Village of Oak Park – North Fire Station
HVAC Upgrade Feasibility Study
CD Project Number – 00400040

Prepared by: Clark Dietz, Inc.

Date: July 2022

Professional Consulting and Design Services

Clark Dietz

Engineering Quality of Life™

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SECTION 1: EXECUTIVE SUMMARY

1.1 Project Scope of Services

The engineering scope of services is to provide a feasibility study on various HVAC system replacements at the North Fire Station at 212 Augusta St., Oak Park, IL. Please note these recommendations do not address the lack of ventilation at the apparatus bay.

1.2 Project Goals

The existing natural gas boiler system is original to the building, approximately 75 years old, and is at the end of its lifespan. Majority of the piping and radiators are also original to the building and have developed leaks and corrosion over time, not performing to the required capacity. Clark Dietz has put together boiler replacement construction drawings to address the immediate need for a new boiler, to maintain heating operation for the upcoming winter. The goal of this study is to explore natural gas heating source design, an all electric system replacement in lieu of natural gas and the option for a future geothermal retrofit. This study shall identify cost associated, lead times, pros and cons with the options presented. Bringing up the apparatus bay to code with proper ventilation is excluded from this study. It is our understanding that is not being addressed at this time.

1.3 Estimated Construction Cost Summary

The following is a summary of the Engineer's Opinion of Probable Cost. See Section 3 for a detailed cost breakdown.

Option 1 ..... $40,000

Option 2 ..... $150,000

Option 3 ..... $100,000

Option 4 ..... $260,000

SECTION 2: PROJECT DESCRIPTION

2.1 Background

2.1.1 Existing System

The existing system information was obtained through site observations and the survey completed by Clark Dietz.

The current system operates with a natural gas boiler, approximately 75 years old. The boiler provides hot water to the domestic water heater, original radiators in the apparatus bay and floor mounted force flow heaters in the sleeping quarters. The sleeping quarters equipment is approximately 30 years old. An air conditioning unit at the attic provides cooling to the sleeping quarters. The associated condensing unit is located on grade in the parking lot. Ventilation air or exhaust is not currently provided throughout the fire station.

The boiler operates at 180F leaving water temperature currently. The radiators and force flow heaters are currently sized for 180F entering water temperature and 160F leaving water temperature.

The piping throughout the fire station has a lot of corrosion, likely due to the mixture in material of steel and copper piping. Piping leaks have been reported from the fire station staff.

2.1.2 Goals of HVAC Upgrades

<u>Boiler and piping replacement</u>

The boiler is at the end of its lifespan. There is a major concern the boiler will not be operational for the upcoming heating season. Replacing the boiler before the heating season is a proactive approach, preventing equipment failure during operation.

The current boiler design includes additional heating capacity to provide proper ventilation air into the fire station apparatus. There is currently no ventilation air provided throughout the building. This can be revised to not account for that future load. When the Village decides to address the apparatus ventilation, a separate dedicated system can be installed in lieu of utilizing the hot water from the boiler.

A high efficiency (95%) boiler will also be provided compared to the old boiler system estimated at 70% efficient. With the existing equipment in place, 180F leaving water temperature is required to meet equipment capacities. Once the equipment is replaced, an optimized 140F leaving water temperature can be achieved increasing boiler efficiency. Refer to geothermal system replacement for more information.

The original piping that is not copper should be removed and replace to address current leaks and corrosion.

<u>New geothermal heat pump system replacement</u>

A geothermal heat pump system with a ground loop will provide a renewable energy option for the fire station, minimizing building energy consumption. The building system would be converted to heat pump system throughout, removing the existing high maintenance force flow heaters and radiators.

Dedicated outdoor air system shall be provided for ventilation air, addressing the lack of ventilation air in the space.

Our recommendation is to include a boiler system as a back up system when the geothermal loop cannot meet the building heating load.

System Control

Currently there is only manual control of the boiler. The boiler pump activates when the room temperature sensor calls for heating.

Both the boiler and geothermal heat pump system shall include optimized controls with a building schedule. Allowing to set occupied/unoccupied schedules, night setback, operation based on outside air, etc. Upgrading the controls will greatly increase energy savings compared to the existing system.

2.2 Option 1 – New Natural Bas Boiler (Currently Designed and Bid)

2.2.1 Overview

Clark Dietz was retained by the village to provide boiler replacement design services. During design various options were discussed, however it was determined that due to budget restrictions, modifications to the system will be limited to removal and replacement of the existing boiler system.

