ASHRAE AUDIT REPORT

Athol Waste Water Treatment Plant

Abstract

This report summarizes the findings from a walk-through and analysis completed by RISE.

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Picture 1: Aerial view of the Athol Waste Water Treatment Plant

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The primary purpose of this report is to review the existing heating, cooling and ventilation systems within the Athol Waste Water Treatment Plant, WWTP, located at 69 Jones Street in Athol, MA. The review of the on-site conditions occurred on June 20th, 2023.

Building Summary

Building Use and Description

The facility is used as the Waste Water Treatment Plant for the Town of Athol. The original plant was built in 1971 with additions and renovations completed in 2009. That included a major Headworks Building addition, new aeration systems, Pump Station Building modifications, new Ultraviolet disinfection and renovations to the front Process Building including a new boiler system.

The Pump Galley Building has three levels which comprise about 870 square feet. The brick and concrete building is minimally heated with electric resistance type, suspended unit heaters. The two (2) model EUL25B73C unit heaters have a 25 kW capacity. The building is rarely occupied for more than a few minutes per day. There is an existing rooftop air inlet hood along with an exhaust fan. The two (2) 7.5 horsepower (hp) and single (1) 20 hp pumps operate continuously and have VFDs (variable speed drives). The remaining two (2) pumps which are located under the stairs operate six times per day for only fifteen minutes. They are controlled by ABB VFDs. At the time of the site visit, pump #2 was operating at 98% speed.

Picture 2: Pump Gallery/Station Building

The Headworks Building is the location at which the raw sewage enters the plant. The original section of the building has one level with the addition having two levels. Together they comprise about 4,010 square feet. The building includes a blower room, an alkalinity supplement chemical storage area (known as the "Mag Room" given the two (2) Magnesium Hydroxide tanks), boiler room, a solids loading area, and a grit removal and channel system.

Picture 3: Headworks Building

The addition to the Headworks Building has four to six inches of rigid board insulation under the roof membrane. The existing portion of the roof was replaced about eight years ago with about two inches of rigid board insulation. The walls have 1 ½" rigid board insulation in between the exterior brick and eight inch concrete blocks. There is a rear insulated overhead door. Doors and windows have thermal pane glass and several skylights exist in the roof.

The Process Building contains the office, laboratory, visitor's restroom, locker room, staff bathroom, electrical room, break room, tool room, Vehicle Storage, Solids Handling Room, and the Chemical Room. There are two levels in this building which comprise about 9,016 square feet. The Solids Room has four (4) large sludge tanks. The calorifier tank room pumps run continuously. The basement sludge pumps only operate one hour per day. The septage pumps operate about one and half hours per day. The Laboratory includes a Fume Hood. Doors and windows have thermal pane glass, and several skylights exist in the roof.

Operations Schedule and Energy Usage

The building is staffed from Monday through Friday from 6:45 AM – 2:45 PM and about four hours during the weekend. The front Process Building is generally maintained at 68°F during the heating season and 70°F for cooling.

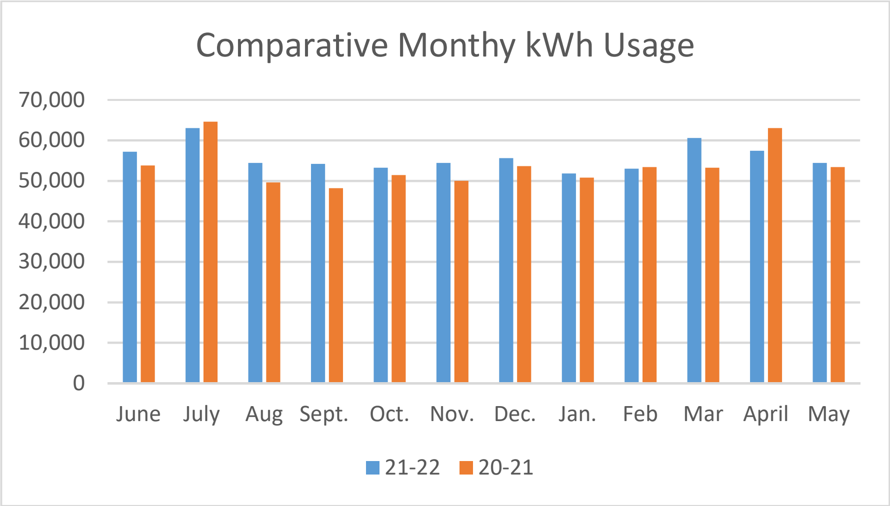
There is no natural gas service at the remote site location of the Athol WWTP. There are two (2) #2 fuel oil storage tanks; one for the Wastewater Headworks Building for which 3,321 gallons were delivered in the period from December 19th, 2019 through March 18th, 2022. The total cost during that time was $9,432 with an average cost of $2.84 per gallon. The most recent price per gallon for oil delivered is $2.63. Looking back to available usage figures from about fourteen years ago, the Headworks building annual oil usage was 3,755 gallons.

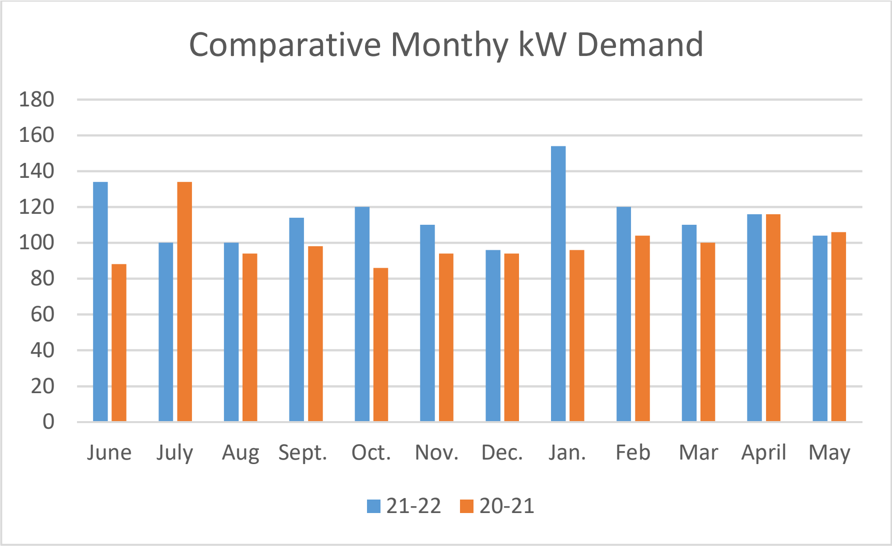
The #2 oil account for the second tank at the WWTP Process Building incurred the following usages:

Period of Deliveries	Total Gallons	Total Price (average $/gallon)
November 2019 – April 2020	3,952	$7,290 ($1.85)
May 2020 – June 2021	4,195	$7,841 ($1.87)
September2021 – June 2022	3,397	$11,024 ($3.25)

The fuel oil usage pattern is fairly typical for this type of building. Looking back to available usage figures from about fourteen years ago, the main building oil annual usage was 3,299 gallons and the price per gallon was $3.04. The usage per square foot per year is in the normal range for the front Process Builidng but seems higher than necessary for the Headworks building. That type of facility would normally have an energy recovery ventilation system to reduce heating loads.

The annual energy usage was 669,200 kWh for the 21-22 season and 645,000 kWh for the twelve months prior. Just before this report was finalized, RISE received the most recent bill showing the summation of the preceding twelve months to be 692,600 kWh. Looking back to available usage figures from about fourteen years ago, the main building electricity usage was 612,000 kWh per year at a blended rate of 16.5 cents per kWh. Monthly electric demand over the past two years has typically ranged from 86 To 120 kW with the annual average firgures at 115 and 101 respectively. This report uses a marginal cost of 16 cents per kWh. The current demand charge is $12.47 per kW. The use of electricity is in a high range of 45 kWh/sq.ft./year. However, much of the electric usage is outside of the buildings so that the builidng square footage becomes less relevant. Gauging the annual usage on a per capaita basis derives a figure of 56 kWh/resident. That figure happens to be just under one-third the usage of a similar waste water treatment plant for a smaller town reviewed a few years ago.





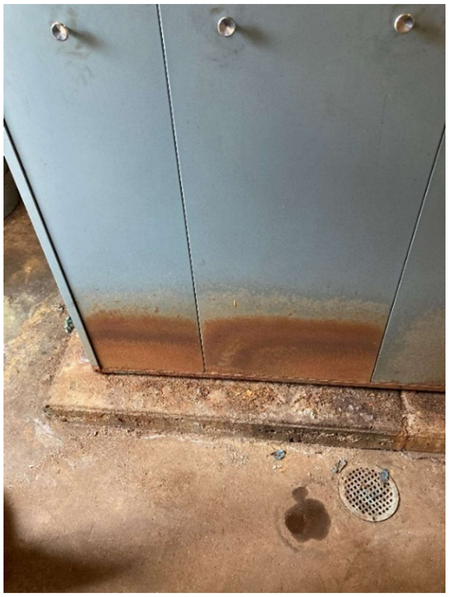
HVAC Equipment

The Head Works Building has a thirteen year old, cast iron boiler. The Smith 19A-7-W series boiler has a Carlin oil-fired burner with a firing range of 6 to 13.2 gallons per hour. The boiler has an IBR **net** minimum output rating of 901,000 Btu/hour and was specified to operate with glycol fluid. The boiler was designed with the intention set up to have a positive pressure fire with a slide damper at the breeching. The barometric damper controls the vertical chimney draft rate. The current boiler size seems to be large for this building especially given that its **gross** output is over 1,000,000 Btu/hour.

