NYSERDA FlexTech Energy Study

Copake Town Hall
230 Mountain View Road

Submitted to:

NYSERDA
Efficiency Planning & Engineering
17 Columbia Circle
Albany, NY 12203-6399

Town of Copake
Copake Town Hall
230 Mountain View Road,
Copake, New York 12516

Submitted from:

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1.0 EXECUTIVE SUMMARY

This project is intended to focus on eligible areas of study under the NYSERDA FlexTech Program, which includes the investigation of opportunities to reduce energy and achieve carbon savings via load reduction and load shifting, and conversion to carbon free fuel. Under this program, a comprehensive analysis of the Copake Town Hall located at 230 Mountain View Road, in Copake NY 12516, was conducted. The goal of the study was to identify and analyze energy conservation and carbon reduction measures and upgrades that will have the largest impact on the building consumption. Additionally, this study included an evaluation of clean heating and cooling technologies, activities which will assist in decarbonization of the facilities, an evaluation and recommendation of potential renewable technologies, and an evaluation of the indoor air quality and recommendations for improvement.

The services conducted as a part of this study included an energy audit of the facility, complete with a walkthrough, energy conservation measure identification, utility and benchmark analysis, an energy analysis to calculate and compare the annual energy consumption of various energy conservation measures, an economic feasibility analysis with high level budgetary first cost and simple payback, and an analysis of the basic feasibility associated with the implementation of each measure. The Town of Copake is located in Columbia County, situated on the eastern border of New York State. In June of 2011, the Town of Copake committed to becoming a Climate Smart Community, by participating in NY State's Climate Smart Communities Program, and in May 2022 created a Climate Smart Communities Task Force to serve as a subcommittee of the Conservation Advisory Committee. Participation in the Climate Smart Communities Program as well as this NYSERDA FlexTech Study demonstrates a commitment to local climate action.

In order to drive down energy usage, reduce carbon, and set the facility up to be net zero-ready, fossil fuel usage must be eliminated by providing a fully electrified clean heating solution. Electrifying buildings and moving away from fossil fuel use can be challenging. Potential roadblocks include possible upgrades to electric infrastructure, wholesale replacement of existing fossil fuel fired HVAC and domestic water systems and components, the introduction of heat pump technology, replacement of fossil fuel kitchen appliances, the consideration of the cost of electricity vs. natural gas, and the impact on the local utility. It is important to select quality electrified solutions - heat pump technology can offer efficiencies more than three times that of simpler electric resistance heating. Incentive programs can assist to reduce first costs, including the NYS Clean Heat program, and both prequalified and custom-measure improvement incentives.

In this study we have evaluated several energy efficiency and carbon reduction measures including HVAC upgrades, the introduction of an air-source heat pump system, the introduction of a ground source heat pumps system and geo-exchange well field, lighting upgrades, building envelope improvements, building envelope improvements, and energy recovery. The results show that implementing an air source heat pump or geothermal system in lieu of a traditional fossil fuel fired heating system, is expected to reduce both energy consumption and energy cost. The air source heat pump system appears to be the most cost-effective option to pursue, however the VRF and GSHP options - although more costly - do provide greater energy and carbon reduction. The results also show that there is significant value in converting the lighting systems to LED and adding occupancy controls. The following is a summary of the existing annual energy consumption, the measures studied, and the associated results:

Table 1.1: Annual Energy Consumption

Annual 2022 Energy Usage - Copake Town Hall				
Electricity	25,168 kwh	85,898 kBtu/h	$ 3,383	$ 0.13 /kWh
Propane	7,041 gal	643,945 kBtu/h	$ 26,357	$ 3.74 /gal
Total	**7,680 ft²**	**729,843 kBtu/h**	**$ 29,740**	**95.0 kBtu/ft²**

Table 1.2: Energy Efficiency Measure Results

Measure Summary											
		Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
EEM No.	Energy Efficiency Measure Description	Annual Electric Savings [kWh]	Electric Peak Demand Savings [kW]	Annual Electric Cost Savings [$]	Annual Fossil Fuel Savings [MMBtu]	Annual Fossil Fuel Cost Savings [$]	Total Energy Consumption Savings [MMBtu]	Total Annual Cost Savings [$]	Total EUI Savings [kBtu/sf]	Est. EEM Cost [$]	Simple Payback [yrs]
EEM-1.1	HVAC Upgrades: Code Compliant - Fossil Fuel AHUs	549	0.7	$74	23.3	$952	25.1	$1,025	0.89	$57,236	55.8
EEM-1.2	HVAC Upgrades: Better Than Code - Fossil Fuel AHUs	886	0.9	$119	79.5	$3,254	82.5	$3,373	2.93	$65,370	19.4
EEM-1.3	HVAC Upgrades: Better Than Code - Electrified AHUs ASHP Split	(31,610)	(12.5)	($4,249)	249.6	$10,217	141.7	$5,968	5.03	$87,788	14.7
EEM-1.4	HVAC Upgrades: Better Than Code - Electrified Distributed VRF	(11,900)	(2.7)	($1,600)	249.6	$10,217	209.0	$8,618	7.41	$175,523	20.4
EEM-1.5	HVAC Upgrades: High Performance - Electrified GSHP AHUs	(13,039)	(6.9)	($1,753)	249.6	$10,217	205.1	$8,464	7.27	$228,884	27.0
EEM-2	Envelope Upgrades	1,910	0.4	$257	68.5	$2,804	75.0	$3,061	2.66	$56,673	18.5
EEM-3.1	DHW Upgrades: Better than Code - Fossil Fuel Fired	0	0.0	$0	9.0	$368	9.0	$368	0.32	$1,645	4.5
EEM-3.2	DHW Upgrades: Better than Code - ASHP	(1,578)	(0.2)	($212)	56.5	$2,311	51.1	$2,099	1.81	$2,830	1.3
EEM-3.3	DHW Upgrades: High Performance - GSHP	(1,263)	(0.1)	($170)	56.5	$2,311	52.1	$2,141	1.85	$7,426	3.5
EEM-4	Lighting Upgrades: LED Fixtures and Controls	29,563	7.4	$3,974	(5.4)	($220)	95.5	$3,754	3.39	$21,448	5.7
EEM-5	Energy Recovery	40	(1.9)	$5	57.2	$2,340	57.3	$2,346	2.03	$9,780	4.2

For a net zero facility, the annual on site PV production or purchased renewable power would need to equal the facility's energy usage. Additionally, incentives are available to drive down the initial cost and reduce the overall payback of the energy efficient measures (see "7.0 INCENTIVE PROGRAMS").

2.0 PROJECT SUMMARY SHEET

Table 2.1: NYSERDA Project Summary Sheet

PROJECT SUMMARY SHEET
FOR: TOWN OF COPAKE

NEW YORK STATE OF OPPORTUNITY. NYSERDA

BASELINE ENERGY SUMMARY - Copake Town Hall

	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	25,168	0	0	0	0	0	7,041	0	0	**730.2**
Average Utility Rate	$0.13	N/A	N/A	N/A	N/A	N/A	$3.74	N/A	N/A	**Total Annual Cost ($)**
Baseline Annual Cost	$3,383	N/A	N/A	N/A	N/A	N/A	$26,356.50	N/A	N/A	**$29,740**

ENERGY SAVINGS SUMMARY - Copake Town Hall

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)						
EEM-1.1 HVAC Upgrades: Code Compliant - Fossil Fuel AHUs	ME	LPG	549	0.7	23.3	3.4%	$944	3.2%	$57,236	60.6
EEM-1.2 HVAC Upgrades: Better Than Code - Fossil Fuel AHUs	ME	LPG	886	0.9	79.5	11.3%	$3,095	10.4%	$65,370	21.1
EEM-1.3 HVAC Upgrades: Better Than Code - Electrified AHUs ASHP Split	R	LPG	-31,610	-12.5	249.6	19.4%	$5,095	17.1%	$87,788	17.2
EEM-1.4 HVAC Upgrades: Better Than Code - Electrified Distributed VRF	ME	LPG	-11,900	-2.7	249.6	28.6%	$7,744	26.0%	$175,523	29.6
EEM-1.5 HVAC Upgrades: High Performance - Electrified GSHP AHUs	ME	LPG	-13,039	-6.9	249.6	28.1%	$7,591	25.5%	$228,884	7.5
EEM-2 Envelope Upgrades	R	LPG	1,910	0.4	68.5	10.3%	$2,821	9.5%	$56,673	0.6
EEM-3.1 DHW Upgrades: Better than Code - Fossil Fuel Fired	ME	LPG	0	0.0	9.0	1.2%	$336	1.1%	$1,645	
EEM-3.2 DHW Upgrades: Better than Code - ASHP	R	LPG	-1,578	-0.2	56.5	7.0%	$1,901	6.4%	$2,830	1.5
EEM-3.3 DHW Upgrades: High Performance - GSHP	ME	LPG	-1,263	-0.1	56.5	7.1%	$1,944	6.5%	$7,426	3.8
EEM-4 Lighting Upgrades: LED Fixtures and Controls	R	LPG	29,563	7.4	-5.4	13.1%	$3,773	12.7%	$21,448	5.7
EEM-5 Energy Recovery	R	LPG	40	-1.9	57.2	7.9%	$2,146	7.2%	$9,780	4.6
EEM-6 Indoor Air Quality										
		TOTAL (All):	-26,442	-15	1,094	137.5%	$37,390	125.7%	$714,604	19.1
		TOTAL (Recommended Only):	**-1,676**	**-7**	**426**	**57.6%**	**$15,736**	**52.9%**	**$178,519**	**11.3**

Measure Status[1]

I	Implemented
R	Recommended
RS	Further Study Recommended
NR	Not Recommended
RME	Recommended 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 Facto

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

3.0 PROJECT OVERVIEW

SITE OVERVIEW

The Town Hall is a single-story structure of approximately 7,680 gross square feet, built in 2000. The facility houses offices for the Supervisor, Clerk, and zoning and planning; meeting/courtrooms; a kitchen; and support spaces such as storage, restroom, lobby, corridor, stairs, and mechanical/electrical. Roof mounted solar PV panels produce power to supplement the building's purchased electricity.

Typical operating hours of the facility are 8am - 4pm, Monday - Thursday, and Saturdays 9am - noon. The Courtroom/Meeting Room is used in the evening at least four times per month.

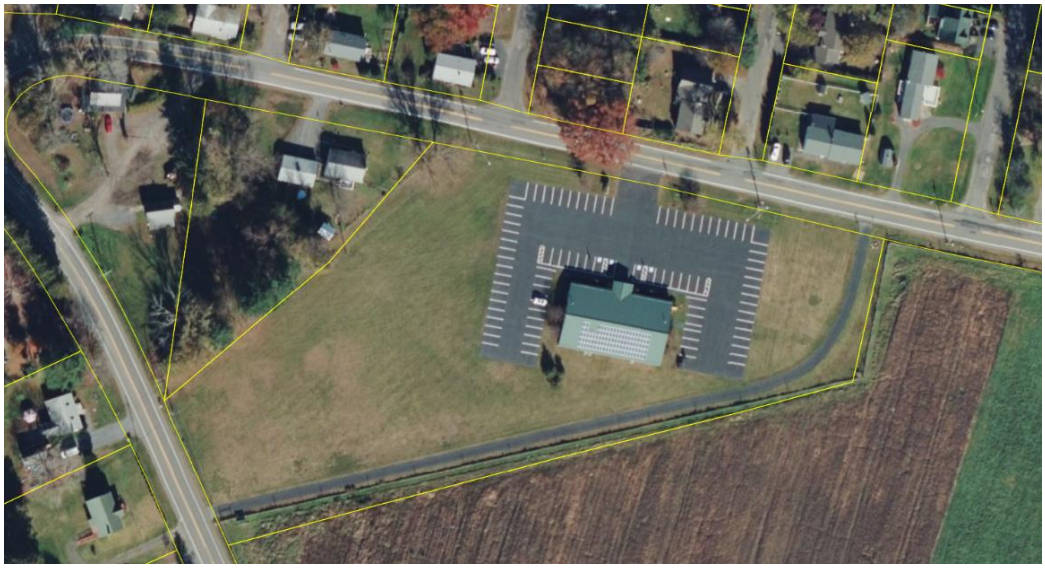


Image 3.1: Ariel View (SDG GIS Tax Parcel Map SDG Map Portal - Map 'Columbia' (giscloud.com))

BUILDING ENVELOPE

Copake Town Hall is a metal framed structure with a metal panel wall system and metal roof. The peaked roof has solar panels covering the majority of the southwest roof, and encloses an unoccupied, unfinished attic above the first floor. The attic is fully ventilated, has limited insulation and limited access to the HVAC systems located within. The building windows are generally double-pane with argon and low-E coating, double hung, with operable sashes.

