BUILDING MECHANICAL SYSTEMS EVALUATION

BYRAM TOWNSHIP MUNICIPAL BUILDING
10 MANSFIELD DRIVE, BYRAM TOWNSHIP, NJ

October 10, 2014

Strunk-Albert Engineering
EXECUTIVE SUMMARY

The Byram Township facility at 10 Mansfield Drive, Byram Township, NJ has been experiencing ongoing issues with the current mechanical HVAC systems; both from a maintenance perspective, as well as a temperature control and/or indoor air quality perspectives.

Strunk-Albert Engineering was contracted to perform a building mechanical evaluation to assess the current state of those systems. Upon visiting the site, meeting with building staff and maintenance personnel, and performing a visual inspection of the various systems present, SAE has developed this report which aims to achieve the following three (3) objectives: define the mechanical systems currently in place; outline various problems and/or deficiencies existing in each of the systems; and, outline potential options that may be taken to replace/upgrade those systems affected. Preliminary cost estimates are provided for each option in a effort to provide the Township with a measure for gauging the feasibility of any future work at the existing building.
INTRODUCTION

Strunk-Albert Engineering (SAE) was contracted by Byram Township to perform an evaluation of the existing mechanical systems in operation at their municipal building located at 10 Mansfield Drive, Byram Township, New Jersey. This facility is used by the Byram Township Finance and Tax Departments, Parks and Recreation Department, Construction Administration Department, as well as the Byram Township Police Department.

This facility is served by two (2) separate mechanical systems which have become increasingly problematic from a maintenance and/or operational perspective which ultimately leads to periods of compromised occupant comfort. The system in operation within Building No.1, as defined in the following section, has become particularly troublesome.

Strunk-Albert Engineering (SAE) visited the site on Monday, September 22, 2014, and had the opportunity to meet and tour the facility with Joe Sabatini and Don Boroughs.

The primary goals of this evaluation are to review existing system conditions, establish deficiencies present in those current systems and provide feasible options for improvement and/or replacement of systems to allow the Township to properly operate the building’s mechanical systems and maintain an acceptable level of occupant comfort.

Please note that SAE’s evaluation is based upon visual inspections and discussion with Byram Township staff and building occupants only. Functional testing of individual systems to confirm their operability was not completed. Original building construction drawings were not available for review.

DESCRIPTION OF EXISTING BUILDING

The building consists of two (2) primary areas: the Finance/Tax/Council Chambers Building and the Police/Parks/Construction Admin Building. For the purposes of this report, these buildings will be referred to as Building No.1 and Building No.2, respectively.

Building No.1 is a single-story wood-framed structure with an approximate floor area of 5,300 square feet. It consists of a large courtroom, as well as a few departmental offices and toilet rooms. Original windows installed in the building were a fixed-type, however, most of these windows have been replaced with double-hung operable windows.

Building No.2 is a single-story structure which is comprised of approximately 12 modular trailer units that have been grouped together to form a single building structure. An exterior T1-11 façade and wood trussed roof have been added to enclose these trailer units. Building No.2 is approximately 6,800 square feet. Most windows existing in the building are a double-hung, operable type. There is an accessible crawl space (with concrete floor) and there is an accessible attic space which is accessed via a 20-ft extension ladder.
Building No.1 Existing Mechanical Systems

1. Central Hot Water Boiler: Heat for Building No.1 is generated via a single oil-fired cast-iron boiler located in a small mechanical room. The Boiler draws oil from the single underground oil storage tank which serves both buildings.
   a. Make/Model: Utica Boilers; Model SFH5200W; Qty=1
   b. Age: 27 years +/- (Built 1987)
   c. Output Capacity: ~231,000 Btu/hr
   d. Burner: Beckett
   e. Draft: Natural
   f. Combustion Air: Small 8”x3” duct stubbed into mechanical room.
   g. Pump: Taco 007-F5; Qty=1.
   h. Fluid: 100% Water (No Glycol)
2. Blower Coil Units: Heating and cooling for the majority of Building No.1 is distributed to the various spaces via one (1) of two (2) horizontal blower coil units which are located in the ceiling space above a mechanical room and men/women toilet rooms. Accessibility to both units is notably limited. Information below is for each of the blower coil units.

