Energy Efficiency Study

Final Report

Prepared for:

Town of Canaan

Canaan, NY

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C&S Engineers, Inc.

Albany, NY

NYSERDA-Approved FlexTech Consultant

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For questions regarding this report or other programs offered by NYSERDA, please contact Joanna Moore at 866-697-3732 extension 3220 or by email at jml@nyserda.org.

We hope the findings of this report will assist you in making decisions about energy efficiency improvements in your facility. Thank you for your participation in this program.

NOTICE

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State of New York

Kathy Hochul, Governor

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Executive Summary

Recommended Measure Summary				
Measure Name	Cost	Savings	Carbon Savings (MT)	Simple Payback (years)
1a - Town Hall HVAC Upgrade*	$ 1,244	$ 329	0.05	3.8
3 - Additional Insulation	$ 5,807	$ 295	1.3	19.7
4 - Temperature Setbacks	$ 575	$ 567	2.8	1.0
Total	**$ 7,626**	**$ 1,191**	**4.2**	**6.4**

**The cost is the incremental cost of replacing the units at the end of their useful life*

A more detailed summary with costs and energy savings for all of the measures can be found at the end of this report in Appendix A: Project Summary Sheet.

The purpose of this report is to identify and evaluate opportunities for energy conservation for the Town of Canaan. This report is the final product of an energy conservation study performed through the NYSERDA FlexTech program.

The following is a brief description of all the Energy Conservation Measures (ECMs) identified and evaluated in this report, their estimated costs, their estimated savings, a simple payback for the measures, as well as C&S's recommendations, for more details see the Energy Conservation Measures section later in this report:

- **1a – Town Hall HVAC Upgrade –** This measure investigates replacing both the courtroom AC system with new, more efficient units.

- **1b – Highway Garage HVAC Upgrade –** This measure investigates replacing the AHU in the highway garage with a new, more efficient AHU which utilizes heat pump technology to provide both cooling and heating.

- **2a – Condensing Boiler –** This measure investigates the replacement of the existing fuel-oil boilers with new, high efficiency condensing boilers at both facilities.

- **2b – Electric Boiler –** This measure investigates the replacement of the existing fuel-oil boilers with new, electric boilers at both facilities.

- **2c – Air to Water Heat Pump –** This measure investigates the replacement of the existing fuel-oil boilers with new, heat pump boilers at both facilities.

- **3 – Additional Insulation –** This measure investigates adding additional insulation to the building envelope of the Highway Garage.

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- **4 – Temperature Setbacks –** This measure investigates replacing the existing thermostat with a programmable thermostat in the lower floor of the Town Hall, to reduce the room temperature set points during the unoccupied hours of the heating season.

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Table of Contents

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Background

The Town of Canaan, NY is currently looking to improve the energy efficiency of their facilities, as well as to earn points towards the Climate Smart Communities program. The Town of Canaan has engaged C&S Engineers Inc. (C&S) to perform a targeted level II energy audit, with the goal of quantifying the energy savings, costs, and payback from these improvements.

The following report is the result of a targeted ASHRAE Level II energy audit focused on the buildings and equipment located at the Canaan Town Hall and Highway Garage. This audit is in accordance with the NYSERDA FlexTech program. C&S Engineers Inc. is a NYSERDA approved FlexTech provider and has performed many similar energy studies through the FlexTech program.

Overview

C&S Engineers, Inc. carried out an ASHRAE Level II evaluation, which estimated the costs, and potential energy savings that could be realized by implementing a number of energy conservation measures at the facility. A more detailed explanation can be found in the “Energy Conservation Measures” section below.

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Facility Information

The Town of Canaan owns both the Canaan Town Hall and the Highway Garage.

The Canaan Town Hall is a one story, 6,000 square foot building. A 157 MBH fuel-oil boiler provides heat to the building by sending hot water to radiators located throughout the building. There are two thermal zones, the downstairs and the upstairs, however the court office is part of the downstairs system despite its location upstairs. The only cooling in the facility is located in the courtroom and the two upstairs bathrooms. Two separate AC systems serve the space, they each have an estimated capacity of 4.5 tons. The AC system is split into two zones; one that makes up the left half of the courtroom and the other, which makes up the right half of the courtroom, as well as the two bathrooms. Due to the way the zoning is set up, there are three separate thermostats in the courtroom: one for the heating and two for the AC. The typical operating hours for the facility is from 9:30am – 2:30pm on Monday, Wednesday, Thursday, and Friday. Meetings and court sessions also meet periodically in the building during the evening hours.

The Highway Garage is a 4,360 square foot building. It contains space for vehicle and equipment storage, as well as a small office. The Highway Garage is open from 7:30am to 3:30pm on weekdays; however, most of the highway workers typically leave the building in the morning to work on the roads. A fuel-oil boiler, which has an estimated heating capacity of 242 MBH, provides heat to the building by sending hot water to three 45.6 MBH unit heaters and one AHU. The unit heaters provide heat to the vehicle bays and tend to stay on for almost the entirety of the heating season. The AHU provides the office area with 63 MBH of heating and an estimated 2.5 tons of cooling at 1000 CFM. The exhaust system in the vehicle bays were plugged up with insulation some time ago and they are no longer operational. Whenever painting or vehicle maintenance is occurring, the doors are kept open to provide ventilation, which lets out all the conditioned air. However, even with the doors open, the fumes can be smelled in the office.

In addition, the Highway Garage has a rodent problem, which has caused extensive damage to both the walls and the insulation of the building. The rats travel through the walls, packing down insulation as well as consuming it. Their urine is corrosive enough that parts of the walls have started to rust out. Because of this issue, as well as the 2011 building add-on, the R-value of each wall in the facility varies greatly. The Superintendent of Highways, Bernhard Meyer, provided C&S with a rough estimate of the R-value around his facility. This information is shown in the graphic below; it should be noted that this image is not drawn to scale.

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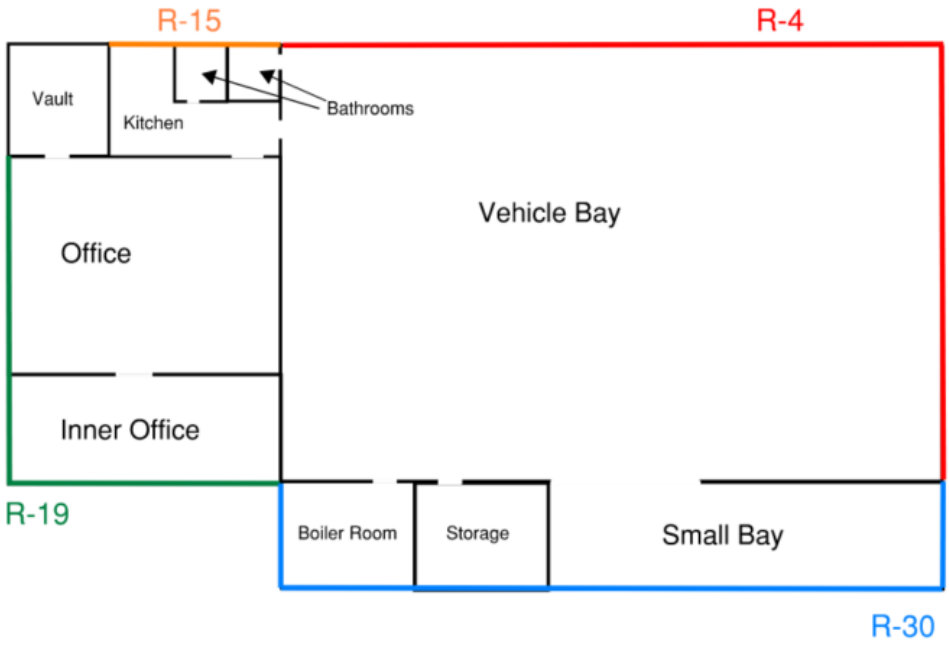

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Utility Analysis

NYSEG is the electric utility provider for the Town Hall and charges the Town at two different rates. One of these is a "Non-Resident Demand" rate, which includes both the electrical supply and demand costs, covering two months each. The other is a "Non-Residential Regular" rate, which only includes supply costs on a monthly basis. Fuel oil is purchased from Main-Care Energy. The Town of Canaan was able to provide utility information throughout 2021, with the exception of two "Non-Residential Regular" NYSEG bills from August and September. The following is a utility analysis for the Town Hall, based off their 2021 utility bills. Values in red are missing "Non-Residential Regular" NYSEG bills.

Town Hall:

Town Hall							
Month	Electrical Demand (kW)	Electrical Supply (kWh)	Fuel Oil Usage (Gal)	kW Costs	kWh Costs	Misc Electricity Costs	Fuel Oil Costs
Jan-21	9.96	721	173.80	$381.54	$146.66	$46.41	$288.09
Feb-21		720	218.70		$74.89	$46.40	$411.18
Mar-21		721	184.10		$75.08	$46.41	$376.12
Apr-21		795	-		$88.53	$47.16	$0.00
May-21	10.68	745	204.90	$221.09	$92.89	$53.36	$427.07
Jun-21		741	-		$91.72	$53.52	$0.00
Jul-21	12.48	1,531	-	$259.96	$218.86	$63.56	$0.00
Aug-21		1,488	-		$210.71	$44.41	$0.00
Sep-21	12.48	552	-	$260.01	$91.83	$35.59	$0.00
Oct-21		578	-		$97.97	$54.65	$0.00
Nov-21	4.44	776	120.30	$93.00	$141.06	$58.00	$299.33
Dec-21		1,610	-		$149.12	$58.46	$0.00
Total	**N/A**	**10,978**	**901.8**	**$1,215.60**	**$1,479.28**	**$607.89**	**$1,801.79**

Utility Rates	
$24.29	$/kW
$0.13	$/kWh
$2.00	$/Gal

Annual Utility Costs	
Electric	$3,302.77
Fuel Oil	$1,801.79
Total	**$5,104.56**

Building Energy Usage Index (EUI): 27.1

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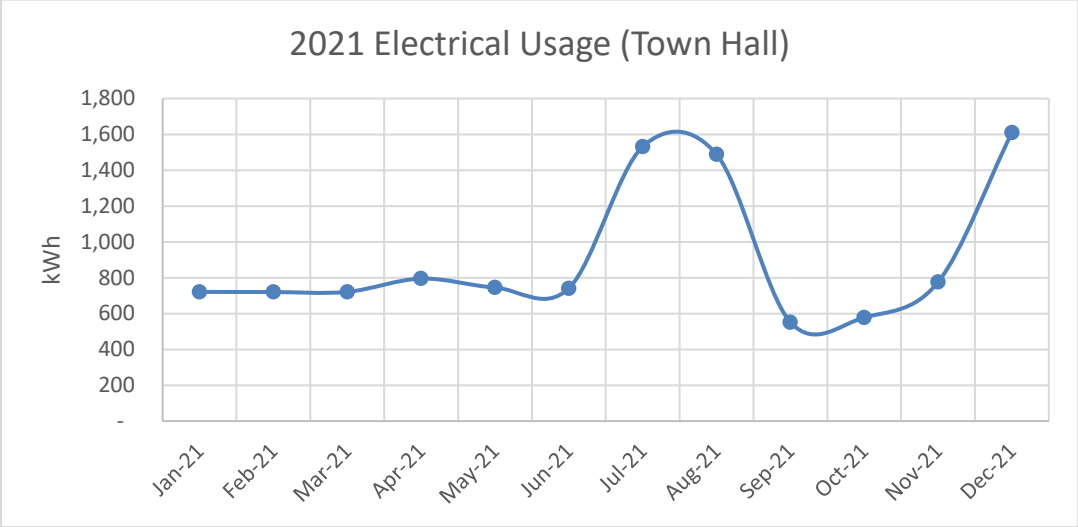

