



Plainfield School District HVAC Assessment Report



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Executive Summary

The purpose of this project is to assess the condition of the existing HVAC systems at six Plainfield Schools to determine if they provide adequate space heating and ventilation air. In addition, the project required identifying HVAC system deficiencies, needed repairs and/or maintenance. Also, the project required recommendations and cost opinions for HVAC system improvements that meet current building codes and provide cooling to spaces currently without cooling. The recommendations considered equipment efficiencies, operation and maintenance, integration with existing HVAC systems and utility capacities, and the ease of installation phasing to minimize disruptions.

Spaces in the six schools with functioning HVAC appear to receive both heating and ventilation. Some spaces also receive cooling. The HVAC equipment, such as Unit Ventilators in classrooms, or all-air system using Rooftop Units were originally capable of providing heating, possibly cooling, and outdoor air ventilation. Spaces with failed or failing HVAC equipment may not provide ventilation through the failing or replacement equipment. These spaces can meet code ventilation requirements if they have operable windows that open to at least 4 percent of the space's floor area. However, natural ventilation is not practical in Connecticut's winter months.

The primary HVAC system improvement needed in most schools is replacement of failing classroom conditioning equipment, namely Unit Ventilators (UVs). Because UVs can have difficulty meeting Connecticut-required sound levels, H.F. Lenz recommends the Dedicated Outdoor Air System for ventilation air, and the separate Refrigerant Split System heat pumps that provide both heating and cooling.

For the High School and Early Childhood Center, UV replacements are not required, but other improvements are needed to improve building ventilation and conditioning, and reduce the chance of unexpected system failures. Unfortunately, some of these projects are expensive. For example, the Air-Cooled Chillers (ACCs) on the roof of the High School were not located with adequate space between units. The heat dissipation between ACCs and condensing units interact, reducing performance and causing early failure, as seen with premature compressor replacement. However, there is no roof space to relocate ACCs, so they will need to be relocated to the ground, which is an expensive project.

For all schools except the High School, any pneumatic HVAC controls should be replaced with electric/electronic/computer HVAC controls to improve space conditioning and outdoor air ventilation, as well as save significant operating costs through energy conservation and obsolete component replacement.

All schools should perform an Existing Building HVAC Commissioning (EBCx) project to determine the detailed state of the HVAC system in each building.

Total cost opinions for each school:

School	EBCx and Electric/Computer Controls	Unit Ventilators w/ Elec Heat	Unit Ventilators w/ Elec Heat & DX Cooling	DOAS & DX Split Systems for Heating	DOAS & DX Split Systems for Heating and Cooling	Custom Improvement Projects for Heating and Cooling
PHS	\$ 186,500.	\$ 0.	\$ 0.	\$ 0.	\$ 0.	\$ 507,900. to \$ 1,451,000.
PCS	\$ 884,200.	\$ 1,542,200.	\$ 2,159,000.	\$ 1,799,200.	\$ 3,238,600.	\$ 0.
PMS	\$ 568,900.	\$ 992,300.	\$ 1,389,200.	\$ 1,686,900.	\$2,083,800.	\$ 0.
MES	\$ 267,400.	\$ 826,920.	\$ 1,157,700.	\$ 964,800.	\$ 1,736,600.	\$ 0.
SHE	\$694,500.	\$ 1,211,300.	\$ 1,695,900.	\$ 1,413,200.	\$ 2,543,800.	\$ 0.
ECC	\$ 250,800.	\$ 0.	\$ 0.	\$ 0.	\$ 0.	\$ 50,800. To \$ 610,800.

Existing Conditions

Six (6) schools were investigated in this assessment:

1. Plainfield High School, 105 Putnam Road, Central Village, CT 06332 - (**PHS**)
2. Plainfield Central Middle School 75 Canterbury Road, Plainfield, CT 06374 - (**PCS**)
3. Plainfield Memorial School 95 Canterbury Road, Plainfield, CT 06374 - (**PMS**)
4. Moosup Elementary School 35 Church Street Moosup, CT 06354 - (**MES**)
5. Shepard Hill Elementary School 234 Shepard Hill Road, Plainfield, CT 06374 - (**SHE**)
6. Plainfield Early Childhood Center 651 Norwich Road, Plainfield, CT 06374 - (**ECC**)

PHS

The Plainfield High School was opened in 2005. All spaces have both heating and cooling. The typical HVAC system is a central all-air Variable Air Volume (VAV) system that provides heating, cooling, and ventilation outdoor air through a duct distribution system. Central heating is provided by two central natural gas-fired water-tube boilers. Plainfield Facilities has observed exterior tube pitting (Photo 1) and surface overheating of the water-tube boiler construction and has made some repairs. However, Plainfield should consider replacement of these boilers as soon as possible to avoid school shutdown during cold weather if the boilers fail.