   a. Make: Westinghouse
   b. Age: Original to Building
   c. Supply Air: 3,000 CFM (estimate). Supply ductwork located in ceiling space to various ceiling-mounted supply air diffusers.
   d. Return Air: Return air ductwork exists mainly with the floor structure with various floor-mounted return air grilles present. Return air ducts rise up from the floor into the ceiling space within the small mechanical closet.
   e. Cooling Method: Split DX refrigeration via outdoor Condensing Unit
   f. Cooling Capacity: 7.5-tons (90,000 Btu/hr)
   g. Heating Method: Hot water coil installed in supply air duct.
   h. Heating Capacity: *undetermined* (see discussion below)
   i. Ventilation Air: Ducted outdoor connection w/ damper allows for mechanical introduction of ventilation air into the HVAC system. Ventilation air intake volumes are undetermined.

3. Outdoor Condensing Units: Outdoor condensing units are coupled to indoor blower coil units as noted above. Information below is for each condensing unit.

   a. Make/Model: York; Model H4CE090A25C.
b. Age: 14 years +/- (Serial number nomenclature indicates 2000 manufacture date)

c. Capacity: 7.5 Tons

4. Miscellaneous Systems:
   a. Several offices exist adjacent to the courtroom which are heated via electric resistance baseboard heaters and cooled via residential-style window air conditioning units. Mechanical ventilation is not present.
   b. Toilet rooms are exhausted via ducted systems. The functionality of these systems were not verified; however, the indoor air quality was perceived by SAE as being compromised which would indicate a non-operating and/or ineffective exhaust system.

Building No.2 Existing Mechanical Systems

1. Central Hot Water Boilers: Heat for Building No.2 is generated via two (2) oil-fired cast-iron boilers located in a small mechanical room. Boilers draw oil from the single underground oil storage tank which serves both buildings.
   a. Boiler No.1 (LEFT)
      i. Make/Model: Slant-Fin; Model TR-50P
      ii. Age: 4 years +/- (2010)
      iii. Output Capacity: ~ 230,000 Btu/hr
      iv. Burner: Beckett
      v. Draft: Natural
      vi. Combustion Air: Louver over exterior door (Non-mechanical)
   b. Boiler No.2 (RIGHT)
      i. Make/Model: Slant-Fin; Model LD-50P
      ii. Age: 10 years +/- (2004)
      iii. Output Capacity: ~ 230,000 Btu/hr
      iv. Burner: Beckett
      v. Draft: Natural
      vi. Combustion Air: Louver over exterior door (Non-mechanical)
   c. Pumps: Three (3); each control via space thermostats.
   d. Fluid: 100% Water (No Glycol)

2. Hot Water Baseboard: Heat for the building is distributed to individual occupied spaces via hot water baseboard. Control for baseboard is attempted via inaccessible thermostatic control valves which are largely ineffective. A master thermostat for each zone pump calls for the pump to energize.
Deteriorating hot water baseboard equipment (pictured left), existing boiler plant (pictured top right), and existing three (3) hot water zone circulators (pictured bottom right)

3. Air Conditioning: Air conditioning to Building No.2 is accomplished via two (2) methods; blower coils installed within the attic coupled to outdoor condensing units, and residential-style window air conditioning units (installed within exterior wall system).

   a. Blower Coil No.1 (Police)
      i. Make: Goodman
      ii. Age: 7 years +/- (2007)
      iii. Supply Air: 800 CFM Supply Air (estimate). Supply ductwork located in attic space to various ceiling-mounted supply air diffusers.
      iv. Cooling Method: Split DX refrigeration via outdoor Condensing Unit
      v. Cooling Capacity: 2.0-tons (24,000 Btu/hr)
      vi. Heating Method: None.
      vii. Ventilation Air: None.

   b. Blower Coil No.2 (Parks & Construction Admin)
      i. Make: York
ii. Age: 4 years +/- (2010)  
iii. Supply Air: 800 CFM Supply Air (estimate). Supply ductwork located in attic space to various ceiling-mounted supply air diffusers.  
iv. Cooling Method: Split DX refrigeration via outdoor Condensing Unit  
v. Cooling Capacity: 2.0-tons (24,000 Btu/hr)  
vi. Heating Method: None.  
vii. Ventilation Air: None.  