Removal and replacement of the existing radiators and cabinet unit heaters, and replacement of existing hot water piping was proposed to be replaced at a later date on future phases. It was also discussed that if for any reason Village elected to go a different route with preferred HVAC system, this provided the most logical cut off point.

Refer to the construction documents designed by Clark Dietz. This addresses the immediate need to maintain the existing HVAC system through future heating seasons. Lowest bid of the project came back just under $40,000.

If desired, a like for like replacement at 216MBH output can be provided in lieu of accounting for any future loads on the hot water system.

2.3 Option 2 – High-Efficiency Gas Fired Furnaces and Condensing units

2.3.1 Overview

The Second Floor is the only part of the building that is fully heated and cooled. The square footage of this floor is similar to a medium sized house. Two residential-type split system furnaces and condensing units would give this floor good zone control and very efficient operation. One system could serve the Day Room/Kitchen and one system could serve the Sleeping Quarters. The furnaces would be sealed combustion burners and 90+% efficient. The condensing units could be selected with high seasonal energy efficiency rating (SEER). If the furnaces would be installed in the attic, it would be advisable to create and insulated room to house them.

The First Floor only requires heating. High-efficiency gas fired unit heaters with sealed combustion burners could easily service this area. The basement could also have a gas fired unit heater.

Remodeling of the HVAC system will likely require compliance with modern ventilation codes. An air-to-air heat exchanger could be installed for toilet exhaust and ventilation air in the living spaces.

Other work included with this option:

1. Remove existing boiler, piping, radiators, force flow heaters, air conditioning system and associated ductwork.
2. If special waste materials are present (asbestos containing materials), they will have to be removed prior to demolition or system components could be abandoned in place.

2.3.2 Utility Impacts

Split system furnaces and condensing unit, and the gas fired units heaters typically provide 20%-30% savings on heating and cooling costs compared to the existing system.

2.3.3 Cost & Schedule

This would be a complete renovation to the HVAC system, but construction would occur incrementally with minimal disruption to the building and site. The probable cost for a new gas furnace system is $150,000. Refer to the detail cost breakdown for more information. Design schedule and construction schedule is approximated to be 2 months or more depending on equipment lead times during time of construction

2.4 Option 3 – New All Electric System

2.4.1 Overview

Provide an all electric HVAC system, removing the existing natural gas boiler and all associated piping and hydronic equipment. The scope of this option includes the following items.

1. Remove existing boiler, piping, radiators, force flow heaters, air conditioning system and associated ductwork.
2. Provide new electric unit heaters to serve the apparatus bay.
3. Provide new air source ceiling cassette heat pump system at sleeping quarters.
4. Heat pump dedicated outside air unit provide code required ventilation air to each heat pump system.

This design would eliminate direct use of fossil fuels at the fire station. The following are impacts to the electricity and utilities of the building.

2.4.2 Electrical capacity

The existing electrical service to the building is 200amp, 240v/3p service. Changing the 216MBH boiler heating load to electric would require about 160amps alone at 240v/3p. The existing electrical service is not sufficient to support an electric heating system, requiring a service upgrade from Comed. 400amp minimum service would be required.

2.4.3 Utility impacts

It is our understanding that all electrical utilities for heating at the fire station are paid by the Village of Oakpark. Currently with the natural gas boiler, there is no heating electrical costs. With an converting the hydronic heat to all electric, it is estimated to triple monthly utility costs during heating season months due to price of gas vs electricity.

If the Village decides to have a generator backup including the hvac system, the required generator load has essentially doubled.

2.4.4 Cost & Schedule

This would be a renovation to the entire existing HVAC system, resulting with higher cost and longer construction schedule. The probable cost for a new all electric system is $100,000. Refer to the detail cost breakdown for more information. Design schedule and construction schedule is approximated to be 4 months or more depending on equipment lead times during time of construction.

2.5 Option 4 – Future geothermal heat pump system

2.5.1 Overview

This project is a good application for a geothermal system because the building loads are balance with exception to the apparatus bay. The apparatus bay requires heating only and should be provided with a separate system. The scope of this option includes the following items.

1. Remove existing boiler, piping, radiators, force flow heaters, air conditioning system and associated ductwork.
2. Parking lot reconstruction to install the new geothermal wells and loop.
3. Install new circulating pump and other head equipment located in the basement.
4. Install new dedicated outdoor air system to provide ventilation air to each heat pump system.
5. Install new ceiling cassete water source heat pump system fed from closed ground source loop to serve sleeping quarters of fire station.
6. Install new boiler system to provide heating redundancy.