MECHANICAL SYSTEMS

The existing building consists of three identical HVAC air handlers located in the attic space that each have a propane furnace for heating, a DX cooling coil, and humidification without energy recovery (Carrier WeatherMaker 8000TS, Model 58TMA125-20). Unit capacity is 123 kbtu/h heating, 2,000 cfm each. Air cooled condensing units are located at grade, one 5-ton unit at 12 SEER for each air handling unit (Lennox HS26-060-2P). There is a great deal of flexible ductwork used, which is routed through the attic space and drops into the spaces below to provide both air conditioning and heat for the facility. This use of flexible ductwork increases the airflow pressure drop, reducing the unit's ability to deliver the proper conditioning air volume to the spaces. Accessibility to the units is poor, and each unit serves approximately 1/3 of the building. One unit, which will be referred to as Unit 1, serves the east side and front of the building up to the entrance. It also serves the corridors related to this L-shaped area. The thermostat for Unit 1 is located in the hallway across from the Jury and Special Session Room 112 with the humidity sensor in Supervisor 113. Another unit (Unit 2), serves the west side and front of the building up to the building entrance and its corresponding corridors, mirroring the previous zone. The thermostat and humidity sensor for Unit 2 are both in the Clerk & Tax Collector Office 116. Finally, Unit 3 serves the

Court House with the related thermostat and humidity sensor located in the Court House and Meeting Hall 101, behind the U.S. flag. No whole building BMS is present, only equipment manufacturer controls (combination of built-in and remote wall mounted). Currently there are some comfort issues with uneven conditioning of the spaces. The building is not equipped with perimeter heat (e.g., fin tube radiation). Occupants try to better control the space temperature by blocking diffusers, opening windows, or using space heaters, etc. The worst problem areas are the bookkeeper's room (the most southwest room) and the 2 offices at the northwest corner of the building. These problem areas are even more pronounced now that both rooms no longer have A/C since condenser 2 is broken.

The restrooms are equipped with ceiling exhaust fans that are ducted to the exterior of the building. They are enabled by wall mounted switches. The kitchen has a hood over the range with an exhaust fan.

ELECTRICAL SYSTEMS

The interior lighting layout is identical what is shown the construction drawings. Lighting control is a mixture of switch or switch and motion sensors (see photos). There are no interior security lights, all interior lights are off at night. The interior lighting is one of 3 fixtures:

- 3 lamp, 31-32W, 4ft, T8 fluorescent bulbs
- 3 lamp, 31W, 2ft, T8 U-bend bulbs
- 6” can fixtures with 15W screw in bulbs (main entrance and vestibule)

Exterior lighting on the sides and back of the building are controlled by photocells and the front door lighting is on a timer. The motion sensors in the hallway are for security and are not related to lighting control.

The primary electrical service is 200A, 208V/3Ph and enters at the mechanical/electrical room. A generator is onsite for back-up power in case of an outage. Roof mounted solar PV panels connected to three inverters produce power to supplement the building's purchased electricity; however this was designed, installed, and is maintained by Hudson Valley Clean Energy Inc., and is separate from the building meter. The PV system is capable of generating up to 917 Amps at 240V.

PLUMBING SYSTEMS

Domestic hot water for the kitchen and restrooms is provided by a 40-gallon propane gas-fired water heater with storage (Rheem Model 21V40-36P).

ADDITIONAL OBSERVATIONS

As a result of the walkthrough, the following observations were made:

- The HVAC equipment is beyond its useful life.
- The extensive use of flexible ductwork limits the capability of the HVAC systems to deliver the required airflow and therefore heat and cool the spaces effectively.
- The HVAC systems rely on attic infiltration for ventilation; however, the air handling units are uninsulated, as are some ducts, and there appear to be some locations where this air may be infiltrating into the occupied space via light fixtures and other penetrations (causing areas of the occupied spaces to feel drafty).
- There appears to be some balancing issues with the air handling systems, which affects occupant comfort. Replacing the flexible ductwork with rigid, adding balancing dampers, and balancing the systems would help correct this issue. However with constant volume systems, it is difficult to satisfy both heating and cooling conditions with the same airflow volume all year.
- The envelope of the facility appears to be lightly insulated. Increasing the insulation at both the roof (attic floor) and exterior walls would improve comfort. However, increasing this insulation at the exterior walls may be difficult as it requires furring out the interior walls or adding a second layer to

the exterior (which would require confirmation of dew point location to prevent condensation within the wall cavity).

- HVAC systems with higher efficiencies are currently available.
- The HVAC systems currently utilize propane which is a high-cost fossil fuel.
- The propane use of the facility is relatively high, which may cause an electrified heating solution to be economically feasible.
- The lighting fixtures are currently fluorescent (mostly T-8s) and therefore would benefit from a conversion to LED to reduce energy consumption.

4.0 ENERGY CONSUMPTION / UTILITY ANALYSIS

The Copake Town Hall is powered by electricity from NYSEG and propane from AmeriGas. The average electrical rate is $0.134 per kWh and the average propane rate is $3.743 per gallon. Additionally, an on-site roof mounted solar photovoltaic array produces power; however this was designed, installed, and is maintained by Hudson Valley Clean Energy Inc., and is separate from the building's meter. Therefore the power produced by the PV array and impact as a source of renewable power is not taken into consideration in the utility summary below.

Table 4.1: Annual Energy Usage Summary

Annual 2022 Energy Usage - Copake Town Hall				
Electricity	25,168 kwh	85,898 kBtu/h	$ 3,383	$ 0.13 /kWh
Propane	7,041 gal	643,945 kBtu/h	$ 26,357	$ 3.74 /gal
Total	**7,680 ft²**	**729,843 kBtu/h**	**$ 29,740**	**95.0 kBtu/ft²**

The calculated Energy Utilization Index (EUI) for the town hall is 95.0 kBtu/sf. The town hall is a mixed-use space consisting of 67% and 33% town courtroom. The national median EUI for office buildings, according to Energy Star Portfolio Manager, is 52.9 kBtu/sf. For courthouses, it is 101.2 kBtu/sf. Based on a breakdown of the building square footage, a weighted EUI was determined to be 68.8 kBtu/sf as a benchmark. The current Town Hall EUI is significantly greater than the benchmark data, which suggests that there is room potential for energy savings. The high EUI is likely due to the age of the equipment and the style of lighting used in the building. Implementation of recommended measures would likely reduce the buildings EUI below the benchmark number with a kBtu/sf of 40.3 (without consideration for interactive effects).

Table 4.2: Benchmarking Summary

Benchmarking				
Area Description	Percent of Area [%]	Area [sf]	Site Energy Usage [kBtu/yr]	Site EUI [kBtu/sf]
Office	67%	5,146	272,202	52.9
Courthouse	33%	2,534	256,481	101.2
Benchmark Baseline	100%	7,680	528,684	68.8
Existing Facility	100%	7,680	729,843	95.0
Savings of Recommended Measures			420,687	54.8
Revised Resulting Performance			309,156	40.3

Table 4.3: Monthly Electrical Usage

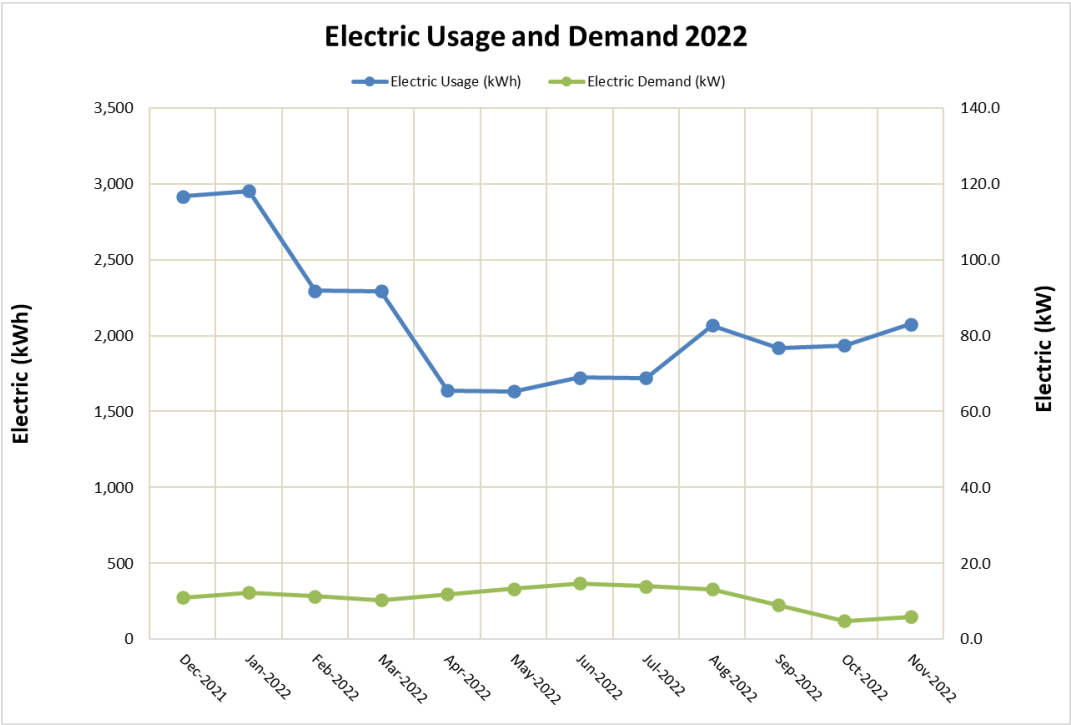
Monthly 2022 Electricity Use - Copake Town Hall				
Statement Date [Month -Year]	Usage [kWh]	Demand [kW]	Total Cost [$]	Total Rate [$/kWh]
Dec-2021	2,916	11.0	$ 513	$ 0.18
Jan-2022	2,953	12.3	$ 518	$ 0.18
Feb-2022	2,296	11.4	$ 334	$ 0.15
Mar-2022	2,293	10.4	$ 343	$ 0.15
Apr-2022	1,638	11.9	$ 208	$ 0.13
May-2022	1,634	13.3	$ 198	$ 0.12
Jun-2022	1,723	14.8	$ 241	$ 0.14
Jul-2022	1,720	14.0	$ 89	$ 0.05
Aug-2022	2,067	13.2	$ 315	$ 0.15
Sep-2022	1,919	9.0	$ 150	$ 0.08
Oct-2022	1,936	4.8	$ 204	$ 0.11
Nov-2022	2,075	5.9	$ 271	$ 0.13
Total	**25,168**	**14.8**	**$ 3,383**	**$ 0.134**

*Red text indicates estimated value. Invoices encompassing multiple months are divided evenly between those months.

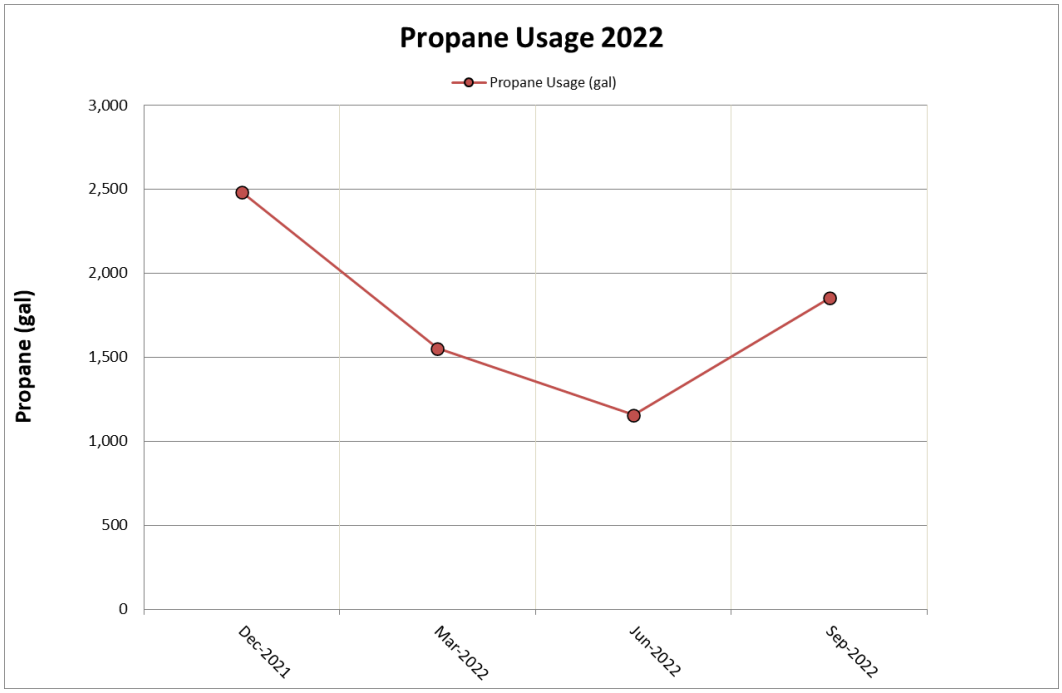
Table 4.4: Monthly Propane Usage

Monthly 2022 Propane Use - Copake Town Hall			
Statement Date [Month -Year]	Usage [gal]	Total Cost [$]	Total Rate [$/gal]
Dec-2021	2,484	$ 8,990	$ 3.62
Jan-2022			
Feb-2022			
Mar-2022	1,551	$ 5,637	$ 3.63
Apr-2022			
May-2022			
Jun-2022	1,155	$ 6,101	$ 5.28
Jul-2022			
Aug-2022			
Sep-2022	1,851	$ 5,629	$ 3.04
Oct-2022			
Nov-2022			
Total	**7,041**	**$ 26,357**	**$ 3.743**

*Red text indicates estimated value



The increase in electric usage over the winter can be attributed to a few things including an increase in the use of lighting (more hours that it is dark), and the use of electric space heaters observed during the walkthrough. Additionally, it is possible that the building had an anomaly of increased occupancy or use during those months. Typically, air conditioning drives up electricity during the cooling season, but the lower usage during the summer months suggests the inefficiencies in the heating season and under-utilization of cooling in the summer (which are supported by the presence of electric space heaters and the inoperable cooling unit, respectively).



The propane is delivered as needed during the year and therefore is not well represented by a monthly diagram, so usage is analyzed seasonally. As expected, the usage drops during the summer when propane usage is limited to the domestic water heater and the kitchen. The propane usage is unusually high in this building, especially as compared to the electric usage, which suggests significant inefficiencies in the HVAC system.