c. Condensing Unit No.1 (Police): Outdoor condensing unit is coupled to indoor Blower Coil unit as noted above.  
i. Make/Model: Goodman; Model GSC130241AE.  
ii. Age: 7 years +/- (2007)  
iii. Capacity: 2.0 Tons  
d. Condensing Unit No.2 (Parks & Construction Admin): Outdoor condensing unit is coupled to indoor Blower Coil unit as noted above.  
i. Make/Model: York; Model YCJF24S41S1A.  
ii. Age: 4 years +/- (2010)  
iii. Capacity: 2.0 Tons  
e. Window Air Conditioning Units: Various capacities.

Deterioration of hot water piping systems within Building No.2 (pictured left) and portions of attic where blown-in insulation systems are no longer present (pictured right)
4. Miscellaneous Equipment

a. Toilet rooms are exhausted via ceiling-mounted exhaust fans interlocked with space light switch. Ductwork was not visible within the attic due to blown insulation but it is assumed that these fans discharge into the attic space.

b. There is a small blower coil unit installed within the attic which acts as exhaust for a room in the Police area. This exhaust is dumped into the attic space and relieved from the building via soffit and ridge vents.

c. There are several hot water unit heaters installed within the vented crawlspace to maintain the space above freezing.

*Bull-nose duct fitting installed directly at the discharge of a blower coil unit installed within the attic of Building No.2 (pictured left). Access to that attic space requires climbing a step ladder (pictured right)*
SYSTEM DEFICIENCIES

Upon review of the buildings’ mechanical systems, we have noted the following system deficiencies within the building.

Building No.1 Deficiencies

1. Blower Coil Units:
   a. Both units are beyond their anticipated life expectancy and replacement is recommended before a total equipment failure occurs.
   b. Unit serving the courtroom generates excessive fan noise most likely due to deterioration of internal equipment components.
   c. Servicability of the units is significantly limited because their installation within the ceiling space. Even after removing ceiling tiles and accessing the units via a step ladder, access is limited due to pipings and electrical conduit systems. Limited access may correlate to problems with routine filter changes. Routine filter changes are especially important with in-floor return air system configurations.
   d. The interior of the unit could not be readily accessed to visually inspect so the state of the DX and HW coils could not be verified. It is likely that the upstream DX coil has accumulated dust/debris if filter maintenance has not be routinely performed.
   e. Hot water heating coil may lack sufficient flow due to hot water pump sizing (see further discussions below). Coils are provided with an electronic control valve; however, manual or automatic balancing valves are not provided as a means for ensuring proper flow to each coil. All of these deficiencies can lead to a failure to maintain space temperature setpoint at design conditions.
   f. A secondary drain pan with automatic overflow switch is not provided. It was noted that no signs of leakage was visible during SAE’s survey.
   g. Refrigerant pipe systems were noted as not being properly insulated with continuous vapor barrier. This degrades system efficiency and can lead to unwanted condensation forming on the pipe walls.
   h. Interiors of supply and return ductwork systems were not visually expected; however, there is a potential that the interiors are dirty and cleaning of these systems should be considered if ductwork systems are reused.

2. Outdoor Condensing Units:
   a. Both units have approximately 5 years of anticipated service life remaining.
   b. Refrigerant pipe systems were noted as having compromised insulation systems. This degrades system efficiency and can lead to unwanted condensation forming on the pipe walls.
   c. Efficiency: 9.5 EER. Minimum efficiencies required for new equipment installations is 11.0 EER. Existing equipment would be considered inefficient by current standards.

3. Boiler:
   a. At 27-years old, the boiler is nearing the end of its anticipated service life (approximately 30 years)
   b. Many of the piping systems, valves and components show significant signs of rusting and deterioration.

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c. Hot water piping systems are not properly insulated. This degrades system efficiency.

d. Non-mechanical combustion air introduction into the space is not Code-compliant. The International Fuel Gas Code v.2009, requires one permanent opening at 1 square inch per 3,000 Btu/hr. With the boiler operating at approximately 285,000 Btuh/hr (input), a permanent opening of 95 square inches is required. Currently a 3"x8" duct (24 square inches) is provided.

e. The pump in place is a Taco 007-F5 circulator. The flow performance for this circulator seems to be inadequate for the connected system. The potential exists that inadequate pressure is generated from this circulator which would limit flow reaching the hot water coils located within the supply ductwork of the boiler coil units. Inadequate flow would cause the first coil in the system to have more heating capabilities than the second coil because greater pressure is required to reach this second coil. Ultimately heating capacity of both blower coil units would be compromised.

f. Efficiency: This 27-year old cast-iron section boiler is estimated to be operating at 78%-80% efficiency.

