtu/SF)
436	0.90	17,520	0.65

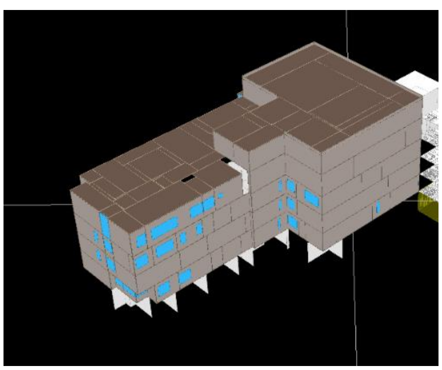


Figure 9: Energy Model Rendering of PS School 2

Figure 10: Colmac CxA-10 (image credit: Colmac)

The Colmac hot water heat pump and Niles steel storage tank are located in the cellar booster pump room. The booster pump room contains two (2) Bell & Gossett inline circulator pumps and one (1) Armstrong duplex booster pump. The booster pump room is located adjacent to the custodian locker rooms and is across from the electric service room.

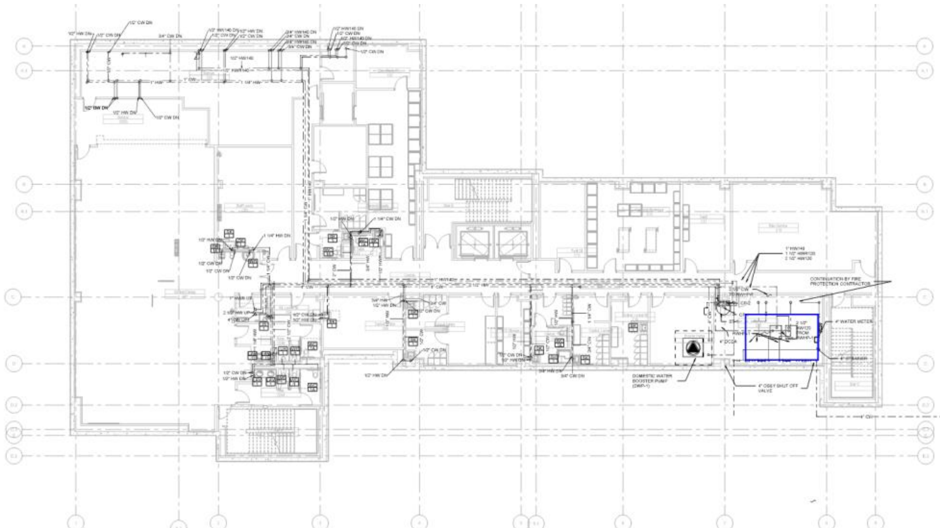


Figure 11: DHW Location

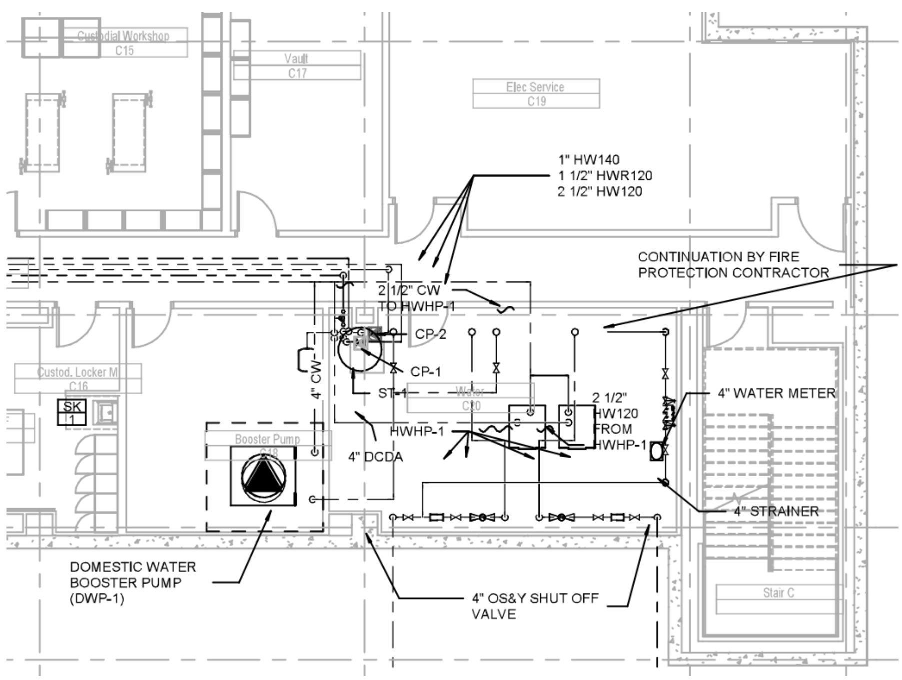


Figure 12: DHW Location Detail

PS School 3:

Another school analyzed was PS School 3, which is an addition to an existing school. It is 4 floors (plus cellar) and 53,628 square feet. It is a K through 8th Grade school and construction is expected to be completed in 2026.

The domestic hot water loads are served by two (2) HPWHs and are split type system. The heat pumps' models are Nyle C60 and has a separate 150 gallon Nyle storage tank. The school will contain 394 students and has a total of 82 faucets (see table below for breakdown). The modeled average of gallons of water per day per student is 2.28. The modeled DHW site energy use per square foot is 3.40 kBtu/SF, see table below for more details.

Table 22. PS School 3 Domestic Hot Water (DHW) Equipment Summary

Area (SF)	Heat Pump Make / Model	System Type (Packaged or Split)	DHW System Heat Pump Mode Capacity (MBH)	DHW Total System Capacity (MBH)
53,638	Nyle C60	Split	200.9	200.9

Table 23. PS School 3 Domestic Hot Water Service Summary

# of Students	# of Lavatory/Classroom Faucets	# of Janitor Faucets	# of Kitchen Faucets
394	67	4	11

Table 24. PS School 3 Domestic Hot Water Energy Summary

Modeled (unmixed) DHW Gal/Day	Modeled Gal/Day/Student	Modeled DHW End Use (kWh)	Modeled DHW End Use (kBtu/SF)
897	2.28	53,394	3.40

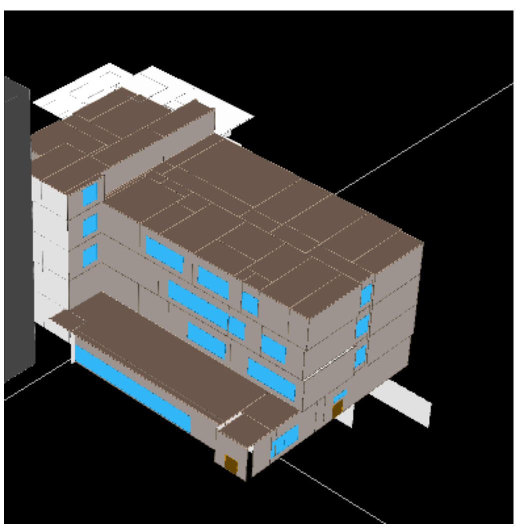


Figure 13: Energy Model Rendering of PS School 3

Figure 14: Nyle C60 (image credit: Nyle)

The split type heat pumps and storage tank are located in the mechanical room on the fourth floor. This mechanical room contains only one (1) Bell & Gossett expansion tank with no other equipment located in this mechanical room. The room is adjacent to the electrical service room and custodian office.