5.0 APPROACH / METHODOLOGY

The analysis to estimate annual energy consumption for each measure was performed using the NYS Technical Resource Manual (TRM) v10.0, a spreadsheet analysis, unless otherwise noted below. Typically NYS Technical Resource Manual (TRM) calculations are more than adequate to address non-complex comparisons so this is the traditional first choice.

The following energy conservation measures were evaluated:

- EEM-1 HVAC Upgrades - Possible upgrades to improve efficiency. The existing HVAC system consists of three propane fired air handling units with DX coils and duct mounted side stream humidifiers located in the attic space, and outdoor condensing units at grade, which provide heating, cooling, and ventilation without energy recovery.
    - EEM-1.1 Code compliant system - Fossil Fuel AHUs: Replacing the existing heating and cooling equipment with code compliant fossil fuel air handling systems. This would essentially be a one-for-one replacement of the propane fired heating and DX cooling units paired with outdoor air cooled condensing units at grade. The intent would be to match the existing zoning. We would recommend replacing the flex duct with rigid, adding volume dampers, and balancing the systems.
    - EEM-1.2 Better than code system - Fossil Fuel AHUs: Replacing the existing heating and cooling equipment with better than code fossil fuel air handling systems. This would essentially be a one-for-one replacement with higher efficiency (condensing) propane fired heating and DX cooling units paired with high efficiency outdoor air cooled condensing units at grade. The intent would be to match the existing zoning but replace the flex duct with rigid, add volume dampers, and balance the systems.
    - EEM-1.3 Better than code system - Electrified AHUs, Air Source Heat Pumps, Split Systems: Replacing the existing heating and cooling equipment with a better than code compliant fully electrified clean heating and cooling air source heat pump system. This system will include three split style air handling units to replace the existing, with reversible heat pump condensing units at grade that will provide heating and cooling with low ambient kits and snow baffles. The intent would be to match the existing zoning but replace the flex duct with rigid, add volume dampers, and balance the systems.
    - EEM-1.5 Better than code system - Electrified, Distributed VRFs: Replacing the existing heating and cooling equipment with a better than code compliant fully electrified clean heating and cooling air source heat pump distributed system (variable refrigerant flow). This system will include distributed indoor evaporators and outdoor reversible heat pump condensing units at grade with low ambient kits and snow baffles. The intent would be to increase the number of zones for better control. Outdoor air would be ducted directly to the individual indoor units.
    - EEM-1.5 High performance system - Electrified AHUs, Ground Source Heat Pumps: Replacing the existing heating and cooling equipment with a high-performance ground source heat pump system with geo-exchange well field. This system will include three air handling units with integral compressors to replace the existing, with new condenser piping and pumps to connect the AHUs to the well field. The intent would be to match the existing zoning but replace the flex duct with rigid, add volume dampers, and balance the systems.

- EEM-2 Envelope Measures - Replacement of existing windows with higher performance glazing and window systems. Improving the exterior wall insulation. Improving the roof insulation at the attic. Reducing air infiltration via weather stripping, caulking, and addressing other areas of concern.

- EEM-3 Domestic Hot Water Heater Upgrades
  - EEM-3.1 Better than Code - Fossil Fuel DWH: Replacement of existing domestic water heater with better than code (condensing) propane fired system. This will represent an improvement over the existing systems.
  - EEM-3.2 Better than Code - Electrified DWH, Air Source Heat Pump: Replacement of existing domestic water heater with better than code system. This will be an ASHP solution.
  - EEM-3.3 High Performance - Electrified DWH, Ground Source Heat Pump: Replacement of existing domestic water heater with high performance system. This will be a GSHP solution.

- EEM-4 Lighting Upgrades - This measure includes the evaluation of converting interior and exterior lighting to LED and upgrading controls (occupancy/vacancy).

- EEM-5 Energy Recovery - Capturing energy from air exhausted from the facility. This energy would be utilized to precondition ventilation air. This can result in downsizing the required heating and cooling equipment.

- EEM-6 Indoor Air Quality - A discussion of how HVAC and envelope modifications will affect and improve indoor air quality, mitigating "infectious disease transmission in accordance with the current ASHRAE Epidemic Task Force Core Guidance".

For each measure analyzed, the following has been provided:

- Measure Description. Brief description of each system, system comparison, and feasibility overview (i.e. pros / cons, project impact, etc.).
- Detailed annual energy and cost analysis complete with anticipated savings.
- High level budgetary order of magnitude opinion of probable construction cost using a combination of RS Means, project experience, and other industry standard methods. This includes a breakdown for equipment, material, and labor.
- Simple payback of each measure.
- Measure reporting in tabular format utilizing NYSERDA's project summary template.

6.0 ENERGY EFFICIENCY MEASURES

EEM-1: HVAC UPGRADES

The existing HVAC system utilizes three propane fired furnaces with DX coils. The furnaces are in the attic with limited accessibility, and the air cooled condensing units are located at grade outside. Each unit has a duct mounted humidifier. The heat is ducted throughout the building, with each unit serving a particular section of the town hall. The existing unit capacity is 123 kbtu heating input, 101 kbtu heating output, 5 tons of cooling, and 2,000 cfm each.

We have evaluated several HVAC upgrade options, including a code compliant system, and both a decarbonized electrified better than code system (air source heat pumps system) and a geo-exchange well field in combination with ground source heat pumps. Each HVAC option has been compared to the existing system as the baseline. These systems have improved energy efficiencies to reduce the energy consumed and utility costs. This measure required onsite inventory of the existing system equipment, arrangement, components, and controls to fully understand the impact and requirements for replacement.

Various options were evaluated for HVAC system replacement as compared to the existing systems, for possible upgrades to improve energy efficiency and include the following:

EEM-1.1 HVAC Upgrades: Code Compliant Fossil Fuel AHUs
EEM-1.2 HVAC Upgrades: Better Than Code Fossil Fuel AHUs
EEM-1.3 HVAC Upgrades: Better Than Code Electrified AHUs ASHP Split
EEM-1.4 HVAC Upgrades: Better Than Code Electrified Distributed VRF
EEM-1.5 HVAC Upgrades: High Performance Electrified GSHP AHUs

EEM-1.1 HVAC Upgrades: Code Compliant - Fossil Fuel AHUs

EEM-1.1 is an HVAC Option for a code compliant system. For this measure we analyzed the feasibility and energy benefit of replacing the existing heating and cooling equipment with a code compliant fossil fuel air handling systems. This would essentially be a one-for-one replacement with propane fired heating and DX cooling coils paired with outdoor air cooled condensing units at grade. The intent would be to match the existing zoning. We would also encourage replacing the flex duct with rigid, adding volume dampers, and balancing the systems. This measure utilizes the existing system capacities and historical utility data as a baseline.

Baseline Assumptions:

- 3 units each at 123,000 Btu/hr input propane fired heating capacity, with 82% heating efficiency
- 3 units each at 5-Ton cooling capacity with SEER of 12
- >75% Flexible ductwork

Proposed Assumptions:

- New propane fired furnace with DX cooling coil.
- 3 units each at 123,000 Btu/hr input propane fired heating capacity, with 80% heating efficiency
- 3 units each at 5-Ton cooling capacity with 11 EER, and 12.6 IEER.
- Rigid ductwork

One thing to note is that there is a bit of a mismatch with the heating capacity vs. the cooling capacity. The cooling capacity of the system matches nicely with the airflow, but the heating capacity may be a bit oversized. A building load calculation would confirm if a unit with less heating capacity would be required.

Table 6.1: EEM-1.1 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-1.1	HVAC Upgrades: Code Compliant - Fossil Fuel AHUs	549	0.7	$74	23.3	$952	25.1	$1,025	0.9	$57,236	55.8

This system would be a relatively low cost and easy replacement as it is in-kind. The results show that the energy performance of the code compliant units is only slightly improved from the existing system. This is because the efficiency of the existing heating system is marginally better than the required code complaint systems. However, the existing systems are operating inefficiently with losses at the uninsulated ducts, drafts caused by infiltration from the attic to the occupied space, long runs of flexible ductwork, and the use of electric resistance space heaters, etc. Some of these deficiencies are captured in the calculation to demonstrate positive savings, but it is likely that the measure would result in additional savings if the issues are addressed with the replacement.

EEM-1.2 HVAC Upgrades: Better Than Code Fossil Fuel AHUs

EEM-1.2 is an HVAC Option for a better than Code system. For this measure we analyzed the feasibility and energy benefit of replacing the existing heating and cooling equipment with a better than code compliant fossil fuel air handling systems. This would be a one-for-one replacement with higher efficiency propane fired heating and DX cooling coils paired with higher efficiency outdoor air cooled condensing units at grade. The intent would be to match the existing zoning but replace the flex duct with rigid, add volume dampers, and balance the systems. This measure utilizes the existing system capacities and historical utility data as a baseline.

Baseline Assumptions:

- 3 units each at 123,000 Btu/hr input propane fired heating capacity, with 82% heating efficiency
- 3 units each at 5-Ton cooling capacity with SEER of 12
- >75% Flexible ductwork

Proposed Assumptions:

- New propane fired furnaces with DX cooling coil.
- Three units each at 107,000 Btu/hr input propane fired heating capacity, with 95% heating efficiency
- Three units each at 5-Ton cooling capacity with 11.2 EER, and 13.0 IEER.
- Rigid ductwork

Table 6.2: EEM-1.2 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-1.2	HVAC Upgrades: Better Than Code - Fossil Fuel AHUs	886	0.9	$119	79.5	$3,254	82.5	$3,373	2.9	$65,370	19.4

This system, like EEM-1.1, is a relatively low cost and easy replacement as it is in-kind, with the benefit of an energy efficiency improvement. This would not require any infrastructure improvements, only minor modifications to accommodate the removal of the existing and installation of the new. The results show a modest improvement in energy, with both energy and cost savings.

EEM-1.3 HVAC Upgrades: Better Than Code Electrified AHUs ASHP Split

EEM-1.3 is an HVAC Option for a better than Code system. For this measure we analyzed the feasibility and energy benefit of replacing the existing heating and cooling equipment with a better than code compliant fully electrified clean heating and cooling solution. This would be an air source heat pump system complete with three indoor AHU replacement units that connect to outdoor with high efficiency reversible heat pump condensing units that will provide heating and cooling. Low ambient kits, mounting stands/racks, and snow baffles would be required. The intent would be to match the existing zoning but replace the flex duct with rigid, add volume dampers, and balance the systems.

Baseline Assumptions:

- 3 units each at 123,000 Btu/hr input propane fired heating capacity, with 82% heating efficiency
- 3 units each at 5-Ton cooling capacity with SEER of 12
- >75% Flexible ductwork

Proposed Assumptions:

- New heat pump AHU split systems (fully electrified solution)
- Three units each at 101,000 Btu/hr heating capacity, with minimum 3.0 COP heating efficiency
- Three units each at 5-Ton cooling capacity with 11.8 EER, and 14.0 IEER minimum
- Rigid ductwork

It appears that the electrical service capacity is adequate to support these modifications.

Table 6.3: EEM-1.3 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-1.3	HVAC Upgrades: Better Than Code - Electrified AHUs ASHP Split	(31,610)	(12.5)	($4,249)	249.6	$10,217	141.7	$5,968	5.0	$87,788	14.7

This is a lower cost measure, which does not require a major overhaul of the existing systems, but provides an electrified heating solution. Since it does replace propane with electricity, it comes with extra electricity costs, but that is eclipsed by the propane cost savings, due in large part to the high cost of propane. However, during the peak of winter, the efficiency of the air source heat pumps is greatly reduced and it provides for an increased peak demand.

EEM-1.4 HVAC Upgrades: Better Than Code Electrified Distributed VRF

EEM-1.4 is an HVAC Option for a better than Code system. For this measure we analyzed the feasibility and energy benefit of replacing the existing heating and cooling equipment with a better than code compliant fully electrified clean heating and cooling solution. This option is a distributed air source heat pump system complete with multiple variable refrigerant flow (VRF) indoor evaporator modules, connected to a bank of outdoor VRF heat pump condensing units. Heat recovery selector boxes will be provided to allow for simultaneous heating and cooling and energy sharing. Low ambient kits, mounting stands/racks, and snow baffles would be required. The intent would be to increase the number of zones for better control. Outdoor air would be ducted directly to the individual units.

Baseline Assumptions:

- 3 units each at 123,000 Btu/hr input propane fired heating capacity, with 82% heating efficiency
- 3 units each at 5-Ton cooling capacity with SEER of 12
- >75% Flexible ductwork

Proposed Assumptions:

- Complete VRF system with indoor evaporator modules and outdoor condensing units (fully electrified solution)
- 303,000 Btu/hr input heating capacity total, with minimum 4.5 COP heating efficiency
- 15-Ton total cooling capacity with 12.8 EER, and 16.0 IEER minimum
- Rigid ductwork for ventilation

This system allows for more precise control of individual spaces for heating and cooling as well as for ventilation. Various indoor module types are available and include ceiling hung units, wall mounted units, console units, and ducted units (similar to fan coils). These units are very quiet, since the compressors are located outdoors. This system allows for energy sharing and simultaneous heating and cooling. It appears that the electrical service capacity is adequate to support these modifications.

Table 6.4: EEM-1.4 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-1.4	HVAC Upgrades: Better Than Code - Electrified Distributed VRF	(11,900)	(2.7)	($1,600)	249.6	$10,217	209.0	$8,618	7.4	$175,523	20.4

The VRF system is a higher first cost system, due in part to the technology required for simultaneous heating and cooling. However, it provides premium energy savings as well as comfort conditions. It would, however, require a wholesale renovation of the existing HVAC system which would be potentially disruptive to the occupants.