Cooling water is provided by air-cooled chillers located on the roofs of PHS. Facilities also noted that the chillers' compressors have been failing and are being replaced as needed. The air-cooled chillers and Direct Expansion Refrigerant (DX) rooftop units may be located on the roof closer than installation requirements allow for necessary airflow movement (Photo 2). The reduced spacing may be causing compressor failures and reduced cooling output. Air-cooled chillers should be relocated elsewhere on the roof, or on the ground, to provide adequate spacing.

Facilities also noted Variable Frequency Drives (VFDs) for HVAC electric motors have been failing and need replacement. This replacement activity should continue so the VFDs can provide energy savings to the PHS. During any HVAC modification project, the existing VFDs should be reviewed by equipment representatives to ensure there is no installation or operational deficiency that could be causing early VFD failures.

PCS

The Plainfield Central Middle School is located adjacent to the Plainfield Memorial Elementary School. The PCS was built in 2 phases. The original building was built in 1980, and the addition was built in 1991. Existing heating is provided using only electric power in either resistance heaters or horizontal ceiling-mounted, or vertical wall-mounted, Unit Ventilators (UVs) with heat pumps. HVAC controls are pneumatic, and they should be replaced as soon as possible. These existing controls lack capability compared to modern electric controls; they leak compressed air that wastes electrical energy; repair parts are becoming obsolete; when they fail or are bypassed by simpler controls additional energy is wasted. For example, the pneumatic controls for the Cafeteria HVAC heating equipment may be failing. When heating controls fail, their failure mode is typically "open", "on," or "100% heat" so the space does not drop below freezing and operators realize something needs repair because the space becomes hot. Facilities also noted that some failed central pneumatic controls were replaced by simpler in-space thermostats to maintain space heating conditions without complete UV replacement.

PMS

The Plainfield Memorial Elementary School is similar to the Central Middle School - all electric heat; two sections of the building, original and new; UVs provide heating and ventilation to most spaces. Several HVAC upgrades have occurred recently, especially after an electrical fire occurred in 2018. The Cafeteria Rooftop Unit (RTU) was replaced and contains electric heat and DX cooling. RTUs also serve the Gymnasium/Auditorium, Media Room, and a large open multipurpose space on the second floor. This large space was a single HVAC thermal control zone, but it was divided into multiple enclosed spaces after the 2018 fire. Since these multiple spaces are combined into one HVAC zone and one thermostat, individual space control is not possible, and thermal comfort complaints may occur. Many UVs are beyond their useful life (NesbittAire, 1995), and their repair parts have become unavailable due to obsolescence. When the UVs eventually fail, Facilities has installed ductless split heat pumps to provide heating and cooling to that space. For example, the Guidance space is now served by an LG split system heat pump. Four or more single heat pump installations have been completed to date. The PMS does not have any central HVAC control system. In the Kitchen, the exhaust fans are leaking, and the Makeup Air Unit (MAU) was installed in 1991.

MES

The Moosup Elementary School is similar to the Central Middle School and the Plainfield Memorial School in many ways. MES has all electric heat; two sections of the building - the 1965 original, and the 1992 addition. The original building has pneumatic HVAC controls, while the 1992 addition has electric/computer HVAC controls. All electric UVs provide heating and ventilation, however, minimal cooling is provided by portable window air conditioning units in some spaces. Note that the Media space has an AHU that provides heating, ventilation air, and electric DX cooling. When the UV controls fail, the UVs are cycled on and off manually using switches or circuit breakers. The Cafeteria/Stage space has a high ceiling (20+ feet), and is heated by two unit heaters. Outdoor air can be provided by an Air Handling Unit (AHU) adjacent to the Stage. Return air moves from the space, under the Stage, to the AHU, while outdoor air is brought in through louver openings in the exterior wall and routed to the AHU. The Cafeteria/Stage space also contains portable air filtration units for infectious disease control. These units pass space air through a high-efficiency filter and discharge the air back into the space. Soon, larger air purification units that use ultra-violet light to destroy infectious agents will be installed in this space in place of the filtration units.

MES and Facilities has thoughtfully provided a list of space-by-space issues, as well as HVAC equipment information for our use (MES Appendix). The space-by-space list indicates many UVs and their thermostatic controls are failing and need of replacement. A dozen spaces provide HVAC control via manual on/off switching.

