Clean Energy Communities

Energy Study

Prepared for:

Copake Recreation Center

305 Mountain View Rd

Copake NY 12516

Audit No: CEC400053-M-02

Submitted by:
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Date: 8/27/2025

For questions regarding this report, please contact CEC@nyserda.ny.gov

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

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State of New York

Kathy Hochul, Governor

New York State Energy Research and Development Authority

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Executive Summary

In consideration of NYSERDA's objectives, the primary focus of this Energy Study is the evaluation of energy efficient electric building technologies. Limited opportunities that reduce fossil fuel use may be considered, however, the evaluation of new systems and equipment that utilize fossil fuels is excluded from the analysis contained herein and as such will not be recommended as energy efficiency improvements. The replacement of systems and equipment that utilize fossil fuels are not eligible for Clean Energy Communities Funding.

This study was performed to understand how your facility is currently using energy and identify ways to reduce energy use and operating expenses.

Specific areas of concern that were identified by the owner for evaluation include high utility bills and reducing the building's carbon footprint.

The following energy efficiency measures (EEMs) and observations to reduce energy use were identified during the site visit:

- Replace interior fluorescent lighting with LED lamps
- Install Air Source heat pump
- Install Geothermal heat pump
- Install Demand Controlled Ventilation system
- Install weatherstripping and airsealing for roof-wall joint and exterior doors

These Energy Efficiency Measures are summarized in the Project Summary Table below and discussed in more detail in the Energy Efficiency Measures section of this report.

Present Energy Use and Cost

The energy use for your facility has been compiled to calculate the Energy Cost Index and the Energy Use Intensity.

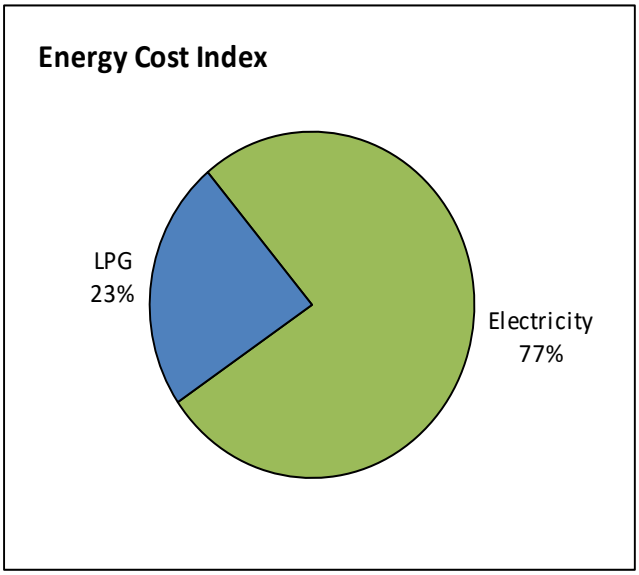
- The Energy Cost Index (ECI) is the total cost of energy divided by the conditioned floor area and is shown as dollars per square foot per year.
- The Energy Use Intensity (EUI) is the total heat content of energy divided by the conditioned floor area and is shown in units of one thousand Btus (kBtu) per square foot per year.

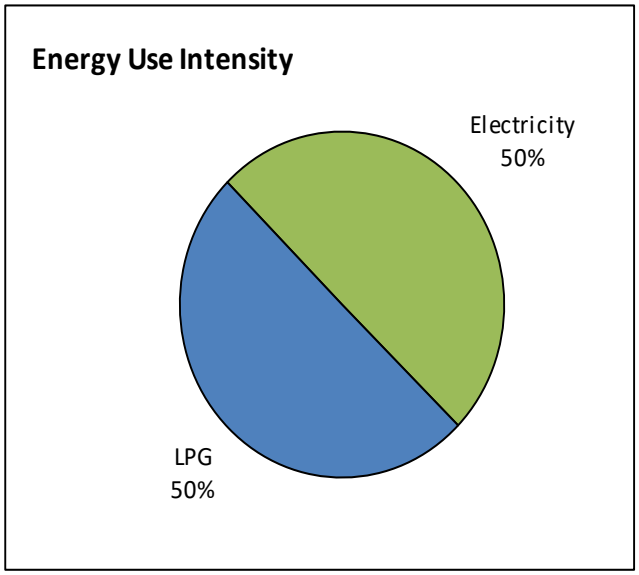
Energy Cost Index

Electricity	$ 3,613	$ 0.77	$/sq.ft./year
LPG	$ 1,103	$ 0.23	$/sq.ft./year
Total Cost	$ 4,716	$ 1.00	$/sq.ft./year

Energy Use Intensity

Electricity	75	mmBtu	16.0	kBtu/sq.ft./year
LPG	76	mmBtu	16.1	kBtu/sq.ft./year
Total Energy Use	151	mmBtu	32.1	kBtu/sq.ft./year





Energy Cost Index $ 1.00 /sf/yr. **Energy Use Intensity 32.1 kBTU/sf/yr.**

Benchmarking Your Building

The EPA's ENERGY STAR Portfolio Manager website allows you to upload energy use information and compare your energy use to that of other buildings of similar use. Portfolio Manager generates a benchmark score that indicates your performance. A benchmark score of 50 indicates average performance while a score of 75 or higher would earn the Energy Star designation. You can use the website to track your energy use over time and document the success of your energy conservation efforts.

You can find the Portfolio Manager at:

https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

Project Summary Table

Energy Efficiency Measures				$ Savings & Cost		
EEM #	Measure Status	EEM Description	Reduction in Greenhouse Gas Emissions (Lbs. CO2e/Year)	Total Annual Savings	Install Costs	Simple Payback (years)
EEM-1	R	Interior Lighting Retrofit	4,178	$ 427	$ 1,262	3.0
EEM-2	R	Ventilate Based On Occupancy	10,003	$ 867	$ 1,800	2.1
EEM-3	RNE	Building Airflow Reduction	525	$ 47	$ 1,170	24.7
		All Energy Efficiency Measures:	**14,706**	**$ 1,341**	**$ 4,232**	**3.2**
		Total of Recommended Measures:	**14,706**	**$ 1,341**	**$ 4,232**	**3.2**

Measure Status Explanation:

(I) - Implemented: Measure has been installed

(R) - Recommended: Energy saved with a reasonable payback (within measure life)

(NR) - Not Recommended: When payback exceeds measure life and equipment is not at end of life

(RME) - Recommended Mutually Exclusive: Energy is saved and recommended over other options for a particular measure

(ME) - Mutually Exclusive: Non-recommended option(s) to a Recommended Mutually Exclusive (RME) measure

(RNE) - Recommended Non-Energy: Recommended based on other, non-energy factors such as comfort, water savings or equipment at end of life

(RS) - Recommended for Further Study: For measures that require analysis beyond the scope of this program.

(BE) – Building Electrification: Measures that should be considered based on greenhouse gas reductions, eliminating on-site use of fossil fuels, or other sustainability factors

Building Electrification Measures				$ Savings & Cost				
EEM #	Measure Status	Building Electrification Measure Descriptions	Reduction in Greenhouse Gas Emissions (Lbs. CO2e/Year)	Total Annual Savings	Install Costs	Simple Payback (years)	Estimated Incentives	Simple Payback after incentives
BE-1	RBE	Install Clean Heating System - Air Source Heat Pump	1,850	($ 72)	$ 17,879	n/a	$ 2,611	n/a
BE-2	RBE	Install Clean Heating System - Ground Source Heat Pump	5,164	$ 349	$ 66,127	189.4	$ 3,339	179.9
		All Measures:	**7,014**	**$ 277**	**$ 84,006**	**303.0**	**$ 5,950**	**281.5**
		Total of Recommended Measures:	**0**	**$ 0**	**$ 0**		**$ 0**	

Simple Payback Period is the length of time it will take to recover the initial capital investment from the energy savings of the new equipment. The Simple Payback Period is calculated by dividing the initial installed cost by the annual energy cost savings. For example, an energy-saving measure that costs $5,000 and saves $2,500 per year has a Simple Payback Period of $5,000 divided by $2,500 or 2 years.

Note on Energy Project Implementation Costs

The "Project Costs" shown in this report for each Energy Efficiency Measure represent an initial estimate of the implementation cost. Unless otherwise noted in the Energy Efficiency Measure description, these costs reflect a preliminary estimate of material and labor. There may be other variables associated with your specific project that will impact the true project costs that the study may not capture. Other external factors that may impact true project costs and payback include material availability, vendor scheduling, access within the facility, general inflation, available measure incentives, and other unknown factors and conditions. For measures which significantly impact your building's usage, it is also important to determine any potential utility rate and/or tariff changes, those of which are beyond the scope of this report. We recommend that you seek several quotes from qualified vendors prior to implementation.

Greenhouse Gas Reductions for the Recommended Measures

Reducing your energy use will reduce the release of greenhouse gases associated with the use of fossil fuels and the production of electricity. If the measures recommended in this report are implemented, the following reductions of greenhouse gases can be expected:

Electricity	6,261	kWh =	7,263	pounds CO2 equivalent
LPG	502	gal. =	7,443	pounds CO2 equivalent
			14,706	pounds CO2 equivalent
			38.9%	reduction

Emissions factors are used to translate the energy savings data from energy efficiency and renewable generation projects into annual GHG emissions reduction values. NYSERDA uses emission factors derived from U.S. Environmental Protection Agency (EPA) emission coefficients to calculate emissions from onsite fuel. The CO2e values represent aggregate CO2, CH4, and N2O emissions.