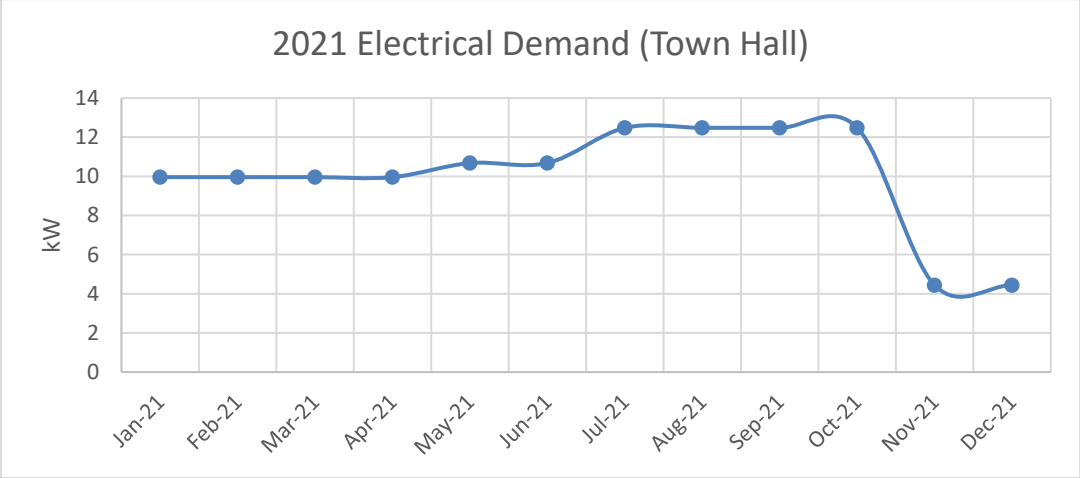

These graphs show the total electric usage and demand for the Town Hall. The energy used per month ranges between 500 to almost 1,600 kWh, varying depending on the time of year. The usage is highest during the summer months, peaking in July. The demand follows roughly the same trend as the usage, excluding the spike seen in December 2021. This spike in electric usage does not appear to be a result of plug-in electric heating, due the drop in demand that accompanies it. Rather, this trend is more indicative of lighting or equipment being left on for an abnormally long period of time.

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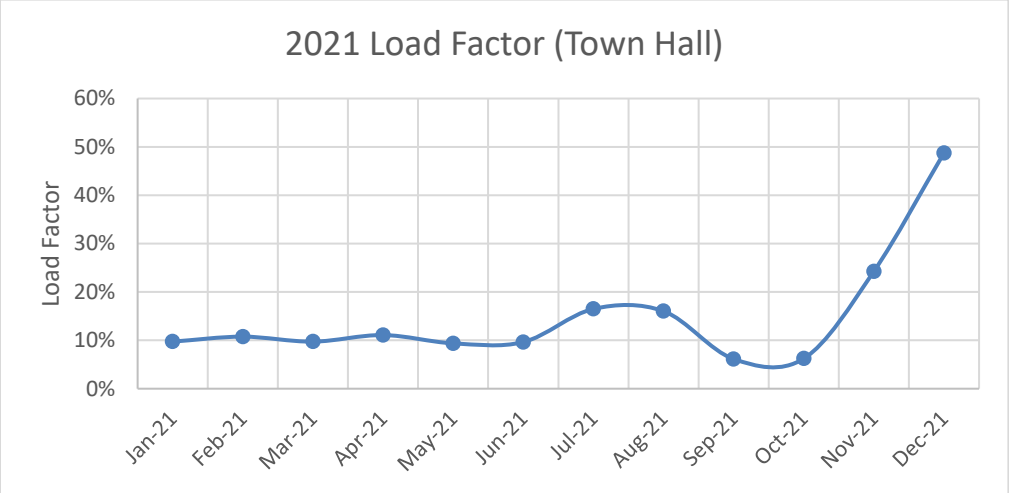
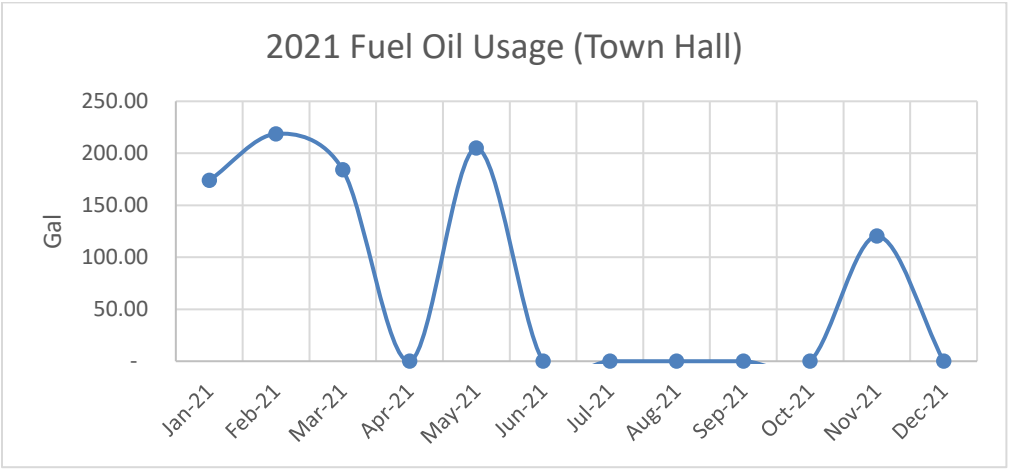


This third graph shows the load factor of the Town Hall. The load factor can be described as the percentage of the total possible electric usage in a month based off the peak demand. A low load factor can indicate that equipment and lighting are turned off when not in use and when areas are unoccupied; a high load factor indicated the opposite. This graph shows that the load factor ranges from 7% to 48%. For the majority of the year, the load factor is under 20%. The spike in November and December may possibly be attributed to changes in operation where equipment or lights were sometimes left on past closing.



This graph shows the fuel oil usage at the Town Hall over the course of the year. It should be noted that fuel oil is purchased in bulk, stored in a tank in the facility, and is used as needed. As the tank gets low, more fuel oil is purchased. As a result of how this process works, the utility bills are not the best method for looking into the usage trends of a facility, given that only refills are monitored. From the graph, it is easy to see that there was more fuel oil consumed during the colder months, because more purchases were made during that time.

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NYSEG is the electric utility provider for the Highway Garage and charges the Town at two different rates. One of these is a "Non-Resident Demand" rate, which includes both the electrical supply and demand costs, covering two months each. The other is a "Non-Residential Regular" rate, which only includes supply costs on a monthly basis. However, NYSEG's first "Non-Residential Demand" bill of the year covered six months instead of the usual two. Fuel oil is purchased from Kosco Heritage Energy. The Town of Canaan was able to provide utility information throughout 2021. The following is a utility analysis for the Highway Garage, based off their 2021 utility bills.

Highway Garage:

Highway Garage							
Month	Electrical Demand (kW)	Electrical Supply (kWh)	Fuel Oil Usage (Gal)	kW Costs	kWh Costs	Misc Electricity Costs	Fuel Oil Costs
Jan-21	10.28	5,569	296.1	$620.71	$563.28	$194.66	$535.05
Feb-21			504.9				$1,003.54
Mar-21			276.1				$600.24
Apr-21			-				$0.00
May-21			-				$0.00
Jun-21			-				$0.00
Jul-21	8.94	864	-	$186.23	$108.80	$65.37	$0.00
Aug-21			-				$0.00
Sep-21	4.98	1,003	-	$103.75	$167.11	$69.93	$0.00
Oct-21			246.4				$635.71
Nov-21	10.19	2,366	155.3	$213.45	$425.17	$89.72	$429.72
Dec-21			133.8				$338.43
Total	**N/A**	**9,802**	**1,612.6**	**$1,124.14**	**$1,264.36**	**$419.68**	**$3,542.69**

Utility Rates	
$32.69	$/kW
$0.13	$/kWh
$2.20	$/Gal

Annual Utility Costs	
Electric	$2,808.18
Fuel Oil	$3,542.69
Total	**$6,350.87**

Building Energy Usage Index (EUI): 59.1

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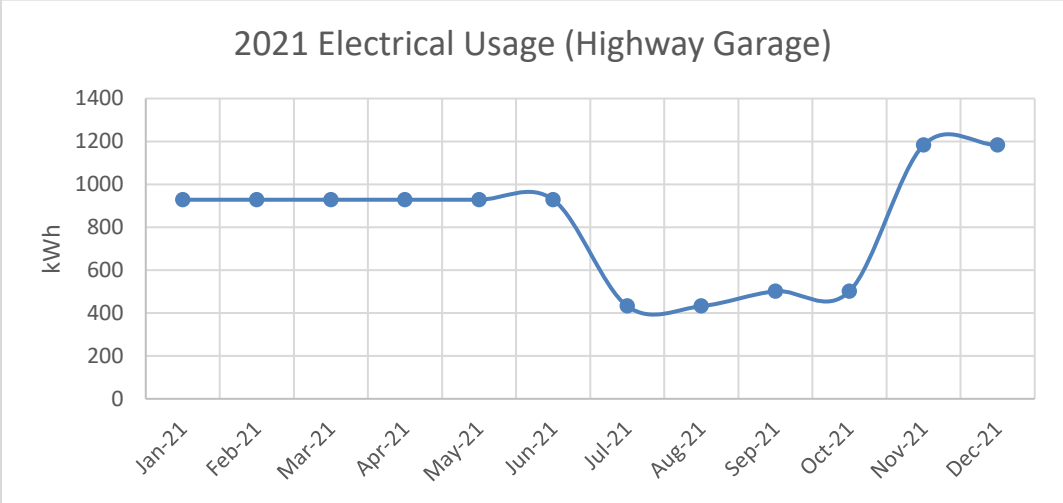

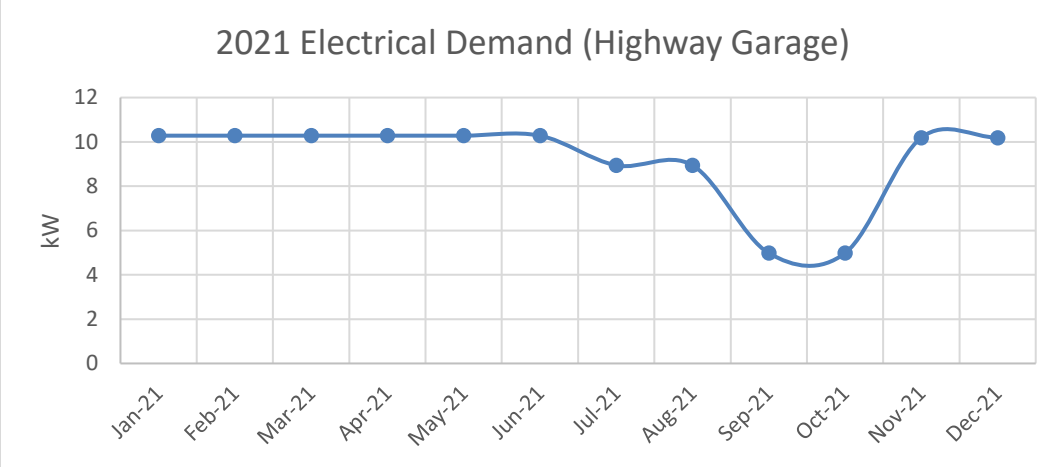

The 2021 NYSEG bills for the Highway Garage did not have electrical usage or demand broken down on a monthly basis. Instead the first six months of the year were lumped together and billed. This lumped billing occurring for the rest of the year, every other month for a two-month span. The trends above show electrical usage and demand drops from July to October. This is likely due the relatively nice weather during this time of the year, which makes it an excellent time to go out and repair the roads. As a result, there is less people in the Highway Garage over the course of the day.

