Manchester by the Sea – Water Treatment Plant

Heat Pump Feasibility Study

Prepared by

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Heat Pump Feasibility Study

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INTRODUCTION

B2Q was engaged by the Town of Manchester-by-the-Sea to complete a feasibility study at the Town's water treatment plant to evaluate the potential for electrifying the building's heating systems. The majority of existing mechanical equipment is original to the building's construction in 1997 and is nearing the end of its useful life. We understand the Town is interested in gaining a better understanding of the options for phasing out fossil fuels in the facility in pursuit of their longer-term carbon reduction goals.

The objective of this study is to perform a screening review of the technical feasibility, advantages, and disadvantages of electrifying the building's heating system through two different heat pump options, including air-to-air and/or water-source heat pumps. The screening includes estimates of the energy and carbon emissions impacts, as well as an estimate of the project economics.

We understand at the time of writing that the Town is planning a significant renovation and addition project to expand the capabilities of the water treatment plant within the next 5 years. This study will not include any analysis of the future building, but the ease of system expansion will be considered for each proposed option in this study. In reviewing this report, we recommend the Town consider each option in conjunction with the long-term plans for the water treatment plant and potential changes to use or conditioning load.

EXECUTIVE SUMMARY

Table 1: Electrification Screening Executive Summary Table.

Proposed Electrification Option	Estimated Heat Pump Heating Capacity	Estimated Heat Pump Cooling Capacity	Estimated Annual Electric Savings		Estimated Annual Fossil Fuel Savings		Estimated Annual Energy Cost Savings	Electrification Opinion of Probable Cost	Estimated Potential Utility Incentive	Estimated Net Cost
	tons	*tons*	*kWh*	*% of Baseline*	*gallons*	*% of Baseline*	*$*	*$*	*$*	*$*
Option 1A: Administrative Area ASHP	10	9	-25,246	*-8%*	1,866	*35%*	$1,687	$364,978	$25,534	$339,444
Option 1B: Workshop Area ASHP	7	6	-16,971	*-5%*	1,337	*25%*	$1,477	$364,797	$17,787	$347,010
Option 2: Filtration Area WSHP	28	24	-31,980	*-10%*	1,175	*22%*	-$2,799	$422,700	TBD	TBD
Total Options 1 & 2	*45*	*40*	*-74,197*	*-23%*	*4,379*	*82%*	*$365*	*$1,152,475*		
Electric Water Heater for Process HW	--	--	-12,547	-4%	332	*6%*	-$1,634	$45,600	TBD	TBD
Total With Electric Water Heater			*-86,744*	*-27%*	*4,711*	*88%*	*-$1,269*	*$1,198,075*		

Table 2: Electrification Screening Summary of CO_2 Emissions Savings.

Option	Estimated Annual CO_2 Emissions Savings w/ 2025 MA Emissions Factor		Estimated Annual CO_2 Emissions Savings w/ 2030 MA Emissions Factor		Projected Annual CO_2 Emissions Savings w/100% Carbon Free Electricity Grid	
	lbs	*%*	*lbs*	*%*	*lbs*	*%*
Administrative Area ASHP	37,476	13%	43,498	15%	50,606	45%
Workshop Area ASHP	27,435	10%	31,483	10%	36,260	32%
Filtration Area WSHP	15,228	5%	22,856	5%	31,859	28%
Electric Water Heater for Process HW	2,473	1%	97,837	1%	8,998	8%

While reviewing the tables above, please note the following:

1. Cost savings are based upon average blended utility rates of $0.24/kWh for electricity and $4.15/gallon for diesel fuel. The electric rates are based on utility data provided by the Town of Manchester-by-the-Sea for FY2023. The diesel fuel value is based on average retail heating oil prices for 2023 as listed by the DOER. Utility rates can be updated upon request.
2. The energy use estimates in Table 1 above are reflective of using the heat pumps to provide heating and cooling in all options. This results in a significant increase in electric energy use and cost for Option 1B and Option 2, as previously no cooling was available to these spaces. The cooling capacities of the proposed heat pump systems are estimated for each option based on the required heat pump heating capacity and are presented in Table 1 for informational purposes. For Option 2, it is important to note that due to the intermittent operation of the raw water pumps and particularly its reduced run hours during winter months, our calculations have accounted for the existing boiler providing heat to the space via the hot water unit heaters located in the filtration room when the heat pumps are not running.
3. Potential utility incentives have only been estimated for select options in the Executive Summary Tables above. The displayed estimates are based on published prescriptive rates of $3,500/ton for VRF systems, up to 150 tons. Potential utility incentives have not been included for Option 2 as this type of system would like go a custom utility incentive route. All incentives will be subject to further analysis and rebate amounts are solely determined by the utilities.
4. The preliminary budgetary opinions of probable construction costs for electrification are based on past experience, previous vendor quotes, and industry metrics. The opinions of probable cost presented are a high-level view of the potential costs to screen the economic viability of the project and are not reflective of what would be produced by a detailed economic feasibility analysis. Refer to the cost sections within the descriptions of each option below for more specific information. ***Please note that there is some important and significant context about the budget cost information in the sections that follow. These notes weigh heavily on how the values in this report can be extrapolated to project future costs at the time of construction and should be considered carefully.***
5. CO_2 emissions reductions estimates presented in Table 1 are based on projected emissions factors for 2025 and 2030 presented in the Greenhouse Gas Emissions Reduction Goal for MassSave published on March 1, 2024, by the Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs. Note that equivalent CO_2 emissions savings will continue to improve over time if New England continues to make progress toward its goal of decreasing carbon intensity on the electric grid. Therefore, Table 1 also presents the potential CO_2 emissions reductions in the future if 100% carbon-free electricity is available in Massachusetts.

Facility Description

General

The Manchester-by-the-Sea Water Treatment plant was constructed in 1997 and is approximately 15,000 ft^2 in size. The building is divided between office areas and lab space, filtration and pumping stations, and a workshop area, as shown in Figure 1.

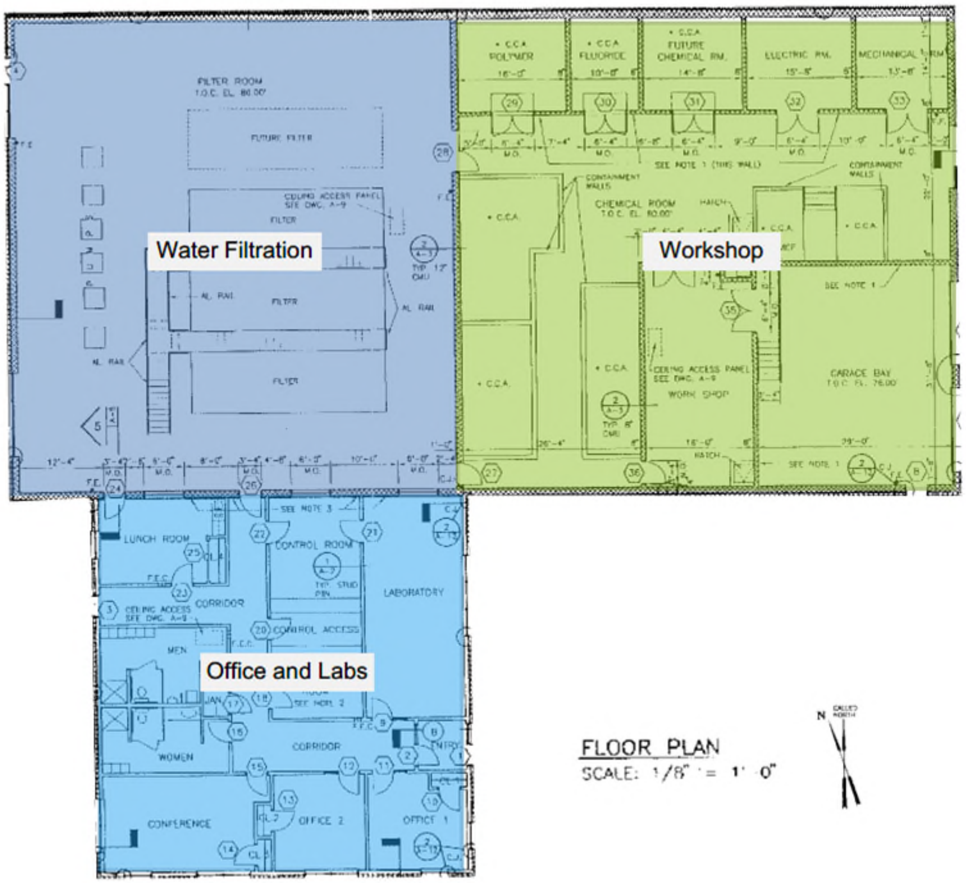


Figure 1: Annotated floorplan of the MBTS Water Treatment Plant

Two air handling units provide conditioned ventilation air to the administrative and workshop areas, while the water filtration area receives untreated outside air from a ventilation fan. Town personnel have expressed concerns about humidity control in the water filtration area and interest in addressing dehumidification concerns. However, the required open-air filtration pools would limit the effectiveness of any mechanical dehumidification provided in the space and make it difficult to achieve the desired humidification levels.

Mechanical Systems

The administrative area is conditioned by a mixed-air unit equipped with a hot water preheat coil and a direct expansion cooling coil. A secondary air handling unit equipped with a hot water heating coil provides 1,000 cfm of outside air to the workshop. In the water filtration area, filtered outside air is provided by a supply fan without any associated heating or cooling coil. The area is heated primarily through unit heaters along the perimeter of the space. Additional details about each air handling unit can be found below in Table 3.

Table 3: Air Handler Detail

Tag	Service	Supply Airflow	Outside Airflow	Fan Horsepower	Heating Capacity	Cooling Capacity
--	--	cfm	cfm	hp	MBH	MBH
AHU-1	Offices & Lab	2,840	500	3	185	111
AHU-2	Workshop	1,000	1,000	3/4	114	n/a
SF-1	Water Filtration	5,800	5,800	2	n/a	n/a

A mix of hot water and electric unit heaters, fin-tube radiation, and the (2) air handler hot water coils are used to heat the building. Hot water is provided by a diesel-fired H.B. Smith cast iron boiler. Installed in 1997, the boiler has a nominal output capacity of 1,014 MBH. Further information about the boiler is included below in Table 4.

Table 4: Boiler Detail

Tag	Make	Model	Year	Fuel	Input Capacity	Output Capacity	Efficiency
--	--	--	--	--	MBH	MBH	%
B-1	H.B. Smith	28A-S/W-05	1997	Diesel	1,342	1,014	76%

Hot water is circulated throughout the unit heaters and fin-tube radiation by a set of (2) heating hot water distribution pumps which operate lead-lag. Auxiliary pumps are dedicated to circulating water through the boiler and the hot water coils of AH-1 and AH-2. Another pump serves the boiler side of the process water heater, a heat exchanger that uses the heating hot water loop to generate 145°F hot water for the treatment plant. Details about each pump can be found below in Table 5.

Table 5: Pump Detail

Tag	Service	Design Flow	Design Head	Nominal Motor Horsepower
--	--	gpm	ft WC	hp
CP-1	Heating HW	61	48	1.5
CP-2	Heating HW	61	48	1.5
CP-3	Boiler	8	10.5	1/15
CP-4	PWH-1	9	22	1/8
CP-5	AH-1	8	12	1/25
CP-6	AH-2	8	10.5	1/15

Domestic Hot Water System

Domestic hot water (DHW) is provided to sinks in the service and administration areas by (2) electric water heaters, rated for 2,000 W and 5,500 W, respectively. Hot water for the treatment process is provided by a water-to-water heat exchanger, as mentioned above, that is designed for 180°F boiler water and an outlet temperature of 145°F.