Energy Efficiency Measure Descriptions

EEM-1 Interior Lighting Retrofit

Electric Savings:	$ 640	5,639	kWh per year
		2.4	kW demand
Fuel Savings:	($ 213)	(14.7)	MMBtu fuel per year LPG
Total Annual Savings:	**$ 427**		
Project Cost:	**$ 1,262**		
Simple Payback:	**3.0**	**years**	

Introduction:

Lighting usually represents a major portion of a facility's electricity use, and given the continuous hours of use, it contributes to the peak electric demand each month. Taking steps to improve the efficiency of your lighting will reduce both the total electric energy used and lower your peak electric demand. Lighting retrofit projects now consist of installing Light Emitting Diode, or LED, light sources in all fixtures. Some fixtures, such as indoor fluorescent fixtures, can be retrofitted to use T-8 replacement lamps, but most fixtures should simply be replaced with LED fixtures. Energy savings of 50% are common when replacing fluorescent and HID light sources with LED sources.

LED light sources for interior applications should list their color on the label; this is expressed in degrees Kelvin, or °K. Lights with higher values will be more blue in color and may not be appropriate for indoor use. Look for values between 3500 and 4000°K for "cool white" light. For spaces where a warmer color of light is desired, select lights with values between 2700 and 3000°K.

Recommendation:

Retrofit interior fluorescent fixtures and replace other fixtures as indicated in the lighting calculations and the Equipment Inventory, both of which may be found in the Appendix. This measure proposes replacing all interior fluorescent and incandescent lighting with LED tubes and LED A9 bulbs.

LED lamps and fixtures should be Energy Star labeled or listed with the Design Lights Consortium (DLC). Your utility incentive program may have other requirements that must be met in order to qualify for incentives.

EEM-2 Ventilate Based On Occupancy

Electric Savings:	$ 29	622	kWh per year
		0.0	kW demand
Fuel Savings:	$ 838	57.6	MMBtu fuel per year LPG
Total Annual Savings:	**$ 867**		
Project Cost:	**$ 1,800**		
Simple Payback:	**2.1 years**		

Introduction:

Demand controlled ventilation is a strategy to reduce ventilation loads to the level required by actual occupancy. This will reduce the volume of outdoor air that must be heated during periods of partial occupancy. If the space temperature rises above setpoint, the outdoor air dampers will still open to provide cooling.

To implement this control strategy, CO2 sensors are installed to monitor indoor air quality and increase the outdoor air volume when CO2 levels rise above a certain level. Other control approaches, such as one or more occupancy sensors, may make sense for some spaces.

Recommendation:

The town hall is conditioned by a constant-volume, centrally-ducted heating and cooling system. This system brings in a fixed, continuous amount of outside air to meet ventilation requirements for a fully occupied building, as specified by ASHRAE standards. The system lacks an economizer function, meaning it cannot use cool outside air for free cooling. The energy used for heating and cooling is directly proportional to the amount of outside air brought in, a significant energy waste during non-peak occupancy hours (e.g., evenings, weekends, and holidays).

This project proposes the installation of demand-controlled ventilation (DCV) controls for the town hall's HVAC system. The DCV system will include the following components:

1. CO2 sensors: CO2 sensors will be installed in high-occupancy areas, such as the assembly hall, meeting rooms, and offices.
2. Modulating Damper Actuators: The existing fixed outside air dampers will be replaced with modulating actuators, allowing the damper to open or close based on the signal from the DCV system.
3. HVAC Control System Integration: The new DCV system will be integrated with the building's existing HVAC control panel to manage the outside air intake."

EEM-3 Building Airflow Reduction

Electric Savings:	$ 0	0	kWh per year
		0.0	kW demand
Fuel Savings:	$ 47	3.3	MMBtu fuel per year LPG
Total Annual Savings:	**$ 47**		
Project Cost:	**$ 1,170**		
Simple Payback:	**24.7 years**		

Introduction:

Reducing air infiltration is vital to creating a more energy efficient building. The purpose of air sealing is to create an effective air tight seal on the building envelope. This will reduce the amount of air flow and heat loss from conditioned to un-conditioned space. Factors that cause high air flow rates include the size and number of openings that connect the conditioned and unconditioned spaces and pressure differences between the interior and exterior of the building. The differences in pressures are typically caused by stack effect, wind, and temperature differences between the inside and outside of the building. An air sealing contractor will use special diagnostic tools to pinpoint and seal hidden air leaks, typically hidden under the attic insulation.

Sealing the largest openings at the highest and lowest levels first is the most effective way to reduce unwanted air flow. These types of openings may include attic access doors, large mechanical chases that house ductwork and vent flues, and wall bypasses. Wall bypasses are holes created by irregular framing and can be found in interior and exterior wall systems. Smaller openings from wire holes, plumbing lines, and gaps around windows, doors and chimney flues are equally as important. Materials that should be considered for different applications are caulks, expanding foam, non-expanding foam, weather-stripping, and rigid insulation board.

Recommendation:

Based on our calculations, the building has an estimated baseline air infiltration rate of 0.30 Air Changes per Hour (ACH). This equates to an infiltration rate of 20,280 cubic feet per hour (CFH), or 338 cubic feet per minute (CFM), for both occupied and unoccupied periods. The current infiltration is primarily due to unsealed joints and gaps, leading to a substantial energy penalty for heating and cooling.

This project proposes to significantly reduce air infiltration by sealing major leakage points in the building envelope. The following measures will be implemented:

1. Air Sealing Roof-Wall Joints

The entire length of the roof-wall joint (338 linear feet) will be thoroughly sealed. This involves using durable materials such as caulk, foam, or a continuous air barrier to create an airtight seal at the junction where the roof meets the exterior walls. This measure will reduce the air

leakage rate at these joints from a present value of 6,490 cubic feet per hour (CFH) to a proposed value of 1,622 CFH. This represents a net leakage reduction of 4,868 CFH at these specific joints, which translates to a total project-level savings of 822,557 CFH in infiltration from the baseline.

2. Installing Door Sweeps and Weatherstripping (WS)

All 3 doors (66 linear feet of cracks) will be sealed with new door sweeps and weatherstripping. This will prevent air from leaking through the gaps around the perimeter of the doors. This measure will reduce the leakage rate at the doors from 80 CFH to 20 CFH, resulting in a net leakage reduction of 60 CFH. The total project-level savings from this measure are 1,980 CFH.

Although this measure saves some energy costs and the payback is high, we still recommend it as it would increase occupant comfort and prevent moisture/mold issues by reducing outside air infiltration.

Building Electrification Measures

The following measures evaluate the impact of replacing your existing fossil-fuel heating systems with clean heating and cooling systems powered by electricity. For space heating, air source heat pumps and ground source heat pumps are available in various system types to provide both heating and cooling to your building.

Fossil fuel-fired water heaters may also be replaced with heat pump water heaters to further reduce your use of fossil fuels.

When combined with renewable electricity, heat pump systems can eliminate the use of fossil fuels in your building.

See Appendix E - Benefits Of Clean Heating and Cooling (CHC) Technologies for more information on these system types.

BE-1 Install Clean Heating System - Air Source Heat Pump

Electric Savings:	($ 954)	(6,824)	kWh per year
		0.4	kW demand
Fuel Savings:	$ 882	60.6	MMBtu fuel per year LPG
Total Annual Savings:	**($ 72)**		
Project Cost:	**$ 17,879**		
Simple Payback:	**n/a years,**	**n/a**	**years after incentives**

Introduction:

Air source heat pumps (ASHP) provide both heating and cooling using electricity to exchange energy with the outdoor air. Existing buildings may be retrofitted with various heat pump technologies to reduce or eliminate their dependence on fossil fuels for space heating. System options range from centrally-ducted cold climate air source heat pumps and mini-split heat pumps to large variable refrigerant flow systems having multiple indoor units supported by each outdoor unit.

At very cold outdoor air conditions, air source heat pumps may require supplemental heat to meet your building's heating load. Supplemental heat may be in the form of electric resistance heat or your existing fossil-fueled heating system, if it remains in service. The extent to which an ASHP system reduces your fossil fuel use will depend on the exact design and control of your new system.

Recommendation:

This measure considers replacing your lpg heating system with a central ducted air source heat pump system serving the entire building. The system type is: Central Ducted ASHP with Integrated/ Modulating controls sized to 100% of the building heating and cooling load.

The proposed heat pumps are assumed to be rated at 13.05 EER full load cooling, 15 SEER. The heat pumps are assumed to be rated at 10 HSPF for heating, which may be adjusted to 2.46 COP. Be sure to specify heat pumps that meet NEEP requirements (Northeast Energy Efficiency Partnerships). See https://ashp.neep.org/#!/product_list/ for current models that meet these requirements. This measure decreases the building's fossil fuel consumption and as such, it would reduce the building's greenhouse gas emissions. It should be considered for building electrification purposes.

BE-2 Install Clean Heating System - Ground Source Heat Pump

Electric Savings:	($ 551)		(4,139)	kWh per year
			0.9	kW demand
Fuel Savings:	$ 900		61.8	MMBtu fuel per year LPG
Total Annual Savings:	**$ 349**			
Project Cost:	**$ 66,127**			
Simple Payback:	**189.4**	**years,**	**179.9**	**years after incentives**

Introduction:

Smaller buildings can take advantage of water-to-air ground source heat pump technology by replacing furnaces and other ducted systems with heat pumps having either open or closed loop ground heat exchangers. Closed loop ground heat exchangers that are properly sized provide water between 32° and 77° for heat pumps to draw heat from or reject heat to. Open loop systems see water temperatures of ~50° throughout the year. This allows heat pumps to operate at higher efficiency than air-source heat pumps that must draw from more extreme outdoor air temperatures.