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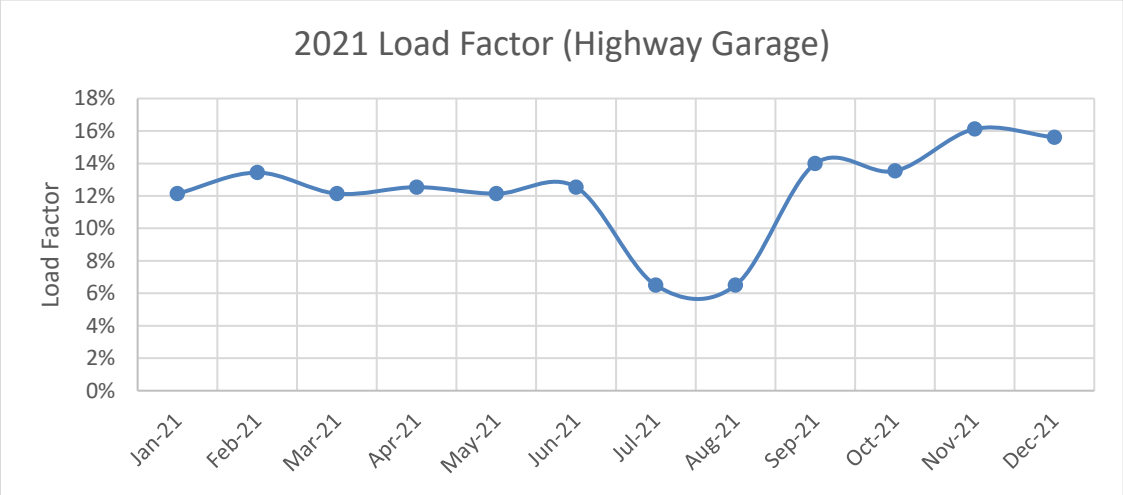
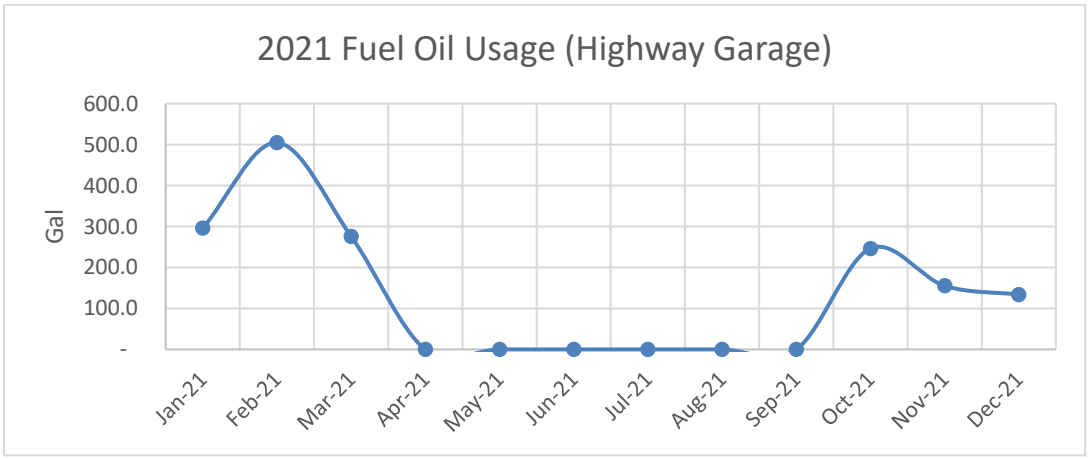


This third graph shows the load factor of the facility. The load factor can be described as the percentage of the total possible electric usage in a month based off the peak demand. A low load factor can indicate that equipment and lighting are turned off when not in use and when spaces are unoccupied; a high load factor indicates the opposite. This graph shows that the load factor ranged from 6% to 16%, and is fairly consistent throughout the year. There is a slight dip in July and August, likely due to people generally not using the facility as much. This is typically the time of year that road repair projects are undertaken, due to the favorable weather. Overall this facility has a low load factor, indicating that the electrically powered equipment in the Highway Garage is turned off while the building is unoccupied.



This graph shows the fuel oil usage at the Highway Garage over the course of the year. It should be noted that fuel oil is purchased in bulk, stored in a tank in the facility, and is used as needed. As the tank gets low, more fuel oil is purchased. As a result of how this process work, the utility bills are not the best method for looking into the usage trends of a facility, given that only refill are monitored. From the graph, it is easy to see that there was more fuel oil consumed during the colder months, because more purchases were made that were reported with the utility bills

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Energy Conservation Measures

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1a – Town Hall HVAC Upgrades

Summary:

Measure Summary									
Unit	kWh Savings	kW Savings	Therm Savings	Carbon Savings (MT)	Cost Savings	Cost	Incremental Cost	Simple Payback (years)	Incremented Simple Payback (years)
Courtroom AC-1	131	6	0	0.02	$165	$9,703	$622	59.0	3.8
Courtroom AC-2	131	6	0	0.02	$165	$9,703	$622	59.0	3.8
Total	**262**	**12**	**0**	**0.05**	**$329**	**$19,405**	**$1,244**	**59.0**	**3.8**

This measure is recommended once the units become inoperable. This is due to the small incremental cost, which is the difference in price between installing a similar unit versus a more efficient unit.

Background:

In the Town Hall, the HVAC system is comprised of an oil-fired boiler that feeds radiators throughout the building and two split-system ACs with indoor air handler units (AHUs). Below is a detailed table of the existing equipment relevant to this measure.

Equipment Type	Cooling Capacity (Tons)	Cooling Efficiency (SEER)	Heating Capacity (MBH)	Heating Efficiency
Courtroom Split System AC 1	4.5	10	N/A	N/A
Courtroom Split System AC 2	4.5	10	N/A	N/A

It should also be noted that the existing units use R-22 refrigerant. R-22 is an ozone depleting refrigerant and as of January 1st, 2020 is no longer allowed to be produced in or imported to the United States. The banning of R-22 could make maintaining these units prohibitively expensive. In addition, according to the New York State Technical Resource Manual (NYSTRM), the average useful life of AC systems is 15 years. These units appear to have been installed in 2005, making them 17 years old. Given the minimal and sporadic use of these systems, it is unclear how much longer these units will remain operable.

This measure looks into replacing the AC system in the Town Hall in-kind with new, more efficient systems. Below is a detailed table of the proposed equipment.

Equipment Type	Cooling Capacity (Tons)	Cooling Efficiency (SEER)	Heating Capacity (MBH)	Heating Efficiency
Courtroom Split System AC 1	4.5	16	N/A	N/A
Courtroom Split System AC 2	4.5	16	N/A	N/A

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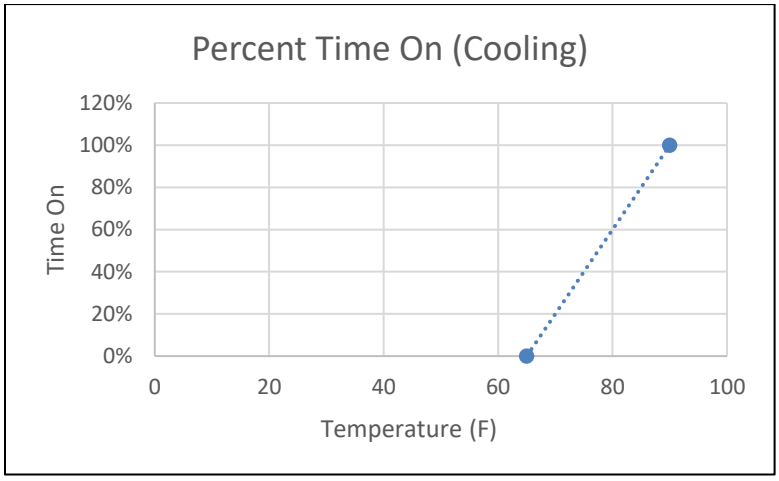
Evaluation:

C&S gathered information from each of these units' nameplates and talked with the facility staff to understand how the existing units were operating. C&S placed a total of twenty temperature sensing data loggers, of which six also had CO2 logging capabilities. Of the twenty sensors, three were collecting data on the discharge air temperature and the room temperature in order to determine how the units were operating from 11/19/2021 through 12/17/2021. C&S was also able to use bin weather data available from the nearby Albany International Airport to estimate typical outdoor air temperatures during operating hours. Unlike the rest of the facility, the courtroom AC system is only active during the cooling season when court or meetings are taking place. Due to the irregular nature of these meetings, it is assumed that the space is occupied from 7p-9p on Mondays, 4p-9p on Tuesdays, and 6p-9p on Thursdays. This data was combined in order to determine what percentage of the time the units were running, which is shown below.



Due to the time of year of the study, C&S was unable to collect any meaningful data on these unit's cooling performance. Instead, a linear approximation was used for the cooling trends. It assumes that the unit is in cooling mode 100% of the time when the outdoor air temperature is 90°F or above, and 0% of the time when the outdoor air temperature is 65°F or below, and varies linearly between these two points.

C&S calculated the energy that would be saved by replacing the AC systems in the Town Hall courtroom in-kind with more efficient units.

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Recommendation:

This measure is recommended once the units become inoperable. This is due to the small incremental cost associate with purchasing a more efficient air conditioning system.

Implementation Information:

C&S recommends engaging a qualified mechanical contractor to handle this replacement.

Energy/Economic Analysis:

The cost savings calculation is calculated below for replacing one of the split AC systems.

kWh Savings = Tons X ((C1/SEER-e) - (C1/SEER-p)) X HR
kW Savings = Tons X ((C1/SEER-e) - (C1/SEER-p)) X M

Where:

Symbol	Value	Units	Description
Ton	4.5	Tons	Cooling Capacity
SEER-e	10	(kBTU/hr)/kW	Existing Efficiency
SEER-p	16	(kBTU/hr)/kW	Proposed Efficiency
HR	65	Hours	Cooling Hours
C1	12	kBTU/ton	Conversion Factor
M	3	Months	Months

Therefore:

kWh Savings = 131 kWh
kW Savings = 6 kW

Savings ($) = kWh Savings X $/kWh + kW Savings X $/kW

Where:

Symbol	Value	Description
$/kWh	$0.13	Cost per kWh
$/kW	$24.29	Cost per kW

Therefore:

Savings = $164.60

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The carbon emissions savings associated with this is shown below.