2.5.2 Utility Impacts

Geothermal heat pump system typically provide 25%-50% savings on heating and cooling costs compared to an air source system such as air source heat pumps in option 2. This also reduces reliance on fossil fuels or electric sourced heating/cooling.

2.5.3 Cost & Schedule

This would be a major renovation to the HVAC system, resulting with higher cost and longer construction schedule. The probable cost for a new geothermal system is $260,000. Refer to the detail cost breakdown for more information. Design schedule and construction schedule is approximated to be 6 months or more depending on equipment lead times during time of construction.

2.6 Option Comparison

Cost Effectiveness

Option 1 natural gas boiler replacement is the option aligning with current funds from our understanding. Geothermal option 4 the upfront costs are higher, but long term savings on utilities will justify the installation. We recommend a boiler for the geothermal heat pump system regardless for heating system redundancy.

Construction Impacts

Option 1 and 2 (natural gas source heating system), can be achieved before the heating season begins if the project is started promptly. This will address the concern of the equipment breaking before the future heating season ends. Option 3 or 4 will not be achievable before heating season arrives due to design time required and the major renovation requiring a longer construction schedule. Option 4 would be best as a future project, following the boiler replacement.

System Lifespan

Option 1 addresses the immediate need of a failing boiler. Options 2 thru 4 will address all existing building maintenance issues and increase energy efficiency. Equipment life expectancy for the furnace, boiler and heat pumps is 20+ years and 25-50 years for the underground infrastructure.

Energy Efficiency

Option 4 provides an energy efficient and reduce use of fossil fuels for the building system. Between a natural gas heating system and electric, the difference is utilizing fossil fuel directly vs indirectly. The electricity required is sourced from a plant utilizing fossil fuels.

Controls Systems

Options 2 thru 4 will provide optimized controls for the entire building, allowing the building to be as energy efficient as possible. Option 1 will address the boiler control only, but the existing equipment remains.

SECTION 3: DETAILED COST BREAKDOWN

The following section consists of the Engineer's Opinion of Probable Cost.

0040040 - Oak Park - North Fire Station Boiler Replacement
Village of Oak Park

July 2022

Clark Dietz
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Project Phase: Program Analysis

Estimate Contingency (%): 20.00%

Description	Unit	Unit Quantity	Unit Cost	Component Totals	Contingency	Component Totals	Sub-Totals
Option 2							$ 122,400
Split System Furnace and Condensing Units	EA	2	$ 30,000.00	$ 60,000.00	$ 12,000.00	$ 72,000.00	
Gas Fired Unit heaters	EA	3	$ 4,000.00	$ 12,000.00	$ 2,400.00	$ 14,400.00	
Gas Piping	LS	1	$ 7,500.00	$ 7,500.00	$ 1,500.00	$ 9,000.00	
Electrical	LS	1	$ 7,500.00	$ 7,500.00	$ 1,500.00	$ 9,000.00	
Existing HVAC demolition	LS	1	$ 15,000.00	$ 15,000.00	$ 3,000.00	$ 18,000.00	
Option 3							$ 83,310
Existing HVAC demolition	EA	1	$ 10,000.00	$ 10,000.00	$ 2,000.00	$ 12,000.00	
Air Source Heat pumps	EA	3	$ 4,000.00	$ 12,000.00	$ 2,400.00	$ 14,400.00	
Dedicated outdoor air system	EA	1	$ 15,000.00	$ 15,000.00	$ 3,000.00	$ 18,000.00	
Dx Piping	LF	90	$ 82.50	$ 7,425.00	$ 1,485.00	$ 8,910.00	
HVAC Controls	LS	1	$ 2,000.00	$ 2,000.00	$ 400.00	$ 2,400.00	
Upgrade Electrical service	EA	1	$ 20,000.00	$ 20,000.00	$ 4,000.00	$ 24,000.00	
Electrical	LS	1	$ 3,000.00	$ 3,000.00	$ 600.00	$ 3,600.00	
Option 4							$ 229,650
Existing HVAC demolition	EA	1	$ 10,000.00	$ 10,000.00	$ 2,000.00	$ 12,000.00	
Geothermal loop & head equipment	EA	1	$ 90,000.00	$ 90,000.00	$ 18,000.00	$ 108,000.00	
Heat Pumps	EA	3	$ 4,000.00	$ 12,000.00	$ 2,400.00	$ 14,400.00	
Dedicated outdoor air system	EA	1	$ 15,000.00	$ 15,000.00	$ 3,000.00	$ 18,000.00	
Boiler	EA	1	$ 12,000.00	$ 12,000.00	$ 2,400.00	$ 14,400.00	
Piping	LS	150	$ 82.50	$ 12,375.00	$ 2,475.00	$ 14,850.00	
HVAC Controls	LS	1	$ 10,000.00	$ 10,000.00	$ 2,000.00	$ 12,000.00	
Electrical	LS	1	$ 20,000.00	$ 20,000.00	$ 4,000.00	$ 24,000.00	
Ceiling Removal and Replacements	LS	1	$ 2,000.00	$ 2,000.00	$ 400.00	$ 2,400.00	
Parking Lot Removal and Replacement	LS	1	$ 8,000.00	$ 8,000.00	$ 1,600.00	$ 9,600.00	