The heat pumps in this type of system each have a loop pump. The building may have multiple heat pumps, but every heat pump must have a dedicated ground source heat exchanger. The heat pumps should have two-stage or variable capacity compressors for the highest efficiency. The loop pump may be constant speed, but two-speed or variable speed pumps offer higher efficiency and are preferred.

Recommendation:

Consider replacing your present heating system with a clean heating and cooling system using ground source heat pumps. This measure decreases the building's fossil fuel consumption and as such, it would reduce the building's greenhouse gas emissions. It should be considered for building electrification purposes.

This measure considers installing a closed loop heat pump system with two-stage compressors and staged pumping. The heat pumps are assumed to be rated at 17 EER full load cooling, 22 EER part load. The heat pumps are assumed to be rated at 3.6 COP full load heating, 4.1 COP part load. Be sure to specify heat pumps that meet NEEP requirements (Northeast Energy Efficiency Partnerships). See https://ashp.neep.org/#!/product_list/ for current models that meet these requirements.

Existing Conditions

The site is a recreation center for the Town of Copake. It is used for weekly and monthly events and other local public gatherings.

The building consists of 4,704 square feet on 1 floor; it was built in approximately 1990. The exterior walls have a block structure with an exterior finish of block and fiberglass insulation. The flat roof has a membrane exterior surface, fiberglass insulation and an interior finished ceiling of wood.

The windows are double glazed sliding vinyl sash. The exterior doors are fiberglass with no glazing, with partial weather stripping.

Major energy end uses include lighting, space heating and cooling, and cooking.

The facility is occupied 5 days per week for a total of 50 hours per week. The HVAC system maintains occupied conditions for 50 hours per week.

Winter space temperatures are normally maintained at 65 and are setback to 60°F during unoccupied periods. Temperature control is provided by programmable thermostats. In the summer, temperatures are maintained at 75 and are setup to 80°F during unoccupied periods.

Lighting Systems

Fluorescent lamps and incandescent lamps with electronic ballasts.

Heating Ventilating and Air Conditioning Systems

Centrally ducted constant volume combined propane furnace and cooling system

Water Heating System

Electric storage type water heater

Other Energy-using Systems

Cooking range, vending machine, garage door opener

See Appendix D for further details regarding the energy calculations performed for this study.

Appendix A

Equipment Inventory

Heating and Air Conditioning Equipment									
Unit Type	Qty	Make/Model	Heating kBtuh	Heating Eff.	Cooling Capacity	Units	EER	Serves/Location	Year
Condensing furnace	1	Heil N9MP2075	75	92%	10	tons	10.0	Whole building	2012

Domestic Hot Water									
Unit Type	Qty	Make/Model	Capacity	Units	Fuel Type	Storage Capacity (gal.)	Eff.	Serves/Location	Year
Storage	1	AO Smith ECT 80 200	5	kW	Electricity	80	100%	Kitchen and bathrooms	2012

Motors									
Unit Type	Qty	Make/Model	HP	Loading	Type	Hours/year	Eff.	Serves/Location	Year
Exhaust Fan	1	4C400C	1/2	75%	Std.	500	70%	Kitchen stove vent	2012
Garage door opener	1	LiftMaster	1/2	75%	Std.	0	70%	Garage door	2012

Interior Lighting Fixtures											
Existing Fixtures						Recommended	Recommended Interior Lighting Efficiency Improvements				
Line #	Area	Qty	Present Lighting Type	Lamps /fixt	Watts /Fixt	Control Type	Measure Type	Qty	Proposed Lighting Type	Lamps /fixt	Watts /Fixt
1	Garage	4	4' 32w T8 Elec. bal.	2	59	No Change	LED Relamp	4	4' LED T8 2200 lu. 17W	2	34
2	Community Room	23	4' 32w T8 Elec. bal.	4	112	No Change	LED Relamp	23	4' LED T8 2200 lu. 17W	4	68
3	Kitchen	8	4' 32w T8 Elec. bal.	4	112	No Change	LED Relamp	8	4' LED T8 2200 lu. 17W	4	68
4	Storage	4	4' 32w T8 Elec. bal.	4	112	No Change	LED Relamp	4	4' LED T8 2200 lu. 17W	4	68
5	Furnace Room	1	4' 40w T12 EE Mag. bal.	2	86	No Change	LED Relamp	1	4' LED T8 2200 lu. 17W	2	34
6	Hallway	2	4' 32w T8 Elec. bal.	2	59	No Change	LED Relamp	2	4' LED T8 2200 lu. 17W	2	34
7	Bathrooms	4	4' 32w T8 Elec. bal.	2	59	No Change	LED Relamp	4	4' LED T8 2200 lu. 17W	2	34
8	Track lighting	1	26w CFL Elec. bal.	4	26	No Change	LED Relamp	1	A19 LED, 14W	4	56
9	Track lighting	1	60 watt Incandescent	4	240	No Change	LED Relamp	1	A19 LED, 14W	4	56

Exterior Lighting Fixtures											
Existing Fixtures						Recommended	Lighting Efficiency Improvements				
Line #	Area	Qty	Present Lighting Type	Lamps /fixt	Watts /Fixt	Control Type	Measure Type	Qty	Proposed Lighting Type	Lamps /fixt	Watts /Fixt
1	Front entrance	8	A19 LED, 9W	1	9	No Change	LED Area Light	8	A19 LED, 9W	1	9

Appendix B

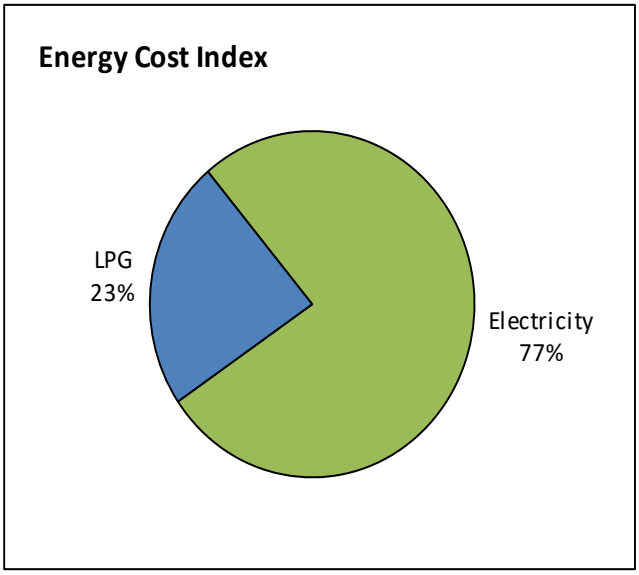
Energy Use and Cost Summary

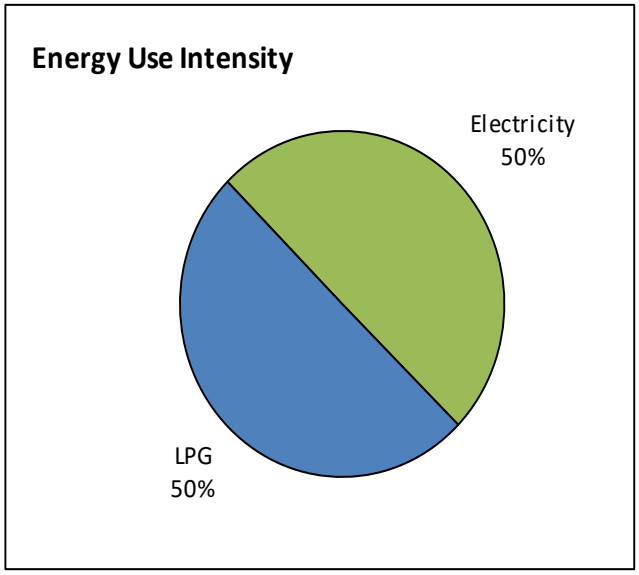
Energy

	Units Used		BTU/unit	mmBTU	% of total	kBtu/sq.ft./year
Electricity	22,046	kwh	3,412	75	50%	16.0
LPG	824	gal.	92,000	76	50%	16.1
Total				151		32.1

Cost

	Energy Cost	Unit Costs		% of total	$/sq.ft./year
Electricity	$ 3,613	$ 0.046	kwh	77%	$ 0.77
LPG	$ 1,103	$ 1.339	gal.	23%	$ 0.23
Total	$ 4,716				$ 1.00





Energy Cost Index **$ 1.00 /sf/yr.** **Energy Use Intensity** **32.1 kBTU/sf/yr.**

Utility Bill Data

The following pages present the energy use and cost data for your facility and establish the value of each type of energy. Electricity is measured and billed in units of kilowatt-hours (kWh) that represent the total amount of electricity used in the billing period. Electricity may also be billed based on the highest rate of use, or peak demand, that occurred during the billing period. Electric demand is billed in units of kilowatts (kW).

Other fuels may be billed in volume units (gallons, hundred cubic feet or ccf, etc.) or based on their heat content (therms, equal to 100,000 British Thermal Units). All energy types may be converted into a common unit, such as BTUs, to facilitate analysis and comparison with other facilities. One million BTUs is abbreviated as mmBtu in this report.

ELECTRICITY CONSUMPTION AND COST ANALYSIS

Copake Recreation Center

Gross Area:	4,704	s.f.
	15,991	Btu/s.f./Yr
	$ 0.77	/s.f.
	4.0	watts/s.f.