Controls Systems

The building utilizes legacy Siebe Environmental Controls electronic controllers for the boilers and AHUs. The boiler utilizes a 2-input controller to control to operate the boiler while the AHUs utilize a 6-stage programmable controller. These controllers have been discontinued and are no longer supported. Equipment such as the unit heaters are controlled via local thermostats.

All equipment associated with the plant processes are controlled via a SCADA system.

Utility Information

Utilities

Electricity Delivery: National Grid

Diesel Delivery: Dennis K. Burke Inc.

The graphs and discussion on the following pages are based on electric utility data obtained from the Town's Massachusetts Energy Insight (MEI) database for July 2018 through December 2023. Diesel delivery records for October 2019 through December 2023 were provided by the Town. Raw water throughput data for January 2021 through December 2023 provided by Woodard and Curran is also included in this analysis.

Monthly Energy Use

The graph below illustrates the monthly electric consumption from July 2018 through June 2021. There is not a clear weather-dependent pattern, especially comparing usage from year to year. Despite the mechanical cooling available in the administrative area and the electric unit heaters throughout the building, it appears that weather dependent HVAC equipment operation does not have a consistent effect on the monthly electricity consumption in the building. The data shown for October 2022 – January 2023, as well as April – July 2023 appears to have been affected by a utility billing/metering issue. The operation of process equipment, such as the 50 to 75-hp raw water pumps, likely has a much stronger influence on total electricity consumption and is dependent on the water demand in the plant's service area, which according to staff is when plant operations are at their peak.

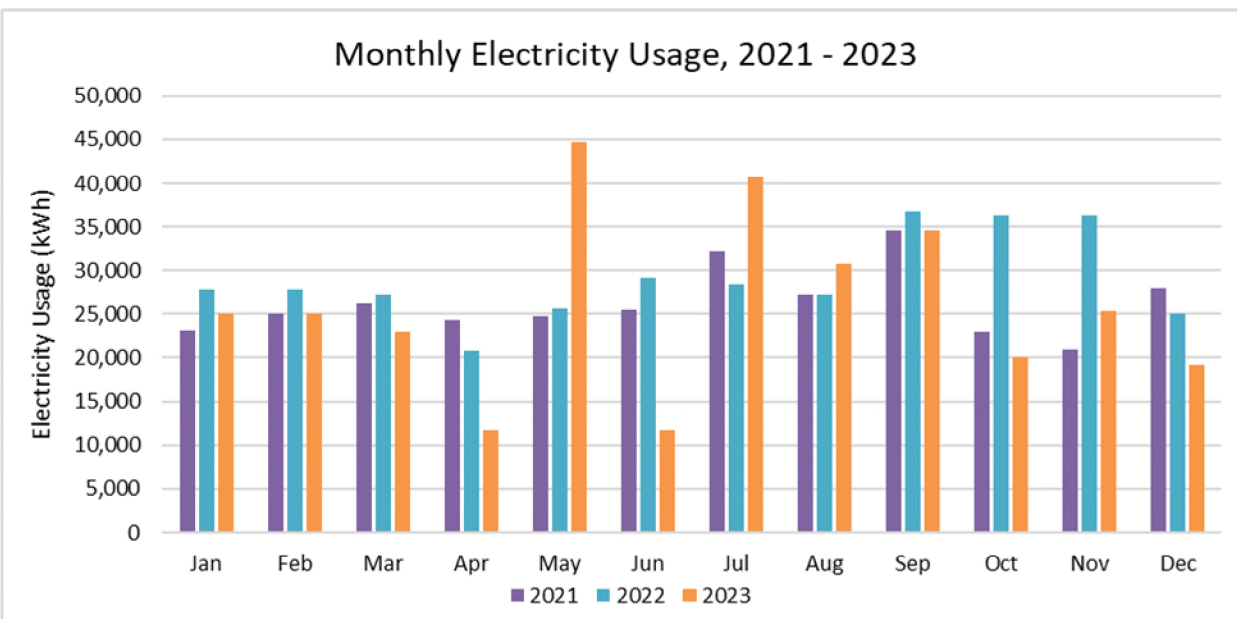


Figure 2: Monthly electric usage.

Trend data of the daily raw water throughput and average temperature from January 2021 through December 2023 was provided to B2Q by the plant operating staff. Total monthly throughput is shown for this period in Figure 3 below. Generally, the water treatment load appears to be consistent throughout the winter months at approximately 5-10 million gallons a month. This winter baseload does not appear to vary significantly from year to year for the available data. In the summer months however, the water treatment load increases significantly, peaking between July and August of each year. More year-to-year variance is observed in the summer months, most notably from July of 2021 when 9 million gallons were treated compared to 2022 and 2023 when 21 and 19 million gallons were treated, respectively. Less severe fluctuations are observed in May, June, and September. B2Q is unaware of any specific factors that would contribute to these patterns aside from changes in demand for treated water.

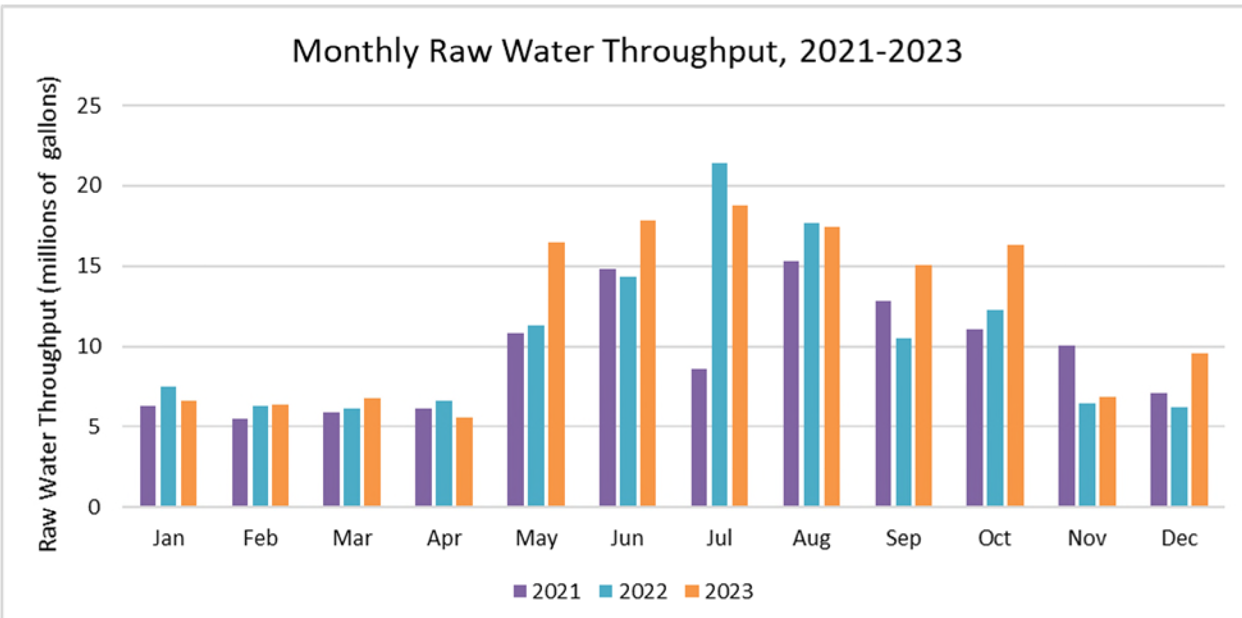


Figure 3: Monthly Raw Water Throughput 2021-2023, in millions of gallons

The graph below illustrates the diesel delivery history provided to B2Q for 2020 through 2023. The month of delivery is noted for each year but does not necessarily correspond to when the fuel was consumed for heating or process purposes. Based on the available fuel delivery data, we estimate that between 3,500 and 6,250 gallons of diesel are used per year. To B2Q's knowledge, the hot water boiler is the only diesel end use in consistent operation, with the building generator being the only other user.

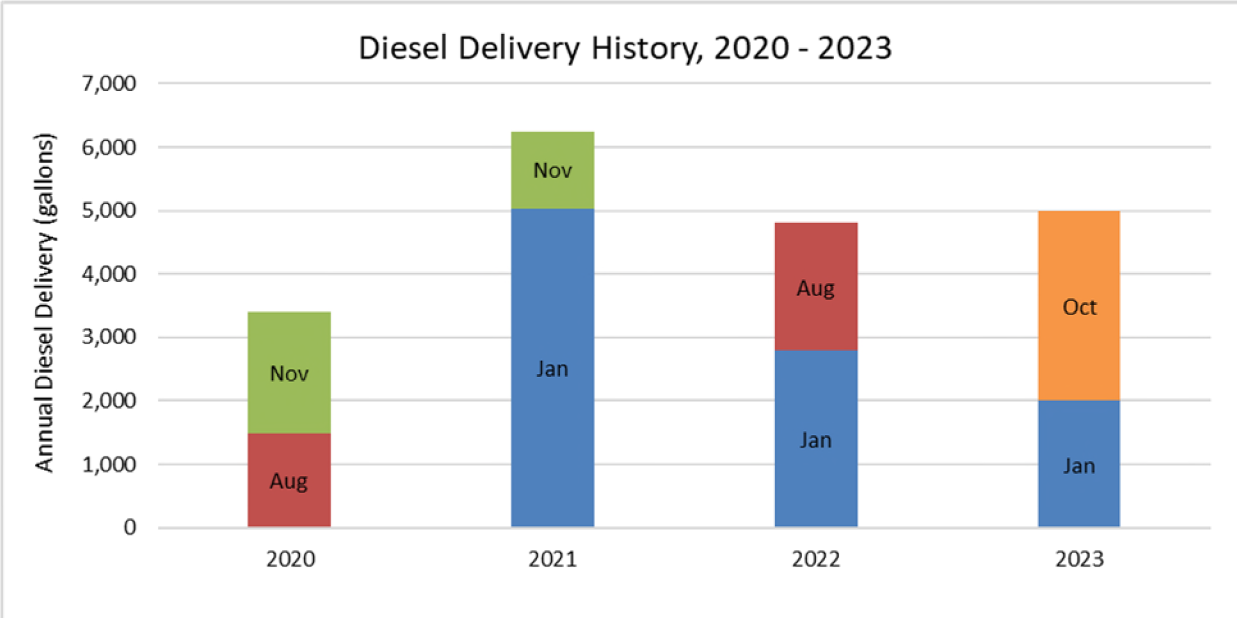


Figure 4: Diesel Delivery History.

ANNUAL ENERGY BENCHMARKING

The table below summarizes the annual energy use and energy use intensity (EUI) for the building for 2020. According to the 2018 Commercial Buildings Energy Consumption Survey (CBECS) conducted by the US Energy Information Administration, the average building EUI in New England is 74 kBtu/ft^2. The average EUI for buildings between 10,000 and 25,000 ft^2 is 57.6 kBtu/ft^2. The total annual EUI for the building is 129.4 kBtu/ft^2. Actual energy consumption may differ slightly as the diesel fuel usage is included from the time of delivery rather than actual time of consumption, which is unknown. This energy usage intensity is significantly higher than buildings of similar size in New England; however, limited information is available in the CBECS sample about buildings with comparable uses. The majority of the yearly energy usage is attributed to electricity usage, which includes the process equipment, pumps, the administrative area cooling system, and the electric unit heaters throughout the building.