4. Toilet Room Exhaust:

   a. Toilet room exhaust systems appear to be largely ineffective at providing proper exhaust. Indoor air quality associated with these toilet rooms was perceived as poor during SAE’s walk-through.

5. Miscellaneous Items:

   a. Several offices adjacent to the courtroom do not have mechanical or natural means for ventilation which is required for all occupied spaces. Failure to have means for ventilation ultimately leads to poor indoor air quality.

   b. There are to provisions for heating to storage room adjacent to the boiler room.

   c. The majority of the existing hot water piping systems were noted as not having proper insulation systems.

**Building No.2 Deficiencies**

1. Boilers:

   a. Some of the piping systems, valves and components show signs of rusting and deterioration.

   b. Only two (2) or three (3) pumps are provided with check valves. The pump without a check valve may have an effected flow performance.

   c. Efficiency: These cast-iron section boiler is estimated to be operating at 81% efficiency.

2. Hot Water Baseboard:

   a. Hot water baseboard heaters each have thermostatic control valves which are supposed to limit flow to that unit’s heating elements. However, a single master thermostat controls that zones circulator pump. If the zone with the master thermostat is not calling for heat, hot water flow is not available in the adjacent spaces served by that zone. This may lead to periods of occupant discomfort due to low space temperatures in adjacent spaces. Also, most thermostatic control valves were noted as not being readily accessible to allow for adjustment by the space/area occupant(s).
b. Many of the baseboard heating units were noted as being rusted and/or partially disassembled from efforts at reaching concealed thermostatic control valves.

3. Blower Coil Units:
   a. No service platforms are provided around units. Access to units requires balancing on the bottom cord of the roof truss system.
   b. At the discharge of both units is a bullnose duct fitting which causes excessive pressure loss to the system. Excessive pressure losses lead to reduced airflows and can lead to reductions in capacity and coil freeze.
   c. Excessive amounts of flexible ductwork systems are utilized which cause excessive pressure loss to the system. As noted above, excessive pressure losses lead to reduced airflows.
   d. Secondary drain pan is not provided with overflow safety switch.
   e. No mechanical ventilation provisions.

4. Outdoor Condensing Units:
   a. Refrigerant pipe systems were noted as having compromised insulation systems.

5. Miscellaneous Items
   a. The building is ventilated via natural means. This requires building occupants to open/close operable windows throughout the year as a means for maintaining acceptable indoor air quality levels. Although this method of providing ventilation to the building is Code-compliant, it may be assumed that windows are not opened during peak summer and winter periods which can lead to compromised indoor air quality during these periods. If windows are opened during these periods, an uncontrolled quantity of outside air may be introduced into the building which can lead to excessive energy use and a potential for introducing excessively humid air into the building.
   b. The attic space is provided with blown-in cellulose installed directly on the ceiling system. It was noted that in various areas, insulation was missing or minimal.
   c. Access to the attic mechanical space requires the use of a portable extension ladder and entrance through a doorway installed approximately 12 feet above grade.
   d. Various exhaust systems discharge into the attic space. Exhaust systems are required to be discharged directly to the exterior.
   e. There are several interior offices without operable windows and thus, no means for natural ventilation. A means for providing ventilation is required by Code to ensure proper indoor air quality for building occupants.
OPTIONS FOR IMPROVEMENTS

Upon review of the buildings’ various system deficiencies and ages, it is apparent that several of the mechanical systems in place are in need of replacement and/or improvements; some with a greater urgency than others. Appendix A of this report define various options that SAE has developed to replace/improve the mechanical systems currently in operation. All options assume the use of the currently available energy sources on site: electricity and no.2 fuel oil. Although it allows for greater efficiencies and operational costs, it is assumed that natural gas is not available on site for use in heating systems. These options are not meant to be a definitive list of available options, but rather, a set of potential replacement options which may be used to scale the significance of each project’s scope. A preliminary assumption was made that the wood-constructed roofs of each building could not readily support new mechanical equipment. Therefore, proposed options that include new outdoor equipment indicates this equipment to be located on grade rather than on the roof.