SHE

The Shepard Hill Elementary School has natural gas-fired hot water boilers that provide heating hot water to space finned-tube radiation units. The natural gas utility is also used for the school's alternate power generator, and for natural gas fired RTUs. The boiler room space is very warm indicating that the equipment and piping insulation needs to be repaired or replaced. Like other Plainfield schools. SHE has pneumatic HVAC controls that are unable to maintain multiple compressed air pressure levels that would provide occupied and unoccupied setpoints.

ECC

The Plainfield Early Childhood Center has a natural gas-fired hot water boiler that provides heating hot water to space finned-tube radiation units. Three AHUs are located in the attic. Each AHU provides heating, cooling and ventilation air to one floor of the building. HVAC controls are local, and not part of a central building control system. The cooling for each AHU is electric DX cooling. The outdoor condensing units for

the three AHUs are located on the ground in a fenced-in area. This area locates the units too close together which affects their operation, cooling output, and life expectancy.

The heating hot water boilers and a gas-fired potable water heater are located in the Boiler room. The boilers' and water heater's flues combine into a single flue routed vertically to the roof. The single flue contains a barometric relief damper that allow room air to enter the flue when the draft of the flue is greater than needed by the boilers and water heater. The damper in this room is in disrepair and has failed in the open position. The damper's open position has reduced the available draft of the flue that can cause the natural gas-fired equipment to operate outside of its normal operation, and can allow products of combustion to leak directly into the Boiler room. Combustion air fans provide combustion air to the boiler room. Plainfield should review these issues and make any necessary upgrades as soon as possible.

Proposed HVAC System Upgrades - Description

HVAC Controls

UPGRADE HVAC CONTROLS FROM PNEUMATIC TO ELECTRIC/COMPUTER

With the exception of the High School and the new wing in MES, the six schools assessed have pneumatic HVAC controls. These pneumatic controls should be replaced with electric/computer controls for the following reasons:

1. The existing pneumatic controls are failing and require significant repairs.
2. Parts for pneumatic controls continue to become more obsolete because electric/computer controls dominate HVAC control systems. This obsolescence makes repair more difficult and expensive.
3. Pneumatic controls use differences in compressed air pressure to turn on or off; or to change a setpoint. They are less capable than modern electric/computer controls that use electronic circuitry and software programs to control HVAC systems.
4. Pneumatic controls need compressed air to operate, and compressed air is expensive to generate. According to Facilities, compressed air leaks are common in the existing pneumatic controls system. Leaks degrade control performance and waste energy.
5. A more capable HVAC control system can improve occupant comfort and save significant energy by improving the operation of the existing HVAC equipment.

Funding for HVAC controls replacement may be obtained from government pandemic funds, or from Connecticut energy conservation programs. Furthermore, the energy efficiency improvements from electric/computer controls can create a short payback time that can be acceptable to most financial managers.

School	Cost Opinion for HVAC Controls Upgrades
PHS	\$ 0.00
PCS	\$ 771,100.00
PMS	\$ 496,200.00
MES	\$ 206,800.00
SHE	\$ 605,700.00
ECC	\$ 218,715.00

HVAC Commissioning

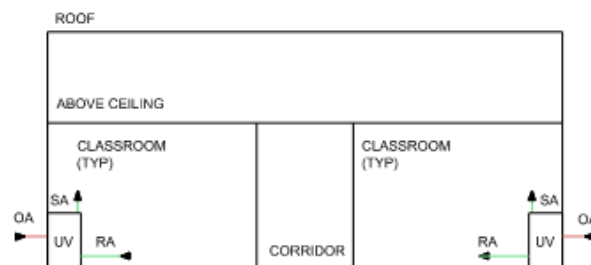
PERFORM EXISTING BUILDING COMMISSIONING (EBCx)

Although this HVAC assessment is comprehensive, there is information that more detailed investigations can obtain. An HVAC system EBCx effort is a detailed review and measurement of all operation modes for each HVAC system. Functional Performance Tests (FPTs) are defined, performed, and recorded to determine the detailed capability of each HVAC system in each school. The commissioning process arose from new building installations that did not operate as the Owner intended. Owner's Project Requirements (OPRs) are now documented before system design, and are checked by FPTs after construction, to ensure the building has been built and designed to the OPRs. Commissioning the Plainfield public school buildings will create an existing baseline of capabilities and deficiencies that become the detailed action plan for upgrades and repairs.