Table 6: Annual energy usage and energy use intensity (EUI).

Building Information		Energy Usage		Performance Ratings			
Gross Area	Calendar Year	Electric Usage	Diesel Usage	Electric Intensity	Electric EUI	Diesel EUI	Total EUI
ft^2	--	kWh	gallons	kWh/ft^2	kBtu/ft^2	kBtu/ft^2	kBtu/ft^2
13,596	2023	311,986	5,001	22.9	78.3	51.1	129.4
Building square footage is estimated via architectural drawings							

HVAC ELECTRIFICATION OPTIONS

The potential electrification options evaluated during this scoping study are described on the following pages. The options discussed are provided as a high-level view of the potential energy savings and costs and are not reflective of what would be produced by a detailed investment grade conceptual design and economic feasibility analysis. Emissions, energy, and cost savings were calculated using high-level estimates based on existing equipment capacities, actual electric and natural gas usage, past experience, published heat pump performance, and typical industry metrics. High level opinions of probable construction costs were estimated based on industry-standard cost estimating guides, as well as past experience and previous budget quotes from equipment vendors and contractors.

ELECTRIFICATION FEASIBILITY CONSIDERATIONS

Determining the feasibility of an electrification option is a complex effort that should account for multiple interactive factors. As shown in Figure 5 below, these factors include the solution availability, technical requirements, site specific conditions, implementation costs, and societal pressures. This study consists of a high-level review of heat pump feasibility, with a focus on technical factors and site-specific conditions. Further evaluation of feasibility based on societal factors, project cost, and the long-term goals of the Owner, in conjunction with the findings in this report, is recommended.

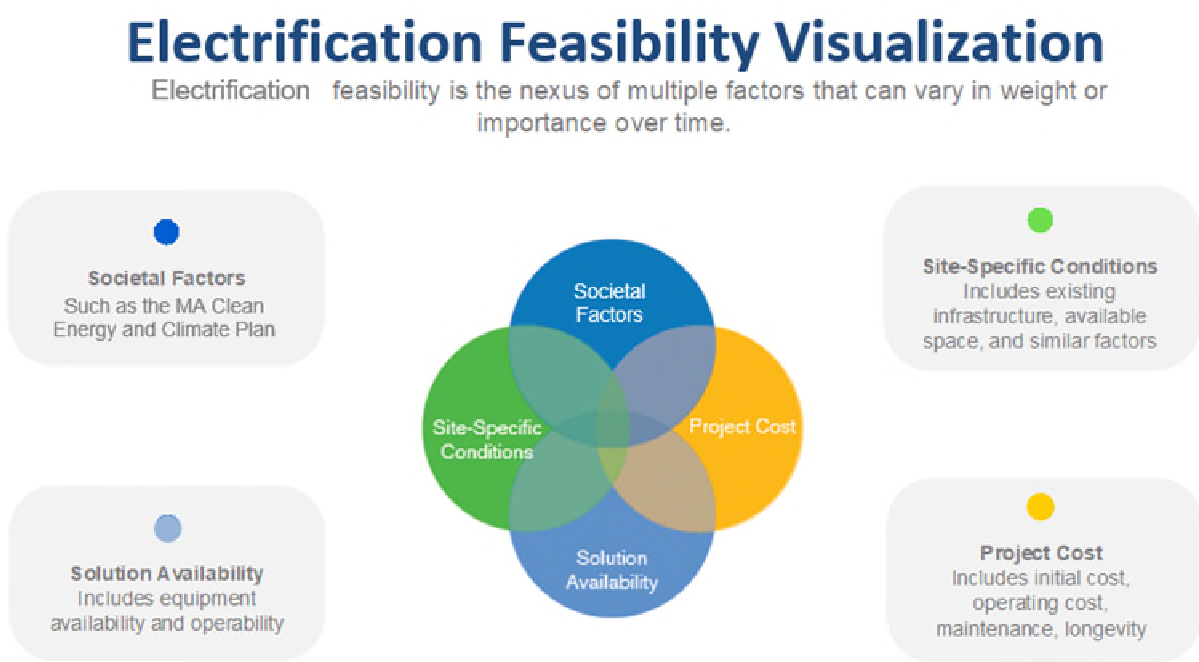


Figure 5: Visualization of prominent electrification feasibility considerations

TECHNOLOGIES CONSIDERED

The following section provides a brief description of each heat pump technology considered in this study. The table below summarizes the general advantages and disadvantages of each technology, which may or may not apply to this specific site.

Option	Advantages	Disadvantages
Air-to-Air VRF Heat Pumps	• Limited need for supplementary boiler operation (may still be needed for backup during power outage) • Potential for full electrification of space heating • Independent of existing infrastructure and terminal equipment, which is approaching end of life in some cases • Potential for heat recovery and simultaneous heating and cooling	• Increased points of failure/pieces of equipment to maintain from small, distributed equipment • Potential safety/maintenance concern of refrigerant in occupied spaces • Potential for exposed equipment and piping, which may impact building aesthetics • New ductwork for ventilation (where required), which also may require architectural modifications to the building
Distributed Water Source Heat Pumps	• Existing Boiler system could remain for backup in times without sufficient raw water flow • Relatively higher efficiency compared to air-to-water or central water-to-water heat pumps	• Multiple pieces of equipment to maintain • Additional equipment (i.e. heat exchanger) to isolate heat pump source loop from raw water flow

Air-to-Air Heat Pumps

Air-to-Air Heat Pumps, also known as air-source heat pumps, directly transfer heat to and from outside air to the spaces served. Heat pumps can operate during both the summer to provide cooling and the winter to provide electrically-sourced heating.

VRF Heat Pumps

Air-to-air heat pump indoor units and outdoor condensing units can be connected 1-to-1 or configured to use one outdoor condensing unit for multiple indoor units. There are also variable refrigerant flow (VRF) systems where one outdoor condensing unit could be connected to as many as 50 indoor units, depending on the equipment. Indoor units can range from wall-mounted units, ducted and non-ducted ceiling cassettes or fan coil units, or floor-mounted units. Condensing units can also be integrated with heat pump coils in air handling units via linear expansion valve (LEV) kits. Condensing units for VRF systems can be capable of operating at low ambient temperatures, depending on the equipment, and therefore VRF heat pumps could be designed to meet most or all a building's space heating needs, as compared with other technologies described below. On the other hand, it is often advisable to maintain a non-electric backup heating source in the event of extreme cold (e.g., less than -10°F) or power outage.

Packaged Heat Pump RTUs

Packaged air-source heat pump rooftop units can be installed in place of traditional rooftop units. Packaged heat pump RTUs are typically offered with a secondary source of heat for supplementary heating during low-temperature operation or backup in the event of equipment malfunction. Secondary heat sources typically come in the form of an electric resistance heating element or a natural gas-fired furnace. Dual fuel heat pump RTUs typically have smaller electrical requirements than heat pump RTUs with electric resistance backup, often leading to no or limited cost to upsize the electrical circuit breaker and feeders to the unit. Existing traditional RTUs can often be swapped out with package heat pump RTUs with minimal roof, structural, or duct modifications, though careful engineering is required to verify such details during the design process.

Water Source Heat Pumps

Water source heat pumps often refer to geothermal heat pump systems, which rely on a Ground Heat Exchanger (GHE) as a source or sink for heat energy. However, water source heat pumps are capable of working with many different water sources. In this case, the incoming raw water flow to the treatment plant would be used as a source/sink for the heat pump loop.

Central Water-Source Heat Pumps

Central water-source heat pumps (WSHPs) transfer heat from water in the source loop to the building hot/chilled water loop. Contrasted to the central air-to-water heat pump, the central WSHP is expected to have a less severe capacity and efficiency derate with outside air temperature due to the consistency of the raw water temperature. However, the operating hours of the WSHP would be limited to the hours when there is sufficient active raw water flow, which is reported to decline in the winter months. A central water-source heat pump could provide heating and cooling to the space(s) served. However, this would require the installation of a new dual temperature hydronic loop and associated end devices.

DISTRIBUTED WATER-SOURCE HEAT PUMPS

Another WSHP option is a distributed WSHP system, which utilizes water-to-air heat pumps. As with the central water-source heat pump, a new distribution loop could circulate water to the space(s) served. Instead of installing new hot/chilled water hydronic coils in each space/end device to make sure of the conditioned water from the central heat pump, the distributed heat pumps would utilize more neutral source water (on the other side of a heat exchanger to isolate and protect the raw water) to directly make warm or cool air to supply to each space. Distributed water-to-air heat pumps are typically more efficient than central water-to-water heat pumps as there is one fewer heat transfer step (water-to-refrigerant-to-air vs water-to-refrigerant-to-water-to-air), the heat pump output can be limited to only what is needed in each space as opposed to having to provide warm/cool enough water for the worst case zone from a centralized system, and because distributed systems have the potential for heat recovery when some spaces are in heating while others are in cooling. This reduces the lift on the compressor and results in less energy use to achieve the same space temperature.

OPTIONS 1A AND 1B: AIR-TO-AIR HEAT PUMPS

ECONOMICS SUMMARY

Table 7: Option 1A & Option 1B Economic Summary.

Proposed Electrification Option	Estimated Heat Pump Heating Capacity	Estimated Heat Pump Cooling Capacity	Estimated Annual Electric Savings		Estimated Annual Fossil Fuel Savings		Estimated Annual Energy Cost Savings	Electrification Opinion of Probable Cost
	tons	*tons*	*kWh*	*% of Baseline*	*gallons*	*% of Baseline*	*$*	*$*
Option 1A: Administrative Area ASHP	10	9	-25,246	*-8%*	1,866	*35%*	$1,687	$364,978
Option 1B: Workshop Area ASHP	7	6	-16,971	*-5%*	1,337	*25%*	$1,477	$364,797

OVERVIEW

This option proposes to install air-to-air heat pumps in the administration and workshop areas of the building. These systems are presented as Option 1A and Option 1B as they could be installed as separate projects if the Town wishes to pursue a phased approach.

OPTION 1A: ADMIN AIR SOURCE HEAT PUMPS

The administration area is currently conditioned by a mixed-air air handling unit located in a closet at the center of the wing. The unit is equipped with a hot water coil and a direct expansion cooling coil. We propose installing a new VRF heat pump system comprised of ceiling-mounted or wall-mounted indoor units in each room currently served by AHU-1 to serve as the primary source of heating and cooling. While VRF systems can often have exposed refrigerant and condensate piping, which could disrupt the aesthetic of the building, but the drop ceiling observed in the area could favor the use of ceiling cassettes, meaning the piping could be routed in ceiling plenums and result in minimal exposed equipment.

To adequately ventilate the space, we propose utilizing an energy recovery ventilator (ERV) to provide the required ventilation. This equipment utilizes dedicated supply and exhaust fans to provide code minimum ventilation airflow in tandem with a fixed polymer "core" heat exchanger that uses exhaust air to pre-heat fresh air in the winter and pre-cool it in the summer. The ERV could be located where AHU-1 is currently located with the existing ductwork being reused if deemed adequate.

It is intended that the required outdoor condensing unit for the heat pump system would be placed at the existing condensing unit location. It is important to note that this location may need to be changed due to the proposed addition to the WTP. B2Q have not accounted for the cost of relocating the outdoor unit and associated piping in our opinion of probable cost.

