Consulting Engineering Services, Inc.

HVAC Replacement Study Report

Colchester Town Hall

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INTRODUCTION AND EXECUTIVE SUMMARY

The Colchester Town Hall is an existing building in the Town of Simsbury, CT. The total gross floor area of the structure of is approximately 33,100 square feet. The structure largely consists of office spaces, meeting rooms, and an unfinished attic space. The building was constructed in 1988.

A study was conducted to evaluate the existing HVAC systems serving the building and to provide replacement options. All spaces are currently heated, tempered, ventilated or air conditioned by a combination of inline and rooftop exhaust fans, inline supply fans, water source heat pump units, air source heat pump rooftop units, and electric unit heaters.

Four HVAC upgrade options were identified as part of the study. These options include a direct 1 for 1 replacement of all heat pumps, a new water source heat pump system with dedicated outdoor air units, a geothermal heat pump system with dedicated outdoor air units, and an air cooled VRF system with dedicated outdoor air units as the potential system types.

EXISTING HVAC SYSTEMS

FIRST FLOOR, SECOND FLOOR AND ATTIC AREAS:

The occupied areas in the building (offices, corridors, small conference rooms, lobbies, etc.) are heated and cooled by water source heat pump units. The units are installed above the ceiling, between joists or in soffit spaces. Supply air is fully ducted and return air is obtained from the ceiling plenum. The heat pumps exchange heat with the building's condenser water loop. The majority of the heat pumps are original to the building

The third floor attics space consists of a large unfinished area with provisions for a future office buildout. The area is heated and partially cooled by a single water source heat pump unit. Per the original design drawings, the heat pump was intended for heating use only. An inline exhaust fan and outdoor air damper temper the space in cooling season.

Restroom and general exhaust is provided by two inline exhaust fans in the attic space, with makeup air transferred from adjoining spaces.

Service personnel on site reported that poor outdoor air damper operation has caused the attic space to experience below freezing temperatures in the past, resulting a sprinkler failure and flooding

Occupants and service personnel on site reported complaints and unit failures in areas served by the water source heat pumps:

- Past and current hot and cold complaints in various areas of the building.
- Unit failures due to clogged heat exchangers. This is likely associated with inadequate water treatment, and the omission of strainers and control valves at the unit's condenser water piping connections. The units are constantly subjected to the flow. The coaxial heat exchangers in the units are among the smallest passageways in the water loop and serve as the collection point for any particulate not filtered out elsewhere.
- Heat pump evaporator coil freezing due to dirty filters, leading to condensate pan overflow and leakage. This is likely associated with poor unit filter access, due to units being installed between floor joists.
- Heat pump evaporator coil freezing due to low refrigerant charge, leading to condensate pan overflow and leakage. This failure in particular will become harder to address in the future; as the units contain R-22, a refrigerant that is no longer produced and can only be obtained from a recycled or recovered source.

All water source heat pump units should be considered past their useful life and due for replacement.

All exhaust fans and ductwork are original to the building and near their expected useful life.

FIRST FLOOR LARGE MEETING ROOMS:

The three large first floor meeting rooms (Rooms 104-106) are heated, cooled, and ventilated by three Trane air source heat pump rooftop units. One unit serves each room. Supply air is fully ducted and return air is obtained from the ceiling plenum.

A permanent means of access to the low roof where the rooftop units are located is not present. The units are currently accessed by a ladder from grade, or by exiting the building through one of the second floor operable windows.

The RTUs are original to the building and past their expected useful life.

The associated ductwork is original to the building and near its expected useful life.

MECHANICAL, ELECTRICAL, AND STORAGE ROOMS

Various mechanical, electrical, and storage rooms in the building are indirectly conditioned by transfer air, or heated by electric unit heaters. Multiple inline and roof mounted exhaust fans serve these spaces, with makeup air transferred from adjoining spaces or return air plenums.

The exhaust fans, associated ductwork, and electric unit heaters, are original to the building and near their expected useful life.