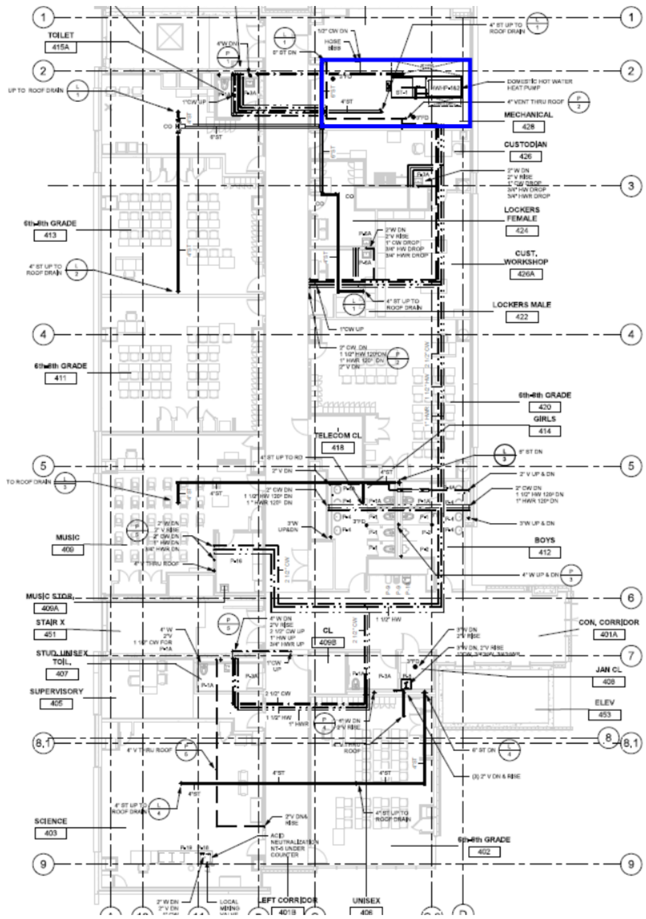


Figure 15: DHW Location

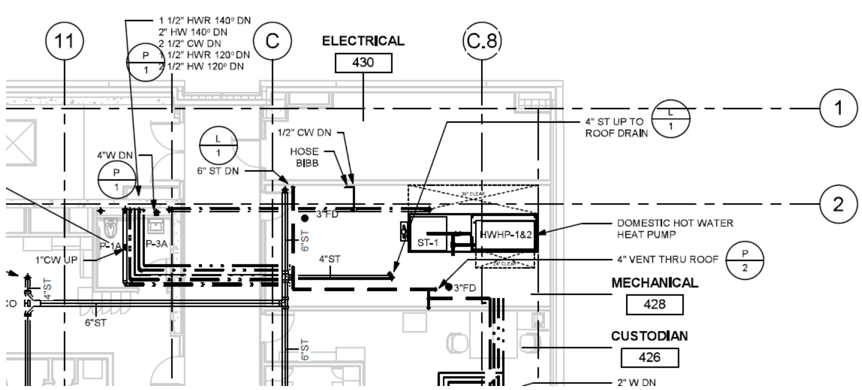


Figure 16: DHW Detail

PS School 4:

The fourth school in this study was PS School 4. It is 3 stories and 81,027 square feet, K through 8th Grade school. Construction is expected to be completed in 2025.

The domestic hot water loads are served by two (2) HPWHs. The heat pump models are AO Smith CHP120 and are packaged systems. The school will contain 684 students and has a total of 116 faucets (see table below for breakdown). The modeled average of gallons of water per day per student is 1.10. The modeled DHW site energy use per square foot is 0.75 kBtu/SF, see table below for more details..

Table 25. PS School 4 Domestic Hot Water (DHW) Equipment Summary

Area (SF)	Heat Pump Make / Model	System Type (Packaged or Split)	DHW System Heat Pump Mode Capacity (MBH)	DHW Total System Capacity (MBH)
81,027	AO Smith CHP120	Packaged	67.4	149.3

Table 26. PS School 4 Domestic Hot Water Service Summary

# of Students	# of Lavatory/Classroom Faucets	# of Janitor Faucets	# of Kitchen Faucets
684	105	3	8

Table 27. PS School 4 Domestic Hot Water Energy Summary

Modeled (unmixed) DHW Gal/Day	Modeled Gal/Day/Student	Modeled DHW End Use (kWh)	Modeled DHW End Use (kBtu/SF)
753	1.10	17,711	0.75

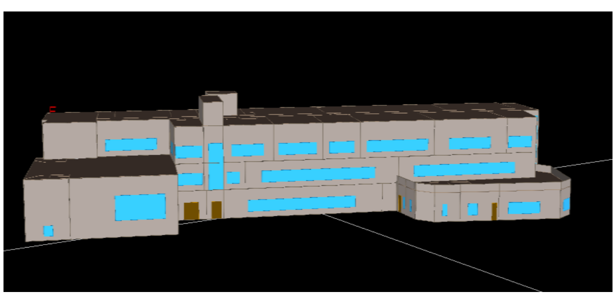


Figure 17: Energy Model Rendering of PS School 4

Figure 18: AO Smith CHP120 (Image Credit: AO Smith)

The heat pump water heaters are located in third-floor boiler room. The boiler room also contains, two (2) Viessmann Vitocrossal 300 CA3B boilers, three (3) primary hot water loop pumps, two (2) secondary hot water loop pumps, two (2) primary chilled water loop pumps, one (1) hot water heat exchanger, two (2) hot water glycol loop expansion tanks, and one (1) chilled water glycol loop expansion tank. The boiler room is adjacent to a storage room, electrical room, and classroom.

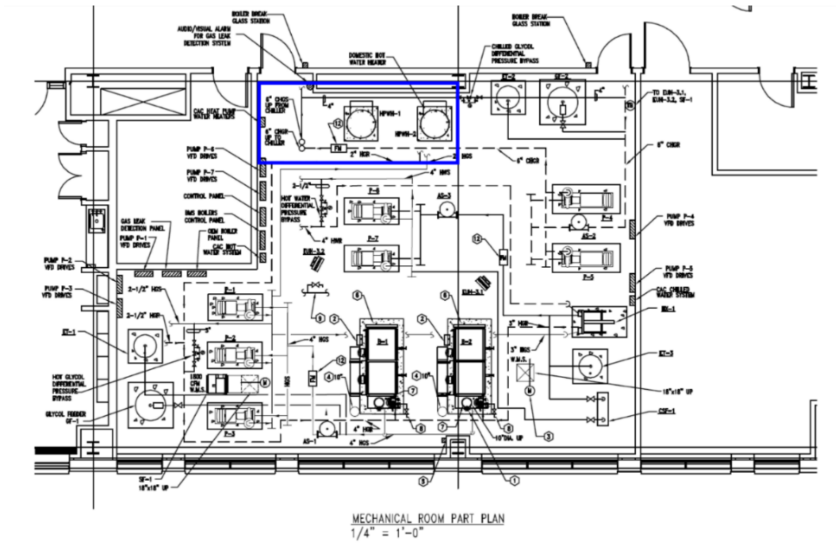


Figure 19: Location

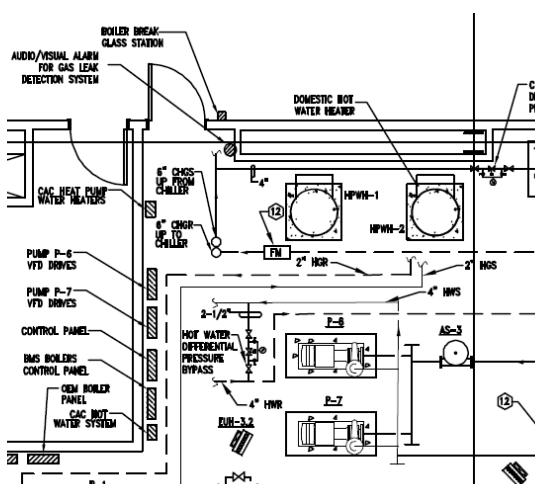


Figure 20: DHW Detail

PS School 5:

The next school studied was PS School 5, which is an addition to an existing school. It is five (5) stories and will be 61,198 square feet. Construction is expected to be completed in 2026.

The domestic hot water loads are served by two (2) HPWHs. The heat pump models are AO Smith CHP120 and are packaged systems. The school contains 540 students and has a total of 84 faucets (see table below for breakdown). The modeled average of gallons of water per day per student is 1.00. The modeled DHW site energy use per square foot is 1.62 kBtu/SF, see table below for more details..

Table 28. PS School 5 Domestic Hot Water (DHW) Equipment Summary

Area (SF)	Heat Pump Make / Model	System Type (Packaged or Split)	DHW System Heat Pump Mode Capacity (MBH)	DHW Total System Capacity (MBH)
61,198	AO Smith CHP120	Packaged	67.4	149.3

Table 29. PS School 5 Domestic Hot Water Service Summary

# of Students	# of Lavatory/Classroom Faucets	# of Janitor Faucets	# of Kitchen Faucets
540	69	5	10

Table 30. PS School 5 Domestic Hot Water Energy Summary

Modeled (unmixed) DHW Gal/Day	Modeled Gal/Day/Student	Modeled DHW End Use (kWh)	Modeled DHW End Use (kBtu/SF)
542	1.00	29,099	1.62

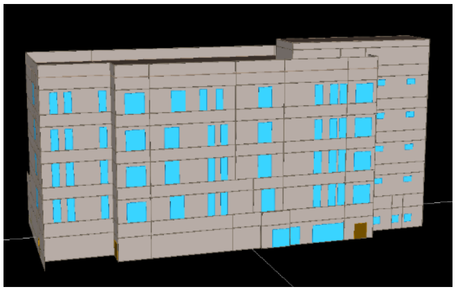


Figure 21: Energy Model Rendering of PS School 5

Figure 22: AO Smith CHP120
(Image Credit: AO Smith)

The heat pump water heaters are located in the rooftop mechanical room. The mechanical room only contains two (2) Bell & Gossett hot water circulator pumps in addition to the water heaters. The mechanical room is adjacent to a stairwell and a storage room.