Figure 6: Location of existing condensing unit for AHU-1

An alternative to the full replacement of the existing unit would be to replace the existing DX coil and install a new heat pump refrigerant coil. Custom refrigerant coils can be connected to heat pump outdoor units using a linear expansion valve (LEV) kit. The new heat pump coil would provide heating and cooling to the spaces served by AHU-1 year-round. The existing hot water coil and associated pump would remain in place as a backup heating source. However, further evaluation of AHU-1's condition, size, and configuration are required to confirm a new heat pump coil can be accommodated without additional modification.

The existing hot water radiation and unit heaters would also remain for backup and supplemental heat. For areas served by AHU-1 which currently have supplementary heating provided via baseboard radiation and/or unit heaters, we have not included the costs to install VRF terminal devices in these spaces as their existing usage is likely very low and would add to the project costs without a major benefit. However, if the Town would like to pursue 100% decarbonization of this building, floor-standing unit heater style VRF units could be installed in the entrances to the building in the administrative areas, as well as in the bathrooms.

Option 1B: Workshop Area Air Source Heat Pumps

Heating is provided to the workshop by AHU-2, a mixed-air unit with a hot water heating coil. The other spaces in the workshop wing—primarily storage and support spaces—receive heat from hot water and electric unit heaters. The Garage Bay is also equipped with unit heaters to provide heat as needed.

We propose installing a new VRF heat pump system comprised of ceiling-suspended or wall-mounted indoor units in each room currently served by either AHU-2 or served by unit heaters as the primary source of heating and cooling.

To adequately ventilate the space, we propose utilizing an energy recovery ventilator (ERV) to provide the required ventilation. This equipment utilizes dedicated supply and exhaust fans to provide code minimum ventilation airflow in tandem with a fixed polymer “core” heat exchanger that uses exhaust air to pre-heat fresh air in the winter and pre-cool it in the summer. The ERV could be located where AHU-2 is currently located within the workshop room. Ductwork would need to be expanded throughout the area as currently the existing ductwork for AHU-2 is limited to the workshop room and would need to be distributed to the garage bay, electrical room, and storage rooms within the workshop wing.

The existing hot water and electric unit heaters could remain as supplementary/backup heating.

Depending on the final selections and sizing of the terminal devices for both options, it is possible that the administrative and workshop wings could share an outdoor condensing unit.

Opinion of Probable Construction Cost

Table 8: Option 1A Opinion of Probable Construction Budget Cost.

Category	Estimated Budget
Demolition	$7,800
HVAC Equipment	$44,600
HVAC Piping, Ductwork, Other Materials	$25,250
HVAC Installation	$63,428
Electrical Branch Circuit Materials and Labor	$31,200
Electrical Service Upgrade	$0
Startup, Commissioning, TAB, Closeout	$41,400
Controls	$15,500
Engineering	$28,600
Envelope Penetrations, Patching, Firestopping	$16,800
Contractor General Conditions & PM Labor	$36,300
Contractor Overhead & Profit	$20,300
Contingency	$33,800
Grand Total	**$364,978**

[1] *Budget assumes no change in main electrical service and distribution. Further engineering needed to confirm and/or estimate costs*

Table 9: Option 1B Opinion of Probable Construction Budget Cost.

Category	Estimated Budget
Demolition	$15,000
HVAC Equipment	$49,600
HVAC Piping, Ductwork, Other Materials	$32,750
HVAC Installation	$58,747
Electrical Branch Circuit Materials and Labor	$21,200
Electrical Service Upgrade	$0
Startup, Commissioning, TAB, Closeout	$49,500
Controls	$15,500
Engineering	$28,800
Envelope Penetrations, Patching, Firestopping	$4,900
Contractor General Conditions & PM Labor	$36,700
Contractor Overhead & Profit	$18,100
Contingency	$34,000
Grand Total	**$364,797**

[1] *Budget assumes no change in main electrical service and distribution. Further engineering needed to confirm and/or estimate costs*

The cost estimate above is meant to provide a high-level opinion of probable cost, and is based on the following assumptions:

- Construction would begin within the next year (given the need to reference currently available pricing estimates) and follow a standard design-bid-build procurement path, such as MAGL Chapter 149. Based on recent market trends, construction costs continue to show steady escalation and customers should consider budgeting an additional 5 – 15% per year for construction starting later than this year. Additionally, alternative procurement methods, such as construction manager (CM) at risk, may increase the required budget.
- Excludes the cost to upgrade the building's electrical service and primary electrical infrastructure, as it appears it could be possible to incorporate the new electrification loads within the existing service capacity; however, this is a high-level assessment, and it is recommended that a licensed professional electrical engineer more thoroughly evaluate the existing infrastructure in preparing for any future phases of design and construction of new heat pump systems.
- No upgrades to the existing standby power system or generator.
- Existing to remain mechanical and electrical equipment is in proper working order and would not need to be upgraded for normal operations and maintenance reasons.
- Includes no "elective" scope for sub-projects that customer may wish to add to improve the overall building functionality and comfort, but that are not explicitly called out in this report as necessary to enable the heat pump retrofit.

- The existing electric and hot water unit heaters, and fin tube radiation will remain in place.
- Excludes weatherization and other building envelope improvements.
- No correction of existing code violations, structural insufficiencies, or hazardous materials.

Given the volatile nature of construction costs in the current market, we recommend that the above estimates be considered preliminary budgets for purposes of vetting whether this building is a good candidate to proceed to the next phase of the process. In general, projects with a full set of design drawings and specifications are expected to have actual contractor bids within +/- 10 – 15% of a third-party cost estimator's projection. In this case, where the proposed system has not been designed, actual costs could vary by a much wider margin and the final design scope is likely to change and be refined as further investigation and coordination are completed in subsequent design phases.

OPTION 2: DISTRIBUTED WATER-TO-AIR HEAT PUMPS

ECONOMICS SUMMARY

Table 10: Option 2 Economic Summary.

Proposed Electrification Option	Estimated Heat Pump Heating Capacity	Estimated Heat Pump Cooling Capacity	Estimated Annual Electric Savings		Estimated Annual Fossil Fuel Savings		Estimated Annual Energy Cost Savings	Electrification Opinion of Probable Cost
	tons	*tons*	*kWh*	*% of Baseline*	*gallons*	*% of Baseline*	*$*	*$*
Option 2: Filtration Area WSHP	28	24	-31,980	*-10%*	1,175	*22%*	-$2,799	$422,700

OVERVIEW

We propose installing distributed water-to-air heat pumps in the filtration room and using the incoming raw water flow as a source/sink. The raw water would pass through an NSF certified heat exchanger and interface with a new closed-loop hydronic system distributing water to water-source heat pumps suspended in the ceiling of the filtration room. Each heat pump would absorb heat from or reject heat to the source loop, recirculating and conditioning the air to meet the space temperature setpoint dictated by local thermostats and/or the BAS. We recommend retaining the existing hot water infrastructure for supplemental heating in times when the raw water pumps are not operating, as facility staff noted a much lower run time for the pumps during the winter. For the purposes of this study, we assume the existing ventilation fan SF-1 would remain in place and continue to bring fresh air into the filtration room as necessary. SF-1 and the associated exhaust fan for the space, EF-4, are controlled via a manual wall switch located in the filtration room.

In the summer, the water-source heat pumps could provide cooling to the space and would reject heat to the raw water loop via the configuration described above. B2Q understands that the Town is interested in dehumidification for the filtration rooms in the summer. While the water-to-air heat pumps are expected to provide some dehumidification, a more effective approach would be to include small new AHUs with WSHP cooling coils and a separate reheat system downstream of the refrigerant coil. The separate reheat system could be electric resistance, hot water, or possibly hot gas reheat. As such, the dehumidification-specific approach would necessarily add cost and complexity to the electrification effort. Additionally, the open-air filtration pools are a constant source of humidity and B2Q understands they cannot be covered without impeding the existing processing procedure. As such, the effectiveness of any mechanical dehumidification efforts in the filtration room could be limited. If the Town wishes to pursue dehumidification in a more focused effort, a separate study could be conducted to explore these alternatives.

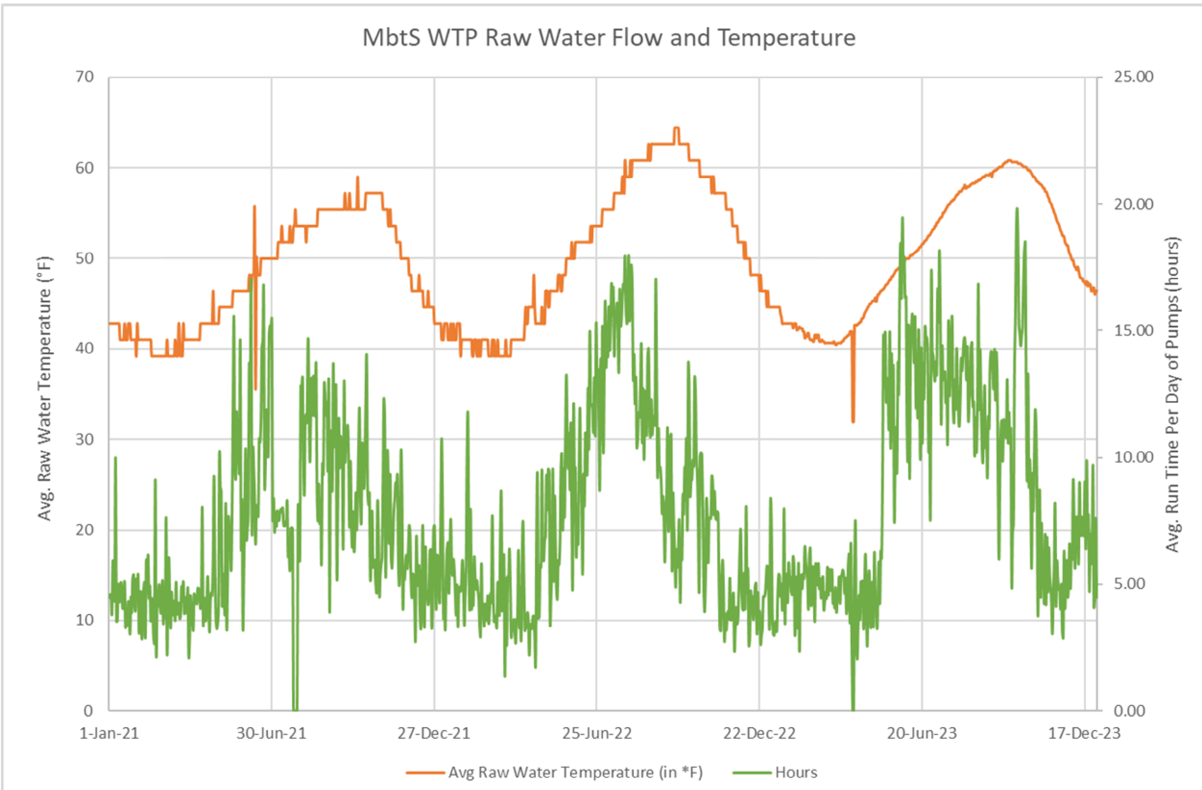


Figure 7: Trend showing the average temperature of the raw water and run hours of the plant pumps

A high-level review of plant flow and temperature trends indicated that there is sufficient raw water flow for water-source heat pumps to operate during 78% of occupied hours throughout the year. Additionally, peak heating and cooling loads are expected to shift the raw water temperature by less than 1°F, bringing the peak daily average water temperature up to 65°F in the summer and down to 38°F in the winter. Conversations with town personnel raised concerns about increased water temperatures facilitating bacterial growth and leading to customer complaints. Town staff indicated that the long (>1 mile) stretch of piping between the treatment plant and the first customers is expected to mitigate any temperature changes experienced by the end user. These effects should be studied in more depth in a follow-on feasibility study, which may require analysis of more granular trend data for the water treatment system. Temporary metering or further study of the HVAC systems may also be required.