EEM-1.5: HVAC Upgrades: High Performance Electrified GSHP AHUs

EEM-1.5 is an HVAC Option for a high performance system. For this measure, we analyzed the feasibility and energy benefit of replacing the existing heating and cooling equipment with a high performance fully electrified clean heating and cooling solution. This option is a ground source heat pump system complete with a geo-exchange well field. The intent would be to provide three units, matching the existing zoning but replace the flex duct with rigid, add volume dampers, and balance the systems.

Geothermal heat pump systems utilize geo-exchange well fields coupled with extended-range water source heat pump-type units to efficiently provide space conditioning with electricity. The indoor units contain compressors, which extract energy from the attached water loop to condition the air. The water loop is pumped through underground vertical wells and uses the naturally constant ground temperature of the earth as both a heat source and sink as needed. This system allows for sharing of energy throughout a water heat pump loop so that simultaneous heating and cooling can occur and benefit from it.

A location for the well field will need to be determined. An open green space is usually the best option because there is horizontal piping required to connect to the vertical wells, and tree root systems should be avoided. However, an area under a parking lot is acceptable as well. All piping will be located below the frost line and therefore will not be visible at grade, apart from a possible buried piping header vault flush with the ground at or near the field. This vault, if needed, would contain piping distribution heads, shutoffs and balancing accessories. The downside of using a parking lot is an increase in restoration costs; however this makes sense when the lot is in need of replacement. This horizontal piping will be more than 5 ft underground, and will require trenching for installation and coordination with underground

utilities. The spacing of the wells is typically 20 feet on center, with 400 feet deep wells and 6-inch diameter bores (which contain butt-fused HDPE piping, U bend, thermal clips, and a high thermal conductivity grout). A 48-hour test-well is recommended to confirm ground composition and thermal conductivity. Shallower sample borings can be performed but this information generally only offers the depth of the casing that would be needed (depth of loose soil to bedrock). Reverse-return piping would be designed to balance the loops and temperatures. A vault in the ground with piping manifolds may be recommended for isolation of the wells.

If we assume that the actual total required cooling demand of the building is a maximum of 15 tons and the heating demand is approximately 184.5 MBH at peak, this would result in a well field of about 8 wells. During the design process, the consumption and capacity peaks of the facility will be reviewed to ensure that enough wells are provided to accommodate any migration of ground temperatures due to a predominately heating or predominantly cooling demand. It is likely that at peak capacity, the well field would be relatively balanced but in consumption, with this being a heating-dominated climate, the system may spend more hours in the heating mode than in the cooling mode.

Baseline Assumptions:

- 3 units each at 123,000 Btu/hr input propane fired heating capacity, with 82% heating efficiency
- 3 units each at 5-Ton cooling capacity with SEER of 12
- >75% Flexible ductwork

Proposed Assumptions:

- Geo-exchange vertical well field, 8 wells
  - 8 x 6-inch diameter vertical bores
  - 400 feet deep
  - 20 feet on center
  - High-performance grout
  - Geo-clips
  - HDPE butt weld with u-bend
- Three geothermal water-to-air heat pumps that are capable of both heating and cooling 18.4 EER, 3.5 COP

This GSHP system can provide both heating and cooling, which allows for decarbonization through electrification. Typically the ground loop would contain a propylene glycol mixture. A heat exchanger between the ground loop and building loop would ensure protection between the ground and building, but is not required. The AHUs would have ECM motors. A duplex redundant set of pumps would be required for the loop (these can be inline or floor mounted) and all pumps would also be variable speed with smart drives. It appears that the electrical service capacity is adequate to support these modifications.

Image: Geo-Exchange Well Field Map

As an alternate, distributed heat pumps may be installed throughout the facility for additional zone control, however the heat pumps do contain compressors and generate some noise. They also are not as small as the VRF indoor units.

Table 6.5: EEM-1.5 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-1.5	HVAC Upgrades: High Performance - Electrified GSHP AHUs	(13,039)	(6.9)	($1,753)	249.6	$10,217	205.1	$8,464	7.3	$228,884	27.0

The table above shows the savings and payback analysis of the geothermal system. There is a high upfront cost for geothermal systems, with a large portion of the costs in the geo-exchange well field. Once the well field is in place, the maintenance costs are relatively low as the underground piping does not have any moving parts requiring maintenance.

To help mitigate the first cost of the GSHP system, incentives are available through the NYS Clean Heat Utility Programs. If eligible, these programs typically offer up to $80 / MMBtu saved, which would amount to a rough estimate of $16,410 for this project.

EEM-2: ENVELOPE MEASURES

In order to drive down energy use and also reduce the necessary equipment capacity, envelope improvements to the building may be made. Possible improvements include the replacement of existing windows with higher performance glazing and window systems, adding insulation to the exterior walls, and adding insulation for the roof on the attic floor. Reducing air infiltration via weather stripping, caulking, and addressing other areas of leakage such as at the light fixture housings at the attic floor with provide further savings.

When improving the exterior wall insulation, consideration must be given to the method. This may be accomplished by furring out from the inside or insulating from the outside if it is constructed in such a manner so that there will not be condensation within the walls. Improving the roof insulation at the attic floor is fairly straight forward, where additional insulation would lay on top of the existing exposed insulation. Glazing upgrades would include selecting windows with U-values and SHGC that exceed the code minimum and have insulated and thermally broken frames. Triple paned windows are not necessary and often do not result in a favorable energy to cost payback.

Baseline Assumptions:

- Wall construction with a thermal resistance value of R=10
- Roof construction with a thermal resistance value of R=20
- Existing windows, estimated U-0.90 and SHGC-0.68

Proposed Assumptions:

- Walls - provide an additional minimum 2" of insulation for an additional R-10. A framing factor of 0.25 has been assumed.
- Roof - provide an additional minimum 3.5" of insulation for an additional R-11. A framing factor of 0.25 has been assumed.
- High performance glazing, equivalent to Energy Star: U-0.27, SHGC-0.38 (to provide a savings of ≥303 kWh/100sf annually, see NYS TRM 10.0)

Values modeled the same in both:

- Wall square footage minus windows calculated from plans
- Existing HVAC systems

Table 6.6: EEM-2 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-2	Envelope Upgrades	1,910	0.4	$257	68.5	$2,804	75.0	$3,061	2.7	$56,673	18.5

The results indicate that although the envelope measures have a longer payback, they would provide significant fossil fuel savings. Additionally, an upgraded envelope may permit a smaller HVAC system for replacement, and increase comfort conditions. This measure is recommended.

EEM-3: DOMESTIC HOT WATER

Domestic hot water for the kitchen and restrooms is provided by a 40-gallon propane gas-fired water heater with storage (Rheem Model 21V40-36P). We have evaluated three DHW upgrade options, including a replacement in kind with a higher efficiency model, an electrified solution and a premium efficiency option. Each DHW option has been compared to the existing system as the baseline. These systems have improved energy efficiencies to reduce the energy consumed and utility costs. This measure required onsite inventory of the existing system equipment, arrangement, components, and controls to fully understand the impact and requirements for replacement.

The three (3) options evaluated for domestic hot water system replacement to improve efficiency include the following:

EEM-3.1 DHW Upgrades: Better than Code - Fossil Fuel Fired
EEM-3.2 DHW Upgrades: Better than Code - ASHP
EEM-3.3 DHW Upgrades: High Performance System - GSHP

EEM-3.1: DHW Upgrades: Better than Code Fossil Fuel Fired

EEM-3.1 is a DHW heater replacement option for a better than code system. For this measure we analyzed the feasibility and energy benefit of replacing the existing domestic water heater with a better than code propane fired water heater. This will represent an improvement over the existing systems.

Baseline Assumptions:

- Existing 40 gallon propane fired water heater with integral storage
- 1.1 gallons per day per person, 75 people.
- 0.58 UEF

Proposed Assumptions

- New 40 gallon propane fired water heater with integral storage.
- 1.1 gallons per day per person, 75 people.
- 0.80 UEF (Energy Star)

Table 6.7: EEM-3.1 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-3.1	DHW Upgrades: Better than Code - Fossil Fuel Fired	0	0.0	$0	9.0	$368	9.0	$368	0.3	$1,645	4.5

This option provides modest energy savings and has a short payback period, but does not make progress towards the goals of de-carbonization.

EEM-3.2: DHW Upgrades: Better than Code ASHP

EEM-3.2 is a DHW heater replacement option for a better than code system. For this measure we analyzed the feasibility and energy benefit of replacing the existing domestic water heater with a better than code compliant fully electrified clean heating air source heat pump system. This will represent an improvement over the existing systems.

A centralized air-source heat pump domestic hot water system will save a significant amount of energy over propane water heating. If installed in conditioned space, however, there will be an increased load on the heating unit due to the heat absorption of the unit in the room. Careful consideration is needed to ensure that the location meets specifications for volume according to the unit manufacturer; the unit may require ducts to circulate air through the space.

Baseline Assumptions:

- Existing 40 gallon propane fired water heater with integral storage
- 1.1 gallons per day per person, 75 people.
- 0.58 UEF

Proposed Assumptions

- New 40 gallon ASHP water heater with integral storage.
- 1.1 gallons per day per person, 75 people.
- Minimum UEF 2.8

Table 6.8: EEM-3.2 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-3.2	DHW Upgrades: Better than Code - ASHP	(1,578)	(0.2)	($212)	56.5	$2,311	51.1	$2,099	1.8	$2,830	1.3

Energy savings are modest, due to the low utilization of the domestic water heater, but the high cost of propane provides for a reasonable payback. This measure is recommended; careful consideration must be taken with installation location due to the cooling nature of the packaged heat pump. Additional heat added to the space to offset the cooling will effectively negate the energy savings.

EEM-3.3: DHW Upgrades: High Performance System GSHP

EEM-3.3 is a DHW heater replacement Option for a high performance system. For this measure we analyzed the feasibility and energy benefit of replacing the existing domestic water heater with a high performance fully electrified clean heating geothermal water heater. This will represent an improvement over the existing systems.

This measure would require connection to a geothermal well field in order to operate, as energy is extracted from the ground to allow this unit to heat the domestic water. This system makes the most sense when pairing with HVAC EEM 1.5 GSHP.

Baseline Assumptions:

- Existing 40 gallon propane fired water heater with integral storage
- 1.1 gallons per day per person, 75 people.
- 0.58 UEF

Proposed Assumptions

- New domestic water to water geothermal heat pump that generates and stores 140°F water.
- Geo exchange well field available with sufficient capacity (assume EEM-1.5 proceeds)
- 1.1 gallons per day per person, 75 people.
- Minimum UEF 3.5

Table 6.9: EEM-3.3 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-3.3	DHW Upgrades: High Performance - GSHP	(1,263)	(0.1)	($170)	56.5	$2,311	52.1	$2,141	1.8	$7,426	3.5

Although the payback is favorable for this measure, it only makes sense if the accompanying HVAC measure is utilized as well.

EEM-4: LIGHTING UPGRADES

This measure is intended to include the evaluation of replacing the existing light fixtures with LED lighting, as well as upgrading the controls with occupancy and vacancy sensors. An inventory of the existing light fixtures was performed, complete with an inventory of controls, space usage, square footage of rooms, and hours of operation.

Baseline Assumptions:

- Existing 1.50 W/SF lighting power density (LPD). Based on fixture count and percentage of lights that are LED vs fluorescent lighting technology.

Proposed Assumptions:

- Proposed maximum of 0.63 W/SF lighting power density (LPD). Based on fixture count and converting to LED technology with a LPD credit for occupancy sensor controls.

Table 6.10: EEM-4 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-4	Lighting Upgrades: LED Fixtures and Controls	29,563	7.4	$3,974	(5.4)	($220)	95.5	$3,754	3.4	$21,448	5.7

An improvement to lighting upgrades has a simple economic payback well within the expected life of the fixtures and is recommended. Care should be taken when selecting replacement fixtures to favor Energy Star or Design Lights Consortium (or similar) certified lighting - lower cost LED lighting will not provide the energy savings as calculated, and is unlikely to be eligible for incentive.

EEM-5: ENERGY RECOVERY

This measure is intended to include the evaluation of incorporating Energy Recovery into the HVAC systems. Energy may be captured from the air prior to exhausting it from the facility. This energy would be utilized to precondition ventilation air. This can result in downsizing the required heating and cooling equipment. The addition of enthalpy (heating and cooling) or sensible only (heating only) energy recovery cores to precondition outdoor air would provide a potential for energy savings. Generally in this climate, we typically see a greater heating reduction impact than cooling reduction impact.

Table 6.11: EEM-5 Measure Summary Results

Measure Summary											
EEM No.	Energy Efficiency Measure Description	Electricity Savings			Fossil Fuel Savings		Total Savings			Payback Analysis	
		Consumption [kWh]	Demand [kW]	Cost [$]	Consumption [MMBtu]	Cost [$]	Consumption [MMBtu]	Cost [$]	EUI [kBtu/sf]	Est. EEMCost [$]	Simple Payback [yrs]
EEM-5	Energy Recovery	40	(1.9)	$5	57.2	$2,340	57.3	$2,346	2.0	$9,780	4.2

Energy recovery is a simple way to increase savings without significant renovation required, especially in an area with significant heating fuel costs. This measure is recommended independently of any other renovation that is enacted, but can help to reduce equipment capacities in an HVAC upgrade. Note that a distributed system, such as VRF, will require additional ductwork (and possibly a large energy recovery unit) to distribute air throughout the building.