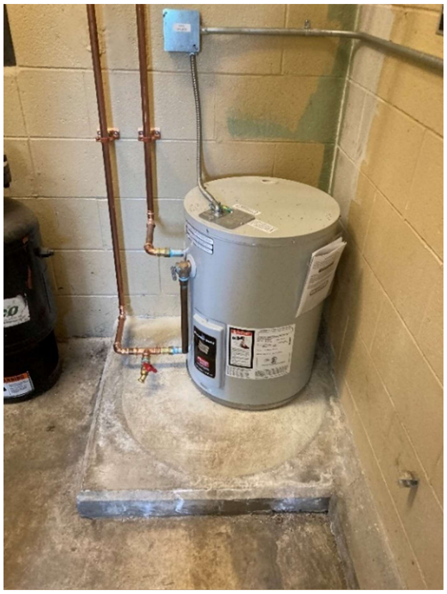
Pictures 4 and 5: The front and rear views of the Headworks Building's Smith hydronic boiler.

It was noted that the bottom edge of the boiler cabinet has either corrosion or burned off paint. Inside the boiler cabinet should be factory installed insulation over the cast iron sections and fire sealing compound in between the sections to prevent the latter.

The boiler distribution system includes two (2) redundant cast iron in-line Taco single speed pumps piped in parallel. The pumps are each driven by a 3 hp motor at 1755 rpm. A Yankee Technology (now Carrier) BMS control panel box contains an Automated Logic SE6104 control module for the boiler system.

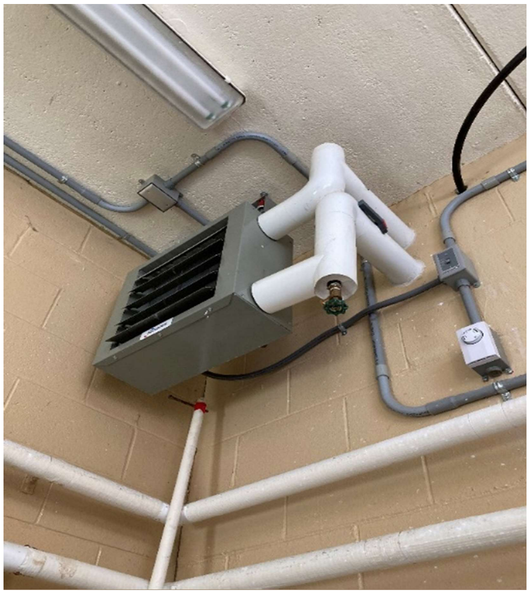


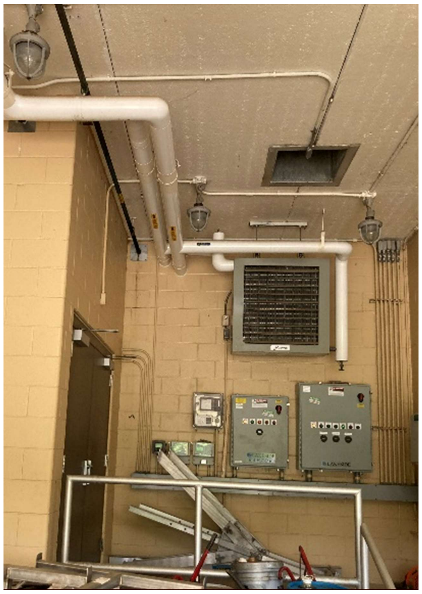
Picture 6: A view of the bottom edge of boiler.



Picture 7: Electric water heater for emergency wash.

There is a small freestanding electric water heater in the Headworks Building boiler room. The Bradford White Corporation model number RE120U6-1NAL has a 19 gallon capacity and one 1,500 watt electric resistance heating element. This tank only serves the wash station in the adjacent Mag Room after passing through the Leonard mixing valve. It was noted that the copper hot piping out of the tank was not all insulated. Insulation applied to the remainder of the piping is recommended. Pipe insulation does exist in the adjoining room.





Pictures 8 and 9: Modine suspended unit heaters in the Headworks Building.

The exhaust fans in the Mag Room are controlled by Johnson Controls exhaust fan temperature reverse thermostat.

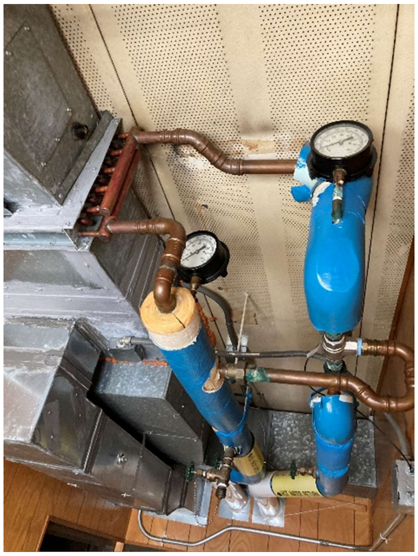
For the main Process Building, there is a roof top unit (RTU) which is designed to provide cooling and ventilation for the laboratory, office, corridor, and shower room. With the use of the hydronic duct coils, the RTU fan also operates during the heating season. An American Standard/Trane model 4TCC3048A4000AA which was manufactured in 2006 was found to be operating at the time of the visit. It has one (1) ¾ horsepower supply air fan, one (1) ¼ horsepower outdoor condenser fan motor and one (1) compressor motor. The RTU has 11 EER and 13 SEER efficiency ratings; a 1,600 cfm supply air flow rate; and a cooling capacity of 46,500 Btu/hour. The RTU operates with R-410A refrigerant which is now in the process of being phased out. Given the need for constant air turnover in this type of facility, it is recommended that the RTU fan shall be operated in the "ON" mode for continuous air flow. Ventilation should occur continuously during occupied hours, not just during a heating or cooling demand fan cycle.

The Process Building has a thirteen year old cast iron boiler which is located in the basement. The Smith 19A-8-W series boiler has a Carlin oil-fired burner. The boiler has an IBR net rating of 1,063,000 Btu/hour and was specified to operate with glycol fluid. The boiler was intended to be set up to have a positive pressure fire with a slide damper at the breeching. The barometric damper controls the vertical chimney draft rate.

Picture 10: The oil-fired, Smith cast iron boiler in the Process Building basement.

The boiler vents into a chimney but it is not clear if there is a liner present. The chimney has a cap base with a fitting for a hood which is missing. There are four stainless steel threaded rods which could secure a cap if located. Perhaps the base was installed to fine tune the chimney draft. Before installing a hood, the flue pipe draft rate should be verified at the stack in the basement both with and without the boiler burner in operation. The boiler provides heat to suspended and wall mounted fan coil units, perimeter fin tube convectors and two (2) in-duct coils associated with the RTU system.

Picture 11: Missing chimney hood above base cap.



Picture 12: Heating coil in RTU ductwork.

The boiler was designed with an indirect domestic hot water tank. That tank has since failed; the current tank is a two year old SuperStor Contender model SSC-119 with a storage capacity of 119 gallons. At the time of the site visit, the boiler temperature was up to 175°F even though the building was operating in the cooling mode. The indirect tank requires the use of the boiler whenever the tank temperature is below the setpoint level. There is a small fractional horsepower pump that circulates boiler water through the indirect tank heat exchanger. The boiler has two (2) redundant in-line heating circulation pumps, one of which has a newer motor. The circulation pumps have single speed 1 ½ horsepower motors.

The installation of a separate heat pump water heater system would be more efficient and operate at a lower cost than the current indirect tank system. Maintaining the boiler at elevated temperatures during the summer, spring and fall requires short cycling of the oil burner. This increases the amount of soot on the cast iron heat exchanger resulting in lower heat transfer and efficiency. If the boiler was smaller or gas-fired, the modest indirect tank load would be a better match. Additional information pertaining to heat pump water heaters is provided later in this report.

Normally, the hydronic heating points of distribution are originally specified to be sized based upon 180°F supply and 160°F return heating water temperatures for a design heating day. Those temperatures would be reduced based on a "reset curve" using a boiler reset control. As the outside temperature goes up, the boiler supply water temperature is reduced by the automatic control. Such controls have been around for over fifty years and are now mandated to be integrated in all new hydronic boilers sold. The reset control keeps the heat flowing through the terminal distribution system longer resulting in improved comfort as compared to a system set up to provide 180°F regardless of the load.

In the present world of high efficiency propane gas-fired boilers, hydronic heating systems are often sized to a 150°F supply and a 120°F return on a design heating day with a reset for the remainder of the season. This would provide an efficient 30°F difference in temperature or "delta T." Having a 30°F delta T allows for more of the heat to be used before it returns to the boiler system and it can improve the boiler efficiency. It also allows the existing or new pump system to be operated at a lower speed through the use of the VFDs. Running the pumps at a lower speed reduces the use of electricity and can reduce the wear and tear on the pump motor.

While the high efficiency gas-fired boiler can operate at the same temperatures as the existing boiler, it would operate more efficiently with 150°F supply and 120°F return temperatures on a design winter day. **For an even lower (125°F supply and 100°F return) temperature the use of an air-to-water heat pump (AWHP) system could be considered.** While most of the existing perimeter heat units could be used with the condensing boiler, many of them would likely need to be upgraded in size (or supplemented with additional units) to operate with sufficient heat if an AWHP system replaced the existing boilers. AWHP systems are limited to a maximum supply water temperature of 140°F. See the Appendix of this report for two (2) examples of fan coil units with built-in modulating fan speed temperature controls which can be designed around lower heating water temperatures.

There are several rooftop exhaust fans as noted in the below table.

Fan Ref.	Brand	Model	CFM	Horsepower
EF-1	Greenheck	CUBE-131-4-X	1,850	1/4
EF-5	Greenheck	CUBE-161-4-X	2,128	1/4
EF-6	Greenheck	CUBE-161-4-X	2,138	1/4
EF-8	Greenheck	CUBE-121-4-X	1,290	1/4
EF-9	Greenheck	CUBE-420-10-X	9,200	1
EF-10	Greenheck	CUBE-161-4-X	2,138	1/4
EF-12	Penn Ventilator	XV-94	*	*
EF-13	Penn ventilator	XV-94	*	*
EF-14	Greenheck	CUE-095-D-X	853	1/8
EF-15	Greenheck	CUE-121-B-X	1,174	1/8
EF-16	Greenheck	CUE-141-B-X	1,825	1/4
EF-17	Penn Ventilator	AB-35	1,855*	*

*This fan appears to be original equipment when the building was built.