In regard to the tie-in point for the heat exchanger to the source, a convenient location could be along the straight run of raw water piping after it enters the building in the filtration room.

However, there is an initial pre-treatment of the raw water as shown in Figure 8 below. This treatment helps consolidate oxidized and errant particles in the raw water so that they can better adhere to the clarifier beads and filter media in the next treatment process. The raw water piping is buried prior to entering the building so there does not appear to be a location in which to pipe to the heat exchanger prior to treatment of the water.

Figure 8: Entry of raw water piping into filtration room

To interface with the heat pump source, a National Sanitation Foundation (NSF) certified double-wall stainless steel heat exchanger, similar to what would be used in domestic water systems in sensitive food manufacturing or cooking systems, would be installed as part of this project to interface with the raw water source but we recommend engaging with a water treatment specialist to better understand the potential effects of the heat exchanger and the pre-treated raw water. The selection of the heat exchanger type (e.g. shell-and-tube, plate-and-frame, or spiral) depends on several factors such as flow rate, temperature range, pressure, and the specific requirements of the water treatment process. Additionally, considerations like material compatibility (how the heat exchanger materials react to the pre-treatment chemicals), maintenance requirements, impacts on raw water flow rate/pressure, and the efficiency of the equipment are crucial in the design and operation of the heat exchanger. The above items should be investigated further in future assessments.

A selection for a representative Daikin WCCW2120 water-to-air heat pump is included as an appendix to this report. It is also recommended that the materials and/or coatings used for the heat pump be suitable for operation in a space with high humidity levels. A concept layout of the WSHP system within the filtration room has been included as an appendix to this report. The intention is to have the units ceiling suspended. The suitability of the roof to support the proposed units and associated piping would need to be reviewed by a licensed structural engineer.

B2Q evaluated the expansion of the water-to-air heat pumps throughout the building, rather than just for the filtration room, as the primary source of heating and cooling for the building. However, as can be seen in Figure 6 above, the average run time of the raw water pumps fluctuates throughout the year with the lowest run times observed during the winter months (average pump run time of 4.7 hours over a 3-year period between January and March). To allow the water-to-air heat pumps to run year-round as necessary, any proposed system for the entire building would necessitate a buffer tank. The buffer tank would allow the heat pump system to operate when the raw water pumps are not operating. This option would need to be reviewed by a water treatment specialist and other process stakeholders to better understand the effects holding the raw water in a buffer tank would have for any prolonged period of time before being rejected back to the raw water system. With the planned expansion of the WTP, the water-to-air heat pump option should be evaluated in more detail in future follow up efforts, as there will be a greater understanding of potential loads and layouts of the expansion and its effect on the facility.

Opinion of Probable Construction Cost

Table 11: Option 2 Opinion of Probable Construction Budget Cost.

Category	Estimated Budget
HVAC Equipment	$119,600
HVAC Piping, Ductwork, Other Materials	$40,000
HVAC Installation	$24,500
Electrical Branch Circuit Materials and Labor[1]	$15,200
Startup, Commissioning, TAB, Closeout	$47,000
Controls	$30,800
Engineering	$42,300
Contractor General Conditions & PM Labor	$42,300
Contractor Overhead & Profit	$18,700
Contingency	$42,300
Grand Total	**$422,700**

[1] Budget assumes no change in main electrical service and distribution. Further engineering needed to confirm and/or estimate costs

The cost estimate above is meant to provide a high-level opinion of probable cost, and is based on the following assumptions:

- Construction would begin within the next year (given the need to reference currently available pricing estimates) and follow a standard design-bid-build procurement path, such as MAGL Chapter 149. Based on recent market trends, construction costs continue to show steady escalation and customers should consider budgeting an additional 5 – 15% per year for construction starting later than this year. Additionally, alternative procurement methods, such as construction manager (CM) at risk, may increase the required budget.
- Excludes the cost to upgrade the building's electrical service and primary electrical infrastructure, as it appears it could be possible to incorporate the new electrification loads within the existing service capacity; however, this is a high-level assessment, and it is recommended that a licensed professional electrical engineer more thoroughly evaluate the existing infrastructure in preparing for any future phases of design and construction of new heat pump systems.
- Includes no "elective" scope for sub-projects that customer may wish to add to improve the overall building functionality and comfort, but that are not explicitly called out in this report as necessary to enable the heat pump retrofit.
- Excludes weatherization and other building envelope improvements.
- No upgrades to the existing standby power system or generator.
- No correction of existing code violations, structural insufficiencies, or hazardous materials.

Given the volatile nature of construction costs in the current market, we recommend that the above estimates be considered preliminary budgets for purposes of vetting whether this building is a good candidate to proceed to the next phase of the process. In general, projects with a full set of design drawings and specifications are expected to have actual contractor bids within +/- 10 – 15% of a third-party cost estimator's projection. In this case, where the proposed system has not been designed, actual costs could vary by a much wider margin and the final design scope is likely to change and be refined as further investigation and coordination are completed in subsequent design phases.

Domestic Hot Water

As part of this effort, B2Q also reviewed the potential to replace the existing potable and non-potable water heating equipment with domestic hot water heat pumps.

Economics Summary

Table 12: DHW Heat Pump Economic Summary.

Proposed Electrification Option	Estimated Heat Pump Heating Capacity	Estimated Heat Pump Cooling Capacity	Estimated Annual Electric Savings		Estimated Annual Fossil Fuel Savings		Estimated Annual Energy Cost Savings	Electrification Opinion of Probable Cost
	tons	*tons*	*kWh*	*% of Baseline*	*gallons*	*% of Baseline*	*$*	*$*
Electric Water Heater for Process HW	--	--	-12,547	-4%	332	6%	-$1,634	$45,600

Overview

Potable hot water is provided to handwashing sinks in the administration area and workshop area by two electric hot water heaters. As this equipment does not currently use fossil fuels and is reported to be in good condition, replacing it with a heat pump hot water heater may not be a high priority at this time. The Town may wish to consider installing heat pump water heaters when the existing equipment reaches the end of its useful life in order to improve its energy efficiency.

An indirect hot water heater is integrated with the existing boiler system to provide non-potable hot water for the water treatment process. As a result of implementing Options 1 and 2, the boiler system is expected to remain off for the majority of the year. While the boiler could continue to operate to serve this water heater, the load is expected to be relatively small and may not be an efficient mode of operation. In order to more reliably serve this load with a non-fossil fuel source, an electric hot water heater could be installed to serve the process hot water load when the boiler is not operating. The existing indirect hot water heater could be retained for backup if the Town wishes. However, energy savings calculations are based on the assumption that an electric water heater would be the primary piece of equipment serving this load. It is also possible that a heat pump water heater could be installed to serve this load, which would use approximately 2-3 times less electricity than an electric resistance model.

A packaged DHW heat pump can achieve the 145°F supply temperature specified for the non-potable hot water process but they are not designed to continuously provide that temperature. Also noted from the original design drawings, is that this process requires a flow rate of 9 gpm. DHW heat pumps we've reviewed can only reliably achieve flow rates of 1-1.5 gpm which is likely not enough for this process. If pursuing either a replacement electric or heat pump water heater, it is recommended that this process be metered so that the replacement unit can be accurately sized.

An alternative to the above options would be an outdoor CO_2-based DHW heat pump, which would not have the same temperature and flow limitations as previously noted. However, these systems are significantly more expensive and should only be considered if the above-described options are deemed infeasible.

OPINION OF PROBABLE CONSTRUCTION COST

Table 13: DHW Heat Pump Opinion of Probable Construction Budget Cost.

Category	Estimated Budget
HVAC Equipment	$3,000
HVAC Piping, Ductwork, Other Materials	$8,000
HVAC Installation	$2,800
Electrical Branch Circuit Materials and Labor[1]	$7,100
Startup, Commissioning, TAB, Closeout	$2,800
Controls	$1,600
Engineering	$3,900
Contractor General Conditions & PM Labor	$11,200
Contractor Overhead & Profit	$2,000
Contingency	$3,200
Grand Total	**$45,600**

[1] Budget assumes no change in main electrical service and distribution. Further engineering needed to confirm and/or estimate costs

Given the volatile nature of construction costs in the current market, we recommend that the above estimates be considered preliminary budgets for purposes of vetting whether this building is a good candidate to proceed to the next phase of the process. In general, projects with a full set of design drawings and specifications are expected to have actual contractor bids within +/- 10 – 15% of a third-party cost estimator's projection. In this case, where the proposed system has not been designed, actual costs could vary by a much wider margin and the final design scope is likely to change and be refined as further investigation and coordination are completed in subsequent design phases.

ELECTRICAL INFRASTRUCTURE

Table 14: Electrical Infrastructure Review Summary

Existing Conditions			Calculated Additional Peak Load			
Rated Capacity	Estimated Peak Demand	Available Spare Capacity	Admin Area Air Source Heat Pump & ERV	Workshop Air Source Heat Pump & ERV	Filtration Room Water Source Heat Pumps	Process DHW
A	*A*	*A*	*A*	*A*	*A*	*A*
800	179	621	29	20	48	6

As part of this study, B2Q performed a high-level preliminary review of the main electrical service and equipment at the WTP. The existing main switchboard is rated for 800A at 480V, 3-phase power. Electrical demand data was not provided for this building, but high-level calculations based on information collected on-site indicated that the existing electrical service has sufficient capacity to support the additional loads of heat pumps. B2Q utilized the existing usage data to estimate a peak demand for the building.

This review should be considered very preliminary given the limited, high-level scope of this study and the lack of data available. Temporary metering should be included in the scope of a follow-on feasibility/design effort per the requirements of the National Electric Code (NEC), as it will ultimately be required for any electrification option. This should involve a licensed professional electrical engineer to more thoroughly evaluate the available capacity and ability of the existing systems to accommodate the increased electrical loads.