EEM-6: INDOOR AIR QUALITY

This measure is intended to include a discussion of how HVAC and envelope modifications will affect and improve indoor air quality. The existing systems rely on infiltration for ventilation air. The outdoor air blends with return air and is supplied to the occupied spaces. The existing units have filter boxes which allow for 4" pleated MERV 13 filters to be utilized. Assuming that the intended volume of outdoor air is being mixed and delivered to the occupied spaces, the total volume of outdoor air provided to the building appears to be adequate. However the following improvements could be made to even further improve the air quality in the building and operation of the units:

- The units are sized for a 0.6"SP drop at 2,000 cfm. The air pressure drop in the system is caused by duct friction, filters, coils, and other obstructions between the fan and furthest supply outlet. This available pressure drop is relatively small, and it is possible that the volume of air delivered to the spaces could be less than desired. It also could unintentionally be compromising the volume of outdoor air delivered to the spaces. To rectify this, the new systems and equipment would be designed to accommodate the necessary system pressure to deliver the volume of air desired.
- The densely occupied spaces could benefit from CO_2 sensing. The new systems could include modulation of the ventilation, not only to provide additional flow when specific densely occupied rooms are appropriately ventilated but also to save energy and dial back the ventilation when the spaces are unoccupied.
- Distributed equipment with more zoning would allow for more compartmentalizing of contagions.
- The design of any new systems will take into consideration the occupancy and space types and amount of ventilation required.

7.0 ADDITIONAL CONSIDERATIONS

Although the main considerations in selecting an HVAC system are typically energy and cost implications, there are several other factors at play.

EXISTING USEFUL LIFE OF EQUIPMENT

A full life cycle cost analysis has not been performed as part of this study. However, each system has a different lifespan. For example, a variable refrigerant flow (VRF) system has an expected useful life of 25 years before replacement becomes necessary, while a fossil fuel domestic water heater can be expected to last 15 years.

Table 7.1: Expected Useful Life of Equipment Summary

Expected Useful Lifespan			
Equipment Description	Years	Equipment Description	Years
Air Handling Unit	15	Envelope Improvements	30
Fossil Fuel Furnace	18	Fossil Fuel DWH	15
Split System AC or ASHP	15	ASHP DWH	20
VRF	25	GSHP DWH	24
Water Source Heat Pump	25	Lighting Fixtures	20
Geothermal Well field	50	Energy Recovery	20

In order to fully capture the replacement and the true cost of each system type, a full life cycle cost analysis may be warranted.

CARBON REDUCTION

Much of the motivation to reduce fossil fuel usage is to address climate change by reducing carbon and greenhouse gas emissions. New York State currently has one of the cleanest electric grids in the nation and has goals of 100% zero emission electricity by 2040. However, today natural gas still remains slightly less carbon intensive per unit of energy than electricity, due to the fossil fuels required to produce and distribute electricity, which is often counter-intuitive. With New York's focus on renewable energy, that is likely to change, especially over the lifespan of equipment with long expected life.

Table 7.2: Greenhouse Gas Emissions Summary

Greenhouse Gas Emissions				
EEM No.	EEM Description	GHG Carbon Emissions	GHG Carbon Emissions Savings	
		(lb CO_2e)	(lb CO_2e)	(%)
N/A	Existing	94859	--	--
EEM-1.1	HVAC Upgrades: Code Compliant - Fossil Fuel AHUs	94438	422	0.44%
EEM-1.2	HVAC Upgrades: Better Than Code - Fossil Fuel AHUs	93648	1211	1.28%
EEM-1.3	HVAC Upgrades: Better Than Code - Electrified AHUs ASHP Split	99072	-4213	-4.44%
EEM-1.4	HVAC Upgrades: Better Than Code - Electrified Distributed VRF	94478	381	0.40%
EEM-1.5	HVAC Upgrades: High Performance - Electrified GSHP AHUs	94743	116	0.12%
EEM-2	Envelope Upgrades	93548	1311	1.38%
EEM-3.1	DHW Upgrades: Better than Code - Fossil Fuel Fired	94746	114	0.12%
EEM-3.2	DHW Upgrades: Better than Code - ASHP	94514	346	0.36%
EEM-3.3	DHW Upgrades: High Performance - GSHP	94440	419	0.44%
EEM-4	Lighting Upgrades: LED Fixtures and Controls	88037	6823	7.19%
EEM-5	Energy Recovery	94127	732	0.77%

All the measures, with the exception of the ASHP HVAC measure, reduce carbon emissions. The electrified heating and domestic hot water options, however, will passively continue to reduce carbon as the New York State electric grid becomes greener and approaches fossil fuel free. Electrified solutions can be directly offset by solar photovoltaics as well.

UTILITY COST INFLATION

New York State has aggressive carbon-reduction goals, which require the electrification of heating systems to succeed. One method of encouraging the switch from fossil fuels to electric heating in our climate is to provide financial incentives and penalties. Already, NYSERDA and the major utility companies have incentive programs to mitigate first costs. In the future, the economic incentives may migrate to utility rates themselves, in the form of electric rate subsidies or carbon taxes. For example, in 2018, Canada implemented a carbon tax based on consumption meant to penalize excessive fossil fuel use. While the future of energy is unknown, it is a possibility to consider.

Additionally, utility rates increase with inflation, and have increased dramatically over the last few years. For the purposes of these calculations, no inflation adjustments have been made, but as utility rates increase over time, the effective payback of energy conservation measures decrease accordingly.

ADDITIONAL ENERGY EFFICIENCY MEASURES

When designing a high-efficiency HVAC system with a high first cost, such as a high-efficiency ground source heat pump system, it is important to include a range of additional energy efficiency measures. If the load of the HVAC system can be reduced, so can the equipment size, which decreases the cost premium required for the high-efficiency option. It is encouraged to include as many energy efficiency measures as feasible to ensure both a high-performing building as well as to mitigate some of the equipment costs.

PROJECT STAGE & NEXT STEPS

This project is in the study phase and as such, many assumptions and generalizations were made in the analyses. It is prudent to make conservative assumptions to avoid overstating energy savings or cost implications. As the design progresses, the models may be refined, and typically more energy savings are demonstrated as not all items are accounted for. Interactive effects of the differing measures have not been accounted for in this report.

The next steps will depend on the system modifications selected and will include the following:

1) Review the report and determine which energy efficiency measures are to be pursued for potential implementation.
2) Engage an Architectural and/or Engineering firm for design, construction administration, and commissioning services. The design professionals will produce construction documents, which include the design of the system upgrades and modifications as well as the selection and specification of equipment, components, materials, and sequence of operations required. Construction administration will include periodic site visits for observation. Commissioning will aid in ensuring that the systems ultimately operate as intended.
3) Engage a Contractor for a quote for services and to determine equipment availability.
4) Engage and Energy Engineer to assist in preparing documentation for incentive submissions.
5) Once a contractor is secured, begin construction to implement measures.

Alternatively, if the system or EEMs selected are not complex and are one-for-one replacements, a Contractor may be engaged early for preliminary pricing and early equipment ordering. If this path is taken, we recommend engaging an engineer to at a minimum assist with the review of the equipment proposed by the contractor.

INCENTIVE PROGRAMS

To assist in financing, there are many incentive programs though the government and utilities that offer financial support for energy efficiency projects. The programs may be aimed toward specific technologies, or simply based upon energy reduction. Generally, incentives are paid upon completion of the construction project and are subject to program guidelines. Estimated incentives for the proposed project are as follows:

Table 7.3: Incentive Analysis

Payback Analysis With Incentives						
EEM No.	Energy Efficiency Measure Description	Incentive Program	Potential Incentive [$]	Adjusted Est. EEM Cost [$]	Adjusted Simple Payback [yrs]	Comments
EEM-1.1	HVAC Upgrades: Code Compliant - Fossil Fuel AHUs	Utility Custom or Prequalified Measures	$71	$57,165	55.8	Custom $0.13/kWh saved and $1.50/therm saved
EEM-1.2	HVAC Upgrades: Better Than Code - Fossil Fuel AHUs	Utility Custom or Prequalified Measures	$115	$65,255	19.3	Custom $0.13/kWh saved and $1.50/therm saved
EEM-1.3	HVAC Upgrades: Better Than Code - Electrified AHUs ASHP Split	NYS Clean Heat Program Though Utility	$11,340	$76,448	12.8	Custom HP: $80/MMBtu annual energy saved
EEM-1.4	HVAC Upgrades: Better Than Code - Electrified Distributed VRF	NYS Clean Heat Program Though Utility	$16,721	$158,802	18.4	Custom HP: $80/MMBtu annual energy saved
EEM-1.5	HVAC Upgrades: High Performance - Electrified GSHP AHUs	NYS Clean Heat Program Though Utility	$16,410	$212,474	25.1	Custom HP: $80/MMBtu annual energy saved
EEM-2	Envelope Upgrades	Utility Custom or Prequalified Measures	$248	$56,425	18.4	Custom $0.13/kWh saved
EEM-3.1	DHW Upgrades: Better than Code - Fossil Fuel Fired	Utility Custom or Prequalified Measures	$0	$1,645	4.5	Custom $0.13/kWh saved
EEM-3.2	DHW Upgrades: Better than Code - ASHP	NYS Clean Heat Program Though Utility	$700	$2,130	1.0	$700 / HPWH, <120 gal tank
EEM-3.3	DHW Upgrades: High Performance - GSHP	NYS Clean Heat Program Though Utility	$1,150	$6,276	2.9	$900 / WWWH + $250 bonus
EEM-4	Lighting Upgrades: LED Fixtures and Controls	Utility Custom or Prequalified Measures	$1,080	$20,368	5.4	$15-$25/fixture, $7-15/sensor
EEM-5	Energy Recovery	Utility Custom or Prequalified Measures	$5	$9,775	4.2	Custom $0.13/kWh saved and $1.50/therm saved

There are additional bonus incentives for installation load reduction measures (energy recovery, envelope upgrades) in conjunction with an electrified heating system through NYS Clean Heat. Note that no incentives are available for the propane measures through the utilities since it is acquired outside of the utilities.

In addition to the NYSERDA and NYSEG incentive programs, there are tax incentives as well, including tax credits and accelerated depreciation. The value of these incentives is dependent on the tax structure of the project owner. Specific incentive programs that may be applicable to this project are described below:

NYSERDA PROGRAMS

NYSERDA Flexible Technical Assistance (FlexTech)

- Shares the cost to produce an objective, site-specific, and targeted study on how best to implement clean energy and/or energy efficiency technologies (NYSERDA pays 50% of study cost)
- For more information: NYSERDA FlexTech

NYSEG INCENTIVES

NYS Clean Heat Program – NYSEG: Incentives for heat pumps for heating/cooling and hot water production. (NYS Clean Heat Rebate Program - NYSEG / NYS Clean Heat Rebate Program for Participating Contractors - NYSEG)

Technology	Incentive	NYSEG territory
ccASHP (Small systems)	$/10,000 BTUH of maximum heating capacity at NEEP 5ºF	$1,000
GSHP (Small systems)	$/10,000 BTUH of full load heating capacity as certified by AHRI	$1,500
Air-Source HPWH (<120 gal)	$/unit	$700
Ground-Source WH (<120 gal)	$/unit	$900
Custom Incentive (for Large Systems), includes ASVRF (air source VRF) and SPVHP (single package vertical heat pump)	$/MMBTU of annual energy savings	$80
Simultaneous Installation of ccASHP & Water Heating	Additional bonus incentive	$250
Heat Pumps + Envelope	Additional bonus incentive $/MMBTU saved by envelope measure	≤30% reduction (existing): $80 >30% reduction (existing): $100
Heat Pumps + Energy Recovery	Additional bonus incentive $/MMBTU saved by ERU	$80

NYSEG Commercial and Industrial Program: prescriptive and custom incentives (Commercial Industrial Rebates - NYSEG)

- Prescriptive rebates: For specific predetermined measures such as: lighting and controls, HVAC and plumbing, commercial kitchen equipment and refrigeration, and process systems
  - (example) NYSEG LED Lighting and Controls Rebates:
    - LED, 2x4s, 24-48W: $20/fixture
    - Wall-mounted occupancy sensors: $7/sensor
    - Plus many other additional fixtures and controls
- Custom rebates: These are performance-based rebates that require site-specific assessment and cost analysis. ($0.13/kWh saved; no incentive for fossil fuels saved if not provided by NYSEG)

Electric Vehicle Charging Stations:

- NYS Electric Vehicle Recharging Income Tax Credit: equal to lesser of $5,000 or 50% of the cost of the property (less any proceeds from grants). This program would require a commercial entity to have tax liability.
- NYSEG DC Fast Charging Incentive Program:
  - The Direct Current Fast Charging (DCFC) Incentive Program provides an annual declining per-plug incentive payable to qualifying public DCFC operators for approximately seven years (2019-2025). The NYSEG incentive initially covers most of the delivery costs associated with the charger, diminishing each year until 2025.
  - The Direct Current Fast Charging (DCFC) Incentive Program provides an annual declining per-plug incentive payable to qualifying public DCFC operators for approximately seven years (2019-2025). The NYSEG incentive initially covers most of the delivery costs associated with the charger, diminishing each year until 2025.
  - A separate NYSEG meter would need to be installed specifically for the DC chargers, with up to a maximum of 10kW of non-EV charger ancillary loads.
  - Plugs with a charging capacity of 50 – 74 kW will be eligible for 60% of the prescribed incentives payment (up to the delivery cost cap), and plugs with a charging capacity of 75 kW or more will be eligible for 100% of the prescribed incentive (up to the delivery cost cap)
  - The table below shows the maximum incentive level that a customer could receive based on the year in which they qualify for the program.