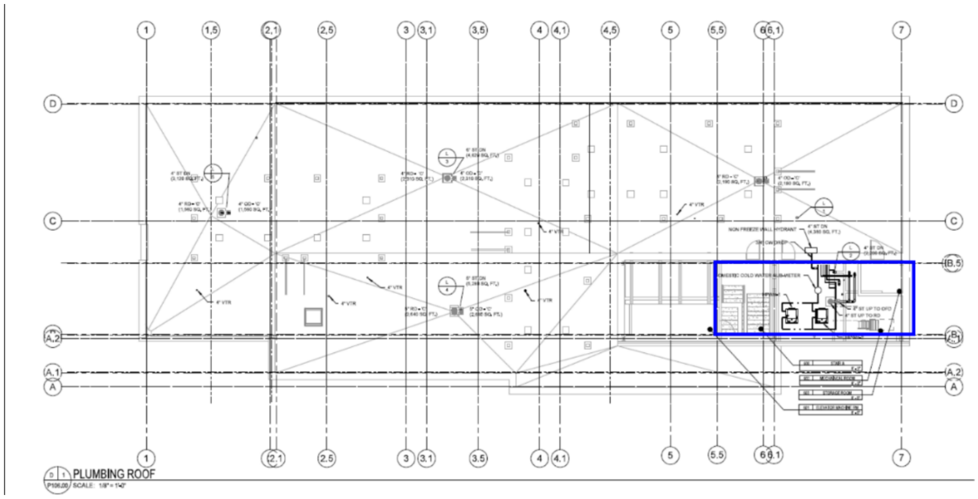


Figure 23: DHW Location

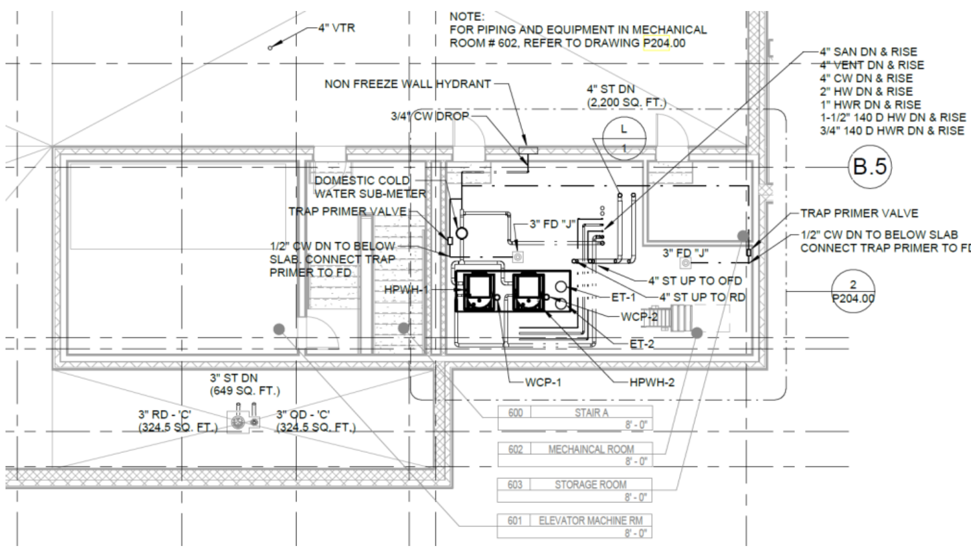


Figure 24: DHW Detail

PS School 6:

The next school in the study was PS School 6, which is an addition to an existing school. It is a four-story building (plus basement) and is 50,742 square feet. Construction is expected to be completed in 2024.

The domestic hot water loads are served by two (2) HPWHs. The heat pump models are Lochinvar CHPA120PD and are packaged systems. The school will contain 344 students and has a total of 72 faucets (see table below for breakdown). The modeled average of gallons of water per day per student is 3.19. The modeled DHW site energy use per square foot is 6.92 kBtu/SF, see table below for more details.

Table 31. PS School 6 Domestic Hot Water (DHW) Equipment Summary

Area (SF)	Heat Pump Make / Model	System Type (Packaged or Split)	DHW System Heat Pump Mode Capacity (MBH)	DHW Total System Capacity (MBH)
50,742	Lochinvar CHPA120PD	Packaged	75.8	157.7

Table 32. PS School 6 Domestic Hot Water Service Summary

# of Students	# of Lavatory/Classroom Faucets	# of Janitor Faucets	# of Kitchen Faucets
344	62	3	7

Table 33. PS School 6 Domestic Hot Water Energy Summary

Modeled (unmixed) DHW Gal/Day	Modeled Gal/Day/Student	Modeled DHW End Use (therm)	Modeled DHW End Use (kBtu/SF)
1,098	3.19	3,513	6.92

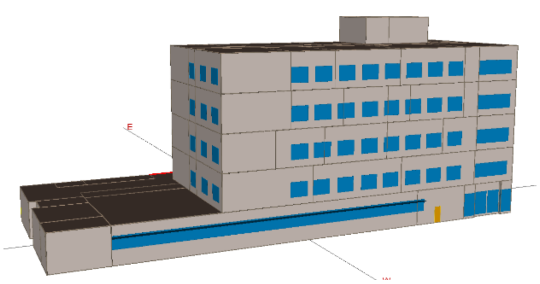


Figure 25: Energy Model Rendering of PS School 6

Figure 26: Lochinvar CHPA120PD
(Image Credit: Lochinvar)

The heat pump water heaters are located in the ground floor water meter room. The water meter room also contains two (2) close coupled centrifugal pumps serving the domestic hot water system, one (1) submersible duplex sump pump, and one (1) expansion tank. The water meter room is located adjacent to the electric service room and kitchen servery rooms.

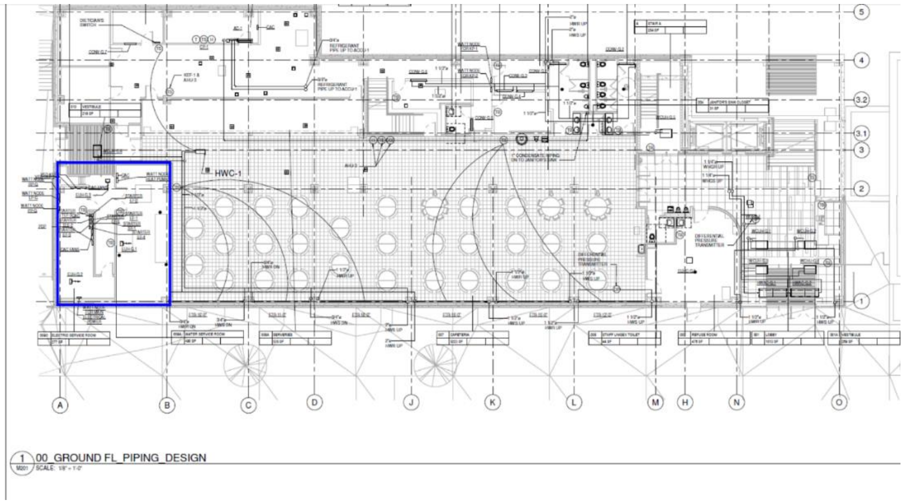


Figure 27: DHW Location

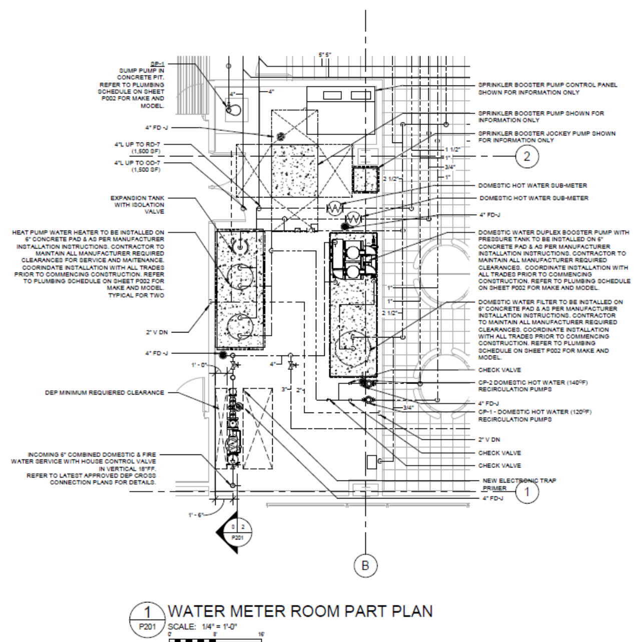


Figure 28: DHW Detail

Appendix C. Manufacturer Cutsheets

CxA AIR SOURCE HEAT PUMP WATER HEATER

STANDARD FEATURES INCLUDE:

- ECM Axial Fan
- 10, 15, 20, 25, & 30 HP compressor options
- 10 and 15 HP models fit through standard 36” door
- Electrical available in 460/60/3 (all models) and 208-230/60/3 (<20HP)
- Industrial PLC with remote mounted color touchscreen with internal controls including lead-lag, staging, temperature output
- BACnet and Modbus via MSTP or Ethernet built in
- 140°F to 160°F (60°C to 71°C) output temperatures
- Machine suitable for outdoor applications
- 304L stainless steel frame and enclosure
- Expandable in arrays of up to eight
- Integrated stainless steel circulator pump
- Double wall and vented 316L stainless steel condenser
- Slide-out tray for ease of access to refrigerant components
- NSF/ANSI 61 potable circuit, UL508A Electrical Box
- Massachusetts Board of State Examiners of Plumbers and Gas Fitters approved

AVAILABLE OPTIONS INCLUDE:

- ECM plenum fan for high static applications
- Compressor VFD for improved efficiency and control
- Cool Weather Package with Intelligent defrost for ambient conditions between 35°F to 50°F (1.6°C to 10°C)
- Freezing Weather Package with Intelligent defrost, trace tape, and pan heater for ambient conditions between 23°F to 35°F (-5°C to 0°C)
- Remote Monitoring via ethernet, Wi-Fi, or cellular
- Electrofin evaporator coating

Made In the USA

LEAD FREE
NSF/ANSI 61
IAPMO R&T

C UL US
LISTED

COLMAC WATERHEAT
A division of Colmac Industries

sales@colmacwaterheat.com / colmacwaterheat.com / 401 N Lincoln • PO Box 72, Colville, WA 99114 USA
Tel: (509) 684-4505 / Toll Free: (800) 926-5622 / FAX: (509) 684-4500

EQUIPMENT SPECIFICATION
CxA-10 Thru CxA-30 AIR-SOURCE HEAT PUMP WATER HEATER
COLMAC INDUSTRIES, INC.