0040040 - Oak Park - North Fire Station Boiler Replacement
Village of Oak Park

July 2022

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Project Phase: ***Program Analysis***

Estimate Contingency (%): ***20.00%***

Description	*Unit*	*Unit Quantity*	*Unit Cost*	*Component Totals*	*Contingency*	*Component Totals*	*Sub-Totals*
Summary							
Option 2						$ 122,400.00	
Bonds and Insurance	%	2.00%				$ 2,448.00	
General Conditions	%	10.00%				$ 12,240.00	
Total - Option 2							$ 138,000
Option 3						$ 83,310.00	
Bonds and Insurance	%	2.00%				$ 1,666.20	
General Conditions	%	10.00%				$ 8,331.00	
Total - Option 3							$ 94,000
Option 4						$ 229,650.00	
Bonds and Insurance	%	2.00%				$ 4,593.00	
General Conditions	%	10.00%				$ 22,965.00	
Total - Option 4							$ 258,000

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Memo

To: Vic Sabliauskas
From: Nirav T. Patel
Date: August 26, 2022
Subject: Oak Park Fire Station 2 Full HVAC Upgrade

Objective

This memo is additional information to HVAC Upgrade Feasibility Study provided August 1st, 2022. Objective of this memo is to address the scope and estimated cost for bringing up the entire building to code, including the apparatus bay.

Existing System

Currently there is no ventilation provided at the apparatus bay. Hot water floor radiant heaters original to the building only existing. There is an existing temperature sensor at the apparatus bay controlling the heaters.

International Building Code (IBC) states, areas in which stationary motor vehicles are operated shall be provided with a source capture system that connects directly to a motor vehicle exhaust system. Currently this is not provided at the North Fire Station 2. In addition to this, indoor vehicle storage facilities must be provided with ventilation at the rate of 0.75 cfm/sf unless there is a system that ventilates this space based on occupancy sensor or active gas detection system. Currently the apparatus bay is not provided with this required ventilation.

Apparatus Bay HVAC Upgrade

The apparatus bay requires heating only and should be provided with a separate system from the geothermal upgrade. If the apparatus bay was included in the geothermal loop, the building loads will become unbalanced. A geothermal system will become inefficient with unbalanced loads. Overtime the geothermal loops would become inefficient because heating dominant loads would lower the ground temperature.

For the apparatus bay we recommend the following to bring the building up to code:

- Vehicle exhaust with CO and NO_2 sensors for ventilation.
- Makeup air unit connected to the exhaust fan system operation. Makeup air unit (MAU) to be provided with electric resistance heating to meet Oak Park's Climate Action Plan to electrifying all buildings, eliminating the use of natural gas.
- Suspended electric unit heaters to maintain heating setpoint. Unit heaters to be interlocked with apparatus door operation to minimize cold infiltration.

The existing 200amp electrical service will not be able to support the electric resistance heat at the MAU and unit heaters. A new estimated 400 amp service will be required.

The probable cost for a full HVAC upgrade, all electric with a new geothermal system service is $317,000. Refer to detail cost breakdown for more information along with estimated engineering fee for this design.

0040040 - Oak Park - North Fire Station Full HVAC Geothermal Replacement
Village of Oak Park