Carbon Savings = (Elec X C1)

Where:

Symbol	Value	Units	Description
Elec	131.1	kWh	Electricity Saved
C1	0.00018	MT of CO2/kWh	NYS Carbon Dioxide Emissions Coefficient

Therefore:

Carbon Savings = 0.02 MT

The cost estimate for replacing one of the existing AC systems in the Town Hall is calculated below. Note that the cost of any lifting equipment is not included in this estimate.

1a - Town Hall HVAC Upgrade				
Item	Material	Labor	Quantity	Total
Demolition	$ -	$ 867.66	1	$ 867.66
Installation	$ 3,733.30	$ 1,889.04	1	$ 5,622.34
Equipment Rental	$ -	$ -	1	$ -
Notes: Costs are from RSMeans Mechanical 2022 and include location factor multipliers for nearby Pittsfield, MA			OHP (15%)	$ 973.50
			Sub Total	$ 7,463.50
			Design Cost (10%)	$ 746.35
			Contingency (20%)	$ 1,492.70
			Total	**$ 9,702.55**

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The following chart shows a simple incremental payback calculation used to show how long replacing this measure would take to pay for itself. This is calculated by dividing the incremental cost by the annual savings. The incremental cost is the difference in price between installing a similar unit versus a more efficient unit.

Incremental Simple Payback Summary	
Incremental Cost	$1,244.43
Annual Savings	$329.20
Simple Payback (years)	3.8

Assumptions:

1. The cooling capacity of the courtroom AC system is between 4-5 tons, these calculations assume a cooling capacity of 4.5 tons.

2. These units are estimated to be in cooling mode 0% of the time when the outdoor air temperature is 65°F. They are in cooling mode 100% of the time when the outdoor air temperature is 90°F, and the percentage of cooling varies linearly between these two temperatures.

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1b – Highway Garage HVAC Upgrades

Summary:

Measure Summary									
Unit	kWh Savings	kW Savings	Fuel Oil Savings	Carbon Savings (MT)	Cost Savings	Cost	Incremental Cost	Simple Payback (years)	Incremented Simple Payback (years)
Garage AHU	-4647.22	-43	450	3.7	-$653	$10,657	$636	N/A	N/A

This measure is not recommended due to the negative cost savings associated with it. However, at the end of the unit's useful life, the incremental cost for installing the proposed unit is relatively small. This might be an easy way to begin the transition off fossil fuels.

Background:

In the highway garage, the HVAC system is made up of a single AHU that uses hot water from the boiler to provide heating to the office and kitchen areas. The vehicle bay of the facility also has three hot water unit heaters which heat the space.

This measure looks into replacing the existing AHU, which has a cooling capacity of 2.5 tons and a heating capacity of 63 MBH. Currently, it has a cooling efficiency of 13 SEER and the heating efficiency is assumed to be the same as the boiler; 87% AFLU. The proposed unit will utilize air-source heat pump technology for both heating and cooling, bringing the cooling efficiency up to at least 16 SEER and the heating capacity to at least 10 HSPF.

According to the NYSTRM, these units have a typical useful life of 15 – 20 years. This unit will likely reach the end of its useful life in the next 4 – 8 years.

Evaluation:

C&S gathered information from each of these units' nameplates and talked with the facility staff to understand how the existing units were operating. C&S placed a total of twenty temperature sensing data loggers, of which six also had CO2 logging capabilities. Of the twenty sensors, two were collecting data on the discharge air temperature and the room temperature in order to determine how the units were operating from 11/19/2021 through 12/17/2021. C&S was also able to use bin weather data available from the nearby Albany International Airport to estimate typical outdoor air temperatures during operating hours. This data was combined in order to determine what percentage of the time the units were running, which is shown below.

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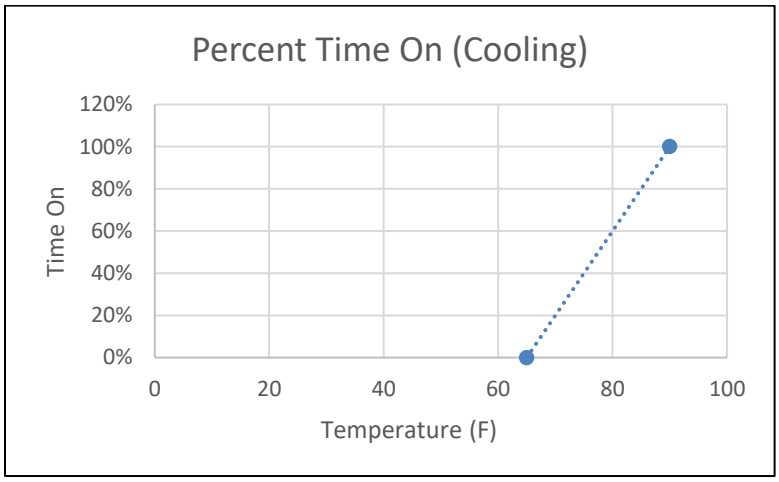

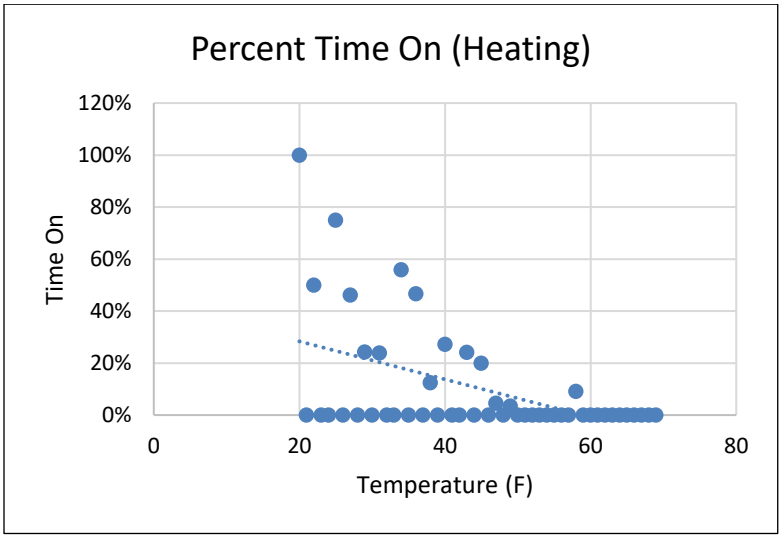

This data shows that during the heating season, the units ran 43% of the time at 0F and 6% of the time at 50F. Since these units are manually switched off until outdoor air temperatures reach about 20°F, the units are assumed to be off whenever the outdoor air temperature is below 50°F.

Due to the time of year of the study, C&S was unable to collect any meaningful data on these unit's cooling performance. Instead, a linear approximation was used for the cooling trends. It assumes that the unit is in cooling mode 100% of the time when the outdoor air temperature is 90°F or above, and 0% of the time when the outdoor air temperature is 65°F or below, and varies linearly between these two points.

C&S calculated the energy that would be saved by replacing the AHU in the Highway Garage with a more efficient unit.

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Recommendation:

This measure is not recommended due to the negative cost savings associated with it. However, at the end of the unit's useful life, the incremental cost for installing the proposed unit is relatively small. This might be an easy way to begin the transition off fossil fuels.

Implementation information:

C&S recommends engaging a qualified mechanical contractor to handle this replacement.

Energy/Economic Analysis:

The cost savings calculation is calculated below for this measure.

Cooling Savings

kWh Savings = Tons X ((C1/SEER-e) - (C1/SEER-p)) X HR

kW Savings = Tons X ((C1/SEER-e) - (C1/SEER-p)) X M

Where:

Symbol	Value	Units	Description
Ton	2.5	Tons	Cooling Capacity
SEER-e	13	(kBTU/hr)/kW	Existing Efficiency
SEER-p	16	(kBTU/hr)/kW	Proposed Efficiency
HR	1,938	Hours	Cooling Hours
C1	12	kBTU/ton	Conversion Factor
M	3	Months	Months

Therefore:

kWh Savings =	839	kWh
kW Savings =	1	kW

Savings ($) = kWh Savings X $/kWh + kW Savings X $/kW

Where:

Symbol	Value	Description
$/kWh	$0.13	Cost per kWh
$/kW	$24.29	Cost per kW

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Therefore:

Savings = $140.54

Heating Savings

Fuel Oil Savings = (MBH X HR-h)/(Eff-e X C1)

Symbol	Value	Units	Description
MBH	63	MBTU/hours	Heating Capacity
Eff-e	0.87	N/A	Existing Heating Efficiency
HR-h	871	Hours	Heating Hours
C1	140	MBTU/Gal	Conversion Factor

Therefore:

Fuel Oil Savings = 450 Gal

Savings ($) = Fuel Oil Savings X $/Gal

Where:

Symbol	Value	Description
$/Gal	$2.20	Cost per Gallon

Therefore:

Savings = $990.86

Additional Cost of Electricity

kWh Savings = (MBH X HR)/(HSPF X C1 X C2)

kW Savings = (MBH X M)/(HSPF X C1 X C2)

Where:

Symbol	Value	Units	Description
MBH	63	MBTU	Heating Capacity
HSPF	10	BTU/W	Coefficient of Performance
HR	871	Hours	Heating Hours
M	7	Months	Months of Heating
C1	0.001	MBTU/BTU	Conversion Factor
C1	1,000	W/kW	Conversion Factor

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kWh Savings = -5,486 kWh
kW Savings = -44 kW

Savings ($) = (kWh Savings X $/kWh) + (kW Savings X $/kW)

Where:

Symbol	Value	Description
$/kWh	$0.13	Cost per kWh
$/kW	$24.29	Cost per kW

Therefor:

Savings = -1784.34

Total Savings = -$652.93

The carbon emissions savings associated with this is shown below.

Carbon Savings = (F X C1) + (Elec X C2)

Where:

Symbol	Value	Units	Description
F	450	Gal. Fuel Oil	Fuel Oil Savings
C1	0.01	MT of CO2/Gal Fuel Oil	Carbon Dioxide Emissions Coefficient
Elec	-946	kWh	Electricity Saved
C2	0.00018	MT of CO2/kWh	NYS Carbon Dioxide Emissions Coefficient

Therefore:

Carbon Savings = 4.4 MT

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The cost estimate for replacing the existing AHU in the Highway Garage is calculated below. Note that the cost of any lifting equipment is not included in this estimate.

1b - Highway Garage HVAC Upgrade				
Item	Material	Labor	Quantity	Total
Demolition	$ -	$ 588.01	1	$ 588.01
Installation	$ 4,651.49	$ 1,889.04	1	$ 6,540.53
Equipment Rental	$ -	$ -	1	$ -
Notes: Costs are from RSMeans Mechanical 2022 and include location factor multipliers for nearby Pittsfield, MA			OHP (15%)	$ 1,069.28
			Sub Total	$ 8,197.82
			Design Cost (10%)	$ 819.78
			Contingency (20%)	$ 1,639.56
			Total	**$ 10,657.17**

Due to the negative annual cost savings associated with this, there is no simple payback period associated with this measure.

Assumptions:

1. As determined by trend data collected from the temperature loggers, the garage AHU is in heating mode 6% of the time when the outdoor air temperature is 50°F. It is in heating mode 43% of the time when the outdoor air temperature is 0°F, and the percentage of heating varies linearly between these two temperatures.

2. These unit is estimated to be in cooling mode 0% of the time when the outdoor air temperature is 65°F. They are in cooling mode 100% of the time when the outdoor air temperature is 90°F, and the percentage of cooling varies linearly between these two temperatures.