Additional fans include two (2) rooftop Greenheck model CUBE-360-7 located over the Headworks Building Screening Room. Those fans have ¾ horsepower motors which are rated at 7,350 cfm. Intake air is brought in via two (2) gravity air inlets located on the roof at the opposite side of the room. Headworks screening rooms are typically vented with six to twelve air changes per hour (ACH). The current rate of air flow if both fans are operating is approximately three times the 12 ACH. The location of the fans is such that the ACH are not likely to be as effective as compared to if the inlets were installed low on the exterior wall.

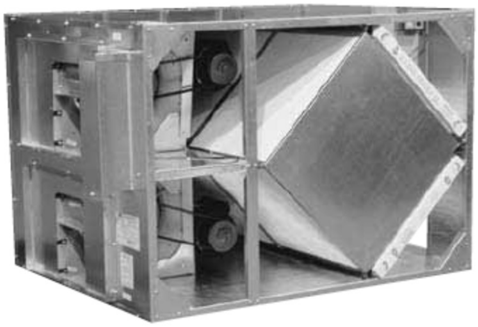
Ventilation Systems Assessment

Ventilation is required by code in these buildings. Effective ventilation during the primary months of heating or cooling are best provided by mechanical equipment. Mechanical ventilation, as defined by the MA building code, takes the form of fresh Outdoor Air (OA) brought in and conditioned (heated or cooled) and exhaust air (EA) ventilation being sent out. For each OA and EA air stream, the code refers to specific rates of cubic feet of air per minute (cfm) for each particular use classification within the building.

Ventilation effectiveness considers the position of the supply and return grilles and the mixing of the ventilation air with the heating and cooling air. When short circuiting occurs, ventilation effectiveness decreases and therefore more airflow is required to ensure that the necessary amount of ventilation gets to the intended room. Ultimately, a room-by-room ventilation calculation is required to finalize the fresh air ventilation rate that is necessary. Such ventilation will only be effective if the total of the exhaust air rate is just a little higher than the intake air flow rate during occupied hours.

For WWTP pump stations, ventilation systems shall have a maximum capacity to comply with NFPA 820. Additional controls to allow staff to adjust the capacity/operation of the system shall be included as discussed more in NFPA 820 Section 9.3. When ventilation systems are operated at a lower capacity, the air quality should be tested routinely to maintain a safe environment for staff and to avoid conditions that can degrade the building structure and equipment. Ideally, a Hydrogen Sulfide (H_2S) sensor could be used to operate the ventilation system at a variable speed.

Incorporating an Energy Recovery Ventilation (ERV) exchanger to recoup approximately 70% of the heat from the exhaust to preheat the fresh incoming airflow brings the building up near to state-of-the-art for the current system. Since a standalone ERV recovers heating and cooling energy (only heating in the case of the Headworks Building), they also reduce the size of the new HVAC equipment necessary to meet building loads. The ventilation airflow rate is not reduced, just the energy used to heat or cool it before it reaches the space. Additional information regarding the RenewAire ERVs is shown in the Appendix at the end of this report.



Picture 13: An example of RenewAire Energy Recovery Ventilator

As might be expected, the implementation of ERVs will have a positive impact on operating costs for years to come. There are two (2) types of ERV exchangers: the wheel and fixed plate types. For this application the fixed plate type would provide reliable and efficient operation. It should be noted that opening windows is not a recommended method of increasing ventilation except on temporary basis in specific cases. Opening windows usually leads to short cycling the air, and not allowing the air to travel properly across the room and eventually decreases ventilation effectiveness and efficiency.

Heat recovery systems like an ERV should only be specified when continuous ventilation must be provided. To operate a heat recovery supply and exhaust ventilation system continuously when outside airflow is not essential uses more electric energy and exhausts more building heat (small heat recovery systems typically recover 60% of the exhausted heat). A better option is to include VFDs/cycle controls on standard ventilation units to allow the WWTF staff to adjust ventilation airflow. When adjusting ventilation, staff should establish a ventilation rate that provides a safe environment for staff when the space is occupied, and adequate ventilation to protect equipment and the building structure from corrosive gases.

For the Headworks Building Screening Room, reconfiguring the intake and exhaust ports and the use of a coated ventilation recovery heat exchange to protect against corrosion are necessary. With the improved ventilation effectiveness, a reduction in the total air flow to 12 ACH may be possible. The NFPA standard appears to require both supply and exhaust fans and monitoring for each. The ERV system could accomplish that. While there is an expected fuel oil energy saving from the use of an industrial ERV system for this application, the initial installed cost of such a system is estimated at around $150,000 resulting in an extended payback period of around 28 years.

With a properly engineered system, the AWHP and/or replacement of the existing rooftop unit with a heat pump RTU system could directly replace both the existing boiler and the direct expansion cooling portion of the existing RTU system to heat or cool the building through a modified two-pipe distribution system. The benefit of the use of such a system would be to convert a major portion of the building's energy use to carbon free electric energy if a significantly sized battery storage system, thermal storage and solar PV (photovoltaic) array were installed at the same time.

The building's electrical system infrastructure is likely to be able to handle the replacement. The removal of most, if not all, of the existing exhaust fans to install a new RTU with ERV incorporating ECM type motors is also likely to be feasible. The retention of the existing boiler as a back-up heating source or the installation of a more efficient propane-fired boiler plant as either the primary heating source or a back up heating source for the AWHP system is also feasible. Once the final equipment configuration is selected, the verification of the electrical system capacity relative to the specific models chosen can occur during the engineering design process.

<u>Ductless split heat pump systems</u>

There are a few areas of the building in which ductless split heat pump systems could be installed to supplement the existing system. However, ductless split systems are not recommended as a building wide solution for several reasons explained below.

A network of efficient, wall mounted ductless split heating and air conditioning blower units could be connected to outside heat pump condensing units. This system heats and cools the building without the inherent penalty of moving a large volume of hot moist air though a duct system for which there would need to be a sizable distribution fan to overcome duct friction loss. In fact, ductless split blower motors typically only use 50 to 60 watts or less of power making them many times more cost effective in distributing the cooling than a central ducted system using a larger motor.

The typical ductless split wall or console mounted units are **not designed for conditioning ventilation air which is necessary throughout this building.** Therefore, a separate air handler or a replacement RTU system would still be required. A second issue is the expected shorter effective lifespan of those units as compared to other options. Down the road, there is the potential for incompatibility of replacement inside units with older outside condensing units. For example, if one was to install a system wherein four (4) inside units were connected to one (1) outside condensing unit, the failure of one (1) of the five (5) components may require the replacement of entire five-piece system. That is, in part, because the ductless split inside units are powered and controlled with the outside units in a proprietary manner. Therefore, ductless split systems were eliminated from consideration for this application.

Completely eliminating any hydronic distribution units would not be feasible in this building without running additional ductwork on all levels. Such a system would be energy inefficient and space consuming duct chases would have to be built and architecturally enclosed.

HVAC System Options

A. Replacement of the existing standard efficiency oil-fired boiler in the Process Building with one (1) or two (2) high-efficiency condensing propane-fired boilers.

While the combustion efficiency of the existing boiler is likely to be around 80%, the seasonal efficiency is estimated to be approximately 75%. The other draw back of the boiler is that it not configured to extract the latent heat of combustion.

There is space to run a new sealed combustion intake and exhaust to connect to new energy efficient boiler system. Modern, stainless steel, condensing boilers would normally be installed and controlled to only have water flow through the boiler when it is operating. Such 94% to 98% efficient boilers would typically be sealed combustion units having a direct combustion air duct to the boiler. Condensing boilers have modulating burners to provide the right amount of heat to serve the building's load given the weather conditions. Condensing boilers have been available in the United States market for forty years.

The stainless steel heat exchangers are designed to extract the latent heat from combustion when the return water temperature is at 130°F or less. The new installation would also allow for the decoupling of the boiler(s) from the existing distribution system through primary-secondary piping and pumping.

The cost savings comes from a lower priced fuel and higher efficiency. Additional annual heat exchanger cleaning savings would also accrue over time.

ECM #1 Details:
Estimated cost: $180,000 (To be fine-tuned after design engineering assessment of the loads.)
Estimated incentive: Not available
Estimated annual savings: $4,140 at current rates
Simple Payback with incentive: 43 (Years)

Assumptions:
#2 Fuel Oil rate: $2.63/Gallon
Propane rate: $1.28/Gallon (Based upon most recent cost of propane at the Athol Police Station.)
Estimated oil usage (gallons) for existing boiler during the entire heating season: 4,000
Estimated gallons of high efficiency propane: 4,984

B. If desired, replacement of the existing RTU with a new RTU utilizing an air-to-air heat pump could be considered. Adding ERV functions into the new equipment would complete the package. This could be done separately or integrated into the RTU. Heat pump RTUs have been available for decades in the domestic market and are the least expensive way to potentially reduce the carbon footprint of this particular building. The electrification system would not be complete without a solar PV system mounted on the roof along with battery storage.

To provide the most impact, a unit that can operated down to zero degrees F should be considered. For example, Daikin offers heat pump RTUs with IEER values of up to 20.6 and in the range of 3 to 28 tons of cooling capacity. The use of variable speed fans within the new variable speed heat pump RTU should be combined with the replacement and/or repair of the existing zone dampers for the building. The use of an economizer during the mild weather and an ERV to precondition the outside air are each important features suggested to be incorporated. The ERV system savings assume that the adjusted base usage case is higher than the existing consumption given the current lack of apparent effective ventilation.

An Illustration of a Daikin heat pump RTU system incorporating an ERV wheel.