School	Cost Opinion for EBCx Services
PHS	\$ 186,500.00
PCS	\$ 113,100.00
PMS	\$ 72,800.00
MES	\$ 60,700.00
SHE	\$ 88,900.00
ECC	\$ 32,100.00

HVAC Equipment Upgrades

OPTION #1: REPLACE EXISTING UVs WITH NEW UVs CONTAINING ELECTRIC HEATING



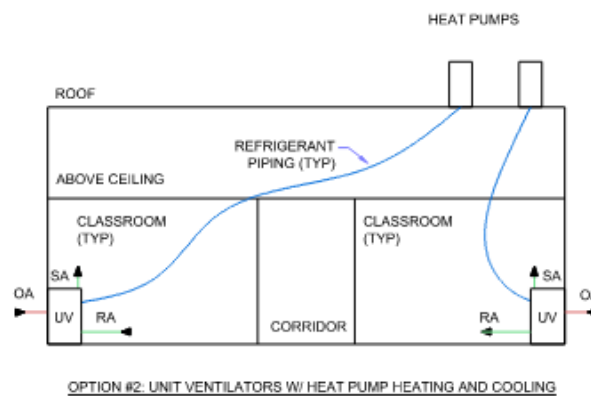
OPTION #1: UNIT VENTILATORS W/ ELECTRIC HEATING

Replacing the existing unit ventilators is the primary need in most of the schools due to their age and poor condition. Some failed UVs have been replaced by ductless split system heat pumps that provide both cooling and heating. However, outdoor ventilation air also needs to be conditioned and provided to the space.

Replacing the existing UVs with new UVs that can provide heating and ventilation air is the most economical way to provide both conditioning and outdoor air to the Plainfield school classrooms:

School	Cost Opinion for New UVs w/ Electric Heat
PHS	\$ 0.00
PCS	\$ 1,542,200.00
PMS	\$ 992,300.00
MES	\$ 827,000.00
SHE	\$ 1,211,300.00
ECC	\$ 0.00

OPTION # 2: REPLACE EXISTING UVs WITH NEW UVs CONTAINING HEAT PUMP HEATING AND COOLING



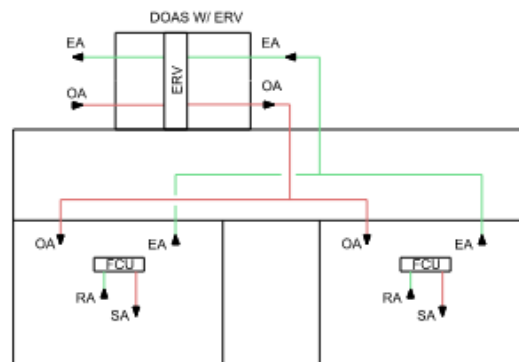
Today's unit ventilators have been significantly improved over the years. UVs can be purchased with electric and DX coils to provide heating and cooling. Furthermore, the DX coil can be connected to an outdoor heat pump, similar to the few already installed at PMS and PCS. The heat pump can provide heating and cooling at much higher efficiencies than an electric coil, which can act as a supplement and back up to heat pump heat. UVs can be also installed with local electric/computer controls that can communicate with a central Building Automation System (BAS). These electric/computer controls can

provide the UV with additional capabilities, such as operation in "free cooling" or "air purge" modes that can increase outdoor air intake to 100% of the supply air flow rate.

Replacing the existing UVs with new UVs that can provide heating, cooling, and ventilation air will achieve Plainfield's goal of adding cooling to the schools' existing heating and outdoor air capabilities while renewing the HVAC systems for another 20 year life span:

School	Cost Opinion for New UVs w/ Heat Pump Heating and Cooling
PHS	\$ 0.00
PCS	\$ 2,159,000.00
PMS	\$ 1,389,200.00
MES	\$ 1,157,700.00
SHE	\$ 1,695,900.00
ECC	\$ 0.00

OPTION #3: REPLACE EXISTING UVs WITH DEDICATED OUTDOOR AIR SYSTEMS FOR VENTILATION AND FAN COIL UNITS FOR ELECTRIC HEATING



OPTION #3: DOAS & FCUs w/ ELECTRIC HEATING

The primary deficiency of unit ventilators is their continued high level of sound output. The American National Standards Institute (ANSI) has developed Standard S 12.60 for Classroom Acoustics using extensive research that shows classroom sound levels directly impact a student's ability to learn. Excessive sound in the classroom decreases the ability to understand a teacher's instruction. Also, younger students have a lower learning disruption threshold than older students, requiring a quieter classroom. In 2005 Connecticut

adopted S 12.60 as a design requirement for new school buildings, with allowable exceptions. This statute appears to still be in force. ANSI S 12.60 limits any classroom sound source to a maximum sound pressure level of 35 dBA. Most unit ventilators have a higher sound pressure level than 35 dBA at their lowest fan speed.