Recommended Next Steps

In summary, further planning and detailed engineering review are necessary in preparation for the next phases of design and construction of energy conservation measures and/or electrification options. Here are the recommended next steps:

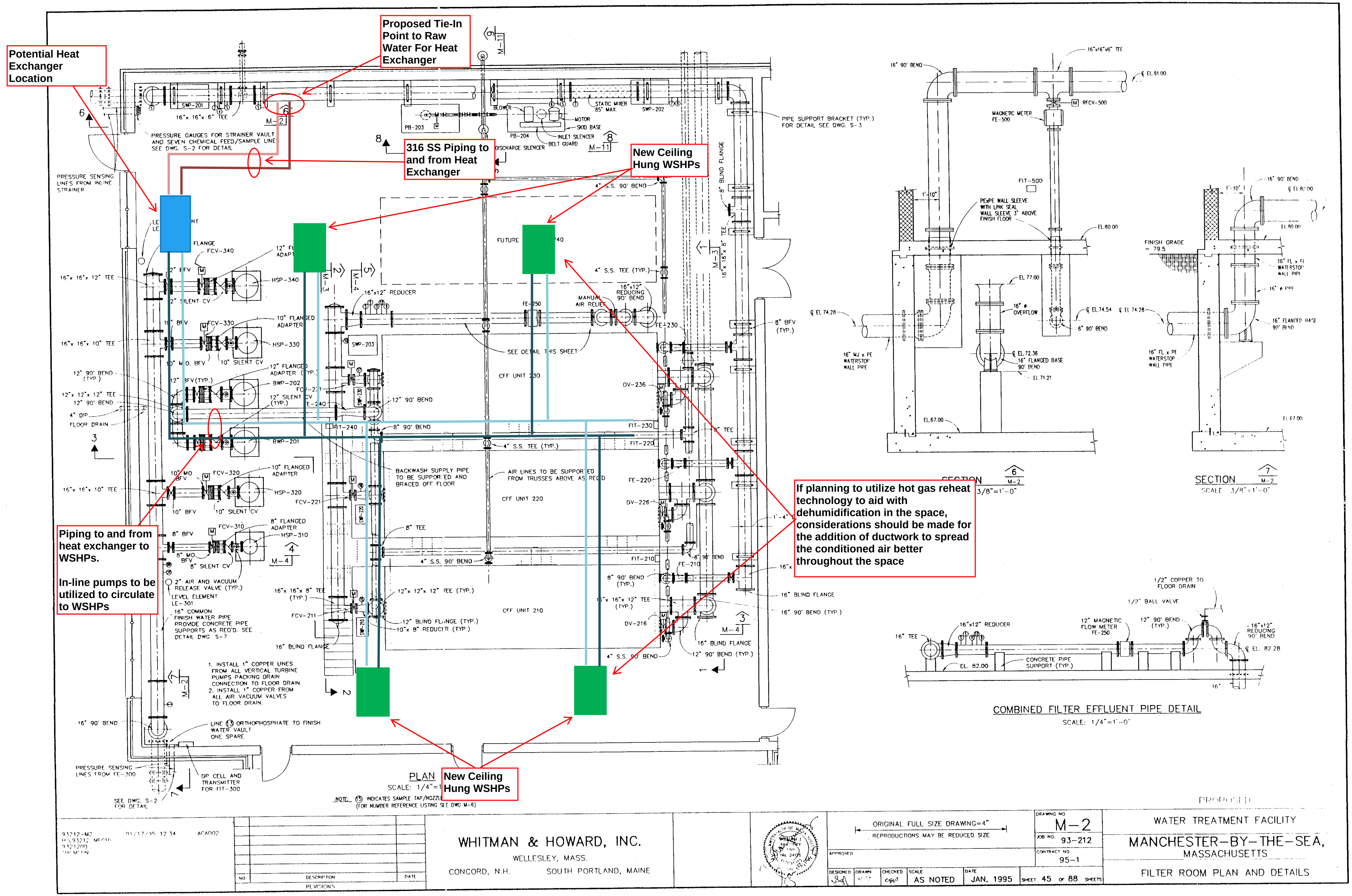
- Internal review to be completed by Manchester-by-the-Sea to determine if interested in pursuing electrification at this building further. Please make B2Q aware of any errors or omissions that may have impacted our results or recommendations. We would be glad to issue an updated report that addresses any such concerns.
- Meet with B2Q to discuss any questions about the information contained in this report, including these Next Steps.
- Coordinate with representatives from National Grid to obtain an estimate of potential utility incentives for the ECMs and electrification options.
- If the WTP is determined to be prioritized for electrification, assess which options outlined in this report are of greatest interest for further investigation. Note that, as discussed above, the factors that influence the choice of one option over another include a multitude of factors, such as estimated construction cost, compatibility with the existing building and equipment, impact on annual energy/operating costs, future expansion, reliability/resiliency, ability to operate and maintain the equipment, etc. so the Town should consider its own goals and priorities in relation to these projects as part of the decision-making process. Note also that the optimal solution for this or any building may be a hybrid that combines multiple system type options across the various types of existing equipment in the building.
- Consider working with stakeholders to secure funding for a follow up effort to conduct a more detailed feasibility study and/or schematic design to better develop the scope of work and obtain a third-party cost estimate to inform capital planning.
- Consider initiating more detailed electric load sub-metering, per NEC requirements. The process hot water flow should also be sub-metered as part of any further evaluations.

We would be happy to meet with you to discuss any questions or comments you have on the above information. Thank you for the opportunity to work with you on this effort.

Sincerely,

Joe Bliss, PE
Sr. Project Manager
B2Q Associates

APPENDIX A - CONCEPT LAYOUT OF OPTION 2


Potential Heat Exchanger Location
Proposed Tie-In Point to Raw Water For Heat Exchanger
316 SS Piping to and from Heat Exchanger
New Ceiling Hung WSHPs
If planning to utilize hot gas reheat technology to aid with dehumidification in the space, considerations should be made for the addition of ductwork to spread the conditioned air better throughout the space
Piping to and from heat exchanger to WSHPs.
In-line pumps to be utilized to circulate to WSHPs
New Ceiling Hung WSHPs
PLAN
SCALE: 1/4"=1'
SECTION 6 M-2
SCALE 3/8"=1'-0"
SECTION 7 M-2
SCALE 3/8"=1'-0"
COMBINED FILTER EFFLUENT PIPE DETAIL
SCALE: 1/4"=1'-0"
1. INSTALL 1" COPPER LINES FROM ALL VERTICAL TURBINE PUMPS PACKING DRAIN CONNECTION TO FLOOR DRAIN.
2. INSTALL 1" COPPER FROM ALL AIR VACUUM VALVES TO FLOOR DRAIN.
NOTE: 15 INDICATES SAMPLE TAP/NOZZLE (FOR NUMBER REFERENCE LISTING SEE DWG M-6)
WHITMAN & HOWARD, INC.
WELLESLEY, MASS.
CONCORD, N.H.
SOUTH PORTLAND, MAINE
ORIGINAL FULL SIZE DRAWING=4"
REPRODUCTIONS MAY BE REDUCED SIZE
DRAWING NO. M-2
JOB NO. 93-212
CONTRACT NO. 95-1
SCALE AS NOTED
DATE JAN. 1995
SHEET 45 OF 88 SHEETS
WATER TREATMENT FACILITY
MANCHESTER-BY-THE-SEA, MASSACHUSETTS
FILTER ROOM PLAN AND DETAILS

APPENDIX B – WSHP SELECTION FOR OPTION 2

SUBMITTAL DATA

Job Name	Drinking Water Treatment Plant - MA
For	
Sold To	
Prepared For	
Customer PO#	
Prepared By	Jon Zuber
Date	2/9/2024

Table of Contents

Job Information	*Technical Data Sheet*
Job Name	Drinking Water Treatment Plant - MA
Date	2/9/2024
Submitted By	Jon Zuber
Software Version	12.00
Unit Tag	WSHP-1

Unit Overview

Model Number	Voltage V/Hz/Phase	Air Flow CFM	Fluid Flow gpm	Cooling Capacity Btu/hr	Cooling Efficiency EER@AHRI	Cooling Efficiency EER@Design	Heating Capacity Btu/hr	Heating Efficiency COP@AHRI	Heating Efficiency COP@Design
WCCW2120	460/60/3	3540	30.00	126611	16.70	19.02	105546	3.90	3.75

Unit

Model Number:	WCCW2120
Unit Type:	Enfinity - Horizontal, Geothermal Range
Unit Construction:	1/2-inch Fiberglass Insulation w/Compressor Sound Blankets
Approval:	ETL, CETL, AHRI

Refrigerant Type	Refrigerant Weight	
	Compressor 1	Compressor 2
R-410A	80 oz	86 oz

Unit Performance

Air & Water Flow

Airflow	Total External Static Pressure	Fluid Flow	Fluid Type	Fluid Pressure Drop
3540 CFM	1.50 inH_2O	30.00 gpm / 3.00 gpm/ton	Water	19.54 ft H_2O

Cooling Performance

Fluid Temperature		Air Temperature				Capacity		Heat of Rejection	EER @ design
Entering	Leaving	Entering		Leaving		Total	Sensible		
°F	°F	Dry Bulb °F	Wet Bulb °F	Dry Bulb °F	Wet Bulb °F	Btu/hr	Btu/hr	Btu/hr	
60.0	70.0	80.0	67.0	58.0	55.0	126611	82713	149333	19.02

Heating Performance

Fluid Temperature		Air Temperature		Capacity	Heat of Absorption	COP @ design
Entering °F	Leaving °F	Entering Dry Bulb °F	Leaving Dry Bulb °F	Total Btu/hr	Btu/hr	
40.0	34.8	70.0	97.7	105546	77430	3.75

Electrical

Unit Voltage	Minimum Voltage	Total Unit MCA	Total Unit Full Load Current
460/60/3	416 V	21.4 A	19.4 A

Compressor RLA	Compressor LRA	Motor FLA	Maximum Recommended Fuse Size / HACR Breaker Size
7.80 A	52.0 A	3.8 A	25 A

Power Connection
None

*Short-Circuit Current = 5 kA rms symmetrical, 600 V maximum

Physical

Unit						
Length	Height	Width	Weight		Connections	
			Shipping	Operating	Water, FPT	Condensate, FPT
78.0 in	29.0 in	44.0 in	792 lb	704 lb	1.25 in	0.88 in

Cabinet		
Construction Type	Piping Hand	Condensate Drain Pan
1/2-inch Fiberglass Insulation w/Compressor Sound Blankets	Right Hand	Stainless Steel

Fan				Controls
Type	Motor		Drive	Type
	Type	Horsepower	Type	
DWDI FC	Standard with VFD Motor	3.000 HP	Belt	Microtech III

Airstream		
Air		Filter
Discharge	Return	(Quantity) Nominal Filter Dimensions
Straight Discharge	Left Hand Return Air	(3) 19 in x 28 in x 2 in

Options

Heating

Heat Exchanger:	Copper Inner Tube / Steel Outer Tube

Dehumidification

Type:	Hot Gas Reheat Coil

Filter Options

Filter Options:	2" 4-Sided, MERV 8 filter

Drain Pan Material

Primary:	Stainless Steel

Controls

Thermostat Mounting:	Remote - Wall Mounted Thermostat
Thermostat Type:	Programmable
Power Connection:	None
Network Card:	BACnet Communication
Control Transformer:	75VA Control Transformer
Condensate Overflow:	Sensor
Freeze Fault Protection:	Freeze Fault Protection

Warranty

Unit Warranty:	4 Yr Compressor Only Extended Parts Warranty, 1st Yr Labor Allowance

AHRI Certification

AHRI CERTIFIED™ www.ahridirectory.org Water Source HP ANSI/AHRI/ASHRAE/ISO13256-1

All equipment is rated and certified in accordance with AHRI / ISO 13256-1 and tested, investigated, and determined to comply with the requirements of the standards for Heating and Cooling Equipment UL-1995 for the United States and CAN/CSA-C22.2 NO.236 for Canada.