ECM #2 Details:
Estimated cost: $110,000 (To be fine-tuned after design engineering. This estimated cost does not include the ECM #1 boiler scope of work.)
Estimated incentive: TBD
Estimated annual savings: $1,830
Simple Payback without incentive: 60 (Years)
When the RTU is determined to be ready for replacement, the incremental cost of the replacement with a like RTU versus the heat pump RTU could be reviewed.

Assumptions:
Electric rate: $0.16/kWh
#2 Fuel Oil rate: $2.63/gallon
Estimated gallons of #2 Oil energy reduction: 2,400
Estimated net kWh energy reduction: (17,134)

C. Air-to-water heat pumps (AWHP) can provide the most comprehensive solution to allow for increased energy efficiency. Whereas the previous two (2) options each only address part of the HVAC system, this option upgrades the entire system. The AWHP system would be comprised of a "heat pump chiller" placed either on the roof (after a structural review) or on a new ground mounted pad. That unit, along with a new RTU air handler with hydronic heating/cooling coils and ERVs, would replace the functions of the existing RTU and boiler. Once the new system is calibrated for the proper amount of ventilation air and ERV(s) are installed, the AWHP would provide either heated or chilled water.

There are certain AWHP models that may not operate at outside air temperatures less than 15°F and/or produce a maximum of 122°F supply water temperatures. If such a unit was selected, the existing or new boiler could operate during the limited number of hours when such conditions occurred unless the perimeter heating system was upgraded in size. Alternatively, the selection of a higher temperature model would need to be weighed against its comparative efficiency. The AWHP system could also provide heated water to the updated perimeter distribution system.

Such an electrification system would not be complete without a solar PV system mounted on the roof along with either battery storage or thermal storage off the AWHP. Given the current status of the limits and expense of battery storage raw materials, AWHPs do have an advantage over other types of heat pumps system. Given AWHPs are a water/fluid based system, the use a **Thermal Energy Storage (TES)** system worth considering. The well insulated tanks could be placed outside, basement or buried in the ground. Several vertical cylinder-shaped tanks could be designed to store the tempered fluid to allow the system to "coast" during periods of high electric demand. This could benefit the Town since the building is charged for kW demand in the electricity bill. Using water to create a "battery effect" may result in lower environmental impacts and a longer lasting method than using electric batteries. Properly controlled, it could also allow the AWHP system to continue to operate longer during a colder weather period instead of turning on the backup boiler.

Picture 14: A Trane TES insulated outside tank system for a larger facility.

ECM #3 Details:
Estimated cost: $340,000 for AWHP, HVAC distribution changes.
(To be fine-tuned after design engineering. The estimated cost does not include TES tank option.)
Estimated incentive: $120,000
Estimated annual savings: $5,339
Simple Payback after incentive: 42 (Years)

Assumptions:
Electric rate: $0.16/kWh
@2 Fuel Oil rate: $2.63/Gallon
Estimated gallons of oil energy reduction: 4,000
Estimated net kWh energy reduction: (31,628)

Heat pump RTUs, ductless split heat pump units and other options will not provide enough electricity and fuel oil savings to pay back within their average lifespan for this application at this time. Solar PV and battery storage would be an additional cost. See the Appendix for information on Aermec and LG AWHP units.

RTUs and air-to-air ducted heat pump systems each have a 20 year estimated life, while ductless split and VRF units are estimated to have a 15 year life span. Generally, AWHPs, ERVs and air handlers may have up to 25 year estimated life expectancies.

Here are some additional factors to consider:

1. The long range plans for the building and available funds to invest in this building.
2. The degree of redundancy required for the HVAC systems.
3. The degree to which the existing equipment is ready for replacement.
4. Maintenance varies between each system. Most systems require regular air filter changes or minimally cleaning of the outside air filter screen.
5. The economizer cycle is required by the building code to be utilized in conditions during the spring and fall when the building does not need heating or mechanical cooling. It is unknown if the existing system is controlled to automatically bring in fresh air and exhaust stale air to cool the building during those conditions. This could be accomplished by installing an ERV system with a by-pass control option as integral to new heat pump RTUs.

Recommendations

HVAC System Recommendations

If the goal is building electrification, it is recommended that the customer consider implementing an AWHP system as described in ECM#3, depending on the ample availability of funds, space and capability to include a solar PV and battery system. **Clearly, the long energy savings payback period for any option results in an extended investment term. For this building, the investment in a new system should be viewed as a capital improvement, betterment of human comfort, a potential for a reduced carbon footprint and improved indoor air quality rather than a source of energy savings resulting in a quick monetary return on investment.**

Domestic Hot Water System Recommendations

While considering the HVAC electrification measures, the installation of a high efficiency, air-to-water domestic hot water heat pump could be considered. Using an oil-fired boiler with only one stage of capacity with no ability to modulate firing rates for domestic hot water heating is not efficient. This configuration combined with a lack of sealed combustion construction results in the boiler inadvertently acting like a cooling tower to the outside. While the combustion efficiency of the boiler is likely to be around 80%, the seasonal efficiency is estimated to be approximately 70% for the generation of domestic hot water during the summer months.

The current boiler is not configured to extract the latent heat of combustion. Oil-fired cast iron boilers are intrinsically not designed for condensing given the potential for corrosion or cracking of the heat exchanger. Therefore, the overall seasonal and combustion efficiencies is limited.

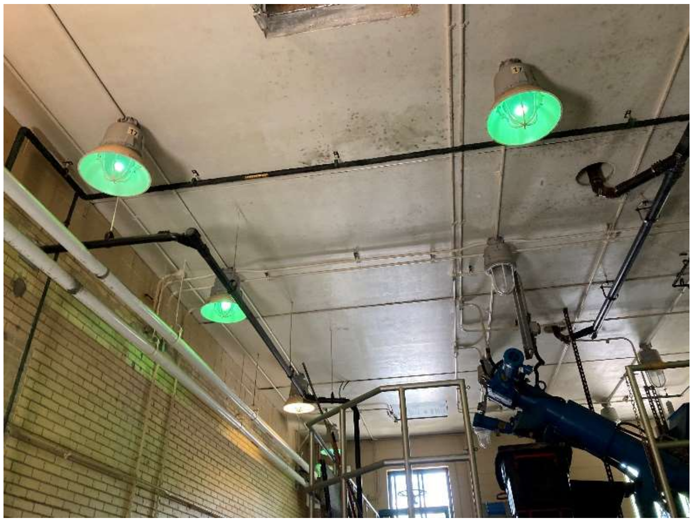
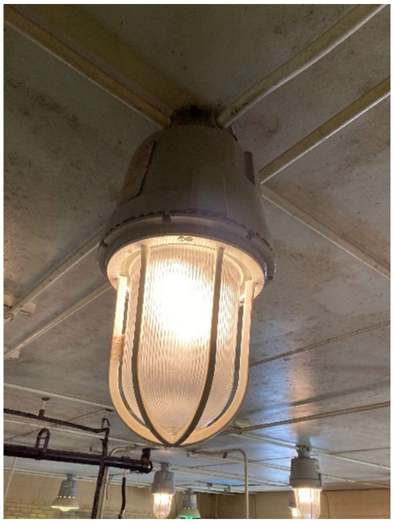
The level of heat within the basement from the boiler would benefit the operation of a heat pump water heater (HPWH). The HPWH would absorb that heat to produce hot water more efficiently through the heat pump refrigeration cycle. Some condensate and basement dehumidification would be by-products of its operation.

Consideration of the use of a multi-stage commercially sized heat pump water heater utilizing stainless steel storage tank(s) has a long payback period at the current rate of energy. While the use of a stainless steel tank should improve upon the measure lifespan, the payback period is longer than the estimated equipment life.

Lighting Systems

The Headworks Grit Removal Room has Appleton Code-Master Emergency Fluorescent fixtures. The lighting consists of a mix of fluorescent tubes, metal halide and LEDs. To the extent that more LED fixtures are installed, the cooling load of the building would slightly decrease. This should be considered in the sizing of new HVAC systems.

Athol Waste Water Treatment Plant Existing Lighting				
Ref.#/Building Location	**Mount**	**Qty**	**Type**	**Run Hours**
1.Headworks Original building	vaportight	6	2L T8	10min/week
2.Headworks Original building	industrial	2	2L T8	10min/week
3.Headworks Original building	exp_jj	6	100W MH	10min/week
4.Headworks Original building	industrial	8	2L T8	1 min/day
5.Headworks Original building	ext wallpack	2	100W MH	exterior
6.Headworks Original building	exp_jj	19	100W MH	5 min/day
7.Process Building- sludge	exp_jj	11	100 MH	2 hrs/day
8.Process Building - office/lab	sm 2x4	2	3L T8	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
9.Process Building - office/lab	sm 2x4	7	2L T8 LED	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
10.Process Building - office/lab	sm 2x4	1	2L T12	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
11.Process Building - office/lab	sm 2x4	18	2L T8	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
12.Process Bldg. - Garage Bay	industrial	3	8' LED	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
13.Process Building - Stairs	industrial	1	8' LED	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
14.Process Building	basket troffer	2	2L T8 LED	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
15. Process Building	basket troffer	2	2L T8	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
16. Process Building	vaportight	5	2L T8	**8hrs/day M-F, 2hours SAT, 2 hours SUN.
17.Process Building- basement	vaportight	2	2L T8 LED	5 min/day
18.Process Building- basement	vaportight	2	2L T8	5 min/day
19.Process Building- basement	vaportight	8	2L T12	5 min/day
20. Pump Gallery	ext wallpack	1	100W MH	exterior
21.Pump Gallery	industrial	18	2L T12	5 min/day