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2a – Condensing Boiler

Summary:

Measure Summary								
Unit	kWh Savings	kW Savings	Fuel Oil Savings	Propane Savings	Carbon Savings (MT)	Cost Savings	Cost	Simple Payback (years)
Highway Garage Boiler	0	0	1,716	-2,405	3.5	-$4,906	$22,980	N/A
Town Hall Boiler	0	0	1,139	-1,559	2.5	-$3,350	$15,094	N/A
Total	**0**	**0**	**2,855**	**-3,964**	**6.0**	**-$8,256**	**$38,074**	**N/A**

This measure is not currently recommended due to the negative cost savings associated with it.

Background:

This measure investigates replacing the boilers in the Town Hall and Highway Garage with new, high efficiency condensing boilers. The boiler in the Highway Garage is nearing the end of its useful life. According to nameplate data, the boiler in the Town Hall has a heating capacity of 157 MBH and a thermal efficiency of 85%. While the boiler in the Highway Garage has a heating capacity of 242 MBH, which was estimated from the building's fuel-oil consumption, and a thermal efficiency of 87%.

This is the first of three methods explored for replacing the existing fuel-oil boilers in the Highway Garage and Town Hall. Specifically, this measure investigates the replacement of the fuel-oil boilers with condensing propane-fired boilers that have a thermal efficiency of 95%.

Evaluation:

C&S gathered information from each of the units' nameplates and talked with the facility staff to understand how the existing units were operating. C&S placed temperature sensing data loggers on the return and supply lines of both boilers to monitor the discharge air temperature in order to determine how they were operating from 11/19/2021 through 12/17/2021. C&S was also able to use bin weather data available from the nearby Albany International Airport to estimate typical outdoor air temperatures during operating hours. This data was combined in order to determine what percentage of the time the units were running, which is shown below.

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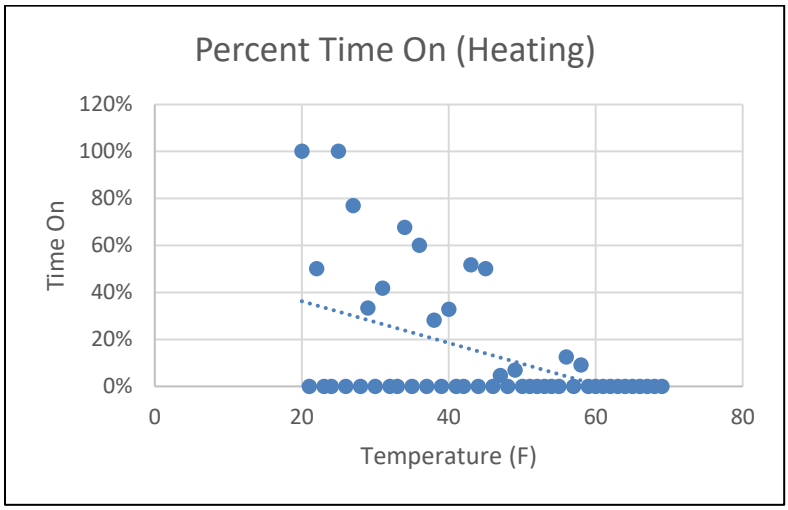

This data shows that during the heating season, the units ran 25% of the time at 0F and 17% of the time at 50F. Since these units are manually switched off until outdoor air temperatures reach about 20°F, the units are assumed to be off whenever the outdoor air temperature is below 50°F. These trends also lines up well with the usage in 2021.

Using spreadsheet analysis, C&S calculated the energy and money that would be saved by replacing the existing boilers with new, condensing boilers.

Recommendation:

This measure is not currently recommended due to the negative cost savings associated with it.

Implementation information:

C&S recommends engaging a qualified mechanical contractor to handle this replacement. Note that a significant portion of the demolition cost includes the removal of the 1,000 gallon fuel oil tank. A qualified tank contractor should be engaged to remove and properly dispose of the existing fuel oil tank.

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Energy/Economic Analysis:

The cost savings calculation is calculated below for this measure.

Fuel Oil Savings = (MBH X HR)/(Eff-e X C1)

Where:

Symbol	Value	Units	Description
MBH	242	MBTU	Heating Capacity
Eff-e	0.87	n/a	Existing Thermal Efficiency
HR	863	Hours	Heating Hours
C1	140	MBTU/Gal	Conversion Factor

Therefore:

Fuel Oil Savings = 1,716 Gal

Savings ($) = Fuel Oil Savings X $/Gal

Where:

Symbol	Value	Description
$/Gal	$2.00	Cost per Gallon

Therefore:

Savings = $3,432.66

Additional Cost of Propane

Propane Savings = (MBH X HR) / (Eff-p X C1)

Where:

Symbol	Value	Units	Description
MBH	242	MBTU	Heating Capacity
Eff-p	0.95	n/a	Proposed Thermal Efficiency
HR	863	Hours	Heating Hours
C1	91.5	MBTU/Gal	Conversion Factor

Therefore:

Propane Savings = -2,405 Gal

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Savings ($) = Propane Savings X $/Gal_p

Where:

Symbol	Value	Description
$/Gal_p	$3.61	Cost per Gal. Propane

Therefore:

Savings = -$8,681.81

Total Savings = -$5,249.15

The carbon emissions savings associated with this is shown below.

Carbon Savings = (F X C1) - (P X C2)

Where:

Symbol	Value	Units	Description
F	1,716	Gal. Fuel Oil	Fuel Oil Savings
C1	0.01	MT of CO2/Gal Fuel Oil	Carbon Dioxide Emissions Coefficient
P	2,405	Gal. Propane	Additional Propane Usage
C2	0.0057	MT of CO2/Gal Propane	Carbon Dioxide Emissions Coefficient

Carbon Savings = 3.5 MT

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An example cost estimate for replacing the existing fuel-oil boiler with a condensing, propane-fired boiler in the highway garage is calculated below. This estimate also includes the additional cost of purchasing a propane tank, as well as disposing of the existing fuel oil tanks.

2a - Condensing Boiler				
Item	Material	Labor	Quantity	Total
Demolition	$ -	$ 3,093.77	1	$ 3,093.77
Installation	$ 8,715.24	$ 3,324.34	1	$ 12,039.58
Equipment Rental	$ 238.12	$ -	1	$ 238.12
Notes: Costs are from a combination of internet research and RSMeans Mechanical 2022, which includes location factor multipliers for nearby Pittsfield, MA			OHP (15%)	$ 2,305.72
			Sub Total	$ 17,677.19
			Design Cost (10%)	$ 1,767.72
			Contingency (20%)	$ 3,535.44
			Total	**$ 22,980.34**

Due to the negative annual cost savings associated with this, there is no simple payback period associated with this measure.

Assumptions:

1. The heating capacity of the highway garage boiler was estimated by using the facility's fuel-oil bills.

2. As determined by trend data collected from the temperature loggers, these units are in heating mode 17% of the time when the outdoor air temperature is 50°F. They are in heating mode 25% of the time when the outdoor air temperature is 0°F, and the percentage of heating varies linearly between these two temperatures.

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2b – Electric Boiler

Summary:

Measure Summary								
Unit	kWh Savings	kW Savings	Fuel Oil Savings	Therm Savings	Carbon Savings (MT)	Cost Savings	Cost	Simple Payback (years)
Highway Garage Boiler	-61,251	-284	1,716	0	6.1	-$11,081	$16,121	N/A
Town Hall Boiler	-39,706	-184	1,139	0	4.2	-$7,354	$12,538	N/A
Total	**-100,958**	**-468**	**2,855**	**0**	**10.4**	**-$18,435**	**$28,659**	**N/A**

This measure is currently not recommended to the negative cost savings associated with it.

Background:

This measure investigates replacing the boilers in the Town Hall and Highway Garage with new, electric boilers. The boiler in the Highway Garage is nearing the end of its useful life. According to nameplate data, the boiler in the Town Hall has a heating capacity of 157 MBH and a thermal efficiency of 85%. While the boiler in the Highway Garage has a heating capacity of 242 MBH, which was estimated from the building's fuel-oil consumption, and a thermal efficiency of 87%.

This is the second of three methods explored for replacing the existing fuel-oil boilers in the Highway Garage and Town Hall. Specifically, this measure investigates the replacement of the fuel-oil boilers with electric boilers, which should have a coefficient of performance (COP) of approximately 1.

Evaluation:

C&S gathered information from each of the units' nameplates and talked with the facility staff to understand how the existing units were operating. C&S placed temperature sensing data loggers on the return and supply lines of both boilers to monitor the discharge air temperature in order to determine how they were operating from 11/19/2021 through 12/17/2021. Additionally, C&S was also able to use bin weather data available from the nearby Albany International Airport to estimate typical outdoor air temperatures during operating hours. This data was combined in order to determine what percentage of the time the units were running, which is shown below.

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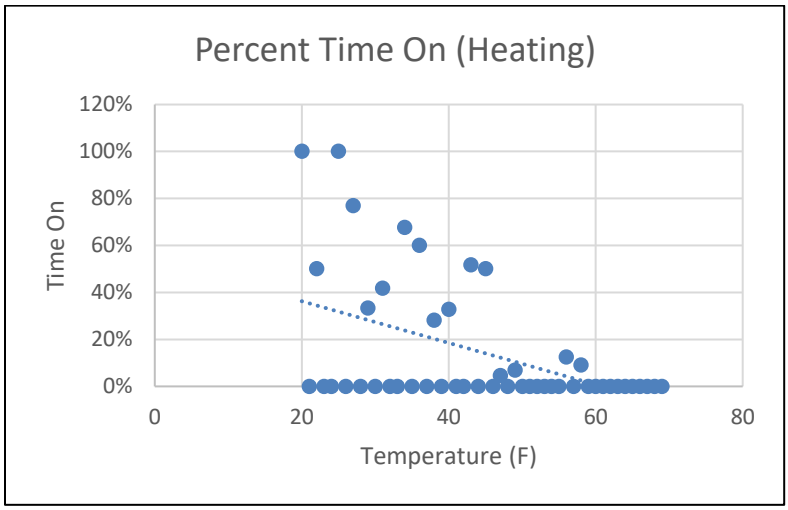

This data shows that during the heating season, the units ran 25% of the time at 0F and 17% of the time at 50F. Since these units are manually switched off until outdoor air temperatures reach about 20°F, the units are assumed to be off whenever the outdoor air temperature is below 50°F. These trends also lines up well with the usage in 2021.

Using spreadsheet analysis, C&S calculated the energy and money that would be saved by replacing the existing boilers with new, electric boilers.

Recommendation:

This measure is currently not recommended due to the negative cost savings associated with it.

Implementation information:

C&S recommends engaging a qualified mechanical contractor to handle this replacement. Note that a significant portion of the demolition cost includes the removal of the 1,000 gallon fuel oil tank. A qualified tank contractor should be engaged to remove and properly dispose of the existing fuel oil tank.

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Energy/Economic Analysis:

The cost savings calculation is calculated below for this measure.