Building No.1 Options:

As all the systems within Building No.1 are nearly at or beyond their expected service lift, the options presented aim to replace the mechanical systems in their entirety. As noted in the scope of work definitions within the following pages, some of the ductwork distribution systems may be reused as appropriate for the proposed system. All options are based on maintaining the existing forced-air approach for heating and cooling. In options where existing systems are maintained, deficiencies found in those systems would be corrected.

Option B1.1: Direct Replacement of Existing Systems with New

Option B1.2 Replacement of Existing Systems with New; Floor-Mounted Blower Coil Units Installed within Mechanical Closet.

Option B1.3: Packaged Heat Pump Terminal Units; Interior-Mounted (Eliminates Boiler)

Option B1.4: Variable-Refrigerant Flow Heat Pump System with Dedicated Outside Air System (Eliminates Boiler)

Option B1.5: Packaged Air-Source Heat Pump; Exterior-Mounted (Eliminates Boiler)

Building No.2 Options:

The central boiler plant within Building No.2 is relatively new and is considered to have a significant service life remaining. Therefore, some of the options below would be structured to maintain this boiler system. All options for improvement would include a means for providing mechanical HVAC to interior spaces currently occupied without ventilation capabilities. Some options maintain the existing radiant approach for heating while others aim convert the building to forced-air systems, as seen in Building No.1. In options where existing systems are maintained, deficiencies found in those systems would be corrected.

Option B2.1: Replace HW Distribution and Baseboard Systems; Maintain Existing Boilers + New HW/DX Forced-Air System for Interior HVAC.


Option B2.4: Variable-Refrigerant Flow Heat Pump System with Dedicated Outside Air System (Eliminates Boilers)

Option B2.5: Packaged Air-Source Heat Pump; Exterior-Mounted (Eliminates Boilers)
CONCLUSIONS

Our investigation into the various systems in operation at the Byram Township’s 10 Mansfield Drive facility uncovered various deficiencies. Those deficiencies ranged from minor installation issues to significant concerns about the remaining service life of various systems. Most notably are the systems in operation in Building No.1 and it is recommended that the Township start planning for upgrades to those systems if the building is to continue to be occupied in its current state rather than waiting until those systems to fail when they are needed most.

Various options for improvement were presented to allow the Township to gauge the financial scale of future potential upgrades. As stated earlier, other options surely exists which could be explored further when a course of action is decided upon. At that point, further discussions and recommendations could be made to aid the Township in the decision making process.

End of Report.

Attachment: Appendix A (16 Pages)
Option B1.1: Hot Water Boiler + Horizontal Blower Coils + Outdoor Condensing Units

Option B1.1 replaces existing boiler (pictured left), in-kind and replaces existing horizontal, hung blower coil units (pictured center), in-kind and outdoor condensing units (pictured right), in-kind.

Energy Source; Heating: Fuel Oil
Energy Source; Cooling: Electricity

Projected Cost Estimate: $165,000

System Overview: This option would aim to simply replace the existing mechanical systems in-kind with equipment installed in a nearly identical fashion as those existing.

System Components: This system would include the following:

- One (1) new no.2 fuel oil boiler.
- New boiler vent piping.
- New hot water circulator, valves and accessories.
- New hot water piping insulation systems.
- Two (2) new horizontal blower coil units installed in same location/manner as existing.
- New blower coil unit hot water valves and accessories.
- Two (2) new outdoor condensing units installed in same location/manner as existing.
- New refrigerant piping + insulation systems.
- New gang bathroom exhaust system(s).
- New/modified ventilation exhaust/relief systems.
- Reuse existing fuel oil piping systems.
- Reuse existing supply/return ductwork systems. Cleaning of these systems would be recommended.
- New standalone programmable thermostats.

Advantages: Option B1.1 offers the following advantages to the Owner:

- Lower installed cost.
- Minimal impact to existing exterior of building.
- Simplified control systems.
• Readily available parts and service technicians.