Pictures 15 and 16: Headworks Addition Grid Removal Room Lighting

Line Item # from above chart	Existing Fixture Type Wattage	Pre-Watt age	Prop. Fixture Type/ Watts	Post-Watts	Pre-QTY	Post-QTY	Location Description	Yearly Hours of Operation	Est. Installed Cost	Potential Available Incentive per line item	Annual Savings	Pay Back Period with Incent.
5	70W MH	95	20LED	25	2	2	Headworks	4380	$611	$0.00	$98	6
7	100W MH	128	50LED	50	11	11	Process - sludge	728	$3,718	$0.00	$100	37
8	3L T8	83	3T8LED	37.5	2	2	Process - office/lab	2288	$286	$30.00	$33	8
10	2L T12	72	2T8LED	25	1	1	Process - office/lab	2288	$130	$10.00	$17	7
11	2L T8	60	2T8LED	25	18	18	Process - office/lab	2288	$2,340	$180.00	$231	9
15	2L T8	60	2T8LED	25	2	2	Process	2288	$260	$20.00	$26	9
16	2L T8	60	2T8LED	25	5	5	Process	2288	$650	$50.00	$64	9
20	70W MH	95	20LED	20	1	1	Pump Galley	4380	$306	$0.00	$53	6
								Total Est. Cost	$8,301	**Total Saved:**	$621	

ECM #4 Details:

Estimated cost: $8,301

Estimated incentive: $290

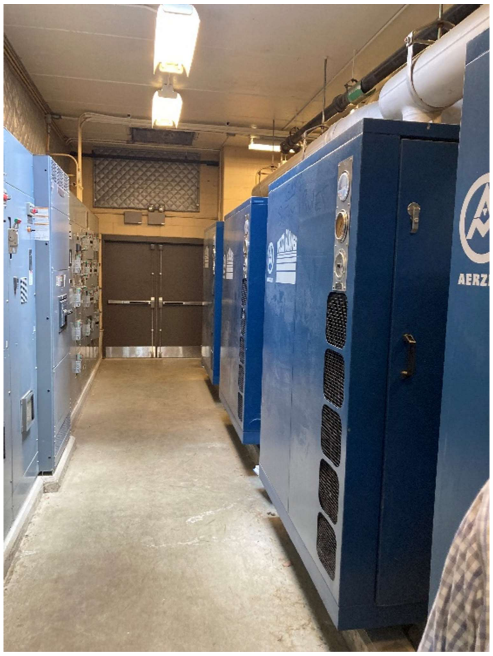
Estimated annual savings: $621

Simple Payback after incentive: 13 Years

Assumptions:
Electric rate: $0.16/kWh
Estimated net kWh energy reduction: 3,881

Other systems

The Process Building has three waste activated variable speed sludge pumps. #2 was found to be operating at about 15 Hertz at the time of the site visit.
The Headworks Building has four (4) large tank aeration AerzAM Delta Blower blowers. Each positive displacement blower has a 125 horsepower motor and a VFD. Each is controlled by an Allen-Bradley PanelView Plus 1000 with a touch screen. At the time of the site visit blower #1 was in manual "Hand" operation with a 5% speed setpoint. The VFD control was reading 24 Hertz.



Picture 17: Aeration Blower machines.

Picture 18: Roof air inlet shutter for Blower Room.

The Headworks Building has an electrical transformer in the boiler room which dates back to the time of the renovation. The Square D Watchdog catalog number EE30T3HB has a 30 kVA capacity and transfers 480 voltage to 208 volts with a 97.5 percent efficiency at 35% of load. The DOE 2016 federally mandated standards for 30 kVA three phase transformer requires a 98.23% efficiency.

A transformer is a crucial component to a mission critical facility like the Athol WWTP. More efficient transformer models save energy by requiring less operating power to provide filtering, conversion, and processing of power to the system, especially when equipment being served power by the transformer units operate continuously.

Picture 19: Transformer in the boiler room of the Headworks Building.

Summary of Findings

Measure Description	Annual Energy and Cost Savings				Payback Period		
	Peak Demand Savings (kW)	Electricity Savings (kWh)	Fuel Oil Savings (Gal.)	Total Cost Savings	Gross Measure Cost	Measure Life (years)	Simple Payback (yr)
ECM#1 – High Efficiency Condensing Propane-fired boilers	-	-	4,000	$4,391	$180,000	25	43
ECM#2 – High Efficiency Heat Pump RTU with ERV		(17,134)	2,400	$1,860	$110,000	20	60
ECM#3 – AWHP System		(31,628)	4,000	$5,339	$340,000	20-25	42
ECM#4 – Lighting Improvements		3,881		$621	$ 8,301	15	13
TOTALS (Recommended Measure)	-	(27,747)	4,000**	$5,960 **	$348,301**	20	58

**The savings and measure costs are not additive since only one ECM is recommended and since there is an overlap between ECMs.

Given the network of complex HVAC systems involved, recommendations for one portion of the system may interact with other portions of the system if all defects are not addressed concurrently.

RISE stands ready and able oversee the necessary changes and to revisit the site after improvements have been made to conduct some additional functional tests as separate phase two of this project to ensure the issues have been adequately addressed.

RISE

Founded in 1977, RISE is nationally recognized for their innovative delivery of conservation services over the past 45 years and have arranged the installation for over $1.4 billion in energy improvements. The RISE Group is a 100% employee-owned multi-disciplinary engineering and technical services firm. They offer professional process, electrical, HVAC, and metallurgical engineering services, as well as comprehensive environmental, microbiological, and non-destructive laboratory testing services. RISE became a part of the organization in 1995, after having operated for eighteen (18) years as an independent, non-profit energy services firm. The RISE project team is also complemented by the resources of Creative Environment. This full-service MEP/FP design firm offers important design support when plans and specifications may be required to complete projects.

RISE staff work directly with energy end-users in all building sectors on behalf of utilities, government agencies, and other program sponsors to deliver efficiency services for their customers in a professional, responsive, and cost-effective manner. They offer energy users comprehensive efficiency services that reduce their environmental footprint and operating expenses.

Disclaimer

Recommendations made in this report are based on engineering estimates and an on-site review of HVAC equipment. It is recommended that you contact the engineer who prepared your report to answer any of your questions.

This report and analysis are based upon cursory observations of the visible and apparent conditions and is not intended to serve as a comprehensive evaluation of all aspects of the distribution system and equipment. Although care has been taken in the performance of these observations, RISE (and/or its representatives) make no representations regarding latent, unobserved, or concealed defects which may exist and no warranty or guarantee is expressed or implied. This report is made only in the best exercise of our ability and judgment.

RISE assumes no responsibility for the safety of the facilities' mechanical or electrical distribution systems and equipment and their compliance with all applicable federal, state and local requirements and shall not be liable under any legal or equitable theory for any claims for direct, indirect, consequential or other damages of any nature, including, but not limited to damages for personal injury, property damage, or lost profits connected with the performance of these services.

Conclusions within this report are based on estimates of the age and normal working life of various items of equipment. Predictions of life expectancy and the balance of life remaining are necessarily based on opinion. It is essential to understand that actual conditions can alter the remaining life of any item. The previous use/misuse, irregularity of servicing, faulty manufacture, unfavorable conditions, acts of God, and unforeseen circumstances make it impossible to state precisely when each item would require replacement. The client herein should be aware that certain components may function consistent with their purpose at the time of our observations, but due to their nature are subject to deterioration without notice.

Estimates of Construction Costs, if any, prepared by the Engineer represent the Engineer's best judgment as a design professional familiar with the construction industry. However, it is recognized that neither the Engineer nor the Owner has control over the cost of labor, materials or equipment; over the Contractor's methods of determining bid prices; or over competitive bidding, market or negotiating conditions. Accordingly, the Engineer cannot and does not warrant or represent that bids or negotiated prices will not vary from the estimate.

Appendix

Why RenewAire?

The Static-Plate Core is the Key!

Since the early 1980's, RenewAire has pioneered the use of the patented Lossnay* exchange core throughout the Americas. Listed below are some of the many reasons why this technology has become the ERV system preferred by leading HVAC professionals around the world.

Positive Airsteam Separation

In the RenewAire core, fresh air never comes in contact with exhaust air passages. Hydroscopic resin plates separate the two airsteams so effectively that ARI certifies zero exhaust air transfer at normal, balanced operating conditions. As a result, RenewAire is perfect for controlled exhaust applications such as toilet areas, as well as for food service and health care occupancies.

No Condensate or Active Defrost

Direct water vapor transfer, driven by vapor pressure, eliminates condensation - and frosting - in virtually all applications and climate zones. No condensation allows for closer plate spacing, resulting in higher efficiencies and easier installations. It also means no need for the dampers or electrical defrost elements that reduce ventilation and rob energy efficiency in competing technologies.

Maintenance - Nothing Could Be Easier

The scheduled maintenance for RenewAire is so simple, it can be performed by any janitorial staff. No expensive service contracts are necessary because there is no wheel disassembly and washing, no seal or belt adjustments and no complex controls to calibrate. The result is the lowest maintenance cost of any ERV.

The Unbeatable RenewAire Warranty

An investment in RenewAire is protected by a 10-year core warranty (2 years on balance of the unit). This commitment - twice as long as coverage on the best wheel products – speaks volumes about RenewAire's reliability, durability and consistent high performance.

Award-Winning Service and Support

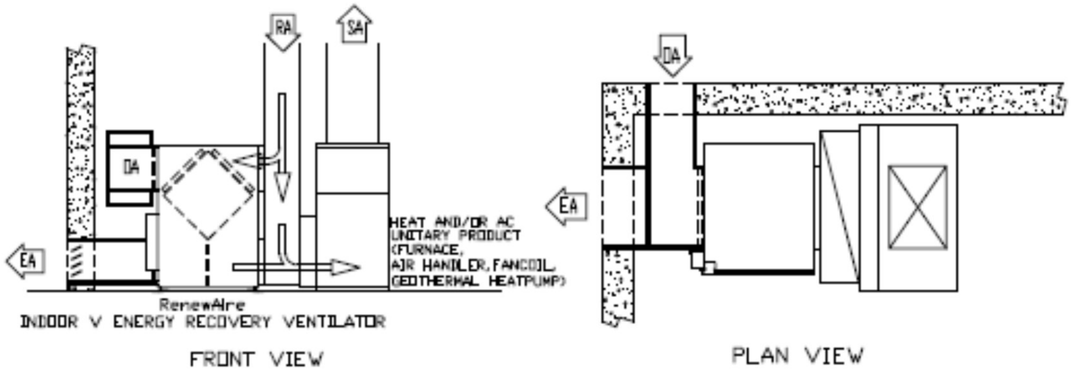
RenewAire's team of professionals knows ERV. And our nationwide network of Sales Reps and quality Distributors are ready to serve you locally. When you call our support number, you'll talk to a knowledgeable factory expert - someone who knows not only our product line, but the best ways to integrate RenewAire with your preferred lines of heating and air conditioning equipment.