	Program Year							
Fixed Annual Incentive (First Year)	2019	2020	2021	2022	2023	2024	2025	Total Incentive
2019	$8,000	$6,857	$5,714	$4,571	$3,429	$2,286	$1,143	$32,000
2020		$8,000	$6,857	$5,714	$4,571	$3,429	$2,286	$30,857
2021			$8,000	$6,857	$5,714	$4,571	$3,429	$28,571
2022				$6,857	$5,714	$4,571	$3,429	$20,571
2023					$5,714	$4,571	$3,429	$13,714
2024						$4,571	$3,429	$8,000
2025							$3,429	$3,429

AMERIGAS INCENTIVES

All AmeriGas incentives are related to propane powered vehicles and therefore do not apply to this project.

TAX INCENTIVES

Federal Tax Incentives for Commercial Geothermal Heat Pumps

- Investment Tax Credit:
  - 30 percent bonus rate for geothermal systems based on total system cost.
  - Additional 10 percent bonus rate for domestic content projects.
  - Construction must begin before January 1, 2035, credit reduces in 2032.
  - Large projects (over 1 megawatt) must meet prevailing wage and apprenticeship requirements.
  - Can offset both regular income taxes and alternative minimum taxes.
- Accelerated Depreciation of Energy Property:
  - Classified as 5-year property.

100 percent bonus depreciation in the first year.Federal Investment Tax Credit for Commercial Solar Photovoltaics

- This is a federal corporate income tax credit based on 10% of the cost of the solar PV system.
- For additional information: www.energy.gov/eere/solar

ENERGY EFFICIENCY FINANCING

Property Assessed Clean Energy Financing (Open C-PACE)

- The full cost of renewable energy improvements (including solar energy, geothermal heat pumps, and air source heat pumps) can be financed through one's property tax bills. This means that the entire cost of these systems (including all labor and including the distribution system and possibly domestic hot water) does not need to be financed through the mortgage. Loan terms may range from 20 – 30 years, with competitive interest rates from a range of potential capital providers.
- For additional information: Open C-PACE financing

8.0 APPENDIX

CALCULATIONS

EEM-1.1: HVAC Upgrades: Code Compliant - Fossil Fuel AHUs

The purpose of this calculator is to compare the energy consumption of the existing system to a proposed improved system.

Equations (NYS TRM 10.0)

1. Annual Electric Savings kWh = ((BCL/1000) * ((1/$SEER_{baseline}$) - (1 / $SEER_{proposed}$)) * $EFLH_{cooling}$) + ((BHL/3412) * (($F_{electric\ Heat}$/$COP_{baseline}$) - (1 / $COP_{proposed}$)) * $BEFLH_{heating}$))
2. Peak Concident Cooling Demand Savings kW = BCL * (1/1000) * [(1 / $EER_{baseline}$) - (1 / $EER_{proposed}$)] * Fload,cooling * CF
6. Annual Fosil Fuel Savings MMBtu = ($kbtuh_{in}$) x ((Eff_{ee} / $Eff_{baseline}$) -1) x ($EFLH_{heating}$/1000)

Inputs	
Full Load Hours $EFLH_{Heating}$	750
Full Load Hours $EFLH_{Cooling}$	768
Fuel Input Rating kBTU/h_{in}	369
Space Heating Input Rating kBTU/h_{in}	369
Efficiency rating of fossil fuel heating $Eff_{baseline}$	82%
Efficiency rating of fossil fuel heating $Eff_{proposed}$	80%
Baseline Cooling Load BCL (BTU/h)	180,000
Baseline Heating Load BHL (BTU/h)	302,580
Average $SEER_{baseline}$	12.0
Average $EER_{baseline,Peak}$	10.6
$EER_{Proposed,Season}$	12.6
$EER_{Proposed,Peak}$	11
Average $COP_{baseline,Season}$	0.0
Average $COP_{baseline,Peak}$	0.0
$COP_{Proposed,Season}$	0.0
$COP_{Proposed,Peak}$	0.0
Coincidence Factor	1
Fossil Fuel heating Factor $F_{fuel\ heat}$	1
Electric heating Factor $F_{electric\ heat}$	0
Cooling Adj Factor $F_{load,cooling}$	1
Correction Factor for Inefficiencies in Baseline	0.9

Assumptions
1. Baseline Heating load is assumed to be 100% of the connected load based on the existing drawings = aproximately 101,000 kbtu total x 3
2. Baseline Cooling load is assumed to be 100% of the connected load based on the existing drawings = aproximately 5 Tons x

Outputs	
kWh Savings	548.57
kW Savings	0.68

Fossil Fuel Savings MMbtu	23

EEM-1.2: HVAC Upgrades: Better Than Code - Fossil Fuel AHUs

The purpose of this calculator is to compare the energy consumption of the existing system to a proposed improved system.

Equations (NYS TRM 10.0)

1. Annual Electric Savings kWh = ((BCL/1000) * ((1/$SEER_{baseline}$) - (1 / $SEER_{proposed}$)) * $EFLH_{cooling}$) + ((BHL/3412) * (($F_{electric\ Heat}$/$COP_{baseline}$) - (1 / $COP_{proposed}$)) * $BEFLH_{heating}$))
2. Peak Concident Cooling Demand Savings kW = BCL * (1/1000) * [(1 / $EER_{baseline}$) - (1 / $EER_{proposed}$)] * Fload,cooling * CF
6. Annual Fosil Fuel Savings MMBtu = ($kbtuh_{in}$) x ((Eff_{ee} / $Eff_{baseline}$) -1) x ($EFLH_{heating}$/1000)

Inputs	
Full Load Hours $EFLH_{Heating}$	750
Full Load Hours $EFLH_{Cooling}$	768
Fuel Input Rating kBTU/h_{in}	369
Space Heating Input Rating kBTU/h_{in}	369
Efficiency rating of fossil fuel heating $Eff_{baseline}$	82%
Efficiency rating of fossil fuel heating $Eff_{proposed}$	95%
Baseline Cooling Load BCL (BTU/h)	180,000
Baseline Heating Load BHL (BTU/h)	302,580
Average $SEER_{baseline}$	12.0
Average $EER_{baseline,Peak}$	10.6
$EER_{Proposed,Season}$	13
$EER_{Proposed,Peak}$	11.2
Average $COP_{baseline,Season}$	0.0
Average $COP_{baseline,Peak}$	0.0
$COP_{Proposed,Season}$	0.0
$COP_{Proposed,Peak}$	0.0
Coincidence Factor	1
Fossil Fuel heating Factor $F_{fuel\ heat}$	1
Electric heating Factor $F_{electric\ heat}$	0
Cooling Adj Factor $F_{load,cooling}$	1
Correction Factor for Inefficiencies in Baseline	0.9

Assumptions
1. Baseline Heating load is assumed to be 100% of the connected load based on the existing drawings = aproximately 101,000 kbtu total x 3
2. Baseline Cooling load is assumed to be 100% of the connected load based on the existing drawings = aproximately 5 Tons x ~

Outputs	
kWh Savings	886.15
kW Savings	0.95

Fossil Fuel Savings MMbtu	80

EEM-1.3: HVAC Upgrades: Better Than Code - Electrified AHUs ASHP Split

The purpose of this calculator is to compare the energy consumption of the existing system to a proposed improved system.

Equations (NYS TRM 10.0)

1. Annual Electric Savings kWh = ((BCL/1000) * ((1/$SEER_{baseline}$) - (1 / $SEER_{proposed}$)) * $EFLH_{cooling}$) + ((BHL/3412) * (($F_{electric\ Heat}$/$COP_{baseline}$) - (1 / $COP_{proposed}$)) * $BEFLH_{heating}$))
2. Peak Concident Cooling Demand Savings kW = BCL * (1/1000) * [(1 / $EER_{baseline}$) - (1 / $EER_{proposed}$)] * Fload,cooling * CF
3. Peak Concident Heating Demand Savings kW = BHL * (1/1000) * [(1/($COP_{baseline}$ * 3.412)) - (1/($COP_{proposed}$ * 3.412))] x CF
6. Annual Fosil Fuel Savings MMBtu = ($kbtuh_{in}$) x ((Eff_{ee} / $Eff_{baseline}$) -1) x ($EFLH_{heating}$/1000)

Inputs	
Full Load Hours $EFLH_{Heating}$	750
Full Load Hours $EFLH_{Cooling}$	768
Fuel Input Rating kBTU/h_{in}	369
Space Heating Input Rating kBTU/h_{in}	369
Efficiency rating of fossil fuel heating $Eff_{baseline}$	82%
Efficiency rating of fossil fuel heating $Eff_{proposed}$	0%
Baseline Cooling Load BCL (BTU/h)	180,000
Baseline Heating Load BHL (BTU/h)	302,580
Average $SEER_{baseline}$	12.0
Average $EER_{baseline,Peak}$	10.6
$EER_{Proposed,Season}$	14
$EER_{Proposed,Peak}$	11.8
Average $COP_{baseline,Season}$	0.0
Average $COP_{baseline,Peak}$	0.0
$COP_{Proposed,Season}$	2.0
$COP_{Proposed,Peak}$	3.0
Coincidence Factor	1
Fossil Fuel heating Factor $F_{fuel\ heat}$	1
Electric heating Factor $F_{electric\ heat}$	0
Cooling Adj Factor $F_{load,cooling}$	1
Correction Factor for Inefficiencies in Baseline	1.1

Assumptions
1. Baseline Heating load is assumed to be 100% of the connected load based on the existing drawings = aproximately 101,000 kbtu total x 3
2. Baseline Cooling load is assumed to be 100% of the connected load based on the existing drawings = aproximately 5 Tons x

Outputs	
kWh Savings	(31,609.71)
kW Savings	(12.51)

Fossil Fuel Savings MMbtu	250

EEM-1.4: HVAC Upgrades: Better Than Code - Electrified Distributed VRF

The purpose of this calculator is to compare the energy consumption of the existing system to a proposed improved system.

Equations (NYS TRM 10.0)

1. Annual Electric Savings kWh = ((BCL/1000) * ((1/$SEER_{baseline}$) - (1 / $SEER_{proposed}$)) * $EFLH_{cooling}$) + ((BHL/3412) * (($F_{electric\ Heat}$/$COP_{baseline}$) - (1 / $COP_{proposed}$)) * $BEFLH_{heating}$))
2. Peak Concident Cooling Demand Savings kW = BCL * (1/1000) * [(1 / $EER_{baseline}$) - (1 / $EER_{proposed}$)] * Fload,cooling * CF
3. Peak Concident Heating Demand Savings kW = BHL * (1/1000) * [(1/($COP_{baseline}$ * 3.412)) - (1/($COP_{proposed}$ * 3.412))] x CF
6. Annual Fosil Fuel Savings MMBtu = ($kbtuh_{in}$) x ((Eff_{ee} / $Eff_{baseline}$) -1) x ($EFLH_{heating}$/1000)

Inputs	
Full Load Hours $EFLH_{Heating}$	750
Full Load Hours $EFLH_{Cooling}$	768
Fuel Input Rating kBTU/h_{in}	369
Space Heating Input Rating kBTU/h_{in}	369
Efficiency rating of fossil fuel heating $Eff_{baseline}$	82%
Efficiency rating of fossil fuel heating $Eff_{proposed}$	0%
Baseline Cooling Load BCL (BTU/h)	180,000
Baseline Heating Load BHL (BTU/h)	302,580
Average $SEER_{baseline}$	12.0
Average $EER_{baseline,Peak}$	10.6
$EER_{Proposed,Season}$	16
$EER_{Proposed,Peak}$	12.8
Average $COP_{baseline,Season}$	0.0
Average $COP_{baseline,Peak}$	0.0
$COP_{Proposed,Season}$	4.5
$COP_{Proposed,Peak}$	4.5
Coincidence Factor	1
Fossil Fuel heating Factor $F_{fuel\ heat}$	1
Electric heating Factor $F_{electric\ heat}$	0
Cooling Adj Factor $F_{load,cooling}$	1
Correction Factor for Inefficiencies in Baseline	1.1

Assumptions
1. Baseline Heating load is assumed to be 100% of the connected load based on the existing drawings = aproximately 101,000 kbtu total x 3
2. Baseline Cooling load is assumed to be 100% of the connected load based on the existing drawings = aproximately 5 Tons x

Outputs	
kWh Savings	(11,900.19)
kW Savings	(2.66)

Fossil Fuel Savings MMbtu	250

EEM-1.5: HVAC Upgrades: High Performance - Electrified GSHP AHUs

The purpose of this calculator is to compare the energy consumption of the existing system to a proposed improved system.