Accessories

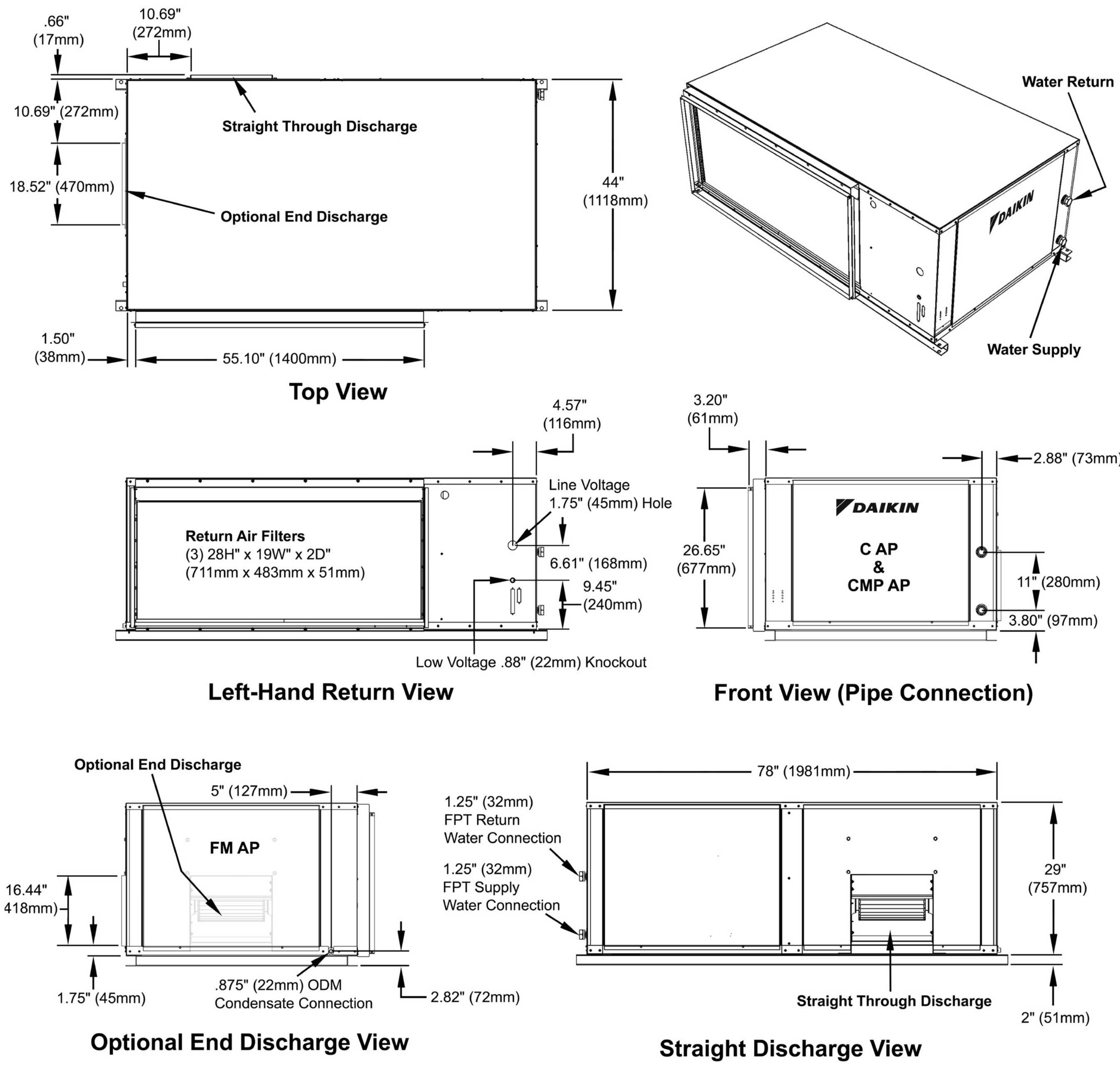
Optional	
Part Number	**Description**
910182848	Hose, Kit Auto Flow, Strainer, Ball Vlv 1.25" x 3ft, 30 GPM
910121754	Room Snsr, Digitally Adjstbl, Temp&Humidity Dsply
105571101	Thermostat Guard with Clear Plastic Ring, Lock & Key (9.7"L x 7.3"H x 3.34"W)
910105754	Kit, Mtrzd Valve, 1 1/4"

Certified Drawing	CCH-CCW-120 Specs
The Water Source Heat Pump product represented on this document will conform to the drawings and specifications set out below, in accordance with the express, written Limited Warranty. Purchaser's acceptance of this drawing certifies that the conforming equipment meets the order specifications. No changes may be made to this document without the prior, express, written authorization of the manufacturer.	Group: **WSHP** Type: **Large Horizontal** Date: **October 2018**

Daikin Enfinity™ Large Horizontal WSHP

Models CCH/CCW – Unit Size 120

Dimensions



C AP = Control Access Panel **CMP AP = Compressor Access Panel** **FM AP = Fan Motor Access Panel**

Notes: Overall Unit Dimensions: 78"L × 44"W × 29"H (Add 2" For Hanger Bracket)
Available in left hand return configuration only - determined by facing the water connection side of the unit.

DAIKIN

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Enfinity Large Horizontal WSHP - Models CCH/CCW – Unit Size 120

Figure 1: Dimensions - filter rack/return air duct collar

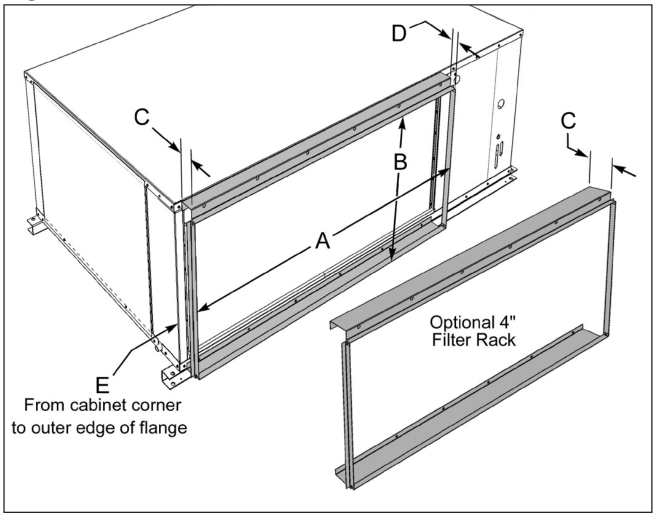


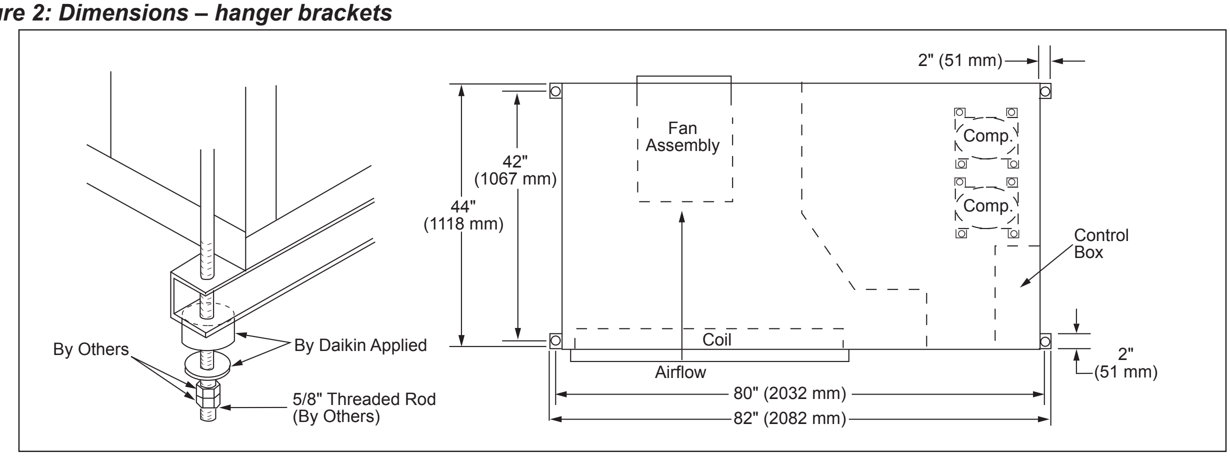
Table 1: Filter rack dimensions

Unit Size	A	B	C	D	E
120	55.10" (1400mm)	26.78" (680mm)	2.20" (56mm) **Optional 4" Filter Rack** 4.20" (107mm)	1.00" (25mm)	3.30" (84mm)

Note: *Dimensions are to the outside edge of the filter rack flanges.*

Hanger Brackets

Figure 2: Dimensions – hanger brackets



Physical Data

Table 2: Large Horizontal Size 120

Unit Size		120
Fan Wheel - D x W (In.)		16 × 15
Fan Motor Horsepower		3.0 / 5.0
Coil Face Area (Sq. Ft.)		10.5
Coil Rows		3
Refrigerant Charge (Oz.)	Compressor 1	74
	Compressor 2	74
Filter, (Qty.) Size (In.)		(3) 28" × 19" × 2
Water Connections		1¼" FPT
Condensate Connections		7/8" ODM
Weight Based on Motor HP		**3.0 / 5.0**
Weight, Operating (Lbs.)		704 / 724
Weight, Shipping (Lbs.)		792 / 812
Weight, Operating (Lbs.) with Economizer		804 / 824
Weight, Shipping (Lbs.) with Economizer		912 / 932

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Certified Drawing	**Digital Display Sensor Specs**
The Water Source Heat Pump product represented on this document will conform to the drawings and specifications set out below, in accordance with the express, written Limited Warranty. Purchaser's acceptance of this drawing certifies that the conforming equipment meets the order specifications. No changes may be made to this document without the prior, express, written authorization of the manufacturer.	Group: **WSHP**
	Type: **Accessory**
	Date: **October 2015**

Digitally Adjustable Display Sensor

Used With:

Water Source Heat Pumps (WSHP) - Sensor Part No. 910121754

SmartSource™ Units - Models GS & GT

Enfinity™ Units with MicroTech® III Controls - Models CCH, CCW; VFC, VFW; LVC, LVW; MHC, MHW & VHC, VHF

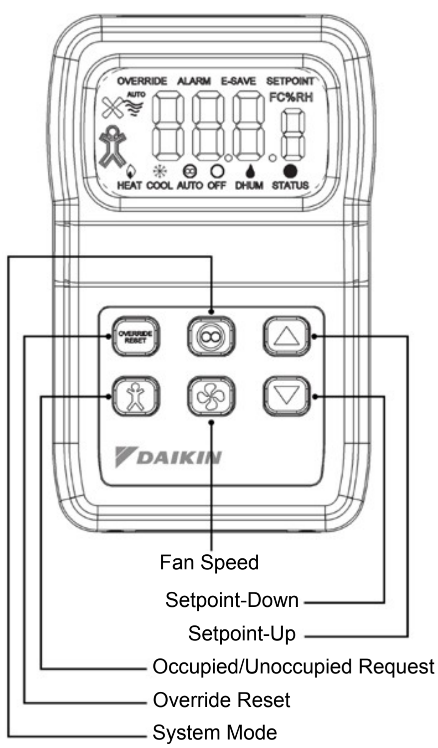
Fan Coil Units (FCU) - Sensor Part No. 910113679

Models With MicroTech III Controls

Overview

The display sensor is used in conjunction with the MicroTech III equipped units as described in the Application Section below. The same sensor is used for Water Source Heat Pump (WSHP) and for Fan Coil Units (FCU) with just a hardware jumper and menu change during configuration. The sensor has a digital display for Temperature, Humidity, Occupancy, Fan Speed, System Mode, Alarm, Setpoint and Status indication. Controls include six buttons for Setpoint, System Mode, Fan Speed, Occupied/Unoccupied Request, and Override Reset. (Figure 1).