August 2022

Clark Dietz
Engineering Quality of Life℠

Project Phase: Program Analysis

Estimate Contingency (%): 20.00%

Description	Unit	Unit Quantity	Unit Cost	Component Totals	Contingency	Component Totals	Sub-Totals
Base Bid							$ 282,210
Existing HVAC demolition	EA	1	$ 10,000.00	$ 10,000.00	$ 2,000.00	$ 12,000.00	
Geothermal loop & head equipment	EA	1	$ 90,000.00	$ 90,000.00	$ 18,000.00	$ 108,000.00	
Heat Pumps	EA	3	$ 4,000.00	$ 12,000.00	$ 2,400.00	$ 14,400.00	
Dedicated outdoor air system	EA	1	$ 15,000.00	$ 15,000.00	$ 3,000.00	$ 18,000.00	
Piping	LS	150	$ 82.50	$ 12,375.00	$ 2,475.00	$ 14,850.00	
HVAC Controls	LS	1	$ 12,000.00	$ 12,000.00	$ 2,400.00	$ 14,400.00	
Upgrade Electrical service	EA	1	$ 20,000.00	$ 20,000.00	$ 4,000.00	$ 24,000.00	
Electrical	LS	1	$ 20,000.00	$ 20,000.00	$ 4,000.00	$ 24,000.00	
Ceiling Removal and Replacements	LS	1	$ 2,000.00	$ 2,000.00	$ 400.00	$ 2,400.00	
Parking Lot Removal and Replacement	LS	1	$ 8,000.00	$ 8,000.00	$ 1,600.00	$ 9,600.00	
Apparatus Bay Ventilation system	LS	1	$ 25,000.00	$ 25,000.00	$ 5,000.00	$ 30,000.00	
Apparatus Bay Engine Exhaust	LS	1	$ 4,000.00	$ 4,000.00	$ 800.00	$ 4,800.00	
Apparatus Bay Unit heaters	LS	4	$ 1,200.00	$ 4,800.00	$ 960.00	$ 5,760.00	

0040040 - Oak Park - North Fire Station Full HVAC Geothermal Replacement
Village of Oak Park

August 2022

ClarkDietz
Engineering Quality of Life℠

Project Phase: *Program Analysis*

Estimate Contingency (%): *20.00%*

Description	*Unit*	*Unit Quantity*	*Unit Cost*	*Component Totals*	*Contingency*	*Component Totals*	*Sub-Totals*
Summary							
Base Bid						$ 282,210.00	
Bonds and Insurance	%	2.00%				$ 5,644.20	
General Conditions	%	10.00%				$ 28,221.00	
Total - Base Bid							$ 317,000
Total Construction Cost							$ 317,000
Estimated Engineering Fees							$26,000
Total Cost							$ 343,000

ARCHITECTURAL
CONSULTING
ENGINEERS

July 29, 2022

Director Rob Sproule
Mr. Vic Sabaliauskas
Dept. of Public Works
Village of Oak Park

RE: VOP Fire Station #3 – Boiler Replacement Review

I toured the first floor and basement of Fire Station #2 on Monday, July 25, 2022, along with both of you. The first floor is heated with cast iron radiators. We did not review the second-floor living spaces, but Vic Sabaliauskas noted that the second floor is heated with cabinet unit heaters, and there is a ducted air handler with a remote condensing unit that provides cooling for the second floor.

This report is broken up into three parts: A) A look at the existing building and systems; B) A review of the proposed boiler replacement design documents; and C) A summary of alternate strategies to eliminate the need to use fossil fuels for the HVAC systems in this building.

A. My observations of the existing system and the building are as follows:

1. The building is a two-story masonry building with an attic and a partial basement at the north end of the building.
    a. Windows have been upgraded and in some cases, based on replacement brick on the façade, reduced in size or removed entirely. These windows appear to be double-paned, tinted, thermal windows.
        i. Because air infiltration can be a large contributor to the heating and cooling load, I recommend a blower door test be performed, if not recently done, to identify locations where air infiltration is occurring so these deficiencies can be sealed up to help improve the passive performance of the building.
    b. Due to the limited nature of this review, it is not known whether there has been any improvement to the thermal insulation in the building.
        i. Older masonry buildings typically have furred-out plaster interior walls with limited space to add insulation, but it is possible insulation was added if the fire station was renovated.
        ii. Since there is a sloped roof and reportedly an accessible attic, attic thermal insulation may have already been improved. If not, we recommend that insulation levels be increased to current code minimum levels, if not greater levels.

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RE: VOP Fire Station #3 – Boiler Replacement Review

	
Fire Station #2 – Looking NW – Note Small Windows Located in Large Sections of Newer Brick Infil	Fire Station #2 – Looking SE – Note Small Windows Located in Large Sections of Newer Brick Infil & Infilled Areas Where Windows Were Likely Removed

2. The existing gas-fired boiler is located in the partial basement.

    a. This boiler is a natural draft, Mt. Hawley boiler with a natural gas input capacity of 270,000 Btuh, and an output capacity of 210,000 Btuh, for a thermal efficiency of 77.7%. It is highly likely that the current actual efficiency is considerably less than the original rated efficiency due to the age of the boiler.