BUILDING VENTILATION SYSTEMS

Outdoor air is provided to the building by an inline supply fan located in the attic space. The fan's supply ductwork connects to a central duct riser, and discharges unconditioned air into the ceiling plenums of the first and second floors.

The current outdoor air delivery method is no longer considered good engineering practice:

- This method assumes the plenum mixes evenly and does not regulate the amount outdoor air provided to individual spaces or heat pumps. Therefore, spaces farther from the discharge point may not receive adequate outdoor air.
- Unconditioned air discharged into the plenum in cooling season could create humidity related issues, such as comfort complaints near the point of discharge, excess dampness, mold, or excess condensation on metal objects in the plenum.
- Unheated air discharged into the plenum in heating season could create cold air related issues, such as comfort complaints near the point of discharge or pipe freezing in the plenum.
- The water source heat pump units serving most of the building are not designed for high levels of moisture removal and are best suited for applications with low amounts of outdoor air, or tempered outdoor air delivered by a dedicated outdoor air unit or energy recovery ventilator.

The supply fans and associated ductwork are original to the building and near their expected useful life.

WATER SOURCE HEAT PUMP CONDENER WATER LOOP

All water source heat pump units in the building exchange heat with a condenser water loop routed through the building. The loop is designed to contain a 40% ethylene glycol solution.

Condenser water loop flow is motivated by two 2 hp inline pumps in a lead/standby configuration.

Heat is added to the loop by a 300 MBH cast iron, oil fired boiler located in the boiler room. The boiler is currently supplied with heating oil from oil by an underground tank. The tank is expected to be replaced shortly with an above ground tank.

Heat is rejected from the loop by a 60 ton closed cell cooling tower. The tower is located in the parking lot and consists of a cooling coil, domestic water spray bar, and water pan with heater.

The heat pump loop, as well as the rest of the building, are controlled by a Honeywell building automation installed within the last few years, with a recently installed Tridium Niagra supervisory controller.

Water source heat pumps loops have potential to provide energy savings by allowing for energy recovery during simultaneous heating and cooling, and evaporative cooling at the cooling tower. These savings outweigh there inherent compressor penalty during heating season:

- Heat Recovery (Simultaneous Heating and Cooling)
    - During heating season and shoulder months, some interior units will remain in cooling mode, rejecting heat to the loop.
    - Exterior units in heating mode will recover the heat transferred into the loop by the interior units, reducing boiler usage.
    - During certain periods of the year, heat recovery can approach a balance point, allowing the boiler and cooling tower to be shut off, producing significant energy savings.
- Evaporative Cooling
    - Water source heat pump systems provided with closed circuit cooling towers provide additional energy savings through evaporative cooling.
    - A portion of the heat rejected from the loop is absorbed through the evaporation of the water spray on the tower coils. This saves energy through reduction heat transfer surface area, tower size, tower fan energy, and loop pump energy.
- Compressor Penalty
    - One disadvantage of a water source heat pump system is a compressor penalty in heating season.
    - In heating mode, heat is transferred into the loop by the boiler. Each heat pump's compressor operates to exchange that heat into the air stream.
    - Operating a compressor to transfer heat is less efficient (more energy intensive) than a more direct means of heat transfer, such as a hot water coil in an air handler. However, if properly applied and operated, the energy savings obtained through energy recovery often outweighs the added cost from this compressor usage.

- Modern heat pump system utilize waterside economizers to reduce compressor usage, by bypassing the loop water into a coil in the air stream, directly heating or cooling the air.

Multiple design and maintenance issues were found on inspection of the system.

- Maintenance staff noted that both loop pumps are required to operate, instead of one, to address space comfort complaints. This could be caused by fouling of heat transfer surfaces, causing additional flow to be required, or by inadequate pump sizing.

- The water source heat pump loop was provided with a chemical pot feeder, however a means of continuous chemical water treatment is not present. Lack of regular chemical treatment can lead to system corrosion and fouling.

- A means of glycol fill was also not present, despite the system utilizing 40% ethylene glycol solution as a basis of design. Lack of a glycol fill station can lead to the system refiling with domestic water as maintenance is performed or leaks are encounter, diluting the glycol solution over time and thereby removing all freeze protection.