Disadvantages: Option B1.1 is characterized by the following disadvantages:

• Servicability of hung blower coil units is troublesome.
• Would require rerouting of various conduits/pipes to facilitate unit removal and ductwork modifications.
• Lower efficiency equipment; higher operating costs.
Option B1.2: Hot Water Boiler + Vertical Blower Coils + Outdoor Condensing Units

Option B1.2 replaces existing boiler (pictured left), in-kind and replaces existing horizontal, hung blower coil units with new vertical type units installed on the floor of a new mechanical room (pictured center) and outdoor condensing units (pictured right), in kind.

Energy Source; Heating: Fuel Oil
Energy Source; Cooling: Electricity

Projected Cost Estimate: $190,000

System Overview: This option would aim to simply replace the existing mechanical systems in kind with the exception of the location and configuration of the indoor blower coil units. This option would provide indoor blower coil units in a vertical configuration which were located on the floor of a newly created mechanical closet.

System Components: This system would include the following:

- One (1) new no.2 fuel oil boiler.
- New boiler vent piping.
- New hot water circulator, valves and accessories.
- New hot water piping insulation systems.
- Two (2) new vertical blower coil units.
- New mechanical closet.
- Two (2) new outdoor condensing units installed in same location/manner as existing.
- New refrigerant piping + insulation systems.
- New gang bathroom exhaust system(s).
- New/modified ventilation exhaust/relief systems.
- Reuse existing fuel oil piping systems.
- Modifications to existing supply/return ductwork systems to facilitate blower coil unit installation changes. Cleaning of existing ductwork systems that would be reused would be recommended.
- New standalone programmable thermostats.
Advantages: Option B1.2 offers the following advantages to the Owner:

- Improved servicability of blower coil units.
- Lower installed cost.
- Minimal impact to existing exterior of building.
- Simplified control systems.
- Readily available parts and service technicians.

Disadvantages: Option B1.2 is characterized by the following disadvantages:

- Requires the creation of a mechanical room within the existing mechanical/custodial room. It is unknown at this point if adequate space is available to make this option feasible. However, if space was available, there would be a need to reconfigure the existing domestic water heater and an existing sink assembly within this mechanical room would have to be eliminated.
- Would require rerouting of various conduits/pipes to facilitate unit removal and ductwork modifications.
- Lower efficiency equipment; higher operating costs.
Option B1.3: Packaged Heat Pump Terminal Units

Option B1.3 replaces existing systems serving office areas with packaged heat pump terminal units. These types are most often seen within the hotel/hospitality market but are also implemented in office areas. Using Option B1.3 within the office areas would require another type of system to be provided for the courtroom space as these units are not appropriate for that application.

Energy Source; Heating: Electricity
Energy Source; Cooling: Electricity

Projected Cost Estimate: $85,000 (*does not include cost for courtroom HVAC)

System Overview: This option would aim to install packaged heat pump terminal units in various areas of the building. It is not suitable for the courtroom space, so this option would most likely be combined with another option.

System Components: This system would include the following (if combined with another option, it would also include the components outlined under that option, as well):

- Five (5) to seven (7) packaged heat pump terminal units with integral, non-programmable thermostats.
- New wall sleeves + exterior louver systems in existing brick facade.
- New gang bathroom exhaust system(s).
- New/modified ventilation exhaust/relief systems.

Advantages: Option B1.3 offers the following advantages to the Owner:

- Easily serviced equipment.
- Improved efficiency equipment.
- Multiple points to temperature control/adjustability.
- Lower installed cost.
- Simplified control systems.
- Readily available parts and service technicians.
Disadvantages: Option B1.3 is characterized by the following disadvantages:

- Requires new exterior louver systems in existing brick façade.
- Non-programmable thermostats eliminates potential for temperature setbacks during unoccupied periods.
- Noise of equipment is directly within occupied space.
- Multiple points of temperature control within a single space can lead to systems *fighting* each other if all units are not set at the same settings.
- Not suitable for courtroom (inadequate ventilation capabilities).
**Option B1.4 + B2.4: Variable-Refrigerant Flow Heat Pump + Dedicated Outdoor Air System**