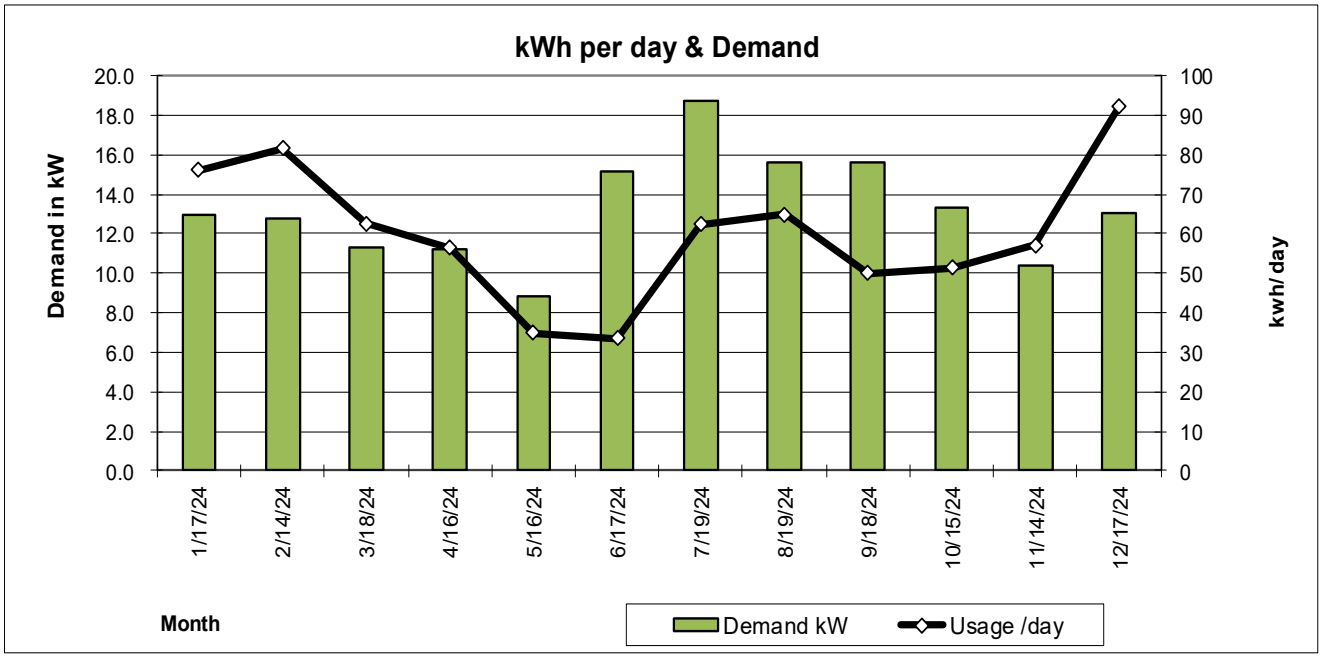
Utility:	NYSEG	
Account #	ends w/ -343	
Rate:	SC	
Meter Charge:	$ 41.00	/ month
Demand Charge:	$ 13.25	/ kW
Supplier:		

Month Ending	Days	Usage Energy kWh	Usage Demand kW	Electricity Charges Utility Cost	Electricity Charges Supply Costs	Total Electricity Cost	Demand Cost	Energy $/kWh	Load Factor	Usage /day
1/17/24	30	2,285	12.9	$ 228	$ 163	$ 391	$ 171	$ 0.078	0.25	76
2/14/24	28	2,287	12.7	$ 221	$ 157	$ 378	$ 169	$ 0.074	0.27	82
3/18/24	33	2,068	11.3	$ 199	$ 53	$ 252	$ 150	$ 0.029	0.23	63
4/16/24	29	1,634	11.2	$ 196	$ 25	$ 221	$ 149	$ 0.019	0.21	56
5/16/24	30	1,046	8.9	$ 118	$ 0	$ 118	$ 118	($ 0.039)	0.16	35
6/17/24	32	1,070	15.1	$ 196	$ 0	$ 196	$ 201	($ 0.043)	0.09	33
7/19/24	32	1,995	18.8	$ 351	$ 32	$ 382	$ 248	$ 0.047	0.14	62
8/19/24	31	2,011	15.6	$ 304	$ 57	$ 361	$ 207	$ 0.056	0.17	65
9/18/24	30	1,498	15.6	$ 278	$ 0	$ 278	$ 206	$ 0.021	0.13	50
10/15/24	27	1,389	13.4	$ 265	$ 30	$ 294	$ 177	$ 0.055	0.16	51
11/14/24	30	1,713	10.4	$ 218	$ 38	$ 256	$ 138	$ 0.045	0.23	57
12/17/24	33	3,050	13.1	$ 274	$ 210	$ 484	$ 173	$ 0.089	0.29	92
	365	**22,046**	**159.0**	**$ 2,849**	**$ 764**	**$ 3,613**	**$ 2,107**	**$ 0.046**	**0.19**	**60**

Annual Energy:	**22,046**	**kWh / year**	**$ 3,613**	**/year**
Peak Demand:	**19**	**kW Peak**		
Average Demand:	**13**	**kW**		

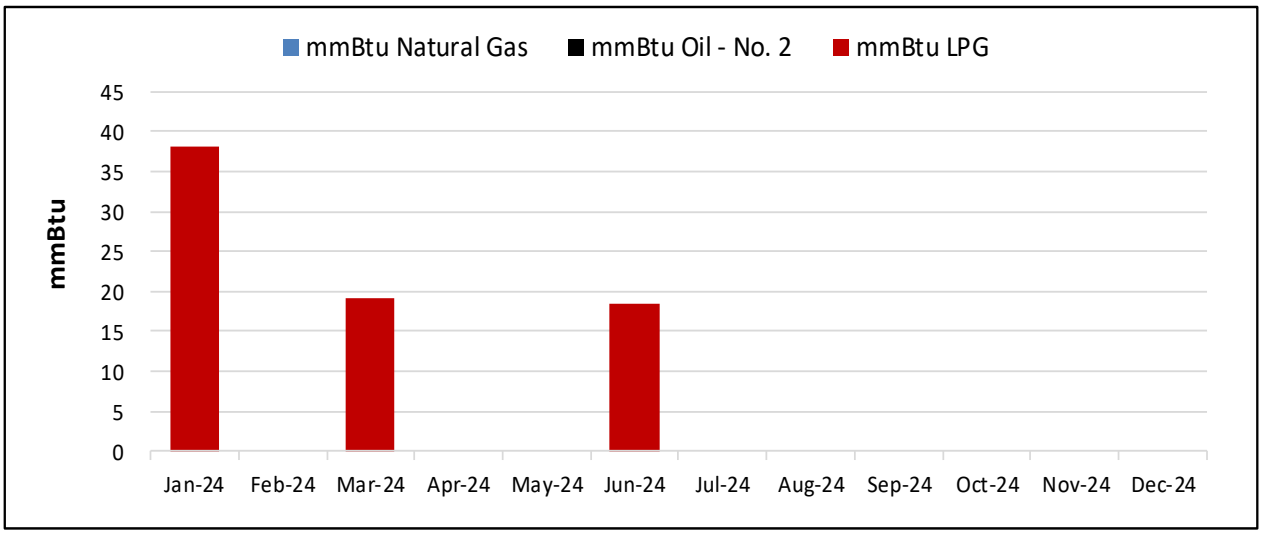
Unit Costs

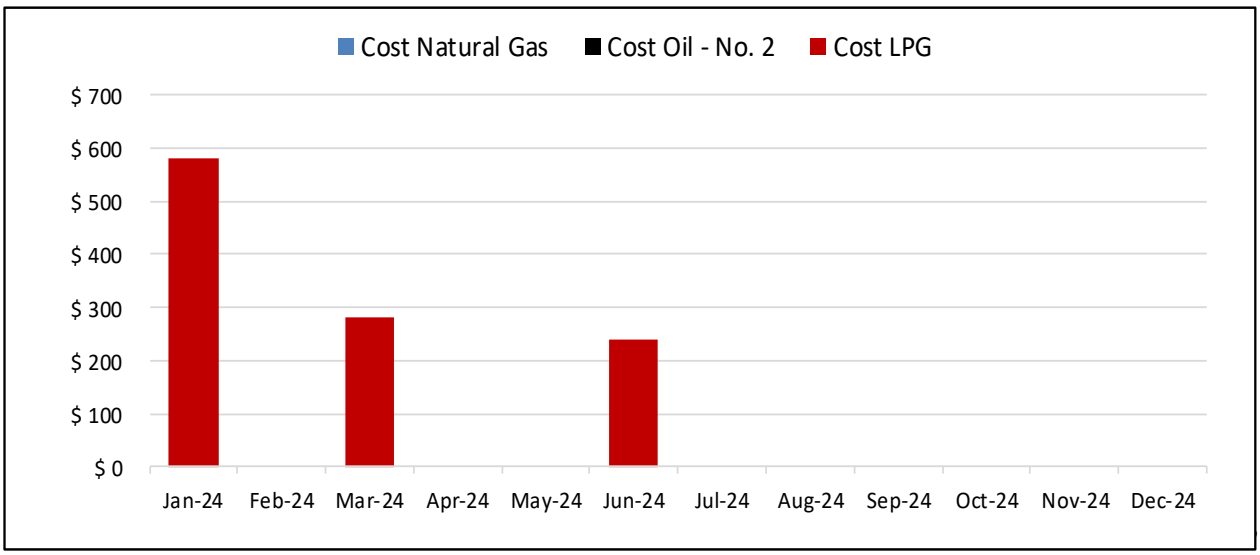
Demand	**$ 13.25**	**$/kW**
Energy	**$ 0.046**	**$/kWh Incremental**
Blended	**$ 0.164**	**$/kWh Blended**