Model: CxA-10,15,20,25,30
Date: April 22nd, 2022

I. GENERAL

The heat pump water heater shall be packaged air source equipment, factory assembled, charged, and tested to UL508 compliance. The heat pump shall be suitable for heating potable water and have the capability of producing no less than 160°F (71°C) water up to 185°F(85°C) under predetermined source conditions, with heating capacity and C.O.P. as indicated on the application specific documents. The unit shall be fully enclosed and suitable for outdoor installation.

Heat Pump water circuit shall be NSF 61 low lead certified by a third-party national testing laboratory for potable water applications.

II. COMPONENTS

Cabinet and Frame: Cabinet shall be 304L stainless steel (316L external skins optional), designed for outdoor operation. Cabinet Supports, channels and beams shall also be constructed of 304L stainless steel. Compartments shall have large access doors for servicing. Refrigerant components shall be in a separate compartment from fan for service during operation. Unit shall have stainless steel drip pan for condensate. Unit shall be designed with slide out refrigeration tray to allow refrigeration component servicing while unit is configured in a side-by-side array and connected to intake and discharge ducting.

Electrical: Control box shall be NEMA 4x or equivalent. Control box shall possess a main disconnect switch to shut off power to all components, and an additional switch to shut off control power.

Fan: Direct-drive EC fan (axial or plenum) with high-performance axial impeller, mounted on an EC motor with integrated control electronics. The fan arrangement shall be draw-through design. Integrated diffuser, optimized inlet ring, aerodynamically optimized guard grill. Profiled blade geometry; impeller made of highly corrosion resistant composite material. Motor impeller statically and dynamically balanced on two planes.

Evaporator Coil: Shall be aluminum microchannel construction. (For corrosion resistant coating see OPTIONS section).

Condenser: 316L Stainless steel, copper brazed plate, vented double wall type. Single wall condenser construction shall not be allowed. UL Listed, NSF 372 compliant, and suitable for up to 365°F (165°C) high temperature operation with potable water. Unit shall be operational pressure rated to no less than 435 PSI (30 Bar).

Refrigerant: Refrigerant shall be R-134a.

Refrigerant Accessories:

A. Filter-Driers: Sweat connection type.
B. Sight Glass: Moisture indicating type.
C. Suction accumulator.

Expansion Valve: Electronic expansion valve shall be specifically designed for heat pump use with field adjustable superheat feature and employed with a dedicated programmable, PID equipped microprocessor controller.

Compressor: Hermetic scroll type by Copeland Corp., suitable for high temperature operation with R-134a refrigerant. Compressor shall have optional variable frequency options to maximize electrical efficiency and capacity for seasonal applications. Compressor shall have belly band heater to maintain proper oil temperature to avoid wear upon compressor startup. Heat pump shall have double vibration isolation between the compressor and unit frame.

Potable Water Circulating Pump: Shall be in-line stainless steel body NSF-61 Certified, centrifugal type, able to deliver rated flow against the external head shown on the drawings.

Air Filter: Factory installed air filter shall have 1-inch thick, rigid polyester filter media that is MERV 4 rated. Filter shall be re-usable and washable with soap and water.

III. CONTROLS

The heat pump unit shall have industrial PLC controls with the following features:

Call for Heat Logic: Unit shall utilize its own logic to analyze up to 4 factory-provided temperature sensors and run via user-specified temperature setpoints. Unit shall have the ability to trigger on via BMS communications (see communications and UI) or a closed contact set.

Constant Leaving Water Temperature Control: Unit shall possess the ability to maintain constant outlet water temperatures via PID control logic, regardless of the inlet water temperature. Setpoint temperature shall be field adjustable.

Refrigeration Cycle Controls:

Unit Protections: Built-in controls shall prevent the following conditions from exceeding boundaries that cause harm or unnecessary wear to physical components: high incoming potable water temperature, compressor short-cycling, high discharge pressure, low suction pressure, and phase failure compressor protection. Alarm notifications shall alert user of extraordinary conditions via touch screen user interface.

Intelligent Defrost: Unit shall have the ability to selectively defrost when conditions and refrigeration cycle performance dictate that frost has accumulated on the evaporator coil.

Communications and UI:

BMS Communication: Unit shall respond and report to external systems through BACnet MSTP, BACnet IP (ethernet), Modbus MSTP, or Modbus IP (ethernet). Unit shall possess the ability to report alarms, water temperatures, and status to external systems.

Data Trending: Unit shall trend recent water temperature and refrigeration cycle data for ease of troubleshooting and system performance. Unit shall possess the ability to download trending data to a provided micro-USB drive with no external hardware required.

Touch Screen: Unit shall have a touch screen with multi-tiered password protected access. The touch screen shall allow live system monitoring and password protected setpoint modifications. Screen shall possess the capability to automatically upload updates via included micro-USB drive without the requirement of any additional hardware.

Arrays of Multiple Units:

Units shall have the ability to integrate into modular arrays and possess the ability to assume leader or follower status within that array. Units shall communicate with each other via ethernet without any external hardware required. Leader unit shall have the ability to report any unit's status within the array to controlling BMS platforms.

Lead/Lag: Units shall possess lead/lag capabilities that will prioritize specific units to run to balance the run hours of all connected units.

Staging: Units shall have the ability to coordinate up to 12 user-defined stages in response to up to 4 tank temperature sensors, delay timers, and user setpoints.

IV. WATER LIMITATIONS

The heat pump has a maximum standard domestic water working pressure of 150 psig.

V. ADDITIONAL OPTIONS

OPTION 1: Electrocoat Evaporator Coating. Evaporator coated with flexible epoxy polymer e-coat uniformly applied to all surface areas with no material bridging between fins. Coating process shall ensure complete encapsulation and uniform dry film thickness from 0.6-1.2 mils on all surface areas including fin edges. Coating shall pass 5,000 hours salt spray resistance per ASTM B117-90.

OPTION 2: Cool Weather Package. Unit shall utilize hot refrigerant gas to defrost evaporator coil with intelligent defrost (listed above) while **continuing to run** and maintain setpoint outlet water temperature.

OPTION 3: Freezing Weather Package. Unit shall possess all capabilities of the cool weather package (Option 3). In addition, all wetted surfaces shall be factory wrapped and plc controlled to provide freeze protection if the PLC is energized during freezing conditions. Cabinet shall be insulated to prevent condensation from forming on exterior surfaces. Heater shall be installed in the drain pan to prevent condensate from freezing in the unit.

615-889-8900 / Fax: 615-547-1000
www.Lochinvar.com

Typical Specification

CHE-SPEC-01

Typical Specification for Lochinvar Commercial Heat Pump Electric Water Heater

The **Commercial Heat Pump Water Heater** shall be Model Number CHPA120PD. The **Water Heater** shall be rated at 12 kW, 240V, single phase, 60 cycle AC as listed by Underwriters' Laboratories. All models meet National Sanitation Foundation NSF-5 requirements. The **Water Heater** shall have an LCD display with built-in diagnostic and troubleshooting information. The **Water Heater's** tank shall be 119 gallon capacity with 160 psi working pressure and equipped with a commercial grade anode. All internal surfaces of the tank exposed to water shall be glass-lined with an alkaline borosilicate composition that has been fused to steel by firing at a temperature range of 1400°F to 1600°F. Internal power circuit fusing shall be provided.

The **Heat Pump Water Heater** shall be capable of operating in Efficiency, Hybrid or Electric only modes. 3/4" NPT inlet and outlet water connections shall be provided. The water heater tank shall have a three year limited tank warranty; the compressor, refrigeration components and all other parts shall have a one year limited warranty. Meets or exceeds the efficiency and standby loss requirements of the U.S. Department of Energy and current edition of ASHRAE 118.1.