*Option B1.4 utilizes a centralized refrigerant-based heat pump system. Multiple outdoor heat pump units (pictured left) are connected to multiple indoor air handling units (pictured top right; other air handling unit configurations available) to provide heating and cooling. Ventilation air is mechanical heated, cooled and introduced into the building via a packaged air source heat pump DOAS unit (pictured bottom right)*

Energy Source: Heating: Electricity  
Energy Source: Cooling: Electricity

Projected Cost Estimate (Building No.1): $275,000  
Projected Cost Estimate (Building No.2): $350,000

**System Overview:** A variable refrigerant, inverter driven air-source heat pump system utilizes standard electricity-driven, refrigerant-based refrigeration and heat pump cycles to provide either cooling or heating capabilities. Unlike conventional air-source heat pump systems, however, these systems can provide full heating capacities on the most extreme winter days and allow for multiple indoor air handlers to be coupled to a single bank of multiple outdoor heat pump units. A separate method for providing and conditioning ventilation air is accomplished by adding a dedicated outdoor air system (DOAS). This DAOS system would be nearly identical to the system outlined in Option B1.5; however, in this option, the DOAS would only provide and condition ventilation air. Heating and cooling loads associated with the building would be handled separately via the VRF system.

**System Components:** This system would include the following:

- Two (2) outdoor VRF heat pumps.  
- New centralized refrigerant piping systems.  
- Multiple indoor blower coil units. (Various options include concealed ducted units and exposed wall, floor and/or ceiling mounted units).  
- One (1) new DOAS unit installed on grade.  
- New interior and exterior-mounted ductwork.  
- New gang bathroom exhaust system(s).
• New centralized building controls.

Advantages: Option B1.4 offers the following advantages to the Owner:

• Multiple points to temperature control/adjustability.
• High operational efficiencies.
• Multiple outdoor heat pumps provide redundancy.
• Improved humidity control of incoming ventilation air.
• Quiet indoor equipment

Disadvantages: Option B1.4 is characterized by the following disadvantages:

• Initial cost
• New equipment on exterior grade.
• More complex control systems.
• System complexity limits available parts and service technicians.
Option B1.5 + Option B2.5: Packaged Air Source Heat Pump(s)

Option B1.5 utilizes multiple packaged air-source heat pump units installed on grade with new interior and exterior-mounted ductwork systems.

Energy Source; Heating: Electricity
Energy Source; Cooling: Electricity

Projected Cost Estimate (Building No.1): $215,000
Projected Cost Estimate (Building No.2): $260,000

System Overview: A packaged air-source heat pump system is a versatile approach to providing heating, cooling and ventilation capabilities within a single mechanical unit. Heating and cooling is provided via a standard electrically-driven, refrigerant-based refrigeration and reversed heat pump cycles. Numerous options/features can be incorporated into the system as the installation warrants. In heating operation, as this system relies on the ability to extract usable heat from outdoor ambient air and pump it indoors, standard heat pumps begin to lose their capacity at lower ambient air temperatures. To account for this, supplemental electric resistance heaters are incorporated in the packaged unit to provide full heating capabilities on the coldest days of the year.

System Components: This system would include the following:

- Several outdoor air-source heat pump units; installed on grade.
- New supply/return air ducting systems; interior + exterior-mounted systems.
- New gang bathroom exhaust system(s).
- New standalone programmable thermostats.

Advantages: Option B1.5 (and B2.5) offers the following advantages to the Owner:

- Increased operational efficiencies.
- Multiple outdoor heat pumps provides redundancy.
• Quiet indoor equipment.
• Options for energy recovery, dehumidification, demand ventilation strategies, amongs others.
• Low-to-moderate control systems.
• Readily available parts and service technicians.

Disadvantages: Option B1.5 (B2.5) is characterized by the following disadvantages:

• Initial cost
• New equipment on exterior grade.
Option B2.1: Hot Water Boiler + Horizontal Blower Coil + Outdoor Condensing Unit

Energy Source; Heating: Fuel Oil
Energy Source; Cooling: Electricity

Projected Cost Estimate: $155,000

System Overview: This option would aim to keep the central boiler plant in operation and make changes only to the existing hot water distribution system. Specifically, the hot water piping system would be altered to allow for each space to have independent control of the baseboard heater and eliminate the reliance of a group of spaces relying on a single zone thermostat. To address the need for mechanical ventilation in completely interior spaces, a new horizontal blower coil unit with integral hot water coil and refrigerant coil would be coupled to the existing hot water boiler and a new outdoor condensing unit.