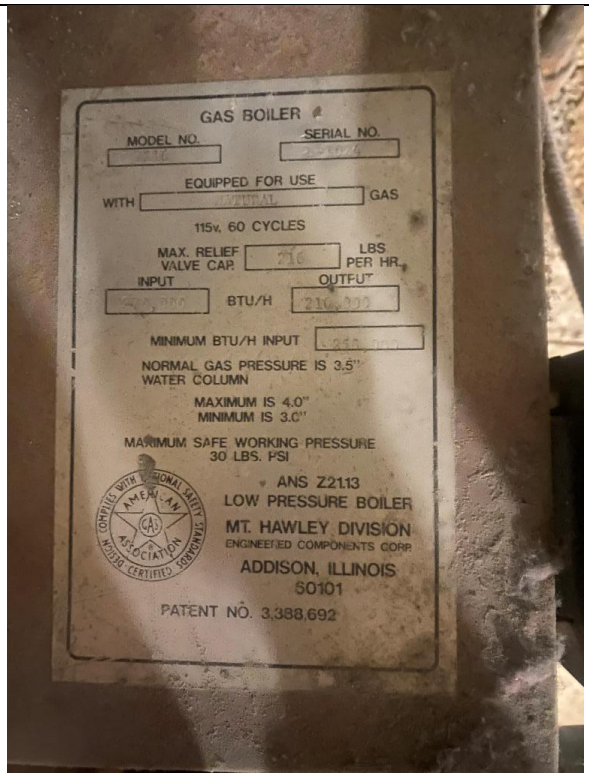
    b. The boiler flue discharges to a masonry chimney on the west side of the boiler room. I did not note any combustion air openings in the basement.

    c. The system includes a circulation pump and piping that distributes hot water to cast iron radiators around the building.

    d. I was not able to identify the age of the boiler specifically, but I was able to discover the company went out of business in the mid-1980s, which means the boiler is at least 35 years old, and likely older than that. Even at the most optimistic date of manufacture, this boiler has exceeded its useful expected life.

    e. Replacement of this boiler is certainly warranted based on age.

RE: VOP Fire Station #3 – Boiler Replacement Review

	
Mt. Hawley Boiler	Boiler Equipment Label

3. The air conditioning system condensing unit is rated for 4 tons of cooling capacity, which we assume is the same as the air handling unit. This unit was manufactured in 2014, which makes it eight years old with another 10-15 years of expected useful life if well maintained.

4. I did not review the air handling unit installation but was told that the unit and duct distribution system is in the attic of the building. If the attic is insulated at the attic floor, this equipment and ductwork can be subject to significant temperatures in the summer cooling season so appropriate insulation should be applied to the ducts after they are properly air sealed to prevent undesirable losses to the unconditioned attic space.

B. Design Review

I reviewed the Oak Park Fire Station Boiler Replacement drawings and specifications, dated May 25, 2022, prepared by Clark Dietz, Inc. It is important to recognize that I am not privy to any of the design discussions or decisions made by VOP staff and the engineer of record (EOR) during the design process. My review and noted observations are being made based solely on the design as presented in the documents, my recent visit to the building, and my discussion with VOP staff and project engineer Nirav Patel.

My observations of the proposed boiler replacement drawings are as follows:

RE: VOP Fire Station #3 – Boiler Replacement Review

1. The drawings call for the demolition of the existing boiler, accessories, and the majority of basement piping.

2. A new Lochinvar KBX-0400 97% efficient modulating boiler with an input capacity of 399,000 Btuh and output capacity of 387,000 Btuh. I have several comments related to the proposed design:

    a. The existing boiler was likely installed before 1985, and, likely, the building improvements since that time such as improved windows and smaller fenestration total area have reduced the heating load of the building since that time.

        i. The new boiler has almost twice the heat output of the existing boiler, which is presumably functioning to keep the building comfortable.

            1. Based on a conversation with Nirav Patel, project engineer for Clark Dietz, the increased boiler size is attributed to future-proofing the design in case the building is brought up to code compliance for an exhaust and makeup air system for the first-floor equipment bay, and a kitchen hood make-up air system.

            2. In my opinion, oversizing the existing boiler now seems to be an unnecessary step since a correctly sized boiler could be installed with provisions for adding a second boiler should those future projects become a reality.

        ii. The new boiler has a 5:1 turndown ratio, so it will track with the building load to some degree, but with the high starting output, the lowest output capacity will be substantially higher than the minimum load required for the building in mild weather which will result in short-cycling of the boiler. Boiler short-cycling causes less efficient operation and often reduces the useful life of the boiler.