Technical Characteristics		
Model Type	Integrated Heat Pump Water Heater	
COP	4.2	
HP Rated Input Power	3.15 HP (2.35 kW)	
HP Rated Heating Output Capacity	11.13 kW	
Power Specification	208/240Vac ~ 60Hz 1Ph	
Maximum Operation Current	67 A	
Refrigerant	R134a	
Refrigerant Charge Quantity	3.3 Lbs (1.5 Kg)	
Electrical Heating Capacity	12.0 kW	
Measured Tank Capacity	111.76 Gal (423 L)	
Operation Modes	Efficiency, Hybrid, Electric	
Max. Water Temperature	**Efficiency/Hybrid**	**Electric**
	150°F (66°C)	180°F (82°C)
Operating Ambient Temperature	20 - 110°F (-6.6 - 43.3°C)	
Unit Operation Noise	59 dB (A)	
Approx. Heater Weight	498 Lbs (226 Kg)	
Approx. Shipping Weight	620 Lbs (281 Kg)	

COMMERCIAL ELECTRIC WATER HEATERS

Lochinvar's Commercial Heat Pump electric water heater is available in 119 gallon capacity and features a heat pump operating with environmentally-friendly R134a refrigerant that will absorb ambient heat from the surrounding air to reduce electrical consumption.

COMMERCIAL HEAT PUMP

ELECTRIC MODELS

STANDARD FEATURES

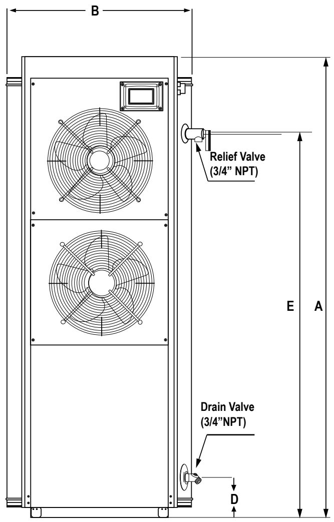
- **Heat Pump** – The 3.15 horsepower Heat Pump transfers heat from the surrounding air to the water in the tank at an industry leading 4.2 Coefficient of Performance (COP). Dual evaporator fans maximize performance and cool the equipment room.
- **Code Compliance** - Meets the U.S. Department of Energy standby loss requirements and the current edition of ASHRAE 118.1.
- **Electronic Control** - The electronic control features an LCD display with three operating modes (Efficiency, Hybrid or Electric) to match the heating requirements of the environment. The LCD display will provide runtime information and troubleshooting alerts.
- **Immersion Heating Elements** - Two 6 kW incoloy sheathed elements provide backup heat to the heat pump. The elements screw in for easy service and replacement.
- **Operating Ranges** - Operating ambient range from 40°F to 110°F with maximum set point temperature of 150°F in Efficiency or Hybrid mode and maximum 180°F in Electric mode.
- **Glass-Lined Steel Tank** - The durable glass lining is fused to the steel tank at 1600°F to assure lasting protection against rust and corrosion while providing clear, clean hot water. 300 PSI test pressure; 160 PSI working pressure.
- **Non-CFC Foam Insulation** - A uniform coverage of thick closed-cell foam insulation minimizes standby heat loss, maximizes heat retention.
- **Tank Saver Anode** - A large diameter, high capacity anode inhibits corrosion of the tank interior for long, trouble-free service.
- **Temperature & Pressure Relief Valve** - Factory installed for optimum safety.
- **Brass Drain Valve** - Designed for effective drainage and positive shut-off.
- **3-Year Limited Tank & 1-Year Parts Warranty*** – See warranty for details.

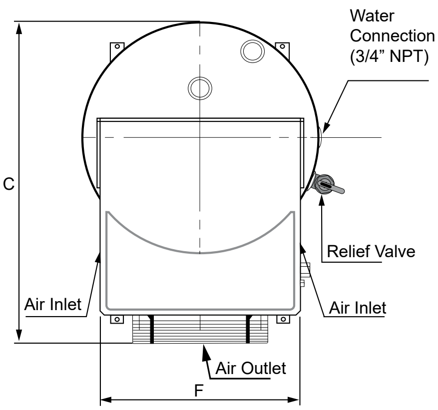
Meets ASHRAE Energy Efficiency Standards

ENERGY STAR AHRI MEMBER LOW LEAD CONTENT NSF UL

Lochinvar®
HIGH EFFICIENCY BOILERS & WATER HEATERS

Dimensions and Specifications





FOR EASE IN ORDERING BY MODEL NUMBER

CHP A 120 P D

Heat Pump / Voltage / Tank Capacity / Element Wattage / Element Qty.

This is a commercial heat pump model that has 120 gallon capacity with two 240 volt 6,000 elements..

Model Number	Nominal Gallon Cap	Rated Storage Cap.	240V Input Watts	Standard Voltage	1st Hr. Rating Hybrid	COP	A	B	C	D	E	F	Ship. Wt.
CHPA120PD	119	120	6,000	208/240	150	4.2	69-1/4"	28"	39-3/4"	6"	57-3/4"	23-3/4"	620

Recovery Rate in Gallons Per Hour														
Mode of	Input		Temperature Rise °F											
Operation	Btu/hr	kW	30°F	40°F	50°F	60°F	70°F	80°F	90°F	100°F	110°F	120°F	130°F	140°F
Efficiency	33,678	10	136	102	82	68	58	51	45	41	37	34	31	29
Hybrid	74,624	22	302	226	181	151	129	113	101	90	82	75	70	65
Electric	40,946	12	165	124	99	83	71	62	55	50	45	41	38	35

COP is determined by DOE test protocol 10 CFR 431, Subpart G, Appendix E, operating in 80°F ambient air with 70°F inlet water and 120°F outlet water temperatures.

Certified for Potable Water and Space Heating Applications
This water heater is suitable for water heating and space heating. Toxic chemicals, such as those used for boiler water treatment shall NEVER be introduced into this system. This water heater may NEVER be connected to any existing heating system or components previously used with non-potable water heating appliances.

Lochinvar®
HIGH EFFICIENCY BOILERS & WATER HEATERS

Lochinvar, LLC
300 Maddox Simpson Parkway
Lebanon, Tennessee 37090
P: 615.889.8900 / F: 615.547.1000
Lochinvar.com

For technical information call 800-722-2101. Lochinvar, LLC reserves the right to make product changes or improvements without prior notice. Dimensions are approximate and should not be used for construction purposes.

(Website Update 12/19) 8/19 Printed in U.S.A.

C60A

Unit Specifications

Operating Conditions

Model Number	C60A
Recovery Rate †	77 Gal/hr
Compressor Type	Scroll
Refrigerant	R134a
Max Water Temp	160° F
Max Working Pressure	150 psig
Ambient Operating Range	Standard: 40° - 120° F
	CWP: 35° - 120° F

Unit Sizing	*Single Pass*	*Multi Pass*
Water Connections	1″ FPT Copper	1″ FPT Copper
Average Water Flow Rate	6 GPM	13 GPM
Condenser Pressure Drop	1.88 ft Head	7.41 ft Head
External Head Pressure Allowed by Unit	7.17 ft Head / 50′ run of 1″ pipe	5.41 ft Head / 50′ run of 1″ pipe

Unit Specifications		
Dimensions	64 1/4″ L x 32 5/8″ W x 34 5/8″ H	
Air Flow Rate	2,800 CFM	
Standard Sound Rating	84 dB	
Weight	Dry: 500 lbs	Operating: 520 lbs

Power Requirements		*Standard Package*				*Cold Weather Package*			
Voltage		208-230/1/60	208-230/3/60	440-480/3/60	575/3/60	208-230/1/60	208-230/3/60	440-480/3/60	575/3/60
Compressor LRA		129	156	75	54	129	156	75	54
Total RLA (Compressor + Fan)		33.1	24	12	10	33.1	24	12	10
Wire & Disconnect Sizing †††	***MCA***	41	29	15	12	62	51	25	20
	MOCP/MFS	50	30	20	15	70	60	30	25
Heating Elements FLA		N/A	N/A	N/A	N/A	18A	18A	9A	7A

Note: Internal hot water circulating pump for heated side provided by nyle.