Fuel Oil Savings = (MBH X HR)/(Eff-e X C1)

Where:

Symbol	Value	Units	Description
MBH	242	MBTU	Heating Capacity
Eff-e	0.87	n/a	Existing Thermal Efficiency
HR	863	Hours	Heating Hours
C1	140	MBTU/Gal	Conversion Factor

Therefore:

Fuel Oil Savings = 1,716 Gal

Savings ($) = Fuel Oil Savings X $/Gal

Where:

Symbol	Value	Description
$/Gal	$2.00	Cost per Gallon

Therefore:

Savings = $3,432.66

Additional Cost of Electricity
kWh Savings = (MBH X HR X C1)/COP
kW Savings = (MBH X M X C1)/ COP

Where:

Symbol	Value	Units	Description
MBH	242	MBTU	Heating Capacity
COP	1.00	kW/kW	Coefficient of Performance
HR	863	Hours	Heating Hours
M	4	Months	Months of Heating
C1	0.293	kW/MBTU	Conversion Factor

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Therefore:

kWh Savings = -61,251 kWh
kW Savings = -284 kW

Savings ($) = kWh Savings X $/kWh

Where:

Symbol	Value	Description
$/kWh	$0.13	Cost per kWh
$/kW	$24.29	Cost per kW

Therefore:

Savings = -$14,857.28

Total Savings = -$11,424.62

The carbon emissions savings associated with this is shown below.

Carbon Savings = (F X C1) - (Elec X C2)

Where:

Symbol	Value	Units	Description
F	1,716	Gal. Fuel Oil	Fuel Oil Savings
C1	0.01	MT of CO2/Gal Fuel Oil	Carbon Dioxide Emissions Coefficient
Elec	61,251	kWh	Additional Electricity
C2	0.00018	MT of CO2/kWh	Carbon Dioxide Emissions Coefficient

Carbon Savings = 6.1 MT

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An example cost estimate for replacing the existing fuel-oil boiler with an electric boiler in the highway garage is calculated below.

2b - Electric Boiler				
Item	Material	Labor	Quantity	Total
Demolition	$ -	$ 3,093.77	1	$ 3,093.77
Installation	$ 6,154.90	$ 1,296.40	1	$ 7,451.30
Equipment Rental	$ 238.12	$ -	1	$ 238.12
Notes: Costs are from RSMeans Mechanical 2022 and include location factor multipliers for nearby Pittsfield, MA			OHP (15%)	$ 1,617.48
			Sub Total	$ 12,400.67
			Design Cost (10%)	$ 1,240.07
			Contingency (20%)	$ 2,480.13
			Total	**$ 16,120.87**

Due to the negative annual cost savings associated with this, there is no simple payback period associated with this measure.

Assumptions:

1. The heating capacity of the highway garage boiler was estimated by using the facility's fuel-oil bills.

3. As determined by trend data collected from the temperature loggers, these units are in heating mode 17% of the time when the outdoor air temperature is 50°F. They are in heating mode 25% of the time when the outdoor air temperature is 0°F, and the percentage of heating varies linearly between these two temperatures.

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2c – Air to Water Heat Pump

Summary:

Measure Summary								
Unit	kWh Savings	kW Savings	Fuel Oil Savings	Therm Savings	Carbon Savings (MT)	Cost Savings	Cost	Simple Payback (years)
Highway Garage Boiler	-20,417	-95	1,716	0	13.5	-$1,177	$66,719	N/A
Town Hall Boiler	-13,235	-61	1,139	0	9.0	-$933	$49,243	N/A
Total	**-33,653**	**-156**	**2,855**	**0**	**22.5**	**-$2,109**	**$115,962**	**N/A**

This measure is not currently recommended due to the negative cost savings associated with it.

Background:

This measure investigates replacing the boilers in the Town Hall and Highway Garage with new, air to water heat pump boilers. The boiler in the Highway Garage is nearing the end of its useful life. According to nameplate data, the boiler in the Town Hall has a heating capacity of 157 MBH and a thermal efficiency of 85%. While the boiler in the Highway Garage has a heating capacity of 242 MBH, which was estimated from the building's fuel-oil consumption, and a thermal efficiency of 87%.

This is the last of the three methods explored for replacing the existing fuel-oil boilers in the Highway Garage and Town Hall. Specifically, this measure investigates the replacement of the fuel-oil boilers with air to water heat pump boilers, which should have a coefficient of performance (COP) of 3.

Evaluation:

C&S gathered information from each of the units' nameplates and talked with the facility staff to understand how the existing units were operating. C&S placed temperature sensing data loggers on the return and supply lines of both boilers to monitor the discharge air temperature in order to determine how they were operating from 11/19/2021 through 12/17/2021. Additionally, C&S was also able to use bin weather data available from the nearby Albany International Airport to estimate typical outdoor air temperatures during operating hours. This data was combined in order to determine what percentage of the time the units were running, which is shown below.

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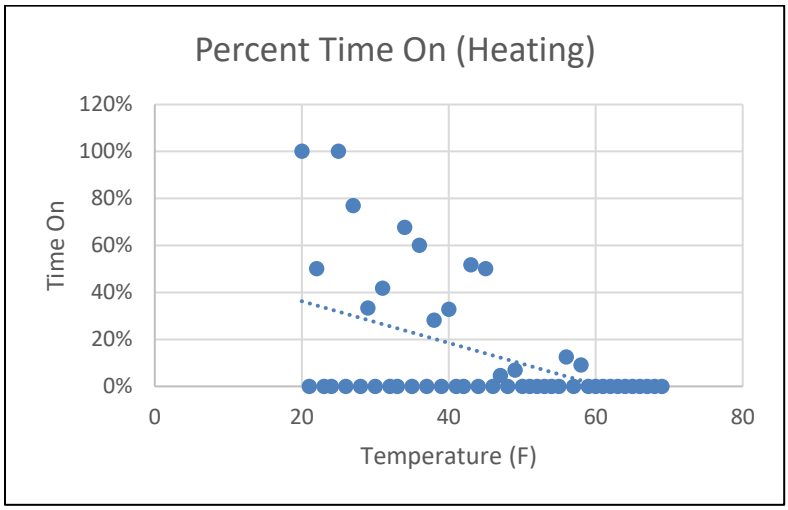

This data shows that during the heating season, the units ran 25% of the time at 0F and 17% of the time at 50F. Since these units are manually switched off until outdoor air temperatures reach about 20°F, the units are assumed to be off whenever the outdoor air temperature is below 50°F. These trends also lines up well with the usage in 2021.

Using spreadsheet analysis, C&S calculated the energy and money that would be saved by replacing the existing boilers with new, air to water heat pump boilers.

Recommendation:

This measure is not currently recommended due to the negative cost savings associated with it.

Implementation information:

C&S recommends engaging a qualified mechanical contractor to handle this replacement. Note that a significant portion of the demolition cost includes the removal of the 1,000 gallon fuel oil tank. A qualified tank contractor should be engaged to remove and properly dispose of the existing fuel oil tank.

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Energy/Economic Analysis:

The cost savings calculation is calculated below for this measure.

Fuel Oil Savings = (MBH X HR)/(Eff-e X C1)

Where:

Symbol	Value	Units	Description
MBH	242	MBTU	Heating Capacity
Eff-e	0.87	n/a	Existing Thermal Efficiency
HR	863	Hours	Heating Hours
C1	140	MBTU/Gal	Conversion Factor

Therefore:

Fuel Oil Savings = 1,716 Gal

Savings ($) = Fuel Oil Savings X $/Gal

Where:

Symbol	Value	Description
$/Gal	$2.00	Cost per Gallon

Therefore:

Savings = $3,432.66

Additional Cost of Electricity
kWh Savings = (MBH X HR X C1)/COP
kW Savings = (MBH X M X C1)/ COP

Where:

Symbol	Value	Units	Description
MBH	242	MBTU	Heating Capacity
COP	3.00	kW/kW	Coefficient of Performance
HR	863	Hours	Heating Hours
M	4	Months	Months of Heating
C1	0.293	kW/MBTU	Conversion Factor

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Therefore:

kWh Savings = -20,417 kWh
kW Savings = -95 kW

Savings ($) = (kWh Savings X $/kWh) + (kW Savings X $/kW)

Where:

Symbol	Value	Description
$/kWh	$0.13	Cost per kWh
$/kW	$24.29	Cost per kW

Therefore:

Savings = -$4,952.43

Total Savings = -$1,519.77

The carbon emissions savings associated with this is shown below.

Carbon Savings = (F X C1) - (Elec X C2)

Where:

Symbol	Value	Units	Description
F	1,716	Gal. Fuel Oil	Fuel Oil Savings
C1	0.01	MT of CO2/Gal Fuel Oil	Carbon Dioxide Emissions Coefficient
Elec	20,417	kWh	Additional Electricity
C2	0.00018	MT of CO2/kWh	Carbon Dioxide Emissions Coefficient

Carbon Savings = 13.5 MT

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An example cost estimate for replacing the existing fuel-oil boiler with an air to water heat pump boiler in the highway garage is calculated below.

2c - Air to Water Heat Pump Boiler				
Item	Material	Labor	Quantity	Total
Demolition	$ -	$ 3,093.77	1	$ 3,093.77
Installation	$ 40,000.00	$ 1,296.40	1	$ 41,296.40
Equipment Rental	$ 238.12	$ -	1	$ 238.12
Notes: Costs are from a combination of previous project experience and RSMeans Mechanical 2022. Estimates include location factor multipliers for nearby Pittsfield, MA			OHP (15%)	$ 6,694.24
			Sub Total	$ 51,322.53
			Design Cost (10%)	$ 5,132.25
			Contingency (20%)	$ 10,264.51
			Total	**$ 66,719.29**

Due to the negative annual cost savings associated with this, there is no simple payback period associated with this measure.

Assumptions:

1. The heating capacity of the highway garage boiler was estimated by using the facility's fuel-oil bills.

4. As determined by trend data collected from the temperature loggers, these units are in heating mode 17% of the time when the outdoor air temperature is 50°F. They are in heating mode 25% of the time when the outdoor air temperature is 0°F, and the percentage of heating varies linearly between these two temperatures.

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3 – Additional Insulation

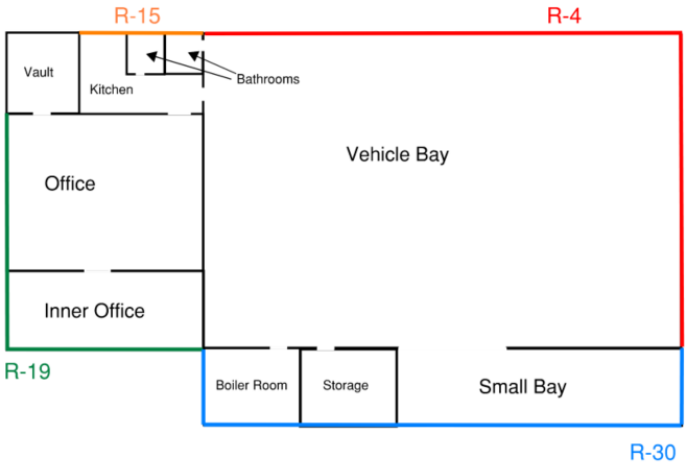
Summary:

Measure Summary							
Unit	kWh Savings	kW Savings	Fuel Oil Savings	Carbon Savings (MT)	Cost Savings	Cost	Simple Payback (years)
Office Insulation	2	0	4	0.0	$9	$1,384	156.3
Vehicle Bay Insulation	0	0	128	1.3	$282	$1,881	6.7
Small Bay Insulation	0	0	0	0.0	$0	$1,360	N/A
Kitchen and Bathroom Insulation	1	0	1	0.0	$3	$1,182	355.6
Total	**3**	**0**	**134**	**1.3**	**$295**	**$5,807**	**19.7**

This measure is currently recommended due to the relatively short payback period associated with it.