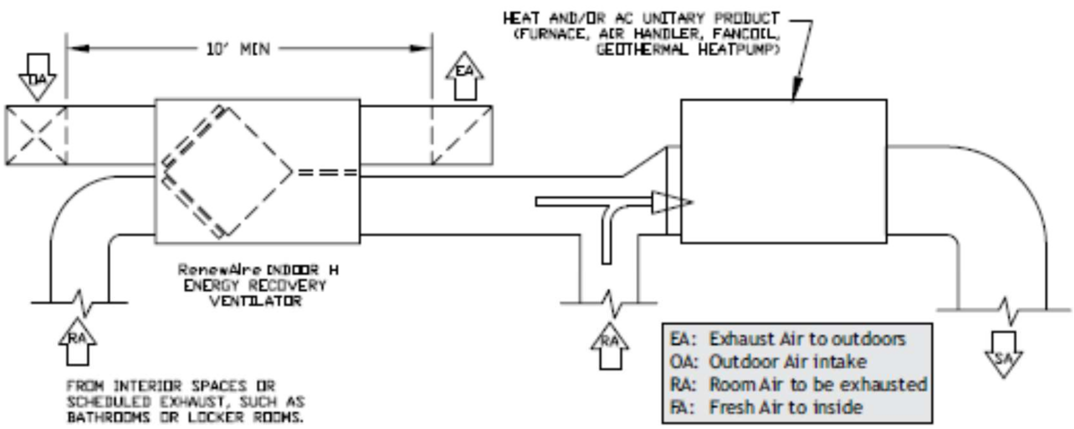
RenewAire VENTILATION
Think Greener. Breathe Better.

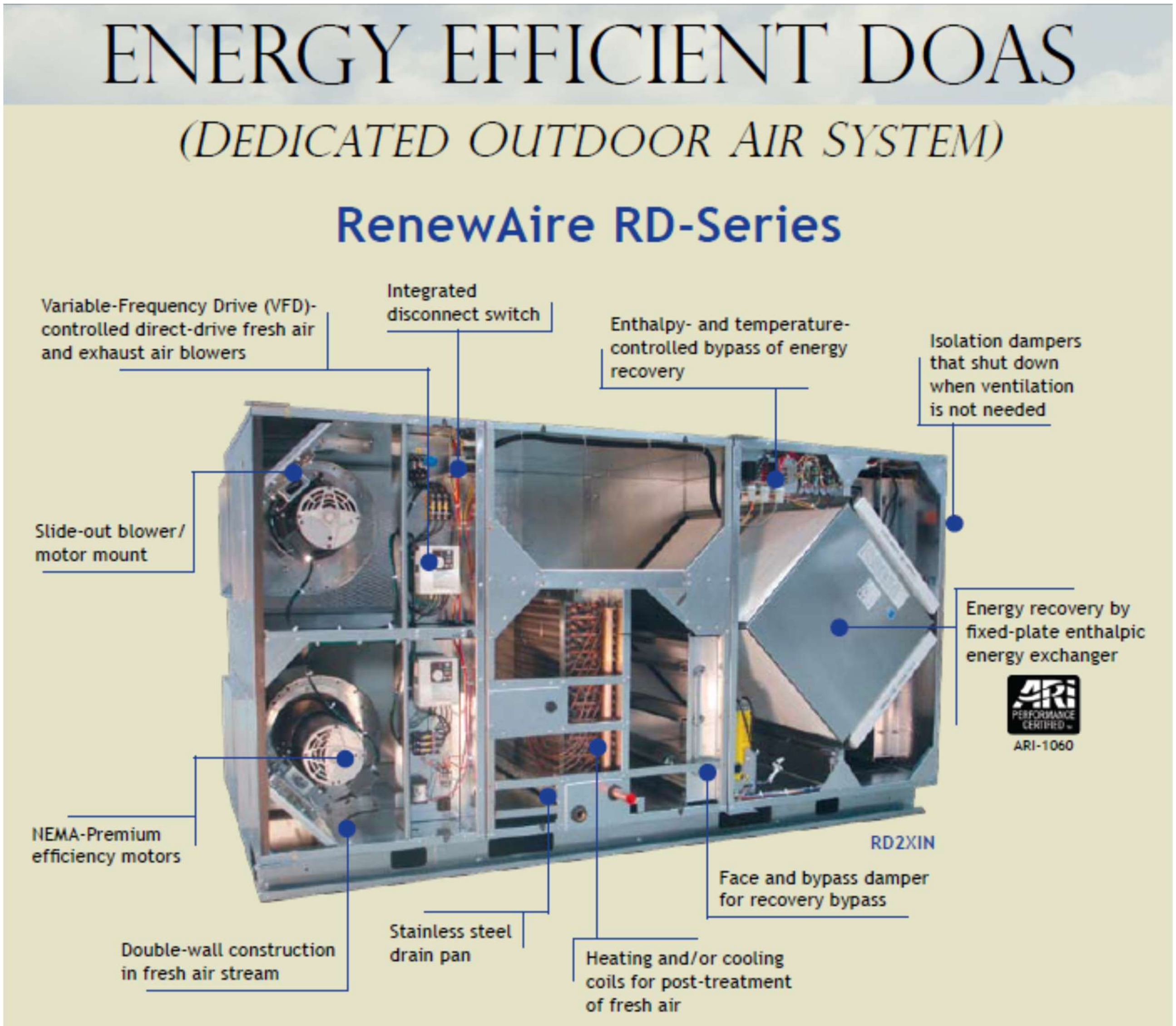
COMMERCIAL INDOOR PRODUCTS

- Horizontal and vertical configuration.
- Wide range of airflow and static capacities.
- ARI certified performance data for efficiency and cross leakage.
- UL tested flammability and smoke generation that meets NFPA 90A and 90B test standards for commercial applications.
- Easy installation and service.
- Ten year core warranty.

RenewAire means *Trouble-Free* ERV.






ENERGY EFFICIENT DOAS
(DEDICATED OUTDOOR AIR SYSTEM)
RenewAire RD-Series
Variable-Frequency Drive (VFD)-controlled direct-drive fresh air and exhaust air blowers
Integrated disconnect switch
Enthalpy- and temperature-controlled bypass of energy recovery
Isolation dampers that shut down when ventilation is not needed
Slide-out blower/ motor mount
Energy recovery by fixed-plate enthalpic energy exchanger
ARI PERFORMANCE CERTIFIED
ARI-1060
NEMA-Premium efficiency motors
RD2XIN
Face and bypass damper for recovery bypass
Double-wall construction in fresh air stream
Stainless steel drain pan
Heating and/or cooling coils for post-treatment of fresh air

ECM Fan Technology

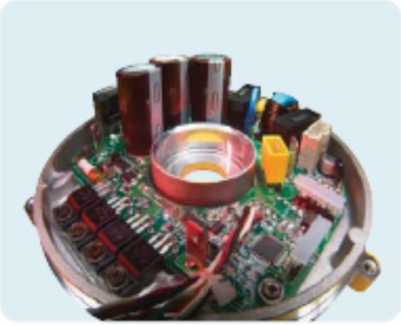
Airtherm introduces a new level of energy efficiency to our Unitaire fan coil units.

Go Green

Already the industry leader in energy efficient fan coil products, Airtherm has taken a leap forward with new ***energy saving*** motor technology that can offer our customers the highest level of energy efficiency which may also qualify for LEED points and utility rebates. In addition to the energy saving benefits, this technology offers building owners ultra quiet operation, enhanced system control and retrofit capabilities with existing Airtherm fan coil installations.

Upgrade and Save

Electronically Commutated Motors (ECM) are highly efficient at full and part load with efficiencies up to 85% compared to 40% with traditionally 3-speed PSC motors. Fan coils are often overlooked by energy conservation professionals because of their fractional horsepower and low power consumption, however Airtherm's solution will allow cost effective energy savings which will satisfy green building initiatives.



Retrofit and Save

Airtherm has engineered their ECM offering so that it is backward compatible with their Unitaire products installed over the years. Simply replacing the existing fan deck with a new ECM fan deck in the existing piped cabinet is easy and quick.

Airtherm Unitaire fan coils can enjoy the energy savings without re-piping or replacing whole units. This allows them to reap the benefits of improved energy efficiency without the mess of remodeling an entire building.

Benefits of Airtherm Fan Coil Units

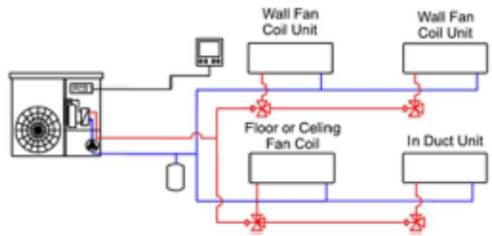
- A special bonding process provides the sturdy cabinets with an attractive powder coat finish.
- Our exclusive Condensate Removal System (CRS) eliminates standing water, improving IAQ by reducing odors and decreasing humidity.
- Two 9" deep end pockets and removable panels provide easy access, saving time and money during installation and maintenance.
- Resilient motor mounts and insulated discharge panels dampen air sounds for quiet operation.
- Reversible coils give added flexibility when piping and installing units.