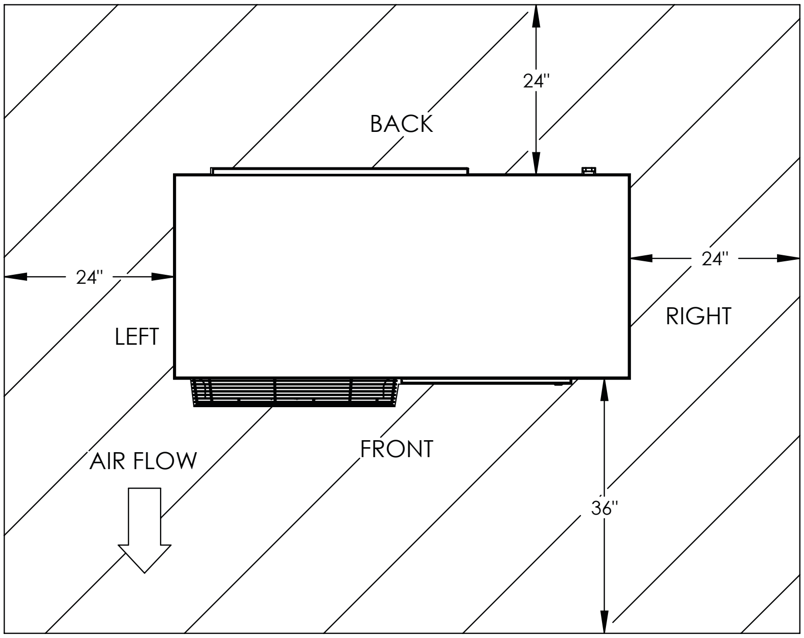
† Water heated from 50° F to 150° F with 75° F entering air temperature and 60 % relative humidity

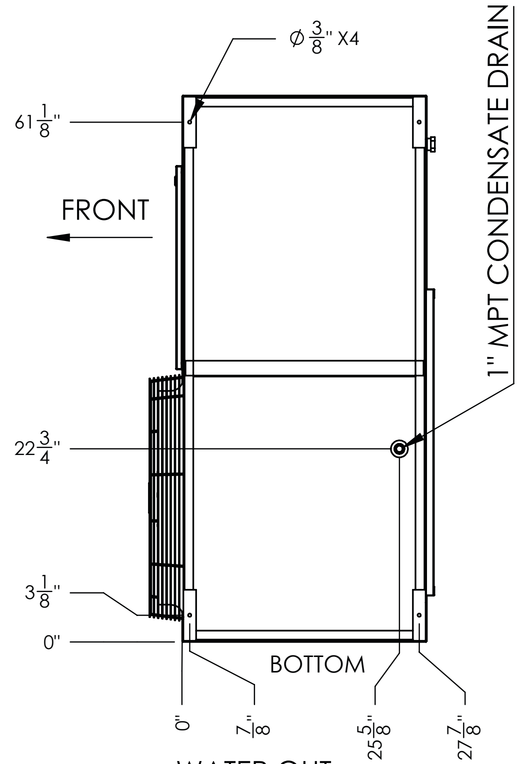
††† Single point electric service

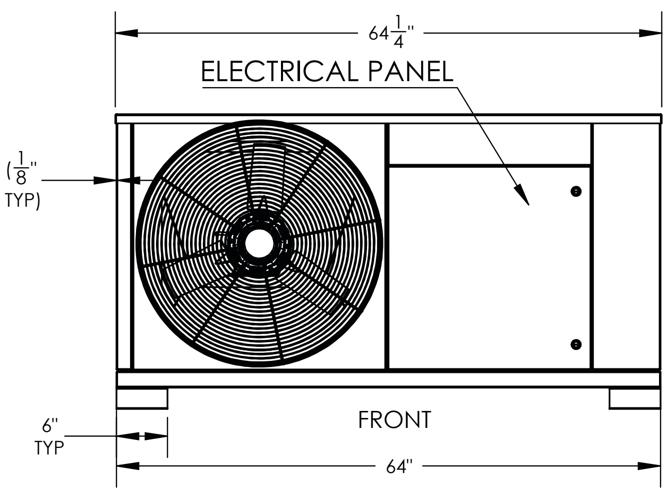
Legend
CWP: Cold Weather Package
LRA: Locked Rotor Amps
RLA: Rated Load Amps
MCA: Maximum Current Ampacity (used for wire sizing)
MOCP: Minimum Overcurrent Protection (minimum disconnect size to be used)