Background:

The Highway Garage has a rodent problem, which has caused extensive damage to both the walls and the insulation of the building. The rats travel through the walls, packing down insulation as well as consuming it. Their urine is corrosive enough that parts of the walls have started to rust and deteriorate. Because of this issue, as well as the 2011 building add-on, the R-value of each wall in the facility varies greatly. The walls contain a mixture of fiberglass insulation, sheep wool, and the occasional old blanket or coat, which is inserted into the walls in an attempt to stop drafts. The Superintendent of Highways, Bernhard Meyer, provided C&S with a rough estimate of each wall's R-values in the facility. This information is shown in the graphic below; it should be noted that this image is not drawn to scale.



This measure looks into adding to the existing insulation to get all the walls in the Highway Garage up to an R-value of at least 30.

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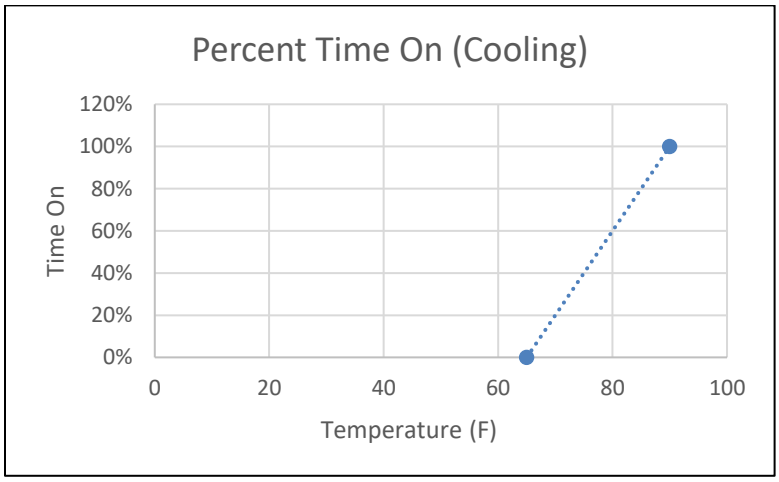
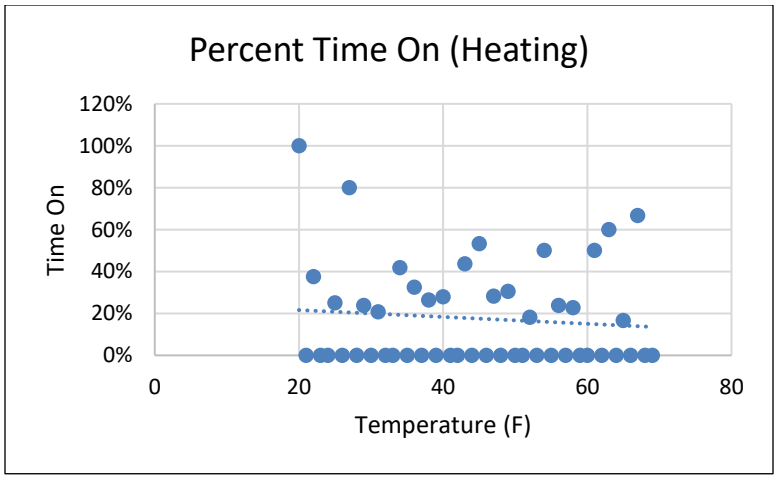
Evaluation:

C&S gathered the existing R-values from speaking to facility staff. C&S also gathered trend data from temperature sensing data loggers placed within the office, kitchen, and vehicle bay areas of the Highway Garage. The indoor air temperature was monitored by these loggers from 11/19/2021 through 12/17/2021. Additionally, C&S was also able to use bin weather data available from the nearby Albany International Airport to estimate typical outdoor air temperatures during operating hours. This data was combined in order to determine what percentage of the time the units were running, which is shown below.





This data shows that during the heating season, the units ran 25% of the time at 0°F and 17% of the time at 50F. Since these units are manually switched off until outdoor air temperatures reach about 20°F, the units are assumed to be off whenever the outdoor air temperature is above 50°F. These trends also lines up well with the usage in 2021.

Due to the time of year of the study, C&S was unable to collect any meaningful data on these unit's cooling performance. Instead, a linear approximation was used for the cooling trends. It assumes that the unit is in cooling mode 100% of the time when the outdoor air temperature is 90°F or above, and 0% of the time when the outdoor air temperature is 65°F or below, and varies linearly between these two points.

Using further spreadsheet analysis, C&S was able to calculate the energy savings associated with the increasing the R-value of the facility's walls.

Recommendation:

This measure is currently recommended due to the relatively short payback period associated with it.

Implementation information:

C&S recommends contacting a professional pest control company for quotes on installing TAP insulation. However, this installation can also be done by town employees if a blowing machine is rented from a hardware store.

Energy/Economic Analysis:

An example cost savings calculation is shown below for the office area. The energy savings associated with other spaces were calculated in a similar manner.

Heating Savings

Fuel Oil Savings = (A X HR-h X (ti - to-avg-h))/(R-e X C1 X eff-h) - (A X HR-h X (ti - to-avg-h))/(R-p X C1 X eff-h)

Where:

Symbol	Value	Units	Description
A	1,035	ft^2	Exterior Wall Area
ti	62.0	°F	Indoor air temperature
to-avg-h	34.4	°F	Average outdoor air temperature while heating is available
HR-h	863	Hours	Hours heating is available
eff-h	87%	N/A	Heating efficiency
C1	140,000	BTU/Gal	Conversion Factor
R-e	19	°F-ft^2-hr/BTU	R-Value of Existing Insulation
R-p	30	°F-ft^2-hr/BTU	R-Value of Proposed Insulation

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Therefore:

Fuel Oil Savings = 4 Gal

Savings ($) = Fuel Oil Savings X $/Gal

Where:

Symbol	Value	Description
$/Gal	$2.20	Cost per Gallon

Therefore:

Savings ($) = $8.59

Cooling Savings - Vehicle Bay
kWh Savings = (A X HR-c X (to-avg-c - ti))/(R-e X C1 X eff-c) - (A X HR-c X (to-avg-c - ti))/(R-p X C1 X eff-c)

Where:

Symbol	Value	Units	Description
A	1,035	ft^2	Exterior Wall Area
ti	72.0	°F	Indoor air temperature
to-avg-c	73.9	°F	Average outdoor air temperature while cooling is available
HR-c	688	Hours	Hours cooling is available
eff-c	13	BTU/W	Cooling Seasonal Energy Efficiency Ratio
C1	1,000	W/kW	Conversion Factor
R-e	19	°F-ft^2-hr/BTU	R-Value of Existing Insulation
R-p	30	°F-ft^2-hr/BTU	R-Value of Proposed Insulation

Therefore:

kWh Savings = 2 kWh

Savings ($) = kWh Savings X $/kWh

Where:

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Symbol	Value	Description
$/kWh	$0.13	Cost per kWh

Therefore:

Savings ($) = $0.26

Total Savings ($) = $8.85

The carbon emissions savings associated with this is shown below.

Carbon Savings = (F X C1) + (Elec X C2)

Where:

Symbol	Value	Units	Description
F	4	Gal. Fuel Oil	Fuel Oil Savings
C1	0.01	MT of CO2/Gal Fuel Oil	Carbon Dioxide Emissions Coefficient
Elec	2	kWh	Electricity Savings
C2	0.00018	MT of CO2/kWh	Carbon Dioxide Emissions Coefficient

Carbon Savings = 0.04 MT

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The cost estimate for adding additional insulation to the walls is calculated below. Note that this estimate includes an estimate cost of labor and a blower rental, assuming the installation will be performed by town employees.

3 - Additional Insulation				
Item	Material	Labor	Quantity	Total
Demolition	$ -	$ -	1	$ -
Installation	$ 944.42	$ 2,963.20	1	$ 3,907.62
Equipment Rental	$ 300.00	$ -	1	$ 300.00
Notes: Costs are from an internet search. Price per square foot varies with the chosen product. The labor costs assume 2 people can install it in 2 days, with an hourly rate of $100 per hour. The blower equipment rental assumes a cost of $150 per day.			OHP (15%)	$ 631.14
			Sub Total	$ 4,838.77
			Design Cost (10%)	$ -
			Contingency (20%)	$ 967.75
			Total	**$ 5,806.52**

The following chart shows a simple payback calculation used to show how long replacing this unit would take to pay for itself. It is calculated by dividing the cost by the annual savings:

Simple Payback Summary	
Cost	$5,806.52
Annual Savings	$392.45
Simple Payback (years)	14.8

Assumptions:

1. All R-values are estimates provided by the Superintendent of Highways, Bernhard Meyer.

2. As determined by trend data collected from the temperature loggers, these units are in heating mode 17% of the time when the outdoor air temperature is 50°F. They are in heating mode 25% of the time when the outdoor air temperature is 0°F, and the percentage of heating varies linearly between these two temperatures.

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4 – Temperature Setbacks

Summary:

Measure Summary							
Unit	kWh Savings	kW Savings	Fuel Oil Savings	Carbon Savings (MT)	Cost Savings	Cost	Simple Payback (years)
Downstairs Thermostat	0	0	139	1.4	$279	$288	1.0
Upstairs Thermostat	0	0	144	1.4	$288	$288	1.0
Total	**0**	**0**	**283**	**2.8**	**$567**	**$575**	**1.0**

This measure is currently recommended due to the relatively short payback period associated with it.

Background:

In the Town Hall, the HVAC system is comprised of an oil-fired boiler that feeds radiators throughout the building and two split-system ACs with indoor air handler units (AHUs). In total, there are 4 thermostats in the building. Two of them control the two AC systems in the courtroom. One thermostat is located downstairs and covers the entire lower floor along with the upstairs courtroom office. The final one covers the rest of the heating in the upper floor of the building.

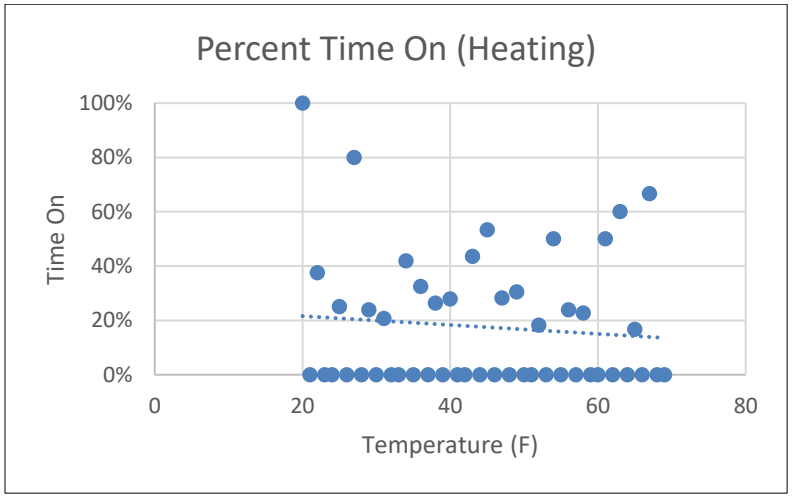
Currently, all of these are simple dial thermostats, which need to be manually adjusted. This measure looks into replacing the thermostat on both floors with a programmable thermostat, so that during the heating season the temperature can be setback from 72°F to 60°F when unoccupied. The lower floor is in use from 9:30a to 2:30p on Mondays, Wednesdays, Thursdays, and Fridays. The upper floor's schedule is more sporadic, due to the courtroom meeting after hours. Based off the calendar for May 2022, a typical schedule of 7:00p to 9:00p on Mondays, 4:00p to 9:00p on Tuesdays, and 6:00p to 9:00p on Thursdays will be used for the courtroom.