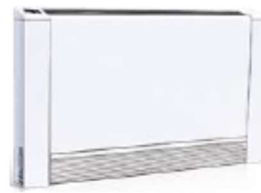
Chiltrix

High Efficiency Chiller Fan Coil Units

CXI DC Inverter Fan Coil Units

3,379 BTU to 11,877 BTU Cooling
3,347 BTU to 9,727 BTU Heating
High Efficiency DC-Inverter Motors





DC-Inverter

The Chiltrix CXI-series FCUs (Fan Coil Units) are available in four different sizes from .28 ton to 1 ton. These DC-Inverter fan motor FCUs are the most efficient fan coils available on the market, using far less energy at any given speed than a standard fan coil unit. The ability to adjust the speed of the motor without compromising efficiency is a crucial additional benefit. Designed for the Chiltrix CX-series chillers of ultra-efficient chillers, these fan coils are also compatible with all chiller systems.

Super-Slim & Universal Mounting

The Chiltrix CXI DC-Inverter FCUs are an incredible 5.1" thin. These universal mount fan coil units can attach flat against the ceiling, stand on the floor, or mount flat on a wall. These units are the thinnest fan coils available yet produce more BTU/CFM per watt of power than any standard fan coil unit.

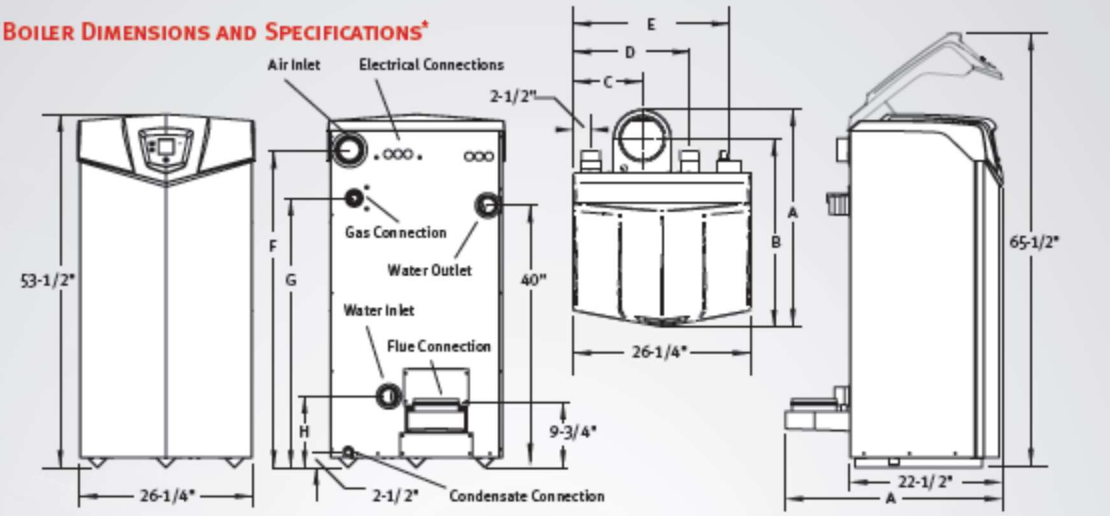
Quiet & Long Lasting

DC-Inverter fan motors last longer and produce far lower sound levels than a standard fan motor with sound levels as low as 24dB. The Chiltrix fan motors are hermetically sealed brushless DC motors that use permanent rare-earth magnets. The DC motors are essentially vibration-free and avoid the "hum" of conventional motors. Get more BTU/CFM per decibel than from any available unit. Standing next to the unit you cannot hear the motor operating, even on high speed.

Chiltrix Model	Cooling BTU*	Heating BTU*	Water GPM	Pressure Drop PSI	Air CFM Volume	Noise dB High	Noise dB Low	Power Watts	Power Supply	Net Dimensions Inches
CXI120	11,877	9,727	2.4	4.05	340	39	28	22	115v 60Hz	51.2W x 5.1D x 25.8H
CXI85	8,498	8,079	1.8	3.98	270	37	28	21	115v 60Hz	43.3W x 5.1D x 25.8H
CXI65	6,451	5,666	1.6	1.89	188	32	27	18	115v 60Hz	35.4W x 5.1D x 25.8H
CXI34	3,379	3,347	1.2	1.57	94	30	24	14	115v 60Hz	27.6W x5.1D x 25.8H
HW72	7,200	7,200	1.9	3.62	512	46	35	40	220 50/60Hz	31W x 9D x 11H

*Maximum values. See capacity test data and sizing guide for varying conditions at www.chiltrix.com/documents/CXI-capacity-test.pdf
Note* Above Heights are without the foot kit. With feet, height is 29 3/8"

FTXL Boiler Dimensions and Specifications*



FTXL Boiler — AHRI Certified — Dimensions and Specifications

Model Number	Input Min MBH	Input Max MBH	Thermal Efficiency	Gross Output MBH	NET AHRI Rating MBH	Turn down	Flow (GPM) Min	Flow (GPM) Max	HEX Water Volume	A	B	C	D	E	F	G	H	Water Conn.	Vent Size	Air Intake	Gas Conn.	Shipping Wt. (lbs.)
FTX400(N,L)	40.0	399.9	98.0%	392	341	10:1	10	105	13	30-1/2"	27-1/2"	10-1/4"	17"	23-1/4"	46-1/4"	39-1/2"	10-3/4"	2"	4"	4"	1"	435
FTX500(N,L)	50.0	500.0	97.7%	488	425	10:1	15	105	12	30-1/2"	27-1/2"	10-1/4"	17"	23-1/4"	46-1/4"	39-1/2"	10-3/4"	2"	4"	4"	1"	468
FTX600(N,L)	85.0	600.0	97.5%	585	509	7:1	15	105	12	30-1/2"	27-1/2"	10-1/4"	17"	23-1/4"	46-1/4"	39-1/2"	10-3/4"	2"	4"	4"	1"	478
FTX725(N,L)	103.5	725.0	97.2%	706	613	7:1	20	150	17	33"	28-1/2"	10-1/2"	17-1/2"	23-1/2"	48-1/2"	41-1/4"	11"	2-1/2"	6"	4"	1"	518
FTX850(N,L)	121.5	850.0	97.0%	825	717	7:1	25	150	16	33"	28-1/2"	10-1/2"	17-1/2"	23-1/2"	48-1/2"	41-1/4"	11"	2-1/2"	6"	4"	1"	535

*Information subject to change without notice Dimensions are in inches. Select "N" or "L" for Natural or LP gas. *The Net AHRI Water Ratings shown are based on a piping and pickup allowancof 1.15. *Lochinvar should be consulted before selecting a boiler for installations having unusual piping and pickup requirements, such as intermittent system operation, extensive piping systems, etc. *The ratings have been determined under the provisions governing forced draft burners.

Smart System Features

- **Smart System Digital Operating Control**
  Multi-Color Graphic LCD Display w/Navigation Dial
- **Loch-N-Link® USB Thumb Drive Port for Easy Programming**
- **Cascading Sequencer with Built-in Redundancy**
  Selectable Cascade Type:
  Lead Lag/Efficiency Optimization
  Multiple Size Boilers
  Front-End Loading
- **3 Reset Temperatures Inputs w/Independent Outdoor Reset Curves for Each**
  Outdoor Sensor
- **Four-Pump Control**
  System Pump with Parameter for Continuous Operation
  Boiler Pump with Variable-Speed Control
  Domestic Hot Water Boiler Pump
  Domestic Hot Water Recirculation Pump Control with Sensor
- **Building Management System Integration**
  0-10VDC Input to Control Modulation or Setpoint
  0-10VDC Input from Variable-Speed System Pump
  0-10VDC Modulation Rate Output Signal
  0-10VDC Enable/Disable Signal
- **Programmable System Efficiency Optimizers**
  Space Heating Night Setback
  DHW Night Setback
  Anti-Cycling
  Ramp Delay
  Boost Time and Temperature
- **High-Voltage Terminal Strip**
  120 VAC/60 Hertz/1 Phase
  Pump Contacts for 3 Pumps
- **Low-Voltage Terminal Strip**
  Building Recirculation Pump Start/Stop
  Proving Switch Contacts
  Flow Switch Contacts
  Alarm Contacts
  Runtime Contacts
  3 Space Heat Thermostat Contacts
  Tank Thermostat Contacts
  System Sensor Contacts
  Tank Sensor Contacts
  Cascade Contacts
  0-10 VDC BMS Contacts
  0-10 VDC Boiler Rate Output Contacts
  0-10 VDC Boiler Pump Speed Contacts
  0-10 VDC System Pump Speed Contacts
  ModBus Contacts
- **Time Clock**
- **Data Logging**
  Ignition Attempts
  Last 10 Lockouts
  Space Heat Run Hours
  Domestic Hot Water Run Hours

Standard Features

- **97%-98% Thermal Efficiency**
- **Modulating Burner with up to 10:1 Turndown**
  Direct Spark Ignition
  Low NOx Operation
  Sealed Combustion
  Low Gas Pressure Operation
- **Stainless Steel Fire-Tube Heat Exchanger**
  ASME-Certified, "H" Stamped
  160 psi Working Pressure
  50 psi Relief Valve
  Combustion Analyzer Test Port
  Fully Welded Design
- **Vertical and Horizontal Direct Vent**
  Direct Vent up to 100 feet
  PVC, CPVC, Polypropylene or AL29-4C
  Factory Supplied Sidewall Vent Termination
- **Smart System Control**
- **Other Features**
  On/Off Switch
  Adjustable High Limit with Manual Reset
  Automatic Reset High Limit
  Manual Reset Low Water Cutoff
  Flue Temperature Sensor
  Low Air Pressure Switch
  Temperature and Pressure Gauge
  Condensate Trap
  Zero Service Clearances
  10-Year Limited Warranty (See Warranty)
  Custom Maintenance Reminder with Contact Info
  Password Security
  Customizable Freeze Protection Parameters