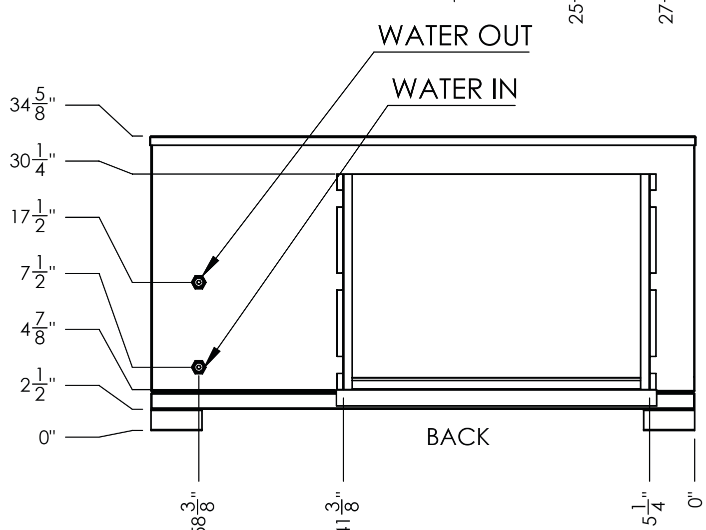
Rev: 2023.05

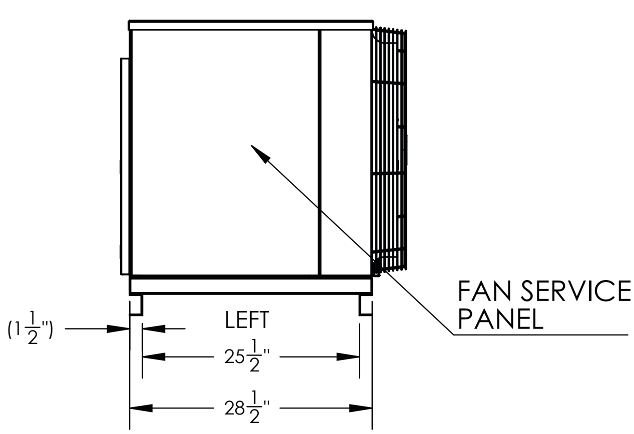
Dimensions

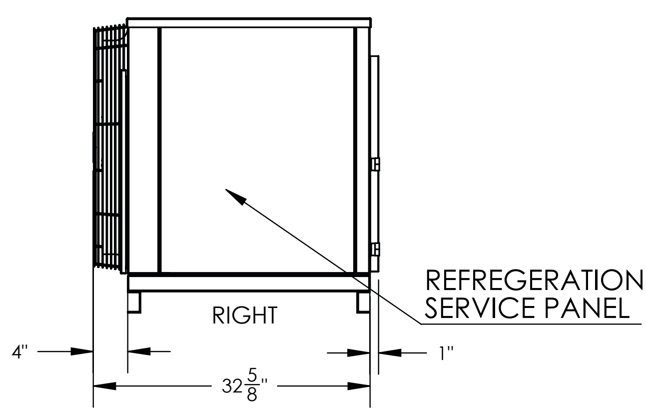










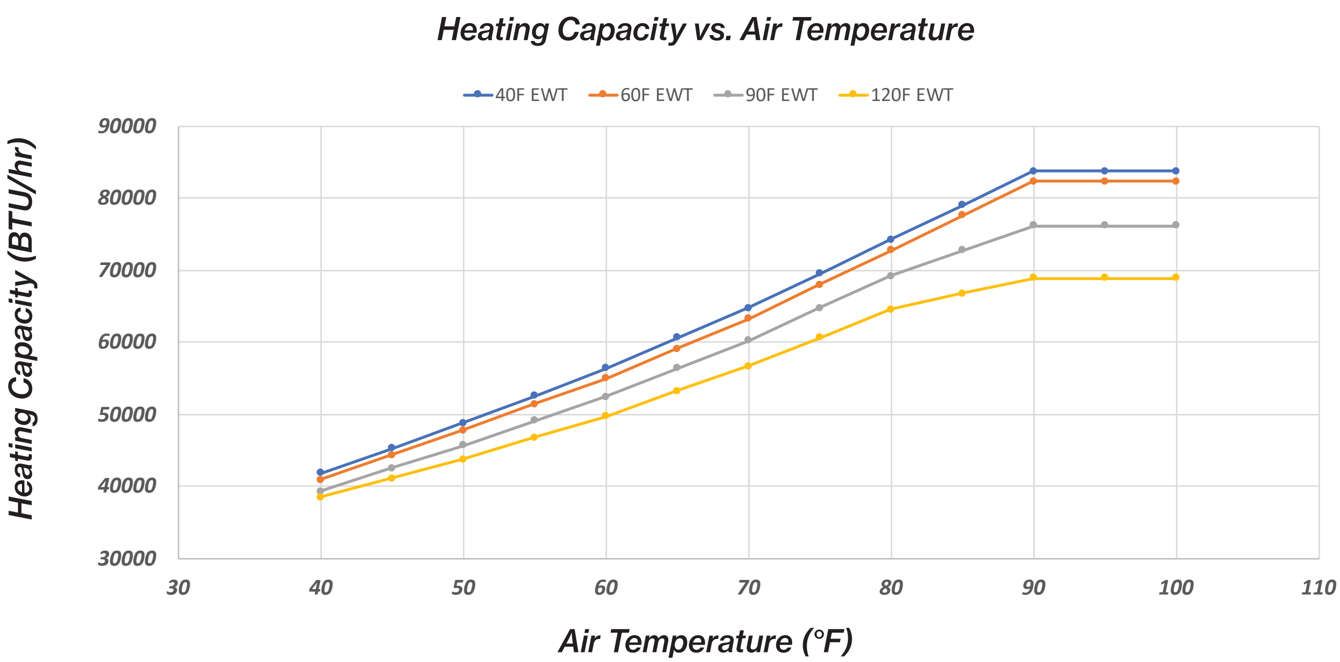


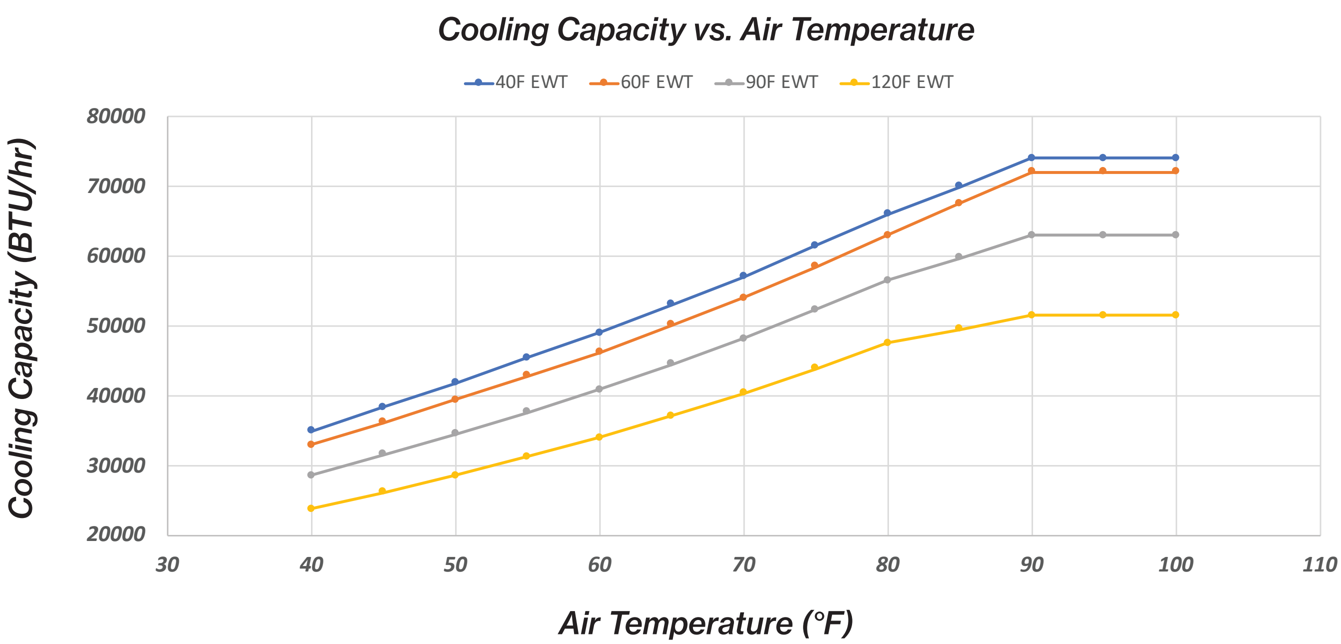
ALL TOLERANCES +/- 1/8"

Performance Data

Model	Entering Air Condition	Air Cooling Capacity (Btu/hr)	Entering Water Temp (°F)	Leaving Water Temp (°F)	Supply Heating Capacity (Btu/hr)	Power Input (kW)	Heating COP	Cooling COP	Combined COP
C60A Axial	40°F 60% RH	33900	50	56	41300	2.35	5.2	4.2	9.4
		33500	60	66	41200	2.43	5.0	4.0	9.0
		32200	70	76	40700	2.65	4.5	3.6	8.1
		30800	80	86	40100	2.90	4.1	3.1	7.2
		29300	90	96	39600	3.18	3.6	2.7	6.3
		27600	100	106	39100	3.53	3.2	2.3	5.5
		25900	110	116	38600	3.90	2.9	1.9	4.8
		24300	120	126	38500	4.32	2.6	1.6	4.3
		22600	130	136	38400	4.80	2.3	1.4	3.7
		20900	140	146	38200	5.32	2.1	1.2	3.3
	50°F 60% RH	40700	50	57	48300	2.40	5.9	5.0	10.9
		40000	60	67	48000	2.51	5.6	4.7	10.3
		38700	70	77	47500	2.74	5.1	4.1	9.2
		37200	80	87	46800	3.02	4.5	3.6	8.1
		35400	90	97	46000	3.28	4.1	3.2	7.3
		33500	100	107	45200	3.61	3.7	2.7	6.4
		31600	110	117	44600	3.99	3.3	2.3	5.6
		29400	120	127	43900	4.41	2.9	2.0	4.9
		27300	130	137	43500	4.89	2.6	1.6	4.2
		25300	140	147	43200	5.42	2.3	1.4	3.7
	60°F 60% RH	47900	50	59	55700	2.45	6.7	5.7	12.4
		47100	60	69	55400	2.60	6.2	5.3	11.5
		45600	70	78	54700	2.83	5.7	4.7	10.4
		43900	80	88	53900	3.09	5.1	4.2	9.3
		42000	90	98	53000	3.39	4.6	3.6	8.2
		39900	100	108	52100	3.73	4.1	3.1	7.2
		37700	110	118	51100	4.11	3.6	2.7	6.3
		35300	120	128	50200	4.54	3.2	2.3	5.5
		32800	130	138	49400	5.03	2.9	1.9	4.8
		30100	140	148	48500	5.57	2.6	1.6	4.1
	70°F 60% RH	56000	50	60	64100	2.53	7.4	6.5	13.9
		55000	60	70	63700	2.71	6.9	5.9	12.8
		53500	70	80	63000	2.94	6.3	5.3	11.6
		51500	80	90	61800	3.20	5.7	4.7	10.4
		49600	90	99	61000	3.50	5.1	4.2	9.3
		47200	100	109	59800	3.85	4.5	3.6	8.1
		44800	110	119	58700	4.23	4.1	3.1	7.2
		42000	120	129	57400	4.67	3.6	2.6	6.2
		39100	130	139	56200	5.17	3.2	2.2	5.4
		36100	140	149	55000	5.72	2.8	1.8	4.7
	80°F 60% RH	64500	50	61	73400	2.78	7.7	6.8	14.5
		64000	60	71	73100	2.84	7.5	6.6	14.1
		62500	70	81	72400	3.07	6.9	6.0	12.9
		60500	80	91	71300	3.33	6.3	5.3	11.6
		58000	90	101	69800	3.63	5.6	4.7	10.3
		55500	100	111	68500	3.98	5.0	4.1	9.1
		52500	110	120	66800	4.37	4.5	3.5	8.0
		49800	120	130	65700	4.82	4.0	3.0	7.0
		46500	130	140	64000	5.32	3.5	2.6	6.1
		43300	140	150	62800	5.87	3.1	2.2	5.3
	90°F 60% RH	74500	50	63	82100	3.1	7.8	6.9	14.7
		73000	60	73	80500	3.15	7.5	6.8	14.5
		72000	70	83	78500	3.2	7.5	6.6	14.1
		69000	80	92	76900	3.46	6.8	5.8	12.6
		66000	90	102	75700	3.75	6.1	5.2	11.3
		62500	100	112	74900	4.09	5.4	4.5	9.9
		59000	110	121	73700	4.47	4.8	3.9	8.7
		54500	120	131	71200	4.91	4.2	3.3	7.5
		50500	130	140	68200	5.4	3.7	2.8	6.5
		46300	140	150	66000	5.9	3.3	2.3	5.6

Performance Graphs





Water heated from 50°F to 150°F with 75°F dry bulb, 60% RH ambient air

COMMERCIAL
HEAT PUMP WATER HEATERS

CHP SERIES
FULLY INTEGRATED HEAT PUMP WATER HEATER

The CHP-120 heat pump water heater is an integrated system designed specifically for the commercial market.