- The cooling tower has severe rust damage and leakage. It could not be determined if the closed water loop coil is still intake. Multiple past repair attempts are visible and the unit is beyond repair.

The water loop piping is original to the building, and within 6 years of its expected useful life. However, the condition of the piping is unknown, and may be poor due to inadequate water treatment.

The boiler is original to the building and at the end of its expected useful life.

The fuel oil tank is original to the building and past its expected useful life. A replacement tank will be installed in the future.

The pumps are original to the building and past their expected useful life.

The water tower is severely deteriorated. Immediate replacement is recommended.

The building automation system was replaced within the last few years and has 10-15 years of expected useful life.

HVAC OPTION 1 – 1 FOR 1 REPLACEMENT

SCOPE OF WORK

- Remove all water source heat pumps and associated control devices in their entirety.
- Remove the existing water source heat pump condenser loop air separator, pot feeder, pumps, closed cell tower and associated control devices in their entirety.
- Provide new medium efficiency water source heat pumps to replace all removed units. All new heat pumps shall include control valve, automatic balancing valves, and y-strainers. Provide ductwork transitions as required. Waterfurnace Versatec 500 series, Bosch/Florida Heat Pump LM Series, or equal.
- Provide a new 60 ton counterflow closed cell tower with variable speed fans to replace the removed closed cell tower. Baltimore Air Coil VF1 series or equal.
- Provide a new combination air/dirt separator to replace the removed air separator. Spirotherm Spirovent or equal.
- Provide a new side stream bag filter to replace the removed pot feeder. Wessels BF series or equal.
- Provide a new glycol makeup unit to maintain fluid concentration. Armstrong Autofill series or equal.
- Provide 2 new variable speed inline pumps to replace the removed pumps. Armstrong 4380 series or equal.
- All existing boilers, water source condenser loop piping, air source heat pump rooftop units, ductwork, diffusers, registers, grilles, supply fans, exhaust fans, and electric heaters shall remain.

PROS

- Replaces all major water source heat pump equipment, except for the boiler.
- Re-usage of existing ductwork and piping minimizes disruption, reduces cost, and maintains all current ceiling heights.
- Lowest cost option.

CONS

- All existing piping will remain. The condition of the piping is unknown.
- Failure of the boiler or tower will affect the entire building.
- All existing HVAC items to remain are at the end of or past their expected useful life.
- Outdoor air will continue to be introduced into the ceiling plenums. While acceptable, this is no longer considered good engineering design practice.

OPINION OF PROBABLE CONSTRUCTION COST

- $461,000

HVAC OPTION 2 – WATER SOURCE HEAT PUMP SYSTEM

SCOPE OF WORK

- Remove all existing HVAC equipment and associated control devices in their entirety.
- Remove and reinstall all ceilings in their entirety.
- Provide new high efficiency water source heat pumps with variable speed compressors, waterside economizers, and associated ductwork to serve all spaces, except for the meeting rooms. Waterfurnace Versatec 700 series or equal.
- Provide three new high efficiency water source heat pumps packaged rooftop units with energy recovery and associated ductwork to serve all spaces. The new units shall be installed in the same location as the removed units, with curb adapters.
- Provide a new condenser water piping loop and associated pumps and accessories to serve all heat pumps.
- Provide two new 285 MBH condensing natural gas fired boilers to transfer heat into the water source heat pump condenser loop. Lochinvar Knight or equal.
- Provide two new 50 ton adiabatic coolers with variable speed fans to reject heat. Baltimore Air Coil Trillium Series or equal.
- Provide new electric unit heaters and baseboard heaters in spaces requiring additional heat or not served by a heat pump.
- Provide one new water source heat pump dedicated outdoor air unit with energy recovery wheel and associated supply and exhaust ductwork. The unit shall be located on the low roof, and ducted into the building to serve all floors. New ductwork will be routed through the building to provide air directly to each space or heat pump unit.