Optional Equipment

CON-X-US® Remote Connectivity
Motorized Isolation Valve
Wireless Outdoor Temperature Sensor
Multi-Temperature Loop Control
Variable-Speed Boiler Circulator
Constant-Speed Boiler Circulator
ModBus Communication
Alarm Bell
Condensate Neutralization Kit
Concentric Vent Kit (FTX400-FTX600)
BMS Gateway to BACnet or LonWorks
High and Low Gas Pressure Switches w/Manual Reset (FTX500-FTX850)

- **Firing Controls**
  M9-Standard Construction
  M13-CSD-1/FM/GE Gap (FTX500-FTX850)

Rebel™ Packaged Singlezone Heating and Cooling Units—Features and Options

1 Variable speed Daikin inverter compressor
- Modulating capacity allows for optimum comfort control
- Best part-load efficiency in the industry
- Dependable and quiet operation
- Superior discharge air temperature control

2 Variable speed Daikin heat pump
- More economic than gas heat during winter
- Hybrid backup heat options for extreme cold weather and defrost operation
- Modulating capacity delivers the industry's best heat pump control

3 Electronic expansion valves
- Optimum control of superheat
- Protects compressor from liquid refrigerant
- Increases efficiency by safely lowering head pressure

4 MicroTech® III unit controller
- Open Choices™ feature provides interoperability with BACnet®, Daikin D3 and LonWorks® communication options for easy integration with building automation systems
- Unit diagnostics for easy serviceability
- Outdoor air and humidity control logic maintains minimum fresh air intake and optimum humidity levels
- Optionally add the SiteLine™ Building Controls solution, which provides real-time data streams for benchmarking performance, monitoring system operations and implementing remote diagnostics and control

5 Hinged access doors
- ¼–turn latch door provide easy access to system components for maintenance and service

6 Ultra-quiet Daikin condenser fans
- UV and corrosion resistant
- Variable speed ECM motors provide tremendous energy savings at lower ambient

7 Variable speed ECM motors or VFDs on all fans
- Greatly increases system reliability and efficiency eliminates belts and bearing setscrews
- Saves energy at light load
- Built-in inverter eliminates control panel heat

8 Hybrid backup heat options
- Gas furnace with turndowns as high as 12:1
- Electric heat option with SCR for precise temperature control
- Hot water heat

9 Refrigeration only controller
- Allows for the use of a third-party RTU controller to run the Rebel's functions while Daikin optimizes and protects the refrigeration system

Rebel™ Packaged Singlezone Heating and Cooling Units—Features and Options

10 Double-wall foam cabinet

- No exposed insulation to the air stream
- Better thermal seal than fiberglass

11 Dehumidification Control

- Hot gas used for "free" reheat
- Tight humidity control without over cooling the space
- Modulating hot gas reheat coil
- Independent reheat and cooling control

12 Stainless steel, double sloped drain pan

- Prevents corrosion
- Avoids standing water for high IAQ

13 100% outdoor air option

- Low-leak dampers
- Double-wall blades, edge and jam seals
- Modulating 100° temperature rise furnace
- Modulating compressor
- Modulating hot gas reheat

14 Durable construction

- Foam-injected panels with an R-value of 7 (3–15) or 13 (16–28)
- Increased insulation value for increased system efficiency
- Double-wall construction for increased indoor air quality

15 Low radiated noise

- Enclosed compressor
- Quiet outdoor fan
- Exellent acoustics at lower speeds

16 Economizer

- Provides free-cooling when outdoor conditions are suitable
- Provides fresh air to meet local requirements
- Integrated economizer operating with mechanical cooling
- Optional demand control ventilation for increased system efficiency

17 2" and 4" slide-out filter racks

- Easy filter changeouts for quick serviceability
- 2" MERV 8 filters are provided

18 Optional energy wheel

- Meets ASHRAE 90.1 2016 effectiveness requirements
- Factory installed and tested
- Single-point power and controls

19 Optional energy CORE®

- Meets ASHRAE 90.1 2016 effectiveness requirement
- Less than 0.5% EATR
- No moving parts
- Factory installed and tested
- Single-point power and control

AHRI 340/360 Certified

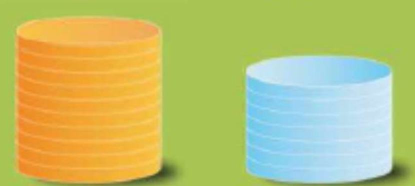
Rebel capacity and efficiency is independently certified by rigorous annual witness testing.

ANK reversible heat PUMP all the heat you want, with extremely high efficiency levels

Aermec
adheres to the EUROVENT Certification Programme: LCP/A/P/R
The products concerned appear in the EUROVENT web site www.eurovent-certification.com

- optimized for heat pump operation
- production of hot water up to 140°F
- production of hot water with outdoor temperatures between -4°F and 107.6°F
- reduces heating costs by up to 30% compared with the best conventional systems (condensing boilers)
- can be combined with all terminals (radiant panels, fancoils and radiators) and is able to produce domestic hot water.
- reduced weight and dimensions, thanks to the use of R410A refrigerant
- offers greater temperature and acoustic comfort
- high efficiency compressors
- also available with circulation pump only, or with storage tank and circulation pump

-30%
ANNUAL ELECTRICITY SAVINGS COMPARED WITH THE BEST CONDENSING BOILERS



-30%
REDUCTION IN EMISSIONS OF CO_2, THE CARBON DIOXIDE RESPONSIBLE FOR THE GREENHOUSE EFFECT

ANK is subjected to the strict energy efficiency tests needed in order to obtain NF certification on the French market, and EHPA on the German, Austrian and Swiss markets.

The Power of MORE

LG Inverter Scroll Heat Pump Chiller

The Power of MORE

MORE efficiency

MORE reliability

MORE redundancy

MORE comfort and control

MORE choices for modular flexibility

Inverter Scroll Heat Pump Chiller

Features and Benefits:

- Condenser Coil Coating Rated at 10,000 HRS[1]
- Variable Speed Condenser Fan Motors
- Variable Speed Compressors
- Cooling Operation from 5 °F to 125 °F
- Heating Operating from -22 °F to 95 °F
- Cooling Water Side Delta from 4 °F to 20 °F
- Heating Water Side Delta from 4 °F to 20 °F
- Cooling LWT from 14 °F to 68 °F
- Heating LWT from 86 °F to 131 °F
- 65 SCCR Standard on 460V-3PH[2]
- 56 SCCR Standard on 208-230V-3PH[2]
- Rated Sound Pressure at 30' is 51-60 db(A)[3]
- 100% Heating Capacity down to 32 °F
- 120F LWT at 17 °F – 80% of Full Capacity

1. Tested per ASTM B-117 2. Approved per CSA (C-US/162279) 3. Tested per ANSI/AHRI Standard 370-2015

www.lghvac.com

LG Air Conditioning Technologies

Inverter Scroll Heat Pump Chiller

Single Frame
ACHH017*BAB
ACHH020*BAB

Double Frame
ACHH033*BAB
ACHH040*BAB

Triple Frame
ACHH050*BAB
ACHH060*BAB

		ACHH***VBAB 208-230V/60Hz/3PH						ACHH***HBAB 460V/60Hz/3PH					
Model Number		017	020	033	040	050	060	017	020	033	040	050	060
Cooling Capacity[1]	(TR)	16.12	18.48	32.42	36.96	48.62	55.45	16.21	18.48	33.42	36.96	48.62	55.45
Power Input[1]	(kW)	18.10	21.50	36.19	43.00	54.29	64.50	18.10	21.52	36.19	43.04	54.29	64.56
EER[1]	(Btu/kW)	10.75	10.32	10.75	10.32	10.75	10.32	10.75	10.30	10.75	10.30	10.75	10.30
IPLV[1]	(EER)	19.46	19.46	19.46	19.46	19.46	19.46	19.46	19.46	19.46	19.46	19.46	19.46
Energy Efficiency	(kW/TR)	0.617	0.617	0.617	0.617	0.617	0.617	0.617	0.617	0.617	0.617	0.617	0.617
Heating Capacity 47°F /105°F LWT	(MBH)	204.7	238.8	409.4	477.6	614.1	716.4	204.7	238.8	409.4	477.6	614.1	716.4
COP 47°F /105°F LWT[2]	(W/W)	3.65	3.59	3.65	3.59	3.65	3.59	3.65	3.59	3.65	3.59	3.65	3.59
Heating Capacity 17°F /105°F LWT	(MBH)	163.8	203.0	327.6	406.0	491.4	609.0	163.8	203.0	327.6	406.0	491.4	609.0
COP 17°F /105°F LWT[2]	(W/W)	2.22	2.16	2.22	2.16	2.22	2.16	2.22	2.16	2.22	2.16	2.22	2.16
Heating Capacity 47°F /120°F LWT	(MBH)	204.7	238.8	409.4	477.6	614.1	716.4	204.7	308.8	409.4	617.6	614.1	716.4
COP 47°F /120°F LWT[2]	(W/W)	3.15	3.10	3.15	3.10	3.15	3.10	3.15	3.10	3.65	3.10	3.65	3.10
Heating Capacity 17°F /120°F LWT	(MBH)	153.5	191.1	307.0	382.2	460.5	573.3	153.5	191.1	307.0	382.2	460.5	573.3
COP 17°F /120°F LWT[2]	(W/W)	2.01	1.96	2.01	1.96	2.01	1.96	2.01	1.96	2.01	1.96	2.01	1.96
Sound Pressure Cooling at 30 feet[3]	db(A)	51	51	54	54	56	56	51	51	54	54	56	56
Sound Pressure Heating at 30 feet[3]	db(A)	55	55	58	58	60	60	55	55	58	58	60	60
Frames		Single	Single	Double	Double	Triple	Triple	Single	Single	Double	Double	Triple	Triple

1. Certified to AHRI 550/590 2. Full Load Heating Performance Tested to AHRI Standard 550/590 3. Tested per ANSI/AHRI Standard 370-2015