ALL FUELS CONSUMPTION AND COST ANALYSIS **Copake Recreation Center**

Month	mmBtu Natural Gas	mmBtu Oil - No. 2	mmBtu LPG	All Fuel mmBtu	Cost Natural Gas	Cost Oil - No. 2	Cost LPG	All Fuel Cost
Jan-24	0	0	38	38	$ 0	$ 0	$ 581	$ 581
Feb-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
Mar-24	0	0	19	19	$ 0	$ 0	$ 282	$ 282
Apr-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
May-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
Jun-24	0	0	18	18	$ 0	$ 0	$ 240	$ 240
Jul-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
Aug-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
Sep-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
Oct-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
Nov-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
Dec-24	0	0	0	0	$ 0	$ 0	$ 0	$ 0
Total	0	0	76	76	$ 0	$ 0	$ 1,103	$ 1,103
$/mmBtu			$ 14.55	$ 14.55				
BTU/unit	1,000,000	138,000	92,000			1 mmBtu =	1,000,000	Btus
kBtu/SF/Yr.	0.0	0.0	16.1	16.1		1 kBtu =	1,000	Btus





Appendix C

Interactions

The Energy Efficiency Measure calculations in this section are stand-alone measures that are not interacted with the other calculations. Each measure shows the energy savings that may be expected if it is the only measure to be implemented. If multiple measures will be implemented, energy savings will likely be lower than the calculations represent.

As an example, replacing an 80% efficient boiler with a 92% efficient boiler will reduce the amount of fuel required to heat the building. If the walls and roof are insulated such that the required heating energy is reduced by 30%, the new boiler will serve a smaller heating load, and the energy savings gained from the boiler replacement will be reduced by 30%.

EEM Calculations

CALCULATIONS FOR INTERIOR LIGHTING RETROFIT

EEM-1 **Copake Recreation Center**

Type:	Units:	Unit cost:	BTU/unit	
LPG	gal.	$ 1.339	92,000	
Electricity	kwh	$ 0.046	3,412	
Demand	kW	$ 13.25	12	Months of demand savings/year

100% of building is air conditioned

HVAC Adjustment Factors		
Cooling	Demand	Fuel
HVACc	HVACd	HVACg
13.00%	20.00%	-2.60%

Existing Interior Lighting Systems					**Recommended Lighting Controls**					**Recommended Interior Lighting Efficiency Improvements**									
Area	Qty	Present Lighting Type	Lamps /fixt	Watts /Fixt	Control Type	% Reduction	Present Hrs./yr.	Proposed Hrs./yr.	# Controls required	Measure Type	Qty	Proposed Lighting Type	Lamps /fixt	Reflect or ?	Watts /Fixt	Project Cost	Annual Savings	kWh/yr. Savings	Payback (Years)
Garage	4	4' 32w T8 Elec. bal.	2	59	No Change	0%	2,500	2,500	1	LED Relamp	4	4' LED T8 2200 lu. 17W	2	N	34	$ 58	$ 27	250	2.1
Community Room	23	4' 32w T8 Elec. bal.	4	112	No Change	0%	2,500	2,500	1	LED Relamp	23	4' LED T8 2200 lu. 17W	4	N	68	$ 662	$ 277	2,530	2.4
Kitchen	8	4' 32w T8 Elec. bal.	4	112	No Change	0%	2,500	2,500	1	LED Relamp	8	4' LED T8 2200 lu. 17W	4	N	68	$ 230	$ 96	880	2.4
Storage	4	4' 32w T8 Elec. bal.	4	112	No Change	0%	2,500	2,500	0	LED Relamp	4	4' LED T8 2200 lu. 17W	4	N	68	$ 115	$ 48	440	2.4
Furnace Room	1	4' 40w T12 EE Mag. bal.	2	86	No Change	0%	2,500	2,500	0	LED Relamp	1	4' LED T8 2200 lu. 17W	2	N	34	$ 14	$ 14	130	1.0
Hallway	2	4' 32w T8 Elec. bal.	2	59	No Change	0%	2,500	2,500	0	LED Relamp	2	4' LED T8 2200 lu. 17W	2	N	34	$ 29	$ 14	125	2.1
Bathrooms	4	4' 32w T8 Elec. bal.	2	59	No Change	0%	2,500	2,500	2	LED Relamp	4	4' LED T8 2200 lu. 17W	2	N	34	$ 58	$ 27	250	2.1
Track lighting	1	26w CFL Elec. bal.	4	26	No Change	0%	2,500	2,500	0	LED Relamp	1	A19 LED, 14W	4	N	56	$ 48	($ 8)	(75)	(5.8)
Track lighting	1	60 watt Incandescent	4	240	No Change	0%	2,500	2,500	0	LED Relamp	1	A19 LED, 14W	4	N	56	$ 48	$ 50	460	1.0
	48		4.9	kW existing					5		48		2.9	kW proposed					

Note: bal. = ballast, EE = energy efficient, STD = standard efficiency, mag. = magnetic, Elec. = electronic, CFL = compact fluorescent lamp

SUMMARY OF SAVINGS BY MEASURE TYPE:		Fixture	Energy Savings		Demand				
	Measure Type	Qty.	Controls kwh/year	Efficiency kwh/year	kW Savings	Project Cost	Electric Savings	Payback (Years)	Measure Description
EEM-1C	LED Relamp	48		4,990	2.0	$ 1,262	$ 547	2.3	Screw-in or Socket based LED lamps
		48	0	4,990	2.0	$ 1,262	$ 547		
	Gross Energy Savings		4,990	kwh					
	Net Energy Savings		**5,639**	**kwh**	**2.4**	**-159**	**gal.**	**$ 427**	**net**

PAYBACK PERIOD:

Estimated Cost Interior Lighting:	$ 1,262	= 3 year payback
Annual Energy Savings (kWh + kW):	$ 427	

CALCULATIONS TO VENTILATE BASED ON OCCUPANCY

EEM-2 **Copake Recreation Center**

INPUT DATA

Closest City: Poughkeepsie
Closest Facility Type: Specialty Assembly Auditorium

Fuel Information	Type:	Units:	Unit cost:	BTU/unit	Efficiency	
Heating	LPG	gal.	$ 1.339	92,000	92.0%	
Cooling	Electricity	kwh	$ 0.046	3,412	5.14	COP
	100%	cooled			17.5	EER

Space Name	Square Footage of Area	ΔkWh	ΔTherm
Meeting Hall	3,998	1,092	576
	kWh:	1,092	576 therms
Billing units:	kwh:	622	626 gal.

CALCULATIONS (from NYS TRM v.6)

Energy Electric Savings = (SF/1000) x ESFcooling $ESF_{cooling}$ 273 kwh/1000 sq.ft.
Fuel Energy Savings = (SF/1000) x ESFheating $ESF_{heating}$ 144 therms/1000 sq.ft.

Annual Savings	Energy Savings	Cost Savings
Heating Savings	626 gal.	$838
Cooling Savings	622 kwh	$29
		$867

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Material & Labor ($ / unit)	Quantity	Total
CO2 sensors	$ 150	2	$ 300
Controls	$ 1,500	1	$ 1,500
		Implementation Cost:	$ 1,800

Implementation Costs:	$ 1,800	= 2.1 years payback
Annual Energy Savings:	$ 867	

CALCULATIONS FOR BUILDING AIRFLOW REDUCTION

EEM-3 **Copake Recreation Center**

INPUT DATA:

Bldg. Volume	47,040 cubic feet			Present infiltration		
		ACH	Period	Cu. ft./hr.	CFM	btuh/deg.
Baseline infiltration rate		0.30	Occupied	14,112	235	254
from heat loss study		0.30	Unoccupied	14,112	235	254
Proposed Reductions	Crack Length	Leakage Rate - cfh		Leakage - net cfh		
Cubic feet per hour	lineal feet	Present	New	Present	Proposed	Savings
Roof - Wall Joint	280	16	4	2,258	564	1,693
Door Sweeps & WS	66	8	2	264	66	198
				2,522	630	1,891

Proposed Reductions	Air changes/Hour			Proposed infiltration		
Air changes/hour	% reduction	Proposed	Period	Cu. ft./hr.	CFM	btuh/deg.
	0%	0.30	Occupied	14,112	235	254
	13%	0.26	Unoccupied	12,221	204	220
Total Infiltration & Reduction	**Occupied**	**14,112**	**14,112**	**0**	cfh savings	
Cu.Ft./hour	**Unoccupied**	**14,112**	**12,221**	**1,891**	cfh savings	

CALCULATIONS:

Leakage = 1/2 x Crack Length x Leakage Rate ***-or-*** ACH x Building Volume

Energy Savings = (Present Leakage - New Leakage) x Accum Hours x Temp Difference x CF2

Energy Cost Savings = (Energy Savings / CF1) x (Unit cost / Efficiency)

	Occupied	Unoccupied	
T Setpoint:	65	60	°F
Q internal gains:	24,053	4,813	Btuh
BLC:	938	938	Btuh/°F
T Balance:	39.4	54.9	°F. T Balance = T Setpoint - (Q internal gains / BLC)
Bin Data for Poughkeepsie, 50 hrs./week			
Accumulated Hours	589	3,642	below balance temp.
Avg. OAT	26.7	35.8	°F below balance temp.
(T Set- Avg OAT)	38.3	24.2	°F difference

Type:	LPG	
Units:	gal.	
Unit cost:	$ 1.339	/gal.
CF1	92,000	Btu/gal.
Efficiency:	92.0%	
CF2	0.018	Btu/hr-°F-cfh