Figure 1: Digital display sensor - P/N 910121754, Fan Coil P/N 910113679



910113679, Fan Coil Unit Model:

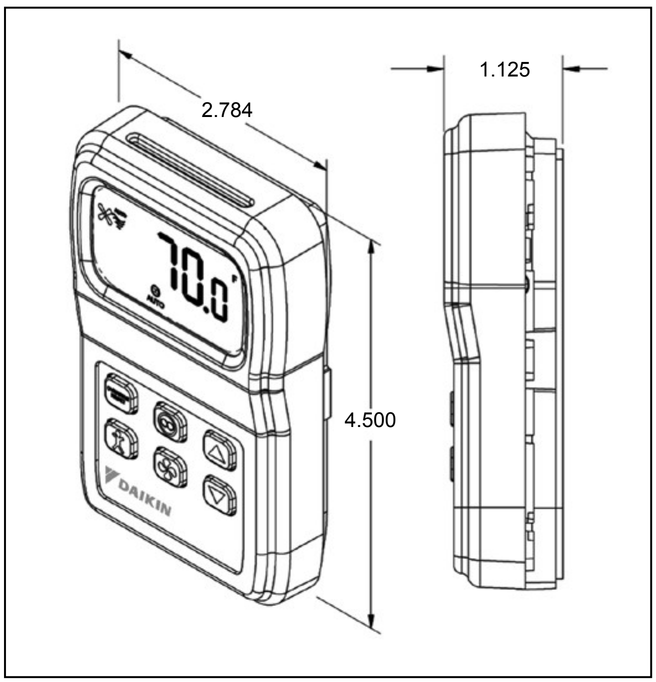
- Display sensor to show room temperature, fan speed (Auto/High/Medium/Low), system mode (Heat/Cool/Auto/Off), alarm, override and occupancy.

910121754, Water Source Heat Pump Model:

- Display sensor to show room temperature, room humidity, fan speed (Auto/On), system mode (Heat/Cool/Auto/Off/Dhum), alarm, override and occupancy.
- De-humidification output contact has an adjustable setpoint and configurable deadband. This output operates automatically using the RH setpoint and deadband in the system "Auto" mode or in the "Dhum" mode.

Sensor Dimensions

Figure 2: Sensor dimensions



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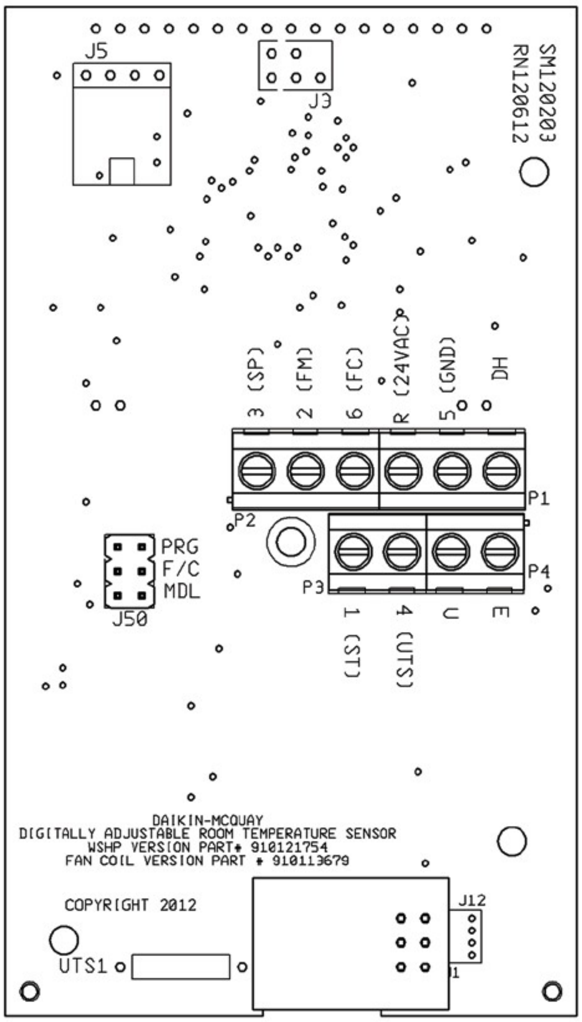
Termination

Daikin Applied recommends using twisted pair of at least 22AWG and sealant filled connectors for all wire connections. Larger gauge wire may be required for long runs. All wiring must comply with the National Electric Code (NEC) and local codes. Do NOT run this device's wiring in the same conduit as AC power wiring. Tests show that fluctuating and inaccurate signal levels are possible when AC power wiring is present in the same conduit as the signal lines. If you are experiencing any of these difficulties, please contact your Daikin Applied representative.

Figure 3: Sensor circuit board



Terminal Descriptions

R........... 15 to 28VAC (AC requires separate shielded wire)

DH........ Dehumidification Contact (Triac from R to DH @170mA, WHSP Only).

U........... Unoccupied Contact. (Terminal grounded when in Unoccupied, VDC only).

E........... System "Off" Indication. (Terminal grounded when in System "Off" mode, VDC only).

1............ Status Indicator Input from the MicoTech III Smart-Source Unit Controller. (5VDC).

2............ Output Signal, and Fan Mode System (0 to 5VDC). Output Signal, System Mode Select for FCU only, (0 to 5VDC).

3............ Output Signal, Setpoint Adjust from 55º to 95˚F (default) or ±5º Configurable. (0 to 5VDC) See Setpoint Analog Range Tolerances. See Table 1.

4............ Output Signal, Room Temp Thermistor Sensor. (10K ATP Z curve, 10K-2).

5............ Ground or Neutral (AC requires separate shielded wire). Common Reference for All Signal Terminals.

6............ Output Signal, Fan Speed Select for FCU only. (0 to 5VDC). Terminal 6 not used for WSHP units.

Table 1: Setpoint analog range tolerance

Setpoint Analog Tolerance		
55° to 95°F Scale	-5° to +5°F Scale	Terminal 3 Analog Output
@ 55°F (min.)	@ -5°F (min.)	0.0 to 0.10 vdc
@65°F	@-2.5°F	1.3 to 1.42 vdc
@75°F	@0°F	2.12 to 2.2 vdc
@85°F	@+2.5°F	2.58 to 2.63 vdc
@95°F (max.)	@+5°F (max.)	3.0 to 4.0 vdc
Sensor Error	Sensor Error	Full Scale ≈ 5 vdc

Specifications

Supply Voltage:

AC Hot....................(R) 7 to 28VAC, 24VAC nominal, 0.17VA

GND/Neutral...........(5) Sensor common reference ground.

Sensor:

Temperature ....10K-2 Thermistor, ±0.36ºF (±0.2ºC)

Humidity ....2% Accuracy from 20 to 80%, Capacitive.

Outputs:

Unoccupied ....(U), Unoccupied = Digital low to ground (Same ground as power source), 100mA @5VDC max.

Dehumidify ....(DH), = Dehumidify = Voltage output (same as supply voltage), 170mA max.

System Off ....(E), System Off = Digital low to ground (Same ground as power source), 100mA @5VDC max.

Fan Speed................(2 or 6), Analog, 0 to 5 VDC.

System Mode ....(2), Analog, 0 to 5 VDC.

Setpoint ....(3), Analog, 0 to 5 VDC.

Temperature ....(4), Analog thermistor resistance.

Sensor Controls:

Setpoint ....2 Up/Down buttons

System.....................1 button to cycle between Heat/Cool Auto/Off/Dhum/Off

Fan...........................1 button to cycle between Auto/High/On.

Occupied ....1 button to check and request change in Occupancy Status.

Override/Reset ....1 button to request timed occupancy override and reset alarms.

Inputs: ....(1), Controller alarm & system status, 5VDC max.

Termination:............10 Terminals, 16 to 22 AWG.

Mounting:................Standard 2" × 4" J-Box or Drywall

Field Setup Jumper J50:

PRG.........................Program Mode, On = Program, Off = Run.

F/C...........................Display Units, On = ºC, Off = ºF.

MDL........................MODEL, On = WSHP.

Display:

LCD

Overall size ....2.04"W × 1.33"H.

Main Digits ....±999.9 Digits @0.6"H

Resolution ....0.5 displayed value, 0.1 for offset adjust

Main Value ....Temp, Humidity & Setpoint, toggling every 5 sec.

Eng. Units ....ºF, ºC, %RH.

System.....................Heat/Cool/Auto/Off/Dhum.

Fan...........................Auto/High/Medium/Low/Off.

Occupied Icon ....Hollow = Unoccupied, Solid = Occupied.

Function ....Override, Alarm, E-Save, Setpoint

Field Configuration Menu:

Requires J50 PRG jumper to be “On”.

Offset.......................Temp or Humidity display, ±2ºF (±1.0ºC) and ±5% RH.

Setpoint range ....Default 55º to 95ºF (13º to 35ºC) or ±5ºF (±3ºC). Adjustable between 55º to 95ºF or ±3ºF (±1.6ºC).

Fan Lock-in.............Any fan speed or off can be locked in System Lock-in. Any system mode can be locked in

Resolution ....Main display can be default .5, or .1 or 1.0 (ºF, ºC or %).

Display Mode..........Temp only, RH only, Setpoint only or any combination.

Dhum DB ....Dehumidify Dead Band adjust, 2% default.

Enclosure Material:

ABS Plastic, UL94V-0.

Ambient:

32º to 122ºF (0º to 50ºC), 0 to 95%RH, Non-condensing.

Agency:

RoHS.

Note: *For complete Installation, operation and maintenance information for the Digitally Adjustable Sensor, refer to IOM 1171.*

Applications

The display sensor can be used on the products shown in Table 2.

Table 2: Product usage guide

Units	Product		Models	Controls	Used with Digitally Adjustable Sensor with Temperature and Humidity Display
Water Source Heat Pumps	Horizonal	Enfinity™	W. CCH, CCW	MicroTech III Unit Controller	Yes
	Vertical		W. VFC, VFW		
	Vertical Stacked		W. VHC		
	Console		W. MHC, MHW		
	Horizontal & Vertical	SmartSource 1-Stage	W. GSH, GSV	MicroTech III SmartSource Unit Controller	
		SmartSource 2-Stage	W. GTH, GTV		
Fan Coils	Horizontal	ThinLine™	FC.H, FH.H	MicroTech III Unit Controller	Yes

The display sensor for water source heat pump applications is shown in Table 3.

Table 3: Water source heat pump application guide

Units	Product		Models	Applications										
				Cooling	Heating	Dehumidification					Electric Heat			Waterside Economizer
				Stages		Smart Dehumidification	Hot Gas Reheat	Simplified	Humidistat Controlled	Dehumidification Only	Boilerless	Supplemental	Primary	3-Way Valve Control
Water Source Heat Pumps	Horizontal	Enfinity	W. CCH, CCW	1	1	No	No	No	No	No	No	No	No	No
	Vertical		W. VFC, VFW	1	1	No	Yes	No	No	No	Yes[1]	Yes[1]	No	No
	Vertical Stacked		W. VHC	1	1	No	No	No	No	No	No	No	No	No
	Console		W. MHC, MHW	1	1	No	No	No	No	No	Yes[1]	Yes[1]	No	No
	Horizontal & Vertical	SmartSource 1-Stage	W GSH, GSV	3	4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Horizontal & Vertical	SmartSource 2-Stage	W. GTH, GTV	3	4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: [1]*With optional Boilerless controls*

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