System Components: This system would include the following:

- Maintain existing boilers + vent piping..
- New hot water circulators, valves and accessories.
- New hot water baseboard + fin tube units + control valves.
- Modified/new hot water piping distribution systems.
- New hot water piping insulation systems.
- New vertical blower coil units (potentially in attic)
- New supply, return and ventilation intake/exhaust ductwork systems.
- New outdoor condensing units.
- New refrigerant piping + insulation systems.
- New gang bathroom exhaust system(s).
- Reuse existing fuel oil piping systems.
- New standalone programmable thermostats.
Advantages: Option B2.1 offers the following advantages to the Owner:

- Maintains existing boilers.
- Lower installed cost.
- Improves on existing hot water baseboard control.
- Replaces existing baseboard units which are starting to deteriorate.
- Simplified control systems.
- Readily available parts and service technicians.

Disadvantages: Option B2.1 is characterized by the following disadvantages:

- Still relies on natural ventilation in most spaces.
- Still relies on window-style air conditioners in many spaces.
Option B2.2: New HW – Split DX Forced Air Systems for Entire Building

Energy Source; Heating: Fuel Oil
Energy Source; Cooling: Electricity

Projected Cost Estimate: $155,000

System Overview: This option would aim to keep the central boiler plant in operation. It would eliminate the existing air conditioning units within the attic, the existing hot water baseboard units in individual offices and various window air conditioning units and replace these systems with new horizontal HW + split-DX blower coil units within the attic space. This would transition the systems within Building No.2 into a very similar system which is currently in operation in Building No.1. All units would have ducted ventilation air intakes.

System Components: This system would include the following:

- Maintain existing boilers + vent piping..
- New hot water circulators, valves and accessories.
- New hot water distribution piping and control valves.
- Automatic propylene glycol feed + chemical feed systems.
- New hot water piping insulation systems.
- New horizontal blower coil units in attic.
- New supply, return and ventilation intake/exhaust ductwork systems.
- New outdoor condensing units.
- New refrigerant piping + insulation systems.
- New gang bathroom exhaust system(s).
- Reuse existing fuel oil piping systems.
- New standalone programmable thermostats.

Advantages: Option B2.2 offers the following advantages to the Owner:
• Maintains existing boilers.
• Improves indoor air quality year-round due to mechanical ventilation introduction.
• Simplified control systems.
• Readily available parts and service technicians.

Disadvantages: Option B2.2 is characterized by the following disadvantages:

• Higher initial cost.
• With equipment installed within the unconditioned attic, antifreeze solution (glycol) is needed within the hot water distribution system.
Option B2.3: Packaged Heat Pump Terminal Units + Split Air-Source Heat Pump

Option B2.3 utilizes packaged heat pump terminal units as discussed in Option B1.3. To serve fully interior spaces, split air source heat pump units would be installed to provide heating/cooling/ventilation capabilities.

Energy Source; Heating: Electricity
Energy Source; Cooling: Electricity

Projected Cost Estimate: $180,000

System Overview: This option would aim to install packaged heat pump terminal units in various areas of the building with exterior exposures. For interior spaces, split system air source heat pumps would be installed.

System Components: This system would include the following:

- 15-30 packaged heat pump terminal units with integral, non-programmable thermostats.
- New wall sleeves + exterior louver systems in existing facade.
- New gang bathroom exhaust system(s).
- New split air-source heat pump systems with supplemental electric resistance heat.

Advantages: Option B2.3 offers the following advantages to the Owner:

- Easily serviced equipment.
- Improved efficiency equipment.
- Multiple points to temperature control/adjustability.
- Simplified control systems.
- Readily available parts and service technicians.
Disadvantages: Option B2.3 is characterized by the following disadvantages:

- Requires new exterior louver systems in existing façade.
- Eliminates existing boiler system which has a long projected service life remaining.
- Non-programmable thermostats eliminates potential for temperature setbacks during unoccupied periods.
- Noise of equipment is directly within occupied space.
- Multiple points of temperature control within a single space can lead to systems fighting each other if all units are not set at the same settings.