	Energy Use - Btu/year			Fuel Use
	Occupied	Unoccupied	Total	gal. / yr
Baseline infiltration rate	5,723,600	22,369,900	28,093,500	332
Proposed infiltration rate	5,723,600	19,371,700	25,095,300	296
			Total Savings	35
				$ 47

IMPLEMENTATION COST & PAYBACK PERIOD:

Item	Matl. & Labor ($ / lin ft)	Quantity (lin ft)	Total	
Weather-stripping	$ 5.00	66	$ 330	
Caulking	$ 3.00	280	$ 840	
	Implementation Cost:		$ 1,170	= 24.7 year payback
	Annual Energy Savings:		$ 47	

CALCULATIONS TO INSTALL CLEAN HEATING SYSTEM - AIR SOURCE HEAT PUMP

BE-1 **Copake Recreation Center**

Building Information	Assembly		Fuel Information	Heating	Cooling	
Location	Poughkeepsie	Climate Zone 5	Type:	LPG	Electricity	
Portion of Building HP will serve:	100%		Units:	gal.	kwh	
Building Heating Load (BHL)	72,729	BTU/h	Unit cost:	$ 1.339	$ 0.046	/kwh
Building Cooling Load (BCL)	42,063	BTU/h	BTU/unit	92,000	3,412	/kwh
BEFLHheating	782	Hours	Heating Eff.	92%	$ 13.25	/kW
BEFLHcooling	574	Hours	CO2	14.83	1.16	lbs/unit

Existing System

Is baseline heating system electric?	N
Is baseline heating system fossil fuel?	Y
If yes, will it remain in place in the efficient case?	Y

Present Heating System	Warm Air Furnace, Gas Fired ≥ 225 kBTU/h
Present Cooling System	Air-cooled AC w/ other heat (≥ 65 and < 135 kBTU/h)
% of Portion to be served by ASHP that is presently cooled	100%

Proposed System

Does proposed ASHP require supplemental resistance heat?	Y		
ASHP Type	Central Ducted		
ASHP Application	Whole	(the ASHP will meet all of the heating load)	
Control Type	Integrated/Modulating		
Heating Capacity	80,000	BTU/h at 5°F	1.0 HP Sizing Ratio
Energy Efficiency Ratio	13.1	EERee	
Seasonal Energy Efficiency Ratio	15.0	SEER	
Heating Season Performance Factor	10.0	HSPF	

Resulting system to be modeled **Scenario 1d**

Central Ducted ASHP with Integrated/ Modulating controls sized to 100%

Adjusted Efficiency Values	Baseline	Energy Efficient				
SEERbaseline	12.7	13.8	EERseason,ee	-0.590	c	cooling offset
EERbaseline	11.0	13.1	EERee	0.961	d	cooling slope
COPseason,baseline	1.00	2.46	COPseason,ee	0.237	a	heating offset
FElecHeat	0.00	1.00	FElecHeat,new	0.815	b	heating slope
EFFbaseline	0.92	1.00	Fload,cooling			
FFuelHeat	1.00	0.98	Fload,heating			
		0.98	Fload,heating,FuelHeat		0.69	CF
		0.98	Fload,heating,ElecHeat			

	Baseline	Energy Efficient	Savings	Units	Savings $	Savings CO2 Lbs/yr.
Cooling Electric Use (kWh/yr.)	1,901	1,746	155	kWh		
Heating Electric Use (kWh/yr.)	0	6,979	(6,979)	kWh		
Total Electric Use (kWh/yr.)	**1,901**	**8,725**	**(6,824)**	**kWh**	**($ 314)**	**(7,916)**
Peak Demand (kW)	2.6	2.2	0.4	kW	($ 640)	
Fossil Fuel Energy Use (MMBTU)	62	1	61	MMBtu		
Fossil Fuel Energy Use : gal.	**672**	**13**	**659**	**gal.**	**$ 882**	**9,766**
Annual Energy Costs	**$ 1,119**	**$ 1,191**	**($ 72)**		($ 72)	1,850
Estimated Project Cost	**$ 2,950**	**per ton =**	**$ 17,879**		**-249 year payback**	

CALCULATIONS TO INSTALL CLEAN HEATING SYSTEM - GROUND SOURCE HEAT PUMP

BE-2 **Copake Recreation Center**

Building Information			Fuel Information	Heating	Cooling	
	Assembly					
Location	Poughkeepsie	Climate Zone 5	Type:	LPG	Electricity	
Portion of Building HP will serve:	100%		Units:	gal.	kwh	
Building Heating Load (BHL)	72,729	BTU/h	Unit cost:	$ 1.339	$ 0.046	/kwh
Building Cooling Load (BCL)	42,063	BTU/h	BTU/unit	92,000	3,412	/kwh
BEFLHheating	782	Hours	Heating Eff.	92%	$ 13.25	/kW
BEFLHcooling	574	Hours	CO2	14.83	1.16	lbs/unit

Existing System

Is baseline heating system electric?	N	
Is baseline heating system fossil fuel?	Y	
Present Heating System	Warm Air Furnace, Gas Fired ≥ 225 kBTU/h	
Present Cooling System	Air-cooled AC w/ other heat	(≥ 65 and < 135 kBTU/h)
% of Portion to be served by GSHP that is presently cooled	100%	

Proposed System

GSHP Loop Type	Closed Loop	GLHP		
GSHP Compressor Type	Two-Stage	0.75	Capacity Ratio	
Estimated Pump Power	60 watts per ton			
Pumping Control Strategy	Staged			
Heating Capacity	80,000	BTU	rating condition	
Energy Efficiency Ratio Full Load	17.0	EER GLHP,full	77	° EWT
Energy Efficiency Ratio Part Load	22.0	EER GLHP,part	68	° EWT
Heating COP Full Load	3.6	COP GLHP,full	32	° EWT
Heating COP Part Load	4.1	COP GLHP,par	41	° EWT

Adjusted Efficiency Values	Baseline	Energy Efficient		
EERseason,baseline	12.7	18.04	EERseason,ee	
EERpeak,baseline	11.0	17.0	EER GSHP, full,ee	
COPseason,baseline	1.00	3.54	COPseason,ee	
FElecHeat	0.00			
EFFbaseline	0.92	0.69	CF	
FFuelHeat	1.00			

	Baseline	Energy Efficient	Savings	Units	Savings $	Savings CO2 Lbs/yr.
Cooling Electric Use (kWh/yr.)	1,901	1,338	563	kWh		
Heating Electric Use (kWh/yr.)	0	4,702	(4,702)	kWh		
Total Electric Use (kWh/yr.)	**1,901**	**6,040**	**(4,139)**	**kWh**	**($ 190)**	**(4,802)**
Peak Demand (kW)	2.6	1.7	0.9	kW	($ 360)	
Fossil Fuel Energy Use (MMBTU)	62	0	62	MMBtu		
Fossil Fuel Energy Use : gal.	**672**	**0**	**672**	**gal.**	**$ 900**	**9,965**
Annual Energy Costs	**$ 1,251**	**$ 901**	**$ 349**		$ 349	5,164
Estimated Project Cost	**$ 10,911**	**per ton =**	**$ 66,127**		**189 year payback**	

Appendix D

Assumptions/Data Used to Develop Energy and Dollar Savings Figures

Building and Occupancy Information

Floor Area: 4,704 square feet

	Avg. # of occupants	Heating Setpoint	Cooling Setpoint	% of base electricity use resulting in internal heat gains	
days /occupied	20	65	75	days	100%
nights/unoccupied	0	60	80	nights	100%
# of computer	20				

Interior lighting, people and occupied levels of internal loads occur for 50 hours per week

Electricity use at night is usually 25% of the usual electricity use during day periods

(This results in an average daytime kW that is 48% of the peak metered kW)

Heating System Information

	% of bldg. served	COP heat	EER	Heat kBTUH	Heating Fuel	Efficiency	
Primary system: Forced Air	100%	0.80	10.00	800	LPG	92.0%	Et
Secondary:	0%	0.80	10.00				Et

100% of building is air conditioned. Does the cooling system have economizer? Yes

Describe the **direct outside air** or **central make-up air** system: Fuel 0% Eff. 0.00 EER for DOAS

0 cfm outside air, running

0 hours / week 0% heat recovery efficiency

Domestic Hot Water

	Fuel	Efficiency						
DHW system energy type	Electricity	100%	Is there a pump to circulate DHW?			No		
Hot Water usage is	0.5	gallons per	person	/ day for	10	persons on	200	days/year

Weather & Schedule Information:

Select nearest weather station for bin data:	POUGHKEEPSIE	for TRM:	Poughkeepsie
Base temperature for heating degree days:	65 °F. yields 6,193 HDD base65	for TRM:	Assembly
Base temperature for cooling degree days:	70 °F. yields 392 CDD base70	for TRM:	AC with Gas Heat

Present Schedule for Occupied/Day HVAC setpoints

Day of week		Start	End	Hours
Sun	1	12:00 AM	12:00 AM	-
Mon	2	7:00 AM	5:00 PM	10.0
Tue	3	7:00 AM	5:00 PM	10.0
Wed	4	7:00 AM	5:00 PM	10.0
Thu	5	7:00 AM	5:00 PM	10.0
Fri	6	7:00 AM	5:00 PM	10.0
Sat	7	12:00 AM	12:00 AM	-
Poughkeepsie, 50 hrs./week				50.0
				118.0