Currently, the cooling is only activated manually when the room is occupied and is otherwise left off, making the cooling application ill-suited for a programmable thermostat. Therefore, no energy savings will be obtained from incorporating the AC system thermostats into the programmable thermostat. However, having three thermostats controlling the same room is confusing, and it may be better to consolidate them into one if possible.

Evaluation:

C&S gathered information from each of these units' nameplates and talked with the facility staff to understand how the existing units were operating. C&S placed a total of twenty temperature sensing data loggers, of which six also had CO2 logging capabilities. Of the twenty sensors, six were collecting data on

the supply temperature and the room temperature in order to determine how the units were operating from 11/19/2021 through 12/17/2021. C&S was also able to use bin weather data available from the nearby Albany International Airport to estimate typical outdoor air temperatures during operating hours. This data was combined in order to determine what percentage of the time the units were running, which is shown below.



This data shows that during the heating season, the units ran 25% of the time at 0°F and 17% of the time at 50F. Since these units are manually switched off until outdoor air temperatures reach about 20°F, the units are assumed to be off whenever the outdoor air temperature is above 50°F. These trends also lines up well with the usage in 2021.

C&S calculated the energy that would be saved by replacing the existing thermostats in the Town Hall with scheduled, programmable thermostats.

Recommendation:

This measure is currently recommended due to the relatively short payback period associated with it.

Implementation information:

This measure is relatively simple to implement, so a Town employee can install and program the new thermostat. However, if the Town does not have an employee on staff that is comfortable with performing the install, then the Town should approach a qualified electrician or controls contractor for assistance.

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Energy/Economic Analysis:

An example of a cost savings calculation is calculated below for the downstairs thermostat.

Fuel Oil Savings = (MBH X A X HR-h)/(Eff-h X C1)

Where:

Symbol	Value	Units	Description
MBH	157	MBTU/h	Heating Capacity (output)
A	50%	N/A	Percent of Building Covered
HR-h	211	Hours	Heating Hours Reduced
Eff-h	85%	N/A	Heating Efficiency
C1	140	MBTU/Gal	Conversion Factor

Therefore:

Fuel Oil Savings = 139.4 Gal

Savings ($) = Fuel Oil Savings X $/Gal

Where:

Symbol	Value	Description
$/Gal	$2.00	Cost per Gallon

Therefore:

Savings = $278.89

Total Savings = $278.89

The carbon emissions savings associated with this is shown below.

Carbon Savings = F X C1

Where:

Symbol	Value	Units	Description
F	139	Gal. Fuel Oil	Fuel Oil Savings
C1	0.01	MT of CO2/Gal Fuel Oil	Carbon Dioxide Emissions Coefficient

Carbon Savings = 1.4 MT

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The cost estimate for upgrading to programmable thermostats is calculated below.

4 - Temperature Setbacks				
Item	Material	Labor	Quantity	Total
Demolition	$ -	$ -	1	$ -
Installation	$ 375.35	$ 125.01	1	$ 500.36
Equipment Rental	$ -	$ -	1	$ -
Notes: Costs are from RSMeans Mechanical 2022 and include location factor multipliers for nearby Pittsfield, MA			OHP (15%)	$ 75.05
			Sub Total	$ 575.41
			Design Cost (0%)	$ -
			Contingency (0%)	$ -
			Total	**$ 575.41**

The following chart shows a simple payback calculation used to show how long replacing this unit would take to pay for itself. It is calculated by dividing the cost by the annual savings:

Simple Payback Summary	
Cost	$575
Annual Savings	$567
Simple Payback (years)	1.0

Assumptions:

1. As determined by trend data collected from the temperature loggers, these units are in heating mode 17% of the time when the outdoor air temperature is 50°F. They are in heating mode 25% of the time when the outdoor air temperature is 0°F, and the percentage of heating varies linearly between these two temperatures.

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Appendix A: Project Summary Sheets

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PROJECT SUMMARY SHEET

FOR: Town of Canaan - Town Hall, 1647 County Route 5, Canaan, NY 12029

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BASELINE ENERGY SUMMARY

	Electric (kWh)	Natural Gas (therms)	#2 Oil (gallons)	#4 Oil (gallons)	#6 Oil (gallons)	Steam (lbs.)	Propane (gallons)	Coal (tons)	Other (MMBtu)	**Total Baseline Use (MMBtu)**
Baseline Energy Use	10,978		901.8							**162.8**
Average Utility Rate	$0.13		$2.00							**Total Annual Cost ($)**
Baseline Annual Cost	$3,303		$1,802							**$5,105**

ENERGY SAVINGS SUMMARY

Measure Description	Measure Status [1]	Fuel Savings Type [2]	Electric		Fuel Savings (MMBtu)	Energy Savings to Total Baseline Use (%) [3]	Annual Cost Savings	Cost Savings to Total Annual Cost (%) [4]	Project Cost	Simple Payback (Years)
			Supply Savings (kWh)	Demand Savings (kW)						
1a - Town Hall HVAC Upgrades*	R	Elec	262.1	12.2	0.0	0.5%	$329	6.4%	$1,244	3.8
2a - Condensing Propane Boiler	NR	Oil2	0.0	0.0	15.7	9.6%	-$3,350	-65.6%	$15,094	-4.5
2b - Electric Boiler	NR	Oil2	-39,706.4	-184.0	158.3	14.0%	-$7,354	-144.1%	$12,538	-1.7
2c - Air to Water Heat Pump Boiler	NR	Oil2	-13,235.5	-61.3	158.3	69.5%	-$933	-18.3%	$49,243	-52.8
4 - Temperature Setbacks	R	Oil2	0.0	0.0	39.3	24.2%	$567	11.1%	$575	1.0
TOTAL (All):			-52,680	-233	372	117.9%	-$10,741	-210.4%	$78,694	-7.3
TOTAL (Recommended Only):			**262**	**12**	**39**	**24.7%**	**$896**	**17.6%**	**$1,819**	**2.0**

Measure Status[1]

I	Implemented
R	Recommended
RS	Further Study Recommended
NR	Not Recommended
RME	Recommeded Mutually Exclusive
ME	Mutually Exclusive to Recommended Option
RNE	Recommended Non-Energy

Fuel Saved

Elec	Electric
NGas	Natural Gas
Oil2	#2 Oil
Oil4	#4 Oil
Oil6	#6 Oil
Steam	District Steam
LPG	Propane
Coal	Coal
Other	Other

MMBtu Conversion Factors

Btu	1,000,000
kWh	0.003412
therms	0.1
#2 gallon	0.139
#4 gallon	0.1467
#6 gallon	0.15
Steam lbs.	0.0012
LPG gallon	0.0915
Coal tons	24

Notes:

[2] Fuel Savings Type: Indicate the reported MMBtu savings fuel type. Select the predominant fuel type if there are MMBtu savings from multiple fuel sources

[3] Energy Savings to Total Fuel Baseline Use is a comparison of the total electric & fuel savings to the total baseline energy use

[4] Cost Savings to Total Annual Cost is a comparison of the total annual cost savings to the total baseline annual energy cost

Instructions:

* Fill in the light blue cells, as appropriate. White cells will auto-calculate.
* Energy savings must be presented as savings at the customer's utility meter(s), not at the individual building or tenant space
* Update the baseline energy use conversion factors in the 'References' tab, as necessary
* Unhide rows to enter more measures, as necessary

PROJECT SUMMARY SHEET

FOR: Town of Canaan - Highway Garage, 1898 Route 295, Canaan, NY 12029

BASELINE ENERGY SUMMARY

	Electric (kWh)	Natural Gas (therms)	#2 Oil (gallons)	#4 Oil (gallons)	#6 Oil (gallons)	Steam (lbs.)	Propane (gallons)	Coal (tons)	Other (MMBtu)	**Total Baseline Use (MMBtu)**
Baseline Energy Use	9,802		1,612.6							**257.6**
Average Utility Rate	$0.13		$2.20							**Total Annual Cost ($)**
Baseline Annual Cost	$2,808		$3,543							**$6,351**

ENERGY SAVINGS SUMMARY

Measure Description	Measure Status [1]	Fuel Savings Type [2]	Electric		Fuel Savings (MMBtu)	Energy Savings to Total Baseline Use (%) [3]	Annual Cost Savings	Cost Savings to Total Annual Cost (%) [4]	Project Cost	Simple Payback (Years)
			Supply Savings (kWh)	Demand Savings (kW)						
1b - Highway Garage HVAC Upgrades*	NR	Oil2	-4,647.2	-42.8	62.6	18.1%	-$653	-10.3%	$10,657	-16.3
2a - Condensing Propane Boiler	NR	Oil2	0.0	0.0	18.5	7.2%	-$4,906	-77.2%	$22,980	-4.7
2b - Electric Boiler	NR	Oil2	-61,251.3	-283.8	238.5	11.5%	-$11,081	-174.5%	$16,121	-1.5
2c - Air to Water Heat Pump Boiler	NR	Oil2	-20,417.1	-94.6	238.5	65.6%	-$1,177	-18.5%	$66,719	-56.7
3 - Additional Insulation	R	Oil2	2.8	0.0	18.6	7.2%	$295	4.6%	$5,807	19.7
TOTAL (All):			-86,313	-421	577	109.5%	-$17,522	-275.9%	$122,284	-7.0
TOTAL (Recommended Only):			**3**	**0**	**19**	**7.2%**	**$295**	**4.6%**	**$5,807**	**19.7**

Measure Status[1]

I	Implemented
R	Recommended
RS	Further Study Recommended
NR	Not Recommended
RME	Recommeded Mutually Exclusive
ME	Mutually Exclusive to Recommended Option
RNE	Recommended Non-Energy

Fuel Saved

Elec	Electric
NGas	Natural Gas
Oil2	#2 Oil
Oil4	#4 Oil
Oil6	#6 Oil
Steam	District Steam
LPG	Propane
Coal	Coal
Other	Other

MMBtu Conversion Factors

Btu	1,000,000
kWh	0.003412
therms	0.1
#2 gallon	0.139
#4 gallon	0.1467
#6 gallon	0.15
Steam lbs.	0.0012
LPG gallon	0.0915
Coal tons	24

Notes:

[2] Fuel Savings Type: Indicate the reported MMBtu savings fuel type. Select the predominant fuel type if there are MMBtu savings from multiple fuel sources

[3] Energy Savings to Total Fuel Baseline Use is a comparison of the total electric & fuel savings to the total baseline energy use

[4] Cost Savings to Total Annual Cost is a comparison of the total annual cost savings to the total baseline annual energy cost

Instructions:

* Fill in the light blue cells, as appropriate. White cells will auto-calculate.
* Energy savings must be presented as savings at the customer's utility meter(s), not at the individual building or tenant space
* Update the baseline energy use conversion factors in the 'References' tab, as necessary
* Unhide rows to enter more measures, as necessary