Equations (NYS TRM 10.0)

1. Annual Electric Savings kWh = ((BCL/1000) * ((1/$SEER_{baseline}$) - (1 / $SEER_{proposed}$)) * $EFLH_{cooling}$) + ((BHL/3412) * (($F_{electric\ Heat}$/$COP_{baseline}$) - (1 / $COP_{proposed}$)) * $BEFLH_{heating}$))
2. Peak Concident Cooling Demand Savings kW = BCL * (1/1000) * [(1 / $EER_{baseline}$) - (1 / $EER_{proposed}$)] * Fload,cooling * CF
3. Peak Concident Heating Demand Savings kW = BHL * (1/1000) * [(1/($COP_{baseline}$ * 3.412)) - (1/($COP_{proposed}$ * 3.412))] x CF
6. Annual Fosil Fuel Savings MMBtu = ($kbtuh_{in}$) x ((Eff_{ee} / $Eff_{baseline}$) -1) x ($EFLH_{heating}$/1000)

Inputs	
Full Load Hours $EFLH_{Heating}$	750
Full Load Hours $EFLH_{Cooling}$	768
Fuel Input Rating kBTU/h_{in}	369
Space Heating Input Rating kBTU/h_{in}	369
Efficiency rating of fossil fuel heating $Eff_{baseline}$	82%
Efficiency rating of fossil fuel heating $Eff_{proposed}$	0%
Baseline Cooling Load BCL (BTU/h)	180,000
Baseline Heating Load BHL (BTU/h)	302,580
Average $SEER_{baseline}$	12.0
Average $EER_{baseline,Peak}$	10.6
$EER_{Proposed,Season}$	21
$EER_{Proposed,Peak}$	14.7
Average $COP_{baseline,Season}$	0.0
Average $COP_{baseline,Peak}$	0.0
$COP_{Proposed,Season}$	4.5
$COP_{Proposed,Peak}$	3.7
Coincidence Factor	1
Fossil Fuel heating Factor $F_{fuel\ heat}$	1
Electric heating Factor $F_{electric\ heat}$	0
Cooling Adj Factor $F_{load,cooling}$	1
Correction Factor for Inefficiencies in Baseline	1.1

Assumptions
1. Baseline Heating load is assumed to be 100% of the connected load based on the existing drawings = aproximately 123,000 kbtu each x 3
2. Baseline Cooling load is assumed to be 100% of the connected load based on the existing drawings = aproximately 5 Tons x 3
3. Proposed data based on Climatemaster TMW-840

Outputs	
kWh Savings	(13,038.76)
kW Savings	(6.92)

Fossil Fuel Savings MMbtu	250

EEM-2: Envelope Upgrades - Glazing

The purpose of this calculator is to compare the existing windows to glazing replacement.

Equations

1. ΔkWh = (SF/100) * (ΔkWh/100 SF) * (SEERbaseline/SEERpart)
2. ΔKW = (SF/100) * (ΔKW/100 SF) * (EERbaseline/EERpart) * CF
3. ΔMMBtu = (SF/100) * ((Δtherms/100 SF)/10) * (Effbaseline/Effpart)

Inputs	
Annual electricity energy savings per 100 SF (ΔkWh/100SF)	303
Peak coincident demand savings per 100 SF(ΔKW/100SF)	0.16
Annual fossil fuel energy savings per 100 SF (Δtherms/100 SF)	43.1
Glazing Area (SF)	501
Coincidence Factor (CF)	0.477
$SEER_{baseline}$	12.0
$SEER_{part}$	12.0
$EER_{baseline}$	10.6
EER_{part}	10.6
$Eff_{baseline}$	0.82
Eff_{part}	1.0

Assumptions
NYS TRM V 10.0 provided values for inputs.
Area applies to window square footage.

Outputs

ΔkWh Savings	1,518
ΔKW Savings	0.4
ΔMMBtu Savings	18

EEM-2: Envelope Upgrades - Wall Insulation

The purpose of this calculator is to compare the energy consumption of a high performance exterior wall system to the baseline wall condition.

Equations (NYS TRM 10.0)

1. $\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$
2. $\Delta kWh\ cooling = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times CDD \times 24 \times F_{ElecCool}) / (1000 \times Eff_{Elec\ Cool})$
3. $\Delta kWh\ heating = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times HDD \times 24 \times F_{ElecHeat}) / (1000 \times HSPF)$
4. $\Delta kW\ cool = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times F_{ElecCool\ x\ CF}) / (1000 \times EER)$
4. $\Delta kW\ heat = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times F_{ElecHeat\ x\ CF}) / (1000 \times (COP \times 3.412))$
5. $\Delta MMbtu\ heating = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times HDD \times 24 \times F_{FuelHeat}) / (1000000 \times Eff_{fuelheat})$

Inputs	
Wall Area SF	4375
Thermal Resistance baseline $R_{baseline}$	10
Thermal Resistance Improvement ΔR	10
Framing Factor $F_{framing}$	0.25
Cooling Degree Days CDD	721
Heating Degree Days HDD	6391
Electric Cooling Factor $F_{ElecCool}$	1
Electric Heating Factor $F_{ElecHeat}$	0
asonal energy efficeincy (SEER or IEER) $Eff_{ElecCool}$	12
Seasonal Average Heating Efficeincy HSPF	0
Heating energy efficeiency COP	0
Fossil Fuel Heating Factor $F_{FuelHeat}$	1
Efficiency of fossil fuel heating equiment $Eff_{FuelHeat}$	82%
CF cool	0.477

Assumptions
NYS TRM V 10.0

Outputs	
ΔkWh Savings	237
ΔKW Savings	0.01
ΔMMBtu Savings	31

EEM-2: Envelope Upgrades - Roof

The purpose of this calculator is to compare the energy consumption of a high performance roof system to a baseline condition.

Equations (NYS TRM 10.0)

1. $\Delta kWh = \Delta kWh_{cooling} + \Delta kWh_{heating}$
2. $\Delta kWh\ cooling = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times CDD \times 24 \times F_{ElecCool}) / (1000 \times Eff_{Elec\ Cool})$
3. $\Delta kWh\ heating = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times HDD \times 24 \times F_{ElecHeat}) / (1000 \times HSPF)$
4. $\Delta kW\ heating = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times HDD \times 24 \times F_{ElecHeat}) / (1000 \times (COP \times 3.412))$
5. $\Delta MMbtu\ heating = ((1/R_{baseline})-(1/(R_{baseline} + \Delta R))) \times A \times (1- F_{framing}) \times HDD \times 24 \times F_{FuelHeat}) / (1000000 \times Eff_{fuelheat})$

Inputs	
Roof Area SF	6062
Thermal Resistance baseline $R_{baseline}$	20
Thermal Resistance Improvement ΔR	11
Framing Factor $F_{framing}$	0.00
Cooling Degree Days CDD	721
Heating Degree Days HDD	6391
Electric Cooling Factor $F_{ElecCool}$	1
Electric Heating Factor $F_{ElecHeat}$	0
asonal energy efficeincy (SEER or IEER) $Eff_{ElecCool}$	12
Seasonal Average Heating Efficeincy HSPF	0
Heating energy efficeiency COP	0
Fossil Fuel Heating Factor $F_{FuelHeat}$	1
Efficiency of fossil fuel heating equiment $Eff_{FuelHeat}$	82%
CF cool	0.477

Assumptions
NYS TRM V 10.0

Outputs	
ΔkWh Savings	155
ΔKW Savings	0.00
ΔMMBtu Savings	20

EEM-3.1: DHW Upgrades: Better than Code - Fossil Fuel Fired

The purpose of this calculator is to compare the existing gas fired storage water heater to a new gas fired water heater.

Equations

1. Existing Fossil Fuel Usage =((GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/1,000,000) * ((1/$UEF_{baseline)}$-(1/UEF_{ee}))
2. Proposed kWh (electric water heaters only) = (GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412) * (1/$UEF_{Baseline}$-1/UEF_{ee})
3. Proposed kW (electric water heaters only) = (GPD / 24 * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412) * (FeDHW/UEFBaseline-1/UEFee*Fderate)

Inputs	
Gallons Per Day GPD	83
ossil Fuel Water Heating Factor F_{FFDHW}	1
Uniform Energy Factor $UEF_{Baseline}$	0.5803
ssil Fuel Water Heating Factor $F_{boilerDHW}$	1
Efficiency $AFUE_{baseline}$	0.80
Efficiency $AFUE_{ee}$	0.85
Uniform Energy Factor UEF_{ee}	0.8
Location Factor F_{loc}	0
Fossil Fuel Heating Factor $F_{FuelHeat}$	1
Heating Factor F_{heat}	0.7
Efficiency Derating Factor F_{derate}	1
Cooling Factor F_{cool}	0.25
Electric Heating Factor $F_{ElecHeat}$	0
Electric Water Heating Factor F_{eDHW}	0
DHW Setpoint °F	130
Supply Main Temperature °F	54.3
ΔT °F	75.7

Assumptions
GPD = 1.1 Gallons per Day in small office of 100 people
Estimated ~75 people including courtrooms = 82.5 GPD

Outputs

ossil Fuel Savings Mmbtu	9
$\Delta kWh_{Cooling}$	-
$\Delta kWh_{Heating}$	-
Proposed kWh	-
Proposed kW	0.00

EEM-3.2: DHW Upgrades: Better than Code - ASHP

The purpose of this calculator is to compare the existing gas fired storage water heater to a new air source heat pump water heater.

Equations

1. Existing Fossil Fuel Usage =((GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/1,000,000) * ($F_{FFDHW}/UEF_{Baseline}+F_{boilerDHW}/AFUE_{baseline}-(1/UEF_{ee}*F_{loc}*F_{FuelHeat}*(F_{Heat}/AFUE_{baseline})$)
2. $\Delta kWh_{Cooling}$ = GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412* $1/UEF_{ee*}F_{loc}*F_{cool}$/SEER/3.412
3. $\Delta kWh_{Heating}$ = GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412* $1/UEF_{ee}*F_{loc}*F_{ElecHeat}*F_{heat}$/(HSPF/3.412)
4. Proposed kWh = (GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412) * ($F_{eDHW}/UEF_{Baseline}-1/UEF_{ee}*F_{derate}$)+ΔkWhCooling-ΔkWhHeating
5. Proposed kW = (GPD / 24 * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412) * (FeDHW/UEFBaseline-1/UEFee*Fderate)

Inputs	
Gallons Per Day GPD	83
Fossil Fuel Water Heating Factor F_{FFDHW}	1
Uniform Energy Factor $UEF_{Baseline}$	0.5803
Fossil Fuel Water Heating Factor $F_{boilerDHW}$	1
Efficiency $AFUE_{baseline}$	0.80
Efficiency $AFUE_{ee}$	-
Uniform Energy Factor UEF_{ee}	2.8
Location Factor F_{loc}	1
Fossil Fuel Heating Factor $F_{FuelHeat}$	1
Heating Factor F_{heat}	0.7
HSPF	0
Efficiency Derating Factor F_{derate}	0.8
Cooling Factor F_{cool}	0.26
SEER	12
Electric Heating Factor $F_{ElecHeat}$	0
Electric Water Heating Factor F_{eDHW}	0
DHW Setpoint °F	130
Supply Main Temperature °F	54.3
ΔT °F	75.7

Assumptions
GPD = 1.1 Gallons per Day in small office of 100 people
Estimated ~75 people including courtrooms = 82.5 GPD

Outputs

Fossil Fuel Savings Mmbtu	56
$\Delta kWh_{Cooling}$	12
$\Delta kWh_{Heating}$	-
Proposed kWh	(1,578)
Proposed kW	(0.18)

EEM-3.3: DHW Upgrades: High Performance - GSHP

The purpose of this calculator is to compare the existing gas fired storage water heater to a new ground source heat pump water heater.

Equations

1. Existing Fossil Fuel Usage =((GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/1,000,000) * ($F_{FFDHW}/UEF_{Baseline}+F_{boilerDHW}/AFUE_{baseline}-(1/UEF_{ee}*F_{loc}*F_{FuelHeat}*(F_{Heat}/AFUE_{baseline})$)
2. $\Delta kWh_{Cooling}$ = GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412* $1/UEF_{ee*}F_{loc}*F_{cool}$/SEER/3.412
3. $\Delta kWh_{Heating}$ = GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412* $1/UEF_{ee}*F_{loc}*F_{ElecHeat}*F_{heat}$/(HSPF/3.412)
4. Proposed kWh = (GPD * 365 Days * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412) * ($F_{eDHW}/UEF_{Baseline}-1/UEF_{ee}*F_{derate}$)+ΔkWhCooling-ΔkWhHeating
5. Proposed kW = (GPD / 24 * 8.33 BTU to raise one gallon of water one degree * ΔT)/3,412) * (FeDHW/UEFBaseline-1/UEFee*Fderate)

Inputs	
Gallons Per Day GPD	83
Fossil Fuel Water Heating Factor F_{FFDHW}	1
Uniform Energy Factor $UEF_{Baseline}$	0.5803
ossil Fuel Water Heating Factor $F_{boilerDHW}$	1
Efficiency $AFUE_{baseline}$	0.80
Efficiency $AFUE_{ee}$	-
Uniform Energy Factor UEF_{ee}	3.5
Location Factor F_{loc}	1
Fossil Fuel Heating Factor $F_{FuelHeat}$	1
Heating Factor F_{heat}	0.7
HSPF	0
Efficiency Derating Factor F_{derate}	0.8
Cooling Factor F_{cool}	0.26
SEER	12
Electric Heating Factor $F_{ElecHeat}$	0
Electric Water Heating Factor F_{eDHW}	0
DHW Setpoint °F	130
Supply Main Temperature °F	54.3
ΔT °F	75.7

Assumptions
GPD = 1.1 Gallons per Day in small office of 100 people
Estimated ~75 people including courtrooms = 82.5 GPD

Outputs

Fossil Fuel Savings Mmbtu	56
$\Delta kWh_{Cooling}$	9
$\Delta kWh_{Heating}$	-
Proposed kWh	(1,263)
Proposed kW	(0.15)

EEM-4: Lighting Upgrades: LED Fixtures and Controls

The purpose of this calculator is to compare existing electrical consumption due to lighting to the proposed soultion.