Proposed Schedule for Occupied/Day HVAC setpoints

Day of week	Start	End	Hours
1	12:00 AM	12:00 AM	-
2	7:00 AM	5:00 PM	10.0
3	7:00 AM	5:00 PM	10.0
4	7:00 AM	5:00 PM	10.0
5	7:00 AM	5:00 PM	10.0
6	7:00 AM	5:00 PM	10.0
7	12:00 AM	12:00 AM	-
Poughkeepsie, 50 hrs./week			50.0

ESTIMATE OF BUILDING LOAD COEFFICIENT & TRUE-UP TO BILLED ENERGY USE

Copake Recreation Center
305 Mountain View Rd
Copake NY 12516

Building Information

Width (typical)	56	feet	Building Floor Area	4,704	sq. ft.
Equivalent Length	84	feet	Roof Area	4,849	sq. ft.
Number of Floors	1.0	floors	Gross Wall Area	2,800	sq. ft.
Avg. Floor to Floor Height	10	feet per floor	Building Volume	47,040	cubic feet
Roof or Ceiling rise is	3	feet in 12' run			

Estimate of Conductive Heat Loss

Surface			Area	R-value	U Factor	U x A Btuh/deg. F.	% of BLC w/o ventilation
Roof	n/a		4,849	13.1	0.077	371	40%
Walls	88.5%	of GWA	2,479	12.8	0.078	194	21%
Glazing 1	9.2%	of GWA	258	3.0	0.333	86	9%
Glazing 2	0.0%	of GWA	0	3.0	0.333	0	0%
Doors 1	2	3x7 doors	42	2.0	0.500	21	2%
Doors 2	1	6x7 doors	21	1.7	0.588	12	1%
	Total Exterior Surface Area		7,649	sq.ft.		684	73%

		ACH	equiv. cfm	Btuh/deg. F.	BLC (without ventilation)	
Est. Infiltration Rate	Occupied	0.30	235	254	938	Btuh/deg. F. Occupied
Est. Infiltration Rate	Unoccupied	0.30	235	254	938	Btuh/deg. F. Unoccupied

		cfm	Fraction	Btuh/deg. F.	**Total BLC with Ventilation**	
Est. Ventilation Rate	Occupied	0	100%	0	**938**	**Btuh/deg. F. Occupied**
Est. Ventilation Rate	Unoccupied		100%	0	**938**	**Btuh/deg. F. Unoccupied**

Heat Gain Estimation

Estimated Solar Gain 0% of building heat loss during occupied periods will be met by solar gains

		kW	# People	Total BTUH	Hours/wk.
Loads & People	Occupied	**5.6**	**20**	24,053	50.0
	Unoccupied	**1.4**	**0**	4,813	118.0

Heat Loss Study - continued

Copake Recreation Center
305 Mountain View Rd
Copake NY 12516

		Current	
Heating T Setpoint:	Occupied	65	deg. F.
	Unoccupied	60	deg. F.
Cooling T Setpoint:	Occupied	75	deg. F.
	Unoccupied	80	deg. F.
HVAC Schedule	Occupied	50	Hrs. per week
	Unoccupied	118	Hrs. per week
Q internal gains:	Occupied	24,053	Btuh
	Unoccupied	4,813	Btuh
Q internal gains:	Schedule	50	Hrs. per week
BLC:	Occupied	938	Btuh/deg. F.
	Unoccupied	938	Btuh/deg. F.

Fuel Data	Heating	Cooling	
Type:	LPG	Electricity	Economizer?
Units:	gal.	kwh	Yes
Unit cost:	$ 1.339	$ 0.046	
BTU/unit	92,000	3,412	
Nom. Eff, COP	0.920	2.931	COP
Avg. Eff, COP	0.920	5.14	Avg. COP
		17.5	Avg. EER
		100%	of bldg. cooled

DOAS Energy Use	
0	cfm
0%	heat recov. Eff.
Heating 0	
0	
0%	eff.
0.00	COP cool
0	hrs/week

Current Poughkeepsie, 50 hrs./week

Bin Mid Pt.	Occupied Hours	Unoccupied Hours	Occ Net Heat Loss BTUH	Unocc Net Heat Loss BTUH	Heating Fuel Use gal.	Cooling Energy kwh	DOAS Hours	DOAS Heating kBtu/yr.
(12.5)	2	8	48,676	63,224	7	0	0	0
(7.5)	2	19	43,984	58,531	14	0	0	0
(2.5)	6	26	39,291	53,839	19	0	0	0
2.5	12	83	34,599	49,147	53	0	0	0
7.5	22	73	29,907	44,455	46	0	0	0
12.5	31	94	25,215	39,763	53	0	0	0
17.5	59	152	20,523	35,070	77	0	0	0
22.5	84	254	15,830	30,378	107	0	0	0
27.5	90	324	11,138	25,686	110	0	0	0
32.5	142	404	6,446	20,994	111	0	0	0
37.5	139	620	1,754	16,302	122	0	0	0
42.5	222	537	0	11,609	74	0	0	0
47.5	250	535	0	6,917	44	0	0	0
52.5	165	513	(2,938)	2,225	13	0	0	0
57.5	275	640	(7,631)	0	0	0	0	0
62.5	262	637	(12,323)	0	0	0	0	0
67.5	244	526	(17,015)	0	0	0	0	0
72.5	210	340	(23,351)	(2,914)	0	274	0	0
77.5	175	181	(27,943)	(5,281)	0	352	0	0
82.5	154	146	(34,386)	(11,724)	0	458	0	0
87.5	61	33	(40,029)	(17,367)	0	214	0	0
92.5	3	5	(42,063)	(19,400)	0	17	0	0
97.5	0	0	(45,168)	(21,236)	0	0	0	0
102.5	0	0	(49,860)	(25,928)	0	0	0	0
	8,760	hours			852	1,315	DOAS fuel use	0
							DOAS cool use	0

Cross Check Against Historic Consumption

	Historic		Calculated	Difference	
Present Annual Heating Fuel Use is	76	mmBTU	78	103%	of present fuel use

Appendix E

Clean Heating and Cooling Technology Overview

BENEFITS OF CLEAN HEATING AND COOLING (CHC) TECHNOLOGIES

Commercial building owners are becoming increasing aware of how their choice of HVAC system impacts bottom line operating costs and the environment. Most conventional heating systems either burn fuel or convert electricity into heat. CHC technologies, such as heat pumps, are different because they don't generate heat. Instead, they move existing heat energy from outside into your facility, which makes them more efficient since they deliver more heat energy than the electrical energy they consume.

There are many compelling reasons to install a CHC System in commercial buildings.

CHC systems:

- Can cost less to run than a traditional fossil fuel heating system.
- Integrate well with renewable and resilient building designs
- Offer the highest efficiency and most cost-effective space conditioning for HVAC
- Offer reduced maintenance costs because the exterior equipment is buried underground
- Offers flexible design and installation with many configurations available.
- Provides superior thermal comfort for all seasons.

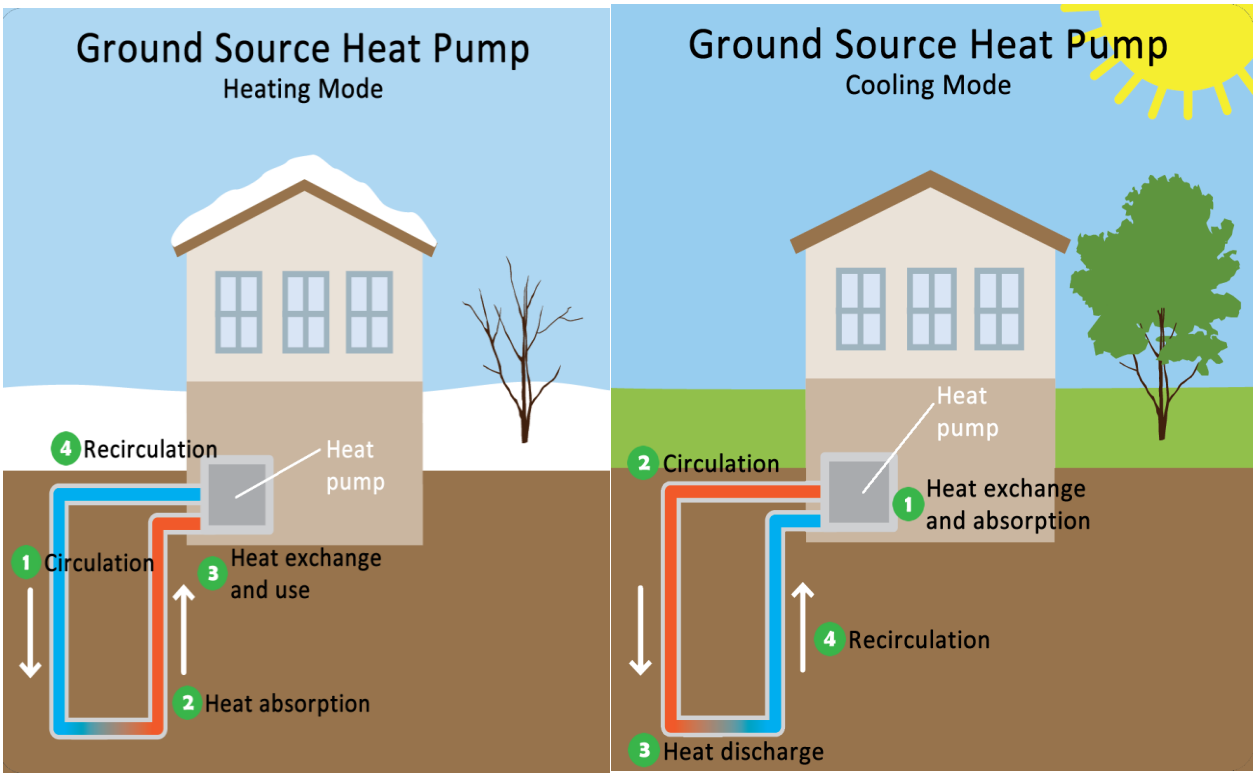
TYPES OF CLEAN HEATING AND COOLING (CHC) TECHNOLOGIES

What is a Ground Source Heat Pump (GSHP)?