            1. This issue could be mitigated with a buffer tank to help prevent short-cycling of the boiler during low load conditions, but there is no such equipment specified for this project.

        iii. The larger size boiler requires larger distribution piping and a larger pump.

            1. For the current boiler as specified including the 20°F temperature rise, header piping sized at 2” diameter should be sufficient, especially considering the limited piping length, however, 3” diameter piping has been specified.

            2. If the boiler was replaced with a unit of similar size to the existing boiler, 1-1/2” piping would be sufficient although 2” diameter piping would provide for less overall pressure drop.

            3. If the project were to include a boiler sized for the current building uses, with plans for a future boiler for possible future projects, it would make sense to install the main piping sized for this future total system capacity, to avoid having to replace this piping in the future.

        iv. Radiators serving the equipment bay are not particularly good at rapid temperature response, which is desirable in a garage bay where the doors are opened while equipment is moved in and out. A suspended hot water unit heater

would be more effective at rapidly addressing this condition and it could be sized to operate with a lower input hot water temperature.

1. It is my understanding that this was discussed with VOP staff, but due to concerns over the amount of money budgeted for the project, adding hot water unit heaters was not included at that time.

2. If the boiler is downsized to support just the current needs of the building, the savings that result could be used to add these unit heaters to the equipment bay for more effective heat recovery after the doors have been opened on a cold day.

3. I would recommend that the cast iron radiators remain as they can provide a base heating capacity with the unit heaters being used for the rapid response heating needs.

b. The schedule indicates this boiler shall operate at 180°F supply water and 160°F return water temperature. This is consistent with the existing boiler operating temperatures.

   i. Condensing boilers need to have a fairly low return water temperature to achieve their rated efficiencies. At the noted temperatures, the boiler will not be in condensing mode so the efficiency will drop from 97% to something closer to 85%.

   ii. The boiler could be operated with an outdoor air reset schedule, although I did not see anything on the drawings indicating that this feature was to be used. In discussions with Nirav Patel, he noted that the boiler will have the reset capability built into the controls and the plan is to implement this strategy in conjunction with VOP staff and Fire Dep

      1. If used, the boiler would operate at a reduced supply temperature whenever the outside conditions do not warrant the higher discharge temperature. The maximum temperature setpoint can be evaluated after the system is deployed to provide the lowest temperature water to the terminal units and still achieve effective heating in all areas.

      2. It might be possible to use lower temperature supply water year round given the building envelope has been improved since the original radiators were installed so having less heat output from these radiators could help interior spaces from overheating, if there aren't other means, such as thermostatic radiator valves, to assist in that function.

      3. Regardless, without a significant drop in return water temperature, the boiler will not achieve the rated efficiency, although it will be substantially more efficient than the existing boiler.

      4. I feel that the outside air reset requirement should be included in the design documents so it is documented as a project requirement to ensure implementation.

C. Alternate Strategies

Several possible alternative strategies meet the intent of the proposed Climate Action Plan that has been created and is being currently considered for adoption by the Village Board. The intent is to move away from the use of fossil fuels for building HVAC systems and otherwise reduce the Village's carbon emissions.

The following are proposed building improvements and system alternatives to the current project as designed:

1. Building Envelope Improvement:
    a. The first step in any building system renovation project should be to make building envelope improvements wherever possible to reduce the overall heating and cooling system size requirements.
    b. Improvements that should be considered include:
        i. Improved attic insulation.
        ii. Infiltration reduction through the use of a blower door test to identify envelope leaks and then the remediation of any leaks discovered followed by a confirmation blower door test.
        iii. Wall insulation in any area being renovated. Given the construction type, adding insulation to the existing walls may not be possible but if the floor plan is changed for any reason, furred out walls with insulation could help improve the building performance.
2. Ground-Source Heat Pump "Boiler":
    a. Ground source heat pump boilers are available on the retail market and have been used for many years. Commonly called a water-to-water heat pump (WWHP), these units extract heat from the ground via a ground loop heat exchanger, and using the work of the refrigerant cycle, generate hot water that can be used for heating purposes.
        i. A standard WWHP unit that utilizes R410a refrigerant produces 120°F hot water which is sufficient for many applications, including for use in cabinet unit heaters, unit heaters, air handling units, baseboard radiation, and radiant floor heating systems. It is not suitable for use in cast iron radiators.
        ii. A high-temperature WWHP that uses R134a refrigerant can produce 160°F hot water which is sufficient for cast iron radiators in addition to the other terminal units mentioned above.
            1. The limitation of this equipment is that the entering loop water temperature must be 45°F or higher, which requires a larger loop field heat exchanger or a cascade type unit that has both a standard WWHP nit merged with a high-temperature WWHP so that standard loop temperatures can be used.
        iii. A standard WWHP could be installed provided the cast iron radiators in the equipment bay are replaced with hot water unit heaters sized to work with 120°F hot water and the cabinet unit heaters on the second floor are evaluated for

performance at the lower temperature or some other means is made to heat the second floor like changing out the existing air conditioning system for a ground-source heat pump air handling system.