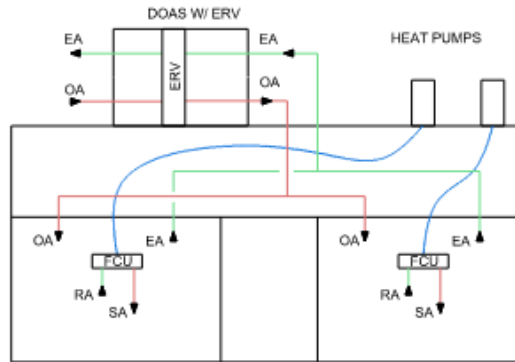
A UV replacement approach that separates outdoor ventilation air from space heating and cooling can be designed to meet ANSI S 12.60. The outdoor air is conditioned by a Dedicated Outdoor Air System (DOAS) and then distributed to multiple spaces. In each space, separate equipment will provide heating or cooling as necessary. One example of this separate heating and cooling equipment is the split system heat pumps that Plainfield has already introduced into some schools. Note that split systems get their name because the outdoor unit is separated, or split, from the indoor unit. Both units are connected by refrigerant piping that provides the energy transfer.

Both the DOAS and the heat pump split systems can deliver air to the space through ductwork. Using sound attenuating HVAC system design, the sound from the DOAS and indoor heat pump unit can be reduced to at or below the 35 dBA equipment goal.

To reduce the initial cost of switching to a separated DOAS - Heat Pump HVAC system, heating only can be provided to the classrooms using an economical fan coil unit with electric heat:

School	Cost Opinion for New DOASs w/ Fan Coil Unit Electric Heating
PHS	\$ 0.00
PCS	\$ 1,799,200.00
PMS	\$ 1,686,900.00
MES	\$ 964,800.00
SHE	\$ 1,413,200.00
ECC	\$ 0.00

OPTION #4: REPLACE EXISTING UVs WITH DEDICATED OUTDOOR AIR SYSTEMS FOR VENTILATION AND HEAT PUMPS FOR HEATING AND COOLING



OPTION #4: DOAS & FCUs w/ HEAT PUMP HEATING AND COOLING

A DOAS - Heat Pump system's initial cost is more expensive than Option #3, but the heat pump's gain in energy efficiency over electric resistance heat can lead to significant energy savings:

School	Cost Opinion for New DOASs w/ Heat Pump Heating and Cooling
PHS	\$ 0.00
PCS	\$ 3,238,600.00
PMS	\$ 2,083,800.00
MES	\$ 1,736,600.00
SHE	\$ 2,543,800.00
ECC	\$ 0.00

CUSTOM SOLUTIONS - PHS - BOILERS, VFDs, and ACCs

The Plainfield High School has central electric/computer HVAC controls, as well as HVAC systems that provide outdoor air ventilation, heating and cooling. Built in 2005, some of the HVAC equipment is at or beyond its useful economic life and needs to be replaced. For example the VFDs controlling HVAC electric motors are failing and need replacement. On the other hand, the central boilers have had issues since installation, and should be replaced before the issues become unrepairable. Similarly, the rooftop installed air-cooled chillers (ACCs) have their own installation issues that affects their performance and component lifespan. ACC replacement should be considered to avoid operational issues and rising repair costs. Please note that the cost opinion for ACC replacement is conservative to provide a maximum budget amount.

When detailed engineering knowledge is obtained during project design, the cost opinion will be optimized. Also note that the ACC replacement budget is based upon a specific design concept, namely relocating ACCs to the ground. Other design concepts, such as replacing the ACCs with a water-cooled chiller plant, may be as cost effective and will produce long-term equipment replacement and energy use savings.

Project	Cost Opinion for PHS Project
Replace VFDs	\$ 85,800.00
Replace Boilers	\$ 422,200.00
Replace Air-Cooled Chillers	\$ 1,451,000.00

CUSTOM SOLUTIONS - ECC - BOILER FLUE DEFICIENCIES, MULTI-ZONE SYSTEMS

The Early Childcare Center has one all-air HVAC system per floor that provides ventilation and cooling but has no multi-zone capability. One control point per floor will likely lead to comfort issues. Changing the system would be difficult because the air handling units are located in the attic, with little or no space for removing or installing equipment. However, by installing some Variable Air Volume (VAV) terminal devices, fan VFDs, and multi-zone controls, each floor can be broken into multiple HVAC control zones that will improve comfort while reducing fan energy.

Project	Cost Opinion for ECC Projects
Repair Boiler Flues and Combustion Air Fans	\$ 50,800.00
Install VAV System on all Floors	\$ 560,000.00