FEATURES

ENERGY SAVING AND ENVIRONMENTALLY FRIENDLY

- Heat pump transfers heat from surrounding area into the tank
- Industry leading 4.2 COP
- Multiple operating modes maximizes efficiency while meeting specific hot water needs
- Large capacity tank enables heat pump to operate more frequently than electric elements, saving money for the end user
- Meets the standby loss requirements of U.S. Department of Energy and the current edition of ASHRAE 118.1
- Environmentally friendly R-134a refrigerant
- ENERGY STAR® Qualified

COMMERCIAL PERFORMANCE

- First hour delivery of 179 GPH
- Rated heat pump power of 3.15 HP (240Vac) or 3.05 (208Vac)
- Electric heating element capacity of 12 kW (240Vac) or 9 kW (208Vac)
- Max water temperature of 150°F in efficiency/ Hybrid modes and 180°F in electric mode
- Operating ambient range of 40-110° F
- Low operating sound measured at 59 dB (A)
- Dual evaporator fans maximize performance and provide room cooling
- 3/4" NPT water inlet and outlet

EASE OF OPERATION

- Integrated design and pre-charged refrigeration system makes for quick and easy install
- Large touch screen LCD display allows for mode selection, provides run information and includes troubleshooting alerts and detail
- Choose from three operating modes: Efficiency, Hybrid or Electric

DEPENDABLE AND LONG LASTING DESIGN

- A. O. Smith-developed glass coated tank
- Tank rated at 160 PSI working pressure
- Commercial grade anode protects the tank and extends the service life
- Proven heat pump technology
- Electric elements have incoloy sheathing and provide excellent protection from oxidation and scaling

THREE YEAR LIMITED TANK WARRANTY

- Backed by 3-year tank and 1-year parts/ compressor limited warranties
- For complete warranty information, consult written warranty or go to hotwater.com

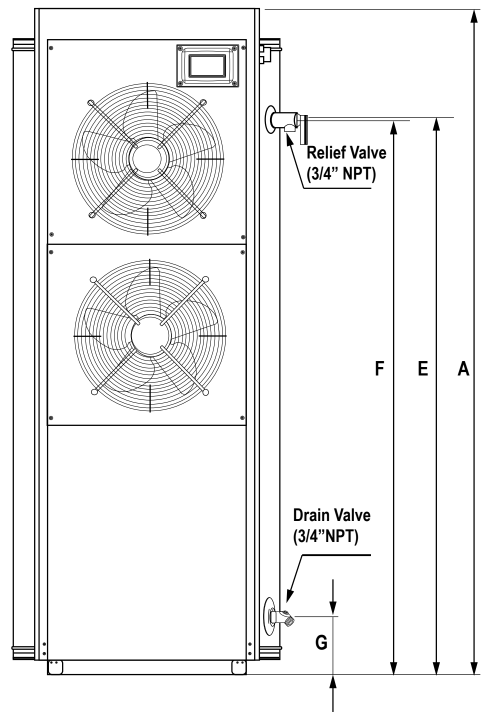
MODEL CAHP 120

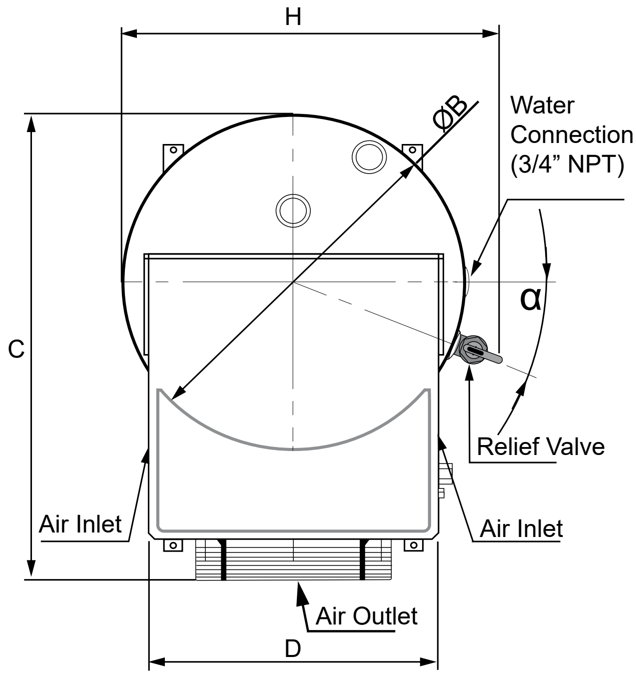
LISTED

Low Lead Content

ENERGY STAR

hotwater.com | 800-527-1953 Toll-Free USA | A. O. Smith Corporation | 500 Tennessee Waltz Parkway | Ashland City, TN 37015





ROUGH-IN DIMENSIONS

Physical Dimensions								
Total Height (A)	Tank Diameter (B)	Maximum Depth (C)	Service Panel Width (D)	Relief Valve Height (E)	Water Outlet Height (F)	Water Inlet Height (G)	Relief Valve Angle α (°)	Maximum Width (H)
69 11/16	28 1/32	39 11/64	23 5/8	58 7/64	57 51/64	6 1/32	22	30 29/32

MODEL SPECIFICATIONS

Model Number	Nominal Capacity	COP	Number of Elements	Total Element Wattage (both elements at 240V)	First Hour Delivery in Hybrid Mode (Gallons)	Recovery in GPH at 100° Temperature Rise in Hybrid Mode	Depends on mode of operation per chart below:	Approx. Shipping Weight (lbs)
CAHP 120	119	4.2	2	12,000	179	90	Efficiency = 41 Hybrid = 90 Electric = 50	620

RECOVERY CAPACITIES

Recovery Rate In Gallons Per Hour

Mode of Operation	Input		Temperature Rise °F												
	BTU/ Hour	kW	°F	30°F	40°F	50°F	60°F	70°F	80°F	90°F	100°F	110°F	120°F	130°F	140°F
			°C	17°C	22°C	28°C	33°C	39°C	45°C	50°C	56°C	61°C	67°C	72°C	78°C
Efficiency	33,678	10	GPH	136	102	82	68	58	51	45	41	37	34	31	29
			LPH	515	386	309	258	221	193	172	155	140	129	119	110
Hybrid	74,624	22	GPH	302	226	181	151	129	113	101	90	82	75	70	65
			LPH	1141	856	685	571	489	428	380	342	311	285	263	245
Electric	40,946	12	GPH	165	124	99	83	71	62	55	50	45	41	38	35
			LPH	626	470	376	313	268	235	209	188	171	157	145	134

Technical Characteristics

Technical Characteristics		
Model Type	Integrated Heat Pump Water Heater	
COP	4.2	
HP Rated Input Power	3.15 HP (2.35 kW)	
HP Rated Heating Output Capacity	11.13 kW	
Power Specification	208/240Vac ~ 60Hz 1Ph	
Maximum Operation Current	67 A	
Refrigerant	R134a	
Refrigerant Charge Quantity	3.3 Lbs (1.5 Kg)	
Electrical Heating Capacity	12.0 kW @ 240Vac and 9.0 kW @ 208Vac	
Measured Tank Capacity	111.76 Gal (423 L)	
Operation Modes	Efficiency, Hybrid, Electric	
Max. Water Temperature	Efficiency/Hybrid	Electric
	150°F (66°C)	180°F (82°C)
Operating Ambient Temperature	40 - 110°F (4.4 - 43.3°C)	
Unit Operation Noise	59 dB (A)	
Approx. Heater Weight	498 Lbs (226 Kg)	
Approx. Shipping Weight	620 Lbs (281 Kg)	

Installation Key Considerations	
Service clearances	A service clearance of 24 inches should be maintained from serviceable parts such as the T&P valve, control system components, drain valve, and anode.
Ambient air temperature	In Efficiency Mode the ambient air temperature must be above 40°F and below 110°F
Room size requirement	Recommended to have a minimum installation space of approximately 3,200 cubic feet. Installation spaces less than the recommended could result in reduced water heater efficiency and performance. If the water heater is installed in a confined space with less than 3,200 cubic feet, provisions should be made to ensure sufficient airflow, such as installing louvered grills or fully louvered doors to ensure the most efficient operation of the water heater. Failure to do so could result in reduced heater efficiency and performance.
Amperage/Overcurrent protection	This water heater requires a 208 or 240 VAC single phase power supply. 208V requires 80 amp power supply at 60 Hz; 240V requires 90 amp power supply at 60 Hz.
Condensate draining	This water heater produces condensate and must be properly drained.
Ducting	There is not an optional ducting kit. Discharge air from the front of the water heater must be into a suitable room.
Indoor/Outdoor	This water heater is approved for indoor use only.
This is a partial list. Please reference the Installation Manual for detailed installation considerations.	

SUGGESTED SPECIFICATION

The heater(s) shall be Commercial Heat Pump Model Number CAHP 120 as manufactured by A. O. Smith Water Products Company or equivalent. Heater(s) shall be rated at 12 kW @ 240V or 9 kW @ 208V, single phase, 60 cycle AC as listed by Underwriters' Laboratories. All models meet National Sanitation Foundation NSF-5 requirements. Water heater shall have LCD display with built-in diagnostic and troubleshooting information. Tank(s) shall be 119 gallon capacity with 160 psi working pressure and equipped with a commercial grade anode. All internal surfaces of the heater(s) exposed to water shall be glass-lined with an alkaline borosilicate composition that has been fused to steel by firing at a temperature range of 1400°F to 1600°F. Internal power circuit fusing shall be provided. The heat pump water heater shall be capable of operating in Efficiency, Hybrid or Electric only modes. 3/4" NPT inlet and outlet water connections shall be provided. The water heater tank shall have a three year limited warranty; the compressor, refrigeration components and all other parts shall have a one year limited warranty. Fully illustrated instruction manual to be included. Meets or exceeds the efficiency and standby loss requirements of the U.S. Department of Energy and current edition of ASHRAE 118.1.

For technical information, call 800-527-1953. A. O. Smith Corporation reserves the right to make product changes or improvements without prior notice.

hotwater.com | 800-527-1953 Toll-Free USA | A. O. Smith Corporation | 500 Tennessee Waltz Parkway | Ashland City, TN 37015