iv. Through proper loop design, the system can maintain full rated capacity throughout the full heating season.

b. A loop field heat exchanger would have to be installed adjacent to the building in the parking lot to the north of the building. It is our understanding that this parking lot may be resurfaced in the next couple of years which would help keep the cost of the loop field down since the cost of the parking lot restoration would be covered as part of another project.

c. These systems are more expensive than other technologies such as an air source heat pump or gas-fired boiler, but they will save operating costs over time due to higher inherent efficiencies of 400% to 500% (COP = 4.0 to 5.0). Since the loop field has a 50-plus year life expectancy (if not longer), and the equipment has a higher than typical expected useful life since all components are inside and there are no gas-fired heat exchangers, these systems often pay back the increased cost to install within a reasonable timeframe, usually far shorter than the expected life of the equipment. The loop field will not typically need to be replaced as it is a one-time expense.

3. Air-Source Heat Pump "Boiler":

a. Air source heat pump boilers are available on the retail market and have been used for many years. Commonly called an air-to-water heat pump (AWHP), these units extract heat from the air like any other air-source heat pump, and using the work of the refrigerant cycle, generate hot water that can be used for heating purposes.

i. A standard AWHP unit that utilizes R410a refrigerant produces 120°F hot water which is sufficient for many applications, including for use in cabinet unit heaters, unit heaters, air handling units, baseboard radiation, and radiant floor heating systems. It is not suitable for use in cast iron radiators.

ii. We are not aware of any high-temperature AWHP equipment but I have not done an exhaustive review of all available equipment.

b. The exterior heat pump equipment would be located adjacent to the building on the north side. A refrigerant line set would connect the indoor unit to the outdoor unit.

c. This type of equipment has about a 200% efficiency (COP = 2.0) which is similar to other air-source heat pump equipment.

d. An AWHP could be installed provided the cast iron radiators in the equipment bay are replaced with hot water unit heaters sized to work with 120°F hot water and the cabinet unit heaters on the second floor are evaluated for performance at the lower temperature or some other means is made to heat the second floor like changing out the existing air conditioning system for an air-source heat pump air handling system.

4. Elimination of the Hot Water Heating System

a. This alternative eliminates the hot water heating system and moves to a forced air system for all heating and cooling of the building.

b. The first floor would be fitted with a ground source OR air source forced air heat pump system.

   i. This system would replace the existing cast iron radiators and recommended hot water unit heater.

   ii. The system could be upsized to provide for rapid heating capability when the garage doors are opened.

c. The second-floor existing ducted air conditioning equipment would be replaced with a ground source OR air source forced air heat pump system that reuses the attic-mounted duct distribution system.

   i. I would recommend that an insulated room be built in the attic around the equipment so that the harsh temperatures that will occur up there in the summer do not affect equipment and to eliminate the freeze hazard in the winter operation.

   ii. Supplemental electric resistance heat might be required for the ground source unit to meet the heating capacity requirement without oversizing the cooling capacity.

   iii. Supplemental/emergency electric resistance heat might be required for the air source heat pump unit to meet the heating capacity requirement without oversizing the cooling capacity, and to provide full heating capacity when the air source heat pump capacity drops too low in extremely cold weather.

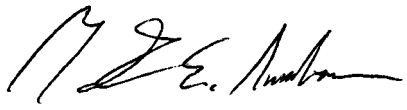
5. In any case, using a ground source or air source heat pump system should be feasible to condition all areas of Fire Station #2 although I recommend a more detailed study be performed to verify all assumptions made in this report.

6. One additional consideration when considering an all-electric solution is whether the existing electrical service is sized adequately. The building currently has a 200-amp, 120-240 Volt, single-phase electric service with emergency backup power provided by an 11-kW natural gas generator.

   a. The backup generator size would be insufficient to heat all areas of the building with an all-electric heat pump system.

   b. The electric service may need to be upsized to a larger electric service, depending on the final system design. This should be reviewed in the recommended feasibility study.

Respectfully Submitted:
Architectural Consulting Engineers



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