GSHP's are self-contained electrically powered systems that provide heating and cooling more efficiently than other types of conventional HVAC systems. This increase in efficiency is obtained due to the GSHP systems coupling with the earth's relatively stable ground temperature. For example, while the temperature of the of the outside air may vary drastically from summer to winter, the ground temperature remains relatively stable, making it an ideal heat "source" for heating and heat "sink" for cooling.

The GSHP system utilizes an electric vapor compression refrigeration cycle to exchange energy between the building load and a ground coupled loop. When in heating mode, energy is transferred from the low temperature ground loop source to the higher temperature heat sink (the load).

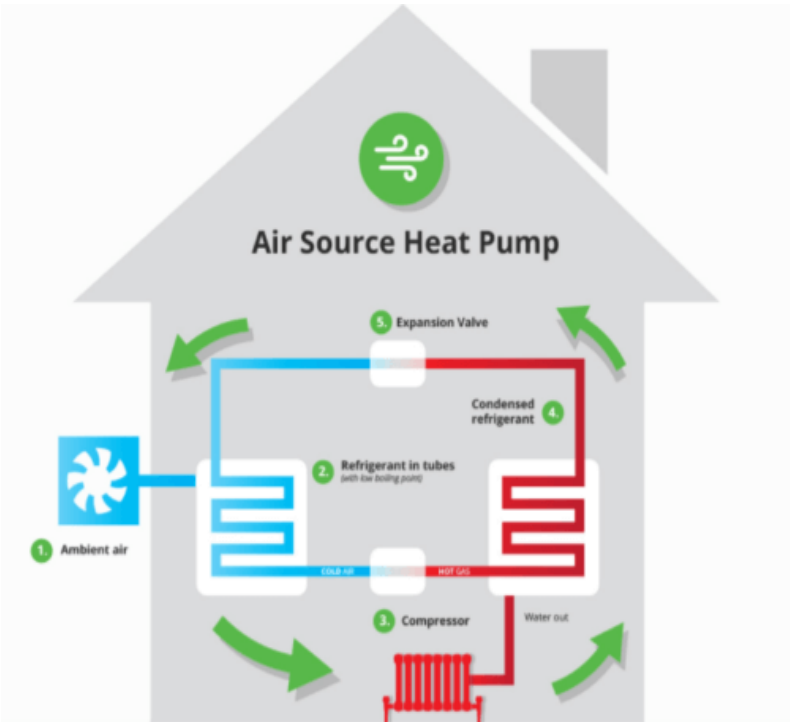
The system reverses during cooling, where the energy is absorbed by the ground loop.



Source: https://www.epa.gov/rhc/geothermal-heating-and-cooling-technologies

What is an Air Source Heat Pump (ASHP)?

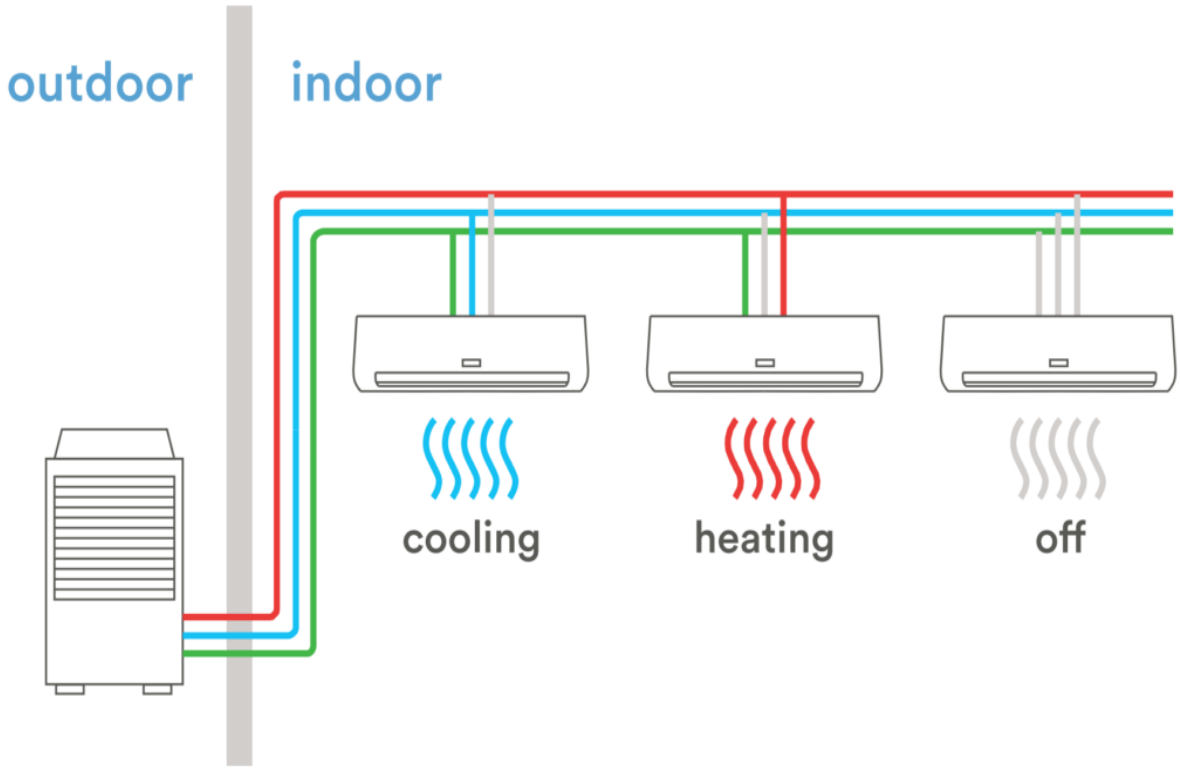
An air source heat pump works much like a refrigerator operating in reverse. Outside air is blown over a network of tubes filled with a refrigerant. This warms up the refrigerant, and it turns from a liquid into a gas. This gas passes through a compressor, which increases the pressure. Compression also adds more heat – similar to how the air hose warms up when you top up the air pressure in your tires. The compressed, hot gases pass into a heat exchanger, surrounded by cool air or water. The refrigerant transfers its heat to this cool air or water, making it warm. And this is circulated around your facility to provide heating and hot water. Meanwhile, the refrigerant condenses back into a cool liquid and starts the cycle all over again.



Source: https://www.ways2gogreenblog.com/2017/10/18/a-brief-introduction-to-air-source-heat-pumps/

What is a Variable Refrigerant Flow (VRF)?

VRF systems use heat pumps or heat recovery systems to provide heating and cooling for all indoor and outdoor units without the use of air ducts. With a VRF system, your building will have multiple indoor units utilized by a single outdoor condensing unit, either with a heat pump or heat recovery system. A VRF HVAC system can heat and cool different zones or rooms within a building at the same time. If the appropriate VRF system is selected, building occupants have the ability to customize the temperature settings to their personal preferences. VRF equipment can be used in conjunction with a wide range of heating and cooling products. This means that a VRF system can be scaled to meet the climate control needs.



Source: https://be-exchange.org/tech_primer/tech-primer-variable-refrigerant-flow-vrf-systems/

Appendix F

Energy Savings Summaries

Energy Efficiency Measures				GHG	Electric Savings			Fuel Savings			$ Savings & Cost		
EEM #	Measure Status	EEM Category	EEM Description	CO2e Lbs./Yr.	kWh	kW	Electric Cost Savings	Fuel Type	Fuel MMBtu Savings	Fuel Cost Savings	Total Annual Savings	Install Costs	Simple Payback (years)
EEM-1	R	Lighting	Interior Lighting Retrofit	4,178	5,639	2.4	$ 640	LPG	(14.7)	($ 213)	$ 427	$ 1,262	3.0
EEM-2	R	Controls	Ventilate Based On Occupancy	10,003	622	0.0	$ 29	LPG	57.6	$ 838	$ 867	$ 1,800	2.1
EEM-3	RNE	Envelope	Building Airflow Reduction	525	0	0.0	$ 0	LPG	3.3	$ 47	$ 47	$ 1,170	24.7
Total of Recommended Measures:				**14,706**	**6,261**	**2.4**	**$ 669**		**46.2**	**$ 672**	**$ 1,341**	**$ 4,232**	**3.2**

Building Electrification Measures				Savings & Cost									
EEM #	Measure Status	EEM Category	Building Electrification Measure Descriptions	CO2e Lbs./Yr.	kWh	kW	Electric Cost Savings	Fuel Type	Fuel MMBtu Savings	Fuel Cost Savings	Total Annual Savings	Install Costs	Simple Payback (years)
BE-1	RBE	ASHP	Install Clean Heating System - Air Source Heat Pump	1,850	(6,824)	0.4	($ 954)	LPG	60.6	$ 882	($ 72)	$ 17,879	n/a
BE-2	RBE	GSHP	Install Clean Heating System - Ground Source Heat Pump	5,164	(4,139)	0.9	($ 551)	LPG	61.8	$ 900	$ 349	$ 66,127	189.4
Total of Recommended Measures:				**0**	**0**	**0.0**	**$ 0**		**0.0**	**$ 0**	**$ 0**	**$ 0**	