PROS

- Provides a complete, new system with a 20+ year expected useful life.
- Provides additional energy savings over the existing water source heat pump system.
- Provides partial boiler and cooling tower redundancy.
- Provides lower water consumption, water spray drift, fouling, corrosion, and maintenance requirements than a closed circuit cooling tower.
- Outdoor air will be provided directly to each space or to each unit.

CONS

- Work will affect all spaces and require most ceilings to be removed and reinstalled, or replaced.
- Some existing ceiling heights may need to be lowered.

OPINION OF PROBABLE CONSTRUCTION COST

- $1,796,000

HVAC OPTION 3 – GROUND SOURCE HEAT PUMP SYSTEM

- Remove all existing HVAC equipment and associated control devices in their entirety.
- Remove and reinstall all ceilings in their entirety.
- Provide new high efficiency ground source heat pumps with variable speed compressors, waterside economizers and associated ductwork to serve all spaces, except for the large meeting rooms. Waterfurnace Versatec 700 series or equal.
- Provide three new high efficiency ground source heat pumps packaged rooftop units with energy recovery and associated ductwork to serve all spaces. The new units shall be installed in the same location as the removed units, with curb adapters.
- Provide a new ground source condenser water piping loop and associated pumps and accessories to serve all heat pumps.
- Provide a new ground source heat exchanger below the parking lot, consisting of 38 bores at 500' deep.
- Provide new electric unit heaters and baseboard heaters in spaces requiring additional heat or not served by a heat pump.
- Provide one new ground source heat pump dedicated outdoor air unit with energy recovery wheel and associated supply and exhaust ductwork. The unit shall be located on the low roof, and ducted into the building to serve all floors. New ductwork will be routed through the building to provide air directly to each space or heat pump unit.

PROS

- Provides a complete, new system with a 20+ year expected useful life. The well field will have a 50+ year expect useful life.
- Most energy efficient option.
- Zero domestic water consumption for HVAC purposes.
- Cooling tower spray system maintenance will no longer be required.
- Zero fossil fuels will be consumed on site for HVAC purposes.
- Outdoor air will be provided directly to each space or to each unit.

CONS

- Work will affect all spaces and require most ceilings to be removed and reinstalled, or replaced.
- A portion of the parking lot will need to be removed and replaced to accommodate the well field.
- Some existing ceiling heights may need to be lowered.
- Highest cost option.

OPINION OF PROBABLE CONSTRUCTION COST

- $2,344,000

HVAC OPTION 4 – VRF SYSTEM

- Remove all existing HVAC equipment and associated control devices in their entirety.
- Remove and reinstall all ceilings in their entirety.
- Provide new VRF ceiling cassette units to serve all spaces, except for the large meeting rooms. Mitsubishi PLFY series or equal.
- Provide three air source heat pumps packaged rooftop units with energy recovery and associated ductwork to serve all spaces. The new units shall be installed in the same location as the removed units, with curb adapters. Trane Horizon or equal.
- Provide three new 15 ton VRF air source heat pump condensing units with heat recovery to serve the new VRF ceiling cassettes. The new condensing units will be located on the existing low roof with new equipment rails. Mitsubishi Y-Series or equal.
- Provide new electric unit heaters and baseboard heaters in spaces requiring additional heat or not served by a heat pump.
- Provide one new air source heat pump dedicated outdoor air unit with energy recovery wheel and associated supply and exhaust ductwork. The unit shall be located on the low roof, and ducted into the building to serve all floors. New ductwork will be routed through the building to provide air directly to each space or heat pump unit. Trane Horizon or equal.

PROS

- Provides complete, new system with a 20+ year expected useful life.
- Zero domestic water consumption for HVAC purposes.
- Cooling tower spray system maintenance will no longer be required.
- Zero fossil fuels will be consumed on site for HVAC purposes.
- Outdoor air will be provided directly to each space or to each unit.
- Good compromise between energy efficiency and upfront cost.

CONS

- Work will affect all spaces and require most ceilings to be removed and reinstalled, or replaced.
- Some existing ceiling heights may need to be lowered to accommodate outdoor air ductwork.

OPINION OF PROBABLE CONSTRUCTION COST

- $1,874,000