Equations

1. Baseline kWh = Existing Watts/square ft * Area / 1000 * burn hours
2. Proposed kWh = Proposed Watts/square ft * Area / 1000 * burn hours* (1 - F_{occ})
3. ΔKW (Demand) = (Existing Wattage - Proposed Wattage) * (1 + $HVAC_d$) * CF
4. MMBTU usage = (Existing Wattage consumption - Proposed Wattage consumption) * $HVAC_{ff}$
5. Cooling Savings = (Existing Wattage consumption - Proposed Wattage consumption) * $HVAC_c$

Inputs	
Existing Watts/ft^2	1.50
Proposed Watts/ft^2	0.63
$HVAC_c$	0.1
$HVAC_d$	0.2
$HVAC_{ff}$	-0.002
Burn Hours	3748
Builing Square Footage	7680
Coincidence Factor (CF)	0.92
Occupancy Ctrls Red. Factor (F_{occ})	10%

Assumptions
$HVAC_c$
$HVAC_d$
$HVAC_{ff}$
Wattage per Square Footage based on Observations

Outputs

Baseline kWh[1]	43,248
Proposed kWh[2]	16,373
kWh Savings	26,875
MMBTU Savings[4]	-5.4
kWh Cooling Savings[5]	2687.5
kW Savings[3]	7

EEM-5: Energy Recovery

The purpose of this calculator is to add energy recovery to the HVAC systems.

Equations

1. $\Delta kWh = units \times (\Delta kWhcooling + \Delta kWhheating + \Delta kWhfan)$
2. $\Delta kWhcooling$ = [((4.5 × $CFM \times Effhx,total \times (Houtdoor,cooling - Hindoor,cooling)$) / (1,000 × $EffElecCool$)] × $hrscooling$
3. $\Delta kWhheating$ = [(1.08 × $CFM \times Effhx,sens \times (Tindoor,heating - Toutdoor,heating)$ / (1,000 × $EffElecHeat$)] × $FElecHeat$) × $hrsheating$
4. $\Delta kWhfan$ = ($kWfan,baseline - kWfan,ee$) × ($hrsheating + hrscooling$)
5. $\Delta kW = units \times$ [((4.5 × $CFM \times Effhx,total \times (Houtdoor,cooling - Hindoor,cooling)$) / (1,000 × EER)] × $CF + \Delta kWfan$
   ΔkWh*fan* = (kWh*fan,baseline* - kW*fan,ee*) * CF
6. □$MMBtu = units \times$ [(1.08 × $CFM \times Effhx,sens \times (Tindoor,heating - Toutdoor,heating)$) / (1,000,000 × $EffFuelHeat$)]× $FFuelHeat \times hrsheatin$

Inputs	
Exist.Total electric power of conventional and ERV/HRV supply and exhaust fans kW*fan,baseline*	0.00
New Total electric power of conventional and ERV/HRV supply and exhaust fans kW*fan,ee*	0.23
Volume of supply air in Cubic Feet per Minute CFM	780.00
Coincidence Factor CF	0.80
Total effectiveness of heat exchanger $Effhx,total$	0.65
Sensible effectiveness of heat exchanger $Effhx,sens$	0.68
Seasonal average energy efficiency of electric cooling equipment Eff*ElecCool*	12.00
Seasonal average energy efficiency of electric heating equipment Eff*ElecHeat*	0.00
Energy efficiency ratio under peak conditions EER	10.6
Efficiency of fossil fuel heating equipment $EffFuelHeat$	0.82
Electric heating factor $FElecHeat$	0
Fossil fuel heating factor $FFuelHeat$	1
Indoor air temperature in heating season $Tindoor,heating$	70.00
Outdoor air temperature in heating season $Toutdoor,heating$	41.89
Enthalpy of outside air in cooling season $Houtdoor,cooling$	29.57
Enthalpy of inside air at 70°F in cooling season $Hindoor,cooling$	25.30
Operating hours in the heating season $hrsheating$	1456
Operating hours in the cooling season $hrscooling$	624

Assumptions

Outputs

kWh Cooling Savings	506.58
kWh Heating Savings	0.00
kWh Fan Savings	(486.72)
kWh Savings	39.73
kW Savings	-1.90

Fossil Fuel Savings Mmbtu	57.18

BUDGET PRICING

Mechanical/Electrical
Engineering Consultants
60 LAKEFRONT BLVD, SUITE 320
BUFFALO, NY 14202

Budget Pricing Cost Estimate			
PROJECT NAME: Town of Copake - Town Hall			
M/E REFERENCE:	221428	DATE:	4/13/2023
DIVISION:	**ENERGY**	BY:	AES

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
EEM-1: HVAC Upgrades						
EEM-1.1: HVAC Upgrades - Code Compliant: Fossil Fuel AHUs						
	Demolition	3	EA	$2,535	$0	$7,605
	Air-Handling Unit (123 mbh input propane)	3	EA	$1,953	$3,640	$16,780
	Condensing Unit (5 ton)	3	EA	$2,844	$5,528	$25,117
	Replacement ductwork	1	LS	$1,444	$6,291	$7,734
	TOTAL					$57,236
	EEM-1.1 TOTAL COST					**$57,236**
EEM-1.2: HVAC Upgrades - Better than Code: Fossil Fuel AHUs						
	Demolition	3	EA	$2,535	$0	$7,605
	Air-Handling Unit (107 mbh in, propane, condens.)	3	EA	$1,953	$5,134	$21,260
	Condensing Unit (5 ton)	3	EA	$3,233	$6,357	$28,771
	Replacement ductwork	1	LS	$1,444	$6,291	$7,734
	TOTAL					$65,370
	EEM-1.2 TOTAL COST					**$65,370**
EEM-1.3: HVAC Upgrades - Better than Code: Electrified AHUs ASHP Split						
	Demolition	3	EA	$2,535	$0	$7,605
	Air-Handling Unit (2000 cfm)	3	EA	$1,355	$2,400	$11,265
	Heat Pump Condensing Unit (10 ton)	3	EA	$4,764	$15,631	$61,183
	Replacement ductwork	1	LS	$1,444	$6,291	$7,734
	TOTAL					$87,788
	EEM-1.3 TOTAL COST					**$87,788**

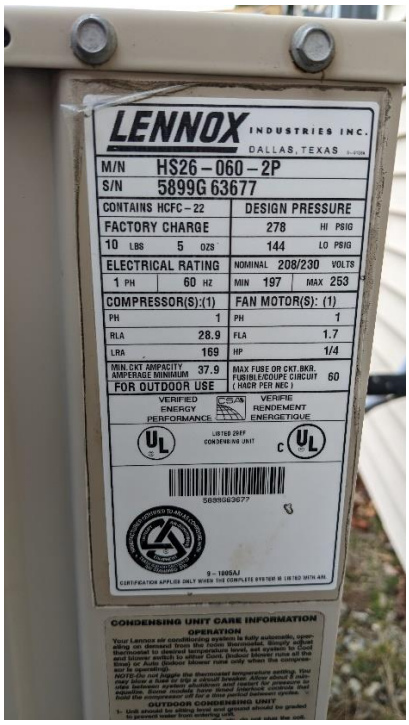
EEM-1.4: HVAC Upgrades - Better than Code: Electrified Distributed VRF						
	Demolition	3	EA	$3,285	$0	$9,855
	VRF Fan Coil Units	20	EA	$390	$2,250	$52,800
	VRF Outdoor Units	2	EA	$1,025	$41,200	$84,450
	Refrigerant piping	1	LS	$6,863	$19,215	$26,078
	Ventilation ductwork	1	LS	$750	$1,590	$2,341
	TOTAL PROPOSED					$175,523
	EEM-1.4 TOTAL COST					**$175,523**
EEM-1.5: HVAC Upgrades - High Performance: Ground Source Heat Pumps						
	Demolition	3	EA	$2,535	$0	$7,605
	Geothermal Heat Pumps	3	EA	$1,900	$7,325	$27,675
	Geo-Exchange Wells	8	EA	$7,500	$10,000	$140,000
	Piping	1	LS	$10,350	$9,564	$19,914
	Pumps	2	EA	$4,267	$8,711	$25,956
	Replacement ductwork	1	LS	$1,444	$6,291	$7,734
	TOTAL PROPOSED					$228,884
	EEM-1.5 TOTAL COST					**$228,884**
EEM-2: Envelope Measures						
	Roof insulation (3.5" batt insulation)	6062	SF	$0.28	$0.53	$4,910
	Wall insulation (2" rigid, furred)	4375	SF	$1.48	$3.29	$20,868
	Windows	501	SF	$16.50	$45.17	$30,895
	TOTAL PROPOSED					$56,673
	EEM-2 TOTAL COST					**$56,673**
EEM-3: Domestic Water Heater Upgrades						
EEM-3.1: Domestic Water Heater Upgrades - Better than Code: Fossil Fuel Fired						
	High efficiency water heater	1	LS	$370	$1,275	$1,645
	TOTAL PROPOSED					$1,645
	EEM-3.1 TOTAL COST					**$1,645**
EEM-3.2: Domestic Water Heater Upgrades - Better than Code: ASHP						
	Heat Pump Water Heater	1	LS	$555	$2,275	$2,830
	TOTAL PROPOSED					$2,830
	EEM-3.2 TOTAL COST					**$2,830**

EEM-3.3: Domestic Water Heater Upgrades - High Performance: GSHP						
	Geothermal Heat Pump (36 mbh)	1	EA	$725	$5,450	$6,175
	Storage tank (40 gallons)	1	EA	$51	$1,200	$1,251
	TOTAL PROPOSED					$7,426
	EEM-3.3 TOTAL COST					**$7,426**
EEM-4: Lighting Upgrades						
	LED Lighting	7680	SF	$0.69	$1.01	$13,077
	Lighting controls	7680	SF	$0.49	$0.60	$8,371
	TOTAL PROPOSED					$21,448
	EEM-4 TOTAL COST					**$21,448**
EEM-5: Energy Recovery						
	Energy Recovery Unit	3	EA	$810	$2,450	$9,780
	TOTAL PROPOSED					$9,780
	EEM-5 TOTAL COST					**$9,780**

Pricing from RSMeans Building Cost Data. Includes differences between options and items related to energy efficiency.

** Energy Efficeincy Measure pricing does not include costs associated with electrical upgrades, controls upgrades or general construction related costs (unless otherwise identified).*

PHOTOGRAPHS

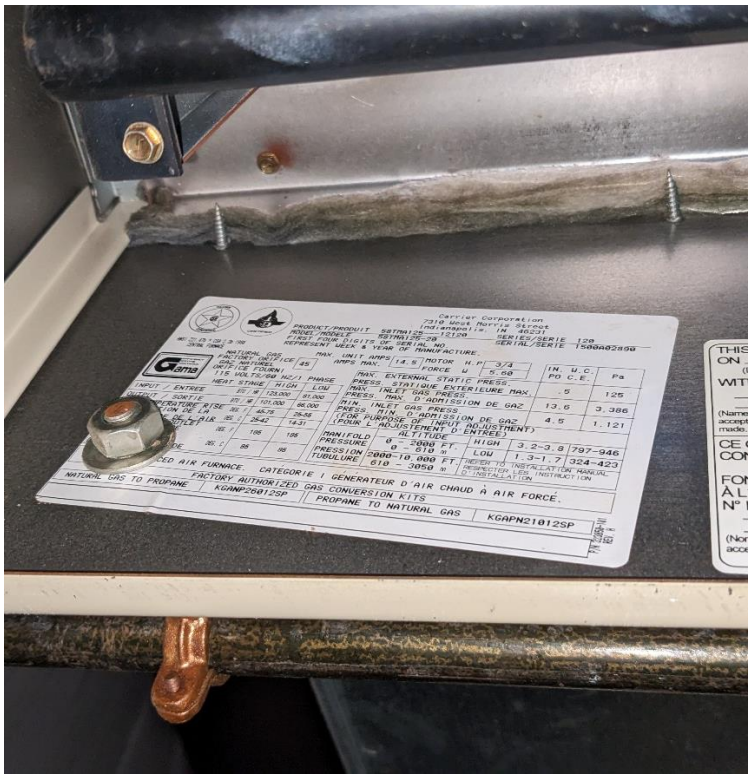


Outdoor Lennox Condensing Units

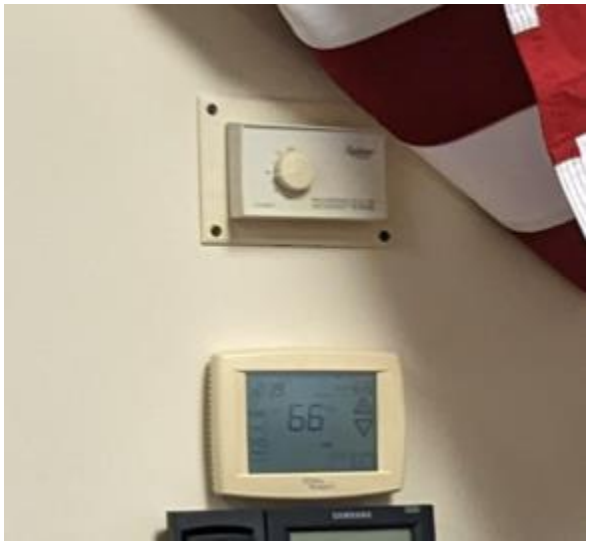
Carrier Horizontal Furnaces in the Attic with Flexible Ductwork

Horizontal Furnace in Attic with Humidifier

Filter Box for Furnace in Attic



One of Three Identical Heating Units in Attic



Wall Mounted Humidistat and Programmable Thermostat

Domestic Hot Water Storage Tank

Disconnect Switch and Main Distribution Panel

70 kW Generator on East Side of Building

Solar Inverters and Meter

Solar Array